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Arise Awake Achieve

Education is the manifestation of the perfection already in man". These are the words of the great philosopher and educator Swami Vivekananda. The contributions of the great people who devoted their life for the cause of education and youth have always inspired the promoters and, therefore, following the preaching of Swami Vivekananda, the promoters established VIT Campus, comprising of Vivekananda Institute of Technology and Vivekananda Institute of Technology (East), in 2008, to usher in technology revolution by using modern management techniques and harnessing potential of India. Another feather in the crown of Vivekananda Group of Institutions is Vivekananda Global University, established in the year 2012. Vivekananda Global University, Jaipur has been formed keeping in mind his teaching and mentoring ideals. The overall development of the techno-managers with a seeking spirit towards education is VGU's vision for its students. It Promises to develop as an institution with a commitment to excellence in education, research and consultancy and promote human advancement. Swami Vivekananda advocated the concept of 'total development' which includes physical, mental and spiritual. He also advocated incorporation of science and technology in curricula and laid emphasis on technical education that will develop industries. Our core values are inspired by Swami Vivekananda philosophy, and our institution is founded on his thoughts and ideas. To meet these ends, Vivekananda Global University encourage development of student's physical, mental, emotional, secular and spiritual faculties.



*"We are what our thoughts
have made us; so take care
of what you think.*

Words are secondary.

Thoughts live; they travel far."

Swami Vivekananda

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Evaluation of Synergistic effect of bio-agents and Fungicides against Root Rot of Chilli (*Capsicum annum L.*) caused by *Rhizoctonia solani* (Kuhn.)

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Abstract

In vitro study were undertaken to evaluate the bio-efficacy of six fungicides and four bio-agents against *R. solani* under controlled condition. Among bio-agents *T. viride* showed maximum growth inhibition of test pathogen *R. solani*. In case of tested fungicides maximum percent growth inhibition was recorded in Carbendazim 50WP followed by Tebuconazole and Vitavax.

Introduction

Chilli is an important vegetable and commercial spice crop. *Capsicum annum L.* and *Capsicum frutescens L.* are two important species cultivated in several tropical and sub-tropical climates both for green and ripe dry fruits. The most important producers and exporters of chilli include China, India, Mexico, Morocco, Pakistan, Thailand and Turkey (Lakshmi et al. 2014). India is the largest producer of chilli followed by China, Mexico and Pakistan. In India green chilli is cultivated in an area of 0.289 million hectares, annual production of 3.446 MT and dried chilli production is 0.830 million hectares with production of 1.862 MT (Horticulture Statistics at a glance, 2017). In last few decades there have been some shifts in disease scenario in chilli, mainly due to introduction of diverse germplasm, cultivar and hybrids. Some diseases like root-rot and damping-off have become wide spread and economically injurious. Root rot, is one of the most devastating and challenging disease, which can damage the crop at any stage. The collar region and roots showed black lesions and shrunk. From the wilted seedlings showing black lesions of roots. *R. solani* is seed-borne and can survive in soil in the absence of host for more than six years. The management of this disease is difficult owing to long saprophytic survival ability of pathogen in soil (Singh and Malthora, 1994).

Materials And Methods

Isolation and Purification of the Pathogen

Samples of root rot infected chilli plants were collected from surveyed field; root rot infected plants were carefully uprooted and brought to laboratory: Isolations of the

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pathogen were attempted from all samples. The pathogen was isolated on potato dextrose agar (PDA) medium. Small pieces (1-2mm) of diseased roots were cut, washed with sterilized water, surface sterilized with 0.1 % mercuric chloride (HgCl₂) solution for 1 minutes followed by three to four washings with sterilized distilled water and were transferred aseptically on 2 % PDA (Potato Dextrose Agar) plates. The plates were incubated in an incubator at 28±1⁰C for seven days. Hyphae coming out from the bits were sub-cultured on the fresh PDA in Petri dishes.

Pathogenicity Test

The pathogenicity of the culture of *R. solani* was tested by growing chilli plants in earthen pots of 20 cm face diameter size. A mixture of garden soil: FYM (3:1) was sterilized in an autoclave. The culture of *R. solani* that was showed maximum disease mortality at the farmers field was used for further studies and multiplied on corn meal-sand (1:1) medium at 28±1⁰ C for 10 days and mixed with sterilized soil @20 g/kg soil. This inoculated soil was filled in the earthen pots and kept in the cage house for seven days and were irrigated with distilled water to allow establishment of the pathogen. Pots with un-inoculated sterilize soil was kept as control. Seedlings of susceptible variety Pusa Jwala were transplanted in both inoculated as well as un-inoculated pots, at the rate of five seedlings per pots. The pots were kept in the cage house and were watered daily to provide good moisture. The germination and symptoms developing on chilli plants were carefully observed. From the diseased plants, showing root rotting symptoms, re-isolation of the pathogen was attempted and the resultant cultures were re-identified. After proving the pathogenicity of *R. solani* culture was used for further studies.

Identification of the Pathogen

The slides were prepared in lacto phenol solution and mounted by DPX mount. These slides were then observed under compound microscope at 10X and 40X power. The morphological, cultural and formation of sclerotia were the principle characters to identify the pure cultures, and compared with the standard reference description (Holliday, 1981, Sneh et al., 1992 and Mordue, 1988) an identity was confirmed as *Rhizoctonia solani*. The culture was identified by comparing the morphological and cultural characters described in standard references of Mordue (1988) for *Rhizoctonia* and was identified as *Rhizoctonia solani*.

In vitro efficacy of fungicides (Poison food technique)

Relative efficacy of different fungicides i.e. Azoxistrobin - 23SC, (Amistar) (Syngenta ltd.) Carbendazim 50WP [BASF India Ltd.], Mumbai, Vitavax power (combi formulation - Carboxin 37.5% + Thiram 37.5%) [Pesticide India Ltd.], Udaipur, Tebucanazole - 250EC (25.9% w/w) [Bayer Crop Science], India Ltd., Mumbai, Rizolex - 50WP [tolclophos-methyl] [Sumitomo chemicals ltd.], Thiram - 75WP, [Gupta Chemicals (p.) Ltd.], Mumbai, was evaluated by using poisoned food technique (Schmitz, 1930) at four concentrations i.e. 50, 100, 250 and 500 ppm. Desired quantity of each fungicide was added separately to sterilized medium,

mixed thoroughly and poured in sterilized Petri dishes and allowed to solidify. Each plate was inoculated with 2 mm disc of fungal culture and incubated at $28 \pm 10^{\circ}\text{C}$. The linear growth after seven days was recorded and per cent inhibition was calculated according to Vincents Formula (1947) as follows:

Where,

Per cent inhibition = $(C-T)/CX100$

C = Diameter of the *R. solani* colony in control.

T = Diameter of the *R. solani* colony in treatment.

A = check was also maintained where medium was not supplemented with any Fungicide.

Evaluation of Synergistic effect of bio-agents and Fungicides against Root Rot of Chilli (*Capsicum annum* L.) caused by *Rhizoctonia solani* (Kuhn.)

In vitro efficacy of bio-control agents (Dual culture technique)

The efficacy of four bio-control agents viz. *T. harzianum*, *T. viride*, *T. aureoviride*, *Pseudomonas fluorescens*), was tested by using dual culture plate method on PDA medium (Johnson et al. 1959). Antagonistic effect of these bio agents were tested against the test pathogen (*R. solani*), 2 mm diameter mycelium bit of seven days old culture of *R. solani* and each bio agents were placed separately at 4 cm distance on the periphery of Petri dishes containing sterilized PDA medium. For each treatment four replications were taken. Inoculated plates were incubated at $28 \pm 1^{\circ}\text{C}$ temperature in BOD incubator. Linear growth of pathogen and zone of inhibition was measured after seven days of inoculation. PDA plates inoculated with pathogen alone served as check.

Results And Discussion

Isolation, purification and identification of the pathogen

The root rot infected chilli samples were also collected from surveyed fields to isolate the pathogen. The rotted root samples from various villages were separately cut into 2 to 5 mm size and surface sterilized, washed thrice with sterile distilled water and were transferred aseptically on potato dextrose agar in Petri dishes and then incubated at $28 \pm 1^{\circ}\text{C}$ for seven days. The growth of the pathogens was frequently observed in Petri dishes.

The most of chilli root rot samples were yielded *Rhizoctonia* and *Fusarium*., whereas, in majority of *R. solani* colonies were recovered from these samples. Pure culture of various fungi (pathogens) was obtained by single hyphal tip culturing technique. As the majority of *Rhizoctonia* colonies were recovered from most of the samples has been identified as *Rhizoctonia solani* on the basis of morphological characters of mycelium and sclerotia formation that were further confirmed by compared with the standard reference and descriptions of (Sneh et al., 1992 and Mordue, 1988) and its identity was confirmed as *Rhizoctonia solani*. Resulted cultures were maintained by periodical transfers on PDA slants for further studies and fungal culture of the pathogen *R. solani* was used for present study.

Pathogenicity Test

Pathogenicity of the recovered culture of *R. solani* was tested by growing susceptible chilli cultivar Pusa Jwala in earthen pots contain sick soil of *R. solani*.

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The development of root rot symptoms on chilli plants was carefully observed. The diseased plants, showing root rotting symptoms, re-isolation of the pathogen was attempted and the resultant cultures were re-identified.

In-vitro evaluation of bio-control agents (Dual culture technique)

Efficacy of four bio-control agents viz; *Trichoderma viride*, *T. harzianum*, *Pseudomonas fluorescens* and *T. aureoviride* was studied in vitro against *R. solani* using Dual culture technique. After 7 days of incubation at 28±1°C mycelia inhibition percent was recorded. Results were indicates that all the bio-agents viz. *T. viride*, *T. harzianum*, *T. viride* (T₃) and *T. aureoviride* were showed antagonistic activity to the growth of *R. solani*. *T. viride* showed maximum 92.21% inhibition of *R. solani* growth in dual culture method, followed by *Pseudomonas fluorescens* showed 84.44% inhibition against *R. solani* growth, whereas *T. harzianum* was 80.57% inhibition, Minimum mycelial inhibition was recorded in *T. aureoviride* 69.28%.

Treatments	Bio-control agents	Growth*	
		Growth of pathogen	Per cent inhibition*
T ₁	<i>Trichoderma viride</i>	6.61	92.21
T ₂	<i>Trichoderma harzianum</i>	17.63	80.57
T ₃	<i>Pseudomonas fluorescens</i>	14.23	83.89
T ₄	<i>Trichoderma aureoviride</i>	27.04	69.28
T ₅	Control	90.00	0.00
SEm±		0.327	0.793
CD at (P=0.05)		1.043	2.531

* Average of four replications; Figures given in parentheses are angular transformed values

Table 1: Evaluation of Per cent inhibition of mycelial growth of *R. solani* with four isolates of *Trichoderma* sp. by dual culture technique

In-vitro evaluation of fungicides (poisoned food technique)

Six fungicides Azoxistrobin, Vitavax power, Tebuconazole, Thiram, Carbendazim 50 WP and Rhizolex were evaluated at four concentrations viz., 50, 100, 250 and 500 ppm using poison food technique against *R. solani*. All the tested fungicides significantly (P=0.05) inhibited the mycelial growth of *R. solani* at all concentrations from 50 ppm to 500 ppm. The tested fungicide Carbendazim 50WP completely inhibited mycelial growth at all concentration followed by Tebuconazole and Vitavax power showed 100 % inhibition of linear growth at 500 ppm concentration. Second best fungicide Tebuconazole showed complete inhibition of mycelial growth at 50, 100, 250 and 500 ppm concentration showed

79.79, 89.69, 92.59 and 100.00% inhibition, respectively. The next was Vitavax power which caused 73.14, 86.18, 92.34 and 100% inhibition of growth at 50, 100, 250 and 500 ppm concentration respectively, followed by Azoxistrobin was found effective with 70.30, 80.50, 87.80 and 92.40 % inhibition of growth at 50, 100, 250 and 500 ppm concentration respectively. Rhizolex was found at fourth number it inhibited 69.37, 80.70, 86.62 and 89.80 % inhibition of growth at 50, 100, 250 and 500 ppm concentration respectively. Thiram was found least effective at all concentrations against *R. solani* with lowest 65.62, 78.76, 85.74 and 88.30% inhibition of growth at 50, 100, 250 and 500 ppm concentration, respectively.

Evaluation of Synergistic effect of bio-agents and Fungicides against Root Rot of Chilli (*Capsicum annum L.*) caused by *Rhizoctonia solani* (Kuhn.)

S. N.	Treatments/ Fungicides	Mycelial growth (mm)*				Per cent growth inhibition*			
		50	100	250	500	50	100	250	500
1.	Azoxistrobin	25.67	17.13	10.13	7.03	70.30	80.50	87.80	92.4
2.	Vitavax	23.67	12.39	7.23	0.00	73.14	86.18	92.34	100.0
3.	Tebuconazole	18.17	9.40	6.07	0.00	79.70	89.69	92.59	100.0
4.	Thiram	31.48	18.87	13.07	10.07	65.62	78.76	85.74	88.3
5.	Carbendazim	0.00	0.00	0.00	0.00	100.00	100.00	100.00	100.0
6.	Rhizolex	28.19	17.51	12.50	9.37	69.37	80.70	86.62	89.8
7.	Control	90.00	90.00	90.00	90.00	0.00	0.00	0.00	0.0
SEm±		1.328	0.393	0.371	0.129	0.397	0.391	0.488	0.407
CD at (P= 0.05)		0.434	1.205	1.135	0.395	1.217	1.199	1.495	1.246

*Average of four replications; Figures given in parentheses are arcsine per cent angular transformed values.

Table 2: Efficacy of different fungicides on the growth of *R. solani* at various concentrations (PPM) in-vitro

Discussion

In-vitro studies for evaluating resident isolates of *Trichoderma* sp. revealed the efficacy against *R. solani* in dual culture method. This was expected as in dual culture, all the modes of antagonism, competition as well as mycoparasitism is simultaneously operative. In the present study the isolate of *T. viride* resident of this region found to be highly effective (92.40%) against the tested pathogen in vitro. Similar results have been observed by several workers, where biological control agents like *T. viride*, *T. harzianum* and *T. aureoviride* have been reported to be effective (83.3, 81.2 and 71.1%), respectively for control of *R. solani* of chilli. The result augmented with; Bunker and Mathur (2001); Mathur and Gurjar (2002); Das and Soma (2011); Subhash et al. (2013). Six fungicides Azoxistrobin, Vitavax power, Tebuconazole, Thiram, Carbendazim and Rhizolex were evaluated in-vitro at four concentrations viz., 50, 100, 250 and 500 ppm using poisoned food technique against *R. solani*. The test fungicide Carbendazim completely inhibited mycelial growth at all concentration followed by Tebuconazole and Vitavax power showed 100% inhibition of pathogen growth at 500 ppm concentration. Similar

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studies were conducted by Rehman et al. (2013) and reported that Carbendazim was the promising for the inhibition of the radial growth of *R. solani* in-vitro, Vadhera et al. (1997) and (Gupta and Arora 1998) also reported that Carbendazim was the most effective to suppress the *R. solani* growth in-vitro and in-vivo against Soybean root rot pathogen *R. solani*.

Conclusion

From the above findings it is concluded by in vitro study application of bio-control agents will be significantly promising and applicable as an alternative to synthetic chemicals and low efficiency and harmful methods for inhibition or control of *R. solani*.

Acknowledgement

The author is thankful to the Vivekananda Global University, Jaipur for providing laboratory facilities.

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Cyber Voyeurism : Offence of the Digital Age

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Abstract

Women have consistently been the targets of numerous sexual offences since the dawn of humanity. They have fallen victim to cyber voyeurism, a growing sex crime that has swept the internet, as a result of recent advances in science and technology. There are laws against cyber voyeurism in the Indian Penal Code and other laws, such as the Information Technology Act, but they haven't had much of an impact on combating this contemporary sex crime. For instance, Section 354C of the Indian Penal Code has additional regulations to safeguard women in this area and makes it unlawful for a man to witness or record a woman doing a private act. It also punishes the spread of these photos. Women, the topic of the voyeur's interest is typically not required to have direct connection with him, therefore they frequently are not aware that they are being observed. Due to the decreased chance that such offences will be recorded, the victims are put in a position where they are subjected to severe injustice and a violation of their human dignity, even though they may not be aware of it. In order to successfully combat voyeurism and other sex crimes that have infiltrated the online world, this paper seeks to examine the gaps in the application of laws relating to cyber voyeurism in India. It also makes recommendations for legislative action.

Introduction

Sexual Offences remains one of the top offences done against the female human body. With the recent advancements in the field of science and technology, women have become victims of a cyber voyeurism, an emerging sex crime which has taken the internet by storm. The Indian Penal Code and the Information Technology Act provides for laws against cyber voyeurism, but these laws have had little impact in tackling this modern sex crime. Section 354C of the Indian Penal Code, for example, provides for special laws to protect women in this sphere, and prohibits a man from watching or capturing the image of a woman engaging in a private act. It further penalizes the dissemination of such images. However, justice is served only when the victim moves a complaint in this regard. In most cases, the voyeur does not have to make direct interaction with the subject of his interest, and hence they are often unaware of the fact that they are being observed. This in-turn reduces the possibility of such offences being reported, which leaves the victims in a situation where they are subjected to grave injustice and violation of human dignity, although they may not be aware of the same.

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Meaning and Definition

- **Meaning of Voyeurism**

The term Voyeurism comes from a French word *voir* which means "to see". Voyeurism is generally defined as a person who derives sexual gratification from the covert observation of others as they undress or engage in sexual activities without their consent or knowledge.¹ A male voyeur is commonly known as "Peeping Tom" However, that term is usually applied to a male who observes somebody secretly and, generally, not in a public place.

- **Cyber Voyeurism**

With the development in technologies, observation of an individual engaged in private acts in both public and private places through sneaky means has become common and easier. A large part of pornographic content available on the web comprises such sneaky and surreptitious videos of individuals engaged in private acts and they don't even have a hint. Cameras may be placed anywhere such as changing rooms or toilets where an individual expects privacy.

Cyber voyeurism is a phenomenon where a person spies on another person, prevalently women, and sees or captures her private moments. Voyeurism can involve sexual or nonsexual acts, but on the Internet, even predominantly nonsexual spying gives you the thrill of being an uninvited guest at someone else's private party. Voyeurism blatantly defies the reasonable expectation of individuals infringing privacy and personal dignity. Voyeurism hurts the privacy as well as the dignity of the individual by infringing upon the right of individuals to control exposure of their bodies without their consent or knowledge. This takes place either by observation or by distribution of videos or images without the consent of the victim.²

But the effects of such acts hurt the dignity of the victim as well as dishonour them in the society. The traumatic effects of voyeurism were well discussed in the case of *R v. Turner*³ where a sports store manager was charged criminally for recording videos of women in the shower room. There was no indication that the footage had been shown to anyone else or distributed in any way. The defendant pleaded guilty and the Court of Appeal confirmed a sentence of nine months' imprisonment to reflect the seriousness of the abuse of trust and the traumatic effect on the victims.

At present, with the advancement in technologies, the stalkers or voyeurs have high-tech gadgets which have taken the crime of Voyeurism to new heights, globally. Statistically, about 40% of college-going students without any criminal records are

¹ Singh Dalla Harpreet. Cyber Crime – A threat to person, property, Government and Societies. IJARCSE. 2013; 3(5).

² Paton-Simpson, Elizabeth. Privacy and the Reasonable Paranoid: The Protection of Privacy in Public Places. The University of Toronto Law Journal, vol. 50, no. 3, 2000, pp. 305–46, <https://doi.org/10.2307/825907>. (Accessed on 13th May 2022)

³ (2006) All ER (D) 95 (Jan)

said to have committed voyeuristic acts.⁴ Most of today's mobile phones come with advanced cameras and fast internet and most of the students are having access to these at a very young age. Moreover, other hi-tech gadgets such as spy pen camera also come at affordable prices. Furthermore, another facet of cyber voyeurism includes blackmailing. There are many cases that are left unreported by the victim and in fact voyeurism is one of the least reported sexual offences against women. There have been also the instances of voyeur blackmailing to distribute the image which makes the victim to agree to his demands. Sometimes this may lead to depressing ending up in suicide

Cyber Voyeurism : Indian Scenario

Technology has advanced by miles, making lives easier of humans but lack of strict and solid laws to regulate their use. Especially with coming of new technologies of mobile and internet there has been a substantial rise in sex crimes in the cyber world. Sexual Harassment of women, outraging the modesty of women and rape are recognised as sex crimes against women in India.⁵ With the passing of Criminal Law Amendment Act, 2013, Cyber voyeurism was added to the list. However, it has been criticised for having a devastating impact on the victim. The effect may or may not be physical one but also emotional and mental. Also, section 66E of the Information Technology Act provide for law against voyeurism.

• Voyeurism under Indian Penal Code, 1860

The provision of section 354C regarding Voyeurism as an offence was added after the recommendations of Justice JS Verma Committee after the heinous Nirbhaya Gangrape incident of 2012. In the wake of this, when committee was going through legal provisions, it was shocking for them to find out that offences such as voyeurism was perceived as minor offences although acts like these are capable to violate basic human rights of women as well as frail children such as right to education and freedom of movement. Hence, section 354C along with other sections added minor offences to mainstream offences with stricter approach.

After the amendment of Criminal Law, section 354C was added to the Indian Penal Code, 1860 which criminalises voyeurism. The provision prescribes punishment for the person who watches or captures the image of a woman engaging in private act without her knowledge or disseminates such image.⁶The punishment for first conviction is imprisonment for one year extendable up to three years with fine and for subsequent conviction, imprisonment of three years extendable to seven years with fine. The offence under Section 354C has been categorised as cognisable, bailable, non-compoundable and triable by any magistrate. The provision seeks to protect victims of voyeurism, who have been watched, or recorded, without their consent and under circumstances where the victim could reasonably expect privacy,

⁴Crime in India, Chapter 5 (NCRB, 2014), available at <http://ncrb.nic.in/StatPublications/CII/CII2014/chapter/Chapter%205.pdf>

⁵*Ibid*

⁶Indian Penal Code, 1860; Section 354C

and where the victims genitals, buttocks or breasts have been exposed.⁷ A reasonable expectation of privacy means that in the circumstances, whether in a public or a private place, the victim has a reasonable expectation that she is not being observed engaging in private acts such as disrobing or sexual acts. The test of reasonable expectation of privacy can be derived from similar provisions in voyeurism laws across the world.

One of the critical views of this provision can be that it is gender specific. Going by the letter of law, this provision clearly shows how voyeurism in India has been criminalized however; it is a gender-biased crime which is punishable only if committed by a male accused as the provision says any man . There is no provision for punishing a female for indulging in the said behavior as opposed to similar laws of other countries on the same crime. At this juncture a comparative analysis may prove useful. By examining the voyeurism laws in India as against other countries, the application of the law in a gender neutral or an equitable manner can be seen while at the same time the inadequacies or Indian law are highlighted on this front. If we compare Indian law on voyeurism with that of other common law countries we will find that, laws in Australia⁸, Canada⁹ and the United States¹⁰ want to deter Voyeurism just as India does. The critical difference being, the law in these three countries includes each and every person carrying out such act to be liable for punishment under the law. All versions of this law are to protect every person in society who is a victim of an illegal act of voyeurism. This person can be either men or women as the case may be. In India, however, ONLY men are termed as voyeurs and be punished for committing the act of voyeurism. The scenario of a woman committing the act of voyeurism thereby harming another woman or man is not even envisaged. Even the Justice Verma report which is the basis on which the Criminal Amendment Bill, 2013 has been proposed used the term whoever to refer to the offenders. The government having accepted a substantial part of its substance from this report should have taken the parameters of the offence of voyeurism as well so as to give full effect and protection to the society as a whole. It

⁷*Ibid*

⁸Australia's Crimes Act of 1910- *A person who, for the purpose of obtaining sexual arousal or sexual gratification, observes a person who is engaged in a private act without the consent of the person being observed to being observed for that purpose, and knowing that the person being observed does not consent to being observed for that purpose, is guilty of an offence*

⁹Supra, footnote 7

¹⁰Revised Code of Washington, 9A.44.115 states that- *A person commits the crime of voyeurism if, for the purpose of arousing or gratifying the sexual desire of any person, he or she knowingly views, photographs, or films another person without that person's knowledge and consent while the person being viewed, photographed, or filmed is in a place where he or she would have a reasonable expectation of privacy; or the intimate areas of another person without that person's knowledge and consent and under circumstances where the person has a reasonable expectation of privacy, whether in a public or private place*

can be understood from the report by the Justice Verma Committee that such an offence can be perpetrated by either Males or Females to give blanket jacket to female offenders is unconstitutional and practically unjust to the other sex.

Another issue in the case of laws like voyeurism or stalking is the consent or the act of disinterest respectively, which plays a decisive role in terming an accused guilty. Both these acts are related to the actions of the victim i.e. to show disinterest in case of being stalked and no consent of being viewed while carrying out an act of privacy. When these deciding factors are in the control of the victim then the onus to prove the presence of act also should be on them. Taking another example with reference to voyeurism if a woman gives consent to a man to see her carrying out a private act and later on files a frivolous complaint, there is no way for the accused to prove the presence of any consent. The fact that the woman filed a case in the first place implies that she is not accepting to give any consent. It is therefore very necessary for the burden to lie on the prosecution to prove the guilt and for there to set guidelines for the accused to prove the absence of signs of disinterest or the presence of consent on the part of the woman.

- **Voyeurism under Information Technology Act, 2000**

Section 66E of the Information Technology Act, 2000 which was inserted through IT (Amendment) Act, 2008, does not explicitly deal with voyeurism but has provided punishment for the violation of privacy of a person through electronic means, the maximum of which is three years with fine.¹¹ This provision was influenced heavily from the US Federal Law- Video Voyeurism Prevention Act of 2004. The purpose of insertion of section 66E was a specific attempt in the

¹¹Punishment for violation of privacy.- Whoever, intentionally or knowingly captures, publishes or transmits the image of a private area of any person without his or her consent, under circumstances violating the privacy of that person, shall be punished with imprisonment which may extend to three years or with fine not exceeding two lakh rupees, or with both

Explanation - For the purposes of this section--

- (a) transmit means to electronically send a visual image with the intent that it be viewed by a person or persons;
- (b) capture, with respect to an image, means to videotape, photograph, film or record by any means;
- (c) private area means the naked or undergarment clad genitals, pubic area, buttocks or female breast;
- (d) publishes means reproduction in the printed or electronic form and making it available for public;
- (e) under circumstances violating privacy means circumstances in which a person can have a reasonable expectation that--
 - (i) he or she could disrobe in privacy, without being concerned that an image of his private area was being captured; or
 - (ii) any part of his or her private area would not be visible to the public, regardless of whether that person is in a public or private place

direction towards prohibiting voyeuristic conduct and by corollary, to protect individual privacy.

As per section 66E, there are essential acts which need to be performed in order to invoke the provision:

- (a) Capturing
- (b) Publishing or
- (c) Transmitting

If a person performs any of the abovementioned acts, intentionally and knowingly, he would be guilty of the offence. The terms capturing, publishing, and transmitting have been defined in the explanation to the section.¹² It is pertinent to notice here that the legislature is committed to not only make publishing or transmitting an offence but also causing to publish or transmit. This is further notified under IT (Intermediary Guidelines) Rules, 2011.¹³

The wordings of the section suggests that, without his or her consent, the act of capturing by a digital or non-digital camera of images of private parts of an individual would be covered under this section. The transmission of objectionable images via electronic means is also covered under this section. The noteworthy expression used in this section is under circumstances violating privacy which basically means that situations which makes a person to have a reasonable expectation that he can change clothes or disrobe in private without the fear that his or her private images may be secretly clicked or any part of his or her private area would be visible whether he or she is in a public place or private place. The clause (e) of Section 66E explaining the expression under circumstances violating privacy recognizes that a person can have reasonable expectation of privacy¹⁴ even in public places say office which is comparatively less than a person in the cool comfort of his home. However, this does not make the expression to mean that anyone can take the privacy of others in the public place, for example by hiding camera in office and surreptitiously clicking her objectionable photo without her consent. Privacy is same everywhere.

Nevertheless, the ambit of provisions under section 66E is limited in nature as the term privacy has always been a matter of question. There is no clear definition of privacy, which makes it subject to the persons interpretation that further may defeat the purpose of the provision. Moreover, India does not have any law that is dedicated to the privacy of the person and only judicial precedents are available to make rules over this matter. Hence, there is need of proper codification with proper definition of the term privacy and video voyeurism. The Section recognizes the right of privacy as inviolable and makes the offence punishable with imprisonment which may extend to three years or with fine not exceeding two lakhs rupees, or with both. The section recognizes the human desire of privacy which needs to be protected and respected in our society and cultural traditions. The Section 66E of the IT Act, 2008 has recognized the right to protect the human body from intrusion

¹²Ibid, at Explanation

¹³Rule 3, IT (Intermediary Guidelines) Rules, 2011

¹⁴IT Act, 2000

by furtive video technology and adequately protects the privacy from the crime of electronic voyeurism, which destroys personal privacy and dignity by secretly videotaping or photographing unsuspecting individuals.¹⁵

However, the offences under Section 66E of IT Act though has been categorized as cognizable but are bailable and since, the reported and unreported incidents are on rise which makes it a major criminal offence against women and gross intrusion of privacy of woman at work place by use of peeping cameras, it is imperative on the legislature to make the offence non-bailable and also enhance the punishment. The offence is not as simple, as it seems to be and is a very serious offence having deep adverse implications. For example, many a times accused person transmits or post the obscene images on internet which in turns would definitely cause irreparable damage to the reputation of the victim girl or her family and would spoil her life. Therefore, the legislature needs to categorize the offence as non-bailable offence in view of the seriousness of the offence.

Cyber Voyeurism : Laws In Various Countries

Voyeurism is not a crime at common law and in common law countries it is only a crime if made so by legislation. Three of the major common law following legal systems is of the USA, the UK and Canada, where voyeurism is prohibited by law and is punishable, though the nature and categorisation maybe different in each country.

- **Canada**

If we look at historical development of law against Voyeurism in Canada, voyeurism was not a crime when the case *Frey v. Fedoruk*¹⁶ came up. It is a decision by the Supreme Court of Canada on the definition of a breach of the peace and whether being a "peeping tom" is a crime. The judges also found that peeping is "not otherwise criminal and not falling within any category of offences defined by the Criminal Law," and that recognizing it as criminal now could lead to many other legal actions, such as adultery or giving insults.

In Canada, anyone circulates or publishes or even distributes or sells any recordings of any voyeuristic act, is punishable under its Criminal Code, 2009. Section 162 of the act provides that everyone is liable for offence of voyeurism if they secretly observe which includes by mechanical or electronic means or makes a visual recording of a person who is in circumstances that give rise to a reasonable expectation of privacy.¹⁷

¹⁵Information Technology Act, 2000

¹⁶(1950)S.C.R. 517

¹⁷The Criminal Code of Canada, 2009; S.162- Everyone commits an offence who, surreptitiously, observes - including by mechanical or electronic means - or makes a visual recording of a person who is in circumstances that give rise to a reasonable expectation of privacy, if the person is in a place in which a person can reasonably be expected to be nude, to expose his or her genital organs or anal region or her breasts, or to be engaged in explicit sexual activity; the person is nude, is exposing

The privacy rights of complainants have been enshrined in the Canadian constitution and have developed through judicial precedents. In the case, **R. v. Mills**¹⁸ the Supreme Court of Canada upheld the constitutional validity of sections 278.1 to 278.91 of the Criminal Code concerning the production of a complainant's personal records in sexual assault trials where the Court acknowledged that there were conflicting rights at play as the rights of the accused to make full answer and defence was to be balanced against the complainant's privacy and equality rights.

In the words of Justice La Forest in the case of **R. v. Dyment**¹⁹, "*privacy is at the heart of liberty in a modern state.*" The right to privacy is also expressly recognized by various international instruments²⁰, which extend to all persons the right to be protected from arbitrary or abusive interference with their privacy. The rights enshrined in these international instruments are expected to inform policy choices regarding the right to privacy in the domestic context. In relationships between individuals, privacy rights are protected in the civil context in some jurisdictions through provincial legislation.

If we take the sexual aspect of the offence, it has two sources: first is the purpose for which the observation is made (e.g. sexual arousal of the voyeur) or, another one is the nature of the subject observed. Prohibiting voyeurism in this context prevents a private citizen from sexually exploiting another private citizen.

- **USA**

The US legislation on voyeurism²¹ is similar to that of Canada. However, US maintain a Sex Offenders Register. Although the same is seen in Canada and other countries like New Zealand, Australia etc. as well, the peculiarity of US is that the Register is publicly accessible.²² Such methods may help prevent potential offenders from committing the crime, as they would fear rejection from the society if their names are recorded in the register.

his or her genital organs or anal region or her breasts, or is engaged in explicit sexual activity, and the observation or recording is done for the purpose of observing or recording a person in such a state or engaged in such an activity; or the observation or recording is done for a sexual purpose.

¹⁸(1999) 3 S.C.R. 668

¹⁹(1988) 2 S.C.R. 417, at p. 427.

²⁰The International Covenant on Civil and Political Rights, Article 17 (Date of accession by Canada: May 19, 1976); American Declaration of the Rights and Duties of Man, Article V (Canada has been a member of the Organization of American States since 1990); American Convention on Human Rights, Article 11; European Convention for the Protection of Human Rights and Fundamental Freedoms, Article 8 (the privacy rights protected in the latter are in respect of the individual vis-à-vis the state).

²¹Video Voyeurism Prevention Act, 2004

²²Studies question effectiveness of sex offender laws, Science Daily (30 August 2011).

• ENGLAND

The history of anti-voyeurism laws in England can be traced back to the Justice of Peace Act of 1361 which provided for the arrest of peeping Toms and eavesdroppers.²³ In England, voyeurism has been recognised as sex crime as the non-consensual voyeurism became a criminal offence in 2004 through Sexual Offenders Act, 2003. Under the act, a behaviour is classified as voyeurism if it involves observing/recording another person doing private act; aiming to get sexual gratification; and knowing that the person being observed or recorded does not have consent to be observed or recorded.²⁴ The Sexual Offenses Act 2003 interprets that an act is regarded as Private act if the place where the act is done is reasonably expected to provide privacy; and either one of the following situations present:

The person's genitals, buttocks or breasts are exposed or covered only with underwear; or

The person is using a lavatory; or

The person is doing a sexual act that is not of a kind ordinarily done in public.²⁵

Therefore, as per the Sexual Offenders Act of 2003, a person is said to be committed the act of voyeurism for not only observing and recording private act of others, but also for installing and recording or even altering any structure of object with intention of enabling him or someone else to commit such offence.²⁶ Moreover, the statute states that a person consents if he or she agrees by choice, and has the freedom and capacity to make that choice.²⁷ Also, as per English courts, even filming one's own partners private acts without consent or knowledge is punishable by law²⁸. So this means that the laws against the act of Voyeurism in England are stricter in its approach which is missing in Indian criminal laws which owes its origin to English laws only.

After the aforementioned legislation, there were different cases as well which developed laws against voyeurism. For instance, in the English case of **R v. Turner**²⁹ where the manager of a sports centre tried to film four women in washroom. However, there was no proof that the footage had been distributed shown to anyone else or distributed in any way. The defendant pleaded guilty. The Court of Appeal confirmed a sentence of nine months' imprisonment to reflect the seriousness of the abuse of trust and the traumatic effect on the victims.

In another landmark case, **R v. Wilkins**, where the offender was caught when his girlfriend found a series of sexual liaisons, including TV and radio presenters, with his lovers. The offender committed voyeurism by hiding cameras in his bathroom and bedroom in his flat. The offender linked the cameras directly to his computer and transferred the videos to DVD for his own viewing. The judge decided that the

²³Justice and Peace Act, 1361 (Eng.), 34 Edw. 3, C.L

²⁴Section 67, Sexual Offenses Act 2003 (UK)

²⁵*Ibid*, section 68

²⁶*Ibid*

²⁷*Ibid*, section 74

²⁸*R vs. Wilkins*, Inner London Crown Court (2010)

²⁹(2006) All ER (D) 95 (Jan)

offenders acts represented a cruel, selfish, betrayal of the trust the victims put in and he was found guilty of committing voyeurism and was sentenced to 8 months' imprisonment and ordered to sign the Sex Offenders Register for ten years. This decision was made by considering the effect on the victims.³⁰

Although there is no express right to privacy under English law and therefore no civil action available for a purported breach of such a right there are a number of rights that, in various ways, relate to privacy. The Human Rights Act 1998 (the Act) incorporated the European Convention on Human Rights (the Convention) into UK law. Article 8(1) of the Convention provides that everyone has the right to respect for his private and family life, his home and his correspondence. Therefore, the Act and the Convention confer a right of having a private life, and provide a number of reasons why a public authority would be justified in interfering with that right. Some have argued that this is tantamount to a right to privacy but the courts in England have rejected that notion.

Recommendations

Combating voyeurism is not an easy task, and it cannot happen by merely passing laws which impose longer terms of punishment. Tackling voyeurism requires planning and cooperation from all sections of societies, from the police to the normal store owners. Bathrooms, washrooms, changing rooms in busy malls, hotels, restaurants and even hostels are common places where voyeurs hide their cameras. It is not practical to expect a rapid increase in the number of such cases being, but what can be done is creating awareness among people to make them cautious of such crimes occurring around them. It could start with NGOs and other agencies coming together to host awareness camps and seminars in schools, colleges, parks etc. with open access for the public. The best possible means to tackle voyeurism is by being self-conscious of one's environment and surroundings. The government could set up agencies to run a periodic check on restaurants, hotels, clothing stores, malls, and other places which are open to public. Such places should be checked routinely for breaches in privacy. If found to be faulty in ensuring such protection, then heavy fines and other penalties should be imposed on the store owner. Laws which would facilitate this would prove to be more effective in combating voyeurism than those laws which only seek to punish the voyeur. This would impose a duty on the store keepers or managers to ensure privacy protection in their stores. Also, the cyber cell should keep a watch on sexually explicit content that's available and shared through video streaming sites and other sites with video downloading features.

Conclusion

Since time immemorial, women have often been discriminated against, and have lacked empowerment though they have made significant contributions to various spheres of human life. There are legislations and various constitutional provisions which provide for special laws for protection of women, however the effectiveness

³⁰Supra footnote 25

of these laws have always remained susceptible to criticism. One of the most peculiar features of voyeurism is that most victims are unaware that their private acts are being watched or captured by someone. The impact which crimes like voyeurism create on the victims is not something to be looked upon lightly. The victims life could undergo drastic changes, and very often it leaves them in a state of emotional trauma which could be compared to that of a victim of rape or physical sexual abuse. There is an immediate need for the government and the law enforcement agencies to take up the issue of cyber voyeurism, and prevent more lives from being tormented by lust driven sex maniacs on the internet. With more and more people gaining access to the cyberspace, it is essential that their privacy, and other rights are given due protection. A system which fails to respect and safeguard the privacy of its citizens surely needs a refurbish. Incorporating the suggestions discussed in this paper could prove to be an effective solution to the issues surrounding cyber voyeurism in India, if implemented properly.

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Economic and social significance of the hand woven Kunbi weaving craft of Goa.

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Abstract

Weaving of the kunbi sari has been a symbol of Goa's cultural heritage. The main purpose of this paper is to revive the kunbi weaving craft in order to preserve this almost extinct craft and to create employment and livelihood opportunities.

In this article a study has been done that aims to present an analysis of the Goan economy activity in the traditional weaving craft of the kunbi sari, based on indigenous knowledge that contributes to the sustainability of traditional woven textiles in Goa. A case study approach was implemented to study the processes, techniques, designs, and colors of this weaving craft in Goa using observation, photography, and semi-structured interviews with the artisans as this sari had a near death experience when the last weaver in Goa stopped weaving, and hence there is a dire need to create awareness about this dying craft.

In order to reach the conclusions, both primary and secondary data has been analyzed in qualitative analysis. Finding of this research reveals that the kunbi weaving craft is contributing towards employment generation and inclusiveness but in terms of social responsibility it is not playing a positive role because of its unorganized structure.

Key words: Goa, weaving craft, Kunbi Sari, Handloom, Sari revival.

Introduction

In this review of literature an attempt is being made to examine and analyse all relevant forces that involve the weaving of the kunbisari. It is believed that in Goa there were mainly three tribes or Adivasis (Sanskrit term used for tribe), they were the Gavddas, Kunbis and Velpis. There is hardly any difference between these tribes other than their professions, which was either fishing or farming, most of these tribes wore a plain weave cotton sari called the kunbi sari that was woven on a handloom. This practice slowly diminished during Portuguese rule.

Weaving is a craft that is as old as the relics of civilization and cotton was considered one, of the first fiber ever used for the weaving of clothes.

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Ever since the dawn of civilization, man realized the importance of cotton, and through weaving, he was able to spin these fibers into long continuous lengths of cloth. Once he became adept in the weaving process, he gradually modified and added touches of beauty to these cotton fabrics.

Methodology

A study on traditional woven kunbi sari has been undertaken to study the processes, techniques, designs, colors used and problems faced by the weavers.

2.1 Significance of the study:

- i. The study will provide in-depth documentation on the production of the kunbi sari.
- ii. The study will provide information regarding techniques and designs used to produce these sarees.
- iii. The working conditions and socio-economic information will give a better insight into the problems of weavers which would help the policymakers to frame new policies and revise the old ones, thereby helping the growth and development of craft and upliftment of craftsmen.

2.2 WEAVING

Weaving encompasses a broad spectrum of warp and weft yarns that are interlaced at right angles to each other on a device called a loom. Most weavers in India used to weave at their own homes and were usually assisted by other members of the family in the various ancillary processes.

Most of these weavers in the early days weaved cloth primarily to meet their own demands or the demands of the village people. Subsequently with the increase in production and development of transport and communication the market for handloom products expanded within India and also abroad.

To preserve/revive our cultural heritage of handloom weaving, the government of India has introduced many credit schemes and has spent crores of rupees. Loans are also given for the purchase of looms for loom less weavers and the establishment of new development centers.

2.3 GOA

Spread over an area of 3,702 square Kilometers, the state of GOA harbors a population of 15.9 lakhs , and 11 talukas in total, with 5 talukas based in the North are Pernem, Bardez, Bicholim, Sattari, Tiswadi, Ponda and 6 talukas in the south which are Mormugao, Dharbondora, Salcette, Sanguem, Quepem, Canacona with Panaji as the capital city of Goa

A major part of the population in Goa consists mainly of Catholics, Hindus, and Muslims, with traces of Jains and Sikhs. Goans engage mainly in fishing and growing paddy. Their staple food consists mainly of rice, curry and fish.

It is said that the Gavddas or Kunbis were the first settlers in Goa and that The Gavddas call themselves the Mull Goemkar which translates as the root Goans or Mull Nivasi which means original inhabitants.

WEAVING THE KUNBI SARI

The traditional Goans wore a sari called the kunbi sari, which was produced on handlooms locally. In remote areas such as Palye (Pernem) a few houses owned a loom to meet their own requirements or had a weavers community who weaved for the whole village. Most of the products included the kashti, valo (towel), chador (bed sheet) and the traditional Gaudo sari. These weavers also weaved to sell their products in village/city fairs to earn their livelihood. And the family members helped in some way or other in making the kunbi sari, but after the invention of the power looms, many traditional weavers in the state abandoned their generation-old weaving practice as there was no space in the market for their handloom products.

The Department head of History, DrPratimaKamat, at Goa University, confirmed that, according to several records, Goa had a vibrant handloom industry at the time of liberation. Besides the Tilves from Paliyem, there were several prominent families who operated handloom units. a lot of natural dyes were imported from Japan in the 1930s by Narcinva Shankar Camotim from Candolim. His son, RanganathKamat, continued this business for quite a few years.

