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Dye Sensitized Solar Cells Sensitized With Natural Pigments Extracted From Mixed Fruits.

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ABSTRACT

Energy crisis is a major issue faced by every country today. Many efforts have been taken to research on the sources of renewable energy. Recent research work is mainly concentrated in solar cells. One of the solutions is the use of Dye Sensitized Solar cells (DSSC) based on TiO_2 has drawn attention worldwide due to their low cost, non-toxicity and easy preparation technique. This paper proposes an alternative source for electricity using mixed fruit extract which is a natural ingredient as dye for TiO_2 based DSSC. The TiO_2 powder was applied on top of the Indium Tin Oxide conductive glass. The carbon coating was done on another glass plate. The redox type of electrolyte was used for the cell. The objective of this work was to develop DSSC in liquid electrolyte commonly applied in photo electrochemical cells. The performance of solar cells using the extract of mixed fruits is analyzed and conclusions are drawn from the results. We obtained about 0.3 to 0.4mV and 150-200mA with the10*5 size of Indium tin oxide glass.

Keywords: DSSC, Indium tin oxide, TiO_2, Natural Pigment, doctor blade.

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INTRODUCTION

Nowadays energy crisis is a big issue for every country in the world. In the earlier days fossil fuels were used as a major form of energy source. Then slowly advancements in technology led to generation of energy by different mechanisms. The energy produced from conventional sources are generally non renewable in nature and are on the verge of extinction. Thus many efforts have been taken to overcome these problems. The methods are being developed to produce energy from renewable resources. The analysis is done on the cost effectiveness of the process and the ease of the process of producing and storing the energy to under suitable conditions.

The electrical energy storage systems have been developed. This is an area where extensive research is being done.[8] The solar cells are one of the good energy generating device to keep the environment free from the toxic gases.[3] Generally other types of energy generating mechanisms involve the release of carbon dioxide or any other harmful toxic gases into the environment. Thus the solar cells do not harm the environment by global warming.

There are two types of solar cells one is the silicon based solar cell and the other is the dye sensitized solar cells.[2] The dye sensitized solar cells (DSSC) are developed based on the concept of photo sensitization of the wide band-gap mesoporous oxide semiconductors. The DSSC based on TiO_2have been drawn attention worldwide due to their low cost and easy preparation technique.[6] The TiO_2 was preferred as it has a very small energy band gap of 3.4eV. Experiment was conducted with the same material and analysed. Figure 1 shows the schematic representation of the DSSC.

MATERIALS USED

CHEMICALS

We have used titanium dioxide as a coating which acts as the photo catalyst to entrap the ultra violet radiation.[6]TiO_2 is a semiconductor having three polymorphisms including tetragongal rutile, tetragonal anatase and ortho rhombic brokite. Rutile structure is the most thermodynamically stable phase, while the other two are metastable.[2]TiO_2 of anatase phase has wider energy band gap of 3.2 eV compared to the rutile phase which has 3 eV and hence it has better photo-activity performance and suitable for DSSC application.[1]It has high porosity and is made into a paste with the help of vinegar, detergent and water. The iodine crystals are mixed with potassium iodide crystals. It is then made into a solution with anhydrous ethylene glycol. The suitable fruits are selected which have the anthocyanin dye present in it.[6] Anthocyanin is a blue, red or violet pigment found in plants and able to absorb visible lights. The main characteristic of the dye is its ability in absorbing the visible light spectrum from red to blue so that it can sensitize the wide band gap semiconductor material.

TOOLS

The indium tin oxide glass was used as an electrode because it has special characteristic of entrapping the solar radiation. The indium tin oxide glass is a special type of glass which has a characteristic of one side being conductive while the other side is non-conducting in nature. This property is known as intelligent. The indium tin iodide glass size taken was 10x5 cm.[1]

We have used multimeter to measure the voltage and current generated from the solar cell with respect to time. The heating mantle was used to heat the glass surface to make the paste of titanium dioxide stick to the glass. [7] The glass rod was used to apply the titanium dioxide paste on the glass by a technique of doctor's blade. The binder clips, tape, cutter, tissue paper, measuring cylinder.

