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PHOTOCONDUCTIVITY OF DYE SENSITIZED SOLAR CELLS (DSSC'S) MADE USING *COFFEE ARABICA* POWDER AND PULP WASTE AS SENSITIZER WITH SUNSCREEN CREAM AS SEMICONDUCTOR SOURCE

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Abstract - *The main aim of this research paper was to investigate the efficiency of DSSC's made using locally available dye stuff. Bioplastic support material made using starch was impregnated with two types of dyes. First dye was coffee pulp waste and the second one was coffee powder which is not adulterated. Himalaya men natural bright cream (SPF 15*) was used as TiO_2 semiconductor source. I^-/I_2 solution was taken as the electrolyte. Carbon black coated bio plastic was used as counter electrode. Electrode – 2 with P_{max} 0.082 and Cell efficiency (η %) 0.244 was more efficient in comparison to the Electrode – 1 with P_{max} 0.065 and Cell efficiency (η %) 0.192. The cells had very less stability for days endurance study. Further investigations on these green DSSC's can help improve their performance.*

***Key Words*: DSSC's, Bio plastic, bio polymer, TiO_2**

1.INTRODUCTION

Alternate energy resources are recommended for any country's growth. Fossil fuels have depleted over years due to over consumption. Abundantly available natural energy resource i.e. the solar energy is best and cheap alternative. However, harnessing the same is the biggest challenge. Researchers are focusing on third generation solar cells which are the Dye Sensitized Solar Cells (DSSC's). A suitable dye, a photo anode made from semiconductor, any counter electrode and a good electrolyte are the basic parts of the cell. Many research papers with variations in these parameters are available in the literature[1-8]. Coffee is a one among the commercial crops grown in Chikkamagaluru of Karnataka state. Hasby et. al. reported HOMO and LUMO (energy gap) obtained for two samples as 3.37919316 eV and 0.28792381 eV. The anthocyanin compounds extracted from Gayo Arabica Coffee husks are potential photosensitizers in DSSC[1]. Coffee has components that are effective dye sensitizers. The efficiency of DSSC's can be improved by drying electrolyte solutions and uniformly distributing semiconductor, dye and counter electrode material. Using a natural bio plastic for hosting all essential components will surely improve the efficiency of DSSC's. In this paper we have tried to using bioplastics made with starch and naturally available materials like coffee pulp waste and coffee powder as dye sensitizer to make our DSSC's economical, easily handle able and environmental friendly.

2. EXPERIMENTAL

2.1 Synthesis of bio plastic

2.5 g of pure starch, 25 cm^3 of distilled water followed 2 cm^3 of hydrochloric acid and 2 cm^3 of propan-1,2,3-triol were added to a beaker and gently boiled for 15 minutes, with a watch glass being put on top of the beaker, to prevent evaporation of water. The pH of the mixture was neutralized using dilute sodium hydroxide. It was then left under a laminar air flow for 2 days to dry out. After two days, plasticized starch in sheet form was obtained[9].

2.2 Preparation of dye-Sensitizer Solutions

- *Coffee robusta's coffee* pulp of was obtained from local pulping agencies and the liquid was used as such.
- Coffee powder made from *robusta* variety which was free from all sorts of adulteration. It was boiled in hot water and filtered. The filtrate used as dye source.

2.3 Preparation of Electrodes

The conductive glass plates (FTO glass, fluorine-doped SnO_2, sheet resistance 8-12 Ω/cm^2) were purchased from Aldrich. The above prepared bio plastic sheets were cut into square wafers. Few were uniformly smeared with Himalaya men natural bright cream (SPF 15*) as TiO_2 source to make them as photo anodes and others were smeared with candle black carbon to form the counter electrode. The bio plastic smeared with sunscreen was then dipped in coffee pulp, dried and excess was washed with alcohol.

2.4 Assembling

Spectrophotometric grade chemicals and regents were used as received. Iodine (0.1 M), potassium iodide (0.05 M) 3-methoxypropionitrile (0.05 M) in acetonitrile (50 mL)

were mixed and used as electrolyte. The electrolyte was poured on the bioplastic and electrodes were assembled. They were checked for leaks after clipping[10,11]. Prepared DSSC's are of the composition provided in Table-1.

Table -1: Sources of TiO_2 and dyes used for preparation of DSSC electrodes

ELECTRODE NUMBER	ANODE (Source of TiO_2)	DYE	CATHODE
1	A-2 (Himalaya men)	Coffee pulp	Candle black carbon
2	A-2 (Himalaya men)	Coffee powder	Candle black carbon

2.5 P-V Studies

A solar panel is deemed efficient if it effectively converts sunlight into usable form. Depending upon the efficiency we can choose the panels of our requirement. With the help of PV studies we can determine efficiency of the solar panel.

Both the test and control electrodes were subjected to PV studies and their corresponding plots were obtained.

Control: zero conductivity with no dye stuff.

For PV studies the slides were illuminated using tungsten filament source placed at a distance of 12 cm from the source.

