



Ethanoic Extractions of Lagerstroemia Speciosa Flowers for Dye Sensitized Solar Cell

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Abstract: Dye-sensitized solar cells (DSSCs) have attracted great interest as potential candidates of “low cost solar cells” in the solution of global energy demand. To accelerate the progress of DSSCs, it is important to evaluate device performance with reliable measurements that will enable more effective comparison and application of new findings in materials and technologies by different research groups. In this perspective, *Lagerstroemia Speciosa* Flowers dye was extracted using two methods of soxhlet and cold ethanol extraction. Our findings show that the open-circuit voltage is low which might be due to reduction in electron conduction. The Conversion efficiency of cold ethanol dye extract is higher than that of the soxhlet ethanol dye extract, which indicate that the dye pigment is more degraded in the latter method. However with further investigation, the constructed DSSC’s be made to serve as a power source for driving self-powered devices.

Key word: - *lagerstroemia speciosa flowers*, Ethanol, Dye Sensitized Solar Cells

1. Introduction

The dye-sensitized solar cell is often compared to photosynthesis in plants. This is because both convert the energy in light absorbed by dyes or pigments into other forms of energy. In plants, light is converted to chemical energy, and glucose is produced. In contrast, the dye-sensitized solar cell converts light to electrical energy by the conversion

of photons into an electric current by charge injection of excited dye molecules into a wide bandgap semiconductor. Thus there is high expectation for this device as the next generation solar cell that will create new applications.

This device is like the LCD display, in which liquid materials and circuits are sandwiched between two glass

plates. The dye-sensitized solar cell however contains the TiO_2 (semiconductor electrode), Dye, Electrolyte (which refers to materials in which the solute disassociates into positive and negative ions when dissolved in a solvent. Electrolytic solutions conduct electricity by the action of ions accepting and releasing electrons), and Catalytic electrode (counter electrode which returns the electrons taken from the cell back to the ions). These are the four main materials sandwiched between two conductive glass plates (Robert Foster et al 2009). The dye-sensitized solar cell has characteristics that do not exist in silicon solar cells such as low-cost source of materials (mainly TiO_2 and dyes), manufacturing methods and absence of silicon which is not required. The device layer is thin (a few tens of microns), visible light is absorbed efficiently and there is only a minimal dependence on the angle of incidence and increased flexibility for application design.

The dye extracted from *Lagerstroemia speciosa* flowers are used for the DSSC manufacturing. The tree is known by the common name Pride-of-India. It is a shrub when compared to large tree with multiple trunks or stems diverging from just above ground level. This species is 15 m in height and has a wide spreading crown. The bark is distinctive as it is light brown in color and often peels from the trunk

in large regions revealing the smooth new bark that is forming underneath. The flowers of this species are purple in color, produced in clusters at the tips of the branches so during flowering season create an attractive shot of color amongst the green foliage. The flowers are up to 7.5 cm wide and have five petals that appear crumpled, which is a characteristic of the Loosestrife family. The yellow color in the center of the flower is the stamens that produce the pollen with 130 to 200 stamens found in a single flower (Staples, G. W. et al. 2005). In this work *lagerstroemia speciosa* flowers dye ethanoic extraction was used in constructing solar cells.

2. Theory of Operation for Dye Sensitized Solar Cells

The schematic of DSSCs shown in Fig.1 rely on processes likened to photosynthesis. In photosynthesis, light is converted into chemical energy. Chlorophyll and other pigments can eject electrons through photo-induced charge separation when struck by photons. The main component of a DSSC is a semiconducting material with a wide band gap. One such material is titanium dioxide (TiO_2). This is deposited as a thin layer onto a transparent conducting oxide (TCO) substrate using a sol-gel technique. The TiO_2 layer is also in contact with a dye.

