e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 10, October 2024

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Development of Dye-Sensitized Layers for Solar Cell Fabrication: A Synthesis Approach

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ABSTRACT: The development of efficient and cost-effective solar cells is crucial for advancing renewable energy technologies. This study reported the synthesis and characterization of novel dye-sensitized layers aimed at enhancing the performance of dye-sensitized solar cells (DSSCs). The synthesized dye sensitizers were designed to optimize light absorption, charge transfer efficiency and stability under operational conditions. A comprehensive analysis of the synthesized materials was performed using spectroscopic techniques such as UV-Vis and FTIR. This study provides a promising synthesis approach for the development of high-performance dye-sensitized layers, contributing to the advancement of DSSC technology.

KEYWORDS: Solar, dye, material, synthesis.

I. INTRODUCTION

Electricity is a crucial catalyst for the industrialization, urbanization and financial advancement of every nation. Various conventional and non-conventional energy sources are utilized for power generation. The increasing and destructive utilization of traditional energy sources is causing predicted energy and environmental emergencies. Solar energy is regarded as a viable option. According to a comprehensive analysis conducted by IntertechPira, the worldwide Photovoltaic (PV) market is projected to grow by 100% in the next five years, reaching a total value of US$ 48 billion. Renewable energy resources are readily available to humanity worldwide. Renewable energy is not only very accessible, but also plentiful in nature. Currently, the renewable energy sector is satisfying 13.5% of the worldwide energy demand. The renewable energy sector in India is now seeing a quicker rate of growth compared to the entire energy market. Transitioning to renewable energy sources for power generation offers advantageous management. The utilization of any form of renewable energy requires a comprehensive assessment of its sustainability, which relies on three key factors: environmental impacts, external costs and economic and financial considerations. Each of these variables significantly influences the implementation of renewable energies. Solar energy is a viable choice in the field of renewable energy resources, since it has the potential to fulfill the growing need for environmentally friendly power. The adoption of solar energy has gained popularity due to its modular and environmentally beneficial characteristics.

In a DSSC, the dye functions as a photosensitizer. Ruthenium (Ru) bipyridyl compounds are the most efficient and stable sensitizers. Despite the fact that Ru-based dyes can achieve conversion efficiencies higher than 10%, their manufacture typically involves complex and time-consuming multi-step techniques, as well as chromatographic approaches. The organic dyes commonly employed in DSSC have similarities to the dyes found in natural substances. Natural dyes are readily accessible, simple to manufacture, economical, non-toxic, environmentally benign, and completely biodegradable.

© 2024 IJMRSET | Volume 7, Issue 10, October 2024| DOI: 10.15680/IJMRSET.2024.0710055

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

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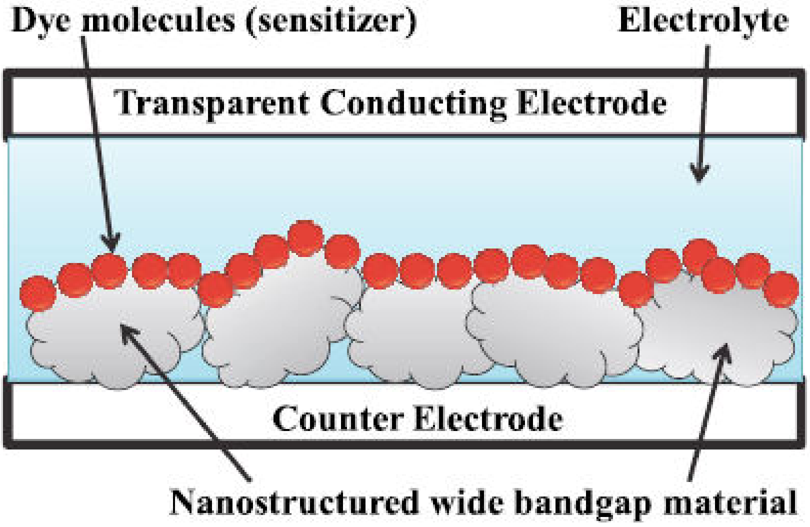
Fig 1: Structure of DSSC



