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AZOBENZENE DYE-SENSITISED SOLAR CELLS USING TiO_2 NANOPARTICLES AND CARBON NANOTUBES

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ABSTRACT

Dye-Sensitized solar cells (DSSC) were constructed using Azobenzene dye and TiO_2-SWCNT (Single Wall Carbon nanotube) composites and tested for their efficiency using the experimental method. Titanium dioxide (TiO_2) nanoparticles were prepared by sol-gel method and characterized by X-ray Diffraction (XRD). Azobenzene dyes were synthesized by chemical methods. UV-Vis spectrophotometry was used to confirm the synthesis of the dye. The prepared TiO_2-SWCNT composites were characterized byField Emission Scanning Electron Microscope(FESEM), and EDAX (Energy Dispersive Analysis of X Rays) methods. The DSSC assembly were prepared using glass slide coated with TUBALL^{TM}BATT [carbon nanotube (CNT) suspended in N-methyl-2-pyrrolidone (NMP) solution] solution and found to be less efficient. The DSSC assembly with Fluorine doped Tin Oxide (FTO) conducting glass showed comparatively higher efficiency.

Keywords: DSSC, Azobenzene, TiO_2-SWCNT composites, FESEM, UV-Vis spectrophotometry

I. INTRODUCTION

The energy demand of the world is increasing every year and the fossil fuels are depleting rapidly. More than 80% of world energy is provided by burning the fossil fuel which rises the amount of carbon dioxide in the atmosphere. Researchers are trying to provide renewable and clean energy technology such as biomass, tidal power, hydropower, and solar thermal [1, 2, 3].Solar cells are the device that is used for the conversion of light energy into electricity by the photovoltaic effect, which can be both physical and chemical phenomenon. It can be defined as a photoelectric cell whose electrical characteristics, such as voltage resistance, and current vary when exposed to light. These cells can be building blocks to creating a solar panel which has over 100-1000 of

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solar cells integrated on the panel. Regardless of the source, i.e. sunlight or any artificial light, they are termed as photovoltaic. They have found wide applications in the sensor industries as photo-detectors used in detecting electromagnetic radiations, light in the visible range or for measuring light intensity[4].O'Regan and Gratzel developed the first dye sensitized solar cell (DSSC) in 1991 by working on the principle of plant photosynthesis [5]. Research on DSSCs are fascinating as this type of thin film photovoltaictechnology has advantages like easeof fabrication,low cost of manufacturing, and light weight product [6].The present research work aimed to use synthesized Azobenzene, TiO_2 nanoparticles, and SWCNT with and without the use of conductive glass to compare the efficiency.

II. EXPERIMENTAL PROCEDURE

The chemicals employed in the present study are nitrobenzene, zinc dust, methanol, ethanol, sodium hydroxide, hydrochloric acid, isopropanol, and nitric acid (Merck, India), titanium tetraisopropoxide(Sigma Aldrich, India), single wall carbon nanotube, and TUBALL^{TM}BATT from OCSiAlPvt Ltd, Luxembourg. Conductive glass was purchased from ShilpentPvt Ltd, India.

Preparation of TiO_2 nanoparticles:For the preparation of TiO_2 nanoparticles isopropanol, titanium tetraisopropoxide, nitric acid, and distilled water were added to a beaker in the ratio 1: 10: 1: 0.2 and stirred well at 30°C, and 200 rpm for 3 hours. Further the mixture was aged for about 48 hours, continued sintering at 600°C for 3 hours [7, 8].The obtained powder was collected and characterized.

Preparation of TiO_2-SWCNT composite:For the preparation of TiO_2-SWCNT composites isopropanol, titanium tetraisopropoxide, nitric acid, and distilled water in the ratio 1: 10: 1: 0.2 and stirred well at 30°C, and 200 rpm for 3 hours. 0.2 g of SWCNT was added to the above solution and stirred for 1 hour. Further the mixture was aged for about 48 hours, continued baking at 80° C for 30 minutes.Final product obtained after baking was sintered using the muffle furnace with a temperature of 600°C. The elemental analysis and morphology studies were performed for the obtained TiO_2-SWCNT composite powder.

