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Fabrication and performance evaluation of Natural Dye Sensitized Solar Cells Using TiO_2 incorporated with Ag nanoparticles

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Abstract - *Dye Sensitized Solar Cell (DSSC) is the latest development in solar cells which attracts researchers due to low cost and nontoxic nature. In this paper, Ag incorporated TiO_2 was used as photoelectrode and hibiscus as dye to fabricate the DSSC. The effect of silver on the output of DSSC was evaluated. UV-Vis spectra characterization was done to confirm the nanoparticles.*

Key Words: Dye Sensitized Solar Cell (DSSC), Nanoparticles, Photoelectrode, UV-Vis spectra.

1. INTRODUCTION

The day-to-day increase in demand for energy requires more supply of energy [1]. It is mainly generated from non-renewable energy sources like fossil fuels. The usage of non-renewable energy sources emits greenhouse gases and other pollutants which affect the environment. In order to save the environment there is a need to reduce the pollution by developing clean and eco-friendly technologies using renewable energy sources [2].

Dye Sensitized Solar Cell (DSSC) belongs to a group of thin film solar cells [3-4]. It works on the principle of photosynthesis in plants. There are different types of dyes available. They are synthetic dyes and natural dyes [5]. In this paper, natural dye was choosen.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

Ethanol, Titanium Tetra Iso Propoxide (TTIP), Silver Nitrate, Trisodium Citrate, Iodine, Potassium Iodide, Triton X 100, Glacial Acetic acid. All the chemicals used were of analytical grade.

2.2 Synthesis of TiO_2 nanoparticles

Ethanol (150 ml) and 3.75 ml of deionized water were added and stirred for half an hour till formation of homogenous solution. 9 ml of TTIP was added drop wise into the homogeneous mixture. The reaction mixture was kept under agitation for 4 hours at 85°C under magnetic stirring. Later, the sample was dried in a hot air oven at 60°C for 30 min and calcined in a muffle furnace for 3 hours at 400°C to yield the anatase TiO_2 phase [6].

2.3 Synthesis of Ag nanoparticles

Silver nitrate ($AgNO_3$) and trisodium citrate ($Na_3C_6H_5O_7$) were used as precursors for the preparation of silver nanoparticles by using chemical reduction method. 50 ml of 0.001 M $AgNO_3$ solution was heated to boil. To this solution 5 ml of 1% $Na_3C_6H_5O_7$ was added drop by drop and stirred continuously while heating until the change of colour was observed. Then it was removed from the heating device and stirred until it cooled to room temperature [7-9].

2.4 Synthesis of Dye solution

Hibiscus flowers were shadow dried and the dried flowers were dipped in boiling distilled water until the formation of colour solution was observed. The obtained solution was used in the fabrication of DSSC.

2.5 Synthesis of Electrolyte

0.127 gm of Iodine (I_2) was added to 10 ml of ethylene glycol. After that 0.83 gm of Potassium Iodide was added and sonicated for 30 min for homogeneous mixing [10].

2.6 Preparation of Electrodes

0.2 gm of TiO_2 powder was ground for 30 min. Subsequently, 12 drops of glacial acetic acid, one drop of Triton X-100 and about 1.5 ml of ethanol was added until the mixture became a creamy paste. Ag nano colloidal solution was added to the paste [7] and sonicated for 1 hour to obtain a homogeneous mixture. This mixture was coated onto Fluorine doped Tin Oxide (FTO) glass restricting the cell active area 1cm^2. Dye solution was added to the coated area and the cell was dried. This forms the photo-electrode.

Counter electrode was prepared by depositing carbon on FTO glass using candle flame.

2.7 Performance evaluation of DSSC

DSSCs are prepared by incorporating different amounts of Ag nano colloidal solution into TiO_2 nanoparticles. The output power was measured every 30 min and compared with each other.