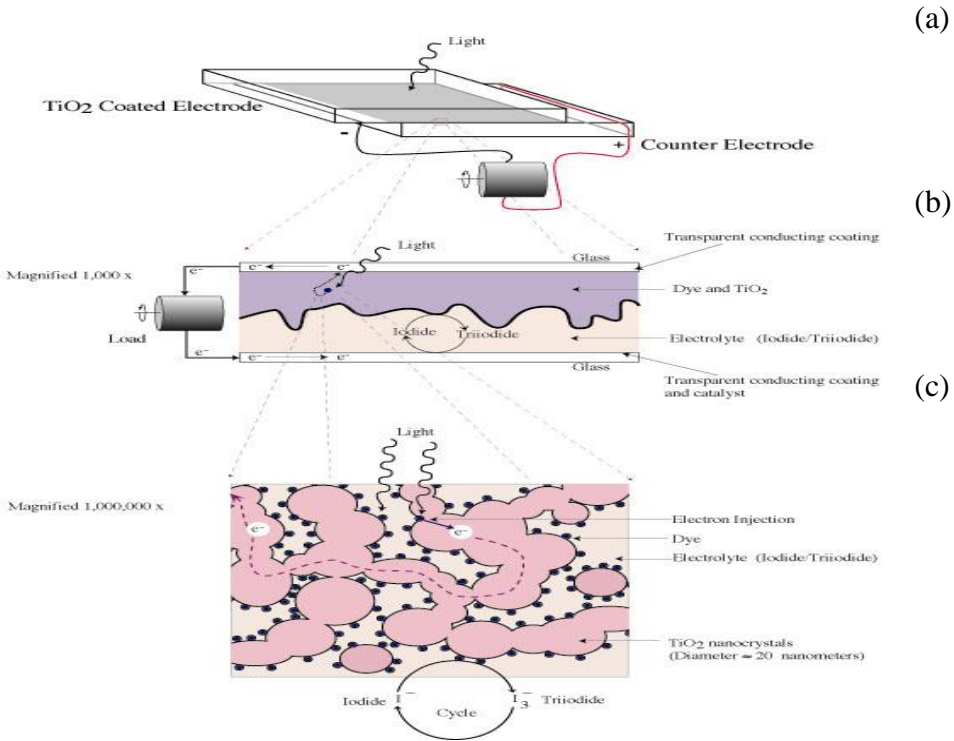


Fig1. Schematic of a dye sensitized solar cell. (Mitchell R. Brooks 2006)

Exposure to sunlight causes electrons in the dye to become excited. This phenomenon is called photoexcitation. The electrons are then ejected from the dye into the conduction band of the semiconducting oxide layer. Regeneration of the lost electrons is handled by a redox process within an electrolyte, common an iodide/triiodide couple, which is in contact with the dye. The final component is a layer of TCO. The voltage generated is related to the difference between the redox

potential of the electrolyte and the Fermi level of the electron within the solid. The electron that was ejected from the dye diffuses through the TiO₂ layer into the conductive oxide electrode where it leads to current generated (Mitchell R. Brooks 2006).

3. Fabrication of the Cell

The methodology used was to first make TiO₂ solution and a plane mirror 2x2cm used as the electrode with its outer coating removed leaving a silver (Ag) layer which is conducting. A window is created in the silver conducting film left to

allow incident light photon to enter and interact with the dye - titanium interface. The titanium paste is poured on the conducting surface of the slide glass. A glass rod is allowed to slide over the titanium dioxide suspension in order to spread evenly and smoothly (Y.Amao et al. 2004). It was annealed and sintered in an oven at 450°C for 30 min. After cooling, the TiO₂ - conductive mirror was soaked with *Lagerstroemia speciosa* dye solution for 30 minutes to allow infiltration. The second plane mirror 2x2cm conducting surface (with its outer- most coating removed) was carbon coated. The carbon coated slide (counter – electrode) is placed face down on top of the dry stained, titanium dioxide coated side of the other slide (electrode) in such a way that the two slides offset so that all of the TiO₂ is covered by the counter electrode. Two binder clips are used to gently hold the plates together at the edges and redox electrolyte containing a mixture of 0.5M potassium iodide and 0.05M iodine was introduced in between the electrodes. The liquid was drawn into the space between the electrodes by capillary action (A.O.Boyo et al 2012).

4. Characterization

Typically, three parameters are used to characterize solar cell output of the type shown in Fig. 1 namely short circuit current (I_{sc}), open circuit voltage (V_{oc}), and fill factor (FF). The ideal value for open circuit voltage is obtained as follows:

$$V_{oc} = \frac{K_B T}{q} \ln \left(\frac{I_l}{I_0} + 1 \right) \quad (1)$$

This equation illustrates the interdependence of I_{sc} and V_{oc} . The fill factor uses I_{sc} and V_{oc} as well as maximum power points of both current and voltage (I_{mp} and V_{mp}) in the following expression:

$$FF = \frac{I_{mp} \times V_{mp}}{I_{sc} \times V_{oc}} = \frac{P_{max}}{I_{sc} \times V_{oc}} \quad (2)$$

The energy conversion efficiency for solar cells is calculated using the equation

Conversion efficiency

$$\eta = \frac{\text{output power}}{\text{input power}} \times 100\% \quad (3)$$

Or

$$\eta = \frac{I_{mp} \times V_{mp} \times FF}{P_{in}} \quad (4)$$

Where P_{in} is the total power in the incident light on the cell. This equation demonstrates the dependency of efficiency computation on the fill factor (K.Takechi et al 2009).