PROCEDURE

ANODE

The indium tin oxide glass with the side which is conducting was taken with the help of tongs and was heated directly by the flame of a spirit lamp. On continuous heating the glass surface turns black by the formation of carbon layer. The glass plate is heated by the flame carefully such that heat is exposed on all sides of the plate uniformly. This is done to avoid the cracking of the plate. Refer figure 2. The carbon layer formed on the one side of the glass acts as the anode for the cell. [10]

CATHODE

The indium tin oxide glass with the side which is conducting was taken and three sides were tapped/insulated with a boundary of 1cm each. [7]The titanium dioxide powder was taken in a beaker and made into a paste by adding vinegar solution in small amounts and a little quantity of detergent. The paste was smeared on the indium tin oxide glass plate with a glass rod by using the doctor's blade technique as shown in figure 3. [9] The glass plate was now heated on a heating mantle at a temperature of $300^{O}C$ for about 20 minutes. The titanium dioxide paste gets stuck to the glass plate. The figure 4 shows the heating of the plate.

DYE PREPARATION

We took strawberries black grapes and watermelon in a beaker. This was crushed into a pulp. This was the fruit extract with the anthocyanin ion.[12] Refer figure 5. This ion has capability of capturing solar radiation. The extract was poured on the titanium dioxide coated plate carefully such that the coating does not get washed off. [6]

ELECTROLYTES

The electrolyte was prepared by taking 127mg of iodine crystals and 830 mgs of KI crystals. This was shaken well to form a coloured solid compound. 10-ml of anhydrous ethylene glycol was added to this mixture to make it into a solution. This acts as a electrolytic solution for the cell which is shown in figure 6. The electrolytic solution was carefully poured on the titanium dioxide coated plate. A cloth is used to wipe the excess solution from the sides of the glass plate.[9] Figure 7 shows the cathode with the electrolyte and fruit extract.

WORKING

The anodic glass plate with the carbon soot layer was placed over the other glass plates with the electrolytic solution. The glass plates were placed over each other in such a way that they offset each other by a small margin. The clips were used to hold the plates together. This is shown in figure 8. The titanium dioxide coated side of the glass plate was irradiated by uv rays. The ends of the multimeter were placed on the surface of the glass plate to measure the current and voltage generated by the irradiation of the cell. [9]

When light hits the anthocyanin dye it ejects an electron into the conduction band of the semiconducting titanium dioxide. The anthocyanin ion is an antioxidant and it itself oxidizes the process. Generally the dye should not oxidize and escape.[12] The electron in the titanium dioxide migrate into the ITO glass and passes through the load to the anodic ITO glass .Here in the anodic compartment it reduces the tri iodide ions to iodide ions.[4]

$$I_3^- \rightarrow 3I^-$$

The carbon soot layer catalyses the reaction and the iodide ions interact with the dye by passing through the electrolyte solution and then reduce the excited dye ions . Thus the iodide ions are reduced to tri iodide again and the dye molecules are ready for further irradiation by light. [5] The working of the cell is illustrated in figure 9.

In general photons are absorbed by dye molecules, which inject electrons from their excited states into the conduction band of the TiO_2 7nano-particles to leave the dye molecule oxidized. Oxidized dye molecules are reduced by a redox electrolyte.

RESULT

From the observations it was inferred that as time progresses the current and voltage produced by the cells also increases. The voltage readings were taken at regular intervals of 30 minutes and plotted against time to analyze the voltage characteristics with respect to the amount of ultra violet radiation being incident on the cell. . During 11:30 AM to 1:00 PM it is constant because during that time the amount of solar radiation produced by the sun is nearly constant but after 2:00 PM it is linearly decreasing. The maximum voltage produced by the cell is only about0.45mV. The graph is shown in figure 10.