3. RESULTS

3.1 UV-Vis Spectra

UV-Vis spectra show the absorbance peak at 424 nm in Fig.1 which confirms the presence of silver nanoparticles in the colloidal solution.

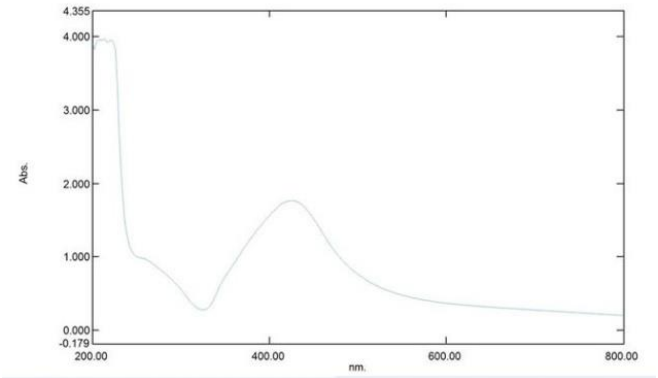

Fig.1: UV Spectrophotometer for silver nanoparticles

In Fig.2 the absorbance peak at 334 nm confirms the presence of TiO_2 nanoparticles.

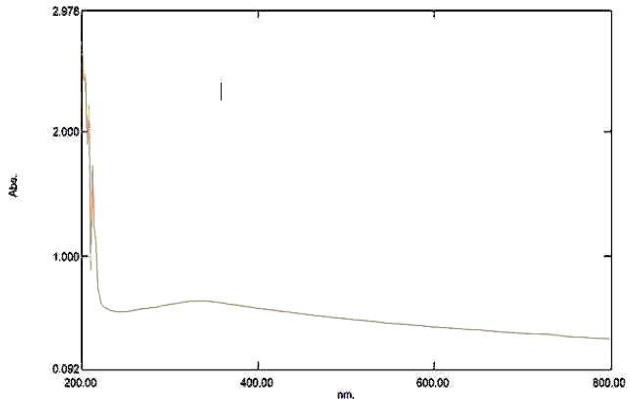

Fig.2: UV Spectrophotometer for TiO_2 nanoparticles

3.2 Performance evaluation of DSSC

The power output of DSSCs at different times is shown in Fig.3.

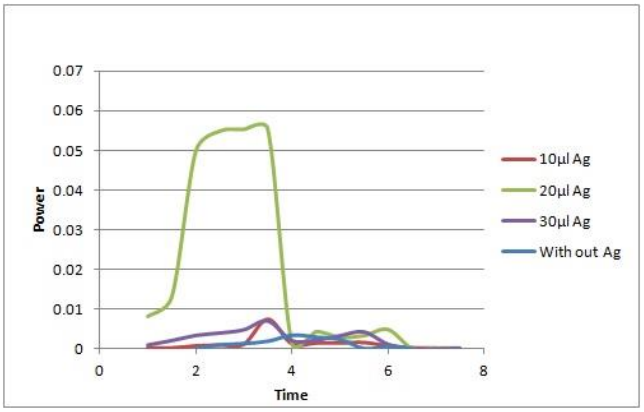

Fig.3: Output power of different DSSCs compared in the time interval of 10:00AM-4:00PM.

It is observed that among all DSSCs, the cell incorporated with 20µl of Ag nano colloidal solution shows high output power compared to other cells.

Further, those cells with incorporation of Ag nanoparticles have shown high power output at 12:30 PM (at 3.5 hrs) whereas the cell without Ag nanoparticles has shown peak power output at 1:00 PM (at 4 hrs). This is due to Surface Plasmon Resonance (SPR) effect of Ag [12-13].

4. CONCLUSIONS

DSSCs were fabricated with nano TiO_2 particles and different amounts of Ag nanoparticles incorporated into TiO_2 respectively using hibiscus as dye. Among them DSSC with 20 µl of Ag nanoparticles incorporated into TiO_2 has shown high performance compared to others.

5. REFERENCES

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