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SYNTHESES TiO_2 NANOCOMPOSITE USING EVAPORATION-INDUCED SELF-ASSEMBLY (EISA) METHOD FOR DSSC

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ABSTRACT

The objective of this study is to synthesize mesoporous titania using the Evaporation-Induced Self-Assembly (EISA) method. The samples were annealled at 400°C for 4 hours. Then the titania was pasted onto FTO glass and immersed in dye N719 for several hours. TiO_2 using EISA method and time immersing in the dye were prepared for comparison. Titanium Tetra Isopropoxide ($Ti(O_iPr_4)$) was chosen as a precursor and Trymethil Ammonium Bromide (CTAB) as a surfactant. From SEM results, TiO_2 EISA produced small TiO_2 particles with high porosity and compact particles. From XRD spectrum, *anatase* phase had been produced by using this EISA method. Percentage efficiency for TiO_2 EISA that being immersed in the dye for 12 hours, and 6 hours is about 2.81% and 2.24%, respectively. The results show that TiO_2 gave a good result in terms of efficiency and will lead to a better DSSC system.

Keywords: EISA method;, titania; FTO glass; N719 dye; DSSC

INTRODUCTION

Dye-sensitized solar cells (DSSC) have been extensively studied in the last decade as a promising photovoltaic technology, because of their potentially inexpensive manufacturing technology compared to silicon solar cells. Dye-sensitized solar cell (DSSC) consists of a dye-adsorbed porous TiO_2 layer on fluorine-doped tin oxide (FTO) glass as a working electrode, a Pt thin film counter electrode and an electrolyte normally containing $I^-/I3^-$ redox couple [1–3]. Under the illumination of solar light, dye molecules are excited and electrons are produced. To generate meaningful electrical power from DSSC, the electrons need to pass four important interfaces of DSSC: dye/TiO_2, TiO_2/FTO, electrolyte/counter electrode, and dye/electrolyte. The nanoporous nature of the TiO_2 layer provides high surface area that is of great importance to the efficient photon-to-electricity conversion because it enhances dye loading and solar light absorption [5]. However, it also provides abundant TiO_2 surface sites (direct route) and bare FTO conducting sites (indirect route), where the photoinjected electrons may recombine with $I3^-$ species in the redox electrolyte ($2e^- + I3^- \rightarrow 3I^-$). The recombination will cause the loss of the photocurrent. So the photovoltaic performance of DSSC is seriously decreased [6-7].

TiO_2 has been widely used in various devices such as dye sensitized solar cells (DSSCs), photocatalysts, photochromic glasses, gas sensors, and for applications such as self cleaning of windows [8-10]. After years of evolutionary research on the production of TiO_2 nanopowder, many technologies that are based on build-up processes such as the gas phase process, liquid phase process, and solid phase process have been practically developed [11-12] In most cases, TiO_2 powder is synthesized through gas-phase reactions such as the combustion of titanium tetrachloride and liquid-phase reactions such as the precipitation of titanium hydroxide followed by calcinations [13]. The gas-phase process yields fine well-crystallized particles; however, the reproducibility of this process is low due to its complicated mechanism. The liquid-phase process is simple and can also be carried out in laboratories; however, its drawbacks are that it needs a large amount of organic materials and it is difficult to obtain particles with both a large surface area and high crystallinity. Therefore, there is a need to develop a simple and efficient method to obtain TiO_2 nanoparticles with a narrow size distribution and high crystallinity [14-15].

METHOD

Synthesis of TiO_2 solution

The CNT/TiO_2 nanocomposite was prepared by using the Evaporation-Induced Self-Assembly (EISA) method. To make the solution, firstly two liquids solution were separately produced and combined at the end of this method. For the first solution, 2.9156g CTAB was blended with 43ml EtOH and stirred for 30 minutes. For second solution, 15ml EtOH was blended with 2.13mL HCl and stirred for 5 minutes. Then 14.89ml Titanium tetraisopropoxide ($Ti(OiPr_4)$) was dropped in small amount using pipette into the mixture of EtOH and HCl. After that the two solutions were combined, and the second solution was drop into the first solution and stirred for more than 10 minutes. Then 15ml distilled water was put into the solution and vigorously stirred for 30 minutes and lastly the gel look solution was transferred into a beaker glass beaker and put into an oven for 7 days at 60°C.

