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A LOW-COST TIO$_2$ BASED SOLAR CELL USING ANTHOCYANINE AS DYE FROM POMEGRANATE

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ABSTRACT

The solar cell has been widely used nowadays as an alternative source of electricity. Solar electricity is cheaper in a long run and the critical capital cost is more expensive. The cost can be minimised if alternative can be done in its design. Here in this research paper efforts are done to do one of such alternative i.e, a low cost TiO2 based solar cell using anthocyanine as dye .The dye sensitized solar cell (DSSC) is an electrochemical solar cell where light absorption accurs by dye molecules attached to a nanostructure TiO2 electrode .In the present study a dye used is obtained from pomegranate juice. The performance of the DSSC is received in term of the fill factor ,energy conversion efficiency and its long term stability .TiO2 films with nanocrystallin structure was prepared by electron beam evaporation technique. A review is done on the Performance results of organic solar cells categorizing the cells by their device architecture.

Key words: Titaniumoxide, Pomegranate, Indium tinoxide,Carbon.

INTRODUCTION

Solar cell technology is used to convert solar energy into electrical energy which can be used to power electrical devices. Solar cells are already used to supplement or replace dependence on conventional energy sources in few homes and businesses. There is the potential, however, for further development and wider acceptance of solar cell use to be the answer to the growing energy situation. Incoming photons from the sun excite electrons in the TiO2/anthrocyanin dye complex. These electrons are transmitted through the SnO conductive coating to the multimeter. Electrons come from the multimeter back into the conducting SnO coating on the carbon (soot coated) plate which donates electrons to the KI3 electrolyte. This reduces the electrolyte, which donates the extra electrons to the TiO2/dye complex, completing the cycle of electron flow [1]. Anthocyanins are a subclass of molecules known as flavonoids that are responsible for the brilliant red, orange, and blue colours of most fruits and flowers. Anthocyanidins lack the sugar component of the parent anthocyanin. Six of the anthocyanidins that occur most commonly in nature are pelargonidin, cyanidin, peonidin, delphinidin, petunidin, and malvidin. Anthocyanins are the mono and diglycosylated forms of anthocyanidins with substitutions at the 3 and 5 positions (Figure1).The most common carbohydrates encountered on anthocyanins include glucose, galactose, rhamnose, and arabinose. Pomegranate is extensively cultivated worldwide and has become a high-value crop for juice production. The retail market now contains numerous pomegranate-related products such as juices, smoothies, flavoured waters, and sports and energy drinks.4 from 2006 to 2008, nearly 320 products containing pomegranate or pomegranate flavouring were launched and PJ currently remains one of the most popular drinks in the *super juice* category. [2, 3].

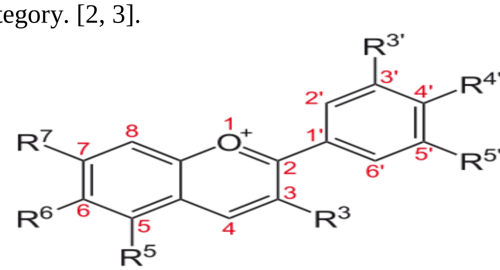

Figure. 1 Structure of Anthocyanine

Reports of TiO_2 with different shape such as Nanoparticles thin films, nanorods, nanowires And nanotubes have spurred a great interest in Studies on TiO_2 nanostructure synthesis and their application [4]. Many excellent reviews and Reports on the preparation and properties of nano materials have been published recently. [5]. the specific surface area and surface-to-volume ratio increase dramatically as the size of a material decreases. [6]

OPERATING PRINCIPLE OF THE DYE-SENSITIZED SOLAR CELL

At its simplest configuration the dye-sensitized solar cell (abbreviated hereafter as the DSSC or the dye cell) is comprised of a transparent conducting glass electrode coated with porous nanocrystalline TiO_2 (nc-TiO_2), dye molecules attached to the surface of the nc-TiO_2, an electrolyte containing a reduction-oxidation couple such as I-/I3 -and a catalyst coated counter-electrode. At the illumination the cell produces voltage over and current through an external load connected to the electrodes. The absorption of light in the DSSC occurs by dye molecules and the charge separation by electron injection from the dye to the TiO_2 at the semiconductor electrolyte interface. A single layer of dye molecules however, can absorb only less than one percent of the incoming light. While stacking dye molecules simply on top of each other to obtain a thick dye layer increases the optical thickness of the layer, only the dye molecules in direct contact to the semiconductor electrode surface can separate charges and contribute to the current generation. Essential to the optical operation of this porous electrode structure is the fact that TiO_2, as a large band gap semiconductor, absorbs only below about 400 nm, letting the major part of the solar spectrum available for the dye molecules.