Preparation of Azobenzene dye: Azobenzene dye was prepared by chemical refluxing method using nitrobenzene, zinc dust, methanol, ethanol, and sodium hydroxide by the procedure available in literature [9]. The obtained Azobenzene dye was characterized by using UV-Vis spectrophotometer.

Preparation of conductive glass using TUBALL^{TM} BATT CNT solution: Conductive glass slides were prepared using TUBALL^{TM} BATT CNT solution by Doctor Blade method.

Assembly of DSSC: The DSSC was assembled using CNT coated glass slides, and conductive glasses separately.

The conductive glasses were checked for the conductive side. One of the glass was coated with TiO_2-SWCNT composite, and the other with azobenzeneusing spin coatingat 3000 rpm for 80 seconds. After adding three drops of iodine solution, both the coated glass was placed on top of each other with the coated sides facing each other. These were held using tapes.The formed solar cell was then tested.

XRD patterns were recorded by using Bruker D2 phaser instrument. FESEM and EDAX were done using ZEISS Sigma FESEM 300 with EDS geometry of ZEISS Sigma 500. UV-Vis spectrophotometry (Systronics, India), Spin Coater, and Solar Cell Experiment Setup (Kamaljeeth Instruments, India) were also used.

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III. RESULTS AND DISCUSSIONS

XRD analysis:

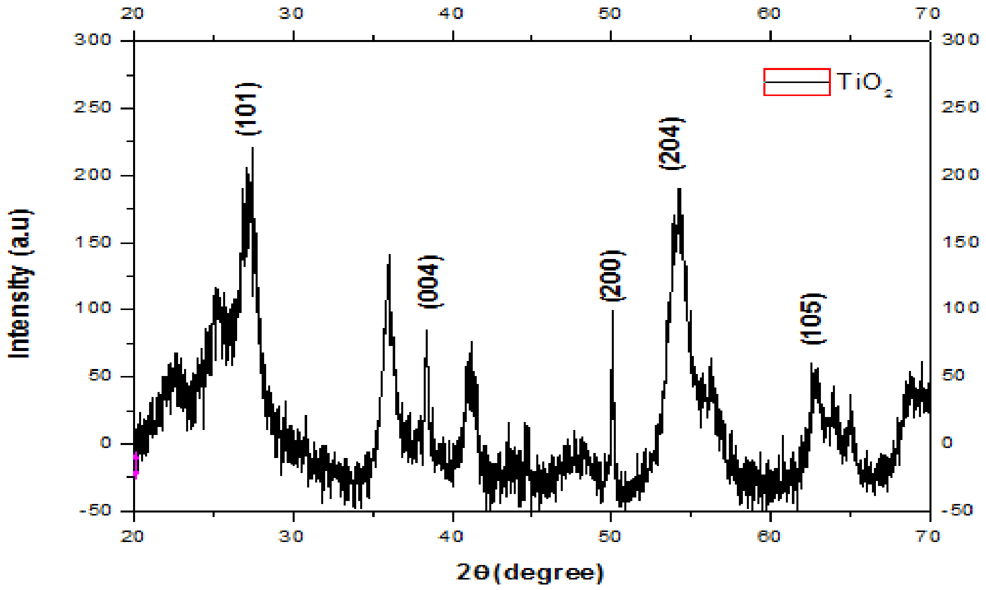

Figure 1: XRD peaks obtained for TiO_2 nanoparticles

The synthesized TiO_2 nanoparticles were characterized using X-ray diffraction technique to get the phase and confirmation of presence of TiO_2. The peaks obtained (Fig. 1) at 2θ values are 27.3°, 38.92°, 50.05°, 54.21°, 62.55° corresponds to the crystal planes (101), (004), (200), (105), (204) respectively indicating the formation of anatasephase of TiO_2 were studied and TiO_2 nanoparticles. The crystal structure of TiO_2 was found out to be Face Centered Cubic (FCC) was confirmed from literature report [10].