Preparation of TiO_2 thin films and solar cells

The thin TiO_2 films were prepared by applying a nanocomposite sample on an electric conducting glass plate. Fluorine-doped tin oxide (FTO) was used as an electric conducting plate. This mixture was doctor-bladed onto the support to generate a $1.0cm^2$ active area, and dried at room temperature for 1 hour. Subsequently, the electrodes were sintered in the air at 400°C for 30 minutes, generating a crack-free, high surface area TiO_2 nanocomposite electrode, the paste was immersed in N719 dye for 1 day.

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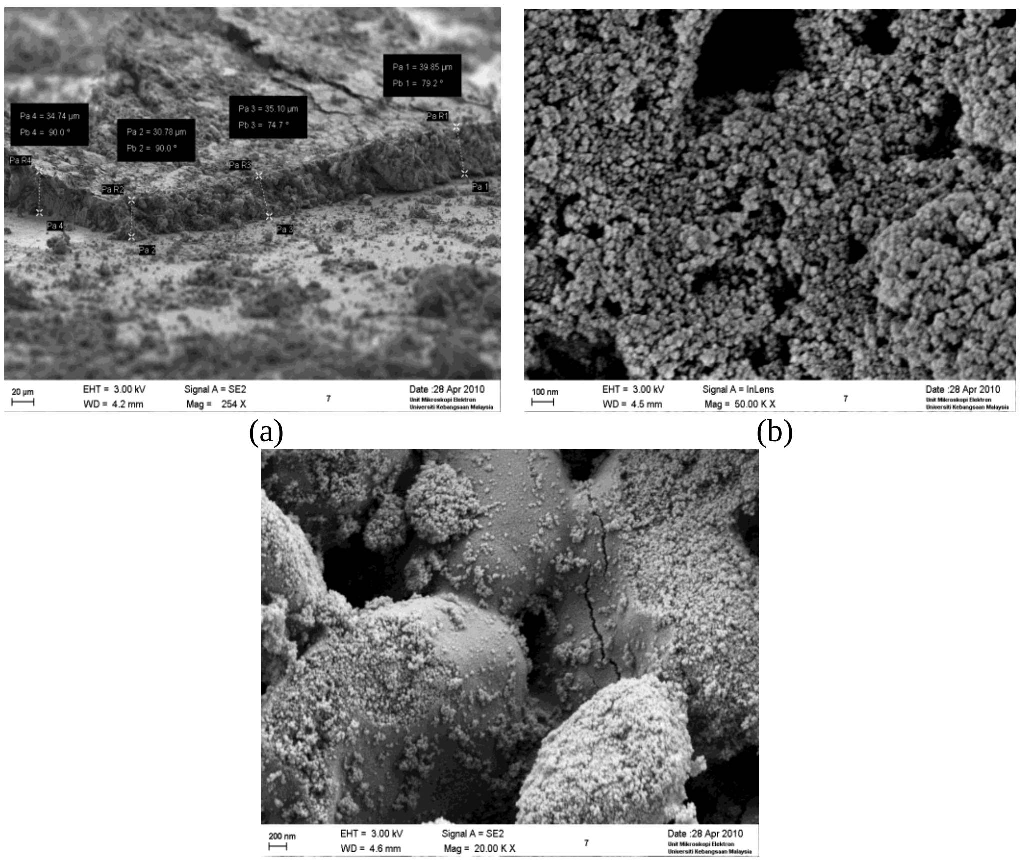
RESULTS AND DISCUSSIONS

Scanning Electron Microscopy (SEM)

The SEM analysis provides microscopic information of the surface structure and morphology of the samples. In this work, it is really a helpful technique to determine the growth mode via the study of a surface roughness, and to determine the effect of the different annealing temperature on the paste samples morphology. From figure 1, the thickness of the paste sample is around 35.10µm with annealing for 400ºC in 4 hours. The measurement range is from 20µm to 200nm and with different magnification 20K x and 50Kx. The surface morphology of the TiO_2 shows that the porosity of the paste is high and the structure is quite compact.