Research in this field has progressed and led to the development of various materials and structures currently employed in photovoltaic technology. Extensive research has been conducted on low-cost solar cells during the past thirty years. Therefore, this study aims to synthesize dye-sensitized layers for use in DSSC. The study began with the selection of various plants known for their potent pigments: *Phyllanthus urinaria, Berberis asiatica*, and *Cassia bakeriana*. These plants were processed to extract the dyes. The plant samples were crumpled and mixed with solvents, specifically ethanol and acetone, to facilitate the extraction of pigments. The mixture was then centrifuged to separate the desired dye from the plant residues, yielding solutions rich in natural pigments.

II. EXPERIMENTAL PROCEDURE

Synthesis of Dye-Sensitizer Solutions: The required solutions of various plants pigments were obtained. All plant samples were crumpled and added to ethanol and acetone. The mixture was then centrifuged to get the required dye.

***Phyllanthus urinaria* Dye**

The genus of flowering plant Phyllanthus (L.) has more than a thousand species, many of which may be found in diverse habitats across the globe. Trees, bushes, and even certain plants belong to this genus, and they all have medicinal value due to the abundance of bioactive substances they contain have been extracted from species of the genus Phyllanthus. Interesting to notice is the hepatitis B virus inhibition effects of crude extracts from Phyllanthus species (HBV). *Phyllanthus amurus., Phyllanthus emblica L.*, and *Phyllanthus niruri L.* have all been the focus of previous reviews due to their extensive biological activity. However, *P. urinaria* has not been subjected to a comprehensive and rigorous study. Recent scientific investigations have focused on the chemical ingredients and the biological features of *P. urinaria* in order to give scientific justification for its ethnopharmacological and traditional applications.

Extract: Plant samples were cleaned well in running water, given a final rinse in distilled water to kill any bacteria, and then dried in the shade for weeks. A powerful electric blender was used to grind the plant leaves into a fine powder. Until needed, the powder was kept in sealed containers. Roughly 500 grams of the material were measured out and extracted using 90% ethanol in a Soxhlet system. The concentrate was obtained by heating the extract in a water bath to no more than 60 degrees Celsius (yield 20% w/w). The extract was dissolved in distilled water and then preserved in ethanol.

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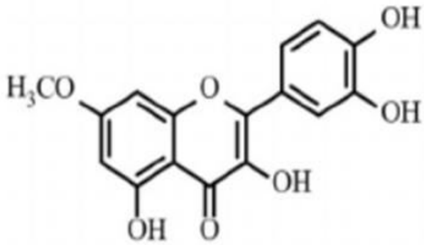
Fig 2: (a) ***Phyllanthus urinaria*** **plant and (b) its leaves (c) Quercetin 7-Methyl Ether**

(a)

(b)



(c)

Berberis asiatica **Dye**

Almost all of the planet is home to one of the over 550 species of plants in the genus Berberis (family Berberidaceae). One of the most well-known traditional remedies for diabetes is a decoction made from Berberis plant roots. Traditional usage of Berberis plants for treating metabolic illnesses (such as diabetes and hyperlipidemia) have been documented in a number of countries, including India, Pakistan, China, and Iran. Berberis species include a wide range of vitamins and minerals, in addition to a wide range of bioactive chemicals such alkaloids, polyphenols, flavonoids, anthocyanins, etc. It has been shown that the quaternary ammonium salt berberine (BBR), which is a member of the benzylisoquinoline alkaloid family, is the most active chemical known from Berberis species and has been shown to be very efficient against diabetes and other metabolic illnesses. The BBR is found in numerous plant species across many different genera. There are a variety of alkaloids in the genus Berberis, the majority of which are concentrated in the plant's roots, followed by the stem bark and the stem itself. Leaves and berries have also been shown to contain it, but at low concentrations. The use of Berberis extract or bioactive alkaloidal components in the treatment of diabetes and other MS has been the subject of many promising research. In addition, their efficacy against diabetes and other metabolic illnesses has been tested in a number of clinical studies, with mixed results. There is a need to look at the species of Berberis and the active alkaloidal components within them, with an eye on how they may help with diabetes and other metabolic illnesses. The molecular mechanism has been explored previously. In previous researches, assessments have been made based on the efficacy of Berberis species against diabetes and metabolic illnesses. This works includes research on use of *Berberis asiatica* extract for application as dye in solar cell.

