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Synthesis TiO_2 with doctor blade technique for dye sensitized solar cell

Surasak Santhaveesuk[a,e1]

[a]Program in physics, sakon nakhon Rajabhat university, 47000, Thailand,
[e1]Corresponding authors; e-mail: surasak31@windowslive.com, Tel mobile :+66 42 970030,
Fax :+66 42 970029

Abstract

A synthesis TiO_2 by sol-gel method with doctor blade technique for dye sensitized solar cell. Was prepared by doctor blade technique. The TiO_2 powder 79.90 % was mixed into 0.1 M. nitric acid (HNO_3) solution adding DI water until p^H 3 – 4 completely and added Triton X-100 for surfactant. Based on was coated on TCO glass by doctor blade technique. And sintered at 450°C for 30 minutes obtaining thin film. Then a prepared polymer gel electrolyte by adding iodide salt potassium (KI) and iodine (I_2) into γ-butryrolactone gelated with 1-methyl-3-propylimidazoliumiodide and 1,2,4,5-tetrakisbromo methylbenzene as a mixture solvent. The maximum ionic conductivity of KI, polymer gel electrolyte was 2.37ms/cm at 30°C. The dye sensitized solar cell showed that energy conversion efficiency of light to electricity were 1.914 %, under irradiation of 100 mW/cm^2.

KEYWORDS: dye sensitized solar cell, TiO_2, thin film, TCO glass, doctor blade technique, energy conversion efficiency

1. Introduction

In between 2000 and 2030 demand the world energy increase will by about 70 %. Fossil fuels, supplying 80 % of all energy consumed worldwide, are facing rapid resource depletion. The resource reserves of fossil fuels throughout the whole world in 2002 were projected to last 40 year for oil, 60 year for natural gas and 200 years for coal. Because of a growing demand for energy, combined with the depletion of fossil resources, global warming and its associated climate change, there is an urgent need for environmentally sustainable energy technologies. Among all the renewable energy technologies, such as wind turbines, hydropower, wave and tidalpower, solar cells, solar thermal, biomass-derived liquid fuels and biomass-fired electricity generation, photo-voltaic technology utilizing solar energy is considered as the most promising one. [1]

Fortunately the supply of energy from the sun the earth is gigantic : 3×10^{34} J a year, or about 10,000 times more than that the global population currently consumes of In other words, covering 0.1 % of the earth's surface with solar cells with an efficiency of 10 % . A photovoltaic system consists of solar cells and ancillary components. Solar cells utilize the energy from the sun by converting solar radiation directly into electricity. In 1954, researchers at the Bell Telephone Laboratories demonstrated the first practical conversion of solar radiation into electric energy by use of a p-n junction type solar cell with 6 % efficiency. With the advent of the space program, photovoltaic cells made from semiconductor-grade silicon quickly became the of choice for use on satellites. The common solar power conversion efficiencies are between 15 and 20 %. However, the relatively high cost of manufacturing these silicon cells has prevented their widespread use. Another disadvantage of silicon cells in the use of toxic chemicals in their manufacture. These aspects prompted the search for environmentally friendly. The dye sensitized solar cells (DSSC) based on sensitization of TiO_2 nanocrystalline by photoexcited dye molecules have been investigated intensively because of its lower cost and potential alternatives to traditional photovoltaic device [2–3]. light to electrical energy conversion efficiencies of DSSC based on liquid electrolytes using organic compound, such as acetonitrile, propylene carbonate and ethylene carbonate as solvent and iodide/triiodide (I^-/I_3^-) redox couple as electrolyte have reached 10 – 11 % under irradiation of AM 1.5 [4–7]. However, This type of liquid-junction cell remains some problems including low long term stability which caused by organic solvent evaporation and leakage of liquid electrolytes, high temperature instability and difficulties in sealing the devices [8].