5. Results and Discussion

Figure 2 - 4 show the absorption spectral of the extracts at different pH values of 1 to 3. The absorption spectra were recorded using a VIS Spectrophotometer (Spectrumlab 23A GHM Great Medical England). It can be seen that the extracts exhibit a maximum at 400nm. It can

be observed from the graph that there are shifts in the absorbance values. The shift in the absorption maxima in the samples illustrates that conjugation of double and triple bonds also shifts the absorption maximum to longer wavelengths. Also, different absorption peaks observed for the soxhlet ethanol is common for highly conjugated systems, and is often solvent dependent.

The performance of the cell was studied by recording the photocurrent voltage characteristic of the cells under an illumination of the sunlight as shown in fig.5. The open-circuit voltage V_{oc} for the soxhlet dye extract is 0.45, open circuit current I_{sc} $4.05\text{mA}/\text{cm}^2$, conversion efficiency 0.51% and fill factor FF 0.37. For the cold ethanol dye extract V_{oc} is 0.48, open circuit current I_{sc} is $4.13\text{mA}/\text{cm}^2$, conversion efficiency 0.55% and fill factor FF 0.38. We noticed that the V_{oc} values are low. The reason is because of the large dark current which may arise from the reduction of the oxidized *Lagerstroemia Speciosa* dye by electron conduction and the low FF was due to the large Ohmic loss in the hole transport layer. The energy

conversion efficiency of the soxhlet ethanol extraction cell is lower than the cold ethanol extract sensitized cell which could be attributed to the degrading of the pigments during extraction process.

Conclusion

Natural dyes were extracted from *Lagerstroemia Speciosa* by using two different techniques for possible application as sensitizers in DSSCs. The *Lagerstroemia Speciosa* flower dye extracted by cold and soxhlet ethanol extraction gave a high photocurrent, voltage and with reasonable efficiency. This could be due to better interaction between the surface of the conducting oxide and the dye molecules. There is no significant difference in Photocurrent-Voltage with the amount of dye. This implies that the amount of adsorbed dye does not have direct correlation with the change in photocurrent. However, studies indicate the change in pH lowers the energy level of the electronic transition between the ground state and the excited states and in turn results in the absorption of photons at higher wavelength.

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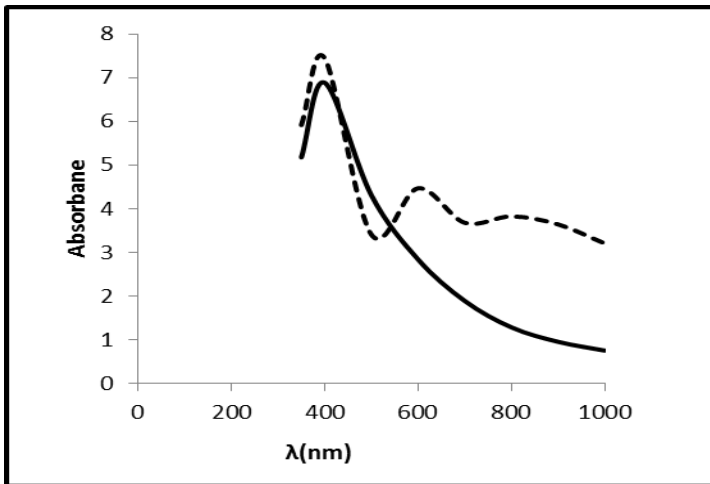


Fig.2 Absorbance of *Lagerstroemia Speciosa* (flower) Dye (— cold ethanol) and (----- soxhlet ethanol) extraction at normal pH of 1.0