An Additional test for stability of coffee dye sensitized solar cells was carried out. The monitoring parameter namely; current output under continuous sun illumination (100 mW/cm^2 and air mass 1.5), in a hermetically sealed solar cell with electrolyte solution devoid of any cooling system was carried out. Observations during the study are as reported and is discussed below.

3. RESULT AND DISCUSSION

The photovoltaic plots for electrode 1 and 2 are as shown in Chart 1 and 2.

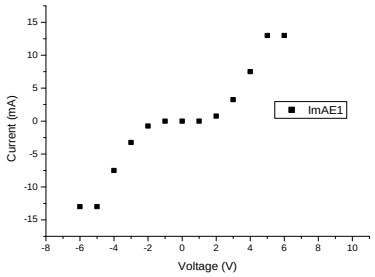


Chart 1: PV plots of DSSC for Electrode -1

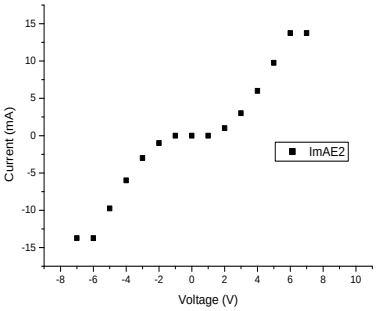


Chart 2: PV plots of DSSC for Electrode -2

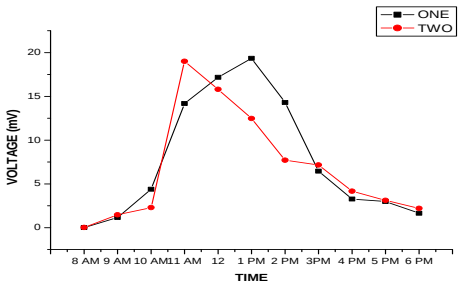
The efficiency of both the solar electrodes was calculated and the results tabulated in Table-2 below.

Table-2: Dye Sensitized Solar Cell efficiency for Electrodes 1 and 2

Code	P_{max}	Cell efficiency (η %)
Electrode- 1	0.065	0.192
Electrode- 2	0.082	0.244

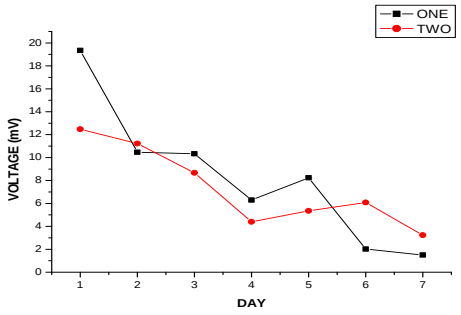
Both the electrodes 1 and 2 were prepared by using Himalaya men natural bright cream (SPF 15*) as TiO_2 source. Candle black carbon was used as the counter electrode. Electrode – 1 however had coffee pulp as the dye source and Electrode – 2 had coffee powder as the dye source. From Table – 2 it is clear that Electrode – 2 with P_{max} 0.082 and Cell efficiency (η %) 0.244 is more efficient in comparison to the Electrode – 1 with P_{max} 0.065 and Cell efficiency (η %) 0.192. It can therefore be concluded that coffee powder from coffee beans had better dye characteristics than the dyes found in coffee pulp of the same variety.

Electrodes 1 and 2 DSSC under sun illumination for time dependent efficiency were carried out for one day (24 hours) and a week-long monitoring was performed each day at 1 PM. The results are as shown in Charts-3 and 4.



Electrodes 1 and 2

Chart-3: Time dependent efficiency for Electrodes 1 and 2 DSSC under sun illumination (100mW &air mass 1.5)



Electrodes 1 and 2

Chart-4: Time dependent efficiency for DSSC Electrodes 1 and 2 under sun illumination (100mW &air mass 1.5) for a week (voltage at 1PM taken)

Time dependent efficiency studies for DSSC's of Electrodes 1 and 2 under sun illumination show that the electrode was stable for a day, but the stability of the electrode decreased and fell down to 2/3 mV on the seventh day which was 20/12 mV on the first day. This destabilization could have occurred from the electrolyte solution that gets absorbed in the bioplastic. More electrolyte solution or conducting bioplastic could be used to eliminate this problem. Alternatively the cream used for the study as TiO_2 source may have degenerated. A separate study on stability of the cream for one week under sun illumination can throw light on the effectiveness of cream as an UV absorbent source and its utilization for energy production in DSSC's.

3. CONCLUSIONS

The major problem in DSSC's is the evaporation of electrolyte. This problem can be mainly solved by using bioplastic as the supporting material. Use of bioplastic makes it environmental friendly and easy to handle. Chikkamagaluru is a malnad of Karnataka and a rich grower of coffee. Using the pulp waste as a dye material can contribute to a green method and even help in waste management. Few parameters need to be standardized in order to maintain the efficiency and durability of the cell.

From this paper we can conclude that Electrode – 2 is a better DSSC in comparison to Electrode – 1.

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