Extract: Soxhlet extraction was performed using methanol as solvent after the plant material was divided into its designated component fruit air dried pulverised to reasonably fine powder. All extracts were rotary evaporated until dry

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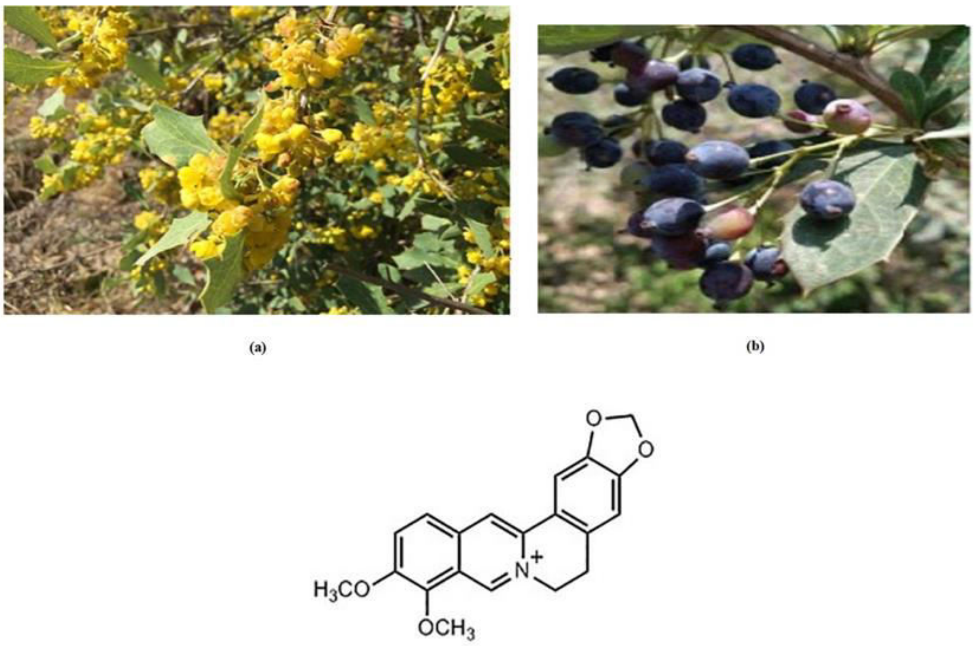
at low pressure. Following extraction, the coarse powder of fruit is air-dried before being processed again (weight of crude extract 100gm). For further analysis, we sealed the concentrated extracts.

Fig 3: (a) Berberis asiatica plant and (b) its fruits (c) Berberine



(c)

***Cassia bakeriana* Dye**

Cassia is a huge genus of tropical plants that includes around 600 different species. Many of these species have been traditionally utilised in traditional Chinese and Indian medicine. Antimicrobial, anti-inflammatory, antioxidant, anti-malarial, anti-mutagenic, and anti-fertility properties are only some of the many biological activities attributed to this genus. More attention has been paid to the development and use of natural medications containing flavonoids because of their wide range of pharmacological action and minimal toxicity. Exploring flavonoids isolated from plants of the genus Cassia for information on their structure and biological activity is an important initial step in the development of novel applications. *Cassia absus, Cassia alata, Cassia fistula*, etc., have all had flavonoids isolated and characterized in previous researches. Seeds, leaves, stems, and pods are all potential sources for flavonoids extraction. Studies into the chemical structure of these flavonoids in extracts have uncovered a wide variety of chemicals, illuminating the complexity of the Cassia genus's metabolic pathways.