In Rasquinhas there were the Shettigars, in Bardez taluka there were the Satardekars, Chafadkars in Ponda, to name a few. The traditional pinkish-red dye used for these saris were with natural ingredients such as iron oxide and rice water. Sometimes, stripes of white, green, purple and indigo were added near the *pallu*. The sari has a two or three-inch wide doobby border with strips of white or gold that run along these borders

The original Kunbi sari was much thicker in density and was usually around 4.5 meters long and is woven using earthy colors. The traditional drape is known as Dethli (knotted) due to the peculiar knot that is tied on the right shoulder which secures the pallu. Unlike the other sarees, the folds of this sari flare out on the right, instead of the usual left side. This sari is worn at the knee level to enhance mobility while working in the fields.

This sari is indigenous to the kunbi community, a scheduled tribe of Goa. The term Kunbi is derived from the Konkani words Kun (people) and bi (seed).

Kunbi, therefore, refers to people who sow seeds or germinate seeds.

Goa's famous designer Wendell Rodricks, along with the help of Poonam Pundit, a textile designer from Delhi, collaborated with Baburao who was the only master weaver left at that time to revive the sari and created a collection inspired by this kunbi sarees that was presented at the Wills Lifestyle in 2011.

But, notwithstanding its fame and popularity, it is still difficult to find the traditional Kunbi garment in Goa.

3.1 PROCESS

The first step involved in weaving this Kunbi sari is spinning the Chakr (spinning wheel) to wind the spools and bobbins locally called (Gaddi).



Plate 1: winding the spools.

Once the spools are complete, the chakra is kept aside and the bobbins are arranged on a creel that is called Sidi locally. Thread from the bobbins is drawn through the eye on the creel that is wound on the warp drum.



Plate 2: bobbins arranged on a creel

Vas, N
Munjal, K

To weave a sari of forty-eight inches, one needs to pick forty-eight threads from the side one at a time for an inch, depending on the design of the fabric, and pass each one through a different notch of a giant comb. The ends of these forty-eight threads are tied into a knot before being arranged on the warp drum (a large cylindrical wheel) which is then rotated.



Plate 3: threads passed through a giant comb

Each rotation of the warp drum provides a length of 3.5 m to the cloth. So for thirty-five meters the warm drum is rotated ten times.



Plate 4: warp drum

To obtain a width of forty-eight inches, the above procedure is repeated forty-eight times, each arranging an additional inch of thread, side by side on the warp drum. All these threads are then collectively wound around a short wooden pole called the warp beam. The beam is then transferred to the handloom, locally called (Haatmaag).

Economic and social significance of the hand woven Kunbi weaving craft of Goa



Plate 5: weaving on the loom

The warp thread and then interwoven with the weft thread using a shuttle containing the weft thread. If the sari has two different colors using the weft threads then two shuttles using two different threads are used. Once the beams run out, the process ends. Approximately around 600 to 800 gm of yarn is needed to produce one Kunbi sari.



Plate 6: a shuttle with red thread

Vas, N
Munjal, K

Each sari takes anything between two days to a week to weave painstakingly and is sold for about 2500/- per sari.



Plate 6: different samples of the woven textile

3.2 Decline and Acceptance

After liberation from the Portuguese in 1961, many traditional weavers in Goa abandoned their generation-old practice, as there was no demand for handloom products in the market. Powerloom-produced fabrics were sold at a much cheaper rate and had much more variety than handloom-woven sarees.

The Directorate of Handicrafts, Textiles, and Coir, in Goa, made efforts to revive the handloom industry in 2016, giving special attention to the Kunbi sari, and as a result the handloom weavers in Goa steadily increased in the last 4 years. Some weavers were also provided advanced training on how to weave a 100-thread count checkered kunbi sari.

CONCLUSION

There is a need to revive this craft in terms of new color combinations with extra warp and weft threads to make it more appealing and acceptable among consumers. Mr. Arvind Bugde, director of the handicrafts, textiles, and coir directorate, stated that he plans to secure a Geographical Indication (GI) for the Kunbi weave by

reviving the original weave and positioning itself as a handloom weaving cluster of 200 to 300 weavers. He also hopes to develop employment opportunities for women, especially for those who belong to Scheduled Tribe and Scheduled Caste communities in rural parts of the state.

Initially, Mr. Baburao and some other weavers were roped in to train the first batch of ten weavers on two separate looms at the first training center that was set up at Madhlamaaj in Mandrem, Pernem taluka in 2016. A handloom support program had also been set up that spans seventy-five hours of weaving or six months of training. The program now covers five training centers with around twelve operational handlooms in North Goa. Two are located in the village of Korgao and one each in Harmal, Alorna, and Mandrem. The wooden looms and other instruments that are stationed at these centers have been specially crafted in Siolim at the Directorates Woodcraft Centre.

A stipend of 1,000/- per month was offered to students who wished to be trained, as they had to be engaged for the full day and had no other source of income. They have now reduced the training to half a day with a monthly stipend of 750/- rupees.

All fresh recruits at the moment are taught spooling, warping, and using the loom to weave bed sheets, durries, and towels during the first four months of their training. These Batches are then sifted through so that they can upgrade their skills and training to weave the Kunbi sari. Those who have mastered the technique of weaving and are highly skilled were offered employment as trainers and assistants at the handloom training centers.

Over the last six months, a few dozen saris and approximately around 300 towels were produced in these five training centers. The production capacity is growing very gradually as more weavers are being trained. For now, the directorate has decided not to waste its resources on weaving generic fabrics and saris in a market where it cant compete. Instead, its plan is to focus on weaving Goas own iconic Kunbi sari and to cater to the overwhelming market for this age-old piece of handloom.

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Economic and
social significance
of the hand
woven Kunbi
weaving craft
of Goa

Impact of Artificial Intelligence on Making our Criminal Justice System Speedy and Efficient

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Abstract

In the world of technological advancement flowing with the verge of artificial intelligence has shown a part of the industrial revolution which can be a matter of evolution in the law enforcement organization and judicial system. From the last few decades our nation is working upon building smart machines that can respond and solve issues of people of a society which will reduce the burden from the court of law and can be an asset for the development of the nation. The author in this research paper has tried to focus upon the significant impact being played by artificial intelligence and machine learning and understanding and developing the mechanism which can be essential for the adjudication of various civil and commercial matters. The author has laid down historical background of artificial intelligence to understand various nuances which can help to build a scenario for the development of artificial intelligence in our society. The author has also reviewed how artificial intelligence can you play a vital role in our criminal justice system with the help of artificial intelligence and machine learning. During the research the author has also observed and evaluated some of the major advancement which has taken place in India with the help of nitiaayog for understanding various aspects of artificial intelligence. The researcher will be evaluating how artificial intelligence can be used in the process of policing in India and how it can control as an effective prison management system for efficient and effective solution in a criminal justice system. The author has also reviewed that how forecasting of crimes can be done with the use of AI in a criminal justice system. Through this research paper author has also focused upon major regulations and laws required followed by how does management system can be different from discrimination and biased mechanism and influence. This research paper will help to evaluate the importance of artificial intelligence in making our criminal justice system efficient.

Keywords: Justice, Artificial Intelligence, Criminal, Crime, Discrimination.

Introduction

Artificial Intelligence (AI) can be shown to be emerging as a viable tool to improve the efficacy of law enforcement organizations across jurisdictions as we see the

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transition to the Fourth Industrial Revolution (4IR) and incrementally equip ourselves in the post-COVID era.

Almost every aspect of our life now that might easily influence our decision-making processes has been impacted by AI. As an illustration, consider online buying, recommending movies on Netflix or Amazon, purchasing airline tickets online, etc. However, whether AI can be employed as a tool to assure better criminal justice while policing is the question that worries administrative or government organizations.

Is the conventional penal system sufficiently prepared to deal with crime and criminals given the growth of more complex crimes? Has technology been able to help us strike a balance between retribution, rehabilitation, and reintegration for a comprehensive sense of justice? Do we progress at the same rate as the rate at which cybercrime is rising? To ensure more equitable outcomes in the criminal justice system, this essay attempts to balance the benefits of applying AI in law enforcement procedures with potential changes.¹

Artificial Intelligence

Science and engineering are combined to build intelligent machines that can respond to and solve issues like people. This process is known as artificial intelligence (AI). The capability and ability of AI to mimic human tasks have grown dramatically over many years of rapid and complicated growth, to the point where the primary emphasis has changed from learning human functions to increasing functional efficiency. A chess-playing AI programme called Deep Blue, created by IBM defeated a human world champion in 1996. Twenty years later, the top Go player in the world was defeated by AlphaGo, a computer programme created by Alphabet Inc.

With such astounding innovation appearing so quickly, AI has sparked public anxiety about the unexpected intelligence and capacities of machine learning at ever-increasing exponential rates, as well as any potential ramifications for intellectual property (IP).

Concerns concerning ownership have been raised now that AI is capable of creating works of poetry and art, 3D prints, and inventions all by itself. People have started to wonder whether AI has a distinct standing in IP because it can produce works that would otherwise be recognised as IP produced by a person. Would an AI's software developer(s) be entitled to the work produced by the AI in light of that?

And would the user have the right to own the produced IP if the user of the AI continuously provided new information sources for the AI to learn from?

Currently, a work must be original and derived from the author's substantial abilities, labour, and judgement to be protected under copyright law. When attempting to assess whether AI has exploited these criteria adequately to do such work, this law presents a significant barrier. An invention must also have novelty,

¹David Mhlanga, *'The Role of Artificial Intelligence and Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals'* (2022).

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creative steps, and applicability for a patent to be awarded. AI is always improving, and because it was created to reduce human labour, it offers fresh approaches to issues that might eventually qualify as patentable ideas.

Historical Background of Artificial Intelligence

It is very much significant enough to analyse the historical perspective² of artificial intelligence.

1950 - The article on building thinking machines by Alan Turing was published in 1950.

1956 - John McCarthy explains what artificial intelligence is in 1956.

1956 to 1974 - To "walk" simple decision paths and arrive at decisions, reason searches or means-to-end algorithms were originally developed between 1956 and 1974. These methods made it possible to parse word strings and solve complex mathematical problems. Natural language processing is the term for word processing. These methods paved the way for the creation of rules and logic for the interpretation and construction of phrases. They also signalled the beginning of game theory, which was implemented in simple computer games.

From **1980 to 1987**, complex systems were created employing algorithms that mimicked the thinking of human experts. It was around this point those expert systems, like decision-making tools, started to emerge. These tools learnt the "rules" of a particular knowledge domain, such as those that a doctor would use to make a medical diagnosis. These systems were able to reason complexly, but unlike humans, they were unable to adapt and broaden their decision-making by learning new rules.

From 1993 to 2009, "neural networks" software with biological inspiration came into being. These networks imitate how live creatures learn to recognize intricate patterns and carry out challenging tasks. One of the initial uses was character recognition for license plate readers.

2010- Present: Big data and deep learning are currently in the spotlight. The gaming industry's low-cost graphics processing units have made it possible to train neural networks using huge data. These networks are layered to simulate how people detect and classify simple patterns into more complex patterns. Automated facial and object identification and recognition, medical image diagnosis, financial patterns, and governance norms are all areas where this software is being used. The Defence Advanced Research Projects Agency's Lifelong Learning Machines project is one example of how AI systems are being developed to continually learn in a manner akin to that of humans.

AI in Criminal Justice: Advantages and Disadvantages

The application of AI in criminal proceedings has been the subject of numerous studies that have been carried out globally. Some of these studies demonstrate that

²*The History of Artificial Intelligence - Science In The News'* (*Science in the News*, 2022) <<https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/>> accessed 27 August 2022.

AI offers important opportunities to guarantee the consistency, predictability, and transparency of the legal system. As a result of the limited software capabilities offered by the IT industry, additional research demonstrates that AI also raises several difficulties. Government representatives and legal organizations participating in legal and criminal proceedings should be aware of the potential advantages of AI and keep a careful check on its effectiveness and development in real time in light of both of these considerations.

The intent of the accused is crucial when dealing with criminal proceedings. A person's conduct can be influenced by several variables that AI cannot account for.

There are several variables to consider when conducting an inquiry, including the person's family history, education, sense of guilt, and other traits. In the criminal justice system, it is important to respect each person's honor and dignity as well as the confidentiality of their personal information. Artificial intelligence is therefore thought to be unable to address all of these issues that come up during criminal proceedings. Successful applications of artificial intelligence include processing statistical data, assisting with the preparation of legal documents, searching the internet for information, and determining if criminal conduct qualifies as such.³

The employment of artificial intelligence algorithms should be open to debate on its scientific validity, the operational importance given to its numerous components, and the conclusions are drawn. Consequently, courts should make decisions about the use of AI in CJS.

The predictive nature of AI has made criminology, law, and forensics more and more in demand. Algorithmic risk analyses are now often employed in law enforcement. One can utilise evaluations and predictive policing to determine whether a person will show up in court or commit a crime. Furthermore, every aspect of the administration of criminal justice is being profoundly affected by the digital revolution that swept the world in the past ten years.

Significant changes in the types of crimes committed and how investigations are carried out are being brought about by the shift to digital culture. We must deliver justice, and this abrupt digital transformation has had an impact. With the transition to a digital environment, we now have rapid and simple access to data as well as new investigational methods that are based on mining and examining enormous data sets. The courts had completely gone digital due to the 2019 pandemic, allowing for unlimited access to all necessary legal data.

Advancements in India's CJS and AI fields

In India, the application of AI has significantly increased across a variety of industries. One notable example of it is the NITI Aayog, which released an essay titled "*National Strategy for Artificial Intelligence #AI4ALL*" to raise awareness among people about the need to employ AI in a controlled and moral way. This article demonstrates how artificial intelligence (AI) may be successfully used in five

³David Mhlanga, '*The Role of Artificial Intelligence And Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals*' (2022).

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important Indian industries: healthcare, agriculture, education, smart cities and infrastructure, smart mobility, and transportation. Through the e-Courts Project, the Indian judiciary previously established a foundational information and communication technology infrastructure, and it is now attempting to leverage the promise of AI. The AI committee of the Supreme Court has already released and tested two programs.

First, a neural translation technology called *Supreme Court Vidhik Anuvaad Software* (SUVAAS) has been introduced to interpret legal documents between English and nine other languages. The Supreme Court Portal for Assistance in Court Efficiency (SPACE), a court management tool, is used for data mining, case monitoring, legal research, and other related tasks. In some areas, this is already being planned and put into action to enhance institutional effectiveness. Therefore, it is clear that the application of AI to the legal industry has started and is expanding quickly.

AI's use in Policing in India and its Experience

In many nations, AI has found use in both courtrooms and police departments. It has aided judges in developed nations in sentencing and deciding whether to grant bail, as well as administrative authorities in understanding and planning the placement of police officers in specific locations. In his recent Constitution Day speech, Former Chief Justice in India Bobde noted that "*AI might increase the judicial system's efficiency through intelligent and situational automation of current non-judicial processes and operations.*" This was said on the occasion of India's 70th Constitution Day. This will speed up judicial decision-making and assist decrease pendency even more.

Examples of AI technologies in criminal detection and treatment abound in various parts of the criminal justice system in India, such as policing. One such instance is the start-up Staqu, which introduced JARVIS, or Joint Branch Of science that studies for Videos Instances & Streams, a video analytics platform, in Uttar Pradesh in November 2019. With the help of AI and analytics tools, this software aims to produce meaningful data from lengthy CCTV surveillance videos with brief, clear real-time notifications, greatly lowering the time needed to produce useful information. Punjab, Haryana, Rajasthan, Bihar, and Telangana are among the eight union territories and states that currently receive services from Staqu⁴. The Punjab Police (2018) used the Police Artificially Intelligent System, which was also created by Staqu, in a similar application.⁵ A database of much more than 1 million records on criminals being held in jails around the Punjab state is made available by the functionality of this product, which also allows for options like face and text

⁴*Using Artificial Intelligence to Address Criminal Justice Needs* (National Institute of Justice, 2022) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed 27 August 2022.

⁵David Mhlanga, *The Role of Artificial Intelligence And Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals* (2022).

searches. The UP Police has also benefited from a product named Trinetra that has similar qualities.

Taking a page from the Satyam scandal (2009), when AI and machines were not in use and the police had to put in a lot of work to reveal the crimes perpetrated by the CFO and CEO who had used the opportunity of night-time to make fake accounting entries and produce questionable financial results.

As opposed to this, a similar crime that was previously conducted by a CA and a tech professional of a power industry PSU to alter the account during late-night hours was discovered thanks to the implementation of computer vision that generated alarms for suspicious activity. The CCTV footage that recorded these two employees served as additional evidence to support this. In light of this, AI can assist in the early detection of crimes today.⁶

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Use of AI in policing: International Experiences

It has been approximately 12 years since the United States employed some of the most effective computing algorithms for "*predictive crime mapping*."

To predict future crime concentrations, the US has utilized Industry mainly (Computer Statistical, or Comparative Statistics), and geographic modelling, and has evolved into a managerial policing paradigm while using Geographic Data Systems (GIS) to map crime. Criminal justice, artificial intelligence, and human rights (Ales Zavrsnik, February 2020) The ability to spot patterns are more dependent on people. The drawback of such situations is that they concentrate on the crime's "*surface*" rather than its "*cause*." However, it does contribute to better living quality, resource management, and crime reduction.⁷

The transition from "*computational mapping*" to "predictive policing" has aided the police in analyzing the volume of data and extracting knowledge that is valuable for use in the field.

The police have used AI to their advantage to intervene ex-post facto after a crime has been committed as well as during the planning (ex-ante) stage of crimes that have not yet been committed.

To combat child sexual abuse, for instance, Interpol oversees the International Childhood Sexual Abuse Image Data (ICSE DB) across Europe (Interpol website). The use of furnishings and other commonplace elements in the backgrounds of abusive photographs has assisted in identifying the culprits and victims.⁸

⁶'Global Programme on Cybercrime' (United Nations: Office on Drugs and Crime, 2022) <<https://www.unodc.org/unodc/en/cybercrime/global-programme-cybercrime.html>> accessed 28 August 2022.

⁷'Artificial Intelligence In Cybersecurity | IEEE CS' (Computer.org, 2022) <<https://www.computer.org/publications/tech-news/trends/the-use-of-artificial-intelligence-in-cybersecurity/>> accessed 26 August 2022.

⁸'Using Artificial Intelligence to Address Criminal Justice Needs' (National Institute of Justice, 2022) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed 27 August 2022.

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To improve the security and efficiency of police departments in the wake of the COVID-19 outbreak, Interpol released international recommendations on April 9, 2020. Cybercriminals have developed new tactics, methods, and processes (TTP) to take advantage of weaknesses in the aftermath of the pandemic. Chatbots that pose as genuine individuals can be utilised in these situations to find the violators. Without requiring human intervention, this can be done to both detect repeat offenders and deter first-time offenders.

Effective prison management using AI⁹

Given its overcrowding and current infrastructure, the management of Indian prisons is complicated. As a result, AI can aid in lowering the tense situation by managing police officers and prisoners well. To properly plan out and design a course for dealing with the miscreants, it can be useful to track both abusive behaviours even by police and convicts.¹⁰

It can improve a prison's function as a suitable correctional facility and manage drug trafficking difficulties in jail with effectiveness. Additionally, using AI, cells can be assigned based on factors including the accused or convicted criminal history, age, family history, and type of crime committed.

Forecasting Crime

Large amounts of data are used in the intricate process of predictive analysis to forecast and develop future outcomes. Police, probation officers, and other professionals who work in the field of criminal justice are primarily responsible for this task and must develop their skills over many years¹¹. The process takes time and is prone to bias and inaccuracy.

AI can suggest rulings, detect criminal enterprises, forecast and reveal those at risk of criminal enterprises, and utilize vast amounts of legal precedent, social variables, and media information.

Researchers from the University of Pittsburgh who are receiving funding from the NIJ are looking into and developing computational methods for statutory interpretation that may speed up and improve the accuracy of the work done by judges, lawyers, prosecutors, admin personnel, and other professionals.

According to the researchers' theory, computer software can automatically identify particular types of sentences that are crucial for legislative interpretation. The objective is to create a solid evidence expert system that can help interpretation for cybercrime and carry it out automatically.¹²

⁹Supra 8.

¹⁰*Using Artificial Intelligence To Address Criminal Justice Needs* (National Institute of Justice, 2022) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed 27 August 2022.

¹¹David Mhlanga, *The Role Of Artificial Intelligence And Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals* (2022).

¹²Supra 10.

To forecast probable criminal recidivism, AI also is capable of analysing vast amounts of records about the criminal justice system. An automated tool for warrant service triage is being developed by researchers at the National Research Institute in collaboration with Durham Police Force and the Arundel Arundel District (Maryland) Sheriff's Office.

The team working with the NIJ is analysing data sets including more than 340,000 records of warrants using algorithms. The algorithms calculate the amount of time before the next occurrence of the event of interest and do survival analysis to forecast the likelihood that absconding offenders would commit new crimes. When there are backlogs, this approach will assist practitioners in prioritising warrant service. To maximise resources, the final tool will also have a geographic reference so that law enforcement officials can target high-risk absconder clusters as well as other people with open warrants.

AI can also assist in identifying possible elderly abuse victims, both physically and financially. Scientists at the College of Texan Health and Science Centre in Houston who were supported by the NIJ examined elder victimisation using AI algorithms. The algorithms can identify the victim, the abuser, and the surrounding circumstances that set financial exploitation apart from other types of elder abuse. They can also distinguish between "pure" and "hybrid" financial exploitation (pure financial exploitation occurs when the victim of financial exploitation suffers no other forms of maltreatment).

The researchers are working on developing these data algorithms into web-based tools so that professionals may rapidly and accurately assess the likelihood of financial exploitation.

The final application of AI is to forecast probable victims of violent crimes based on relationships and behaviour. Algorithms were utilised by the University of Illinois and the Chicago Law Enforcement to gather data, create initial groups, and compile information that would be used to build social networks and conduct analysis to identify persons who might be high-risk. Since then, the Chicago Police Department's Violence Reduction Strategy has included the study that was funded by the NIJ.¹³

The use of AI in Criminal Justice poses risks

In most of its applications, AI technology is still in its infancy. The use of AI will then be evaluated by criminal justice and in particular law enforcement, in light of fundamental rights principles like privacy and non-discrimination, as well as in light of the growing misconception that AI algorithms are much more unbiased and smarter than living beings, while in fact, they could indeed actually convey human error.¹⁴

¹³Supra 7.

¹⁴David Mhlanga, *The Role of Artificial Intelligence and Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals* (2022).

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Discrimination and Bias

Since humans-built AI, even though its mode of operation forbids any human involvement, there is some margin for mistakes. All datasets used by AI algorithms to produce results are made up entirely of human data, which means that any bias present in those datasets is also present in the AI outcomes.¹⁵

According to independent study studies, the application of AI may cause some groups of people to be searched and stopped by law enforcement more frequently than others, for example, violating the ideals of equity, equality, and fairness.

As an illustration, regional discrimination may rise as a result of AI monitoring criminal "*hotspots*," which are more tightly policed than other locations and hence see greater arrest rates.

It is crucial to note that private businesses, like Clearview, the world's largest facial network corporation built for law enforcement usage, provide the databases that are used by law enforcement.

Even though High - quality professional is contractually obligated to government agencies, it implies a provisional transmission of some governmental functions from the public to the private sector. This could have unintended consequences, including a contaminated database or cyberpiracy that would violate the privacy rights of thousands of people.¹⁶

Required Regulation

The application of artificial intelligence (AI) in law enforcement means a high degree of accountability, impartiality, and transparency to prevent discrimination and the violation of fundamental rights.

The Artificially Intelligent Act, which the European Commission proposed on April 21, 2021, will codify the standards of the EU's trustworthy AI paradigm. According to the European Commission, AI must be "*legally, ethically, and technically robust, while respecting democratic values, human rights, and the rule of law.*"¹⁷

The fundamental feature of the EU AI Act is the introduction of a "*product safety framework*" based on four risk classifications (minimum, limited, high, and unacceptable). Through a new required CE-marking process, it enforces criteria for market entry and certification of "*High-Risk AI Systems.*"¹⁸

¹⁵Darrell Allen, '*How Artificial Intelligence is Transforming the World*' (Brookings, 2022) <<https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/>> accessed 28 August 2022.

¹⁶'*Artificial Intelligence In Cybersecurity* | *IEEE CS*' (Computer.org, 2022) <<https://www.computer.org/publications/tech-news/trends/the-use-of-artificial-intelligence-in-cybersecurity/>> accessed 28 August 2022.

¹⁷David Mhlanga, '*The Role Of Artificial Intelligence And Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals*' (2022).

¹⁸'*Artificial Intelligence In Cybersecurity* | *IEEE CS*' (Computer.org, 2022) <<https://www.computer.org/publications/tech-news/trends/the-use-of-artificial-intelligence-in-cybersecurity/>> accessed 28 August 2022.

This regime, which forbids the use of databases owned by private corporations, also applies to everyone in machine learning training, testing, and dataset validation concerning the legality of AI outcomes.¹⁹ Recent calls for a prohibition on private face recognition databases like Clearview by the European Parliament express opposition to mass surveillance.

Moving forward with AI's problems for the system of Criminal Justice

With cutting-edge technology and sophisticated monitoring of items, crowds, perimeters, and vehicles, AI-based technologies have completely changed how we think about modern security.

The risk assessment and operation of the criminal justice system have become more technologically sophisticated with the evolvement of AI systems (*big information analysis tools, machine learning*). However, if these systems are not used carefully, they could have significant negative effects on the criminal justice system.²⁰

It's critical to realize that AI relies on human stereotypes and prejudices based on the information that people feed these algorithms. If proper caution is not used right away, there is a considerable likelihood that previous inequalities will be reinforced. To decide on policing and punishment with objectivity, a solution to make it much more neutral must be found.

Contrary to developed nations like the US, India has not yet seen widespread use of AI, making it difficult to explore the more complex problems it presents. In the US, judges have used AI to determine punishment and determine whether to issue bail.

However, the "*risk of recidivism*", or likelihood of reoffending, is a matter of opinion and cannot be accurately measured with the use of artificial intelligence. Increasing AI's precision to better reflect cognitive biases to the point that it becomes negligible or careless is one potential approach.

This is possible if software development businesses conduct in-depth research on the effects of utilizing AI in the administration of criminal justice and on bias in AI. To transfer different viewpoints to the algorithm, it is also crucial to involve a variety of stakeholders in the software development process.

The justice system is not the only one facing this challenge from AI; the entire IT sector is as well. For the effectiveness of AI to result in more reliability and transparency again for police and prosecutors, it is crucial to account for the prejudices experienced by those who have been detained or locked up when designing software.

A practical strategy would be to acknowledge the flaws and close the gaps for the improvement of the criminal justice system as AI develops and influences society.

¹⁹Darrell Allen, '*How Artificial Intelligence Is Transforming The World*' (Brookings, 2022) <<https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/>> accessed 28 August 2022.

²⁰David Mhlanga, '*The Role Of Artificial Intelligence And Machine Learning Amid The COVID-19 Pandemic: What Lessons Are We Learning On 4IR And The Sustainable Development Goals*' (2022).

The Purification and Physiochemical Analysis of Domestic Waste Water

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Abstract

This study was necessary in the search for a decentralized wastewater treatment system that is straightforward, affordable, and highly effective for household use in underdeveloped countries. This article describes the typical quantity and pollutant loads of wastewater produced by private homes as well as some of the treatment, disposal, and re-use options that are available. Although there are environmental and health risks associated with this practice, it is nonetheless regarded as a critical environmental design factor in new building.

Introduction

In Australia, reticulated supplies that are managed by a local or statutory authority are commonly used to provide potable household water to residences in urban areas. In rural, remote, and residential areas where potable water cannot be supplied by a reticulated supply, water may be independently obtained from ground or surface waters or collected in rainwater tanks. The wastewater produced by residential buildings can both be collected by a particulate sewer system and processed at a wastewater treatment facility, or it can be handled locally and disposed of¹⁻⁵.

One of the world's most urbanized countries, in Australia, the majority of residential homes have access to a regulated water supply and a sewerage system that are managed by a local or statutory authority. There are few opportunities for the reuse of domestic wastewater in many locations due to the current infrastructure for supply and sewerage services, as well as the fact that reuse of wastewater in areas with sewerage systems may be restricted in many places⁶⁻¹⁰. The treatment methods for domestic wastewater are described in this study. Reusing wastewater, frequently from individual residences, may be an option that's being looked into. Despite the possibility of recovered storm water, these options are not considered.

Waste Water Characterization

It is well known that households with limited access to potable water use a lot less water overall. They also generate less wastewater. Homes with reticulated mains water use a lot more water overall, and planning normally uses 900 to 1000 litres

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every day. Table 1 provides estimates of average internal domestic use as well as revised demand based on the use of various household flow reduction devices. While using these tools frequently leads in less internal water use, this is not always the case. The conservation of water that should come from using home wastewater again is mostly correlated with the commodity value of water. In terms of the cost of supply, it is now undervalued. It is reused domestic wastewater reuse wont be taken seriously until potable water supply costs are much higher than they are now. The two major waste streams that make up domestic wastewaters are typically the toilet wastes (also known as black water) and other home wastes (sometimes known as gre ywater or sullage) . Domestic graywater is wastewater from the home that has not been in contact with toilet waste.

Aims and Objectives

The main purpose of this article is:

- To reduce domestic waste water
- Reduce the transmission of excreta related disease.
- Reduce water pollution and consequent damage to aquatic biota.

Characterization of Domestic Wastewater

As is more thoroughly wastewaters are often treated by adding oxygen so that microorganisms can make use of the wastewater. Serving as food. The broad formula is: Oxygen and sewage result in Wastewater cleaned by bacteria plus new bacteria Domestic wastewaters nature is complicated that it prevents a full understanding of it.

Analysis

However, given that it is relatively simple to gauge the amount of the concentration of oxygen required by the bacteria when they oxidize the effluent. A simple way to describe the amount of organic materials in wastewater is the how much oxygen is needed for it to oxidize. As a result, if, for instance, half a gram of oxygen is used to oxidize each litre of a certain effluent.

Pollutant distribution of household waste

Table 1. Distribution of pollutants in household waste.		
Greywater	Pollutant	Blackwater
64%	Flow	36%
66%	BOD	34%
40%	Suspended solids	60%
10%	Nitrogen	90%
72%	Phosphorus	28%
Minor	Pathogens	Major

Dhadda, S
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Bhasin, M

Prediction of the distribution of chemical/physical contaminants between the two wastestreams was done using the characterization studies. About 65 percent of the flow, 70 percent of the phosphorus, and 63 percent of the BOD are contributed by greywater, whereas about 61 percent of the suspended particles, 82 percent of the nitrogen, and 37 percent of the BOD are contributed by black water. Additionally, the characterization investigations showed that a variety of indicator organisms might be anticipated in raw bath and laundry wastewaters, indicating a possibility for pathogenic.

Wastewater treatment and disposal Domestic waste water needs to be purified before use. So, here a number of methods present to treat the water Sewage treatment plant and reticulated sewerage system The wastewaters are transferred to a central facility where the management authority decides on the treatment and disposal system in the most typical scenario, when houses are connected to a sewerage system (88 percent of the Australian population). Wastewaters are typically treated utilizing fundamental physical and biological processes to a secondary standard¹¹⁻¹⁴. The management authority may be granted a permit by a state Environmental Protection Agency, and the resulting effluent may then be applied to the land or discharged into a river or coast. Reusing some of the cleaned waste stream for above-ground irrigation is becoming more and more popular. While many local authorities are increasingly looking into re-use possibilities, each suggested scheme must carefully consider the long-term sustainability of land application of wastewaters.

Aeriated Waste Water Treatment System

Aeration, mixing, and pumping of the effluent are all provided by mechanical devices in autonomous wastewater treatment (AWT) systems, which are compact, self-contained, proprietary biological treatment systems. A single tank or two tanks are used in AWT systems to expedite aerobic decomposition of wastewater. Various combinations of pumps, fans, air blowers, contact media for bacterial growth, settling chambers, and chlorination chambers are used to produce a final effluent. The final effluent produced should be clear and odorless and should fulfil quality standards authorized by the State Department of Health with the necessary management and maintenance (including periodic sludge removal). In recent years, the number of AWT systems has significantly expanded; in NSW alone, there are currently almost 20,000 units. However, they are not designed for intermittent use, and the effluent quality suffers as a result of shock loads that may result from episodic use. . The suggested final effluent quality parameters for these systems are SS less than 30 mg/L and BOD less than 20 mg/L. For thermotolerant coliforms, or faecal coliforms, it should also have less than 10 organisms per 100 mL and less than 0.5 mg/L of free residual chlorine. Effluent from these systems is often applied to the land by surface or sub-surface irrigation after chlorination. Generally speaking, a minimum of 200 m² should be used, and the land area should be properly planted and used just for irrigation. Local government has been finding it

challenging to administer and manage these systems as their number has increased. The efficacy of the chlorination system and the proper sizing of the planted area for irrigation in relation to hydraulic and nutrient loads are other cited issues in addition to maintenance.

Reuse Management Options

While also modernizing the conventional methods of treatment and disposal, the internal domestic wastewater separation permits the development of alternative solutions for wastewater management, one of which can be wastewater reuse. The use of a segregated waste treatment system becomes more alluring and cost-effective if the following outcomes occur: lower effluent pollutant concentration and mass; decreased potential for pathogenic contamination if effluent is to be discharged; conservation of water resources; and the possibility of beneficially recycling valuable nutrients to the soil.

Anaerobic Biological Treatment System

The process by which facultative anaerobic and anaerobic microscopic populations break down organic materials into methane and carbon dioxide is known as anaerobic digestion. Low sludge production, small occupied areas, and high load devices set anaerobic treatment apart from land treatment technology. Numerous resources are developed in the interim. According to Cille's research, the anaerobic treatment approach can only be more economical when the sewage's COD content is greater than 4000 mg/L. However, as resources got more limited, this strategy was gradually improved, and it is now demonstrating even more outstanding benefits. Anaerobic sewage treatment is the subject of increasing research attention, and as a result, important strides have been made in both laboratory and practical settings.

Experimental

Among the nitrogen pollutants detected in sewage are organic nitrogen ammonia and a negligible quantity of nitrogen nitrite and nitrate. Some organic nitrogen is microbiologically converted into inorganic nitrogen for the growth of the plants. Some of the organic nitrogen that was affixed to the suspended material is also eliminated through precipitation and filtration. Additionally, this nitrogen undergoes hydrolysis to form an amino acid, which is subsequently broken down to become NH_4eN . The primary techniques utilized to extract Nitrogen from sewage in the end include ammonia volatilization, biological Nitrogen removal, plant, and microbe absorption. Among other things, phosphorus in sewage can be found as organic phosphate, polyphosphate, and phosphate. Therefore, organic phosphate and polyphosphate should be converted into phosphate via hydrolysis and microbial degradation^{15,16}. When the pH is close to 7, phosphate dissolves and assumes the form of di-hydrogen phosphate. Phosphorus is eliminated from artificial wetland systems using three main methods: microbiological assimilation and absorption, chemical.

Result and Conclusion

The results of the experimental investigations, for example turbidity, color, odor, acidity, pH, alkanity, BOD, COD, etc. of the domestic waste water before and after the treatment are presented in the table given below:

Table 2. Analysis results of domestic waste water before and after treatment.

S. No.	Parameters	Limiting values	Pretreatment values	Posttreatment values
1.	Turbidity	5-10	47	9
2.	Odour	Nil	High	Nil
3.	Colour	Nil	Greenish black	Nil
4.	Acidity	20-25	27	17
5.	pH	7.5-7.9	9.2	7.7
6.	Alkanity	25-30	350	20
7.	Chloride	0.025-0.03	0.06	0.029
8.	BODs	Upto 5	330	7
9.	CODs	Upto 50	439	17

Acknowledgement

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Visionary Concepts of Mechanical Engineering Contributions, Challenges & Constraints

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Abstract:

This paper is entitled "Visionary Concepts in Mechanical Engineering: Contributions, Challenges & Constraints" defines the elements of a vision that will keep the mechanical engineering profession at the forefront of great challenges and great contributions over the next 15 years and the potential impediments to this evolution. It also describes constraints. Mechanical engineers develop technological solutions that promote a cleaner, healthier, safer, and more sustainable real world. It also provides advanced technical knowledge and the foundation for a safer world. In this context, we also list some strategic topics in mechanical engineering that help create global and sustainable technological solutions that meet the basic needs of all. Mechanical engineers need new knowledge and skills to implement systems engineering approaches in multi-scale systems.

Keywords : Challenges, Contribution, Constraints, Strategic themes, system approach

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Introduction

The role and scope of the mechanical engineering profession have changed. The expanding boundaries of disciplines, the growing need to address global issues, rising expectations of work and diversity, and rapid technological innovation are changing both what mechanical engineers do and how they do increase [1]. These key factors influence the mechanical engineering profession and motivate major changes in mechanical engineering education. Simson Lamo said: Either the engineering profession will become wider, or society will suffer because the classification is too arbitrary [2].

Mechanical engineers should explore the grand challenges facing our world and strive to be at the forefront of developing new technologies that address energy, the environment, nutrition, housing, water transportation, safety, and health. Our engineers should also follow the joy of discovering, creating, and applying technological solutions that can improve human life. To realize this vision, we must recognize the need to raise public awareness of the important contribution of



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mechanical engineering to a sustainable world and a harmonious quality of life. To get on the road to this vision, we need to focus on improvement of [3]:

- Advocate for influencing policy decisions on issues related to science, engineering, and technology.
- An interdisciplinary and systems engineering approach to multiscale systems.
- Partnerships between academia, industry, and government to scale up research and development and train the next generation of engineers
- Lifelong learning for talented engineers and technical managers worldwide. Engineers create that which never was Mechanical engineers must have the opportunity to tap into creativity that will make the profession special.

1.1 Strategic themes for mechanical engineering:

Sustainable development through new technologies and technologies to respond to global environmental pressures caused by economic growth.

Lead the implementation of the system design approach for both large and small systems.

Participate in international cooperation on critical knowledge and skills

Work on new bio-Nano technologies to provide solutions in diverse fields such as healthcare, energy, water management, environment and agriculture.

Develop technological solutions for the remaining 90% living below the poverty line.

Critical choices on the path to achieving the vision:

To realize this vision over the next 15 years, mechanical engineering will require many key decisions from professional organizations and leaders. These aren't really decisions, they're also things mechanical engineers have to do. These decisions should be considered part of the critical path that professionals must follow to create a technical solution [4].

2.1 Increase public awareness:

Engineering organizations seek articulated, objective, science-based, and technically correct policies that clearly define the risks and rewards and the benefits and consequences of new technologies that affect everyone in the world. You must provide information.

2.2 Update lifelong learning:

Because of the accelerating rate of change in the development of new scientific discoveries and technological breakthroughs, the current practices of universities and professional societies are not adequate to prepare globally competent engineers and engineering leaders. How can these institutions, as currently structured, prepare students for jobs that don't yet exist and use technologies that have not yet been invented, in order to solve problems that have yet to be defined? What should be the core knowledge of the discipline to meet future requirements? What learning strategies will be most effective in engaging our people in learning basic technical knowledge and in acquiring higher-order thinking skills to innovatively solve

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problems? What will be the processes for lifelong education to help all mechanical engineers stay current with technological advances? There is an urgent need to address these questions in a collaborative way that strengthens a global engineering workforce.

2.3 Take leadership seriously:

Mechanical engineers must accept new mandates to provide political, social, industrial, professional, and cultural leadership in order to bring the engineer's perspective to larger social issues. Engineering leaders need diverse means to encourage professional diversity and to attract and retain high-performing and talented employees.

2.4 Lead in Multi-disciplinary and systems engineering approaches:

No country, sector, or profession can meet major challenges alone. The high technological complexity and multiple scales (dimensions of magnitude and time) at which systems interact today require engineers, scientists, social scientists, economists, and others to develop interdisciplinary solutions. It requires the cooperation of many experts.

Critical Uncertainties or constraints ahead for the mechanical engineering:

Mechanical engineers must monitor and manage to change conditions to create solutions designed for a cleaner, healthier, safer, and more sustainable world. Our interconnected world requires international will and cooperation. This is seen as a decision that puts global interests ahead of national interests, on the part of all countries, across diverse cultural traditions and political systems. Mechanical engineers should consider past accomplishments and lessons learned to inspire the next generation of problem solvers. Key constraints on the road to vision include:

Are you willing to make decisions and invest in big issues?

Will there be enough international cooperation to meet the grand challenges?

Are we educating young people about tech phobia?

How will you deal with future conflicts and natural disasters?

How do nature's regulations and international agreements affect technology development?

How will population growth and migration affect technology?

How much time do you need to address environmental priorities?

Is society built on lessons learned?

How does mechanical engineering fit into the interdisciplinary world?

Contributions of mechanical engineers to achieve the vision:

Looking ahead to a new era of technology, mechanical engineering offers new subjects and new versions of old subjects. Design, Analysis, and Plumbing now fall under the new subject area. Areas such as nanotechnology and clean technology have also been introduced into the scientific and industrial fields. Designing small concepts, analyzing them, and creating small but wide-ranging applications can be seen in the near future [5].

Future-oriented developments in mechanical engineering are not confined to these areas and are far from renewable energy sources such as solar energy. Concurrent Design provides engineering, design, and construction services for solar energy. Mechanical engineers design solutions that generate economic development for communities and countries and, among other things, contribute to the quality of life of societies.

Visionary Concepts
of Mechanical
Engineering
Contributions,
Challenges &
Constraints

Conclusion

Rapidly developing economies are intensifying global environmental pressures and competition for energy, water, and other high-demand resources. Mechanical engineering tackles the challenge of developing new technologies and techniques that support economic growth and promote sustainability. In the near future, engineers will work with both very large and very small systems, requiring interdisciplinary and multi-scale engineering knowledge and coordination at longer distances and time scales. The ability of individuals and organizations to learn, innovate, adopt, and adapt more quickly will propel developed countries forward. Mechanical engineering education is being restructured to meet the needs of many individuals with good technical knowledge and professionalism, as well as sound management, creativity, and problem-solving abilities. The dominant players in any industry are organizations that work together to achieve success, not through conflict, but through the integration of competitive markets and new ways of collaboration.

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Celebrities as a brand and their influence on consumers in India

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Abstract

Fame refers to an attribute of a person who is well known to the public, such as Bollywood actors, athletes, entertainers and others, for their achievements in areas other than those of the recommended product class (Kannan, 7 July 2017). The general belief among advertisers is that advertising messages delivered by celebrities offer a higher level of attraction, attention and possibly news recall than those delivered by non-celebrities. This article explains how celebrity endorsements have emerged as one of the most popular promotional tools of late. It has become a trend and is perceived as a winning formula for product marketing and brand building. It's easy to pick a celebrity, but difficult to create a strong connection between the product and the endorser. This paper helps to analyze the impact of celebrities on brands and examine the relationship between them, as well as the impact of celebrities on consumer purchasing behavior and consumer brand preferences.

Keywords: Fame, Celebrity, Celebrity Endorsement, Brand, Brand equity, Advertisement.

Introduction

Every day consumers are exposed to thousands of voices and images in magazines, newspapers, billboards, websites, radio and television. Every brand tries to steal at least a fraction of a person's time to educate him or her about the amazing and different features of the product in question. In this modern age, people tend to ignore all commercials and advertisements while browsing through the magazines and newspapers or watching TV. But even then, the glamour of a celebrity rarely goes unnoticed. Therefore, celebrity endorsement in advertising and its impact on the overall brand is of great importance. In this process, companies hire celebrities

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from a certain field to appear in their advertising campaigns. The product's promotional features and imagery are matched with a celebrity's image, which tends to persuade a consumer to make their choice from a variety of brands.

