INTERNATIONAL JOURNAL FOR TRENDS IN ENGINEERING & TECHNOLOGY
VOLUME 36 ISSUE 1 – MAY 2019 - ISSN: 2349 – 9303

Design and Performance Analysis of Multilayer Coating of SnO_2 Doped TiO_2 Coated Photovoltaic Solar Cells

Mr. S.Arun kumar[1]
[1]Assistant Professor(Supervisor),
Department of Mechatronics Engineering,
Kongu Engineering College,Perundurai,
Erode-638060,TamilNadu,India.
arunmts12@gmail.com

P. Ajithkumar[2]
[2]U.G.. Scholar,
Department of Mechatronics Engineering,
Kongu Engineering College,Perundurai,
Erode-638060,TamilNadu,India.
ajithprakash998@gmail.com

B. Aneesh[3]
[3]U.G.. Scholar,
Department of Mechatronics Engineering,
Kongu Engineering College,Perundurai,
Erode-638060,TamilNadu,India.
aneeshbharathi999@gmail.com

E. Balaji[4]
[4]U.G.. Scholar,
Department of Mechatronics Engineering,
Kongu Engineering College,Perundurai,
Erode-638060,TamilNadu,India.
rajubalaji0057@gmail.com

N. Nithyavathy[5]
Assistant Professor
Department of Mechatronics Engineering,
Kongu Engineering College,Perundurai,
Erode-638060,TamilNadu,India.

Abstract— This investigation deals with the synthesis of pure SnO_2 doped TiO_2 nanoparticles and fabrication of solar cell by hydrothermal method. The preparation of pure TiO_2 involves mixing of Titanium Tetrachloride and Tin Chloride with double distilled water taken as first precursor solution and Ammonia solution was taken as one of the precursor solutions. The titanium precursors were added dropwise into the first precursor under vigorous stirring in room temperature with an equal interval of time. The photocatalytic activity of the SnO_2-mixed TiO_2 nanoparticles dramatically increased. The increased photocatalytic activity is mainly attributed to the improved charge separation of the TiO_2 nanoparticles with the SnO_2. The Obtained nanoparticles are coated in the solar cells and the solar cells are tested with several characterizations. After performing the post-synthesis treatments of SnO_2 doped TiO_2, the fine nanopowders are obtained. To assess the physical and chemical properties of the powders, they were characterized using FTIR, E-DAX, UV-VIS SEM analysis. The band gap of TiO_2 nanoparticles was identified by UV-VIS spectral analysis. SEM analysis which revealed the morphology of the TiO_2 nanoparticles E-DAX which confirms the purity of TiO_2 nanoparticles. The Efficiency analysis is done on several layers of coated solar cells.

Index Terms— Efficiency, Nanoparticles. Photocatalytic. Solar cell. Temperature.

1 INTRODUCTION

Renewable energy is the energy which is collected from renewable resources, which are naturally available, such as sunlight, wind, rain, tides, waves, and geothermal heat [4]. Solar energy is an important source of renewable energy resources. Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.A solar cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, in which electrical characteristics, such as current, voltage, or resistance vary when exposed to light. Generally, a single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts[3]. The working mechanism of solar cells is based on the three factors: Adsorption of light in order to generate the charge careers, holes (p-type) and electrons (n-type), Separation of charge careers, and the collection of charge careers at the respective electrodes establishing the potential difference across the p-n junction[10].

The photovoltaic (PV) effect was first observed by Alexandre-Edmond Becquerel in 1839. Earlier photovoltaic solar cells are thin silicon wafers that transform sunlight energy into electrical power [4]. The modern photovoltaic technology is based on the principle of electron-hole creation in each cell composed of two different layers (p-type and n-type materials) of a semiconductor material, as shown in Figure 1.1. In this arrangement of the structure, when a photon of sufficient energy impinges on the p-type and n-type junction, an electron is ejected by gaining energy from the striking photon and moves from one layer to another [10]. This creates an electron and a hole in the process and by this process, electrical power is generated.