Several species of Cassia have been shown to possess antidiabetic properties. Extensive research has been conducted on the effectiveness of extraction technique and action mode. The extract has been shown to lower blood sugar and increase glycogen levels. The methanolic extract has been shown to induce hypoglycemia effects in both type I and type II diabetics. This study provided the groundwork for use of extract of plant *Cassia bakeriana* as dye in solar cell.

Extract: Samples of leaves from specimens of *Cassia bakeriana* were taken. Experts were able to positively identify the plant. *C. bakeriana* leaves were baked at 40 degrees Celsius for 10 days before being dried and ground into a powder in a ball mill. Three times with two litres of ethanol 96%, the dry powder of the leaves was extracted by maceration at room temperature for seven days. Using a rotary evaporator at 40 degrees Celsius and decreased pressure, 82 grams of extractives and 68 grams of filtrate were obtained from the mixture. After being dried out, 70 g of ethanolic leaf extract (EL) was redissolved in 9 parts methanol to 1 part water (v/v) to make 250 millilitres. Hexane

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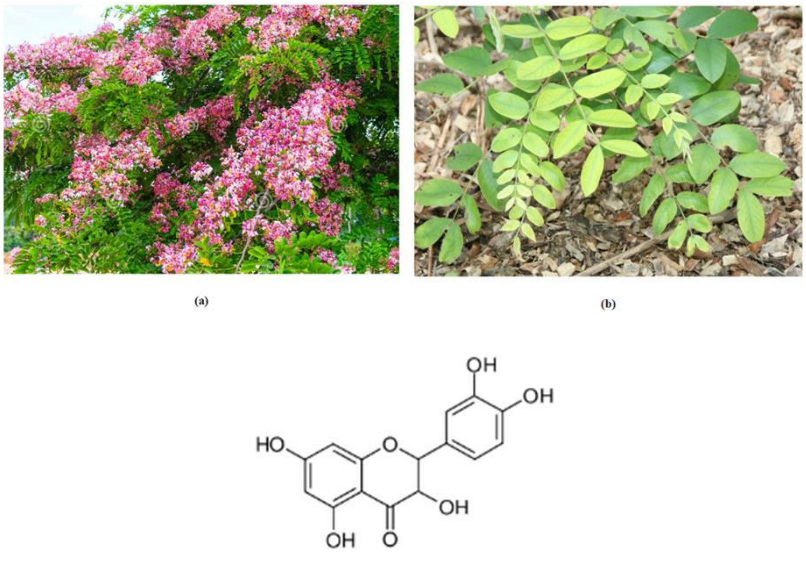
(8.07 g), dichloromethane (34.35 g), ethyl acetate (10.8 g), and methanol (14.36 g) were separated from the EL extract. The efficacy of these fractions as dye was then evaluated.

Fig 4: (a) Cassia bakeriana plant and (b) its leaves (c) Epicatechin



Characterization of Synthesized Natural Dyes: Below given figures show the FTIR and UV-vis spectra of plant based natural dye sensitizers.

Fig 5: UV-vis spectra of (a) *Phyllanthus urinaria* dye, (b) *Berberis asiatica* dye and (c) *Cassia bakeriana* dye