A graph with the voltage was plotted against time and another in which the current was plotted with time. The current readings were taken at regular intervals of 15minutes and plotted to analyze the current characteristics with respect to the amount of ultra violet radiation being incident on the cell. The range of 150 to 200 mA of current was achieved during the study period. The graph is shown in figure 11.

CONCLUSION

The voltage produced was a very low value thus it can be increased by using different materials for the glass plates such as fluorine doped tin oxide or any other suitable material. [10] The titanium dioxide can be replaced by other photocatalyst materials like zinc oxide.

Further studies can be done to improve the production of the voltage. This can be done by varying the type of glass plates, the photocatalyst and the type of extract. [6]The extracts which are dark in color might yield better results.

The thickness of the TiO_2 used for this experiment is determined by the thickness of the tape used to keep the glass piece stable. The doctor blade method is a widely proven method which has been used for the uniform coating on the glass plate. There are several other techniques which can be tried for coating of TiO_2.[7]

In this paper we have been successfully created a dye sensitized solar cells using TiO_2 by using mixed fruit extract. The conductivity nature of glass plate is increased by coating and by heating. This is an attempt made to check the possibility of preparing DSSC with Indium tin oxide coated glass. The output is being checked whether the traces of power output and graph are plotted between voltage versus time and current versus time. For every 15 min the values are recorded and found that there is increase in power as time increase. It is found that during the afternoon there is a slight increase in the power generation by the cell this is because of the increase in the intensity of the solar energy incident on the cell. Further it gives clear idea that thickness of material and proper coating is also very important to enhance the solar activity. The thickness of the titanium dioxide layer applied on the glass plate can be varied to obtain different results.

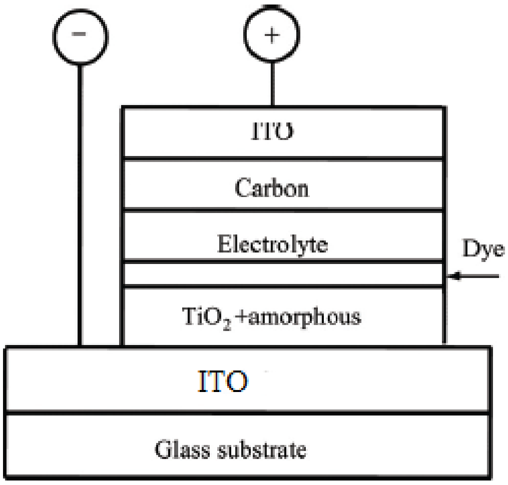

Fig 1: Schematic representation of the DSSC[2]

Fig 2: Carbon layer formation on glass

Fig 3: TiO_2 coated glass

Fig 4: Heating Cathode

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Fig 5: Fruit extract

Fig 6: Electrolyte Solution

Fig 7: Cathode with Dye

Fig 8: Complete Cell

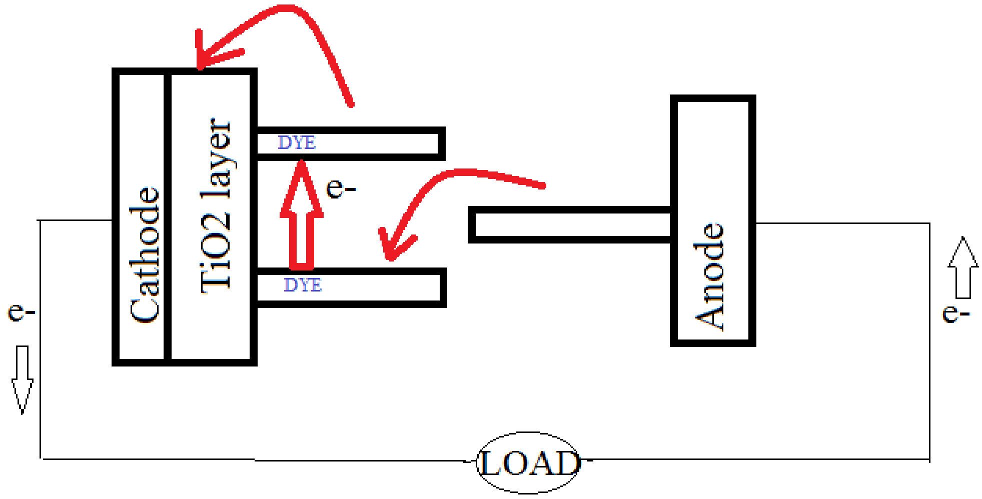

Fig 9: Working of Cell[4]