In this paper. We can synthesis nanocrystalline titanium dioxide (TiO_2) with sol-gel method for dye sensitized solar cell. Was prepared by sol-gel with doctor blade technique. Used titanium dioxide powder 79.90 %. Was mixed into 0.1 M. nitric acid (HNO_3) in an iso-propanol solution adding DI water (distilled water) until pH 3 – 4 completely and after added triton X – 100 for surfactant. And based on coated on transparent conducting oxide glass (TCO glass) with doctor blade technique. And the after a prepared polymer gel electrolyte by adding iodide salt potassium in iodine (KI/I_2).Were studied in properties of dye sensitized solar cell and studied energy conversion efficiencies of light to electricity, under irradiation of 100 mW/cm^2

2. Experimental

2.1 Materials

Iodide salt potassium and Iodine (KI and I_2 (A.R. grade), γ –butyrolactone, 1–methyl–3–propylimidazolium iodide and 1,2,4,5–tetrakisbromo methylbenzene were used as received. Conducting glass plates TCO glass (Transparent conducting oxide glass; fluorine doped tin oxide over layer, sheet resistance 8 Ω/sq) was purchased from Solaronix SA, Switzerland. Sensitizing dye bis (tetrabutyl ammonium)-*cis*-di thiocyanato) -*N,N*- bis (4-carboxylato-4-carboxylic acid-2,2-bipyridine) ruthenium (II) (or commercial name is N719 dye) was purchased from Solaronix SA, Switzerland. Other solvents and reagent were used as received.

2.2 Preparation nanocrystalline titanium dioxide

Nanocrystalline titanium dioxide film was manufactured by following procedure. Sol gel processing of titanium dioxide prepared using by mixing powder 79.90 %.Was mixed into 0.1 M. nitric acid aqueous solution in an iso-propanol solution adding distilled water (DI) until pH 3 – 4 completely and after a few drops emulsification reagent of Triton X – 100 for surfactant. And control the stability as well as phase formation of the colloidal. Or the slurry became a translucent blue-white liquid.

A conducting glass sheet transparent conducting oxide glass was coated with doctor blade technique. Finally, the titanium dioxide porous film and sintered by firing the conducting glass sheet at 450 °C for 30 minutes. After that, a titanium dioxide porous film immersed electrode absorbed dye was prepared for 24 h to absorb the dye adequately, the other impurities were washed up with anhydrous ethanol and dried in moisture-free air.

2.3 gel polymer electrolyte

A series of mixtures were prepared by adding 0.5 g iodide salts potassium, 0.05 g iodine, 1.0 ml 1–methyl–3–propylimidazolium iodide, and 0.1 g 1,2,4,5–tetrakisbromomethylbenzene into 2.0 ml γ – butyrolactone. The polymer gel electrolyte were obtained until the mixtures became homogenous and unflowable stering at temperature of 70-80 °C .

2.4 Assembling of dye sensitized solar cell

Dye sensitized solar cell was assembled by dropping a drop of gel polymer electrolyte into the aperture between the TiO_2 porous film electrode (anode electrode) and a Pt plated conducting glass sheets (cathode electrode, prepared by electrodepositing). The two electrodes were clipped together and a cyanoacrylate adhesive was used as sealant to prevent the electrolyte solution from leaking.

2.5 Measurements

The photovoltaic test of dye sensitized solar cell was carried out by measuring the J-V (current density-voltage) characteristic curves. The under irradiation of white light Xenon arc lamp was used as an source and the intensity of the incident light was 100 mW/cm^2. The active areas of the cells are about 0.25 cm^2. The detailed surface images were obtained by means of scanning electron microscopy (SEM). surface morphology, roughness and fractality of the modified titania film were examined with digital instrument nanoscope, transmission electron microscopy (TEM), X-ray diffraction (XRD) spectra of porous nanocrystalline TiO_2 film by a X-ray diffraction XRD, Cu-tube (Philips X'Pert).

The photoelectronic performance [i.e. fill factor (FF) and overall light to electrical energy conversion efficiency (η)] were calculated by the following equations [9].:

$$FF = \frac{V_{\max} J_{\max}}{V_{oc} J_{sc}} \tag{1}$$

$$\eta(\%) = \frac{V_{\max} J_{\max}}{P_{in}} \times 100 = \frac{V_{oc} J_{sc} FF}{P_{in}} \times 100 \tag{2}$$

Where J_{sc} is the short-circuit current density (mA/cm^2), V_{oc} is the open-circuit voltage (V), P_{in} is the incident light power, $J_{\max}$ (mA/cm^2), $V_{\max}$ (V) are the current density and voltage at the point of maximum power output on the $J-V$ curve, respectively.