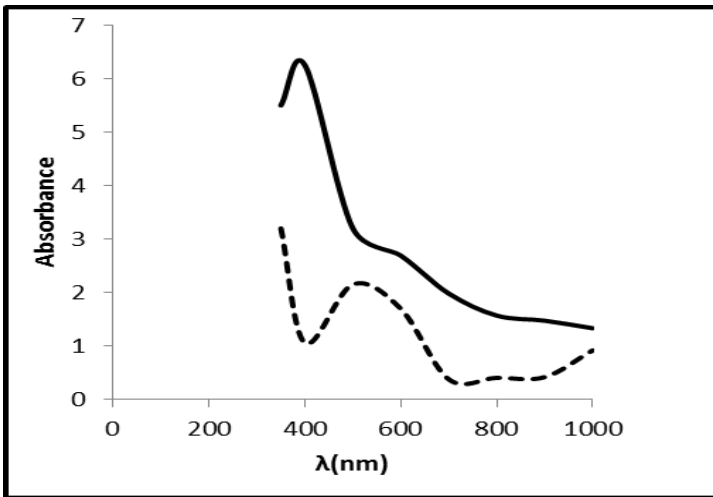


Fig.3: Absorbance of *Lagerstroemia Speciosa* (flower) Dye (— cold ethanol) and (----- soxhlet ethanol) extraction at pH of 2.00

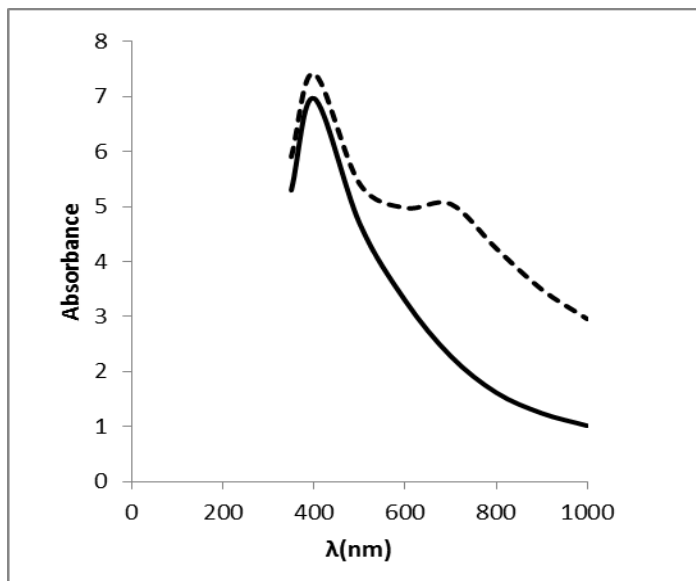


Fig.4: Absorbance of *Lagerstroemia Speciosa* (flower) Dye (— cold ethanol) and (----- soxhlet ethanol) extraction at pH of 3.0

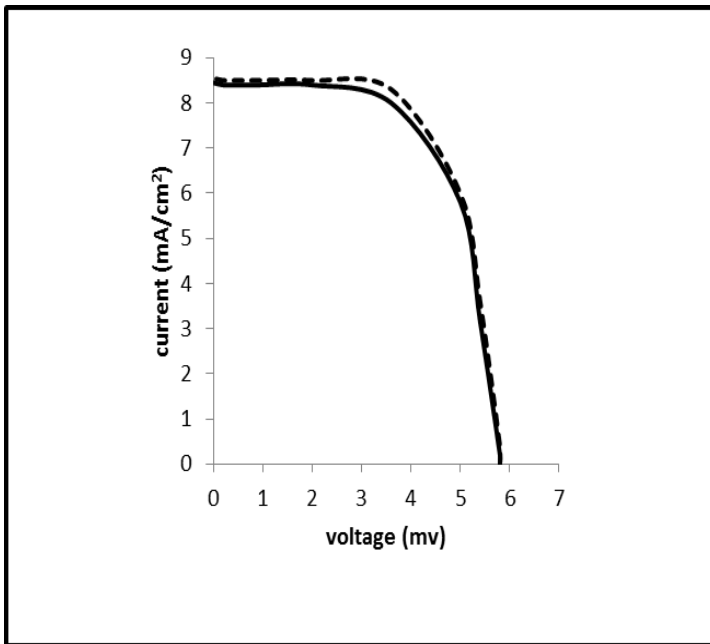


Fig. 5 Photocurrent-Voltage curves for *Lagerstroemia Speciosa* (flower) Dye (— cold ethanol) and (----- soxhlet ethanol)

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