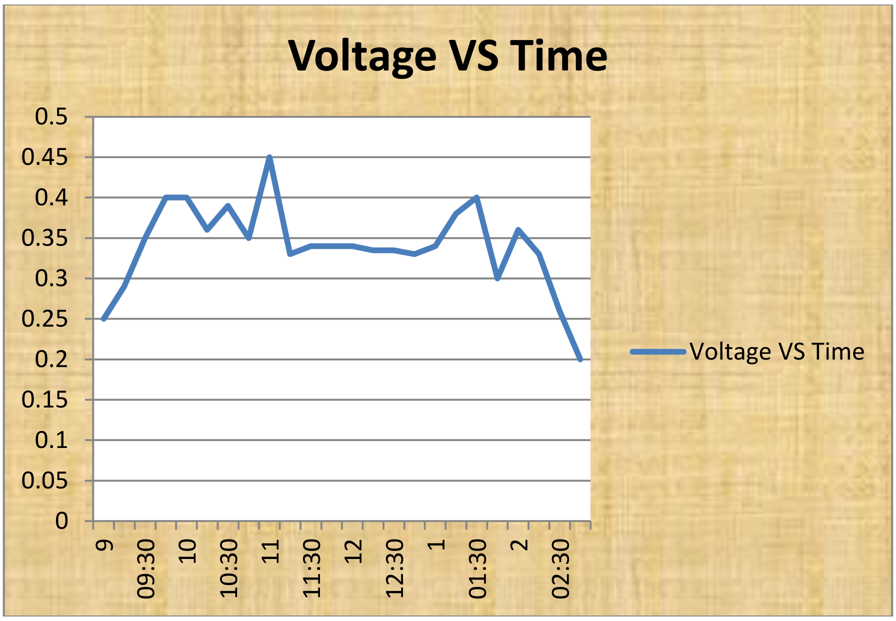

Fig 10: Plot of Voltage Vs Time

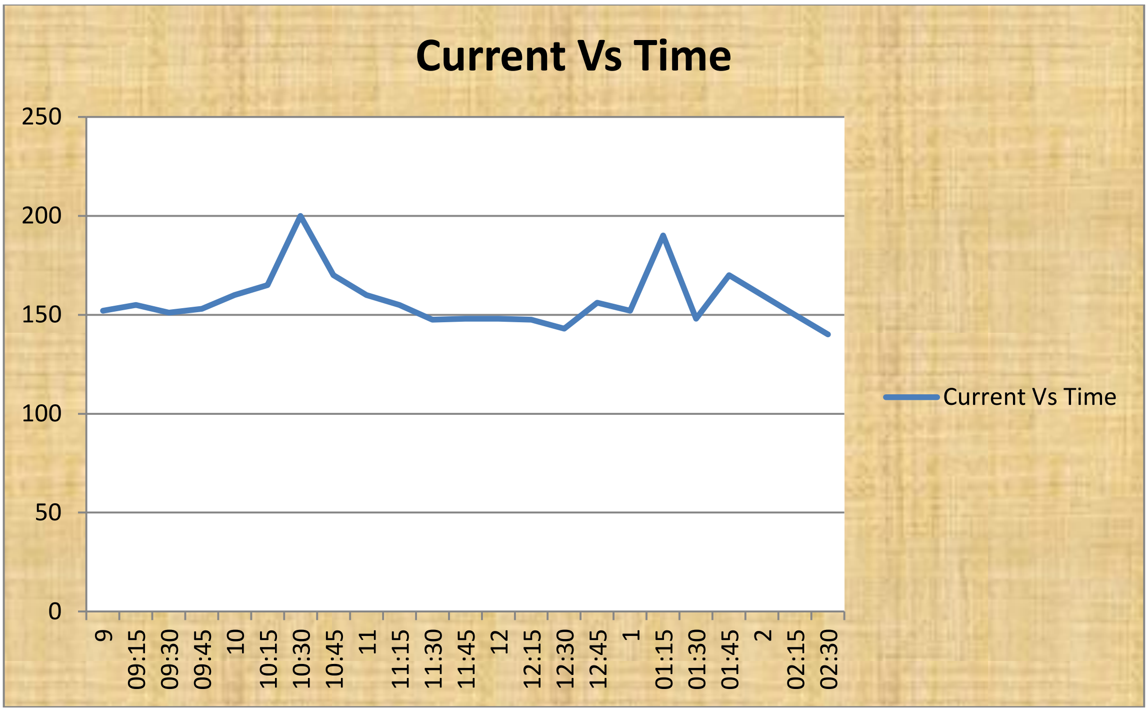

Fig 11: Plot of Current Vs Time

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REFERENCES

[1] M. Fitra, I. Daut, M. Irwanto, N. Gomesh, Y.M. Irwan, TiO_2 Dye Sensitized Solar cells cathode using Recycle Battery; Elsevier: Energy Procedia 2013; 36: 333-340.

[2] Takeo OKU, Naiaki KAKUTA, Kengo KOBAYASHI, Atsushi SUZUKI, Kengi KIKUCHI, Fabrication and Characterisation of TiO_2- based dye sensitized solar cells; Elsevier: Progress in Natural Science: Materials International 2011; 21: 122-126.

[3] Green M A, Emery K, King D L, et al Solar cell efficiency tables(version 28); Progress in Photovoltaics: Research and Applications 2006; 14: 455-461

[4] Brijesh Tripathi, PankajYadav, Manoj Kumar, Theoritical upper limit of short-circuit current density of TiO_2nanorod based dye sensitized solar cells; Elsevier: Results in Physics 2013; 3: 182-186.

[5] Papageorgious N, Gratzel M, Infelta PP, On the relevance of mass transport in thin layer nanocrystalline photoelectrochemical solar cells; Sol Energy Materials and solar cells 1996, 44:405-438.