UV-Vis Spectroscopy:

The UV-Vis spectroscopy reading obtained for the prepared sample showed a broad peak at 333 nm (Fig. 2). This is the absorbance range of Azobenzene,which confirm the synthesis of Azobenzene [8].

FESEM:

The FESEM images obtained shows that SWCNT was blended well with TiO_2 nanoparticles (Fig. 3 (a)). The 200 nm resolution image shows the presence spherical shaped TiO_2 nanoparticles (Fig. 3 (b)). The size of the TiO_2nanoparticle was estimated to be at 40-50 nmusing IMAGE J software.

EDAX:

EDAX was done on the TiO_2-SWCNT composite. The EDAX image and composition analysis graph is shown in Fig 4, and Fig. 5 respectively. From EDAX the composition of the mixture was analyzed (Table 1). The composition analysis shows that the TiO_2-SWCNT composite contains 25.39% carbon, 23.84% titanium, and 50.77% oxygen.

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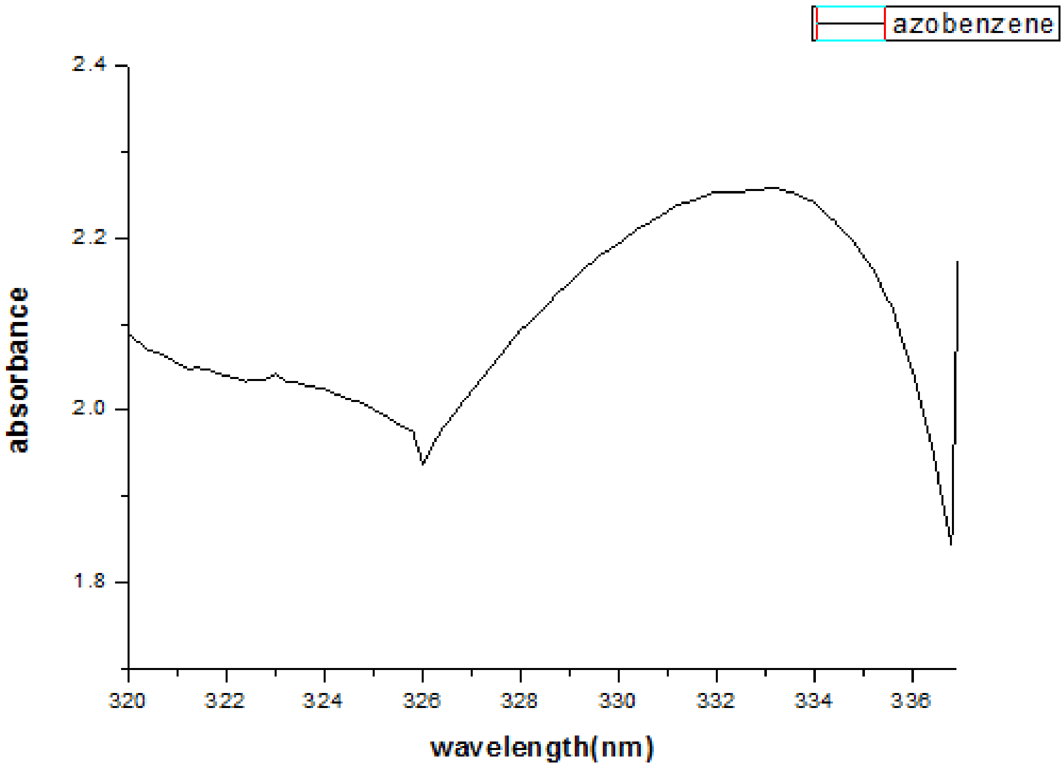
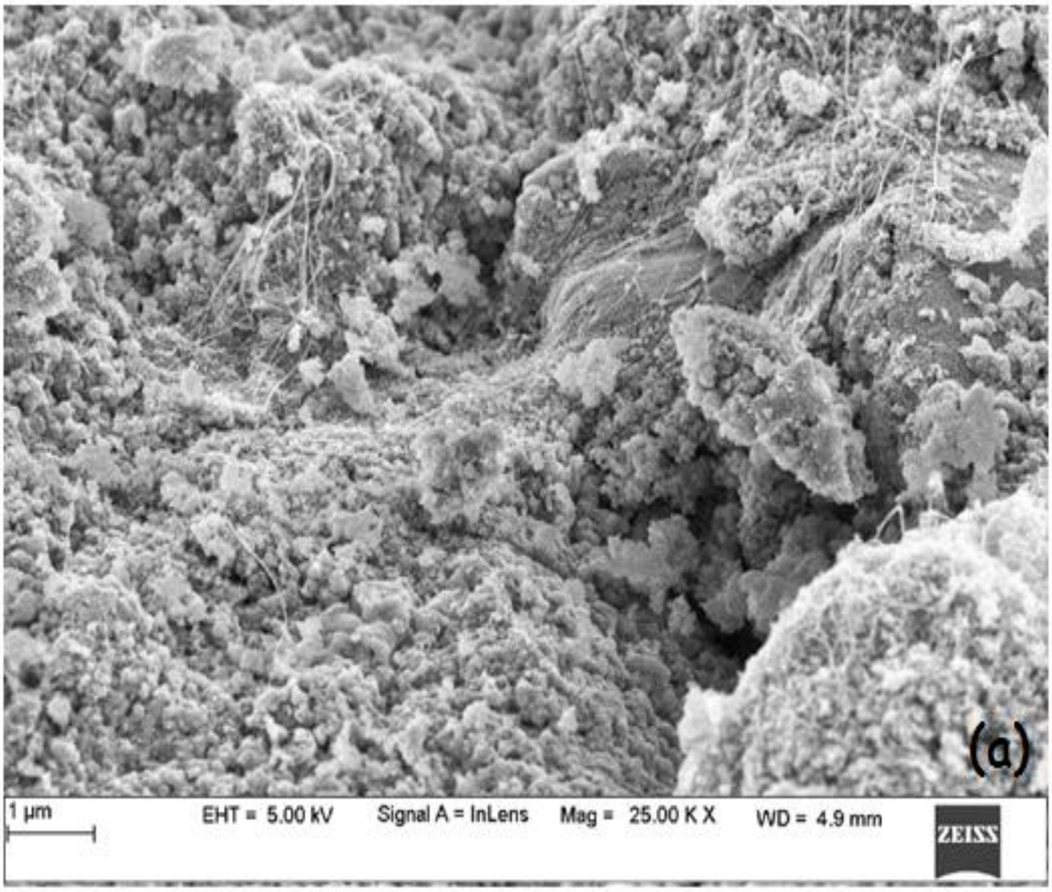