Each product has an image. The consumer tries to consume a brand that best suits their own personality. The celebrity endorser fits in between these interactions, where they attempt to bring the product's image closer to what the consumer expects by projecting some of the cultural meanings inherent in their image onto the product. The common belief among advertisers is that brand communications messages delivered by celebrities and celebrities generate greater appeal, attention and recall than those delivered by non-celebrities. The quick reach and impact of messages are all too important in today's competitive environment.

Celebrity endorsement is a way to get brand exposure amidst the hustle and bustle in the market. There is a great influence of celebrity endorsements among consumers through TV advertising in India as Indians are very fond of celebrities and there is a huge fan base. A consumer reading promotional messages for products from two different companies, one product message containing a celebrity endorsed product and the other not believing that the celebrity endorsed product will have more purchases and therefore greater value. (Kumar, May 2011). More and more companies prefer the celebrities of different fields in India like the cricketers, bollywood celebrities and other sports personalities to endorse their brands. Marketers spend enormous amounts of money on celebrity endorsement deals because they believe celebrities are effective spokespersons for their products or brands (Katyal). Television is something watched across India by people of all classes, whether they are lower class, middle class or upper class, they all watch TV for entertainment. In India, the power of celebrities can rightly be measured by their successful endorsement. Celebrities such as movie stars and cricketers have not only attracted a great deal of public attention here, but also increased sales.

The practice of using celebrities in advertisements to promote products dates back more than a hundred years and continues to this day. Sports and film celebrities have a number of recommendations under their belts. Products ranging from cement to pens are used by celebrities to communicate. Celebrity advertising uses the image of a famous person to sell products or services by focusing on the person's money, popularity or fame to promote the product or services. In today's fast-growing, media-obsessed culture, celebrity endorsements have skyrocketed. India and Taiwan are two examples that have seen tremendous growth in celebrity-targeted media fashion, with celebrities appearing in 24 percent and 45 percent of ads, respectively. People tend to follow or buy products recommended by their favorite celebrity. Sometimes people used to buy products that didn't even suit them, just because their favorite movie star or athlete is promoting that product, they end up buying those products. Nowadays, many ads are endorsed by celebrities. Even celebrities support multibrands. It has created a lot of confusion in the minds of customers regarding purchasing the product.

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Brand

The Dictionary of Business & Management defines a trademark as: a name, term, sign, symbol or design, or combination thereof, intended to identify the goods or services of a seller or group of sellers and obtain them from which distinguish competitors.

What does Celebrity means?

The term celebrity refers to a person who is well known to the public, such as B. Actors, athletes, entertainers and others, for their achievements in areas other than those of the supported product class (Friedman, 1979). The general belief among advertisers is that advertising messages delivered by celebrities offer a higher level of attraction, attention and possibly message recall than those delivered by non-celebrities. Marketers also claim that celebrities could detract from the credibility of the claims being made, increase the memorability of the message, and have a positive effect that could be generalized to the brand (ANJUM, DHANDA, & NAGRA, 2012). Celebrities are positioned as marketing tools, valued for their interconnected meanings that can be associated with products and then passed on to consumers. This approach positions consumers as relatively passive recipients of celebrity meanings, representing a top-down model (celebrity to consumer), and celebrities as meaning bearers. The approach is outdated in a fragmented modern world where social media and mass media give the consumer more control in choosing between celebrities and prominence (Emma N. Banister, 2013)

Rise of celebrity culture

Celebrities play an important role in modern culture. For many people, film and television stars, athletes, pop stars, the royal family, chefs, and business tycoons serve as arbiters of taste, morality, and public opinion, thereby influencing purchasing behavior. Celebrities range from world famous A-listers to reality TV stars who sometimes become overnight hits by appearing on shows like The X Factor, Big Brother, Master Chef or on MTV celebrities who sometimes appear with no discernible talent video sharing websites have made a name for themselves.

Companies harness the power of celebrities and use them to promote almost anything. Because celebrities are instantly recognizable and capture consumer interest, they can draw attention to a brand in a way no other type of advertising can. As long as the celebrity is authentic, he or she can help bring credibility and influence to a brand in how it is perceived. Many consumers believe that if a product is good enough for a star, it's good enough for them. While celebrity influence is most evident among the younger generation, it is present across all age groups. Teenagers adore the icons of the moment (e.g. Justin Bieber, Taylor Swift or One Direction), while adults tend to admire older, more enduring celebrities ambitious as well as playful driven motives to engage in celebrity entertainment

experiences. Non-fans have no ambitious motive and are predominantly driven by playful motives. In both situations, celebrity entertainment experiences reinforce recommended brand attitudes(Hung, 2014)

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The lifecycle of celebrity popularity varies a lot. People tend to commensurate the personalities of the celebrity with the brand thereby increasing the recall value Celebrity. Brand association like Garnier endorsed Tara Sharma & Simone Singh, Agni Diamonds & Riama Sen don't get much brand recall. On the other hand, HPCL has had increased popularity and share of voice due to the endorsement of the brand through Tennis star Sania Mirza(Mukherjee, 2012)

What is celebrity endorsement?

The use of celebrities to increase sales and brand awareness is called celebrity endorsement. Celebrities often name advertisements for products and services that may or may not be professional. Browsing TV channels reveals that some celebrities endorse multiple brands, or one brand is endorsed by another speaker. For example, Amitabh Bachchan introduces Parker, Hymora, Nablatan Oil, Cadbury Daily Milk and more. Cork, on the other hand, was supported in this category by Hrithik Roshan, Aishwarya Rai, Aamir Khan, VirendraSehwag and others (Jain, 2011)

Today, marketers want to not only maximize product sales, but also create brand equity. To create brand equity, they use celebrities in their advertising(ANJUM, DHANDA, & NAGRA, October 2012).Prominent attributes are the main component for them to be selected as approvers. Consumers are always trying to choose the product that suits their image. As a result, the majority of respondents prefer the style and appeal of celebrities, influence their purchasing decisions, and enhance the effectiveness of celebrity-supported advertising. Respondents conclude that celebrity-approved ads influence purchase decisions. (Afsheen Khan, 2016)

Celebrity endorsements as a strategy

Marketers agree with that big name endorsements have numerous benefits, key amongst them being constructing credibility, fostering agree with and drawing interest or all or any of that may translate into better emblem sales. As with branding, agenciesought toattempt tohold consistency among the endorser and the emblemto set up a robustcharacter and identity. More importantly, agenciesought to view celeb endorsements as long-time period strategic selections affecting the emblem. Ainternationalemblemneed toadmirenearby needs, wants, and tastes even as endorsing. An endorsement have becomemaximума successwhile the endorser is likewiseinquisitive about the affiliation with the emblemnow no longermost effective for economic benefit, howeveradditionally for his/her personalphotographconstructingadditionally. Several celebrities have ventured into the style and add-onscompanies and greater are at the way. Jennifer Lopez, Sean Combs, and Jessica Simpson all have apparel lines; Victoria Beckham designs jeans; Elizabeth Hurley has released a swimming gearemblemeven as Kylie Minogue already has a flourishing underwearembem, referred to as Love Kylie. In

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Munjal, K

addition, the listing of celebrities which have released perfumes named after them is gradually increasing: Jennifer Lopez, Britney Spears, Paris Hilton, Celine Dion, Mary-Kate and Ashley Olsen, Cindy Crawford, etc. Major stars do now no longer honestly paintings for the endorsement fee, however are influenced via way of means of true affection for the product (Mukherjee, 2012)

Is celebrity advertising effective?

Marketers now are seeking for to undertake 360 diploma emblem stewardship wherein the emblem sees no limits at the range of touch factors viable with a goal client. Advertising ideas, thus, revolve round this approach, and the celeb endorsement selections are made via those strategic motives. Celebrities do have a few not unusual place traits which consist of their recognition, their reputation or their reputation however every celeb may also have his or her very own specific photograph or cultural meaning (Mukherjee, 2012). In the cutting-edge and current duration marketing and marketing messages have inspired client behavior of youngsters, in addition to their social behavior. Nowadays youngsters are endorsed to be independent, assertive, dynamic and cool. These messages with which purchasers are continuously beset delivered approximately cultural adjustments and have been seemed as a client phenomenon standard of the western society. youngsters and younger people's being uncovered to marketing and marketing messages designed through mass-media and marketers. Behavior adjustments are because of marketing and marketing messages having been construed taking into consideration age businesses and the younger people's interests, desires and aspirations (Adriana Anca Cristea, 2014). The take a look at concluded that the ones merchandise have greater market place proportion which can be encouraged through celebrities in that regular celebrities. Consumer has visible the classified ad through celebrities as reliable, knowledgeable. And they have got additionally affected and related to celebrities and furthermore they sense that celebrities are cap in a position to steer the call for of the merchandise. So we are able to say that the celeb endorsement has high quality effect on organisation in addition to emblem and customers. (ANJUM, DHANDA, & NAGRA, October 2012)

Compatibility of the Celebrity's Persona with the Overall Brand Image

Companies should ensure a match between the brand being endorsed and the endorser so that the endorsements are able to strongly influence the thought processes of consumers and create a positive perception of the brand. Tiger Woods endorsing the Buick brand makes no sense at all. There is just no believability that Tiger is dying to drive a Buick. And without believability a celebrity endorsement is worthless. Companies should monitor the behavior, conduct and public image of the endorser continuously to minimize any potential negative publicity. Companies need to involve celebrities who do not recommend competing products or other completely different products to ensure a clear transfer of personality and identity between the recommender and the brand. If a celebrity is used to endorse a brand, the obvious result may be that the celebrity may obscure the brand. Therefore, when

presenting a supporter, keep in mind that the supporter is promoting the brand, not the other way around. Celebrities are no substitute for ideas. A brand without focus will never find the right celebrity to match the brand. Once you become a celebrity, it's difficult to get out. If the brand is functioning reasonably well after interrupting the celebrity campaign, it will be difficult to separate the message role from the celebrity role in selling the brand. The Global Brand requires a Global Brand Management Team. This regional and international organization was established to maintain brand leadership through the efficient and effective use of celebrities. To expand your brand globally, you need to ensure that your recommendation strategy understands your cultural sensitivities. Even though it is challenging to measure the effects of celebrity endorsements on companies' brands, companies should have a system combining quantitative and qualitative measures to measure the overall effect of celebrity endorsements on their brands (ANJUM, DHANDA, & NAGRA, October 2012)(Mukherjee, 2012)

Whether Celebrity is a Brand User

Various celebrities believe in social messages and support NGOs and social activities. They have to tell the audience. One of the most successful campaigns was run by PETA. In this campaign, celebrities such as Shilpa Shetty, Ameesha Patel, Yana Gupta, Sheetal Malhar and Mahima Choudhary claimed to believe in PETA's philosophy and thereby support the brand. On the other hand, some understand that Amitabh Bachchan has never used a Navratan phone. Britney Spears finds himself in favor of one brand of cola and repeatedly drinking another brand of cola on tape. (Jain, 2011)(Mukherjee, 2012)

Brand, celebrities & consumer

Most brands start a life without personality. Let's face it. Brands alone never walk, talk, or take pictures. However, by being associated with a celebrity, the product or company name can instantly take on glitz, charm and sophistication. D. Reeder (Green Light L.A.) states: Celebrity use stays here. But what does the unanswered question look like? Now, in order to derive a strategic path for backstory, backstory brands need to assess the impact of selected celebrities on their respective brands. For a successful brand recommendation roadmap, it is important to look at the relationship between the brand and the consumer spirit. Celebrity Recommendations Have a Great Impact on Purchase Decisions In markets where advertising regulates consumer purchases, celebrity recommendations are more likely to be selected. Products with any of the following characteristics:

High price-to-cost margin

Large potential customer pool

The need to coordinate different customer groups.

According to Zafer & Baker, the use of multiple celebrities or one celebrity depends in part on the timescale used by the campaign to influence. If the campaign has a long-term strategy, the agency will be more cautious because the potential downsides outweigh the potential upsides. A brand advocate is not just a spokesperson for the brand, but a person who acts as a testimony to the benefits of

the brand(Mukherjee, 2012). Celebrities act as a navigation aid to help consumers internalize the (acceptable) cultural values they need to shape and develop their understanding of identity. I accessed it. The nature of the consumer-celebrity relationship evolves over time. Some are fleeting and supportedSocial networks make it easier for people to get in and out of relationships and make others more permanent. Consumers deliberately negotiate their identities by a variety of means, using celebrities as a possible source of information for manipulating themselves(Emma N. Banister, 2013) Celebrities play an increasingly important role in modern culture and consumption patterns, acting as mediators of taste, style and public opinion around the world. Their support and creative input can bring brand attention, credibility, and other intangible benefits in ways that other types of advertising cannot. This new global report analyzes how advertisers can harness the power of celebrities to connect emotionally with consumers and increase sales (Network, April 30, 2014)

Conclusion

Needless to say, celebrity endorsements are always a powerful marketing tool that attracts most consumers. Consumers favor celebrity-sponsored ads compared to non-celebrity ads. Consumers are always trying to choose the product that suits their image. As a result, the majority of respondents prefer the style and charm of celebrities. This clearly shows that it influences purchasing decisions and enhances the effectiveness of celebrity-sponsored ads.Ads influences consumers' purchasing decisions and thus influences brand production. You can also conclude that companies are rushing to celebrities to improve their product image, brand awareness, awareness, retention and credibility.

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Celebrities as
a brand and
their influence
on consumers
in India

RIGHT TO INFORMATION: AN ANALYSIS WITH REFERENCE TO BANKING SECTOR IN INDIA

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Abstract

In India there are most of the publically owned financial institutions such as (banks like SBI, Insurance Companies like LIC, Mutual Funds and Stock Exchange). In a rapidly unfolding economic scenario the life of the citizens is surrounded by financial institutions like bank, insurance companies, and capital market. The cases have been taken up separately regarding the various exemption clauses that have number of issues involving them.²The focus of this chapter is on the information which can be disclosed and which is exempted under Right to Information Act 2005. This chapter will help in clearing the concept of Section 8, section 9 and section 24 which defines the information that can be exempted under the act and section 2(f), 2(i) and 2(j) which defines the information that can be provided under the Act and the implementation and interpretation of these two sections by the Central Information Commission³

Keywords : Financial Information, Banking Sector, Customer, Agent, Principal.

Introduction

1.1 Commonly Claimed Exemptions

PIOS claim exemption of information relating to account holder and commercial activities of a bank under: -

- Section 8(1)(e): Fiduciary relationship with the account holder;
- Section 8(1)(d): commercial confidence of the account holder as well as the bank;
- Section 8(1)(j): personal information of the account holder;

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²Supra note 1, pp.

³Disclosure and Non Disclosure of Information under the RTI Act, 2005, retrieved from

<https://cic.gov.in/sites/default/files/Disclosure%20vs.%20Non%20Disclosure%20of%20Information%20Under%20RTI%20Act%2C%202005%20by%20Nikhil%20Goyal.pdf>, last assessed on May 1, 2022.

- Section 8(1)(g): can cause harm to officers investigating a case or, making a recovery from a defaulter;
- Section 8(1)(b): cases relating to debt recovery tribunal, civil court etc, which may lead to contempt of court and
- Rarely section 8(1)(a): economic interests of state in policy matters like Forex matters, Strategy about interest rates etc. are usually sought to be exempted under this section⁴.

Valuation report of property acquired by banks for recovery, loans taken by individuals/companies, bank account of public trust is ordinarily exempted from disclosure. The authorized person or the partners of an account can claim disclosure of information. Applying the severability as per section 10 the statutory RBI inspection reports of banks should be disclosed.⁵

RBI being the regulator can inspect institutions which may have attempted to defraud the public of their moneys kept with such institutions in trust by acting as a regulator who can inspect such institutions and can initiate remedial measures where necessary, for serving the public interest. The provisions of the section 10(1) of the RTI Act, in particular therefore be judiciously used when necessary to adhere to this objective.

1.2 Bank Account Details

1.2.1 Details of bank accounts of a customer

Details of bank accounts of a customer are the account holder personal information. It has a commercial angle and is held by the bank in the fiduciary capacity.

No third party could, under the RTI act seeks disclosure of information relating to the customers accounts because the banks have to keep confidentiality in relation to the account of the customers.

The bank declined the details of the account as the information sought by the appellant was holding in commercial confidence.⁶

Any person who has got letter of authority for collecting this information from the bank is entitled for the information. Bank can part with the information only to their own account holder⁷.

The various request for a copies such as details of interest rate, term of loan, purpose of the loan, etc. as well as details regarding loan agreement, repayment schedule, draw-down schedule, repayment of interest rate details etc. of various individuals and corporate with the RBI were refused under section 8(1)(d) and (e). The Commission took the view that the information regarding the particular projects of the loan cannot be disclosed as it will affect the competitiveness of those

⁴ Ibid

⁵ Ibid

⁶ [CIC/PB/A/2008/00562-SM].

⁷ [PBA/07/474].

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parties and would therefore be exempt as clearly provided in section 8(1)(d) of the Act⁸.

It is likely to adversely affect the competitive position of the wife. If the wife has filed a maintenance suit against the husband, moreover nearly because the appellant happens to be the husband of an account holder, he cannot surely access the account details of his wife.

The CPIO denied the instructions given to a particular branch of the bank by various customers regarding the details of the stop payment during a certain period under the provisions of section 8(1)(e) and (i) of the RTI act. There is no ambiguity in the decision of the CPIO.⁹

Only if the appellant is a borrower or guarantor or her property should have been mortgaged to the bank, than only she is entitled for the entire information. This is also personal information and this information is held in fiduciary capacity.¹⁰

The appellant can seek directions from the court to the bank to produce information if he has already filed the criminal case.

1.2.2 Account in the name of a group/public body/society

Only a person who is authorized to deal with the financial institutions of an account can ask for details of that particular account.

Unless the disclosure would serve any larger public interest, the details of a public trust account cannot be placed in the public domain routinely¹¹

Section 8(1) (d), (e), (j) of the RTI Act exempt information from disclosure regarding the account holders even if they happen to be of the societies.

Even if the account holder is the public body the bank cannot be expected to disclose its accounts to non-authorized persons. The State Government or the Gram Sabha itself can be approached or any other public authorities when the appellant wants to know about the finances and the accounts of the Gram Sabha.

Merely because the appellant is a shareholder he is not entitled to any information unless authorized from the company.

Fiduciary information also includes the information details of the self-help groups which cannot be disclosed even if the subsidy on the cost of the project taken up by such groups is provided by the state government¹²

Even if a person is a member of the society, the bank cannot disclose the information unless he is authorized by the society for doing so.

⁸[CIC/PB/A/2008/00574-SM].

⁹[CIC/SM/2010/000737].

¹⁰[PBA/2008/00965].

¹¹[CIC/SM/A/2009/000772].

¹²[CIC/SM/A/2009/001821]

Those authorized by the board or the management body of corporate entities or association of persons, to operate the bank account are entitled for disclosure of the information.¹³

1.2.3 Account Details of the deceased

The account details of the deceased can be disclosed to his/her legal heirs or the nominee.

It is best advised by the banks that where the appellants and respondents have produced a will favoring them as the rightful successors to the deceased or where some have produced a succession certificate then the right course of action is that the claimants should get the dispute settled and then approach the bank.¹⁴

Proper succession certificate is a must requirement for the claimants and then the applicability question of either Section 8(1)(j) or confidentiality of a third party account does not arise.

1.2.4 Change of the name of account operator

The appellant herself was the authorized person operating her account previously and her name was changed by the branch on some document basis, so she will be entitled for the copies of those documents.

Loans

1.3 Details of Loan

The repayment terms and the date and quantum of loan are not to be disclosed routinely.

The appellant as the guarantor in respect of a loan transaction between the public authority and a third party via Laso Exports, has a definite locus standi in this transaction and in fairness should be allowed access to the relevant information.¹⁵

Information can be provided to the guarantor for loans in which he has given guarantee.¹⁶

The transaction between the SBI and the Standard Chartered bank in regard to the debt, to which the appellant was the guarantor, did not in any way impact the appellant as guarantor, and was a transaction distinctly separate and independent¹⁷.

The extent of landholding reported by the borrower of this particular account against which the bank had sanctioned him any loan (to be disclosed).¹⁸

The fact in the case is that a loan was sanctioned by the bank to a customer who produced the land records of the complainant by way of mortgage. Since the bank itself realized that the customer had not produced valid records and had obtained the

¹³ [PBA/06/351]

¹⁴ [CIC/SM/A/2010/000454].

¹⁵ [CIC/AT/A/2010/900494].

¹⁶ [PBA/08/351]

¹⁷ [CIC/AT/A/2010/000457]

¹⁸ [CIC/SM/A/2010/000717]

loan not in a valid manner, it reported the matter to the police. In normal circumstances, the loan account details of any borrower are not to be disclosed being in the nature of commercial confidence as exempt u/s 8(1)(d) of the rti act, in this case, however once it is admitted by the bank itself that the documents produced by the borrower did not belong to him but belonged to someone else, the commercial confidence which the bank has to guard can no longer exist. The disclosure of this information to the complainant would help a larger public interest in as much as it would exhibit an act of fraud perpetuated on a bank and thereby would serve as a warning to all concerned.¹⁹

The photocopies of certain documents including letters sent by the bank to a certain chartered accountant and others in his reply dated 28 February 2008, the CPIO conveyed his inability to disclose the information claiming exemption case. We now direct the CPIO to provide to the appellant within the 10 working days from the receipt of this order attested copies of all the available documents as desired²⁰.

1.3.1 Does the act provide for the penalty for providing false information under Section 4(1) (b) of the Act?

Information commission under section 20(1) can impose penalty at the time of deciding any complaint or appeal when the PIO knowingly given incorrect information. Under section 5(4) IC can penalize PIO, APIO or other officers whose assistance has been sought by PIO.

But where it is the public authorities obligation to publish information under section 4(1)(b) which means the head of the public authority is responsible for the correctness of the 4(1)(b) disclosures then in such cases the PIO cannot be held responsible for section 4(1)(b) disclosures.

When incorrect information has been imparted to the complainant and if he/she has suffered any loss or other detriment then Information Commissioner has the power to require the public authority to compensate the complainant under section 19(8)(b). But IC cannot do so voluntarily and for that matters the citizen has to make a complaint under section 4(1)(b) and establish the fact that she has suffered the loss due to the incorrect disclosure of information.

In a landmark decision, compensation was awarded by the CIC for the non-publication of information under section 4 (1)(d) which is another obligation of the public authority similar to the one under section 4(1)(b).

In the present case, the issue is publishing of information of beneficiaries on the Old Age Pension Scheme and not a failure to respond to an RTI application.

The RTI Act 2005 is quite clear on the issue of suo moto disclosure, which are what complainants in the present case demand.²¹

¹⁹ [CIC/PB/C/2008/00448-SM].

²⁰ [CIC/SM/A/2009/000704].

²¹Supra Note 1, at 53

1.3.2 Reasons for rejection of the loan applications

Banks and Financial Institutions have been advised by the Reserve Bank of India that in case of all categories of loans irrespective of any threshold limits, including credit card applications, they should convey in writing the main reason/ reasons which in the opinion of the bank /financial institutions have led to the rejection of the loan applications.

The Banks and other Financial Institutions website should place the modified fair practices code and should also give wider publicity.

1.4 Bank Customer Relationship: Concept and Cases²²

The relationship between a banker and a customer depends on the activities; products or services provided by the bank to its customers or availed by the customer.

Thus the relationship between a banker and the customer can be termed as transactional relationship. The business of the bank depends much on the strong bond which it has with the customer.

Trust plays an important role in building healthy relationship between a banker and the customer.²³

1.4.1 Definition of a Banker

The term banker is not defined but what banking is? Has been defined by the banking regulations act (Banking Regulation Act), 1949.

Section 5(b) defines banking which means accepting for the purposes of lending or investment of deposits of money from the public repayable on demand or otherwise and withdrawable by cheque, draft, and order or otherwise.

The word banker includes any person acting as banker and any post office saving bank as per the section 3 of the Indian negotiable instruments act 1881.

As per the section 2 of the bill of exchange act 1882,²⁴

Banker includes a body of persons, whether incorporated or not who carry on the business of banking

In Banking Regulation Act, section 5(c) defines Banking Company as a company that transacts the business of banking in India. Since a banker or banking company undertakes banking related activities then the meaning of the word banker or a banking company can be derived from section 5(b) as a body corporate that: -

- a) Accepts deposits from public ;
- b) Lends;
- c) Invest the money so collected by way of deposits and
- d) Allows withdrawals of deposits on demand or by any other means.

²² Supra Note 37 ,pp.5-9

²³ *Banking & Insurance* , retrieved from
<https://sol.du.ac.in/mod/book/view.php?id=1225&chapterid=862>.

²⁴ Banker includes a body of persons, whether incorporated or not who carry on the business of banking

Banks accept deposits from anyone who offers money for that purpose so it means accepting deposits from the public.

It does not accept deposits unless a person has an account with the bank. There has to be an account relationship with the bank for depositing or borrowing money.²⁵

For undesirable persons, a bank can even refuse to open an account. It is a bank's right to open an account.

For opening up an account the RBI has stipulated certain norms under KYC Guidelines and the banks have to strictly follow them.

Banks can also carry out activities mentioned in section 6 of the act in addition to activities mentioned in section 5(b) of the banking regulation act.

1.4.2 Who is a Customer?

The term customer has not been defined by any act.

The word customer has been derived from the word custom which means a habit or tendency to do certain things in a regular or particular manner.

When a crossed cheque payment is received by the banker in terms of section 131 of the negotiable instruments act in good faith and without negligence from a customer then the bank does not incur any sort of liability to the true owner of the cheque by reason only of having received such payment.

So it is a mandatory requirement that to become a customer, an account relationship is a must. An account relationship is said to be a contractual relationship²⁶.

It is generally believed that any organization or individual which conducts any sort of banking transaction with a bank is the customer of the bank. However, there are many persons who do utilize the services of the bank but in actual do not maintain any account with the bank.

So there are 4 broad categories of the bank customers: -

1. Existing customers i.e. those who maintain an account relationship with the bank.

2. Former customers i.e. those who had an account relationship with the bank.

3. There are those who visit a branch of the bank frequently for availing banking facilities such as purchasing a draft, encashing a cheque etc. but these people do not maintain any account relationship with the bank.

So technically they are not customers as they do not maintain an account with the bank.

4. Potential/ Prospective Customers: - those who intend to have an account relationship with the bank. Even though no account has actually been opened by the bank in its books or records. On an account opening form duly filled in and signed by him to the bank and the bank has accepted it for opening the account then also the person shall be deemed to be a customer²⁷.

The concept of No Frill account has emerged whereby according to the directions of RBI, accounts can be opened up with NIL or with a meager balance

²⁵ Supra note 57.

²⁶ Ibid

²⁷ Srinivas Madhav, *Transparent Revolution Right to Information In Action*, Asia Law House, Hyderabad, 2008

whereby the practice which was followed in the past was that for opening account there has to be an initial deposit in cash.

With the implementation of core banking solution the customer is customer of the bank and not of any particular branch as he can operate his account from any branch of the bank and from anywhere, because earlier the term customer was used only with respect to the branch where the account was maintained and he was not treated as a customer for other branches of same bank²⁸

In case of any cause of action which arises the customer is requested to approach the branch with which it had opened account and not with any other branch²⁹

1.4.3 Know Your Customer Guidelines and Customer

Reserve Bank of India has defined customer as per the know your customer guidelines:

- (i) A person or an entity that maintains an account and or has a business relationship with the bank.
- (ii) The beneficial owner i.e. one on whose behalf the account is maintained
- (iii) Stock brokers, chartered accountants, solicitors etc. who are the beneficiaries of transactions which are conducted by the professional intermediaries as are permitted under the law.
- (iv) And any person or entity connected with a financial transaction which can pose a significant reputational and other risk to the bank for example a wire transfer or issue of a high value demand draft as a single transaction.

1.5 Banker Customer Relationship

Banking is known as a trust based relationship. The bank and the customer share numerous sort of relationship. The type of transaction decides the type of relationship which is between the banker and the customer. The relationship is based on the contract and on certain terms and conditions. Through his relationship certain rights and obligations are being conferred both on the part of the banker and on the customer.

However, there is also the long lasting relationship between the bank and the customers which are known as the personal relationship. Some banks have generation to generation banking relationship with their customers.

So to term it in a very simple way the banker customer relationship is fiduciary relationship. The relationship which is according to the terms and conditions should not be leaked by the banker to a third party³⁰

1.5.1 Classification of relationship

General relationship and the Special relationship are the two categories of relationship between the bank and its customers.

²⁸ Ibid.

²⁹ Ibid.

³⁰ Supra Note 37.

According to section 5(b) of the Banking Regulation Act, the banks business hovers around accepting of deposits for the purpose of lending. Thus the relationship which arises out of these two activities are known as the General Relationship. Whereas the relationship which arises out of the activities mentioned in Section 6 of the banking regulation act is termed as special relationship³¹.

1.5.1.1 General Relationship

1.5.1.1.1 Debtor Creditor

When a customer opens an account with a bank, he fills in duly signed account opening form. By signing the form, he enters into an agreement or a contract with the bank. When the money is deposited in his bank account the customer becomes the creditor and the banker becomes the debtor of the customer. The money so deposited by the customer in his account becomes the bank property and it has the right to use the money as it likes. The manner of utilization of funds which is deposited by him then the bank is not bound to inform the depositor. Bank does not give any security to the depositor i.e. debtor. It is only when the depositor demands the banker pays. The position of the bank position is quite different from the normal debtors.

As the banker does not pay money on its own, it is not required to repay the debt voluntarily.

The demand is to be made properly at the branch where the account exists and in a proper manner and during the working hours and the working days³²

The terms and conditions has to be followed by the customer which are mentioned in the passbook (as such mentioned in the account opening form) which is issued to the customer only after the account has been opened and to the understanding those terms and conditions are mentioned and have been read and understood by the customer.

Since past whereby the printed handbill containing the terms and conditions of the account along with the account opening form use to be given by the banks but now for convenience and information of prospective customers a few banks have uploaded the account opening form, terms and conditions for opening account, rate charge in respect of various services provided by the banks on their websites.

There are instances whereby the bank becomes a debtor in cases of issuance of demand draft, mail, telegraphic transfer as in these circumstances bank owns money to the payee/beneficiary³³.

1.5.1.1.2 Creditor Debtor

One of the most important activities of the bank is the lending money. The resources which are mobilized by the banks are utilized for lending operations.

³¹VK Dewan, *ewans Exhaustive Commentary on The Right To Information Act, 2005*, Maxomm India Private Ltd., New Delhi, 2017

³² Ibid.

³³ Id., at p.50

Customer who borrows money from the bank owns money to the bank. The banker becomes the creditor and the customer becomes the debtor in cases of the loan/advances account.

Before utilizing the credit facility, the borrower executes the documents and offer security to the bank.

The banker acts as a bailee, trustee, principal, agent, lessor, custodian etc. depending upon the type of the services rendered and the nature of the transaction, this is what makes the relationship wider and complex between the bank and the customer³⁴.

1.5.1.2 Special Relationship

1.5.1.2.1 Bank as a Trustee

As per Sec. 3 of Indian Trust Act, 1882 A "trust" is an obligation annexed to the ownership of property, and arising out of a confidence reposed in and accepted by the owner, or declared and accepted by him, for the benefit of another, or of another and the owner.

So on behalf of the beneficiary the trustee is the holder of the property.

As per Sec. 15 of the Indian Trust Act, 1882 A trustee is bound to deal with the trust-property as carefully as a man of ordinary prudence would deal with such property if it were his own; and, in the absence of a contract to the contrary, a trustee so dealing is not responsible for the loss, destruction or deterioration of the trust-property. So the trustee has the right to reimburse of expenses according to section 32 of the Indian trust act.

There is a special contract in case of trust between the banker and the customer i.e. when a person entrusts with another person some valuable items with an intention that such items would be returned on demand to the keeper then the relationship becomes of a trustier and trustee.

The facility of Escrow Accounts i.e. when the customers avail services of the bank in respect of keeping certain valuables or securities for safekeeping or deposits certain money for a specific purpose then in such cases the banker acts as a trustee. Banks charge fee for safekeeping valuables³⁵.

1.5.1.2.2 Bailee-Bailor

Section 148 of the Indian Contract Act, 1872 defines "Bailment" "Bailor" and "Bailee". A "bailment" is the delivery of goods by one person to another for some purpose, upon a contract that they shall, when the purpose is accomplished, be returned or otherwise disposed of according to the directions of the person delivering them³⁶

The person delivering the goods is called the "Bailor". The person to whom they are delivered is called, the "Bailee".

Where the banks secure their advances by obtaining the tangible securities or the physical possession of the securities goods(referred to as the pledge) , valuable

³⁴ ibid

³⁵ Supra note 57

³⁶ Id., at p.9

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bonds etc then in such cases the bank becomes the bailee and the customer the bailor . Banks also keeps articles, valuables, securities etc. of its customers in the safe custody and then acts a bailee. As a bailee the bank is required to take care of the goods bailed.

1.5.1.2.3 Lessor and Lessee

Sec.105 of Transfer of property Act 1882 defines lease, Lessor, lessee, premium and rent. As per the section A lease of immovable property is a transfer of a right to enjoy such property, made for a certain time, express or implied, or in perpetuity, in consideration of a price paid or promised, or of money, a share of crops, service or any other thing of value, to be rendered periodically or on specified occasions to the transferor by the transferee, who accepts the transfer on such terms.

Definition of Lessor, lessee, premium and rent:

- (1)The transferor is called the lessor,
- (2)The transferee is called the lessee,
- (3)The price is called the premium, and
- (4)The money, share, service or other thing to be so rendered is called the rent.

The agreement of Memorandum of letting is being entered into by the customers which attracts the stamp duty which is the safe deposit vault /locker facility provided by the banks to the customers. This is also known as the Ancillary Service.

In the relationship of the bank and the customer as that of lessor and the lessee,the banks lease their immovable property to the customers and hence give them the right to enjoy such property during the specified period that of the banking or the office hours and charge rentals in return.When the locker holder becomes defaulter in payment of the rent then the bank has the right to break open the locker and in these cases the bank does not assume any liability or responsibility for any damage to the contents kept in the locker. Banks do not insure the contents kept in the lockers by the customers.

1.5.1.2.4 Agent and principal

The Indian Contract Act, 1872 defines an agent as a person employed to do any act for another or to represent another in dealings with third persons. The person for whom such act is done or who is so represented is called the Principal

When the bank collects the cheques, bills and make payments to various authorities viz rent, telephone bills, insurance premium etc. in behalf of the customers then in such cases banks acts as an agent of its customers and thereby charges for these services.According to the Indian contract act the agent is entitled to charges, but no charges are levied in collection of local cheques through clearing houses. Charges are levied only when the cheques are returned in the clearing houses³⁷

1.5.1.2.5 As a Custodian

A bank acts as such position because it takes responsibility for a customers securities. When the DMAT account is to be open then the banks becomes the custodian and banks also takes responsibility for a customers securities.

³⁷ Ibid

1.5.1.2.6 As a Guarantor

As per sec 31, of Indian Contract Act guarantee is a contingent contract ". Contingent contract is a contract to do or not to do something, if some event, collateral to such contract, does or does not happen. So banks give guarantee on behalf of the customers and thereby enter into their shoes³⁸
Then we can say that there is a transactional relationship between the banker and the customer.

1.5.2 Termination of Relationship between a Banker and a Customer.

The relationship between a bank and a customer ceases on:

- (a) The death, insolvency, lunacy of the customer;
- (b) The customer closing the account i.e. Voluntary termination;
- (c) Liquidation of the company;
- (d) The closing of the account by the bank after giving due notice and
- (e) The completion of the contract or the specific transaction.

1.6 Disclosure and Non-Disclosure Agreement

RTI ACT in India had varied challenges to beat. RTI implementation has been prohibited since British times by several laws: -

- 1) **Section 123 of the Indian Evidence Act, 1872**³⁹ - No one shall be permitted to give any evidence derived from unpublished official records relating to any affairs of State, except with the permission of the officer at the head of the department concerned, who shall give or withhold such permission as he thinks fit.
- 2) **Official Secrets Act, 1923** - is India's anti undercover work act control over from British colonization. Under this act no one can approach, inspect or may be jump over a prohibited government website or space. All public servants were prohibited from disclosing any information to the public.
- 3) **Rule 11 of the Central Services (Conduct) Rules, 1964** - No Government servant shall, except in accordance with any general or special order of the Government or in the performance in good faith of the duties assigned to him, communicate, directly or indirectly, any official document or any part thereof or information to any Government servant or any other person to whom he is not authorized to communicate such document or information⁴⁰.
- 4) **Oath by the Public Servant** - public servant swears before joining the duty that the information is a state secret.
- 5) **Archives Policy Resolution of 22 December 1972** - States each one document is classified for thirty years and without government permission not even unclassified material is communicated to anyone outside the government.
- 6) **Rule 9 of all India services (Conduct) Rules, 1968** - No member of the Service shall except in accordance with any general or special order of the

³⁸ Ibid

³⁹ The Indian Evidence Act, 1872, Bare Act

⁴⁰ The Central Civil Services (Conduct) Rules, 1964

Government or in the performance in good faith of duties assigned to him, communicate directly or indirectly any official document or part thereof or information to any Government servant or any other person to whom he is not authorized to communicate such document or information⁴¹.

1.6.1 Committee on Right to Information

1.6.1.1 Srikrishna Committee

The committee has recommended amending the RTI Act in a manner that tilts the law in favor of privacy and against disclosure of information. As per the *Caravans* reporting, the committee has recommended amending the existing Section 8(1)(j) of the RTI Act.

In its present form, Section 8(1) (j) of the RTI Act provides that there can be disclosure of the information, which relates to the personal information or which can cause unwarranted invasion of the privacy of the individual only when the CPIO or the SPIO or the Appellate Authority is satisfied that larger public interest justifies the disclosure of such information. Proviso to this section provides that the information which cannot be denied to the Parliament or a State Legislature shall not be denied to any person.

The proposed amendments to Section 8(1) (j)⁴², as reported in the *Caravan*, will allow for the disclosure of personal information, only if the following principles are fulfilled:

- (a) the personal data relates to a function, action or any other activity of the public authority in which transparency is required to be maintained having regard to larger public interest in the accountability of the working of the public authority;
- (b) If such disclosure is necessary to achieve the object of transparency referred to in clause (a) and
- (c) any harm likely to be caused to data principal by the disclosure is outweighed by the interest of the citizen in obtaining such personal data having regard to the object of transparency referred to in clause (a).

The proportionality test can be applied across the law in various situations and is a means of ensuring a more transparent decision-making process. While English and European courts are required by their governing legislation to follow this test, the Indian parliament is yet to incorporate this test into Indian legislation. The Indian Supreme Court of course isn't that shy and has incorporated this test into Indian

⁴¹The All India Services (Conduct) Rules, 1968

⁴²*(j) information which relates to personal information the disclosure of which has not relationship to any public activity or interest, or which would cause unwarranted invasion of the privacy of the individual unless the Central Public Information Officer or the State Public Information Officer or the appellate authority, as the case may be, is satisfied that the larger public interest justifies the disclosure of such information:*

Provided that the information, which cannot be denied to the Parliament or a State Legislature shall not be denied to any person.

jurisprudence, although it is questionable whether past Indian judges have actually understood the proportionality test as conceptualized in Europe.⁴³ The test proposed by the Committee of Experts requires a three -fold test: first whether personal data in question has implications for transparency and accountability of a public authority, second whether disclosure of the personal information is required to achieve transparency and third whether disclosure of the personal information outweighs the harm that would be caused to the citizen while keeping in mind the competing objective of transparency.

1.6.2 Disclosure of information

Information to the public which ensures the transparency and accountability in the working of the public authorities is provided through the RTI ACT, 2005.

Section 2 (f) of the RTI Act, 2005 defines the word information to maintain transparency and by this section reference can be drawn to the information which can be provided to the public⁴⁴

Section 2(i)⁴⁵ of the Act defines record which includes documents, files, any reproduction of images or any other material produced by a computer or any device. Section 2(j)⁴⁶ of the said Act defines right to information which can be explained in simple words by information which is accessible or which is under the control of

⁴³*Is the Srikrishna Committee giving us a way to balance the Rights to Information and Privacy*, retrieved from <https://thewire.in/law/is-the-srikrishna-committee-giving-us-a-way-to-balance-the-rights-to-information-and-privacy>, last assessed on May 3, 2019.

⁴⁴*information means any material in any form, including records, documents, memos, e-mails, opinions, advices, press releases, circulars, orders, logbooks, contracts, reports, papers, samples, models, data material held in any electronic form and information relating to any private body which can be accessed by a public authority under any other law for the time being in force;*

⁴⁵*record includes* (i) Any document, manuscript and file;
(ii) Any microfilm, microfiche and facsimile copy of a document;
(iii) Any reproduction of image or images embodied in such microfilm (whether enlarged or not); and
(iv) Any other material produced by a computer or any other device;

⁴⁶*right to information means the right to information accessible under this Act which is held by or under the control of any public authority and includes the right to*

(i) Inspection of work, documents, records;
(ii) Taking notes, extracts, or certified copies of documents or records;
(iii) Taking certified samples of material;
(iv) Obtaining information in the form of diskettes, floppies, tapes, video cassettes or in any other electronic mode or through printouts where such information is stored in a computer or in any other device;

public authority and includes the right to inspect, taking notes or any information which is stored in computer or any other device.

1.6.2.1 Which organizations are covered?

1.6.2.1.1 Public authority

To clarify as to whether an organization is covered under the RTI act, principles can be defined which define the coverage of an organization under the RTI act 2005

Definition of public authority: as defined under section 2(h)⁴⁷ of the said act:

In other words the definition includes any authority, body, institution of self-government which is established or constituted by or under the constitution for example parliament, the supreme court, the election commission or we can say it includes authorities by any other law made by the parliament which includes bodies like the information commission, life insurance corporation of India etc. or authorities which are made by the state legislature and covers within its ambit organizations like the state agricultural marketing boards established by the state legislature or by the notification issued or order made by the appropriate government and includes anybody owned, controlled or substantially financed for example public sector industries which are owned by the government. The three conditions i.e. owned, controlled, substantially financed are alternative and not cumulative, similarly non-government organizations substantially financed, directly or indirectly by funds provided by the appropriate government.

1.6.2.1.2 Organization controlled by the government

Organization which is under the control of the government is a public authority. If 50% or more of the board is made up of government officers who are nominated by the government, they are so nominated to represent the views of the government. A government officer, once nominated by the government to perform certain functions, is expected to act in accordance with the government's position. The nominee discharges his duties not in a private capacity but as a representative of the government. Like any other government officer, he does not require directions from the government to carry out each of his duties- as a government officer he is assumed to be acting on behalf of the government, if he does not do so he would be failing in his duty

⁴⁷ *Public Authority means any authority or body or institution of self-government established or constituted,*

(a) by or under the Constitution;

(b) by any other law made by Parliament;

(c) by any other law made by State Legislature;

(d) by notification issued or order made by the appropriate Government, and includes any

(i) body owned, controlled or substantially financed;

(ii) non-Government Organisation substantially financed, directly or indirectly by funds provided by the appropriate Government;

The State Bank of India is a public authority. RTI Act provisions would also apply to all foreign branches of SBI.

Moreover, the cooperative banks though not public authorities in terms of the rti act yet they come under the supervisory control of RBI and in respect of Section 2(f) any information which it can access under its authority from the cooperative banks, then in respect of that information, a citizen can approach the RBI which shall be bound to furnish the information by collecting the same from the cooperative bank⁴⁸

Every public authority is under a mandatory requirement of section 5(1) of the RTI ACT,2005 that it has to appoint as many CPIOs in all administrative units or offices under it as may be necessary to provide information to persons requesting for the information under this act.