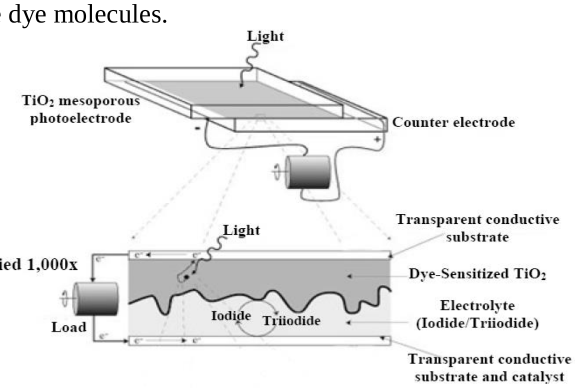

Figure. 2 schematic representations of the structure and components of the dye-sensitized solar cell

The overall oxidation-reduction reaction ultimately powers the device, and is written as follows:

A. hν + Dye -> Dye*
B. Dye* + TiO_2 -> e-(TiO_2) + Dye+
C. e-(TiO_2) + ITO -> TiO_2 + e-(ITO) [this electron will go into the ITO and then through a load]
D. 3I- + 2Dye+ -> I3 - + 2Dye
E. I3 - + 2e-(C.E.) -> 3I- + (C.E.)

METHODOLOGY

The materials used are

- Nanocrystalline Titanium Dioxide (TiO_2)
- ITO clean conducting glass slides
- Pomegranate juice diluted with distilled water
- Triiodide solution for electrolyte (iodine crystal+potassium iodide+ethylene glycol)
- Ethanol in wash bottles
- Binder clips
- Multi-meters and wires with alligator clips

Preparation of dyeTiO_2

TiO_2 paste is produced in the laboratory using nanocrystalline grade TiO_2 powder, 0.15M acetic acid, a few drops of deionized water, and a surfactant. The nanocrystalline TiO_2 paste is applied as a thin film onto glass plates that have one side made electrically conductive by a thin film of indium tin oxide (ITO). The thickness of the TiO_2 matrix is kept constant by covering the length of three edges of the plate with Scotch® tape to a width of ~2mm. This also provides a small electrical contact strip where alligator clamps can be attached. The ITO plates are checked using a multimeter to make sure that the conducting side is facing up, and then TiO_2 paste is applied to conducting side of the ITO using a glass rod and quick downward sweeping motions (Figure 1). Plates are redone if there are any inconsistencies or streaks in the applied TiO_2 paste. In order to dry and strengthen the TiO_2 coating, the plates are heated (sintered) over a Bunsen burner flame for ~13-15 minutes, In the mean time, get some fresh Pomegranate and crush them into pulp then prepare fresh juice. Add a few drops of pomegranate juice over the titanium dioxide .Leave it for about three minutes as the anthocyanin dyes bind to it. We can see the titanium dioxide is dyed purple from the anthocyanins. Now carefully wash the titanium dioxide with ethanol to remove additional pomegranate chemicals. Now we got dyed titanium dioxide.

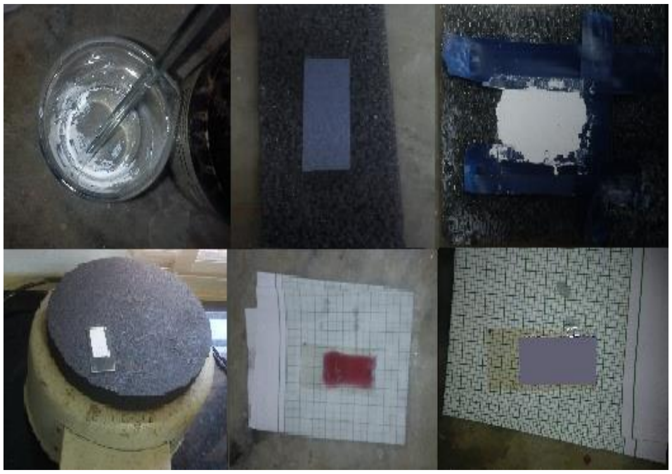

Figure. 3 Preparation of dyeTiO2

Preparation of Counter Electrode

ITO is coated over the glass substrate with different thickness using sputtering Technique .Take a lit candle and pass the conductive side of another piece of indium tin oxide glass through it several times i.eto build up a layer of soot, it doesn't need to be too thick .Now we produced counter electrode of photo voltaic cell.

Figure. 4 Preparation of Counter Electrode

Preparation of electrolyte

Take 127mg of pure iodine crystals and add to it 830 mg of potassium iodide this will produce brown potassium triiodide. Add 10mlof anhydrous ethylene glycol and mix until dissolved.