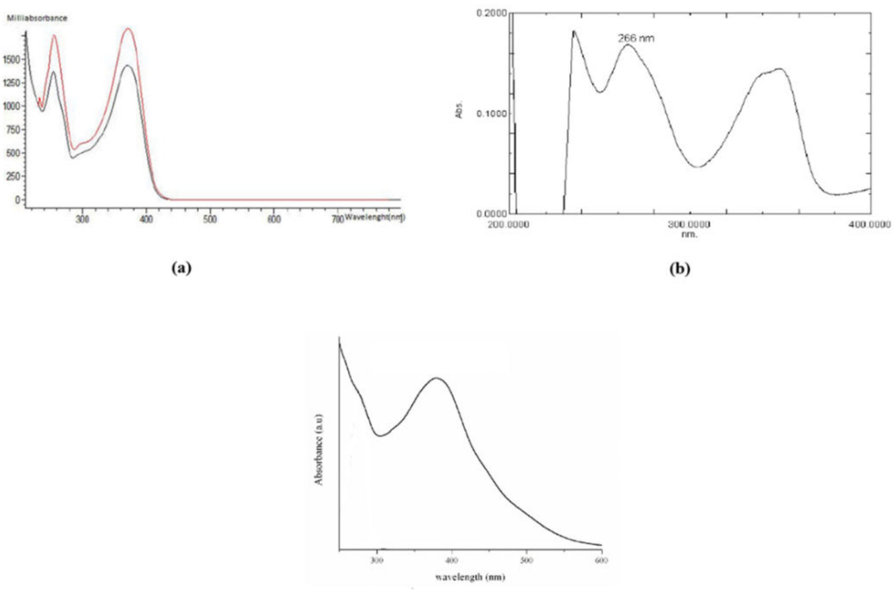


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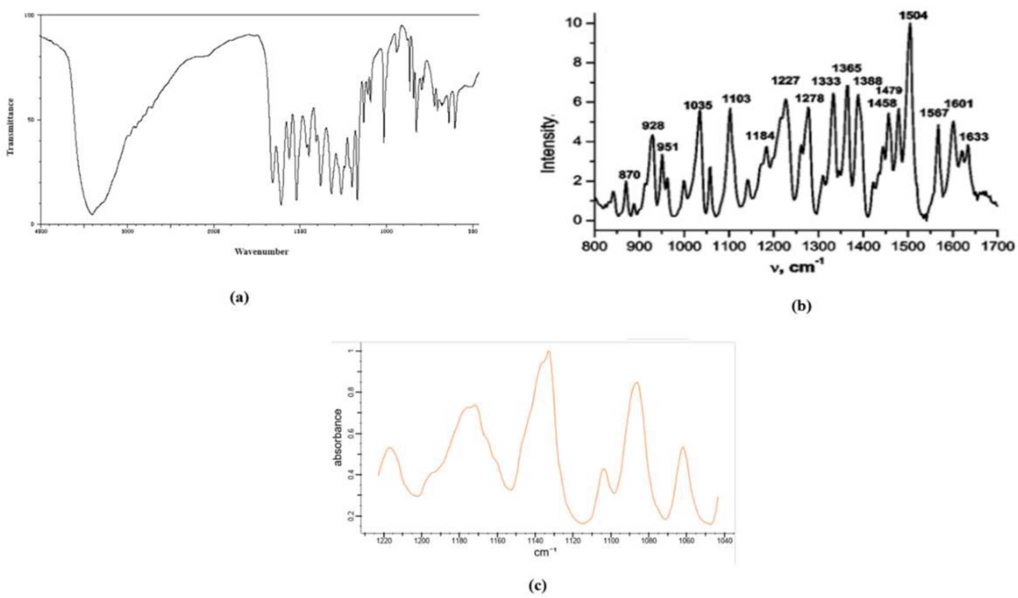
Fig 6: FTIR spectra of (a) *Phyllanthus urinaria* dye, (b) *Berberis asiatica* dye and (c) *Cassia bakeriana* dye



III. CONCLUSION

The synthesis and development of novel dye-sensitized layers for solar cell fabrication have demonstrated promising advancements in enhancing the efficiency of dye-sensitized solar cells (DSSCs). Through a detailed synthesis approach and comprehensive characterization using spectroscopic techniques, this study highlighted their potential for practical solar cell applications. This work paves the way for further refinement of sensitizer materials, contributing to the sustainable development of solar energy technologies.