(a) (b)

(c)

Figure 1: SEM images for TiO_2 thin film sample annealing for 400ºC for 4 hours

X-ray Diffraction (XRD)

Figure 2 presents the X-ray diffraction (XRD) results of the mesoporous TiO_2 that were prepared by the Evaporation-Induced Self-Assembly (EISA) method. The XRD patterns show that anatase phase can be identified in the nanocomposite; the rutile and brookite phase of TiO_2 was not observed. The XRD peaks were measured from angle range 20° -

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60° at 2θ position. The lattice point that had been found at 2θ position of 25.48°, 27.47°, 30.76°, 48.08° and 54.41° are (101) (004) (112) (200) and (105) for temperature 400°C. The TiO_2 major peak is located at 25.48º with lattice point of (101). The anatase phase and crystalline structure are the important factor for this dye sensitized solar cell study. This is because anatase phase has bigger bandgap around 3.2eV compare to rutile phase but anatase phase also could be interrupted by the impurity that changing it from anatase to rutile phase.

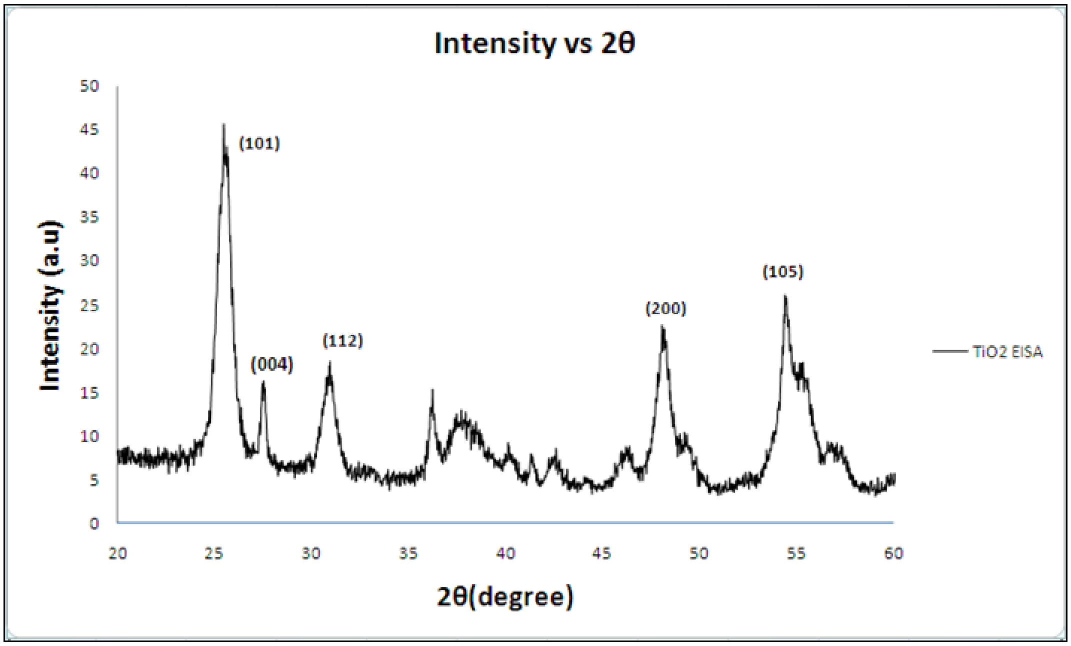

Figure 2: The XRD pattern of TiO_2 paste sintered at 400°C for 4 hours

I-V Curve

In Figure 3, the current–voltage curve of the sample for 100 Wm^{-2} illuminations is shown. The short-circuit current *(J_{sc})* is the maximum current value achieved when the cell is short-circuited. The open-circuit voltage *(V_{oc})* is given by the potential difference between the TiO_2 conduction band edge and the electrochemical potential of the redox couple in the N 719 electrolyte. The fill factor (FF, the ratio between the maximum cell output power and the product V_{oc} x I_{sc}) and energy conversion efficiency (η) with respect to incident light were measured. The parameter values are shown in Table 1.