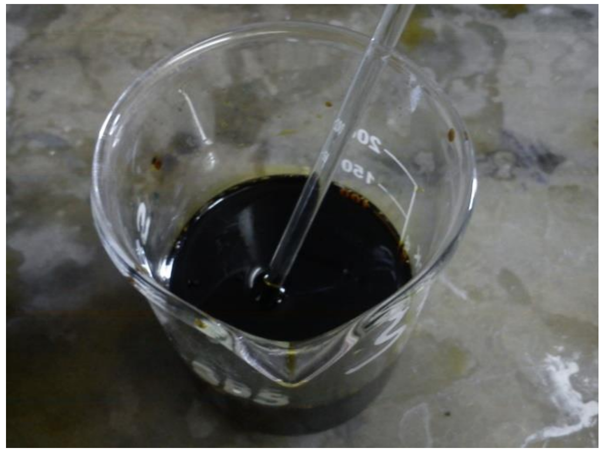

Figure. 5 Preparation of electrolyte

Preparation of DSSC

Take the electrodes and electrolyte; add a few drops of the electrolyte solution onto the dry titanium dioxide coated electrode. Now place over it the carbon soot coated electrode Make sure that the two sides with coatings face each other. Now use binder clips to hold together the assembly.

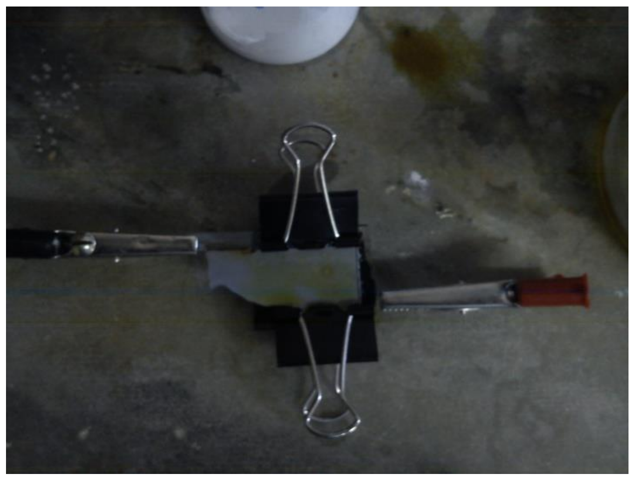

Figure. 6 Preparation of DSSC

Testing of DSSC

To keep the titanium dioxide side is the negative side and, while the carbon soot is the positive side. Connect this assembly to appropriate meter and get hit

It with a very high bright light. Now we can look our solar cell is making a very small amount of current and this current is proportional to the intensity of light and also it gives very small amount of voltage in millivolt range

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Figure. 7 Testing of DSSC a) In normal light b) In torch light c) In bright sun light

EXPERIMENTAL RESULTS

Thus far in the research the following variables have been determined: the sensitizing dye, the counter electrode, and the electrolyte. The conducting plates used have all been ITO and the dyed TiO_2

a) Current versus Time
b) V-I Characteristics of solar cell

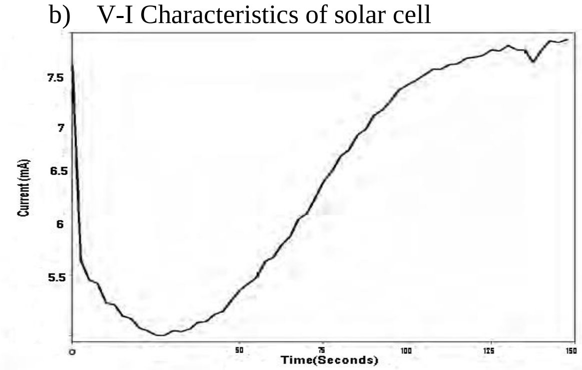

Figure. 8 Current versus Time

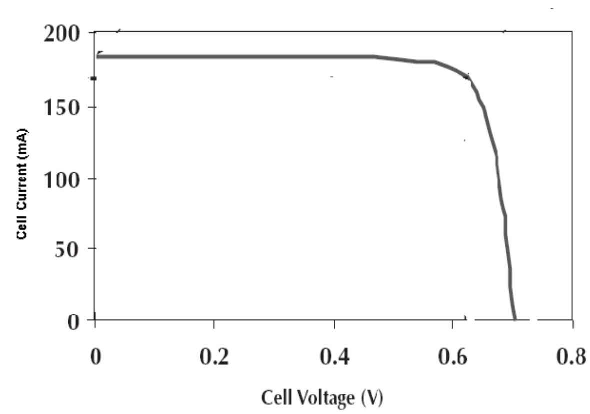

Figure. 9 V-I Characteristics of Solar cell

RESULTS AND DISCUSSION

Thus our best potential achieved is around 1.36 V and our best current achieved is at 7.2mA this was achieved using anthocyanine as Dye from Pomegranate Coated TiO_2 and carbon coated counter electrode

In short, compared to Si based solar cells dye sensitized solar cells are of low cost and ease of production, their performance increases with temperature, possessing bifacial configuration - advantage for diffuse light, have transparency for power windows, color can be varied by selection of the dye, invisible PV-cells based on near-IR sensitizers are feasible, and they are outperforms amorphous Si. Moreover, DSSC shows higher conversion efficiency than polycrystalline Si in diffuse light or cloudy conditions. It is believed that nanocrystalline photovoltaic devices are becoming viable contender for large scale future solar energy converters.

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