REFERENCES

1. Amadi, Lawrence & Jenny, Shaichi & Ahmed, Asif & Brown, Nikia & Yadav, Sunil & Brown, Destiny & Ghann, William & Gayrama, Alec & Jiru, Mintesinot & Uddin, Jamal. (2015). Creation of Natural Dye Sensitized Solar Cell by Using Nanostructured Titanium Oxide. Nanoscience and Nanoengineering. 3. 25-32. 10.13189/nn.2015.030301.
2. Bhattarai, Keshab & Dhakal, Devendra & Pandey, Indira & Subba, Bimala & Sharma, Khaga. (2023). Phytochemistry, Biological Activities, and Chemical Profiling of Berberis asiatica. BIBECHANA. 20. 236-247. 10.3126/bibechana.v20i3.57711.
3. Chandra, Kumar. (2020). Application of Natural Dye in Dye Sensitized Solar Cells and its Characteristics. International Journal of Management, Technology And Engineering, 10 (6), 75-83.
4. Cunha, Luís & Morais, Sérgio & Aquino, Francisco & Chang, Roberto & de Oliveira, Alberto & Martins, Mário & Martins, Carlos Henrique & Sousa, Laís & Barros, Tricya & Silva, Claudio & Nascimento, Evandro. (2017). Bioassay-guided fractionation and antimicrobial and cytotoxic activities of Cassia bakeriana extracts. Revista Brasileira de Farmacognosia. 27. 91-98. 10.1016/j.bjp.2016.08.002.
5. Cunha, Luís & Morais, Sérgio & Martins, Carlos Henrique & Martins, Mário & Chang, Roberto & Aquino, Francisco & de Oliveira, Alberto & Moraes, Thaís & Machado, Fabrício & Silva, Claudio & Nascimento, Evandro. (2013). Chemical Composition, Cytotoxic and Antimicrobial Activity of Essential Oils from Cassia bakeriana Craib. against Aerobic and Anaerobic Oral Pathogens. Molecules. 18. 4588-4598. 10.3390/molecules18044588.
6. Du, Guankui & Xiao, Man & Yu, Siman & Wang, Mengyi & Xie, Yiqiang & Sang, Shenggang. (2018). Phyllanthus urinaria: a potential phytopharmacological source of natural medicine. International Journal of Clinical

and Experimental Medicine. 11. 6509-6520.

7. Falcón-Hidalgo, Banessa & Fuentes Bazan, Susy. (2016). Phyllanthus urinaria (Phyllanthaceae), first record of an alien species naturalized in Cuba. 37. 11-13.
8. Ganta, Deepak & Villanueva, Rolando & Combrink, Keith. (2019). Natural Dye-Sensitized Solar Cells: Fabrication, Characterization, and Challenges. Advances in Solar Energy Research, Springer, 129-155.
9. Karmakar, S & Zaman, Q & Hossain, M & Siddika, Ayesha & Tabassum, Samia & Ibrahim, A & Huque, S. (2023). Locally Available Natural Dyes for Dyesensitized Solar Cells. Dhaka University Journal of Applied Science and Engineering. 7. 38-44. 10.3329/dujase.v7i1.62885.
10. Rahul & Singh, Shruti & Singh, Pramod & Kakroo, Sunanda & Hachim, Dhafer & Dhapola, Pawan & Khan, Zishan. (2020). Eco-friendly dye sensitized solar cell using natural dye with solid polymer electrolyte as hole transport material. Materials Today: Proceedings. 34. 1-7. 10.1016/j.matpr.2020.04.775.
11. Saklani, Sarla & Kothiyal, Subhash. (2011). Berberis asiatica: Potential fruits as nutrceuticals. International Journal of Pharmacy and Technology. 3. 1586-1604.
12. Saleh, Hatem & El-Agez, Taher & Taya, Sofyan & abdel-latif, Monzir & Batniji, Amal. (2014). Dye-sensitized solar cells with natural dyes extracted from plant seeds. Materials Science-Poland. 32. 547-554. 10.2478/s13536-014-0231-z.

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