Similarly, it has been provided under section 19(1) that officers senior in rank to the CPIOs should be identified as Appellate authority for receiving and deciding appeals.

In it was laid down that the UCO Bank shall, within a month from the receipt of this order, designate larger number of CPIOs to cater to the information need of the citizens and designate more appellate authorities, preferably in the Zonal offices, so that appellants do not have to go all the way to its corporate office for filing appeals⁴⁹.

According to a news report the Supreme Court has given RBI last chance to alter its disclosure policy. The court has observed that there was no fiduciary relationship between the RBI and the financial institutions. And moreover its the statutory duty of the RBI to uphold the interests of the public at large, the depositors, the economy and the banking sector. This court was also of the opinion that the RBI should act with transparency and not hide information that might embarrass the individual banks. The court however said some matters of national economic interest like disclosure of information about currency or exchange rates, interests rates, taxes, the regulation or supervision of banking, insurance and other financial institutions, proposals for expenditure or borrowings and foreign investments could harm the national economy, particularly if released prematurely. However, lower -level economic and financial information like contracts and departmental budgets should not be withheld under this exemption referring to 2015 verdict of the apex court ⁵⁰

1.6.3 Non Disclosure of Information

The RTI Act provides for the information to the general public but there are various circumstances in which the information which is held by the public authority is very sensitive in the sense that the disclosure of which will either tantamount to affecting the security and the sovereignty of the State or would lead to invasion of privacy of an individual which is a fundamental right guaranteed under article 21 of the

⁴⁸ [PBC/08/282]

⁴⁹ [CIC/SM/A/2009/000874 & 1622]

⁵⁰ Supreme Court gives RBI last chance to alter disclosure policy, *The Hindu*, April 26, 2019.

constitution of India and would be an offence if disclosed such information. Transparency is a safe guard to the political authorities but the totalitarian transparency can leads to inefficiency to the Government⁵¹. So not all the information that the government generate should be given to the public; there is always some information which are sensitive and should be kept secret so that no harm can be cause.

Section 8 of the RTI Act is of importance as it specifies nine grounds under which the information can be exempted from disclosure. Commissions, citizens and common people should know these nine grounds but on the same side these restrictions should not transcend the restrictions prescribed in Article 19(2) of the Indian Constitution that places limitations on the liberty of Speech and Expression⁵².

Though the public authority is liable to disclose all the informations as per section 2(f), 2(i) and 2(j) of the RTI Act, 2005 but on the same set there are some information which cannot be disclosed to the public as to maintain secrecy, which are mentioned as an exemptions under the RTI Act under the following sections:-

- I. Information the disclosure of which would affect the sovereignty and integrity of India, the Security of the State (Section 8);
- II. Information the disclosure of which would involve an infringement of copyright subsisting in a person (Section 9) and
- III. The intelligence and security organization or any information which is furnished by such organization to the government (Section 24).⁵³

2 Judicial Interpretation

2.1 In Shri SC Sharma v Ministry of Home Affairs

The Supreme Court has held that the the commission had taken the view that the matters connected with interception of telephones were governed by the provisions of Indian telegraph Act, 1885 and were distinctly related to the security of India. The orders of interception of telephones u/s 5(2) of the Indian Telegraph Act, 1885, were themselves sensitive for national security, sovereignty & integrity. Therefore, these are firmly within the ambit of Section 8(1)(a) of the RTI Act, and cannot, thus, be disclosed. The process of review of a matter connected with any top secret interception order must stand on the same footing as the main order itself and by inference be exempt from disclosure requirement u/s 8(1)(a) of the RTI Act. It would be both imprudent and improper to apply the criteria of severability and to

⁵¹ <http://docs.manupatra.in/newline/articles/Upload/F8FF5487-7DF0-4F0F-9A11-74F3C2585AC9.pdf>

⁵² Disclosure and Non Disclosure of Information under the RTI Act, 2005, retrieved from <https://cic.gov.in/sites/default/files/Disclosure%20vs.%20Non%20Disclosure%20of%20Information%20Under%20RTI%20Act%2C%202005%20by%20Nikhil%20Goeel.pdf>, last assessed on May 1, 2022.

⁵³ Ibid

determine one part of the process as classified and other as open. The entire process of telephone interception is one and indivisible and thus, not liable for disclosure. Therefore, the information as sought by the Appellant in his RTI request attracts exemption under Section 8 (1) (a), (g) & (h) of the RTI Act⁵⁴.

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2.2 Reserve Bank of India and Ors.Vs. Jayantilal N. Mistry and Ors.⁵⁵

It was held that the Court had to weigh between the public interest and fiduciary relationship (which is being shared between the RBI and the Banks). Since, RTI Act is enacted to empower the common people; the test to determine limits of Section 8 of RTI Act is whether giving information to the general public would be detrimental to the economic interests of the country? To what extent the public should be allowed to get information? In the context of above questions, it had long since come to our attention that the Public Information Officers (PIO) under the guise of one of the exceptions given Under Section 8 of RTI Act, have evaded the general public from getting their hands on the rightful information that they are entitled to. And in this case the RBI and the Banks have sidestepped the General public's demand to give the requisite information on the pretext of "Fiduciary relationship" and "Economic Interest". This attitude of the RBI will only attract more suspicion and disbelief in them. RBI as a regulatory authority should work to make the Banks accountable to their actions. Furthermore, the RTI Act under Section 2(f) clearly provides that the inspection reports, documents etc. fall under the purview of "Information" which is obtained by the public authority (RBI) from a private body. From reading of Section 2(f), it can be inferred that the Legislature's intent was to make available to the general public such information which had been obtained by the public authorities from the private body. Had it been the case where only information related to public authorities was to be provided, the Legislature would not have included the word "private body". Hence, the RBI is liable to provide information regarding inspection report and other documents to the general public⁵⁶. *Bhagawal Seth vs. Bank of Baroda*⁵⁷

In this case CIC observed that apart from commercial confidence there is also a fiduciary relationship between banks and the customers. So before providing the information the bank has to check the public interest. In this case the bank refuses to provide the information as if bank will provide it will lead to the breach of trust and may also harm the party as the competitiveness position of the third party⁵⁸.

2.3 Organizations beyond the Purview of the Act

There are certain organizations that have been deliberately put beyond the purview of the act due to the nature of the work performed by them. As per section 24 of the

⁵⁴ Appeal No. CIC AT/A/2006/0000567

⁵⁵ Supra note 6

⁵⁶ Ibid

⁵⁷ CIC/PB/A/2008/00558-SM

⁵⁸ Ibid

RTI Act⁵⁹, 2005 the act shall not apply to the intelligence and security organizations which are specified in the second schedule or the information which is furnished by such organizations to the government.

Though these organizations are exempted from disclosing any information but these authorities needs to be reminded that the exemption under section 24 of the RTI Act, 2005 is not absolute and can be withdrawn when there are cases relating to allegations of corruption or human rights violation and hence these organizations are required to appoint a CPIO and an Appellate Authority and attend to the RTI requests of petitioners⁶⁰. The verifiable allegations need to be proved in cases of corruption and whether the allegations have evidentiary support are to be

⁵⁹24. Act not to apply to certain organizations.

(1) Nothing contained in this Act shall apply to the intelligence and security organizations specified in the Second Schedule, being organizations established by the Central Government or any information furnished by such organizations to that Government: Provided that the information pertaining to the allegations of corruption and human rights violations shall not be excluded under this sub-section: Provided further that in the case of information sought for is in respect of allegations of violation of human rights, the information shall only be provided after the approval of the Central Information Commission, and notwithstanding anything contained in Section 7, such information shall be provided within forty-five days from the date of the receipt of request.

(2) The Central Government may, by notification in the Official Gazette, amend the Schedule by including therein any other intelligence or security organization established by that Government or omitting there from any organization already specified therein and on the publication of such notification, such organization shall be deemed to be included in or, as the case may be, omitted from the Schedule.

(3) Every notification issued under sub-section (2) shall be laid before each House of Parliament.

(4) Nothing contained in this Act shall apply to such intelligence and security organizations, being organizations established by the State Government, as that Government may, from time to time, by notification in the Official Gazette, specify: Provided that the information pertaining to the allegations of corruption and human rights violations shall not be excluded under this sub-section: Provided further that in the case of information sought for is in respect of allegations of violation of human rights, the information shall only be provided after the approval of the State Information Commission and, notwithstanding anything contained in Section 7, such information shall be provided within forty-five days from the date of the receipt of request.

(5) Every notification issued under sub-section (4) shall be laid before the State Legislature.

⁶⁰ CIC/AT/C/2007/00044-51

determined by the circumstances of those allegations and evidence produced by the party⁶¹.

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2.3.1 Central Bureau of Investigation (CBI)

The CBI on 9th June 2011 has been added in the list of organizations which is exempt from disclosure. However the same has met with resistance from RTI activists. A few cases related to CBI decided after 9th June 2011 are discussed below:-

Vide notification dated 09/06/2011 u/s 24(2) of the RTI Act, the CBI has been added at S.No.23 bringing it within the Second Schedule of the RTI Act thereby exempting it from the application of the RTI Act. If reliance is placed on the decision of the Supreme Court of India in P. Mahendran v. State of Karnataka⁶² then there is no express notification that the notification shall come into force with any date prior to the above mentioned date and there does not appear any intention of affecting the existing rights and to be prospective in nature⁶³.

According to the Commission the notification does not appear to be in consonance either with the letter or the spirit of the Act- in particular Section 24 for the simple reasons that: CBI is not an intelligence or security organization for it to be covered under section 24 and so it cannot be included in the Second Schedule. Moreover, no reasons were provided by the DOPT or the Ministry of Personnel, Public Grievances and Pensions as is required u/s 4(1) (d) of the RTI Act, to justify its inclusion along with NIA and NIG so it appears to be an Arbitrary Act⁶⁴.

Division Bench of the Madras High Court dismissed a petition challenging June 9 notification of Government of India excluding the CBI from the Act and observed that the security of the state is a broad concept and could be affected in various ways including corruption involving officials, unauthorized disclosure of state secrets, economic offences to de-stabilize national economy etc. Therefore, intelligence gathering is an inseparable part of the work of a security agency and so the judges said to include the CBI in the Second Schedule of the RTI Act.

Conclusion

Hence, right to know acquires greater importance to make available all the information required by the people to become informed citizens. The RTI is Mix tool of both the disclosure and non disclosure of information. Every information can be provided with exemptions. But this Right to Information Act, 2005 has proved to be a beneficial source of providing the information. With the filing of an application they can have access to any information except the exemptions made in section 8 of the Act. So to maintain the transparency and accountability in the country Right to Information is the best source as it provides all the information which is held by the public authority but every good thing comes with some exemptions to prevent the

⁶¹ CIC/AT/A/2007/01260

⁶² AIR 1990 SC 405

⁶³ CIC/SM/C/2011/000117/SG/13230

⁶⁴ CIC/SM/C/2011/000117/SG/13230

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misuse of it, Section 8, section 9 and section 24 is the exemptions to it to prevent the misuse of the Right to Information Act, 2005⁶⁵

⁶⁵ Supra Note 70.

A Narrative Assessment of the Literature on Environmental Pollution and Mental Health

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Abstract

Since the development of global industrialisation processes and technology, pollutant agents have increased enormously in modern society. Although the impact of pollution on public health is well understood, little is known about the link between environmental toxins and mental health. A PubMed and EMBASE literature search yielded 134 publications on the topic of pollution and mental health, which were included, cited, reviewed, and summarised. Major environmental pollutants (air pollutants, heavy metals, ionising radiation, organophosphate pesticides, light pollution, noise pollution, environmental catastrophes) have been linked to a variety of mental health disorders, including anxiety, mood, and psychotic syndromes, according to new evidence. The pathogenesis of these drugs involves both direct and indirect effects on the brain, as a result of their biological effects on humans. The underlying pathophysiology involves both direct and indirect effects of toxic agents on the brain, due to their biological effects on the human Central Nervous System or stress levels caused by long-term exposure to pollutant agents. The majority of new evidence is still inconclusive. Further research is needed to determine how industrial production, resource exploitation, proximity to waste and energy residues, noise, and lifestyle changes are linked to psychological distress and mental health problems in the impacted communities.

Introduction

Since the development of global industrialisation processes and technology, pollutant agents have increased enormously in modern society. It is generally recognised that various environmental contaminants can have a variety of consequences on the health of living organisms. Even though psychological and psychopathological implications are inadequately investigated and characterised, it is claimed that some pollutants may have an impact on human mental health. In fact, even though there is so much evidence, these elements are still undervalued.

The pollution caused by man's activities has been incorporated into the natural forces of our planet's balance since the industrial period. Anthropocene refers to the period of human industrialization. The term "pollution" can be used to describe the

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detrimental influence of some global changes and the noxious activity of new components on the ecosystem and human existence [1].

Polluting agents are widely distributed on the earth in a complex manner, making it difficult to quantify the benefits and costs of pollution to humans. Pollution and its consequences should be compared to those from healthy surroundings, such as medically or recreationally regulated living situations, in an experimental setting [2,3]. Environmental contamination is part of the "flow" of global events that is causing postmodern society to alter [4]. Polluting substances can also have a negative impact on the human neurological system, which can have serious ramifications for people's mental health. Psychogenic illnesses, endogenous disorders, and external disturbances are the three primary kinds of mental health problems based on their causes [5].

Indeed, pollution has an effect on gene expression and neural tissue structure (Gene x Environment interaction), as well as causing social stress due to unhealthy and bad living conditions in degraded surroundings.

Because psychogenic disorders are the outcome of stress, shock, or any type of psychological trauma in infancy, adolescence, or adulthood, pollution can operate as a psychogenic agent in this scenario.

In 2014, Anakwenze and Zuberi pointed out that the influence of pollution on human health can be due to an instantaneous cause-effect link, but more importantly, long-term impacts, which are frequently merely postulated and inadequately characterised or shown. According to this, a pollutant's damage can be caused by "direct" biochemical mechanisms of the polluting agents on neural tissue, or indirectly, by the creation of a stressful long-term environment that affects mental health. "Genetic interference," "gestational interference," and "post-gestational interference" are three types of "direct" influence [6].

The term "genetic interference" refers to the biochemical modification of human DNA and the subsequent transmission of genetic mutations to subsequent generations, which increases the likelihood of mental disease.

In the "g" category, "The embryonic or foetal tissues are directly affected in the "stational interference" model of action, involving the physiological processes of neurodevelopment, triggering the etiopathogenesis of a mental illness or generating a condition of vulnerability that may favour its onset. During the "In addition, according to the "post gestational interference" concept, the pollutant interacts with psychosexual processes beginning at birth and continuing through childhood/adolescence, or into adulthood, promoting mental disease or distress.

Methods

Air pollution, based on chemical emissions essentially derived from various urban and industrial activities, can have significant consequences on human neurodevelopmental processes and on the Central Nervous System (CNS) [6]. Heavy metals are the most studied components of air pollution that have been associated with neurotoxicity; they include polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOCs), black coal, environmental tobacco smoke, carbon

dioxide (CO), ozone, nitrogen dioxide and sulfur dioxide, particulate matter (PM) including fine particulate matter.

Also, Children, the elderly, individuals with pre-existing health problems, socially excluded or economically poor people, and ethnic or cultural minorities are all said to be more vulnerable to the effects of air pollution (probably due to an additive effect to their preexisting vulnerability).

Exposure to urban pollution is increased if children live near major roads, landfills, or factories, and it can substantially impair children's health, especially when combined with socioeconomic disadvantage. CO is a contaminant found in both indoor and outdoor environments, and it is the result of incomplete hydrocarbon combustion. CO is a component of pollution from automobiles, gas stoves, and cigarette smoke. CO can pass through the placenta and into the foetal blood, where it can reach the developing brain.

CO, according to Levy, is responsible for abnormalities in neurodevelopment, particularly when exposure occurs during the prenatal period. Vrijheid et al. discovered a connection between CO exposure during prenatal life and impairments in cognitive development after 14 months of age, regardless of socioeconomic status.

Conclusion

Pollution and mental health are a problem that is both important and poorly understood. The goal of this narrative review was to summarise the available evidence on pollution sources and their relationship to psychopathology.

Air pollutants, heavy metals, ionising radiation, organophosphate insecticides, light pollution, noise pollution, and environmental catastrophes were all deemed polluting components. It has been stressed that the impacts on individuals and collectives might be direct on tissues (for example, central nervous system tissue) or indirect, mediated by stress or stigma 486 after exposure to a known pollution.

This is a very new topic of research, and more research is needed to understand how contaminants' direct and indirect impacts might harm groups and contribute to mental health problems. The majority of the contaminants described have inconclusive data.

The fact that most evidence comes from retrospective research with a lack of longitudinal studies may be a limitation of this study, and there may be a role for socioeconomic position as a mediator of the stated effects of pollution on mental health in different layers of the population. More research is needed to determine how industrial production, the exploitation of certain 493 resources, proximity to waste and energy residues, noise, and lifestyle changes are linked to psychological anguish and mental health problems.

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Synthesis of Schiff Base From Benzaldehyde

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Abstract

Schiff bases contain imine as functional group which can be synthesized from carbonyl compounds and amine. Condensation products of primary amine and carbonyl compounds are known as Schiff bases. Nowadays Schiff bases and their metal complexes are being employed as catalyst, polymers and dyes. They are commonly utilized in industry and exhibit a wide spectrum of biological activities. Because of their broad range of biological activity, these chemicals are extremely essential in the pharmaceutical industry. Antibacterial, antifungal, antidiuretic, antitumor, anticancer, herbicide, herbicidal and anti-inflammatory properties are all present in the majority of them. Transition metal complexes of Schiff base ligands have extensively researched in terms of biological function.

Keywords: *Schiff bases, Antibacterial, stoichiometry, azomethinnie, antifungal,*

Introduction

The Schiff Bases are ligands that are utilized to synthesis complicated molecules. The nucleophilic addition reaction of both aldehyde and amine results in it. The reaction produces water as a byproduct. $RCH=NR$ is the general formula for Schiff Base, where both R stand alkyl/aryl substituents¹. Hugo Schiff (1864) discovered Schiff Base, a versatile chemical generated by the condensation of primary amines with carbonyl compounds under certain reaction conditions². Imine or azomethinnie ($-C=N-$) are other names for them³. A bond of imine ($C=N$) has the rare features of being both strong and reversible due to a quick hydrolytic reaction. Modern chemists are surprised by the stoichiometry of reaction, which they correctly interpret as Schiff base condensation according to reaction 3, in which aniline and benzaldehyde combine in a stoichiometry to produce an imine derivative and a water molecule. Schiff supplied the structural formula of the condensation product in a subsequent article, as shown in reaction 2. Schiff proposed a cyclic structure for the base in order for nitrogen to acquire its normal valence. Schiff bases are traditional ligands for metal ions of the p, d and f blocks that have made substantial contributions to the development of coordination chemistry on both fundamental and applied levels, with a focus on catalysis. Food, dye industry, analytical chemistry, catalysis, fungicidal, agrochemical and biological activity are only a few of the many uses for Schiff Bases.

Schiff bases are a type of ligand that binds to metal ions via the azo-methine ($C=N$) linkage which is required for biological activities such as antifungal, antibacterial, anticancer, diuretic effect. Due to their preparative accessibility and structural

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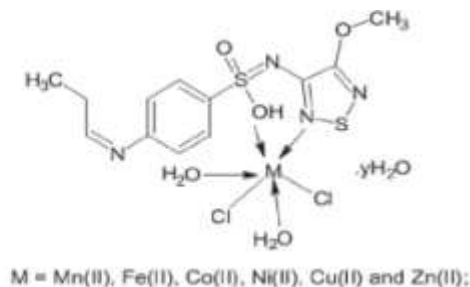
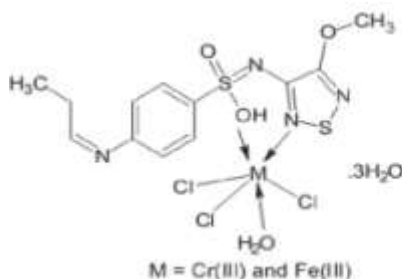
variation, Schiff bases complexes are considered to be among the most important stereo chemical models in main group and transition metal coordination chemistry. In organic synthesis, Schiff bases are most commonly used. They're employed as pigments and dyes, catalysts, organic synthesis intermediates and polymers for superoxide and hydroxyl scavenging, among other things. Analgesic and anti-inflammatory properties have been observed in Schiff bases generated from thiazoles. Antioxidant activity is demonstrated via Schiff bases of chitosan and carboxyl methyl-chitosan. Anthelmintic and analgesic properties of furan semicarbazone metal complexes have been found. Schiff bases have, an unusual trait in that they can be utilized as a corrosion inhibitor. They've been investigated extensively as class of ligands and the azo-methine nitrogen atoms have been shown to pair with metal ions. Schiff base shows a remarkable selectivity, sensitivity and stability for certain metal ions such as Ag(II), Al(III), Co(II), Cu(II), Gd(III), Hg(II), Ni(II), Pb(II) and Fe(III) due to their ligation nature¹⁰.

Aims & objectives

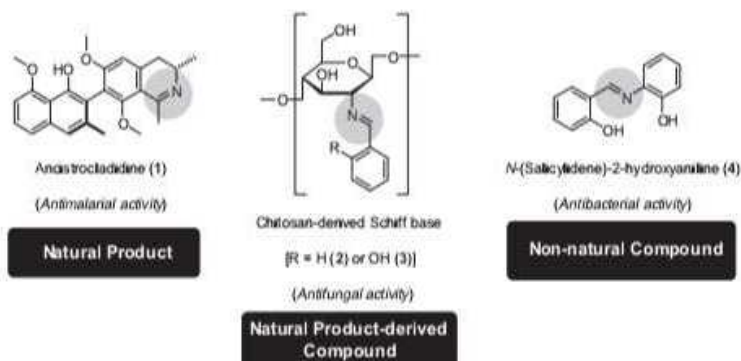
1. To synthesize Schiff base from benzaldehyde and aniline
2. Characterization by NMR spectroscopy, FTIR spectroscopy.
- 3.

LITERATURE REVIEW

1. M.A Mohamed et al. produced metal complexes of Schiff base generated from 2-thiophene carboxaldehyde and 2-aminobenzoic acid and found that E.Coli and gram-positive bacterial strains were inhibited by the Fe(III), Co(II), Ni(II) complex¹¹.

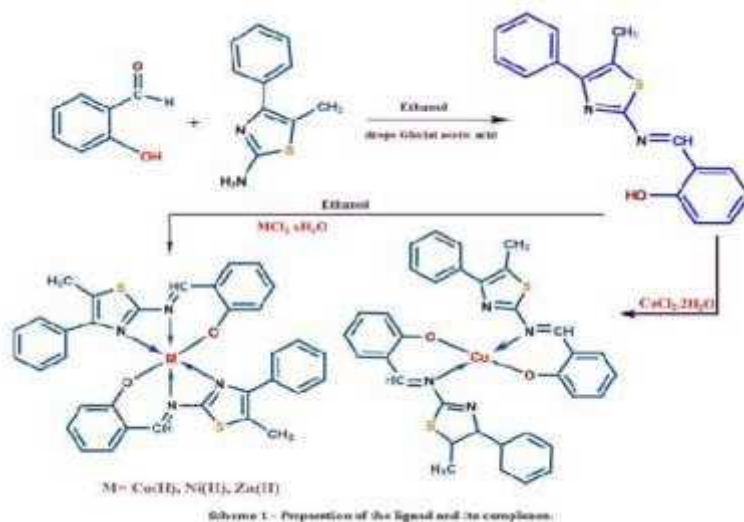


2. Tumer et al. created Schiff base and its metal complexes which appear to be able to combine lipophilic layers in order to improve gram-negative bacteriapermeability. Increased lipophilicity, also improves the penetration to Schiff bases and their metal complexes into lipid membranes, limiting the organisms ability to expand further¹².



Examples of bioactive Schiff bases. The imine or azomethine group present in each molecular structure is shaded.

3. Ammar A. Labib et al. produced Schiff base complexes with thiazole moiety and examined their anticancer efficacy and molecular docking 13.



4. The morphology, geometric structure and thermal stability of synthesized SBDA were examined by Yan-Hua Cai and Wen Luo using a supersonic speed gas impacting approach to create Schiff Bases and p-aminobenzoic acid (SBDA).

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5. El- Sherif et al., created the 2-Aminomethylthiophenyl -4-bromosalicylaldehyde Schiff base and its metal complexes which were tested for antibacterial activity under experimental conditions, the complexes have antibacterial characteristics and have more inhibitory action than the parent ligand¹⁵.

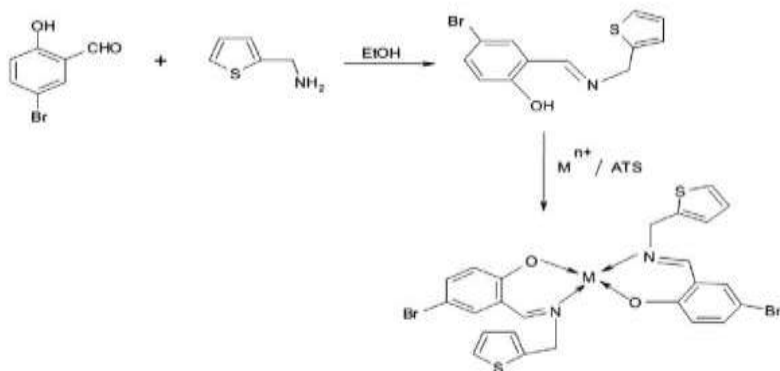
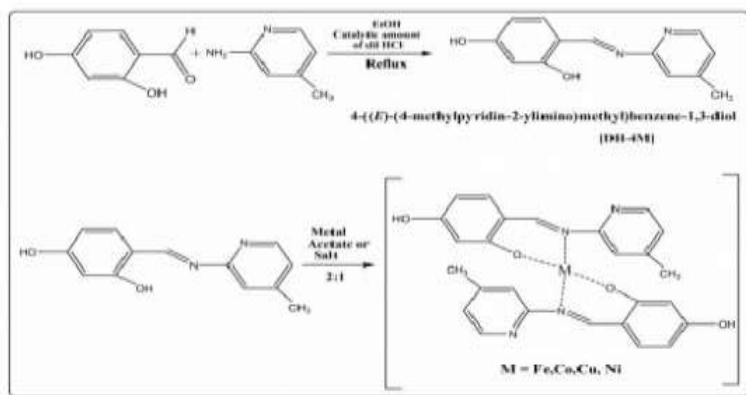


Fig. 3 – Suggested structure of Schiff base ligand and its metal(II) complexes where M = Cu(II), Ni(II) and Zn(II).

6. S.S Rajput et al. developed heterocyclic methyl substituted pyridine Schiff base transition metal complexes and tested them biologically¹⁶.



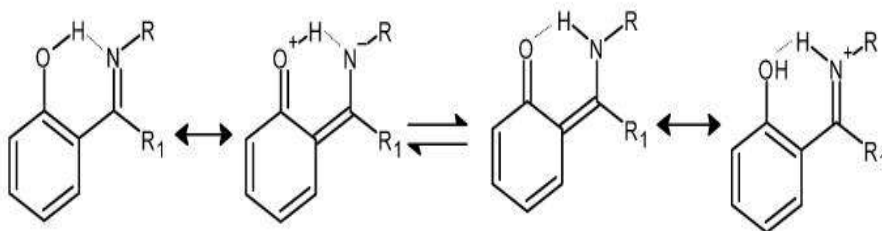
Scheme 1 Synthesis of heterocyclic Schiff base ligand and its metal complexes

7. Dutta et al have found that Schiff bases are versatile chemical compounds that are rising in popularity as a result of their numerous applications. Schiff bases with imines or azo-methine functional groups are made by combining primary amines with carbonyl compounds, although they can also be found naturally in plants¹⁷.

8. Schiff bases are a diverse collection of chemicals distinguished by the presence of double bond connecting carbon and nitrogen atoms. Their diversity is derived from the numerous ways in which alkyl or aryl substituents can be combined is

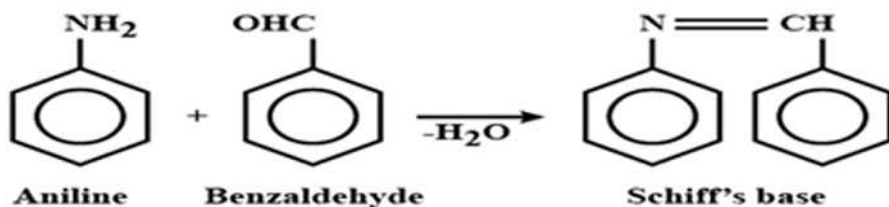
found by Edyta et al. By choosing hydrazides, dihydrazides, hydrazones and mixed derivatives like hydrazide-hydrazones from the several types of molecules that can be categorized as Schiff bases.

Synthesis of
Schiff Base
From Benzaldehyde



In this reaction, benzaldehyde and aniline is mixed in 1:1 ratio and refluxed for 4-5 hours at 40-45 °C temperature.

After that the reaction, it is filtered and dried and purity of compound will be checked by TLC.



Results & Discussions:

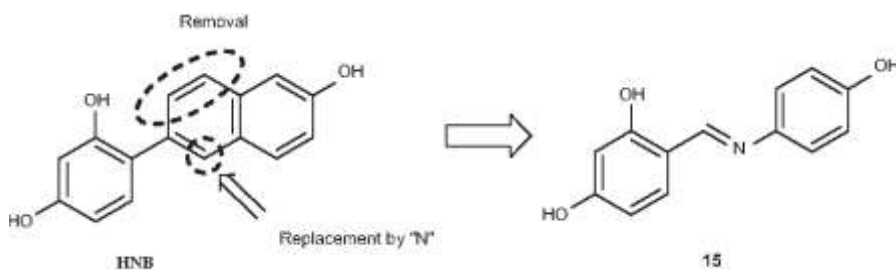
Color after mixing: - light yellow

Change in color after synthesis:- orange color

Boiling point of Schiff base is 248 °C

Molecular weight 181.233 gm/mole

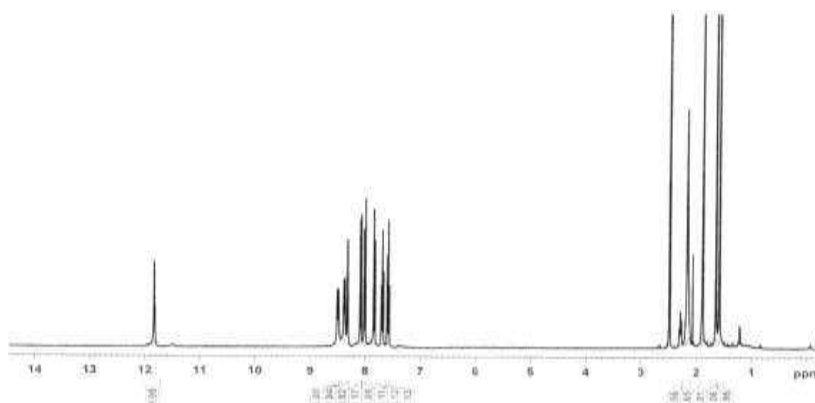
Formula: - C13H11N



PROTON NMR SPECTRA: Within the 9.35-8.90 ppm area of ^1H NMR spectra in DMSO, there is distinct singlet that corresponds to the azo-methine proton. The type of substituents on the benzal moiety has a big impact on the position of this signal. The rate of exchange, relaxation duration, solution concentration and solvent

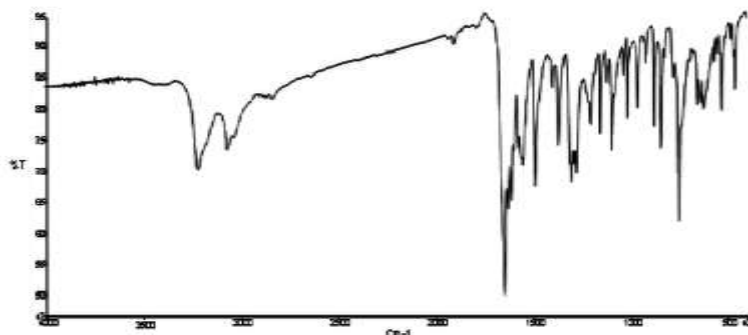
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utilized all have a significant impact on the form, position and integration value of the signal of the aromatic proton of the triazole ring.



FTIR SPECTROSCOPY:

The Schiff base IR spectra reveal medium to strong intensity absorption bands at 1615-1650 /cm, which can attributed to the C=N stretching mode. Aromatic rings have been detected in the 1500-1400, 110-1050 and 900-700/cm areas by their unique ring vibrations. Near 3050/cm, the distinctive $\nu(\text{C-H})$ modes of ring residues can be seen. Stretching vibrations of the methoxy and CH=N groups emerge between 3000 and 2800/cm. (OH) can be attributed to the strong or medium bands between 3428 and 3325/cm at the Schiff bases that do not include hydrogen bonding.



Conclusions:

Imine ligands such as Schiff base semicarbazones and their derivatives have so been extensively investigated for catalytic, pharmacological, industrial and other purposes. Because of their simplicity of manufacture, adaptability and varying denticity, Schiff base ligands are considered to be fascinating ligand.

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A Thematic Focus For Comprehension And Action In Food And Health- Nutritional Security: Domestic And International Implications From Legal And Social Standpoint

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Abstract

Food, with its primal connotations of nurturance and sustenance, carries powerful psychological, economic, physiological and political meaning. It is a significant marker of ethnicity and migrants. In fact, indulgence in food habits serve as a cohesive and stabilising force in a potentially threatening environment. In the industrialized world, food security is taken for granted where stable political and social structures ensure that everyone has access to safe and nutritious food sufficient to maintain a healthy and active lifestyle. The picture in developing world could not be more different almost one billion people are chronically undernourished, regularly consuming less than 2000 calories per day (FAO, 2006). There are also further two billion people who, despite having access to an adequate source of calories, nevertheless lack essential nutrients. This means that up to half

of the world's population at any movement of time may suffer from malnutrition. Fortification of food with vitamins and minerals provides an excellent basis to compare conventional and biotechnology-based approaches to improve nutrition. In fact, the maintenance of food habits may serve as a cohesive and stabilizing force in a potentially threatening environment.

Keywords: Food, Health, Nutrition, Human Rights, Legal Implementation

Introduction

International human rights law lays down obligations of Governments to act in specific mode or refrain from acts to promote and protect human rights and fundamental freedoms from its individuals or groups. Basic human rights are inherent to all as irrespective of nationality, gender, ethnic origin, colour, religion, language social and financial status, all individuals of the respective nation are entitled to our human rights. These rights are interrelated, interdependent and indivisible. Universal human rights are often expressed and guaranteed by law, in the forms of treaties, customary international law, general principles and other sources of international law (1). All human rights are indivisible be it civil and political rights, such as the right to life, equality before the law and freedom of expression; economic, social and cultural rights, such as the rights to work, social security and education, or collective rights, such as the rights to development and self-determination, are indivisible, interrelated and interdependent. Improvement of one right facilitates advancement of others. Likewise, deprivation of one right adversely affects the others (2).

International Perspectives

Context shows a powerful light on authors of 1948 Universal Declaration of Human Rights (UDHR) to recognize definitive and universal first modern statement of human rights. This is particularly important when one come's to examine later human rights documents derived from and codify the rights expounded in the UDHR. Science of human nutrition deals with effects of food on people. It starts with the physiological and biochemical processes involved in nourishment focusing how substances in the food provide energy or are converted into body tissues and the diseases that result from insufficiency or excess of essential nutrients(malnutrition). In today's world, the role of food components in development of chronic degenerative disease like coronary heart disease, cancers, dental caries, etc., are major targets of research activity(3). Scope of nutrition extends to any effect of food on human function such as fetal health and development, resistance to infection, mental function and athletic performance. There is growing interaction between nutritional science and molecular biology which may help to explain action of food components at cellular level and diversity of human biochemical responses (4). Nutrition also deals in context to why people to eat specific foods, even after being advised as being unhealthy. The study of food habits thus, over laps with social sciences of psychology, anthropology, sociology and economics. Dietetics and community nutrition is application of nutritional knowledge to promote health and wellbeing. Dietitians advise people in what, when,

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how much to eat to restore or maintain optimal health, and to help in the treatment of disease. People expect to enjoy eating the foods that promote these things; and the production, preparation and distribution of foods provides many people with employment (5).

The World Health Organization (WHO) states health to be “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. Configuring the same, mental well-being to the spirit. Social wellbeing is the role. The definition specifies health to be ideal must be complete in all forms. Good health is one of the many good things that they would like to have. Health is an area of life where outcomes are often conceptualized as inputs. Health is an elusive concept, and environmental change is leading to monitor new health risks and exposure to new forms of danger. Development, in its many facets is inputs can have very positive but also negative effects on physical and mental health (6).

Relevancy of Food

Food, with its primal connotations of nurturance and sustenance, carries powerful psychological, economic, physiological and political meaning. It is a significant marker of ethnicity and migrants. In fact, indulgence in food habits serve as a cohesive and stabilizing force in a potentially threatening environment (7). The sharing of a food culture is a basis of collective identity and commensality and also a means of expressing both inclusion and otherness. A healthy diet means different to diverse people (8).

In the industrialized world, food security is taken for granted where stable political and social structures ensure that everyone has access to safe and nutritious food sufficient to maintain a healthy and active lifestyle. The picture in developing world could not be more different almost one billion people are chronically undernourished, regularly consuming less than 2000 calories per day (FAO, 2006). There are also further two billion people who, despite having access to an adequate source of calories, nevertheless lack essential nutrients. This means that up to half of the world's population at any moment of time may suffer from malnutrition. Fortification of food with vitamins and minerals provides an excellent basis to compare conventional and biotechnology-based approaches to improve nutrition (9).

Fortification has been successful in the developed world where in it has significantly reduced the incidence of deficiency diseases. Many processed foods, including bread, packaged cereals, milk and soft drinks are fortified with vitamins and minerals so the average diet contain micro nutrients well in excess of requirements. In developing countries, the less robust and reliable food distribution infrastructure, poor governance and the lack of funding renders such programs inefficient and unsustainable, especially when trying to reach remote areas are the major hurdles. Only iodine fortification and, to a lesser extent, vitamin A supplementation has met degree of success, but other programs failed, especially at the local level when dealing with small and remote villages (10).

Problems concerning Food and Healthcare

Poverty continues to afflict third world countries. Its increasing number in the world, while macroeconomic policies, recession in the west, debt servicing in the third world and the impacts of structural adjustment policies often mean cutbacks in already poor health services and increases in differential access to resources and health care. Yet people are living longer, their lifestyles are changing and so too are the diseases from which they suffer (11). Relationship and interactions between health and development have become complex. It is by no means clear that health status automatically improve with rising levels of development in any given country, and this certainly cannot be said for all inhabitants. Both concepts of 'health' and 'development' are, in any case, notoriously difficult to define and almost impossible to quantify in a way that all would find acceptable. Nevertheless, health care professionals, researchers and policy-makers are all aware that health status is changing with development, and it is not invariably changing for the better then people are living longer but, the question over quality of life years added remain standing. The large numbers of people in many countries for whom development has not led to health improvements suffer the most. For example, many people, especially among the poor and particularly in the so-called third world, are experiencing twin threats from infectious and chronic/degenerative diseases. The problems are not confined solely to poor countries, and retrenchment in public-sector and private expenditure on health and health care is now commonplace, meaning that publicly provided healthcare is often diminishing and overstretched (12).

In other areas of social life, there is a greater willingness to assume that increased spending is a good proxy for real success. Perhaps it is wishful thinking that makes people assume that more means more but still it is a common assumption in the field of health. This also makes resourcing a sacred cow. To sacrifice health inputs for transportation inputs at the margin is to condemn the population to an increase in coughs and sneezes. Any list of inputs into the health care production-function will usefully begin with medical care, narrowly defined. The candidates on the side of personnel will be its general practitioner's/ hospital doctors/ radiographers/ physiotherapists/ pharmacists/ hospital nurses/ district nurses/ health visitors/ dentists and other health care professionals (13).

To this must be added capital stock such as hospital beds, diagnostic equipment, therapeutic facilities, medical supplies stored up (drugs, clean sheets, surgical gloves), medical complements on offer (wheelchairs, dentures, walking-frames). The figures are normally expressed as a ratio ('per 100 000 of population') so as to obtain an indication of their significance. Often they are disaggregated by area, region or other subgrouping lest national data conceal local disparities. Occasionally they will be presented not as simple numbers (say, of ambulances or of scanners) but as an economic measure. The measure might be the cost of technology in a general practitioner's clinic or the market value of the referrals made to a top-notch specialist. Utilization is important as well as brute availability (14).

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Specific Aspects for Health Promotion and Care

Thus, data should be collected on patient consultations and outpatient visits, medical tests performed and vaccinations administered, prescriptions written and dressings changed. In case of hospitals, relevant statistics would be patient's treatments delivered, bed occupancy census. Although patient built bed is a piece of rusting metal that gathers dust. It is not a medical input until it is filled. A doctor watching television during duty hours is not different from an unskilled individual. Doctor hours committed to patient care would be a better statistic (15). To obtain a consistent series, numbers should reflect comparable standards. Statisticians should ensure that treatments are quality-constant. Otherwise quality will be sacrificed to contain the cost. The task of adjustment is not an easy one. Quality is difficult to define. Not everyone agrees on what quality really means. It is more difficult still to measure. There is no central agency that collects and processes the data: 'We have no mandatory national system and few local systems to track the quality of care delivered to the American people. Despite the lack of consensus, policy-relevant proxies must nonetheless be found. There are three approaches that can be employed in the reconstruction of information that is not accessible to the naked eye.

One approach is to use input as a measure of standards. Relevant indicators would include capital equipment per staffed bed, staff member's time per patient visit, doctor/patient or nurse/patient ratios, vintage of capital, specialists on the hospital's panel, computerized record-keeping. Other indicators will have an educational element. An inference of investment in high-level proficiency may be drawn from involvement in research, decennial recertification, in-service training per hospital professional, 'conspicuous production' in the form of staff educated in the high-prestige 'ivy league'. Other statistics will concentrate on the thrust of the encounter. Group practices might be used as a quality indicator since they allow general practitioners to fine-tune and focus their skills. Preventive medicine might be taken to suggest that the doctor is improving the stock of health through introducing the patient to exercise, weight loss and a nutritious diet. Another approach is to use goal attainment to track the attributes of the service. The proof of the pudding is in the eating. If the patients return speedily to work, experience less-than-average cross-infection, do not report an allergic reaction or an addiction, do not come back with complications or a relapse, express satisfaction with the product supplied, enjoy longer life-expectancy because the disease is gone, one inference might be that the quality of the attention provided was high (16).

Over the last three decades, close scrutiny has been done in issues of health care financing in countries focusing all levels of economic development. Desire for alternative/ complementary ways to generate financial resources for health care has in part been driven by need, namely resource shortages and rapidly rising costs. At the same time, however, policy choices have been influenced by particular ideas and values concerning the role of the state, and its perceived responsibilities to finance and provide health care (17).

The 41st session of the Committee on Food Security (CFS) rendered opportunities for countries like- El Salvador, India and Jordan to share national experiences in implementing the Right to Food Guidelines, and for all CFS Member Countries, to

reaffirm their commitment to implement the Right to Food Guidelines and strive for realization of the right to adequate food for all (18).