Figure 2: UV-Vis Spectrophotometric graph of Azobenzene



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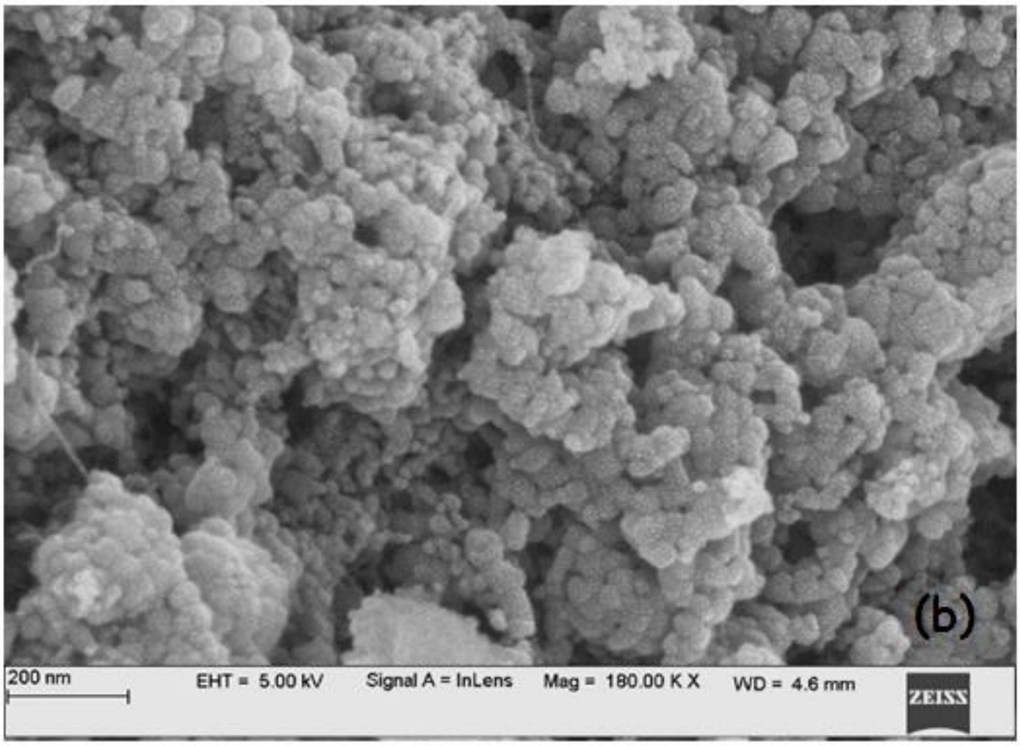