[6] DiahSusanti, MaulaNafi, HariyatiPurwaningsih, RindangFajarin, George EndriKusuma, The preparation of Dye sensitized solar cells from TiO_2 and Tamarillo Extract, Elsevier: Procedia Chemistry 2014; 9: 3-10.

[7] M. Fitra, I. Daut, M. Irwanto, N. Gomesh, Y.M. Irwan, Effect of TiO_2 thickness Dye solar cell on charge generation; Elsevier: Energy Procedia 2013; 36: 278-286.

[8] Yue W, Zhou W, Crystalline mesoporous metal oxide[I]; Progress in Natural Science, 2008; 11: 1329-1338.

[9] G.G.G.M.N. Hemamali, G.R.A.Kumara, Dye Sensitized Solid State solar cells Sensitized with Natural Pigment Extracted from the grapes; International Journal of Scientific and Research Publications November 2013; Issue 11: 1-3.

[10] Jin-A Jeong, Han-KiKim, Thickness effects of RF sputtered TiO_2passivating layer on the performance of DSSC; Solar energy materials & solar cells 2011; 95: 344-348.

ISSN: 0975-8585

[11] R Baskaran, S R. Selvi, Solar Photovoltaic Powered Membrane distillation as sustainable clean energy technology in desalination; Current Science 2015; 7: 1247-1254.

[12] S. Sridhar, A. Muthulakshmi, D. Diana Florence, R Baskaran, Applications of homogeneous oxidative methodologies for study of degradation of prototypical textile dyes; Research Journal of Pharmaceutical, Biological and Chemical Sciences 2014; 5: 1022-1026.