National Provisions relating to Food and Healthcare

The primary responsibility for ensuring right to food and freedom from hunger rests with national governments. It is acknowledged that hunger is both a violation of human dignity and obstacle to social, political and economic progress, and a number of countries have enshrined the right to food in their constitutions. Yet to date, nil country has adopted national legislation to specifically realize this right. Right to food does not mean that the state's duty is to distribute food to all its citizens. It does, however, have an obligation to respect the right to food by not interfering with individuals' efforts to provide for themselves. It must also protect people from infringement of their rights by others. It should help those who do not already enjoy the right to food by creating opportunities for them to provide for themselves. If these three safeguards fail to secure adequate food for all as a response the state should provide, especially to those who because of age, disability, unemployment or other disadvantages cannot fend for themselves (19).

Food safety implies absence or safe levels of contaminants, bacteria, naturally occurring toxins or any other substance that may make food injurious to health. Agricultural development is not only the key to increasing food availability, but as a major employer in most developing countries. It helps to bring rural people out of poverty, but the right to food comprises more than just food production. Markets full of food are useless if people do not have access to them. Efficient national food supply systems must be accompanied by appropriate marketing facilities, equitable rural development policies and adequate opportunities to produce food or earn enough money to buy it. Development of the transportation and communications infrastructures is essential.

Facilitating enjoyment of the right to food does not necessarily mean it's the duty of the state in all aspects of the food system. But the state to take steps ensuring that private markets to able to perform well. There are measures governments take to promote private food markets without resorting to inefficient and costly price control and direct food assistance. By reducing barriers to obtaining trade licenses, they can make it cheaper and easier for companies to enter the market. They can also encourage trade and keep food prices affordable by reducing value-added taxes on food commodities and by enacting legislation prohibiting monopolies. Public access to price data, through radio broadcasts or other means, can also be an effective way to ensure that small traders have the information they need to enter the food business.

According to the Food and Agriculture Organization of the United Nations (FAO), more than one billion people are undernourished. Till date, FAO has supported number of publicly operated food price information systems in developing countries to make data more readily available.

In today's world, over two billion individuals suffer from a lack of essential vitamins and minerals in their food. Nearly six million children die every year from malnutrition or related diseases, that is about half of all preventable deaths. The

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majority of those suffering from hunger and malnutrition are smallholders or landless people, mostly women and girls living in rural areas without access to productive resources. Although, many people might imagine that deaths from hunger generally occur in times of famine and conflict, the fact is that only about 10 percent of these deaths are the result of armed conflicts, natural catastrophes or exceptional climatic conditions. The other 90 percent are victims of long-term, chronic lack of access to adequate food. Combating hunger and malnutrition is more than a moral duty or a policy choice. In many countries, it is a legally binding human rights obligation.

The right to food has been recognized in the 1948 Universal Declaration of Human Rights as part of the right to an adequate standard of living and enshrined in the 1966 International Covenant on Economic, Social and Cultural Rights. It is also protected by regional treaties and national constitutions. Furthermore, the right to food of specific groups has been recognized in several international conventions. All human beings, regardless of their race, color, gender, language religion, political or other opinion, national or social origin, property, birth or other status have the right to adequate food and the right to be free from hunger (20).

At the World Food Summit organized by FAO in 1996, States agreed to halve the number of undernourished people by 2015. They also called for the obligations arising from the right to food as provided for under international human rights law to be clarified. In response, the Committee on Economic, Social and Social Rights issued its general comment No. 12 (1999), which defines the right to food. In the United Nations Millennium Declaration, adopted by the General Assembly in 2000, States committed themselves to halving the proportion of people suffering from hunger by 2015. In 2004, FAO adopted the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security, providing practical guidance to States in their implementation of the right to adequate food.

Conclusion

The concluding remarks of this article is that healthcare is a combination of different aspects belongs to food, diet pattern, nutrition, implementation of laws and policies at international and national level. Universal Declaration of Human Rights (UDHR) recognized as definitive and universal during framing that crucial first modern statement of human rights. This is particularly important when one come's to examine later human rights documents derived from and codify the rights expounded in the UDHR. Science of human nutrition deals with effects of food on people. It starts with the physiological and biochemical processes involved in nourishment focusing how substances in the food provide energy or are converted into body tissues and the diseases that result from insufficiency or excess of essential nutrients (malnutrition). In today's world, the role of food components in development of chronic degenerative disease like coronary heart disease, cancers, dental caries, etc., are major targets of research activity. The scope of nutrition extends to effect of food on human function such as fetal health and development, resistance to infection, mental function and athletic performance, etc. There is a

growing interaction between nutritional science and molecular biology which may help to explain action of food components at cellular level and diversity of human biochemical responses.

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A Thematic Focus
For Comprehension
And Action In
Food And Health-
Nutritional Security:
Domestic And
International
Implications From
Legal And Social
Standpoint

Influence of TiO_2 , MoO_3 , and ZnO on the Power Conversion Efficiency of Perovskite – Based Solar Cell

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Abstract

In recent years, perovskite-based solar cell technologies have sparked much interest. The power conversion efficiency (PCE) of Perovskite-based solar cells is enhanced not only by adding new material to the photon absorbing layer, but also by altering the electron and hole transport layers. Titanium dioxide is commonly used in electron transport layers (ETLs), but it has been shown that replacing TiO_2 with Molybdenum trioxide improves PCE. We use the GPVDM software to simulate a perovskite-based solar cell and investigate the PCE for TiO_2 and MoO_3 ETL layers by altering their thickness. The influence of electron and hole drift-diffusion, carrier continuity equations in position space to describe charge flow within the device, Poisson's equation, and charge carrier recombination have all been investigated in the context of solar cell simulation. We discovered that by substituting TiO_2 with MoO_3 , PCE enhanced the most by 10.23% for ETL layer thickness $2\text{E}-7$.

Keywords: Perovskite, PCE, ETL, MoO_3 , GPVDM.

Introduction

Earth receives 26000TW of solar energy, making the sun the world's largest energy resource. Due to rising worldwide energy demands, solar energy is a serious contender, capable of powering about 300 earths. These statistics demonstrate the need of researching photovoltaic devices to meet the gradually increasing demand for energy without impacting climate.

The traditional crystalline solar cell has an upper limit of 29% PCE on paper, till now we have reached the efficiency of 24% to 25% in the labs, and that costs a premium price[1,2]. Perovskite solar cells (PSCs) have a high-power conversion efficiency (PCE) and could be a good alternative and solar cell of the future. PSCs are based on the thin-film technique, which provides good PCE with less material, eventually lowering the device's manufacturing cost. One of the challenges with PSCs is the stability, which every manufacturer strives for by investing in a device that can survive for more than 25 years while reducing cost.

Structure of Perovskite

Perovskite is a compound with a unique crystal structure ABX_3 (X = oxygen, halogen) discovered by Russian mineralogist L.A. Petroski and named after him. A

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is a cation that is shared by 12 X anion and occupies the Cubo octahedral site, whereas B is shared by 6 X anion and occupies the octahedral site. CaTiO_3 is the first perovskite discovered and it has an orthorhombic crystal structure. Furthermore, oxides perovskite compounds reported have cubic and tetragonal structures like SrTiO_3 , CaRbF_3 , etc. Fig. 1. Depicts the structure of perovskite.

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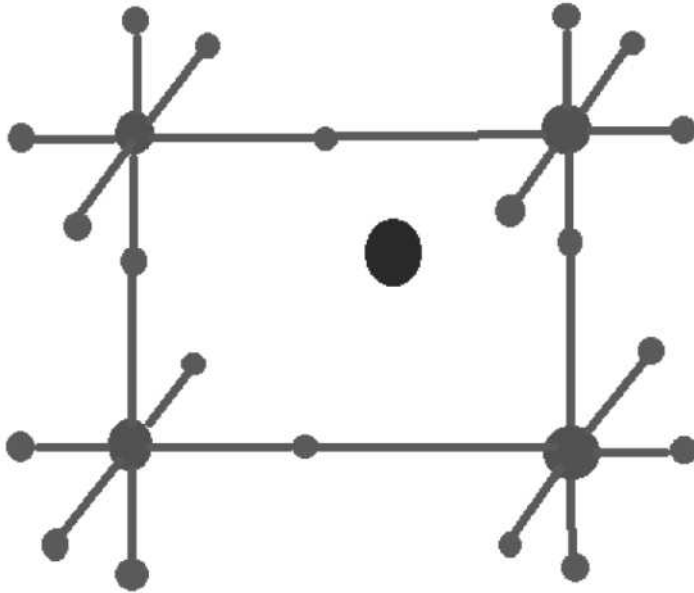


Fig. 1. The crystal structure of perovskite.

Fig. 1. Depicts the ideal structure of perovskite which is of the cubic lattice. However, the ideal cubic structure possesses just a few perovskites and most of the oxides have a distorted structure with low symmetry.

Until 2009 the discovery of perovskite solar cell brought halide perovskite into an area of interest. Oxides are dominating in perovskite due to their electrical properties such as ferroelectricity and superconductivity. While halides perovskites got little attention until organic-based halide perovskite was reported to exhibit a transition from semiconducting to metallic behavior with increasing perovskite layers[3].

Properties of perovskite oxides[4].

- The most well-known property of perovskite oxides is their dielectric properties such as ferroelectricity, and piezoelectricity. It possesses ferroelectricity and superconductivity.

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- Many of them exhibit electrical conductivity closer to that of metals, with ionic and mixed ionic electronic conductivity.
- They also possess catalytic properties mainly in oxidation reactions.

Properties of perovskite halides

- ❖ A high absorption coefficient with excellent metal-organic properties like high electron and hole diffusion length gives perovskite-based solar cells an edge over silicon solar cells [5–7].
- ❖ Electronic properties of perovskite very while band gap decreased as its transition from 2D to 3D. It provides a narrow band gap which is beneficial for absorption in the visible region.
- ❖ Absorption and photoluminescence can be tuned by varying compositions of halides[8].

Important research in the area of perovskite solar cell

In 2009 Kojima *et al.* reported work in which 3D perovskite $\text{CH}_3\text{NH}_3\text{PbX}_3$ ($X = \text{I}, \text{Br}$) was applied in the dye-sensitized solar cell as an inorganic sensitizer which give 3.1% and 3.8% PCE for bromine and iodine respectively[9]. They have successfully achieved a high photovoltage of 0.96 V for $X = \text{Br}$. It was just starting phase of perovskite cells later many works were reported which are maintained here. In 2011 a work reported in which $\text{CH}_3\text{NH}_3\text{PbI}_3$ was deposited on nanocrystalline TiO_2 of the layer thickness of 3.6 micrometers which showed a ten times greater absorption coefficient than conventional ruthenium-based molecular dye. The 6.5 percent PCE was obtained from $\text{CH}_3\text{NH}_3\text{PbI}_3$ -based solar cells[10].

Organic-inorganic halides are ionic which leads them to easily dissolve in a polar solvent which gives raised the issue of their stability for liquid electrolyte-based solar cells. This issue was overcome by substituting a solid hole conductor for a liquid electrolyte. Kim *et al.* reported a work in which they used $\text{CH}_3\text{NH}_3\text{PbI}_3$ as a photon harvester and a solid hole conductor 2,2',7,7'-Tetrakis[N,N-di(4-methoxyphenyl) amino]-9,9'-spirobifluorene (spiro-MeOTAD) was infiltrated on pores of MAPbI_3 . These modifications in solar cells gave results up to 9% PCE and a fill factor (FF) of 0.66. The solution-processable perovskite solar cell was reported by Lee *et al.* to solve issues of disorder metal oxide which causes low PCE[11]. In this approach, they use mixed perovskite halide $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$ and substituted TiO_2 with Al_2O_3 which improved the device PCE to 10.9%. A work in which ZnO substituted TiO_2 was reported by Liu *et al.* in 2014[12]. They use fact that ZnO possess greater electron mobility than TiO_2 . This approach gave PCE of 15.7% in addition to improved open-circuit voltage gain and fill factor. Later on, Saliba *et al.* used a mixer of FAPbI_3 and MAPbI_3 as monovalent cations with the addition of CsPbX_3 to give three cations perovskite composition[13]. The device demonstrated a PCE of 21.1%. After one year Yang *et al.* reported work that use additional iodide as anion and gave a PCE of 22.1%[14]. Fig. 2 represents the above important research in graphical form with years.

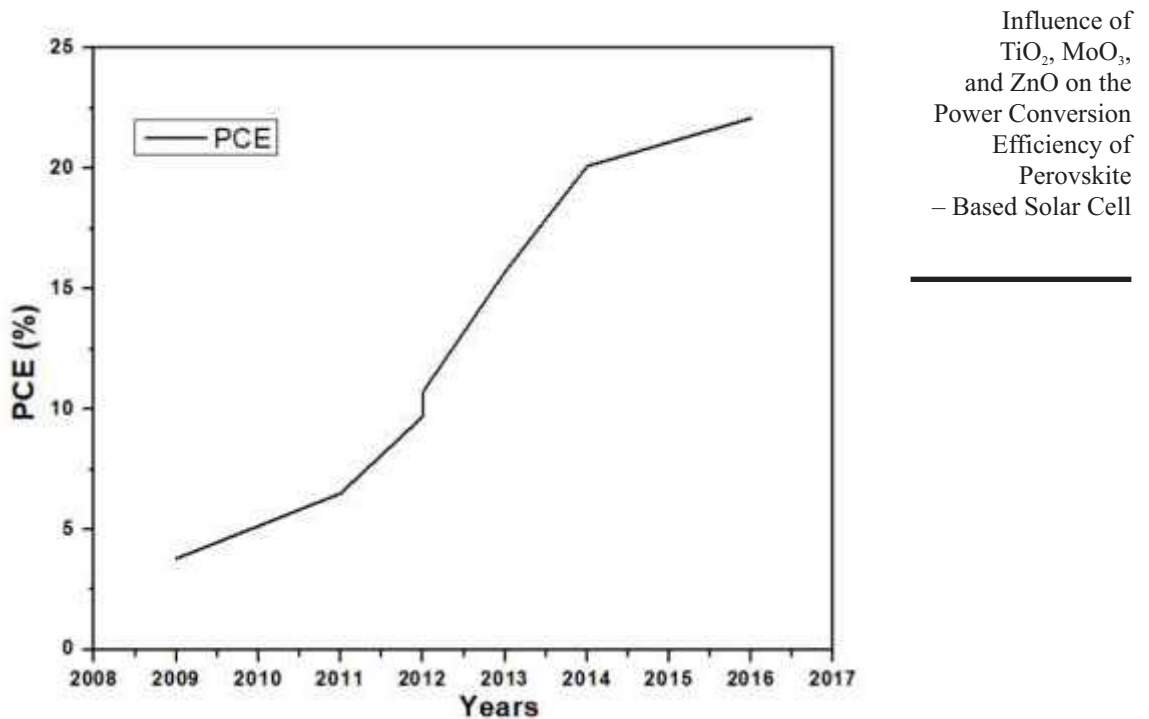


Fig. 2. Demonstrate the breakthrough in the research of perovskite solar cells

Now the issue that arises with perovskite solar cells is the absorption of light due to the electron transport layer (ETL) and its stability. In recent years, there is a lot of researchers approaches many ways to overcome these problems of perovskite solar cells. They have modified ETL which is not only responsible for the absorption of light but also contributed to the instability of perovskite solar cells. Some researchers try to lessen the number of layers or some try to use some other material to get a better result.

Issues related to the stability of perovskite solar cell

Perovskite compounds, as we know, are bound together by ionic bonding, making them easier to produce at low temperatures. It does, however, lower the decomposition temperature, resulting in inferior thermal stability when compared to silicon. The use of organic cations, which can survive lower temperatures than inorganic cations but have substantially bigger sizes in comparison to their inorganic counterparts, necessitates the formation of a stable octahedral form in three-dimensional perovskite [15]. Some potential paths to stabilized perovskite structure have been reported [16], however further research is needed in this field to confirm the long-term stability of perovskite solar cells. We increased the stability of halide perovskite after a lot of research by substituting ions and utilizing better contact material. They are substantially more stable than the criteria of the

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International Electrotechnical Commission (IEC) 61215 standard for real-world applications. However, to achieve economic output, it is necessary to have high confidence in the product's ability to last for 25 years.

In recent years a lot of research has been conducted to get desired device stability. For replacing stable silicon, we should first start looking for material from its group which has great stability so, carbon and its allotropes are considered a good candidate. To protect perovskites from the air and thermal decomposition Hu *et al.* proposed a blocking layer of graphene between spiro-OMeTAD and Au electrode [17]. The graphene layer is deposited with help of CVD, the result shows that 94% of PCE can be maintained after 96 hours in 45% humidity or thermal annealing for 12 hours at 80 °C which is lot better than 54% PCE maintained without graphene. Bi *et al.* used a nano carbon layer to prevent the diffusion of ions or molecules into the perovskite layer to remain stable in humidity and rose thermal stability [18]. Another approach is to use graphene in HTL, Cao *et al.* use nanographene as HTL, which increases PSCs stability and maintained PCE in 45% humidity its PCE is 12.8% which is improved by doping tri-sulfurannulated hexaperi-hexabenzocoronene (TSHBS) up to 14% [19].

The physical properties of ZnO are similar to TiO₂ but electron mobility is much which makes it a suitable replacement for TiO₂ in ETL [20]. To enhance the stability of PSCs ZnO is modified by treated with methylammonium chloride [21] or treated with CNT [22] which prevents degradation of perovskite, and is used as electron transport material (ETM). Nagaraj *et al.* use graphene quantum dots (GQDs) to modify SnO₂/ZnO ETL enhanced PCE and stability [23]. As per results 4% of GQDs modified ETL employed in PSCs give 19.81% PCE. Wang *et al.* successfully modified ZnO by treating it with ethylene diamine tetraacetic acid [24]. Modified ZnO proved to have high electron mobility, PSCs employed modified ZnO yield 20.39% PCE. It retains 95% of its initial PCE after exposing to humid atmosphere for 3604 hours. PSCs used aluminum doped ZnO can yield 18.9% PCE and retains 82 percent PCE after aging for 100 hours in humid atmosphere [25].

Molybdenum trioxide (MoO₃) due to its good absorption in UV region gained lot of attention in the application of solar cells. MoO₃ decorated with CsPbBr₃ demonstrate two times greater photo response which showed its importance in optoelectronics [26]. Pérez-del-Rey *et al.* employed modified MoO₃ with 2,2',2''-(1,3,5-Benzinetriyl)-tris(1-phenyl-1-H-benzimidazole) (TPBi) for charge transport layer in PSCs give 82% of Fill factor and yield 19% PCE while annealed MoO₃ give maximum PCE of 19.3% and 82.5% FF [27]. MoO₃ can also use as HTL in PSCs which overcome the issue of high cost and lower conductivity [28].

Synthesis of perovskite halides

Organic-inorganic lead and tin halides perovskite are commonly utilized in solar cells. Its good electromagnetic waves absorption created a lot of interest for PSCs, but because of its toxicity, researchers began looking for alternatives. Tin can become an alternative due to its ionic state similar to that of the lead having +2 and +4 valency which has piqued the curiosity of researchers [8].

The factor should be considered during the synthesis of halide perovskites

- ✦ The essential factor is the size, and structure of perovskite to be considered.
 - ✦ Another most important consideration is its stability and nature such as toxicity etc.
 - ✦ To get a potential device one should consider its optical and charge carrier properties.
- Goldschmidt tolerance factor[8] give idea about stability of perovskites which is given by

$$t = \frac{r_A + r_X}{2\sqrt{r_B + r_X}}$$

where r_A , r_B , and r_X respectively stand for the ionic radius of A, B cation and X anion. Based on stability mainly MABX_3 , FABX_3 , and CsBX_3 are the most stable perovskite halides synthesized by researchers in the lab.

Synthesis of halide perovskite thin films

Halides perovskite thin films can be synthesized in either one step[9,29–31] or two steps[32]. $\text{CH}_3\text{NH}_3\text{X}$ (MAX) is synthesized by HX, treating methylamine in methanol solution followed by crystallization. For the fabrication of perovskite films, we use their precursor salt (MAX, FAX, CsX, PbX_2 , and SnX_2) and dissolve them into the solvents such as N,N-dimethylformamide (DMF), γ -butyrolactone (GBL) or dimethyl sulfoxide (DMSO). These solutions lower the crystal growth and nucleation. Some other methods are deposition with the assistance of antisolvent, hot-casting, and gas or vacuum pumping which can be used for fabrication.

Two-step method in which we first deposit mesoporous TiO_2 on the compact film of TiO_2 and then followed by spin coating of BX_2 (B = Pb, Sn) dissolve in DMF. After drying the solution, MAX is spin-coated and annealing is done for 20 min at 100 °C temperature to get film of MABX_3 . Spray-coating, brush painting, ink jet, or screen printing are some of the other methods used for the fabrication of uniform perovskite thin film.

Synthesis of nano, micro, and large crystal of perovskite

ITC (Inverse temperature crystallization), AVC (Antisolvent vapor-assisted crystallization), and vapour phase melt are some of the methods used in synthesis of halide perovskite single crystal. Maculan *et al.* reported a approach to synthesised single crystal of MAPbX_3 (X = Cl) using ITC method. They have dissolved stoichiometric amounts of MAX and PbX_2 in DMSO:DMF [33]. Microcrystals of Cs_4PbX_6 (X = Br) can be prepared by Couette-Taylor flow method in which CsX and PbX_2 precursor dissociate in DMF and medium reactor solution prepared by 10% oleic acid in n-hexane medium reactor [34]. Metal halide perovskite can be prepared by either bottom up approach or top down approach. For top down approach several method such as ball milling [35] and for bottom up approach hot-injection method was reported by weerd *et al.*[36].

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Methodology

The solar cell application of $\text{CH}_3\text{NH}_3\text{PbX}_3$ is tremendous but due to the high toxicity of lead, we need to find material that can lead successfully. There is numerous research has been done in this direction on materials like germanium, bismuth, tin, etc. tin halide showed a promising candidate for replacing lead, and it is getting a lot of attention from researchers. In 2019 DFT analysis of organic-inorganic tin halide for its electrical and optical properties was done by Liu et al. [37] according to the $\text{CH}_3\text{NH}_3\text{SnI}_3$ show better absorption than organic-inorganic lead iodide in the visible region which gives a slight edge to $\text{CH}_3\text{NH}_3\text{SnX}_3$ over $\text{CH}_3\text{NH}_3\text{PbX}_{3-3}$ in solar cells application. Feng et al. [38] studied the effective mass, electrical and optical properties of $\text{CH}_3\text{NH}_3\text{SnX}_3$ ($X = \text{Cl}, \text{Br}, \text{I}$) according to findings energy bandgap ranges from 1.6 to 2.8 eV with decreases while going from Chlorine to Iodine. The effective mass of the carrier decreases as we moved towards heavier halide but the optical dielectric constant doesn't decrease while moving towards heavier halide.

Many researchers worked on PSCs with help of simulation software such as GPVDM. GPVDM is the general-purpose photovoltaic device modal used for the simulation of photoelectric and optoelectrical devices. Electrical and optical simulation of PSCs with help of GPVDM was reported in 2021 by Mishra *et al.* [39]. Hima *et al.* worked on organic-inorganic lead halide perovskite solar cells, and study the influence of layer thickness on PCE [40]. As per finding PCE can improve by varying layer thickness, and PCE increased from 9.96% to 12.9% by adjusting layer thickness. Another approach to finding the impact of the layer thickness of PSCs by Yasodharan *et al.* with GPVDM [41]. Here, they used glass on top of the FTO layer and obtained the highest PCE of 14.5%. A comparative study on PSCs for the experimental and simulated results was observed in which 18.43% PCE was demonstrated by GPVDM while 15.93% PCE was successfully achieved experimentally [42]. The tin halide perovskite-based solar cells were also studied by this software. Ikyo *et al.* studied organic-inorganic tin iodide-based PSCs in which they use ZnO as HTL and PEDOT:PSS (Poly (3,4-ethylenedioxythiophene): Polystyrene sulfonate) as ETL [43]. 13.9% PCE obtained at 600nm layer thickness, in addition to FF (fill factor) and V_{oc} (open circuit voltage gain) decreases with increasing absorber thickness.

Here, we use a solar cell consisting of five layers of FTO/ETL/ $\text{CH}_3\text{NH}_3\text{SnX}_3$ /spiro-MeOTAD/Au as shown in Fig. 4 here, we have taken 500 nm thickness of FTO, 700 nm thick ETL, 600 nm thick perovskite, 900 nm thick spiro-MeOTAD as HTL, and 100 nm for Au to made contact. we vary the ETL layer material and its thickness for determining its influence on PCE and Fill factor. spiro-MeOTAD act as hole transporting material these layers possess advantages of environment-friendly and high conductivity. The $\text{CH}_3\text{NH}_3\text{SnX}_3$ perovskite layer act as an active photovoltaic layer which used to produce charge carriers (electron and hole) by absorbing a photon. GPVDM is a simulation tool with the help of this software we demonstrate the influence of layer thickness and change in ETL material on PCE, fill factor, I-V, and J-V characteristics of $\text{CH}_3\text{NH}_3\text{SnX}_3$.

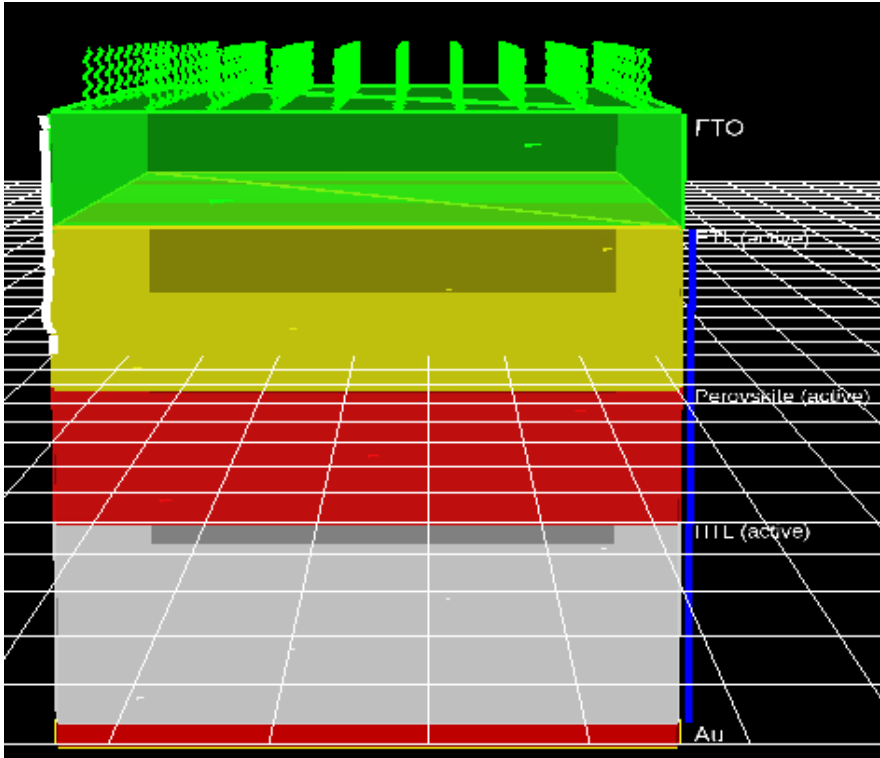


Fig. 3. Depicts the structure of CH₃NH₃SnX₃ based Heterojunctions solar cell

Device simulation

GPVDM is a free general-purpose solar simulation software that solves the Poisson equation, bipolar drift-diffusion equations, and carrier continuity equations in the one-dimensional and time domain.

$$\frac{d}{dx} \epsilon_o \epsilon_r \frac{d\phi}{dx} = q(n - p) \text{ ----- (1)}$$

$$J_n = q\mu_c n \frac{\partial E_c}{\partial n} + qD_n \frac{\partial n}{\partial x} \text{ -----(2)}$$

$$J_p = q\mu_p p \frac{\partial E_v}{\partial p} - qD_p \frac{\partial p}{\partial x} \text{ -----(3)}$$

$$\frac{\partial J_n}{\partial x} = q \left[R_n - G + \frac{\partial n}{\partial t} \right] \text{ -----(4)}$$

$$\frac{\partial J_p}{\partial x} = -q \left[R_p - G + \frac{\partial p}{\partial t} \right] \text{ -----(5)}$$

Carrier mobility and recombination factor can be calculated by getting information about the energy distribution of trapped carrier states [44]. Another method is Charge Extraction by Linearly Increasing Voltage (CELIV) technique, it is very useful when it comes to determining the carrier mobility [45]. Villers *et al.* demonstrated the relation between microsecond transient photocurrent measurements and morphology of thin film to the identification of layer that

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blocked charge-carrier in polymer: fullerene bulk-heterojunctions [46]. Some parameters need for simulation are carefully picked and stored in software to simulate the device, like the energy bandgap[38]. By device simulation, some parameters like average, electron, and hole mobility at P_{max} , open-circuit voltage gain, fill factor, etc., are represented below.

Table 1. Device simulation parameters for TiO_2 as ETL layer.

Device parameters	$CH_3NH_3SnCl_3$	$CH_3NH_3SnBr_3$	$CH_3NH_3SnI_3$
The energy band gap (eV)	2.8	2.0	1.7
Average mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999766E-03	1.999811E-03	1.999834E-03
Hole mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999593E-03	1.999682E-03	1.999724E-03
Electron mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999938E-03	1.999941E-03	1.999944E-03
Trapped electron at V_{oc} (m^{-3})	1.698383E+17	1.769753E+17	1.936808E+17
Trapped hole at V_{oc} (m^{-3})	2.384891E+17	2.704246E+17	2.614621E+17
Free electron at V_{oc} (m^{-3})	7.124416E+21	8.674927E+21	1.097931E+22
Free hole at V_{oc} (m^{-3})	8.802662E+22	1.023663E+23	1.008651E+23
Fill factor (a.u.)	0.812832	0.812492	0.82200
Power conversion efficiency	21.038	20.73	9.97

Table 2. Device simulation parameters for MoO_3 as ETL layer

Device parameters	$CH_3NH_3SnCl_3$	$CH_3NH_3SnBr_3$	$CH_3NH_3SnI_3$
The energy band gap (eV)	2.8	2.0	1.7
Average mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999766E-03	1.999811E-03	1.999834E-03
Hole mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999593E-03	1.999682E-03	1.999724E-03
Electron mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999938E-03	1.999941E-03	1.999944E-03
Trapped electron at V_{oc} (m^{-3})	1.698383E+17	1.769754E+17	1.936808E+17
Trapped hole at V_{oc} (m^{-3})	2.384894E+17	2.704249E+17	2.614626E+17
Free electron at V_{oc} (m^{-3})	7.124420E+21	8.674932E+21	1.097932E+22

Free hole at V_{oc} (m^{-3})	8.802662E+22	1.023663E+23	1.008651E+23	Influence of TiO ₂ , MoO ₃ , and ZnO on the Power Conversion Efficiency of Perovskite – Based Solar Cell
Fill factor (a.u.)	0.812654	0.8124	0.822005	
Power conversion efficiency	21.053	20.76	9.99	

In tables, 1, 2, and 3 contain simulation data like fill factor, power conversion efficiency, electron and hole mobility, trapped and free electron and hole at open circuit voltage etc that were taken for a very small thickness of ETL of 10 nm for TiO₂, MoO₃, and ZnO respectively. This shows that as we move towards such a small thickness device parameters become independent of material or constant for all these materials. Here, we have fixed the thickness of ETL at which it highest PCE for simulate device parameter but 10 nm is very small thickness to be achieved at commercial level so, we should take thickness which give second highest PCE and Fill factor which is also material dependent.

Table 3. Device simulation parameters for ZnO as ETL layer

Device parameters	CH ₃ NH ₃ SnCl ₃	CH ₃ NH ₃ SnBr ₃	CH ₃ NH ₃ SnI ₃
The energy band gap (eV)	2.8	2.0	1.7
Average mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999766E-03	1.999811E-03	1.999834E-03
Hole mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999593E-03	1.999682E-03	1.999724E-03
Electron mobility at P_{max} ($m^2v^{-1}s^{-1}$)	1.999938E-03	1.999941E-03	1.999944E-03
Trapped electron at V_{oc} (m^{-3})	1.698383E+17	1.769752E+17	1.936806E+17
Trapped hole at V_{oc} (m^{-3})	2.384890E+17	2.704237E+17	2.614596E+17
Free electron at V_{oc} (m^{-3})	7.124413E+21	8.674917E+21	1.097930E+22
Free hole at V_{oc} (m^{-3})	8.802662E+22	1.023663E+23	1.008651E+23
Fill factor (a.u.)	0.8128	0.812531	0.822203
Power conversion efficiency	21.022	20.68	9.88

Results and discussion

We simulate the device by altering the layer thickness for TiO₂, MoO₃, and ZnO one by one, then comparing the results to determine the best one that provides good PCE and high stability.

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Simulation for TiO₂ as ETL.

In this simulation, we use FTO substrate, TiO₂ for the electron transport layer, CH₃NH₃SnX₃ as absorber layer, spiro-MeOTAD as HTL, and Au for contact. We started by simulating to see how material and layer thickness affects PCE, thus we fixed all parameters and changed them one by one until we obtained the best PCE

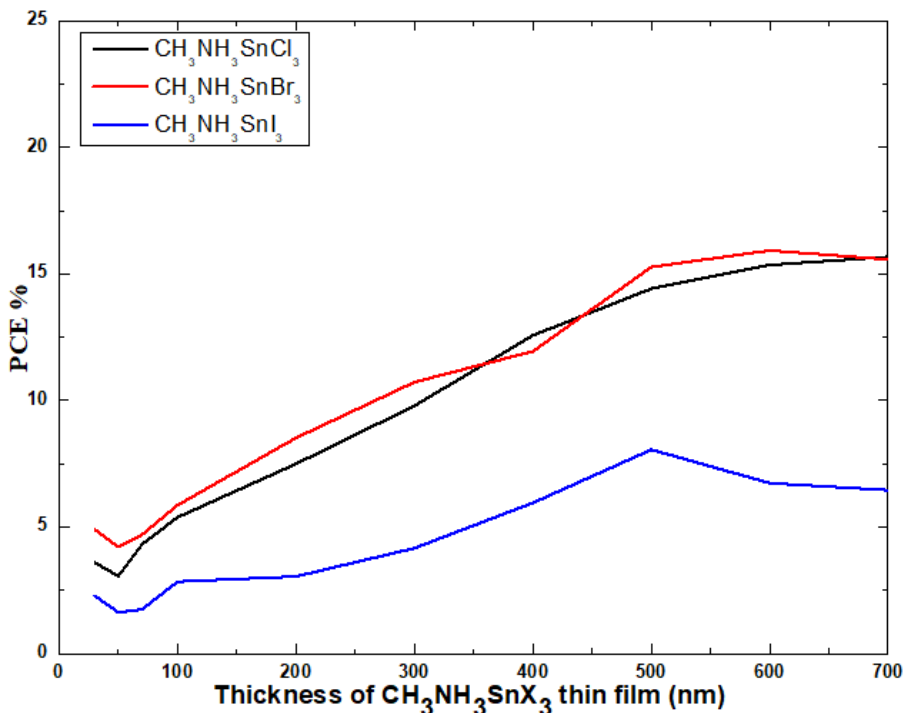


Fig. 4. Dependence of the layer thickness of CH₃NH₃SnX₃ on PCE.

Fig. 4 presented the influence of perovskite layer thickness on PCE. From the figure, we can say that the CH₃NH₃SnBr₃ layer of thickness 600 nm shows a maximum PCE of 15.92, while CH₃NH₃SnCl₃ and CH₃NH₃SnI₃ maximum PCE obtained is 15.67 and 8.06 at a layer thickness of 700 and 500 nm, respectively. It also shows that PCE increases with increasing layer thickness up to a maximum point, after which it starts to decrease. We fix the CH₃NH₃SnX₃ layer thickness that gives us the highest PCE and FTO layer at 500 nm and now alter the TiO₂ thickness for each halide to get a maximal PCE value.

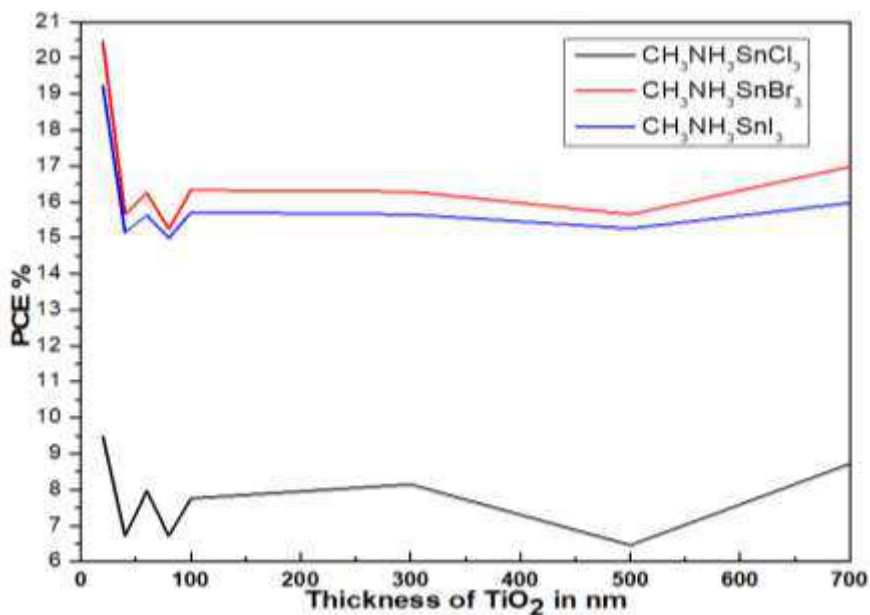


Fig. 5. Influence of TiO₂ layer thickness on PCE.

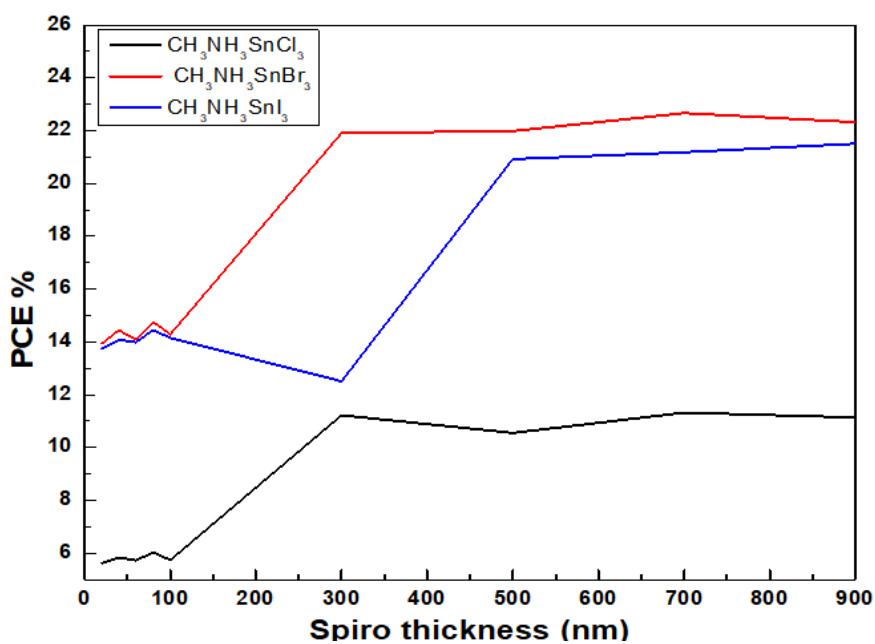


Fig. 6. Influence of Spiro layer thickness on PCE

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In fig. 5 shows the impact of TiO_2 layer thickness on PCE. At a TiO_2 thickness of $1\text{E-}8$, the maximum PCE obtained for $X = \text{Cl, Br, and I}$ are 19.24, 20.46, and 9.48, respectively. But the 10 nm thickness is too small as we discussed above so at such thickness device parameter becomes independent of the material, we should consider of second highest which is at 700 nm. It also shows an erratic change in PCE as layer thickness increases. As layer thickness increases there are some sharp dips and peaks.

Now we look at the effect of Spiro layer thickness on PCE while keeping all other layer thicknesses constant during the observation period at which they acquire the best PCE. FTO, TiO_2 , and perovskite layer thickness are kept fixed at $1\text{E-}8$, $7\text{E-}7$, and $6\text{E-}7$, respectively, and PCE is observed while varying Spiro layer thickness. The effect of Spiro layer thickness demonstrates in Fig. 6. At Spiro layer thickness of $9\text{E-}7$, the maximum PCE obtained for $X = \text{Cl, Br, and I}$ are 21.51, 22.32, and 11.14, respectively.

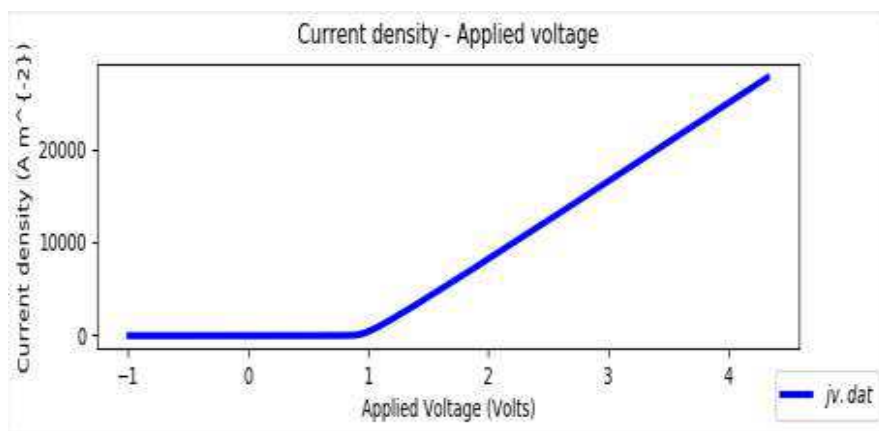


Fig. 7. J-V characteristics of $\text{CH}_3\text{NH}_3\text{SnX}_3$ thin film.

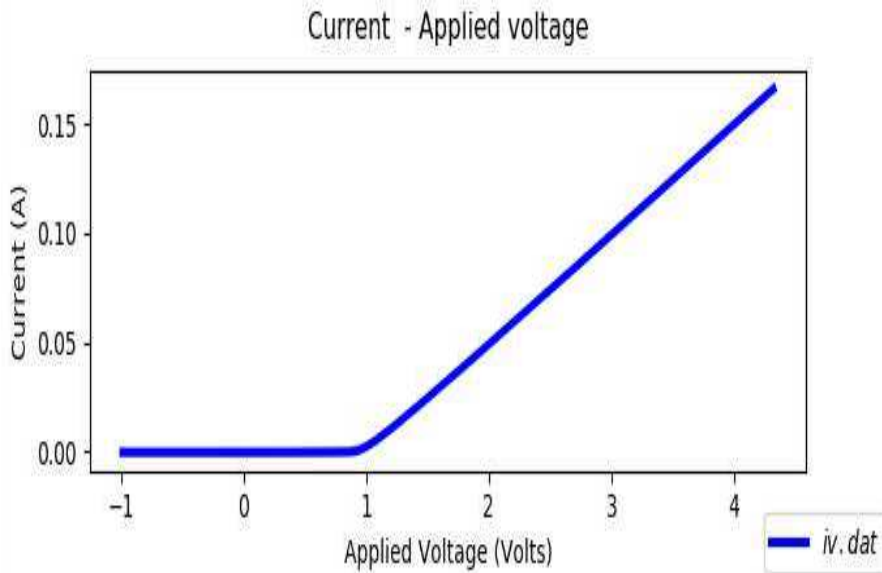


Fig. 8. I-V characteristics CH₃NH₃SnX₃ thin film.

The I-V and J-V characteristics are studied, and Fig. 8 and 7 represent I-V and J-V curves for CH₃NH₃SnX₃.