Figure 3: FESEM Image of TiO_2-SWCNT composite

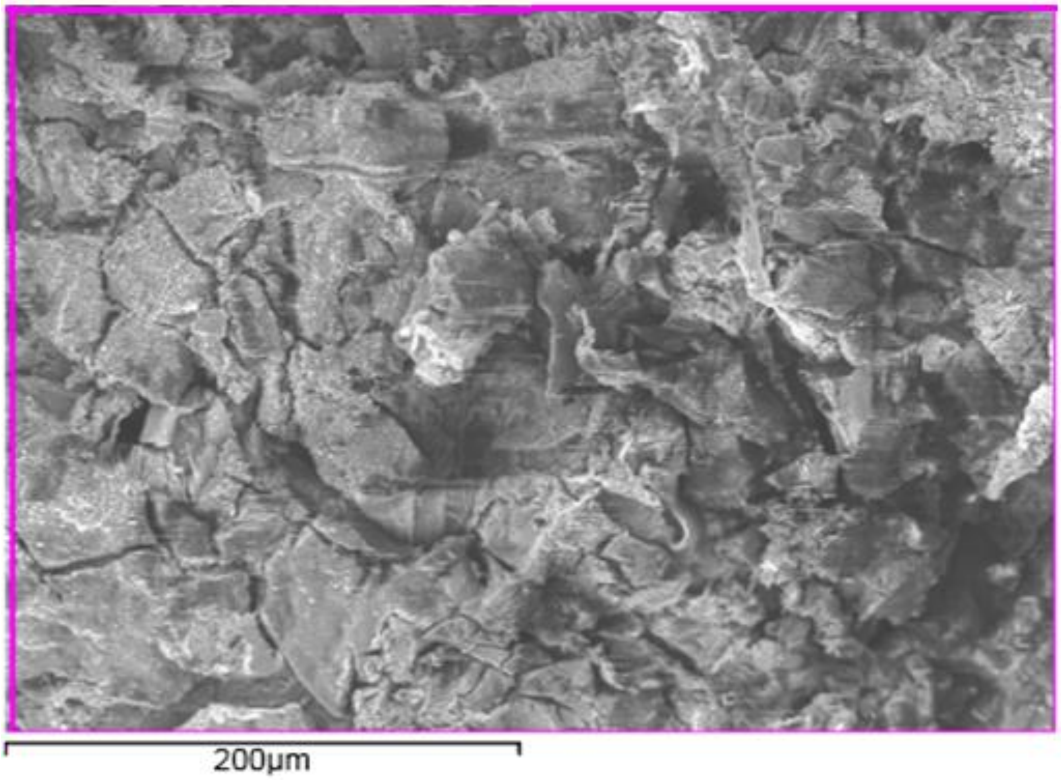

Figure 4: EDAX image of TiO_2-SWCNTcomposite

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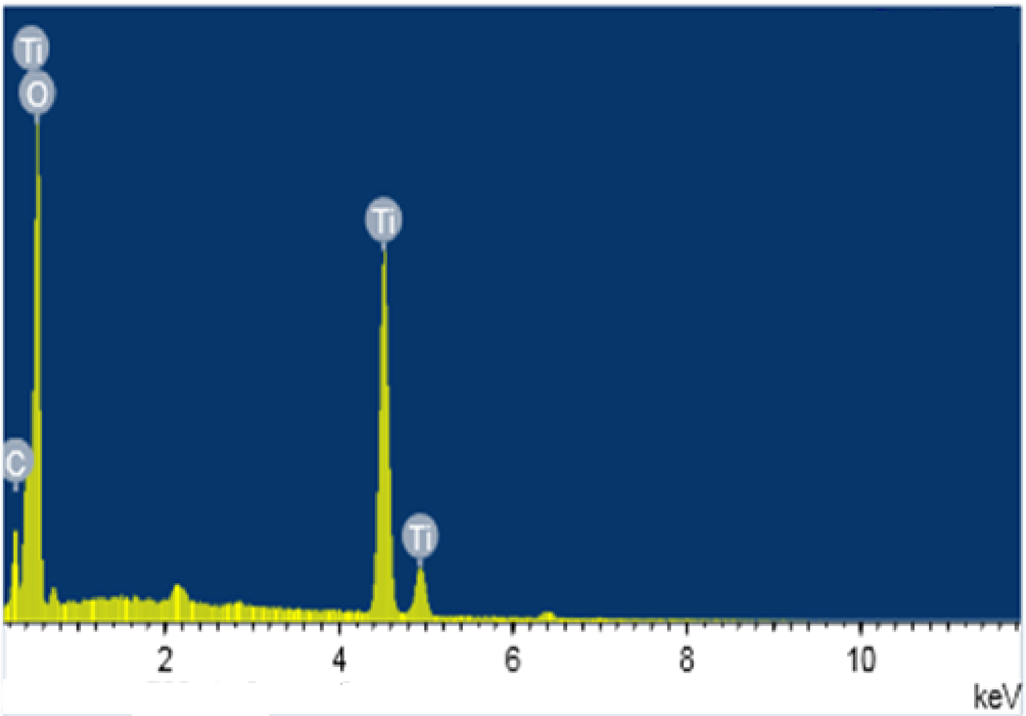

Figure 5: EDAX composition analysis of TiO_2-SWCNTcomposite

Table 1: EDAX chemical composition analysis

Element	Atomic %
O K	50.77
Ti K	23.84
C	25.39

Solar cell testing and efficiency:

The assembled DSSC with TUBALL^{TM} BATT CNT coated glass slides showed higher resistance, and the efficiency was found to be less. The assembled DSSC with conductive glass slides were used for efficiency testing.

The efficiency of the solar cell was calculated using the following formula (1): [11]

Efficiency (η) = Pmax/(E*Ac) ………………… (1)

Where ‘Pmax’, ‘E’, and ‘Ac” are the maximum power obtained, light intensity in W/cm2, and surface area of the solar cell, and found to be 0.156 mW, 0.055 W/cm^2, and 100 cm^2, respectively. The calculated efficiency for a single DSSC was 2.83%.

VI. CONCLUSION

TiO_2 nano particles were synthesized and confirmed using XRD. Later the synthesized TiO_2 nano particles were functionalized with SWCNT to get TiO_2-SWCNT composite. This was confirmed using FESEM and the particle size obtained was around 40-50 nm. The particles were in spherical shape for TiO_2 and carbon nanotubes were firmly bonded to TiO_2 nanoparticles. Azobenzene dye was synthesized and was characterized by UV-Vis spectrophotometer. Absorbance of Azobenzenewasfound to be at 333 nm. Conductive glasses were prepared

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using TUBALL^{TM}BATT showed high resistance and the assembled DSSC had low efficiency. The efficiency of assembled DSSC with FTO conductive glass was calculated using the solar cell efficiency setup. The efficiency for a single DSSC of 100 cm^{2}was found to be 2.83%. The efficiency can be further improved by increasing the light absorbance of the dye, controlling the size distribution, and functionalization of TiO_2-SWCNT.

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