Table 1: Table for IV curve graph parameter

Indicator	N719 – 6 hours	N719 – 12 hours
V_{oc} (V)	0.60	0.68
J_{sc} (mA/cm^2)	8.38	7.51
Fill Factor, FF	0.44	0.54
η (%)	2.24%	2.81%

From table 1 above, it show that the open-circuit voltage *(V_{oc})* are 0.6V for 6 hours and 0.68V for 12 hours and the short-circuit current *(J_{sc})* are 8.38mA/cm^2 for 6 hours and 7.51mA/cm^2 for 12 hours. For the fill factor (FF) percentage value are around 0.44 and 0.54 calculated from the maximum cell output power and the product (V_{oc} x I_{sc}). The efficiency (η) for this EISA TiO_2 are 2.24% for 6 hours and 2.81% for 12 hours immersed in N719 dye.

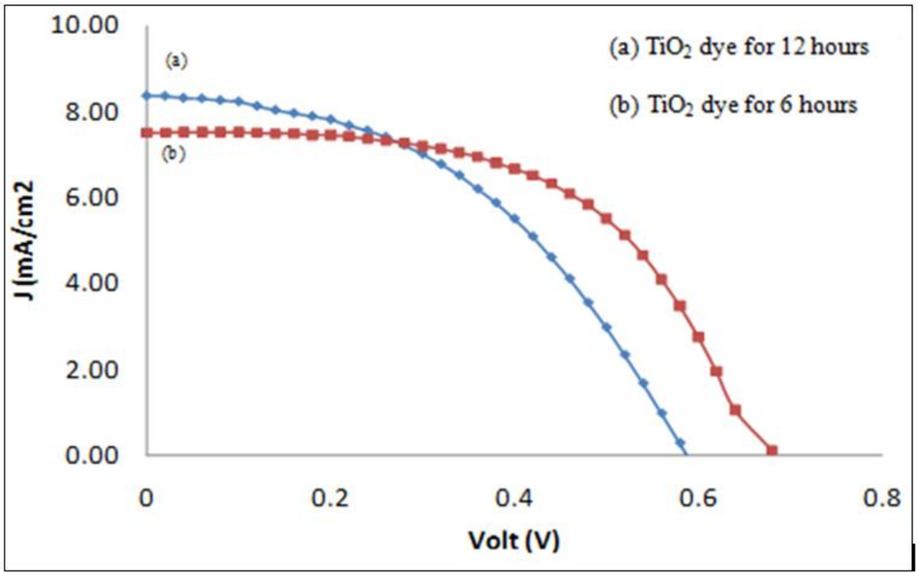

Figure 3: The IV curve graph of TiO2 thin film paste immersed in N719 dye for (a) 12 hours and (b) 6 hours

CONCLUSION

In conclusion it is shows that the TiO_2 particles using EISA method are composed of (101) plane, anatase type with major peak of 25.48° at 2θ position for temperature of 400°C. The SEM analysis showed the porosity of the thin film is high and in compact shape with thickness around 35.10μm after annealled at 400°C for 30 minutes. The time immersed in N719 dye give some effect to the value of the efficiency (η) calculated from I-V curve. It shows that the 12 hours of immerse ion the in dye with 2.81% give higher efficiency value as compared to 6 hours of immerse ion in the dye with 2.24%. This shows that from the time of immerse ion in the dye, better efficiency percentage for dye-sensitized solar cell is expected.

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