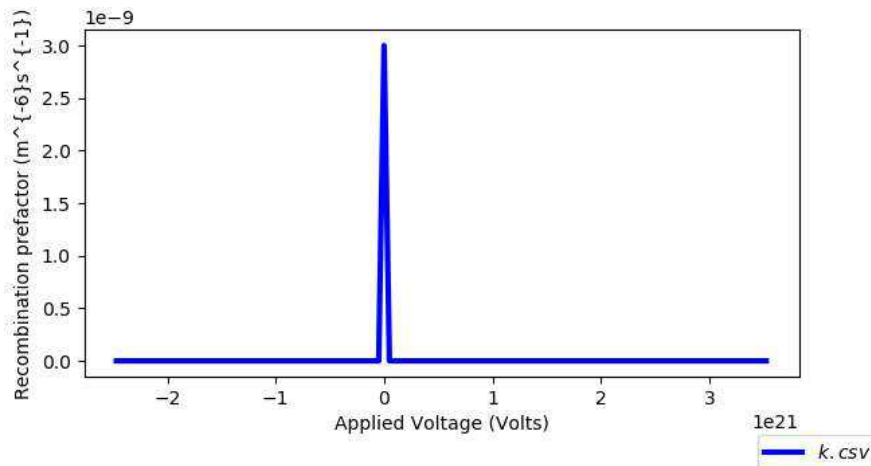


Fig. demonstrates recombination prefactor

Optical simulations

Here, we demonstrate optical simulation for TiO₂, MoO₃, and ZnO as the electron transport layer. We will fix the thickness of the perovskite layer and ETL at which

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they give maximum PCE and 500 nm thickness for FTO, 900 nm for spiro-MeOTAD, and 100 nm for Au.

Optical simulation for TiO_2

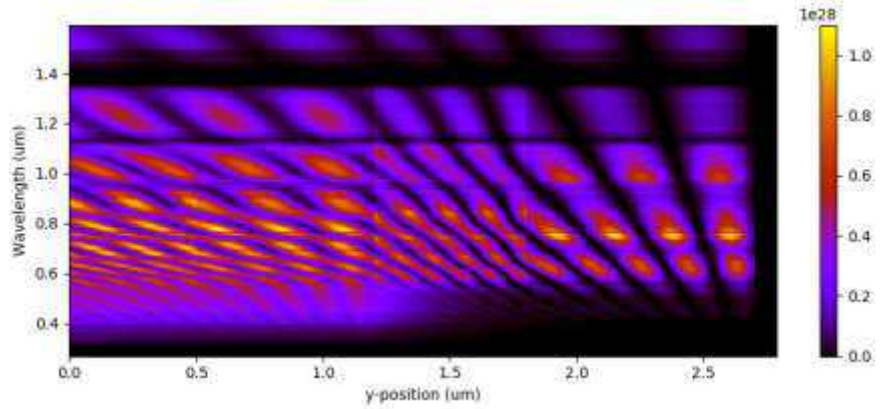


Fig. Represent photon distribution in the device.

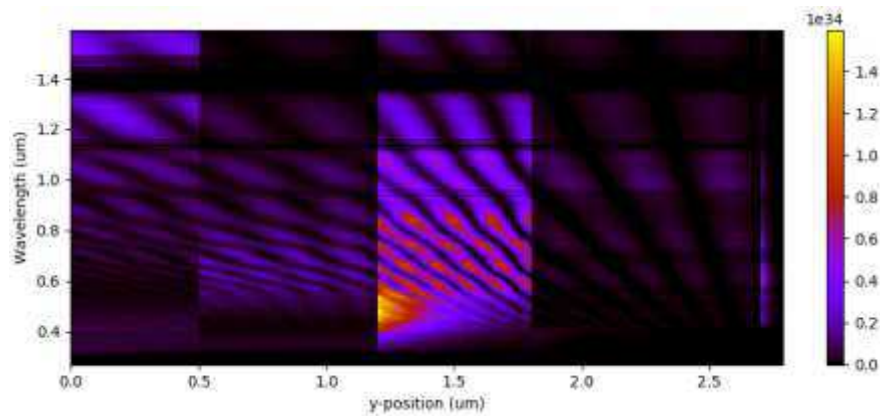


Fig. Demonstrate absorbed photon density.

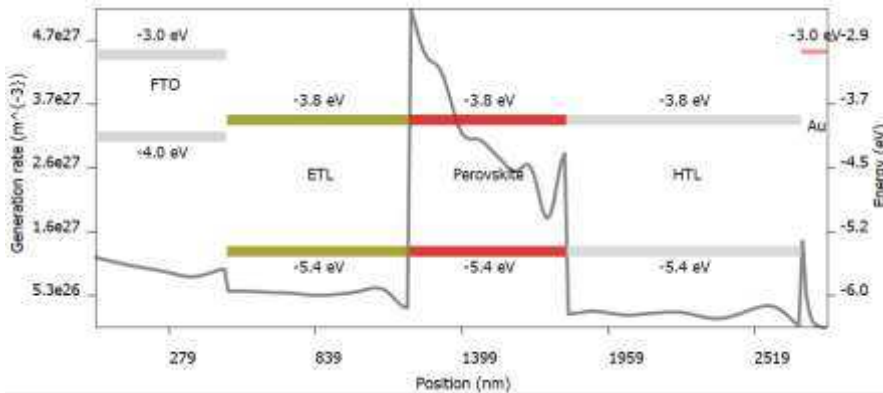


Fig. Demonstrate generation rate of the device.

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Modeling of Quartic Potential for moving object in n-dimension

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Abstract

The paper will discuss the quartic potential when the object is moving. The quartic potential depends on the time, velocity & statistics of particle. The paper will present model about quartic potential with respect time, velocity & statistics coordinates. Quartic potential is the part of potential which is inversely proportional to fourth power of distance.

Key words: Quartic potential, Gradeint, eigen values, potential changes

Introduction: The coulomb potential is governing electromagnetic interactions. By the applying the rules of quantum mechanics gets the various secondary effective potentials. (Kesarwani & Varshni, 1979) [1] Suggested that spacing of the energy levels depends on potential and Eigen values also find by potential. They suggested

$$R_n = \frac{E_n - E_{n-1}}{E_1 - E_0}$$

The factor of effluence R_n on m can be examined by comparing the corresponding curves and found that the great value of m , the earlier is position of the maximum and more rapid in decision. (J. Adeleke, E. Ezugwu, & A.Osinuga, June 2021) [2] Described four hybrid CG methods which satisfied the descent property and also globally convergent. The suggested methods gave better performance than the CG descent method, acclaimed known as CG.(Carvente, Jaramillo, & Degollado, 2019) [3] found a families to transversal wormhole solutions which are parameterized by a parameter l . They considered a set of several massive scalar fields with a self interaction term. They used the Langrangian density for N complex massive scalar fields

$$l_\varphi = -\frac{1}{2k} \left[\sum \nabla_\mu \varphi_i \eta \nabla^\mu \varphi_i^* + V(|\varphi|^2) \right]$$

With Quartic potential

$$V(|\varphi|^2) = \sum_1^N v^{l_i} = \sum_1^N \left(\eta_N \frac{m_\phi^2 c^2}{h^2} |\phi_i|^2 + \eta_\lambda \frac{\lambda}{2h^2} \left| \phi_i^2 \sum_1^N |\phi_i|^2 \right| \right)$$

According to (M.Bender & Boettcher, 1998) [4] quasi exactly solvable have a finite portion of energy and Eigen functions. It depend on a parameter J

$$V(x) = x^6 - (4J - 1)x^2$$

They found for each integer J this determinant is a polynomial of degree J in the variable E . Thus roots of this polynomial are all real and is quasi exact energy Eigen values of the potential.(F.Lopes & Ferreira, 2019) [5] Presented a parallel

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implementation in FPGA of the sum algorithm using SGD as a training method. The purpose of the implementation was to achieve a high rate of data processed in order to meet the demands of computationally intensive application. The computation of the exponential function is in hardware instead of LVTS.(Chen, Li, & Zhaang, 2015) [6] Verified the model of concentrator mirror and the diametric solar model. They concluded on based parabolic trough solar concentrator and the geometric construction of receiver was optimized. The concentrator mirror and the diametric solar model were verified by experiment and were found that result of theory and experiment with each other.(Li, 2013) [7] Described the conjugate descent generated a sequence of point $\{x_k\}$ with initial guess $x_0 \in R^n$

$$x_{k+1} = x_k + \alpha_k d_k$$

$$\text{Where } d_k = \begin{cases} -g_k & k = 0 \\ -g_k + \beta_k d_{k-1} & k \geq 1 \end{cases}$$

Where $g_k = g(x_k)$ and β_k is a scalar. They proposed different conjugate gradient algorithms correspond to different choices for the scalar parameter β_k . For classical conjugate gradient methods, the β_k is selected. So that with minimize a strongly quadratic convex function, the direction d_k and d_{k-1} are conjugate of the quadratic function.(Kaoudi & Quianne-Ruiz, 2017) [8] Presented a cost based optimizer with using gradient descent algorithm. The optimizer used a new abstraction for easy parallelization of GD algorithms and further optimization that leads to performance speed up.(Oviedo, S.Suarez, & Duarte, 2020) [9] Designed a sizing methodology that has a nested simulation model for power and energy balances. The sizing used the gradient descent method for discrete functions. The methodology used simulation of different combinations of capacities of generators and storage systems to evaluate the ability of the combinations to feed the electric demand.

Preliminary: - Let us consider N atoms set of atomic coordinates $X = (r_{1n}, r_{1y}, r_{1z} \dots r_{2x}, r_{2y} \dots)$ and the potential $v(x)$. The Potential v is written as a function of the coordinate $\{x_i\}, \{y_i\}, \{z_i\}, i = 1, 2, 3 \dots i = 1, 2, 3 \dots N$ of the atoms in the system. Let the direction $\alpha, \beta, \gamma : V = V[\{s_i, t_i, u_i\} \alpha, \beta, \gamma]$ where

$$s_i = \frac{x_i}{\alpha}, \quad t_i = \frac{y_i}{\beta}, \quad u_i = \frac{z_i}{\gamma}$$

The gradient potential

$$\nabla U = \begin{bmatrix} \frac{\partial V}{\partial S_1} \\ \frac{\partial V}{\partial S_1} \\ \dots \\ \frac{\partial V}{\partial t_1} \\ \frac{\partial V}{\partial t_1} \\ \dots \\ \frac{\partial u_1}{\partial V} \\ \frac{\partial u_1}{\partial V} \\ \dots \\ \frac{\partial \alpha}{\partial V} \\ \frac{\partial \beta}{\partial V} \\ \frac{\partial \gamma}{\partial V} \end{bmatrix} = \begin{bmatrix} -F_{x1}\alpha \\ -F_{x2}\alpha \\ \dots \\ -F_{y1}\beta \\ -F_{y2}\beta \\ \dots \\ -F_{z1}\gamma \\ -F_{z1}\gamma \\ \dots \\ -\frac{1}{\alpha} \sum F_{xi}x_i \\ -\frac{1}{\beta} \sum F_{yi}y_i \\ -\frac{1}{\gamma} \sum F_{zi}z_i \\ -\frac{1}{\alpha} \sum F_{xi}x_i \\ -\frac{1}{\beta} \sum F_{yi}y_i \\ -\frac{1}{\gamma} \sum F_{zi}z_i \end{bmatrix} = \begin{bmatrix} -F_{x1}\alpha \\ -F_{x2}\alpha \\ \dots \\ -F_{y1}\beta \\ -F_{y2}\beta \\ \dots \\ -F_{z1}\gamma \\ -F_{z1}\gamma \\ \dots \\ -\frac{1}{\alpha} \sum F_{xi}x_i \\ -\frac{1}{\beta} \sum F_{yi}y_i \\ -\frac{1}{\gamma} \sum F_{zi}z_i \\ -\frac{w_{xx}}{\alpha} \\ -\frac{w_{yy}}{\beta} \\ -\frac{w_{zz}}{\gamma} \end{bmatrix}$$

Let $f(x)$, x in n -dimensional space $X = (r_{1n}, r_{1y}, r_{1z} \dots r_{2x}, r_{2y} \dots)$. Let $f(x)$ take as potential energy function corresponding to $V(r)$ by the conjugate gradient descent take the start point r_0 . Now calculate the $V_i(r_i)$. Then we use algorithm

1. Start from point r_0 , set $i=0$
2. Calculate $V_i(r_i)$, $F_i = -\nabla V_i(r_i)$.
3. If $V_{i-1} - V_i < \epsilon$
4. Minimize $V(r_i + \alpha F_i)$ with respect to scalar quantity α
5. Set $r_{i+1} = r_i + \alpha F_i$ and $i = i + 1$
6. Return to stage 1.

Methodology: - The energy minimization goal is then to find x such that V is a minimum. In the C.G method inter atomic force gradient of the function is used to aid in finding the minimum. We consider a scalar field with self inters action. The $V = V[\{s_i, t_i, u_i\}, \alpha, \beta, \gamma]$ and

$$S_i = \frac{x_i}{\alpha}, t_i = \frac{y_i}{\beta}, u_i = \frac{z_i}{\gamma}$$

Then the gradient can be finding by the change in the potential with respect to the position regarding the different coordinate.

$$\begin{aligned} \nabla V &= \left(\frac{\partial}{\partial x_i}\right)V + \left(\frac{\partial}{\partial t_i}\right)V + \left(\frac{\partial}{\partial u_i}\right)V \\ \nabla V &= \left(\frac{\partial V}{\partial x_1} + \frac{\partial V}{\partial x_2} + \frac{\partial V}{\partial x_3} \dots \dots\right) + \left(\frac{\partial V}{\partial t_1} + \frac{\partial V}{\partial t_1} + \frac{\partial V}{\partial t_1} \dots \dots\right) \\ &\quad + \left(\frac{\partial V}{\partial u_1} + \frac{\partial V}{\partial u_1} + \frac{\partial V}{\partial u_1} \dots \dots\right) \\ &= \sum \left[\left(\frac{\partial}{\partial x_i}\right) + \left(\frac{\partial}{\partial t_i}\right) + \left(\frac{\partial}{\partial u_i}\right) \right] V \dots \dots \dots (1) \end{aligned}$$

The sum of the field preserves the spherical symmetry of the stress energy moment tensor so the quartic potential

$$V(|\phi|^2) = \sum_1^N v^{|i|} = \sum_1^N \left(\eta_N \frac{m_\phi^2 c^2}{h^2} |\phi_i|^2 + \eta_\lambda \frac{\lambda}{2h^2} \left| \phi_i^2 \sum_1^N |\phi_i|^2 \right| \dots \dots \dots (2) \right)$$

$k = \frac{8\pi G}{c^4}$, h is the reduce plank constant..

From (1) and (2) we get

$$\begin{aligned} &= \sum \left[\left(\frac{\partial}{\partial x_i}\right) + \left(\frac{\partial}{\partial t_i}\right) + \left(\frac{\partial}{\partial u_i}\right) \right] \sum_1^N \left(\eta_N \frac{m_\phi^2 c^2}{h^2} |\phi_i|^2 + \eta_\lambda \frac{\lambda}{2h^2} \left| \phi_i^2 \sum_1^N |\phi_i|^2 \right| \right) \\ &= \sum \sum \left[\eta_N \frac{m_\phi^2 c^2}{h^2} \left(\frac{\partial}{\partial x_i} \right) + \left(\frac{\partial}{\partial t_i}\right) + \left(\frac{\partial}{\partial u_i}\right) |\phi_i|^2 + \eta_\lambda \frac{\lambda}{2h^2} \left(\frac{\partial}{\partial x_i} \right) + \left(\frac{\partial}{\partial t_i}\right) \right. \\ &\quad \left. + \left(\frac{\partial}{\partial u_i}\right) \left| \phi_i^2 \sum_1^N |\phi_i|^2 \right| \right] \\ &= \sum \sum \left[\eta_N \frac{m_\phi^2 c^2}{h^2} \left\{ 2\phi_i \phi_{i,x} \dot{x} + 2\phi_i \dot{\phi}_i + 2\phi_{i,u} u \right\} + \eta_\lambda \frac{\lambda}{2h^2} \left\{ (2\phi_{i,x} \dot{x} \sum |\phi_i|^2 \right. \right. \\ &\quad \left. \left. + |\phi_i|^2 \sum 2|\phi_{i,x}| x) + \left(\sum |\phi_i|^2 2\phi_i \dot{\phi}_i + |\phi_i|^2 \sum 2|\phi_i| |\dot{\phi}| \right) \right. \right. \\ &\quad \left. \left. + (2\phi_{i,u} \dot{u} \sum |\phi_i|^2 + |\phi_i|^2 \sum 2|\phi_{i,u}| \dot{u} \right) \right\} \\ &= \sum \sum 2\phi_{i,x} \dot{x} \left\{ \eta_N \frac{m_\phi^2 c^2}{h^2} \phi_i + \eta_\lambda \frac{\lambda}{2h^2} \sum |\phi_i|^2 \right\} + \\ &2\phi_i \dot{\phi}_i \left\{ \eta_N \frac{m_\phi^2 c^2}{h^2} + \eta_\lambda \frac{\lambda}{2h^2} \sum |\phi_i|^2 \right\} + 2\phi_{i,u} \dot{u} \left\{ \eta_N \frac{m_\phi^2 c^2}{h^2} + \sum |\phi_i|^2 + |\phi_i|^2 \right\} \\ &+ |\phi_i|^2 \eta_\lambda \frac{\lambda}{2h^2} \left\{ \sum 2|\phi_{i,x}| \dot{x} + \sum 2|\phi_i| |\dot{\phi}| + \sum 2|\phi_{i,u}| \dot{u} \right\} \end{aligned}$$

Here η_N, m_ϕ, λ and h are constant so we can write

$$= \sum \sum 2\phi_{i,x} \dot{x} \{ G_1 \phi_i + G_2 \sum |\phi_i|^2 \} + 2\phi_i \dot{\phi}_i \{ G_1 + G_2 \sum |\phi_i|^2 \} + 2\phi_{i,u} \dot{u} \{ G_1 + \sum |\phi_i|^2 \} + |\phi_i|^2 G_2 \sum 2|\phi_{i,u}| \dot{u} + \sum 2|\phi_{i,x}| \dot{x} + \sum 2|\phi_i| |\dot{\phi}| + \sum 2|\phi_{i,u}| \dot{u}$$

This is the expression to rapid change in the quartic Potential with respect of x, t and u .

Conclusion and Result: - The Quartic Potential is depending on the coordinates of x, t and u . We consider the three coordinates here but it can be generalized in n -coordinates. The paper discussed the change in different direction and applied the concept of gradient on it with three coordinates. The change in the potential can be written in the form of separate coordinates as

$$\nabla V_x = \sum \sum 2 \frac{\partial \phi}{\partial x} \frac{\partial x}{\partial t} \{G_1 \phi_i + G_2 \sum |\phi^2_i|\}$$

$$\nabla V_t = \sum \sum 2 \phi_i \frac{\partial \phi}{\partial t} \{G_1 + G_2 \sum |\phi^2_i|\}$$

And

$$\nabla V_u = \sum \sum 2 \frac{\partial \phi}{\partial u} \frac{\partial u}{\partial t} \{G_1 + \sum |\phi^2_i|\}$$

These are the change in the Quartic potential with respect to x, t and u and G_1, G_2 are constant whose we already taken.

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Production and Modeling of Organic Thin Film Transistor

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Abstract

Organic Thin Film Transistors OTFTs are made to develop high performance, flexible organic electronic circuits of light weight. It is an interesting topic for research and for professional works. The full analysis of these OTFTs gives knowledge about various type of electronic circuits and their performance. The model is designed for devices that operate in the linear depletion and saturation regimes. P3HT devices are fitted for good agreement with the designed model.

Keywords: OTFT; Depletion Regimes; Saturation Regimes; Sub-threshold Slope

Introduction

In the previous years, electronic components on flexible substrates have seen a substantial growth in development and improvement. Printed electronics became possible by the invention of conductors and soluble organic semiconductor. Printed electronics is generally attached with organic electronics and its main feature is the use of organic materials for realizing circuits and devices. The main advantages of organic devices that have developed over many generations are mechanical flexibility, low cost, light weight and straight forward fabrication at a low temperature which allow a cost efficient production of organic devices. These devices on flexible substrates can generally provide large benefits on different fronts because of cost effective fabrication.

Organic thin film transistor (OTFT) have a huge range of applications such as Radio Frequency Identification, e-paper [2], flat panel display, solar cell [3], ring, oscillator, sensors, static random access memory [1]. These transistors have developed into a back plane driver in organic light emitting diode (OLED) in large area flexible displays [4].

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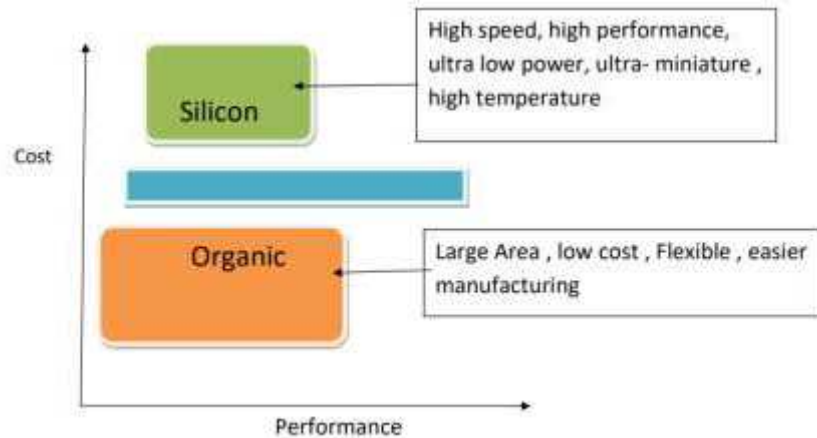


Figure 1.1 Cost versus performance of organic and inorganic semiconductors.

In future this technology may be developed as combine efforts in the area of physics, chemistry, and material science in high speed in graphics.

Because of inferior mobility (μ), organic transistors have lower performance in comparison with conventional transistors. The production cost and flexibility of silicon based devices are obvious constraints. These organic transistor provide an ideal solution because the transistor are not expensive, promising enough to realize large area electronics circuits. OTFTs fabricated on the flexible substrates are improved in comparison to Hydrogenated Amorphous Silicon (Si-H) based TFTs. By increasing mobility of organic transistors by a number of factors, in excess of $15 \text{ cm}^2/\text{Vs}$ [5] for single crystal and $3.2 \text{ cm}^2/\text{Vs}$ for thin film [6].

By optimizing the fabrication method and furthermore, by synthesizing innovative materials, mobility can be boosted even more. The performances of organic transistors are not comparable with silicon transistor, it will be used in a variety of novel applications that are not achievable with conventional semiconductors, and it will be considerably more cost-effective to implement.

ORGANIC THIN FILM TRANSISTOR (OTFTs)

OTFT device is normally a layered structural design made of a thin film of OSC, three electrodes source (S), drain (D), gate (G) and dielectric. The drain electrodes and source inject into and extract the charge carriers, making connection with the active semiconducting surface. The gate is separated from the semiconductor sheet by a dielectric, which controls the channel's conductivity. The TFT structure with gate on top of a semiconductor is comparable to the metal oxide semiconductor field effect transistor (MOSFET). Because it is easier to deposit active material on top of dielectric rather than at the bottom, the bulk of OTFTs are created as bottom gate structures.

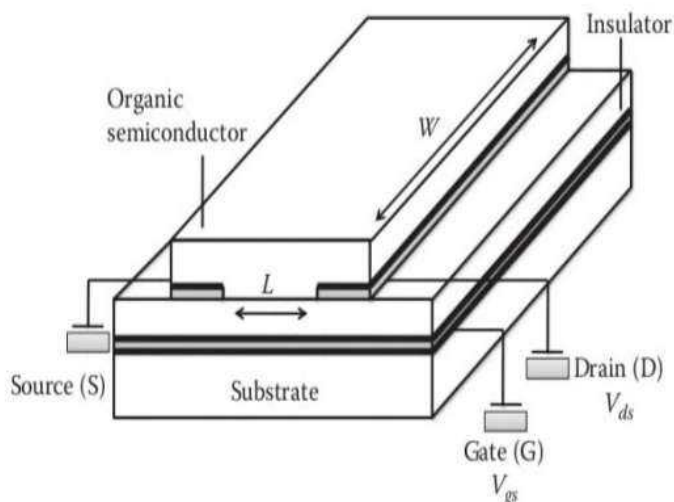


Figure 1.2: An OTFT device arrangement is shown schematically in this diagram

Thermal treatment procedures can be safely used to build the insulating layer in these systems without causing any damage to the OSC layer. Based on the relative position of S/D electrodes with regard to the OSC layer, the bottom gate configuration can be classified as top contact or bottom contact. Because of the large carrier injection area and low contact resistance, the OTFT in a bottom gate top contact (BGTC) structure performs bottom gate bottom contact (BGBC).

OTFT Parameters, Structures, Models, Materials and Fabrication

1.1 PARAMETERS OF ORGANIC THIN-FILM TRANSISTORS (OTFTs)

Field effect mobility, threshold voltage, on/off current ratio, and sub- threshold slope are all used to describe the performance of an OTFT. These parameters determine the applicability of an organic transistor.

1.1.1 MOBILITY

The average charge carrier drift velocity per unit electric field is used to determine a device's mobility. It demonstrates how quickly charge carriers can travel along a conducting path. The processing speed of the gadget is determined by this setting. High mobility is crucial for producing a large on current, which is required for memory applications.

As a measure of mobility,

$$\mu = \mu_0 (v_{gs} - v_t)^\alpha$$

where, μ_0 is the band mobility of an OSC at very low v_{gs} (~0.5 volt).

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α varies between 0.2 and 0.5 depending on the device's conduction mechanism, doping density, and material dielectric permittivity. Another factor that affect the mobility is grain size of active layer [8].

2.1.2 VOLTAGE THRESHOLD

The threshold voltage is the minimal gate voltage required for accumulating charge carriers at the OSC-dielectric interface and generating a conducting path between the source and drain.

It is strongly influenced by doping concentration, channel length (L), insulator dielectric constant (K), and active and dielectric layer thickness. Devices with a shorter length and a thicker OSC have lower threshold voltages [9], according to Kano et al. Furthermore, the thickness has decreased.

Furthermore, due to high gate capacitance, a reduction in the threshold voltage is greatly reduced as the thickness of the insulating layers increases (C_{ox}). Organic material structures in the trap states that are caused by the non-crystalline structures and defects.

1.1.2 ON/OFF CURRENT RATIO

The on/off current ratio, is defined as the ratio of accumulation to depletion zone currents, has a significant impact on a transistor's performance. The channel conductivity, mobility, charge density, and semiconductor and dielectric thickness all have a significant impact on this current ratio. Short channel devices are also used to achieve a greater current ratio. For display and memory applications, the ratio should be above 10^6 . The I_{On}/I_{Off} ratio is increased by decreasing the thickness of the dielectric and semiconducting layers.

Because of the off- dominance current's over the on-current, the current ratio was shown to be more dependence on t_{osc} . For display applications, the number 108 is required, short channels are frequently used. Fabricating devices allows for a large on/off current ratio.

1.1.3 SUB-THRESHOLD SLOPE

In a logarithmic scale, the sub-threshold slope (SS) is the ratio of alternate in gate biasing to alternate in drain current.

Large differences can be detected when the drain and gate biasing is changed, because of a change in the channel's conductivity. The mobility increase for carrier hopping is inextricably linked to the sub-threshold operation of an OTFT. The steeper the slope, the lower trap density demonstrates superior switching behavior. A larger carrier injection density from the source contact may also aid in the achievement of a high switching density response.

The sub-threshold slope is an important feature that dictates how well a transistor may be used as a switch. The slope is heavily influenced by the quality of an active thin-film made throughout the manufacturing process. One of the best ways to improve switching response is to use a self-assembled monolayer (Sam) of a

dielectric. By creating a SAM of aluminum-oxide (Al_2O_3) on aluminium (Al), Kaneko et al. demonstrated a low sub-threshold slope of roughly 100 m v/dec [11].

1.2 OTFT STRUCTURES

OTFTs are distinguished by the layer ordering, regardless of the materials used or the size of the space. The structures are also categorized according to the relative positions of the source (S), drain (D), and gate (G) contacts in relation to the OSC layer. TFTs with a single gate were initially proposed and manufactured in the 1960s. Since that time, huge efforts have gone into the construction of innovative structures.

Dual gate, cylindrical gate, and vertical channel, which resulted in increased performance. Gate control through electrostatics over the channel, there are certain advantages and disadvantages connected to each of them. The performance of various OTFT structures is detailed in the section below.

1.2.1 SINGLE GATE STRUCTURE

The structure of a thin-film transistor is primarily distinguished by the gate location, which can be either on the top or bottom, and is referred to as top gate and bottom gate structures, respectively. The success of if the underlying OSC in top gate architectures deteriorate significantly. Because contamination occurs during the high-temperature deposition of a metal gate, bottom gate configurations are preferable over top gate structures.

Figure 2.1 depicts Top gate top contact (TGTC) and top gate bottom contact (TGBC) OTFT structures, Figure 2.2 depicts bottom gate top contact and bottom gate bottom contact structures.

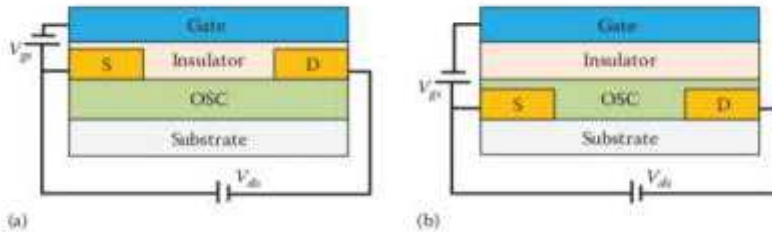


Figure 2.1 Structures of the Top Gate OTFTs (a) TGTC and (b) TGBC

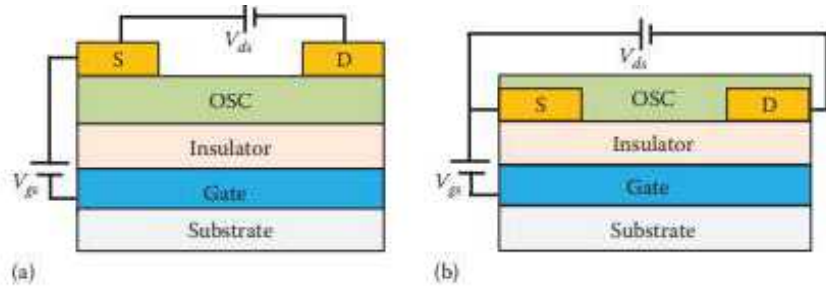


Figure 2.2 Structures of the Bottom Gate OTFTs (a) BGTC and (b) BGBC

The type of OTFT, its performance is heavily influenced by its structure of materials and dimensions. The charge carriers take a different route between the source and the drain, which causes this. Because of the huge injection surface for the charge carriers, a top contact structures exhibits a greater current. Bottom contact structures, despite their low performance, are promising for low-cost flexible electronic applications because they can be produced using basic printing techniques, making them ideal for large-area display applications.

The performance in terms of I_{ds} , μ , I_{on}/I_{off} , V_t and SS for differential single gate structures.

TABLE 2.1 Performance of Single Gate OTFTs in Different Configurations

Materials of Different Layers	Structure	I_{ds} (μA)	μ (cm^2/Vs)	I_{on}/I_{off}	V_t (V)	SS (V/dec)	Biasing (V)	
							V_{ds}	V_{gs}
OSC: Pentacene, S/D: Au, I: Al_2O_3 , G: Al, Sub: Glass	TGTC	-4.9	0.307	9×10^6	-1.0	0.096	-1.5	0 to -3
	TGBC	-2.5	0.246	2×10^5	-0.5	0.155		
	BGTC	-4.5	0.395	5×10^7	-1.2	0.094		
	BGBC	-3.4	0.301	4×10^7	-1.0	0.098		
OSC: Pentacene, S/D: Au, I: SiO_2 , G: $n^+ Si$, Sub: Si	BGTC	-12	0.085	NR	-3.2	NR	-25	0 to -20
	BGBC	-0.4	0.0014	NR	-8.5	NR		
OSC: Pentacene, S/D/G: PEDOT/ PSS, I: PET, Sub: Plastic	BGTC	-32	0.01	10^5	-32	7.2	-100	0 to -100
	BGBC	-8	0.004	10^5	-30	14.5		
OSC: Pentacene, S/D: Au, I: Al_2O_3 , G: Al, Sub: Glass	BGTC	-1.2	0.45	1.6×10^8	-0.9	0.18	-5	0 to -2
	BGBC	-0.1	0.15	8.5×10^4	-0.1	0.79		
OSC: P3HT, S/D: Ti, I: PMMA/ TiO_2 , G: Au, Sub: Si	TGBC	-1.4	0.015	8.4×10^6	-1.3	NR	-10	10 to -10

2.2.2 DUAL GATE STRUCTURE

(FG) collects the carriers in the channel, while the bias on the back gate (BG) further increases the conductivity of the channel.

To obtain better charge carrier modulation on the semiconductor layer, dual gate architectures are used to construct organic transistors. An organic dual gate transistor has a number of advantages, including a greater on-current, a steeper on-current curve, sub-threshold slope and most important better control on the threshold voltage in comparison to single gate.

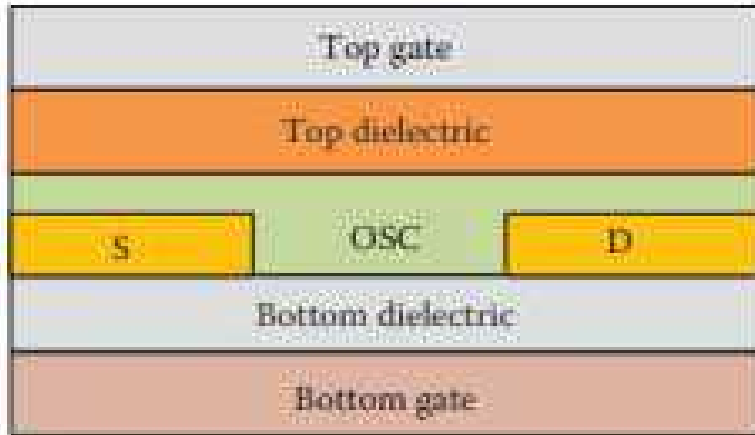


Figure 2.3 Dual Gate OTFT Structure

Figure 2.3 shows a dual gate OTFT structure with a gate in the front (on bottom) with its front dielectric (FD), source/drain connections, and organic semiconductor, and a gate in the back (or top) with a back dielectric (BD). The carriers in the channel are accumulated by the front gate (FG), which a bias on the back gate (BG) improves the channel's conductivity. Controlling V_t from the outside can enable the equipment to operate in a highly controlled manner.

TABLE 2.2 Performance of Different Dual Gate OTFTs

Materials of Different Layers	Mode	I_{ds} (μA)	μ (cm^2/Vs)	I_{on}/I_{off}	V_t (V)	SS (V/dec)	Biasing (V)	
							V_{ds}	V_{gs}
OSC: PDPP-TNT, S/D: Au	BG	-40	0.42	6.4×10^5	-2.3	0.83	-40	20 to -40
BD: D139, FD: SiO_2	FG	-40	0.42	6.2×10^6	-2.5	0.75	-40	20 to -40
BG: Al, FG: Si, Sub: Si	DG	-82	0.90	1.8×10^7	-0.3	0.42	-40	20 to -40
OSC: Pentacene,	FG	-0.7	0.02	3.2×10^3	-2.0	2.0	-3	5 to -15
S/D: Au, BD/FD: SiO_2	DG	-1.5	0.1	3.8×10^3	-2.2	1.3	-3	5 to -15
BG: Al, FG: n ⁺ Si, Sub: Si								
OSC: Pentacene,	BG	-0.1	0.005	2.3×10^4	12	3.3	-20	20 to -20
S/D: Au, BD/FD: Al_2O_3	FG	-1	0.03	5×10^6	-2.8	0.48	-20	20 to -20
BG/FG: Titanium, Sub: Glass	DG	-10	0.06	1×10^6	-0.8	0.47	-20	20 to -20
OSC: PTAA, S/D: Au, BD: Polyisobutylmeth- acrylate, FD: SiO_2 , BG: Au, FG: n ⁺ Si	DG	-10	0.0017	NR	-2.6	NR	-20	30 to -30

2.2.3 VERTICAL CHANNEL STRUCTURE

The thin-film morphological abnormalities low carrier mobility and large channel length limit the performance of a standard OTFT. Using a low-cost shadow masking approach in top contact is quite difficult. However, it's critical to cut down on the number of people that smoke. One approach to do this is to shorten the channel length. Nishizawa et al. addressed this gap by investigating a vertical framework for the OTFT that shows promise for the production of shorter devices [13]. Vertical transistors are made up of five layers, including metallic layers for the source, drain, and gate, as well as two semiconductor layers, as indicated in the diagram.

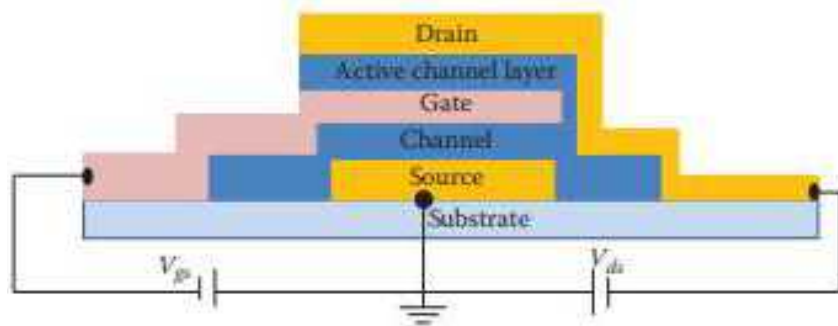


Figure 2.4 The Vertical OTFT is depicted in this diagram.

TABLE 2.3 Performance of Vertical TFTs with Different Combinations of Materials

Materials of Different Layers	Structure	I_{ds} (μA)	μ (cm^2/Vs)	I_{on}/I_{off}	V_t (V)	Supply Voltage (V)	
						V_{ds}	V_{gs}
OSC: P3HT, S/D: Gold, I: SiO ₂ , G: n ⁺ Si, Sub: Si	TC	-3.2	0.0083	164	-1	-40	20 to -20
	BC	-1.8	0.0038	55	+1	-40	20 to -20
OSC: Pentacene, S-ITO, D: Gold, G: Al, Sub: Glass	SIT	-40	NR	10 ³	-1	-3	0 to -1
OSC: Pentacene, S/D: IZO, I: Tantalum oxide, G-Tantalum, Sub: Glass	Multichannel	-22	NR	NR	NR	-20	0 to -20

Due to the creation of a Schottky contact at the interface between the active layer and the gate [14], Kudo et al. demonstrated a high-performance vertical static induction transistor. Chen and Shih also mentioned that vertical top and bottom contact transistors [15] based on P3HT each with a channel. Due to a large reduction in contact resistance, I_{off} is reduced when comparing the vertical TC structure to the planar OTFT, the vertical TC structure outperforms the planar OTFT by a factor of 11. Surprisingly, mobility and flexibility are also important factors.

2.2.4 STRUCTURE OF A CYLINDRICAL GATE

Organic materials are attracting a lot of interest because they have a unique combination of electrical and mechanical qualities that make them ideal for smart textiles. Cylindrical gate (CG) OTFTs have recently proven to be promising enough to build circuits for wearable electronics due to their low cost and low power consumption. Excellent bending stability and hysteresis free functioning furthermore, circular structures are designed to reduce size and increase packing density. A metal yarn core serves as the gate electrode in the construction of CG-TFTs, which is then followed by a thin insulating layer. The OSC layer is next applied, followed by the S/D contact (metal or conductive polymer). Thermal evaporation or soft lithography are used to create them. A cylindrical OTFT's structure and cross sectional view are given in the diagram.

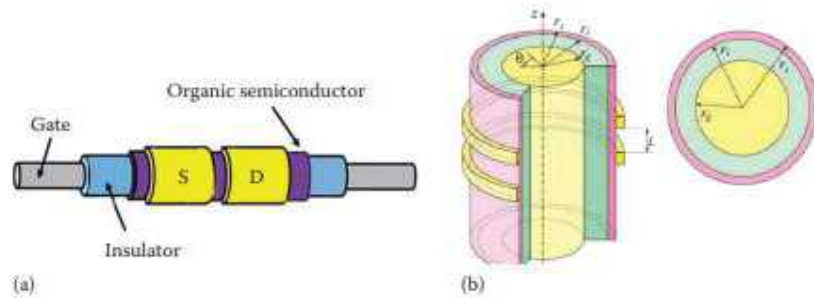


Figure 2.5 (a) Basic construction and (b) Schematic Cross-Sectional image of the CG-OTFT

TABLE 2.4 Performance of Cylindrical OTFTs

Materials of Different Layers	I_{ds} (μA)	μ (cm^2/Vs)	I_{on}/I_{off}	V_t (V)	Supply Voltage (V)	
					V_{ds}	V_{gs}
OSC: Pentacene, S/D: Au, I: PVCN, G: Al wire, Sub: Al	-10	0.53	4.2×10^3	-7.05	-40	0 to -40
OSC: Pentacene, S/D: Au, I: PVP, G: Al wire, Sub: Al wire	-7	0.24	2.5×10^3	-4.78	-40	0 to -40
OSC: Pentacene, S/D: Au, G: Polyimide, I: Polyimide, Sub: metallic fiber	-0.7	0.04	7×10^3	-17.3	-50	0 to -100
OSC: Pentacene, S/D: PEDOT: PSS, G: Polyimide, I: Polyimide, Sub: metallic fiber	-0.34	0.06	3×10^3	-9.6	-50	0 to -100

2.3 OTFT MODELS

To forecast and optimize the performance of electrical devices and circuits, analytical models are frequently used in simulators. In device simulation, these models must be detailed enough and have a high level of accuracy. The circuit implementation is convergent. The model must, in essence, consider materials parameters and physical foundations of a device's structure are taken into consideration. The models must be basic and straightforward to apply, as well as upgradeable, reducible, and customizable. In this paper, we discuss a few potential OTFT models section that follows.

2.3.1 COMPACT DIRECT CURRENT (DC) MODEL

Because organic transistors [8] have similar behavior to metal-oxide-semiconductor (MOS) transistors, the MOS models are adapted and extended to study their

features. For the OTFT, a variety of mathematical models were created, most of which were based on by including empirical characteristics into the traditional transistor model on the basis. Using the MOS model, the drain current in an OTFT changes from linear to saturation regime as follows:

$$I_{ds} = W/L \mu C_{ox} (V_{gs} - V_t) V_{ds} \quad \text{for linear regime, } V_{ds} < V_{gs} - V_t$$

$$I_{ds} = W/2L \mu C_{ox} (V_{gs} - V_t)^2 \quad \text{for saturation regime, } V_{ds} > V_{gs} - V_t$$

This transistor operation over the threshold voltage is demonstrated in this model. Several models have been proposed to mimic carrier transport in organic transistors. Marinov et al. [7, 17] demonstrated a tiny DC OTFT model with transistor operation from the ohmic to saturation regimes. The performance of an OTFT usually deviates from the norm. Due to critical characteristics such as bulk leakage, which distinguishes it from a typical transistor contact resistance, the contact-OSC interface, OSC-dielectric interaction, current device design, trap states, channel length modulation, gate bias-dependent mobility, and gate bias-dependent mobility, and a slew of other factors complicate the process. A proposed OTFT model that is united typical MOSFET equations were used in order to get the most out of these transistors, these criteria must be taken into account to the fullest extent possible.