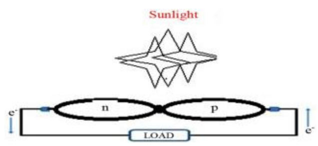

Figure 1.1 Photovoltaic Effect

2 EXPERIMENTAL SECTION

2.1 Preparation Of TiO_2 Amorphous Gel Nanoparticles

Titanium tetrachloride($TiCl_4$) was used as a starting material. When $TiCl_4$ was dissolved in water, the exothermic reaction and hydrolysis reaction, which generated $Ti(OH)_4$, was occurred [2]. To prevent the hydrolysis reaction and reduce the exothermic reaction rate, titanium tetrachloride was dissolved in ice water and adjusted to 1 M titanium solution. TiO_2 amorphous particles were prepared by neutral precipitation of 0.5 M titanium tetrachloride aqueous solution with ammonia aqueous solution as a neutral agent [6]. The white precipitate was washed with double distilled water until Cl^- and NH_4^+ ions were removed (usually 5 times washing). The precipitates were dried by freeze dryer [9]. The final particles were amorphous in nature and their average particle size was around 5 nm [11].

2.2 Synthesis Of SnO_2 Mixed TiO_2 Nanoparticles

TiO_2 and SnO_2 gel nanoparticles were dispersed in 70 ml of double distilled water (SnO_2 content = 0-10 atomic %) [9]. The SnO_2 is weighed for 22.563 gm to dissolve in distilled water [7]. The Electrical Weighing balance is used to obtain the accurate weight of the sample. The SnO_2 gel nanoparticles were prepared by the same synthesis method of TiO_2 gel nanoparticles [1].

The final solution was adjusted to pH value less than 1 to make the solution completely soluble and more acidic. The final solution (pH less than 1) was transferred to the Teflon lined hydrothermal bomb [2]. The Hydrothermal treatment is done using Autoclave apparatus [5]. An Autoclave is a pressure chamber that is used to sterilize equipment and supplies. When these items are placed inside the autoclave they are exposed to high-temperature steam for about twenty minutes [8]. The equipment specifications for the Autoclave apparatus is tabulated as shown in table 4.1.After hydrothermal treatment, the obtained product was washed with double distilled water using magnetic stirrer. The Magnetic Stirrer is set 1000 RPM speed for 30 minutes for every time of washing.

3 RESULTS AND DISCUSSION

3.1 UV-VIS Spectroscopy

The Light absorbance at different wavelengths are showed in the graph which is shown in figure 3.1. From the UV-VIS Graph, the energy band gap voltage is found as 3.48eV.

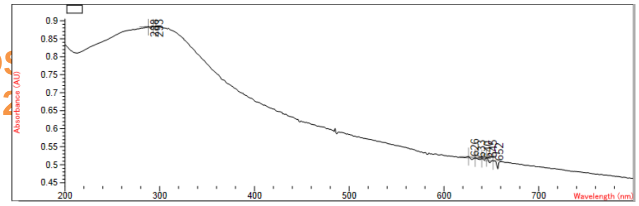

Figure 3.1 UV-VIS Graph

3.2 Fourier Transform Infrared Spectroscopy

Fourier-transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high-spectral-resolution data over a wide spectral range. The FTIR results give the chemical bonding at different light absorbance values. The FTIR results are analyzed with the help of IR Chart. The Chemical Bond formation is tabulated as shown in table 3.1.

Table 3.1 FTIR analysis with IR Chart

Absorption (Cm^{-1})	Bond Strength	Bond Nature	Bond Structure	Formation	Bond Name
3850.7	Medium	Sharp	O-H	Stretching	Alcohol
3370.1	Medium	-	N-H	Stretching	Aliphatic Primary amine
2921.0	Strong	Broad	N-H	Stretching	Amine Salt
1625.57	Strong	-	C=C	Stretching	α,β-Unsaturated Ketone
1385.06	Medium	-	C-H	Bending	Alkane
1117.08	Strong	-	C-O	Stretching	Secondary Alcohol
1021.02	Strong	-	C=C	Bending	Alkene
660.58	Strong	-	C=I	Stretching	Halo Compound

3.3 Field Emission Scanning Electron Microscope Analysis

The Field Emission Scanning Electron Microscope (FESEM) has a much brighter electron source and smaller beam size than a typical SEM increasing the useful magnification of observation and imaging up to 500,000x. The FESEM images of SnO2 doped TiO2 coated solar cells at different ranges[12]. The FEESEM image at 2µm is shown in figure 3.2. These images give the details of coating layers and types of nanostructures formed in the coating layers.