2.3.2 CHARGE DRIFT MODEL

To create analytical models for organic transistors, a few characteristics are typically stated, field-dependent mobility and contact resistance are examples of these characteristics. One thing that all OTFT models have in common is the ability to improve mobility [17]. When the gate overdrive voltage is high then the field dependent mobility occurs. It is a critical aspect in assessing a more realistic depiction of OTFT performance

$(V_{gs} - V_t)^\alpha$ is a charge expression

The current per unit width is described in the drift model as

$$I_{ds}/W = \mu_x q_x |E_x|$$

Where $|E_x| = V_x/x$ denotes the electric field, and q_x denotes the areal charge density.

$$q_x = C_{ox} (V_{gs} - V_t - V_x)$$

At a location x in the channel $0 < x < L$, the field dependent mobility μ_x can be defined.

$$\mu_x = \mu_0 (V_{gs} - V_t - V_x)^\alpha$$

where, The voltage at a point x is V_x , and the mobility improvement factor is α .

An OTFT's structure has a significant impact on its properties. In comparison to the top contact, the bottom contact has a higher trap density and thus a higher alpha value. Heterogeneities are formed in the bottom contact structure during the deposition of semiconductor surrounding the contacts, according to Cosseddu and Bonfiglio [10]. As a result, the number of trap states increased and the number of trap states decreased a significant increase in mobility and drain current.

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2.4 MATERIALS

Efforts have been made in the recent decade to synthesis novel organic materials to improve transistors performance. The theory's applicability has grown as new high-performance organic materials have emerged. Organic transistors have become extremely popular. These materials beg to be pushed. Cost-effectiveness, characteristics, and processing are all factors to consider. The material constituents have a big effect on the performance of an OTFT. The active layer; nevertheless, the materials for other layers, such as the background layer, must be chosen carefully. The dielectric and electrodes play an important play an important role as well. Aside from that, the device is suitable for achieving the task due to the right substrate material selection flexible circuitry at low cost. This section discusses various materials such as semiconductors, electrodes, dielectrics, and substrates.

2.4.1 ORGANIC SEMICONDUCTORS

OSC's in order to make them more commercially viable conducting polymers and tiny molecules are two types of organic semiconductor. Due to their increased molecular weight, polymers have lesser mobility than their counter parts. The goal is to achieve high mobility. Semiconductors grain sizes should be bigger. The performance of highly organised thin films improves dramatically OTFTs. Small molecules have a higher mobility ($>3.2\text{cm}^2/\text{Vs}$) [19] polymers ($>0.9\text{cm}^2/\text{Vs}$), although due to advances in fabrication processes, this gap is closing a large number of conducting polymers, as well as a small number of conducting polymer and the potential for molecular organic materials to be used as the layer in which is the active layer in organic devices classified as p or n-type OSCs [20].

2.4.1.1 p-type

In their accidentally doped state, the majority of the OSCs examined the charge carrier thus far has been the hole. A lot of research is being done right now on polymers and conjugated oligomers. P3HT, P3OT, and P3DT are poly (3-hexylthiophene), poly (3-octylthiophene), and poly (3,3-dialkylquarterthiophene), respectively (PQT-12), copper phthalocyanine (CuPc) [18].

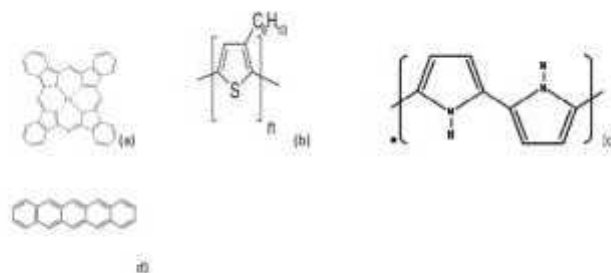


Figure 2.6 Chemical Structures of different p-type organic semiconductor materials (a) CuPc (b) P3HT (c) Polyprole (d) Pentacene

2.4.1.2 n-type

The development of high-performance p-type OSCs has occupied the majority of research efforts. Synthesizing new n-type semiconductors, on the other hand, has received less attention while attempting to create a complementary product. Both types of semiconductors are needed in an inverter. The advancement of n-type semiconductors is also crucial [20]. The graphic depicts the chemical structures of some of the most extensively used n-type OSCs.

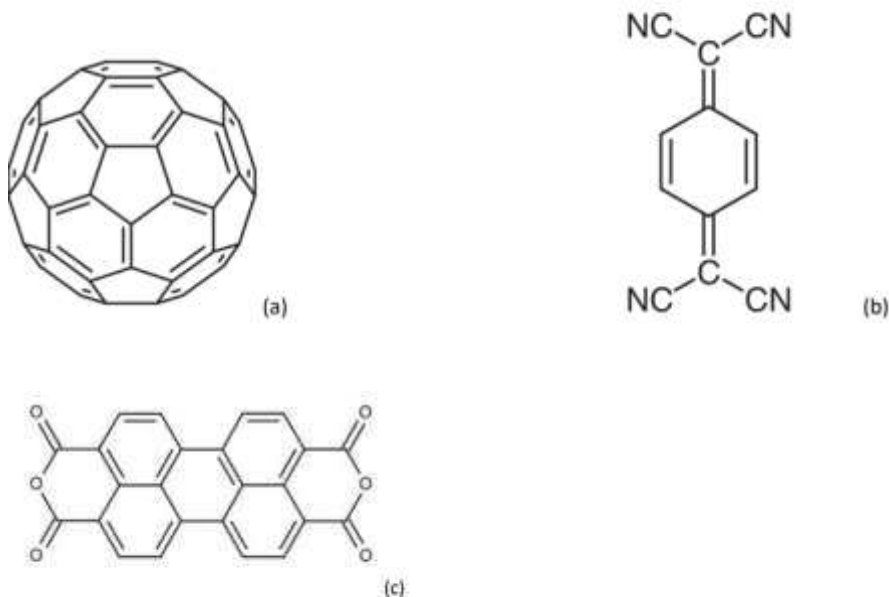


Figure 2.7 Chemical Structure of different n-type organic semiconductor materials (a) TCNQ (b) PTCDA
(c) F₁₆CuPc

2.4.2 ELECTRODE MATERIALS

The material used to make electrodes is just as the semiconductors in producing a high-performance device. High contact resistance should be avoided by choosing the contact metal for the source and drain electrodes. It means that the contact with the active layer must be kept at a low interface barrier, allowing for a large number of carrier injections. Due to its high conductivity, gold metal is frequently utilised in p-type OTFTs. Work function is a measure of how well something works (5.1eV). It's a good metal to use with.

Most p-type OSCs have a HOMO level approximately 4.9eV. As a result, there is a low interface barrier (0.2eV) between gold and p-type OSCs have ohmic features,

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they're suitable for forging relationships. The adhesivity of gold is improved by adding titanium (Ti), chromium (Cr), and nickel (Ni). With the substrate and gate dielectric and gate dielectric, the material used for the gate electrode should have excellent adhesion and patterning properties. Furthermore, the gate metal's work function should be comparable to that of the semiconductor in order to attain a low threshold voltage. Silicon with a lot of dopants is one of these electrode materials. Silicon, aluminium, and indium tin oxide (ITO) [11, 12, 16, 20].

Table 2.5 summarizes the work functions of a few common inorganic contact materials. Because of its high work function, indium tin oxide is often utilized as an anode in organic display systems. (5ev) and enough visible spectrum transparency alternatively, low-work-function metals including lithium, calcium and magnesium are commonly used. The cathode terminal is made out of those metals.

In order to construct a truly flexible organic device, a novel series of conducting polymers must also be used to fabricate the electrodes. Organic electrode materials that are regularly utilised include:

TABLE 2.5 Inorganic Electrode Materials' Work Functions

Materials	WF (eV)
Ca (Calcium)	2.87
Al (Aluminum)	4.0-4.28
Ni (Nickel)	4.1-5.0
Pt (Platinum)	5.65
Cu (Copper)	4.7
Cr (Chromium)	4.5
Au (Gold)	5.1
Ti (Titanium)	3.84
Fe (Iron)	5.0
Co (Cobalt)	5.0
ITO (Indium tin oxide)	5.3
Heavily doped silicon	3.9

- Polythiophene
- Polypyrrole
- Polyanilene
- Polyaniline : camphor-sulfonic acid, or PANI:CSA
- Poly (3,4 –thylenedioxythiophene)
- Poly (3,4 – ethylenedioxythiophene) :polystyrene sulfonated, or PEDOT:PSS

Examples

Draw the chemical structures of (a) eumelanin (b) 3,4- dihydroxy-I-phenylalanine, (c) poly (3,4-ethylene dioxythiophene) (PEDOT), three extensively used organic electrode materials (I-DOPA).

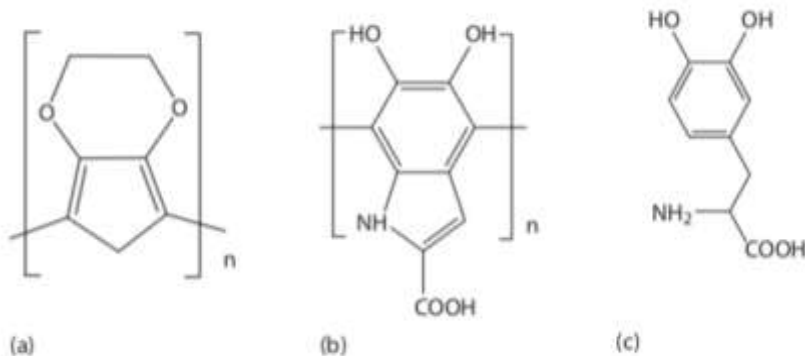


Figure 2.8 Chemical Structures of commonly used organic electrode materials (a) Eumelanin (b) PEDOT (c) L-DOPA

2.4.3 GATE DIELECTRIC MATERIALS

Current leakage between the gate and active layer is prevented using gate dielectric material. It also serves as a in top-gate organic transistors, there is a passivation layer. Carriers of charges accumulating on a semiconductor the dielectric constant and dielectric layer thickness have a significant impact on the dielectric interface. The dielectric layer's substance should be durable adhesion to the substrate in an appropriate manner it must also create an appealing use interface. To avoid dipoles and trap states, work with the semiconductor. A dielectric substance must possess a number of desired features: High resistance and a high dielectric constant. Because high $-k$ materials have smaller band gaps than low- k materials, they can achieve a steep sub-threshold slope and low threshold voltage. Constants dielectric of in this table, inorganic dielectric materials that are commonly utilised are included table2.6.

Several high- k dielectrics, such as La_2O_3 , HfSiO_x , Pr_6O_{11} , HfLaO , HfO_2 and others V_t and SS were significantly reduced when Al_2O_3 was used. The thickness of the dielectric layer, in addition to the high- k material, should be low to function at lower voltages and to in submicron devices, remove short channel effects. It should

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also have a high breakdown voltage and a high breakdown current as well as long – term stability a variety of options are available to meet these objectives. SiO₂, PVP, ZrO₂, Al₂O₃ and P₄VP are examples of dielectric materials. Organic dielectric materials such as PMMA, PVP, PI, PS and PVA indicate processing ability through low cost production procedures, good adhesion, and reasonable dielectric characteristic. Table 2.7 summarizes the dielectric constants of a few organic compounds. Because of their limited conductivity, organic dielectric based TFTs require a high working voltage.

TABLE 2.6 Dielectric Constants of Inorganic Dielectric Materials

Materials	Dielectric Constant
Nd ₂ O ₃ (Neodymium oxide)	11.7
SiO ₂ (Silicon dioxide)	3.5–4.5, 3.9
TiO ₂ (Titanium dioxide)	80-100
Al ₂ O ₃ (Aluminum oxide)	8.5-9
MgO (Magnesium oxide)	9.8
Si ₃ N ₄ (Silicon nitride)	6.2-7.1
HfO ₂ (Hafnium oxide)	22,25
LaAlO ₃ (Lanthanum aluminum oxide)	26
Ta ₂ O ₅ (Tantalum pentoxide)	26
ZrO ₂ (Zirconium dioxide)	25, 17.5
La ₂ O ₃ (Lanthanum oxide)	30

TABLE 2.7 Organic Dielectric Materials Constants

Production and Modeling of Organic Thin Film Transistor

Material	Dielectric Constant
PI (Polyimide)	2.6
P4VP (Poly (4-vinyl phenol))	5.3, 2.56
PVA (Polyvinyl alcohol)	7.8, 8.3
P3DDT	3:24
P (VDF-TrFE)/(PVDF)-blend	10.3
PS (Polystyrene)	2.6
P4VP-co-PMMA	4.1
Porous PI (Porous polyimide)	1.67
D139	7.4
PVP (Polyvinyl phenol)	5.3, 3.8, 6.4
PMMA (Polymethyl methacrylate)	3.6, 3.3

Examples

Draw the chemical structures of the following popular organic dielectric materials: (a) silicon network polymer, (b) polystyrene (PS), (c) polymethyl methacrylate (PMMA) (d) poly (vinyl phenol) (PVP) and (e) parylene (PVA)



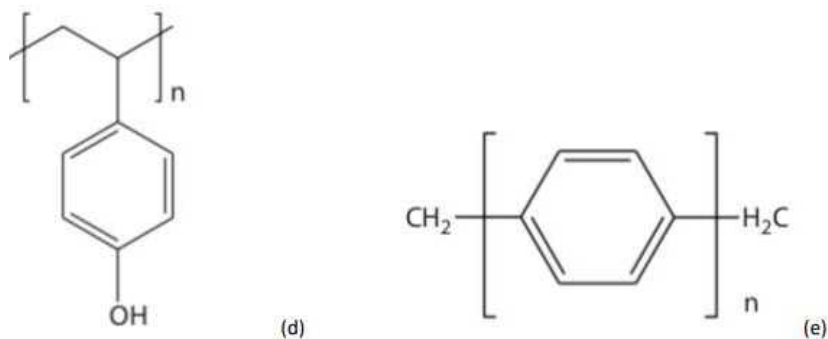


Figure 2.9 Chemical structures of commonly used organic dielectric materials (a) silicon network polymer (b) Polystyrene (c) PMMA (d) PVP (e) Parylene

2.4.4 SUBSTRATE MATERIALS

The type of substrate material used for each device is largely dictated by the device's intended use. Silicon is used in electronics not just because of its inherent qualities, but also because of its propensity to form an oxide. Thermal oxidation was used to create the layer. OLED (organic light emitting diode) displays require a glass substrate to be manufactured. Organic, on the other hand, is a type of food that is made from natural ingredients. Flexible electronics cannot function without substrates. Peng et al. [21], a group of researchers, published their findings in 1990. The first TFT on a glass substrate was described. Garnier followed suit et al. created a TFT on a polyimide substrate that is flexible showed a high level of efficiency [22]. TFT manufactured on silicon or glass provides equivalent performance. Bao et al. [23] reported the first fully printed P3HT- based organic transistor in 1997, a substrate made of ITO-coated polyester. Previously, many fully printed organic transistors and circuits were built on flexible substrates like polyethylene, plastic, paper, polyimide, polyethylene naphthalate (PEN), fiber opened the door to a new age of low-cost flexible printed electronics.

2.5 FABRICATION

Despite the fact that similar sets of materials are utilized to manufacture them, the approach employed to the way materials are deposited during manufacturing has a big impact on the performance of different OTFTs. Physical vapor deposition, chemical vapor deposition, and solution processing are some of the most often utilized fabrication techniques [11, 12, 18]. The creation of organic and inorganic materials uses a variety of fabrication processes. Thermal vacuum evaporation and sputtering manufacturing procedures are two types of physical vapor deposition (PVD) techniques, whereas solution process approaches include processes include spin coating, dip coating, and inkjet screen printing. Organic materials enable the manufacturing costs dramatically. Semiconductors made up of small molecules,

such as Pentacene, are typically deposited using vacuum. Because they have a limited solubility in organic solvents. Conducting polymers, such as P3HT and polythiophene, are not, and can be applied using spin coating or ink-jet printing methods since they are soluble in solvents such as chloroform and toluene.

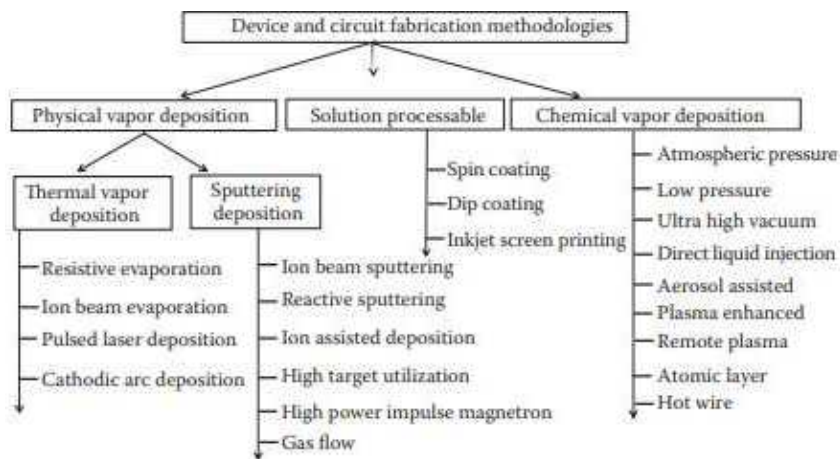


Figure 2.10 Different Fabrication Methodologies Used in Organic and Inorganic Devices and Circuits.

2.6 CONCLUDING REMARKS

In recent years, organic electronics research has made great progress. Organic transistors have they have a bright future ahead of them, with a wide range of applications. Nonetheless, it still confronts a number of obstacles that must be overcome in order for it to become a commercially successful and sustainable technology.

The following points have been identified as being useful researches, academicians, and industry personnel based on the extensive research given in this chapter to address the limitations of OTFT technology.

- Many analytical models for OTFTs have been created in recent years, most of which are based on the standard MOS transistor model and include field-dependent mobility, grain size, contact resistance. As well as modulation of the channel length, the vast majority of models are built on this foundation. Charge transport is restricted to the conducting channel. Bulk sheet resistance becomes important in organic semiconductors at a certain position. This resistance has a significant impact on the current conduction and while it can be minimised by using thinner OSC layers, it can't be eliminated completely. As a result, it needs to be taken into account. Creating fashions to absolutely recognize the conduct of the OTFT.

■ In terms of semiconducting layer thickness, an OTFT's performance is being studied with zeal. The dielectric thickness, on the other hand, is an important influencing factor that has a considerable impact on the threshold voltage and mobility. When it comes to studying the device, OTFT structures are also important in terms of layer thickness. This is as a result dissimilarity, the charge carrier's journey between the source and drain. As a result, it's far critical examine the effect of the thickness of the material.

■ Organic devices using flexible substrates have been implemented and developed with much effort. Organic digital structures, on the other hand, have received only a few attempts. Several OTFT- based applications necessitate the use of inverters and universal logic gates; as a result, significant work is required toward their development. Because of this, the majority of organic circuits are built on p-type designs. In comparison to n-type organic materials, p-type organic materials have stronger field effect mobility and stability. Because the large threshold voltage provides a full swing at the output organic transistor, an organic circuit with only p-type components does not operate. As a result, the noise margin gets less.

■ The materials used at different layers have a significant impact on the performance of an OTFT. In recent years, significant progress has been made toward the synthesis of various high-performance new p-and n-type semiconductors. However, only a small amount of study has been done on the impact of different materials on the performance of inverter circuits. As a result, in order to address the effects of various materials, it is important to examine the static and dynamic responses of inverter circuits using various TFT.

3 PROCESS/ DEVICE SIMULATION TOOL AND SIMULATION CONDITIONS

The Silvaco Atlas 2-D numerical device simulator is used to design and build OTFT devices and circuits with tiny molecules or conducting polymers as the semiconductor layer. The next sections go through specifics of a device simulation tool as well as simulation circumstances.

3.1 SIMULATION SETUP

The electric characteristics of many organic device and circuits, is described in this section. Silvaco Inc. is

a company that specializes in electronic design automation. Computer –aided design (TCAD) technique and software (EDA) simulation software for devices. To solve a problem the term “EDA” refers to a group of software tools that work together. A number of models and techniques for constructing complex electronic devices, circuits, and systems TCAD is a subset of EDA that simulates semiconductors. The fabrication process as well as the operation of semiconductor devices process TCDA is used to model the manufacturing, where as device TCDA is used to represent the device functioning. Simulation results for the semiconductor process and device include a variety of numerical calculations based on standard physical

principles models with built-in density of states distributions such as exponential and double Gaussian, the Poole-Frenkel (PF) electric field dependent mobility model, and others Bimolecular Langevin models, as well as steady state and transient recombination models. The recombination model is a mathematical representation of the process of recombination Silvaco's overall structure is seen in figure 3.1. TCDA software is a platform that combines a number of different tools into one. Atlas is a silicon device simulator that can also be used to simulate organic devices.

This simulates the properties of many single gate and dual gate OTFT devices as well as the performance of circuit designs based on these devices. For the simulations of organic devices, the Poole-Frenkel and Gaussian distributions for the traps are used. The morphology of organic materials is not directly addressed by models. In the equations, the zero-field mobility (μ_0) [25] term reflects the reliance of the effect of the grain size of organic materials and operation temperature on the conduction device. In figure 3.2 the major heads of an Atlas code are depicted graphically.

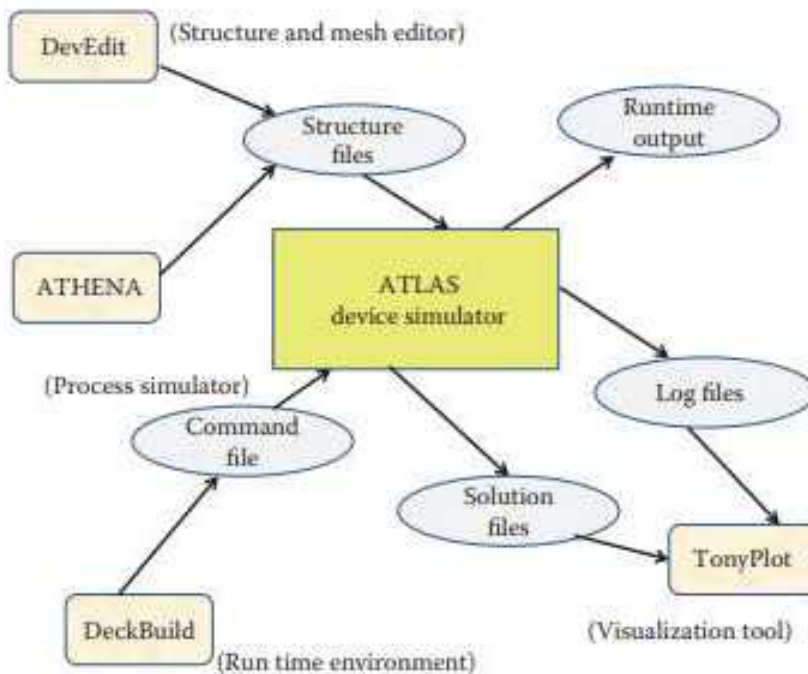


Figure 3.1 Flow chart of functioning among various tools of two-dimensional device organic module simulation.

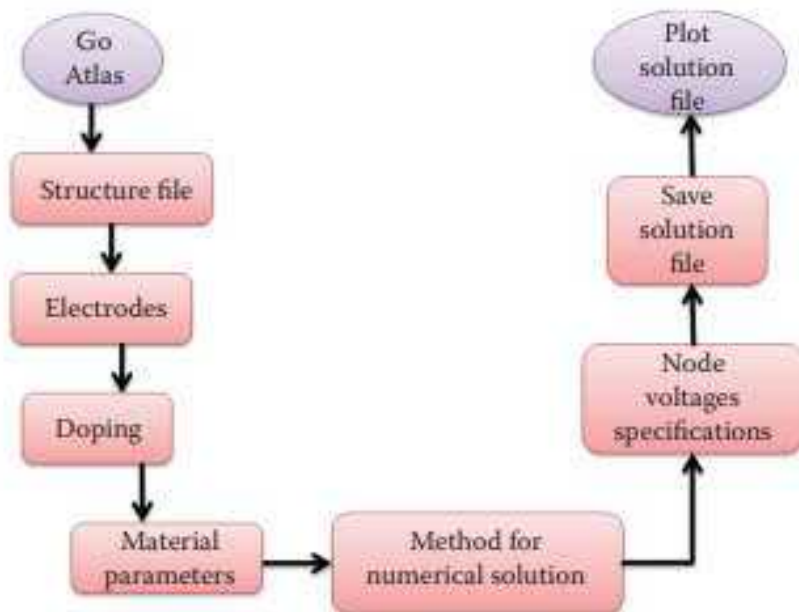


Figure 3.2 Flow chart of functioning among various steps of two- dimensional device organic module simulators

3.2 DEVICE SEMULATION STEPS

In general, the simulation domain is defined by converting the structure into a grid of finite elements to explore the behaviour of an organic/inorganic device. Based on the gadget, a set of discrete basic equations, each point of the simulation domain is subjected to physics, and the solution is carried out by the computer. The behaviour of the device under inquiry is determined using a simulator. Atlas pentacene, for example, is a widely used organic substance, and the simulator has a library of it. CuPc and tetracene aside from that, it allows users to add their own content materials that have been defined the Atlas simulation code can be separated into two parts. (1) Identifying structural dimensions and mesh requirements, (2) Identifying material properties, and (3) applying the suitable material operational models and physical models.

3.2.1 DEFINING STRUCTUREL DIMENSIONS AND MESH SPECIFICATION

The dimensions of the different layers, as well as the placement of electrodes, are defined in the first section. The insulator and active organic material layers have been established. In the TC structure, the source/drain (S/D) contacts are at the contacts in the BC structure are placed before the OSC, whereas the contacts in the BC structure are placed first layer. After defined all of the TFT layers with the

correct dimensions and properties, we may move on to the next step. Individual simulation domains are divided into a finite element grid for materials simulations. Mesh is a complicated grid of triangles in a form known as mesh. During these specific times, the model includes calculations based on fundamental device physics equations relating to the electric field, electric potentials, and charge carrier densities at grid sites. The density of the data affects the accuracy of simulation results mesh, with higher density mesh necessary at certain areas such as junctions or interfaces between different materials.

Example 3.1

```
# title Organic Thin Film Transistor Simulation atlas
#
width=100 mesh smooth=1 space.mult=1.0
#
x.m
l=0
spac=0.5
x.m
spac=0.5, l=10
x.m
spac=0.5 l=20
x.m
spac=0.5 l=30 l=30
#
y.mesh l=-0.030 spacing=0.005 y.mesh l=-0.030
y.mesh l=0.0 spacing=0.005 y.mesh l=0.0
y.mesh l=0.03 spacing=0.005 y.mesh l=0.03 spacing=0.005 y.mesh l
y.mesh l=0.0357 spacing=0.01 y.mesh l=0.0357 spacing=0.01 y.mesh l
y.mesh l=0.0557 spacing=0.01 y.mesh l=0.0557 spacing=0.01 y.mesh l
#
number of regions=1 y.min=0.0 y.max=0.030 y.material=Pentacene
name=Pentacene
2nd region y.min=0.030 y.max=0.0357 material=Al2O3 y.min=0.030 y.max=0.0357
3rd region y.min=-0.030 y.max=0.0
x.minimum=10, maximum=20
#
elec num=1 elec num=2 elec num=3 x.max=10.0 y.min=0.0 material=Gold name=source x.max=10.0
y.min=0.0
max=0.030 -0.030 -0.030 -0.030 -0.030
elec num=2 elec num=1 elec num=2 name=gate material=alum y.min=0.0357
y.max=0.0557
```

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3.2.2 DEFINING MATERIAL PARAMETERS AND APPLICATION OF THE APPROPRIATE PHYSICAL MODELS

The physical models used to anticipate results with suitable boundary conditions are described in the simulator's second part. Poole-Frenkel mobility model to assess the static and dynamic behaviour of the device. The circuit and device this mobility model is written as follows [25,26].

$$\mu = \mu_0 \exp \left[-\frac{\Delta h}{k_B T} + \left(\frac{\beta h}{k_B T} - \gamma \right) \sqrt{E} \right]$$

where, E represents the electric field.

Example 3.2

```
# Physical models for mobility and faults cont dfile=l5don.dat afile=l5acc.dat afile=l5acc.dat afile=l5acc.dat  
afile=l5acc.dat afile=l5acc.dat afile=l
```

```
nta=2.5e18 ntd=1.0e18 wta=0.129 wtd=0.5 nta=2.5e18 ntd=1.0e18 wta=0.129 wtd=0.5
```

```
nga=0.0 ngd=0.0 ega=0.62 egd=0.78 wga=0.15 wgd=0.15 wga=0.15 wgd=0.15 wga=0.15 wgd=0.15 wga=0.15  
wgd=0.15 wga=
```

```
sigtae=1.e-17 sigtde=1.e-15 sigtdh=1.e-17 sigtah=1.e-15 sigtde=1.e-15 sigtdh=1.e-17
```

```
\
```

```
siggae=2.e-16 siggah=2.e-15 siggde=2.e-15 siggdh=2.e-16
```

```
#
```

```
deltaep.pfmob=1.792e-2 betap.pfmob=7.758e-5 mobility
```

```
pfmob.p print model
```

```
#
```

```
e.field j.electron j.hole j.conduc j.total output
```

```
e.velocity h.velocity e.velocity h.velocity e.velocity
```

```
e.mobility e.field flowlines h.mobility qss e.temp qss e.temp qss e.
```

```
h.charge temperature
```

```
j.disp photogen impact recomb val.band con.band qfn qfp recomb val.band con.band qfn qfp recomb val.band  
con.band qfn
```

```
u.rad tot.doping tot.doping tot.doping tot.doping tot.doping tot.doping to
```

```
#
```

```
# Create a file to save the structure.
```

```
outf=hagen.str
```

```
hagen.str. tonyplot tonyplot tonyplot tonyplot tonyplo
```

3.2.3 OPERATIONAL BIAS CONDITION AND RUN SIMULATION

The Atlas code third portion establishes the simulation's operating bias conditions, such as V_{gs} and V_{ds} , in order to acquire the device's electrical properties.

Production and
Modeling of
Organic Thin
Film Transistor

Example 3.3

```
# Characteristics of Transfer (Ids vs Vgs) # init # init # init # init # init # init # init #  
maxtrap=100 carriers=1 hole technique
```

```
vdrain=-1.5
```

```
outf=idvg.log log outf=idvg.log log outf=idvg
```

```
solve name=gate vgate=0.0 vstep=-0.2 vfinal=-3.0 vgate=0.0 vstep=-0.2 vfinal=-3.0
```

```
log out
```

```
Idvg.log tonyplot
```

```
# Characteristics of the Final Product (Ids vs Vds) Biasing
```

```
Initiate the solution
```

```
#
```

```
solve the previous
```

```
solve vgate=-0.0 name=gate outf=vg-0.0.bin onefile vgate=-0.0 name=gate  
outf=vg-0.0.bin
```

```
onefile vgate=-1.5 name=gate outf=vg-1.5.bin vgate=-1.5 name=gate outf=vg-  
1.5.bin vgate=-1.5 name=gate outf
```

```
onefile vgate=-1.8 name=gate outf=vg-1.8.bin vgate=-1.8 name=gate vgate=-1.8  
name=gate vgate=-1.8 name=gate vgate=
```

```
vg-0.0.bin infile=load
```

```
prioritise
```

```
logging outf=vg-0.0mpfhm.log logging outf=vg-0.0mpfhm.log logging outf=
```

```
vdrain=0.0 vstep=-0.05 vfinal=-0.5 name=drain solve vdrain=0.0 vstep=-0.05  
vfinal=-0.5
```

```
solve name=drain vdrain=-0.5 vstep=-0.5 vfinal=-3.0 vdrain=-0.5 vstep=-0.5  
vfinal=-3.0 vfinal=-3.0 vfinal=-3
```

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```
exit the application
#
vg-1.5.bin infile=load

prioritise

logging outf=vg-1.5mpfhm.log logging inf=vg-1.5mpfhm.log logging inf=
vdrain=0.0 vstep=-0.05 vfinal=-0.5 name=drain solve vdrain=0.0 vstep=-0.05
vfinal=-0.5

solve name=drain vdrain=-0.5 vstep=-0.5 vfinal=-3.0 vdrain=-0.5 vstep=-0.5
vfinal=-3.0 vfinal=-3.0 vfinal=-3

exit the application

#

vg-1.8.bin infile=load

prioritise

logging outf=vg-1.8mpfhm.log logging inf=vg-1.8mpfhm.log logging inf=
vdrain=0.0 vstep=-0.05 vfinal=-0.5 name=drain solve vdrain=0.0 vstep=-0.05
vfinal=-0.5

solve name=drain vdrain=-0.5 vstep=-0.5 vfinal=-3.0 vdrain=-0.5 vstep=-0.5
vfinal=-3.0 vfinal=-3.0 vfinal=-3

exit the application

# Make a graph of your simulation findings.

vg-0.0mpfhm.log tonyplot tonyplot tonyplot tonyplot tonyplot tonne -vg-
1.5mpfhm.log -overlay

vg-1.8mpfhm.log

quit
```

3.3 PERFORMANCE PARAMETER EXTRACTION

To compare transistor performance, electrical parameters are measured. The SG-OTFT parameters can be derived from the transfer characteristics accumulation and depletion zones. Mobility, threshold voltage (V_{th}), sub-threshold slope (SS), and on-off current ratio are the metrics collected, (I_{On}/I_{Off}) as well as trans-conductance (gm) performance metrics and gathered. Using conventional equations to drive the slope of the transfer characteristics OTFT parameters are produced, owing to the similarity in their operations and features, ion is a kind of ion. I_{off} is the leakage current at $V_{gs}=0$ V and the maximum value of V_{ds} voltage, whereas I_{max} is the maximum saturation current at given V_{gs} . V_{th} is a voltage that is used to determine whether something is safe or note, derived from the transfer characteristics at the highest value of current's incline. The weak inversion regime of the transfer characteristics is used to calculate sub-threshold voltage swing SS. Individual TC and BC performance parameters are impacted by t_{osc} and t_{ox} thickness differences in depth. The subject of OTFTs is brought up.

Example 3.4

The organic module of a two-dimensional numerical device simulator is used to realize the single gate in top contact organic thin-film transistors.

- 1) Draw current flow lines for BGTC from the source (S) to the drain (D). OTFT structure at $V_{ds}=-1.5$ V and $V_{gs}=-3$ V
- 2) For the device dimensions and materials listed in table 3.1, draw the OTFTs characteristics. To begin, run the simulations. $V_{gs}=-1.5$ to -3 V, with a 0.3 V step size, for biasing voltages with a step size of 1 V and V_{ds} ranging from 0 to -3 V.
- 3) Compile a list of the TC and BC transfer characteristics ($I_{ds}-V_{gs}$). For the OTFT in logarithmic scale and the TC/Bc current ratio table 3.2 provides dimensions and materials. Simulate the drain $V_{ds}=-1.5$ v and $V_{gs}=0$ to -3 V with a 1V step size.
- 4) Using the examples of top and bottom contact OTFTs, explain how semiconductor and thickness dielectric thickness affect them simulations.

Solutions:

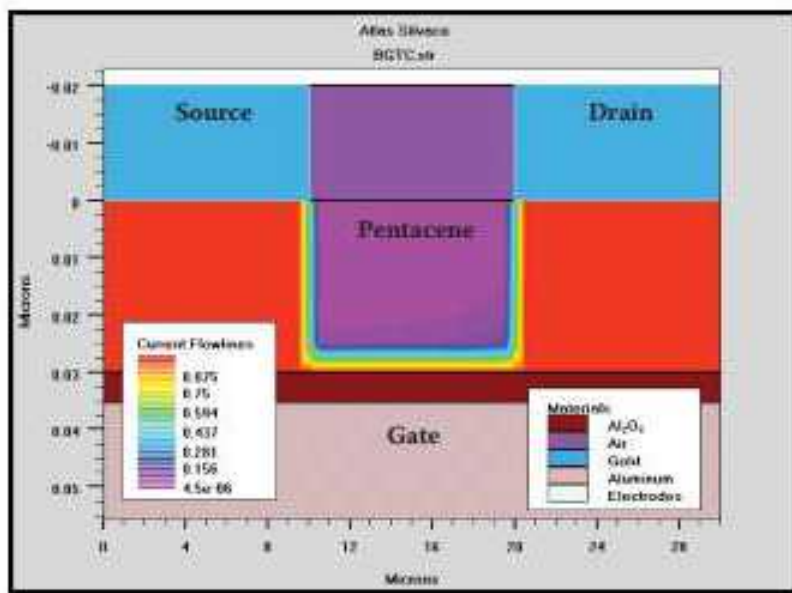
- 1) Both structures typical physical dimensions and materials table 3.1 sum the findings. Electrical quantities are first and foremost, the validity of the TC structures characteristics and parameters is confined by the information provided. Results of the experiments the structure of the BC is then investigated. Substances, dimensions, and operating conditions are all same [24]. OSC is used to make the conducting channels, for a proper comparison on a standardized platform pentacene (p-type), 10 and 100 μ m long and wide materials respectively whereas Al_2O_3 as a dielectric layer, 5.7 nm is useless.

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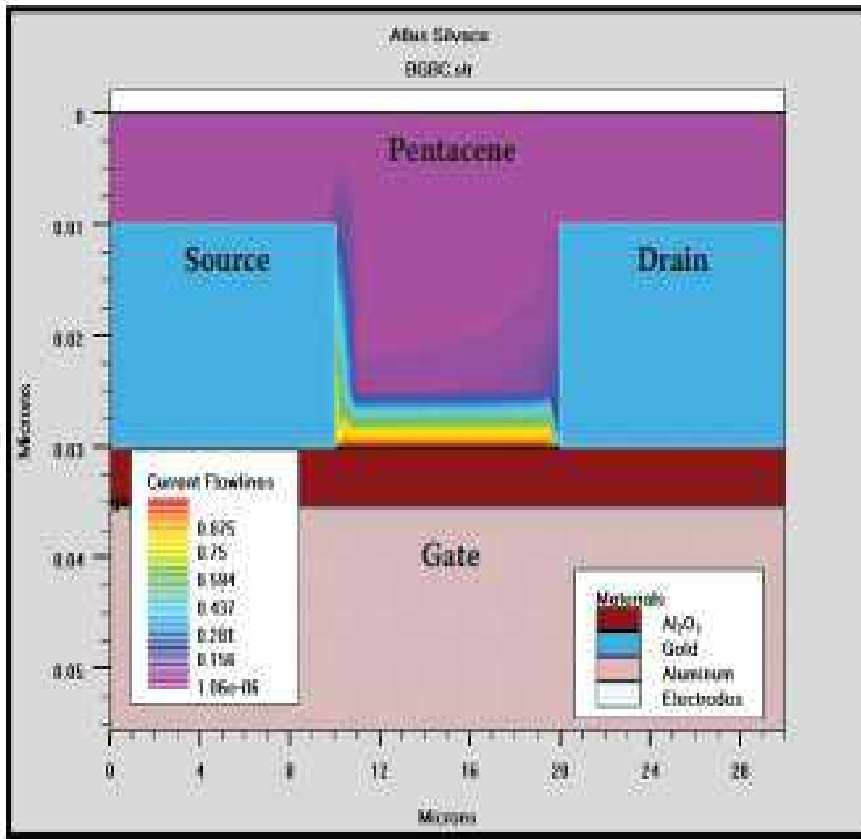
Table 3.1 Device Dimensions and Materials of TC and BC OTFTs

Dimensional Parameter	Value	Material
Channel width (W)	100 μm	—
Channel length (L)	10 μm	—
Thickness of dielectric (t_{ox})	5.7 nm	Al_2O_3
Thickness of OSC (t_{osc})	30 nm	Pentacene
Thickness of S/D contact (t_s/t_d)	20 nm	Gold
Thickness of gate electrode (t_g)	20 nm	Aluminium

A 30 nm thick film of pentacene serves as a semiconducting active layer in the other parameter of the device, as shown in figure 3.4. Field-effect mobility of up to $1\text{cm}^2/\text{Vs}$ is demonstrated by devices. The gate electrode was made of aluminum with a thickness of 20 nanometers. A 20-nanometer thick gold coating source and drain contact electrodes. Figure 3.3 demonstrates the current flow lines from S to D in top and bottom contact structures, obtained at $V_{\text{ds}} = -1.5\text{ V}$ and $V_{\text{gs}} = -3\text{ V}$.



(a)



(b)

Figure 3.3 Schematics of (a) BGTC and (b) BGBC OTFTs representing current flow lines from S to D contacts.

- 2) Figure 3.4 illustrates the solution in section 3.3.
- 3) Transfer characteristics (I_{ds} - V_{gs}) in logarithmic scale figure 3.4a shows the plots for TC and BC structures, as well as the TC/BC ratio. In this diagram, the BC current ratio is plotted against V_{gs} ($V_{ds} = -1.5V$) figure 3.5 b.
- 4) Effects of OSC and insulator thickness variations figure 3.6 through 3.9 shows the effects of t_{ox} on TC and BC structural behaviour at $V_{gs} = -3V$.

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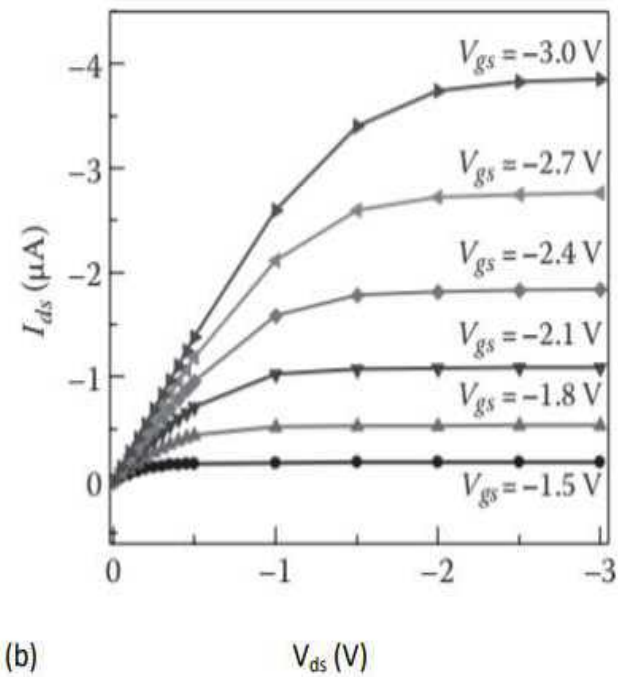
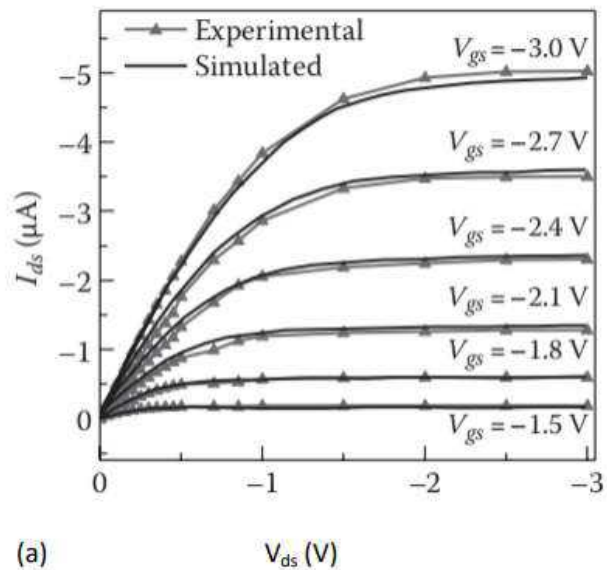


Figure 3.4 Output characteristics of (a) TC and (b) BC OTFTs

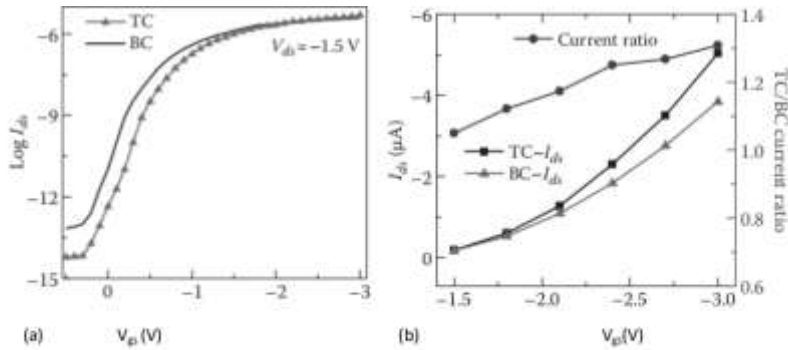


Figure 3.5 (a) I_{ds} - V_{gs} characteristics in logarithmic scale for TC and BC structures and (b) TC/BC

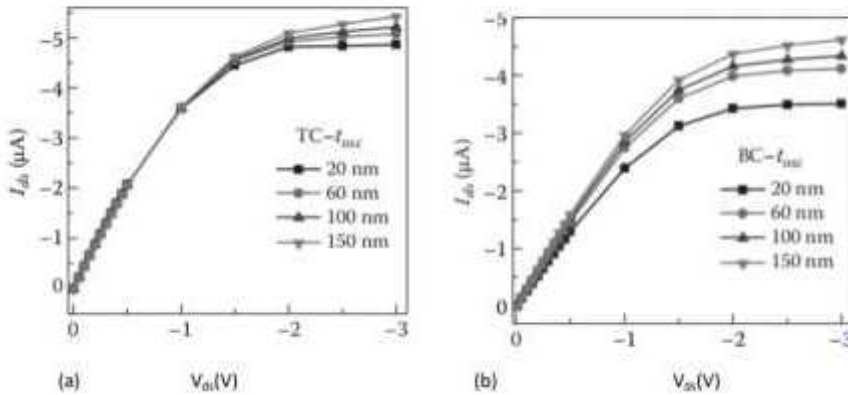


Figure 3.6 I_{ds} - V_{gs} characteristics as a function of t_{osc} for (a) TC and (b) BC structures at $V_{gs} = -3$

3.4 CONCLUDING REMARKS

This chapter focuses on top and bottom contact OTFTs with semiconductor and dielectric thickness ranging from 20 to 150 nanometers. The outcomes show that the TC structure is more mobile than other structures. OSC and dielectric films that are thinner show this phenomenon. It's worth noting that there's a big difference in mobility and V_t . V_t is observed to be higher for t_{ox} variation when compared to t_{osc} . When t_{ox} is increased from 20 to 40, both TC and BC structures are 2 times greater. However, a 20% and 80% decrease in V_t is observed for TC and BC structures. Furthermore, with increased t_{osc} , an increase in trap states occurs, resulting in a 14-fold rise in SS, limiting switching behaviour. Furthermore, the findings indicate that structural differences are significant in prediction outcomes.

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the performance of a company, the thickness of the semiconducting and dielectric layers determines the thickness of the OTFTs. Because of the low-cost printing methods that may be used to make flexible displays, it is recommended. The performance of the OTFT must be significantly improved. Integrated circuits are another example of OSC and dielectric thickness scaling at their optimum one of the most important regulating parameters for device performance development and usable in high-end applications is OSC and dielectric thickness scaling at the perfect thickness.

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Simulation of Tandem Si Perovskite Solar Cells Using GPVDM Software

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Introduction

In this era, where we come up with tons of challenges, one of the most crucial among those is finding better energy providing solutions. And renewable sources of energy are in trend and has always been a choice. Solar Power is one such source that is used for a variety of reasons around the world. Solar energy is captured using solar cells, which are then converted into electrical energy for usage in homes, businesses, and public lighting.

Though Photovoltaic energy (PV) production is little in scale, its rapidly growing demand, innovation and production as we are in verge to lack our primary fuel source i.e. Fossil Fuel based energy which is depleting day by day.

Its not been that long since when people started considering Solar energy as one of the most crucial and important source of energy. Where its availability is immense in nature, extraction of it indeed difficult.

We started developing solar cells some century back. There are many types of solar cells and solar cell materials have undergone several hit and try processes in production as great amount of research have found more efficient and feasible materials for the use in different types of solar cells. In research, the most frequently used materials are GaAs i.e. Gallium Arsenide and Silicon based solar cells which have proven to be the best in industrial applications.

However, Innovation is the key to the progress and hence research of new material called Tandem Si Perovskite, which is new ray of hope have opened up to enhance Photovoltaic cells (PV) cells further.

Tandem cells are stacks of p-n junctions, each made up of a different bandgap energy semiconductor. Each one reacts to a particular part of the solar spectrum, resulting in increased overall efficiency. The component cells are stacked in decreasing bandgap order. Each cell harvests photons that surpass its bandgap, and the light is automatically filtered.

On the other hand, Perovskite is a mineral named after Lev Perovski, the founder of the Russian Geographical Society. It is found in the Ural Mountains. The mineral has a perovskite structure, with an ABX₃ lattice. The lattice structure is shown by the molecular cation (positively charged) A in the centre of a cube, while cations B occupy the corners and anions (negatively charged) X occupy the faces.

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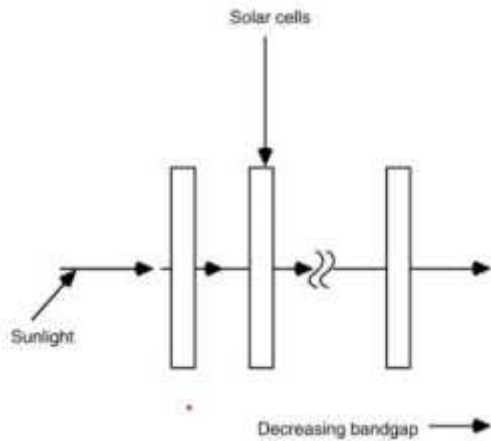


Fig 1. Arrangement of bandgaps in tandem cells

The features of perovskite can be modified by changing the atoms or molecules in the structure, such as superconductivity, enormous magnetoresistance, spin-dependent transport, and catalytic capabilities.

The comparison of power conversion efficiencies of Perovskite Tandem based devices to emerging PV research technology and classic thin-film PVs over the previous decade explains the growth in interest for Perovskite solar cells.

The graph shows how rapidly efficiency % of different materials has improved with time. It has been observed that the performance has enhanced and gradually increased with passing years.

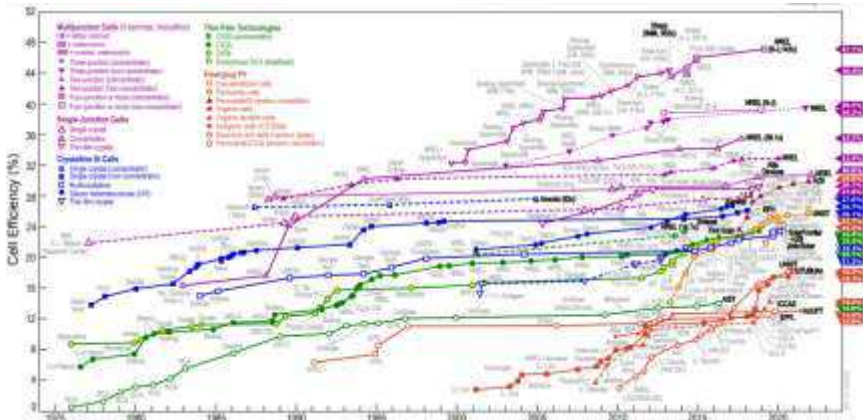


Fig 2. Power conversion efficiency by year for different materials

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When it comes to the fact, the Solar cell efficiency is the amount of energy in the form of a sunlight that can be converted into photovoltaics into electricity by the solar cell. The annual energy output of a photovoltaic system is determined by the efficiency of the solar cells employed in the system, as well as latitude and climate.

Perovskite solar cells frequently exceed 70% photon energy utilization and have the potential to become cheaper than crystalline silicon solar cells, which are presently 1000 times cheaper than GaAs solar cells. Perovskites have been around for more than a decade, but researchers have only recently recognized them to be useful. Perovskite cells have been shown in recent investigations to have an efficiency of more than 23%.

Solar Cells

Solar cells, often known as PV cells, are devices that use the photovoltaic effect to convert photon energy (light energy) into electrical energy. Solar cells are often constructed of silicon or gallium arsenide (GaAs). The efficiency and prices drop as the materials progress from amorphous (non-crystalline) to polycrystalline to crystalline silicon.

Solar cells commonly referred to as solar cell panels or simply solar panels.

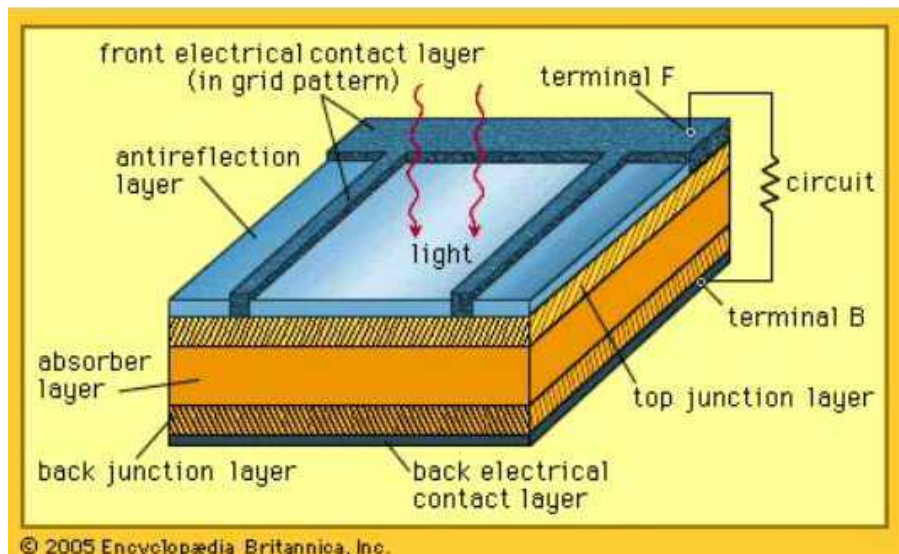


Fig 3. Solar Cell Structure

Solar panels are especially useful in situations where electric power is required in distant terrestrial locations where traditional power sources are unavailable or too expensive to install.

Solar panels are a preferred power source for most space facilities due to their capacity to operate in the absence of fuel (communications and weather satellites, space stations, rovers).

Solar Cell: Operation and Structure

The maximum voltage a solar cell can produce when lighted is known as the open-circuit voltage (V_{oc}). When a cell is lit, the highest current it may produce is known as the short-circuit current (J_{sc}). When a cell is lit, its efficiency (η) is the greatest current it can produce.

To reduce reflection losses, light enters the device through an antireflection layer and is directed to the energy-conversion layers beneath it. The front contact, absorber or active layer, and back contact are the most common energy-conversion layers. Other layers, such as buffer layers, can be found within the absorber region of solar cells. The electric current is carried out to an external load by the contact layers. In most cases, the front contact is arranged in a grid. The conductivity of both contact layers is excellent. Metal is used for the back contact. The interaction of photons with the active layer of the cell is what makes solar cells work. Photons are converted into electrons and holes by the active layer, which is a layer of material. For efficient device operation, a thickness of 50 nm for an organic solar cell is regarded extremely thin, whereas 400 nm is considered very thick.

The wavelengths of the sun's light range from ultraviolet (UV) through visible light (VL) or infrared (IR) (IR). The human eye can only see wavelengths in the VL range. Some layers in solar cells absorb light, while others conduct charge carriers out of the cell. Semiconductors are the finest at absorbing VL. The absorber material in a solar cell takes up the majority of the space. Electrons in the absorber layer are excited from a lower energy "ground state" to a higher energy "excited state" when light strikes the solar cell.

The electrons become free to move through the solid after being attached to the atoms. Holes arise when electrons are not present in their original place.

As a result, electrons and holes serve as the device's charge carriers.

Contact layers are used to control current flow via the charge carriers, resulting in an electric field that produces the photovoltaic effect. Because an extremely thin device can't absorb enough photons, it can't reach higher efficiency. To gain greater efficiency, an extremely thick device can theoretically absorb all photons incident on it from the sun.

The longer electrons and holes must travel from the source of generation to the contact layers where they exit the device to conduct beneficial work in the external circuit, the thicker the device becomes.

This will prolong the electrons or holes stay in the device after photogeneration, making it more likely that an electron would collide with a hole, or vice versa, annihilating each other's opposite charges and causing them to be destroyed instantly. Recombination is the term for this phenomenon. Recombination reduces efficiency because some photon energy is squandered in the process as electrons or holes. Recombination is the term for this phenomenon.

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Recombination reduces efficiency because some photon energy is squandered in the process as electrons or holes.

The recombination rate (R) is calculated as follows:

$$R(x) = kn(x)p(x)$$

Where,

$n(x)$ is at any particular place in the device, the density of electrons

$p(x)$ is the density of holes at any given point in the device

k is the recombination constant

The effectiveness of the recombination process is determined by the recombination constant.

There is no recombination if k is equal to zero.

In the **GPVDM**, n_{free} to p_{free} recombination constant, which is commonly set to $1e-20$, denotes this. Charge carriers must spend as little time in the device as feasible to avoid recombination, and they must proceed quickly towards the contacts to reach the external circuit. The electron and hole charge carrier mobility determines the speed at which electrons and holes move within a device.

Mobility (μ) is the time taken by a charge carrier to exit the device after being generated. The average mobility for a device is given by:

$$\mu_{\text{average}} = \frac{(\mu_e + \mu_h)}{2}$$

μ_e is the electron mobility

μ_h is the hole mobility

μ_{average} is the average mobility

Solar cells are diodes in appearance; however, they are not ideal diodes. They have both series (R_s) and shunt resistance (R_{shunt}) in reality.

Due to the flat broad contacts on the solar cell, there is often a capacitance associated with the device. The series resistance accounts for the resistance of the contacts.

The contaminants in the active layer that cause short circuits between the front and rear contacts are referred to as shunt resistance. The solar cell will not work if R_{shunt} equals zero, i.e. it is fully shorted. The solar cell would operate better if R_{shunt} is really large (say $1 \text{ M}\Omega$).

Tandem Solar Cells

Splitting the spectrum and employing a solar cell that is optimized for each portion of the spectrum is one way to improve the efficiency of solar cells. A tandem solar cell can be used to achieve this. Individual cells or series of cells can be used to create such cells.

By connecting many devices in series to form a tandem cell, each device's spectrum can be narrowed, resulting in improved overall efficiency. They're a lot less difficult to make. However, because each cell has the same current flowing through it, the band gaps inside the device are confined. Growing tandem cells monolithically is the most typical preparation method. This configuration assures that all of the cells grow as layers on the substrate, with tunnel junctions connecting them.

Simulation of
Tandem Si
Perovskite Solar
Cells Using
GPVDM Software

Perovskite Si Tandem Solar Cells

The outstanding and successful integration of a perovskite cell with a silicon cell to create a tandem solar device has demonstrated significant potential for exceeding current single junction silicon devices. Perovskites with an adjustable bandgap offer a compelling prospect to develop perovskite-silicon tandem solar cells with enormous potential for exceeding each subcell's intrinsic power conversion efficiency (PCE).

It is a new generation of solar cells which is currently under research for sustainable power generation. It has outstanding photovoltaic properties including broad absorption range in visible light spectrum, highly impactful power of absorption of light and great electrical properties. In recent days of its appearance, the efficiency of a cell was as low as 4%. But there's something promising about this solar cell that leads to the great development in recent years and found ways to improve it. And currently, the cell efficiency is about 28.2%.

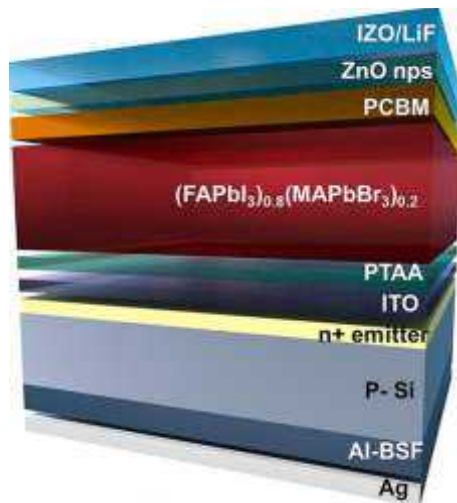


Fig 4. Structure of Perovskite Si Tandem Solar Cell

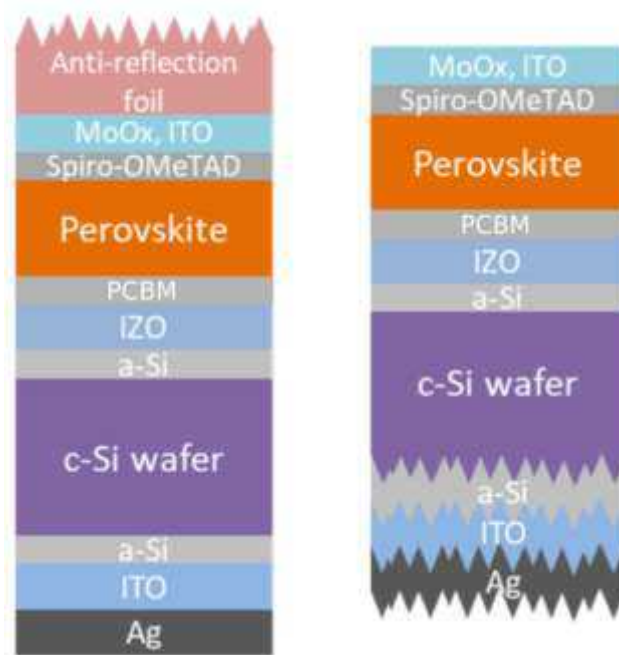


Fig 5. C - rear-side textured silicon tandem with a flat interface to the perovskite, and planar cell with textured anti-reflection foil on the front contact

The efficiency of solar cell depends of various factors. A few are listed below:

The annual energy output of a photovoltaic system is determined by the efficiency of the solar cells employed in the system, in combination with latitude and climate. *Reflectance, thermodynamic efficiency, charge carrier separation efficiency, charge carrier collecting efficiency, and conduction efficiency* values are all elements that influence a cell's conversion efficiency. Other characteristics, such as quantum efficiency, open-circuit voltage (VOC) ratio, and Fill factor, are assessed instead because these parameters are difficult to monitor directly. Because reflection losses affect "external quantum efficiency," the quantum efficiency value accounts for them.

Quantum efficiency, VOC ratio, and fill factor metrics are used to account for recombination losses. The fill factor value accounts for the majority of resistive losses, but they also contribute to the quantum efficiency and VOC ratio values.

- **Infinite-stack limit and thermodynamic efficiency limit:** The voltages need to be reduced to less than 97% of the band gap (the percentage is not constant over all the cells). Using incoming focused solar radiation, the greatest theoretical efficiency determined is 85.8% for an infinite number of cells.

- **Ultimate efficiency:** When a photon with a higher energy is absorbed, the excess energy above the band gap is transferred to the carrier combination's kinetic energy. As the kinetic energy of the carriers slows to equilibrium velocity, the surplus kinetic energy is transformed to heat via phonon interactions. The greatest theoretical efficiency of traditional single-junction cells with an appropriate band gap for the solar spectrum is 33.16 percent, or the **Shockley–Queisser** limit. Solar cells with various band gap absorber materials increase efficiency by breaking the solar spectrum into smaller bins, each with a greater thermodynamic efficiency limit.

- **Quantum Efficiency:** When a cell is operated under short circuit conditions, quantum efficiency refers to the percentage of photons converted to electric current (collected carriers). Optical losses such as transmission and reflection are included in the "external" quantum efficiency of a silicon solar cell. A spectrum measurement is the most useful way to express quantum efficiency. Because some wavelengths are more effectively absorbed than others, spectral studies of quantum efficiency can provide useful information on the quality of semiconductor bulk and surfaces.

- **Fill Factor:** The fill factor is another key element in the overall behavior of a solar cell (FF). This factor is a measure of a solar cell's quality. This is the available power divided by the open circuit (VOC) and the short circuit current (ISC) at the maximum power point (Pm):

$$\text{Fill Factor} = \frac{P_m}{V_{\text{Open Circuit}} + I_{\text{Short Circuit}}} = \frac{\eta \times A_c \times G}{V_{\text{Open Circuit}} + I_{\text{Short Circuit}}}$$

The fill factor ranges from 53 to 84 percent. A typical silicon PV cell has an 82 percent fill factor.

Technical Methods that improve efficiency:

- **Selecting better Transparent Conductor:** The objective is to use films with high transmittance and electrical conductance, such as indium tin oxide, conducting polymers, or conducting nanowire networks.
- **Increasing the visible spectrum's light scattering:** Aluminum absorbs only ultraviolet light and reflects both visible and infrared light, resulting in minimal energy loss. Aluminum can boost cell efficiency by up to 23%
- **Radiative cooling:** Arise of about 1 °C in solar cell temperature results in a 0.48 percent reduction in efficiency. To avoid this, solar panels might be coated with a transparent silica crystal layer. The silica layer functions as a thermal black body, radiating heat into space as infrared radiation and cooling the cell by up to 15 degrees Celsius.

- **Coatings and textures that are anti-reflective:** Antireflective coatings may cause greater harmful interference with incident solar light waves. As a result, the photovoltaic would receive 99% of the sunshine. Another way for reducing reflection is texturizing, which involves changing the surface of a solar cell such that reflected light strikes it again.
- **Passivation of the rear surface:** The CIGS absorber is electrically connected to the back electrode Molybdenum via nanoscale point contacts on the Al₂O₃ layer and line contacts on the SiO₂ layer. E-beam lithography is used to make point contacts on the Al₂O₃ layer, while photolithography is used to create line contacts on the SiO₂ layer. In contrast, the passivation layers have no effect on the morphology of the CIGS layers.

Literature Review

Researchers have been working on the increasing the efficiency of solar cell since long. Advancement in harvesting solar energies is still a challenge. Although the solar energy from the sun comes in great amount, we rather end up harvesting few of the total sum. In the last five decades, the innovations in solar cells has gradually increased.

Perovskite, Tandem and Perovskite Si Tandem solar Cells are appreciably innovated in last few decades. In the research by Meillaud et al. [1] Tandem solar cells are particularly appealing for thin-film silicon technology since they allow for the bypassing of practical efficiency restrictions as well as the reduction of degradation effects. According on the data, efficiency limits for tandem solar cells were calculated using the following assumptions: (a) a perfect balance between top and bottom cell current densities, and (b) the idealized situation, in which the bottom cell absorbs all of the light transmitted by the top cell.

In the following review by Ameri et al. [2] due of the photocurrent imbalance between the subcells in tandem solar cells, optical simulations are utilized to find the best device stack. In recent years, organic tandem solar cells have made significant advances [2]. There are chances to obtain power conversion efficiencies of over 10%. Despite the fact that vacuum-processed tandem solar cells have currently achieved greater record performance than solution-processed tandem solar cells, the latter has received the majority of attention. This proves the value and appeal of large-scale roll-to-roll printing of organic solar cells. Constructing high-potential materials and enhancing the stability of the intermediate layer will allow organic tandem solar cells to achieve efficiency levels higher than 15%.

Also, a review shows the study of trends in polymer tandem solar cell by Youet. al [3] that in the last five years, polymer tandem solar cell research has made significant progress, with efficiency now exceeding 10%. Polymer tandem solar cells are a promising new area for OPV technology to realize their promise of low cost and great efficiency.

The study of Perovskite Si Tandem solar cell shows that it is getting more promising in the review [4], Tandem solar cells, which combine perovskite and silicon solar cells, are intriguing possibilities for achieving power conversion efficiencies of >30% at realistic costs.

The most advance study by Marko Jostet. al[5] claims CIGS Perovskite Si Tandem solar cell to give efficiency up to 30% and more. Based on semiempirical material properties, the optimized device achieves a short-circuit current density of 19.8 mA cm² and 32 percent PCE, indicating a high optical potential. In the case of a CIGS single-junction device, the increase in energy output is more than 50%. The findings show that perovskite CIGS tandem solar cells have a lot of potential, and provides optical parameters for 30 percent PCE.

GPVDM Software

The GPVDM (General-purpose Photovoltaic Device Model) is an open-source one-dimensional or two-dimensional optoelectronic device model that can be used to mimic solar cells, LEDs, diodes, and other optoelectronic devices. It simulates by using the finite difference approach to solve drift-diffusion equations and ray tracing or the transfer matrix method to solve optical equations. It was developed by **Dr. Roderick C. I. MacKenzie** and offered to the public to encourage more Perovskites research.

The following equations are used to simulate charge transport:

- Gauss's Law:

$$\nabla \epsilon_r \epsilon_0 \cdot \nabla \varphi = q \cdot (n - p)$$
- Electron driving terms:

$$J_n = q \mu_e n \nabla E_e + q D_n \nabla n$$
- Hole driving terms:

$$J_p = q \mu_p p \nabla E_v - q D_p \nabla p$$
- Hole Continuity:

$$\nabla \cdot J_p = -q \left[R_p + T_p + \frac{\partial p_{free}}{\partial t} \right]$$
- Electron Continuity:

$$\nabla \cdot J_n = q \left[R_n + T_n + \frac{\partial n_{free}}{\partial t} \right]$$

Active, other, and contact layers are the three types of layers in GPVDM. Because the electrical model is solved over the active layers, they have their own set of 14 electrical parameters that can be tweaked to suit your needs.

The electrical contacts are defined by the contact layers, but no electrical equations are solved over them. Over the other layers, no electrical equations are solved.

Simulations

The goal of the simulation is to confirm that the results from the simulation performed using the information available in the paper will follow trend of the results in the paper, through qualitative analysis.

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 Bhatasar, R

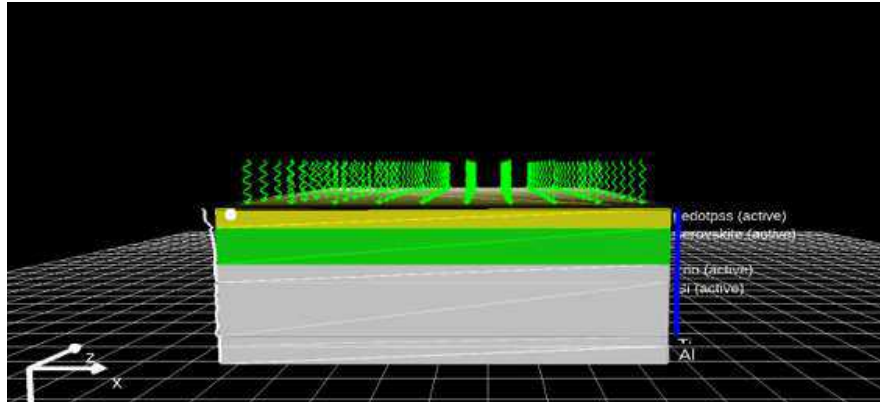


Fig 6. Structure of Tandem Si perovskite Solar Cell

Table 1: Characteristic of Layer

Layer	Thickness	Optical Material	Layer Type
ITO			Contact
PEDOT.PSS			Active
PEROVSKITE			Active
ZnO			Active
Si			Active
Ti			Other
Al			Other

Table 2: Electrical Parameter used in simulation

Electron trap density		$m^{-3} eV^{-1}$
Jsc	$-2.1559e+02$	$A m^{-2}$
vsi	$1.52789e+00$	V
Hole mobility at pmax	$1.6000000e-03$	$m^2 v^{-1} s^{-1}$
Electron mobility at pmax	$1.6000000e-03$	$m^2 v^{-1} s^{-1}$
Average carrier density at Pmax	$2.258705e+20$	$m^{-2} V^{-1} s^{-1}$
Recombination constant	inf	m^{-1}
Power conversion efficiency	16.83	%
Recombination Rate	$9.261730e+26$	$m^{-2} s^{-1}$
Trapped holes at voc	$0.0000000e+00$	m^{-2}
Trapped hole to free electron		m^{-2}
Recombination time constant	nano	s

at voc		
Voltage at max power	8.15878e-01	V
Fill factor	0.845178	a.u
Xi		eV
Eg		eV
Voc	0.924020	V
Current density at max power	-2.063772e+02	type
Average mobility	1.600000e-03	

Table 3: Parasitic Components

Shunt resistance	1.2	Ohms m2
Series resistance	1.001859e+00	Ohms
Other layers	0.0	m

Table 1 indicates the additional layers that were added to the structure, as well as their specifications. Table 2 comprises the active layer's electrical parameters, as seen in the GPVDM electrical parameter editor.

Table 03. The parasitic component parameters are highlighted, as well as the contact information.

For a Tandem Si Perovskite layer thickness of 1 mm, a simulation was done to verify the short circuit current (Jsc), open circuit voltage (Voc), and conversion efficiency found in the reference.

According to the table of simulation, the inaccuracy in Voc is within an acceptable range (around 10%), however the error in Jsc and conversion efficiency is extremely high

The following explanations can be used to explain the high Jsc mistakes and conversion efficiency:

- Because the reference paper did not provide all of the simulation parameters, some had to be assumed or the built-in parameters had to be used, such as the parasitic component and contact parameters.
- The defined doping levels for the active layers determine a lot of the solar cell's performance. Because this was not specified in the reference study, the software's default levels were used.
- The GPVDM is periodically updated. The thesis program was downloaded in 2022, whereas the reference article was published in 2021. The interface has been improved, and the database has been updated in the newer versions. On their website, they have a fresh version accessible for download. The built-in values may have been affected as a result of this.
- To completely comprehend how a solar cell-based technology works, information on the electric characteristics of thin films and their interfaces is required.

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- Cell Voc and fill factor, which may be found in the film's bulk, are determined by perovskite absorbers and carrier recombination durations, which are dictated by the density distribution of defect states in the band gap.
- The fill factor and carrier selective contact materials rely heavily on electron and hole transport properties.
- Despite this, the results suggest that the validation isn't wholly off because at least one parameter matched.
- Furthermore, the graphical results show comparable trends to those seen in the reference paper.

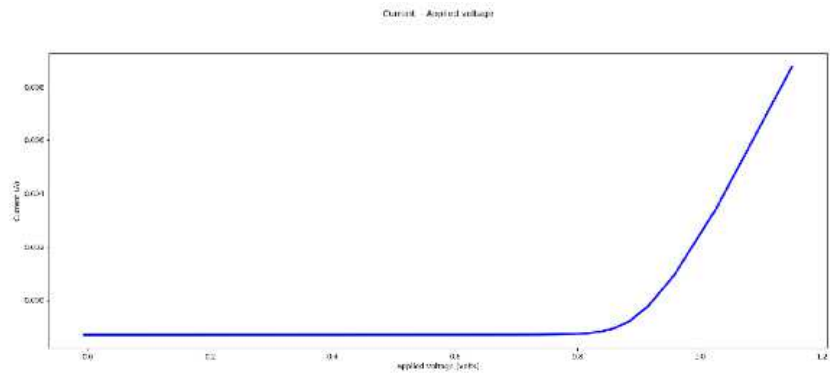


Fig 7. Current vs Applied Voltage

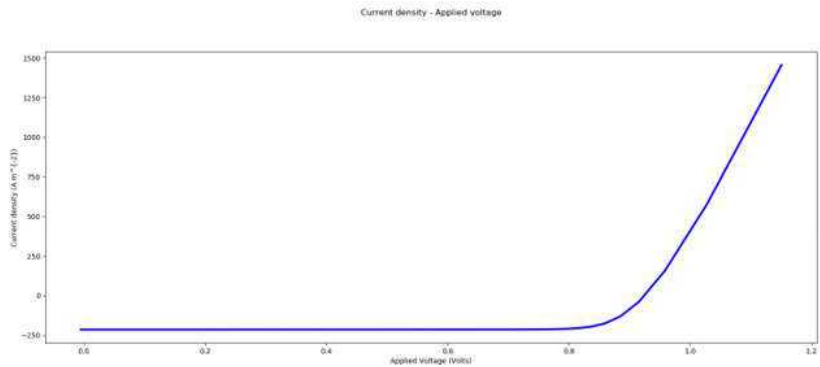


Fig 8. Current density vs Applied Voltage

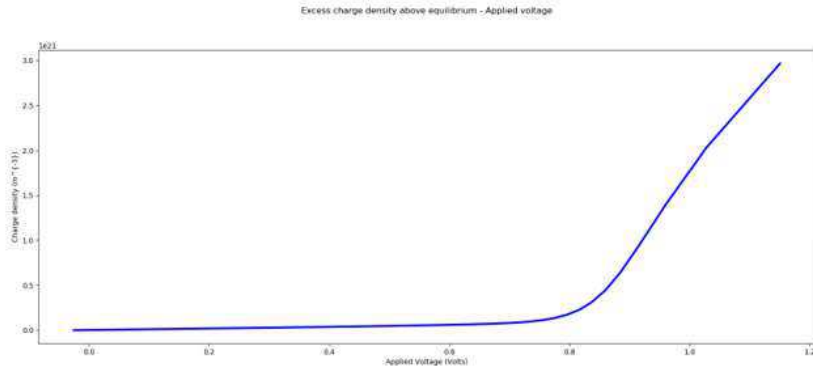


Fig 9. Excess Charge density (above equilibrium) vs Applied Voltage applied

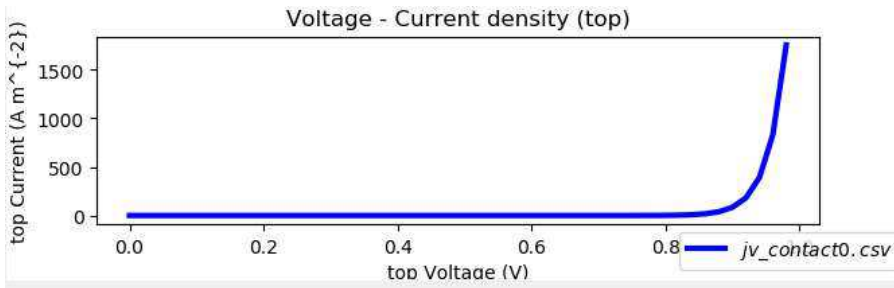


Fig 10. Voltage vs current density

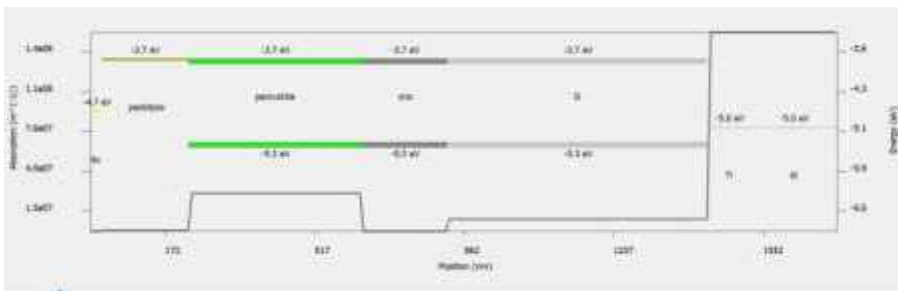


Fig 11. Generation Rate (obtained from optical simulation)

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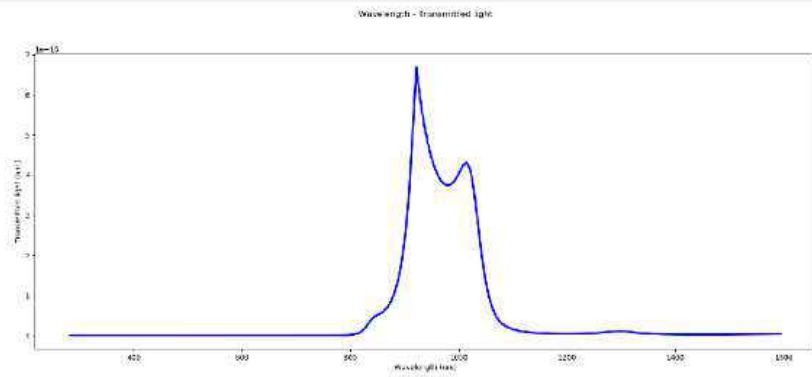


Fig 12. Wavelength vs Transmitted Light

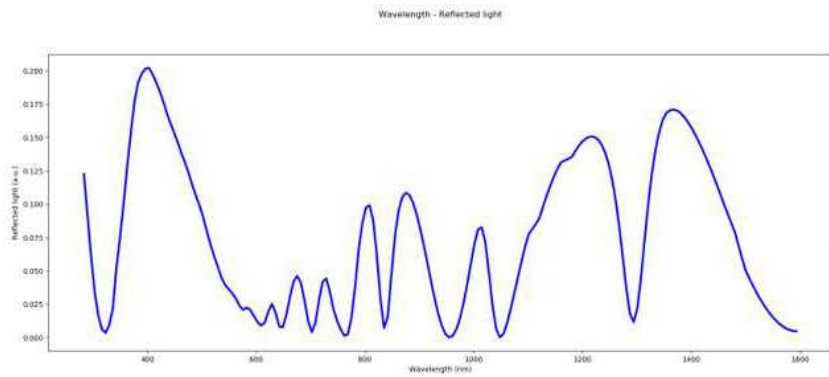


Fig 13. Wavelength vs Reflected Light

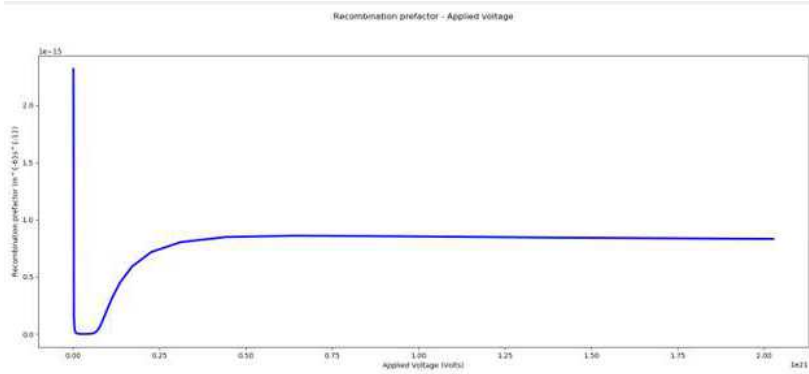


Fig 14. Recombination Pre-factor-Applied Voltage

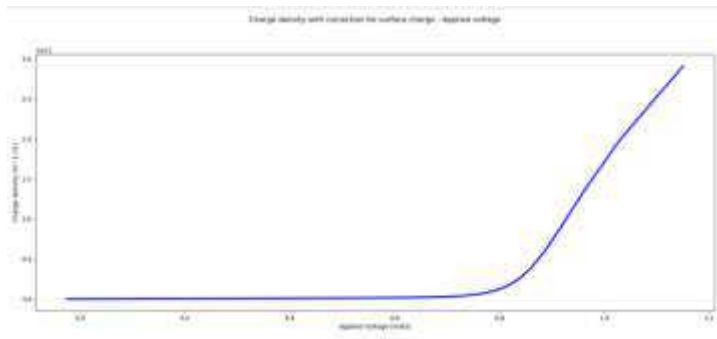


Fig 15. Charge density with correction for surface charge vs applied voltage

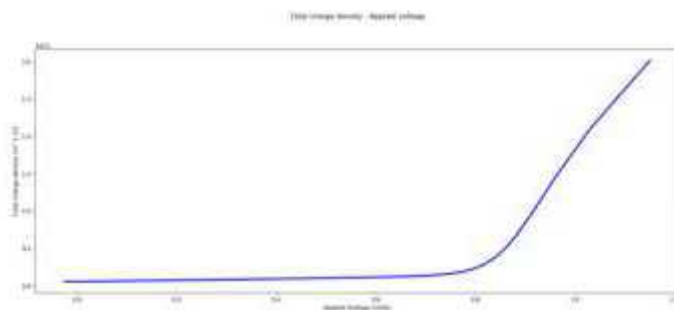


Fig. 16 Total Charge Density vs applied voltage

Result and Discussion:

The structures illustrate the layers in the models, as well as the thicknesses that were chosen and kept constant during the simulation[4].

Furthermore, the graphic depicts how the structures appear in the GPVDM interface. Incoming sunlight is indicated by the green arrows, which are similarly depicted in the previous drawings. The goal of the project, as shown in the figures, is to change the front and rear contact materials while keeping all other characteristics constant. For both cells, an initial simulation was run with Fluorinedoped Tin Oxide (FTO) as the front contact and Silver (Ag) as the back contact. For the tandem solar cell, the rest of the simulations for various contact materials were done. The back contact material was held constant with Ag. The front contact materials chosen for the study were PEDOT.PSS, Indium Tin Oxide (ITO), Silicon dioxide (SiO₂), Perovskite, Zinc Oxide (ZnO), Ag, and Aluminium (Al)[6].

The original simulation was done with the FTO in the front contact, which was then changed for further research.

The electrical parameters are GPVDM's built-in values. The thicknesses of the layers were chosen from GPVDM's built-in settings. In addition, the glass thickness was determined through trial and error in order to maximize efficiency. All simulations were done with 1.0 suns of light intensity.

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The findings of altering the front contact material in the modelled perovskite/Si tandem solar cell are summarized. The graphs in figures depict the acquired results given in the result.

They demonstrate that SiO₂ as the front contact material has the highest Voc and efficiency. For Ag and Al, the highest Jsc was achieved. ITO received the highest FF.

Due to a lack of adequate data for simulation, all findings were derived under assumed conditions and parameters. As previously stated in this paper, the software has flaws that prohibit the results from being close to true values. It's worth noting that the efficiencies discovered in this study are qualitative rather than quantitative. To ease the movement of electrons and holes out of solar cells, highly conductive front and back connections are required. The back contact is usually made of metal. As a result, Ag was employed as the back contact for this project. When simulated as a back contact, aluminium (Al) produces results similar to silver (Ag), although silver was chosen because it is the most conductive metal [7].

Furthermore, because the band gap has a direct effect on Voc, the ideal band gap is critical to the performance of a solar cell as measured by the PCE. Increasing the band gap to its optimal value improves Voc and consequently cell activity. Given this, which of the oxides performs better is largely determined by their relative band gap values. Due to its extremely large band gap value, SiO₂ performs the best. ZnO is the second most abundant mineral after SiO₂ [8].

Because the tandem cell already includes a silicon active layer, it is unnecessary to add another layer of silicon. Although it would increase efficiency, it would also increase the device's cost. The efficiency of a silicon base cell with FTO as the front contact is only around 1.48 percent, compared to 11.02 percent for a perovskite/Si tandem cell with the same front contact. This demonstrates the superiority of tandem cells. Tandem cells work by dividing the spectrum and utilizing several band gaps. In this example, the tandem silicon perovskite cell can absorb high-energy photons using perovskite on top and low-energy photons using silicon on the bottom [5].

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Nomenclatures and Abbreviations

Photovoltaic	PV
Mobility	
Efficiency	η
Power conversion efficiency	PCE
Average mobility	
Electron mobility	
Hole mobility	
Recombination time constant	
Recombination constant	
Density of electrons at any given point in the device(x)	
Density of holes at any given point in the device(x)	
Recombination rate	R
Band gap	
Fill factor	FF
Fluorine-doped tin oxide	FTO
Gallium Arsenide	GaAs
General-purpose Photovoltaic Device Model	GPVDM
Infra-red	IR
Indium tin oxide	ITO
Short-circuit current	
Current density versus applied voltage curve	J-S
Light emitting diode	LED
Free electrons	
Free Holes	
Perovskite solar cel	PSE
Photovoltaic	PV
Series resistance	
Shunt resistance	
Silicon	Si
Titanium oxide	
Ultra-violet	UV
Visible light	VL
Open-circuit voltage	
Electron affinity	
Zinc	Zn
Zinc oxide	

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