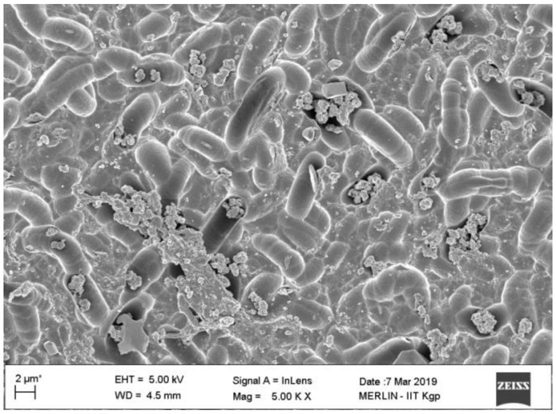

Figure 3.2 FESEM image at 2µm

4.4 I-V Characterization

Solar Cell I-V Characteristic Curves show the current and voltage (I-V) characteristics of a particular photovoltaic (PV) cell, module or array giving a detailed description of its solar energy conversion ability and efficiency. The Coated Solar cells with the tapping wire are to be taken for the IV characterization. The IV meter has two output wires and these wires are connected to the cathode and anode terminal wires of the coated solar cells. The Mercury lamp is switched on and the input power is fixed to 150 W/m2. With this input power, the current and voltage readings are noted. The current and voltage values are noted for several coating layers using the IV meter. These current and voltage readings are tabulated in table 3.3.

Table 3.2 Closed environment I-V Readings

No. of. layers coated	Voltage (v)	Current (mA)
Uncoated	0.360	7
1	0.502	40
2	0.506	39.4
3	0.506	33.7
4	0.507	38.5
5	0.483	38.7

5 CONCLUSION

The Nanoparticles of SnO2 doped TiO2 are synthesized using hydrothermal treatment with the autoclave apparatus with equal molar concentration 1M. The coating of the solar cells is varied with different layers like 1,2,3,4,5 layers. It is inferred that the enhanced charge separation contributed to the increase of photocatalytic activity. The SnO2-doped TiO2 nanoparticles showed the increase of photocatalytic activity with increasing of Ti contents. This should be due to both the increase of the energy bandgap of 3.48eV by Sn-doping and decrease of particle size. It achieves a maximum efficiency of 7.13%.

References

[1] Akhir, M.A., Mohamed, K., Lee, H.L. and Rezan, S.A., 2016. Synthesis of tin oxide nanostructures using hydrothermal method and optimization of its crystal size by using statistical design of experiment. Procedia Chemistry, 19, pp.993-998.
[2] Choi, H.G., Yong, S.M. and Kim, D.K., 2012. Synthesis and photocatalytic properties of SnO2-mixed and Sn-doped TiO2 nanoparticles. Korean Journal of Materials Research, 22(7), pp.352-357.
[3] Green, M.A., Emery, K., Hishikawa, Y., Warta, W. and Dunlop, E.D., 2013. Solar cell efficiency tables (version 41). Progress in photovoltaics: research and applications, 21(1), pp.1-11.
[4] Hersch, P. and Zweibel, K., 1982. Basic photovoltaic principles and methods (No. SERI/SP-290-1448). Solar Energy Research Inst., Golden, CO (USA).
[5] Kavitha, M., Gopinathan, C. and Pandi, P., 2013. Synthesis and characterization of TiO2 nanopowders in hydrothermal and Sol-Gel method. International Journal of Advancements in Research & Technology, 2(4), pp.102-108.
[6] Kumar, A. and Pandey, G., 2018. Different Methods Used for the Synthesis of TiO2 Based Nanomaterials: A Review. American Journal of Nano Research and Applications, 6(1), p.1.
[7] Kumar, V., Singh, K., Singh, K., Kumari, S., Kumar, A. and Thakur, A., 2016, May. Effect of solvent on the synthesis of SnO2 nanoparticles. In AIP Conference Proceedings (Vol. 1728, No. 1, p. 020532). AIP Publishing.
[8] Pi, X., Li, Q., Li, D. and Yang, D., 2011. Spin-coating silicon-quantum-dot ink to improve solar cell efficiency. Solar Energy Materials and Solar Cells, 95(10), pp.2941-2945.
[9] Sharma, A., Karn, R.K. and Pandiyan, S.K., 2014. Synthesis of TiO2 nanoparticles by sol-gel method and their characterization. J. Basic Appl. Eng. Res, 1(9), pp.1-5.
[10] Sharma, S., Jain, K.K. and Sharma, A., 2015. Solar cells: in research and applications—a review. Materials Sciences and Applications, 6(12), p.1145.
[11] Viet, P.V., Thi, C.M. and Hieu, L.V., 2016. The high photocatalytic activity of SnO2 nanoparticles synthesized by hydrothermal method. Journal of Nanomaterials, 2016.
[12] Wu, L., Yan, H., Li, X. and Wang, X., 2017. Characterization and photocatalytic properties of SnO2-TiO2 nanocomposites prepared through gaseous detonation method. Ceramics International, 43(1), pp.1517-1521.