3. Results and discussion

The photovoltaic test of the dye-sensitized solar cell (DSC) composed of polymer gel electrolyte of were prepared by adding iodide salt potassium and iodine into γ–butyrolactone gelated with 1–methyl –3–propylimidazolium iodide and 1,2,4,5–tetrakisbromomethylbenzene as a mixture solvent. The mixture with the ratio of potassium /iodine (KI : I_2) was 10:1. were measured and experimental, and the results were summarized in (Table 1.). Prepared by adding iodide salt potassium would dissolve were polymer gel electrolyte. In our experiment, by the complete solution of these iodide salts potassium in polymer gel electrolyte. And from studies investigated physical properties of TiO_2 thin film. Prepared nanocrystalline TiO_2 by sol-gel method with doctor blade technique. XRD identified the phase formation for anatese structure show (Fig 1) , scanning electron microscopy (SEM) magnification of as 80,000 and transmission electron microscopy (TEM) images level that the thin film nanocrystalline structures size 100-200 nanometer (nm). (Fig. 2 and 3)

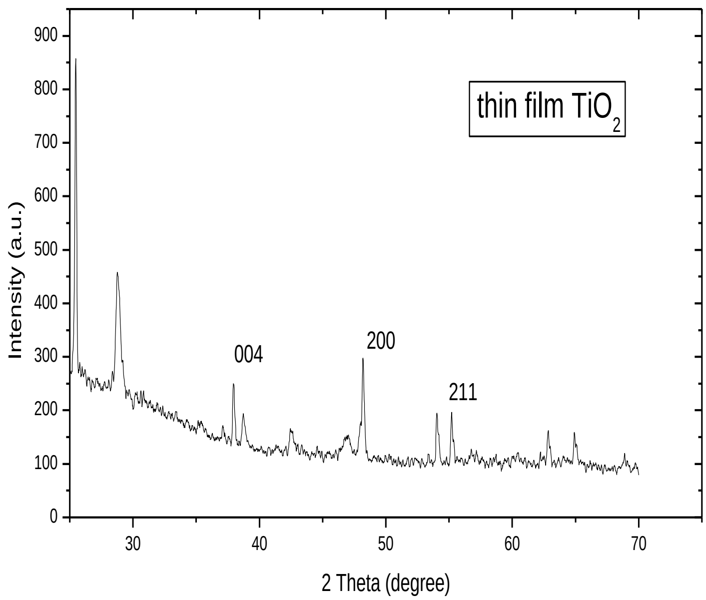

Figure 1. X-Ray diffraction pattern of nanocrystalline thin film TiO_2.

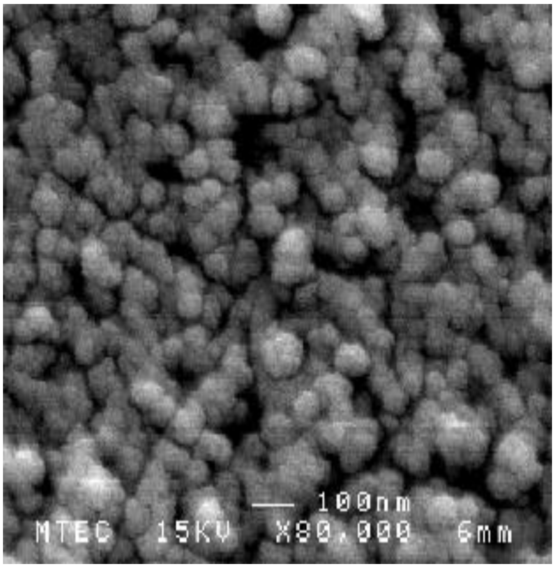

Figure 2. scanning electron microscopy (SEM) pattern of nanocrystalline thin film TiO_2

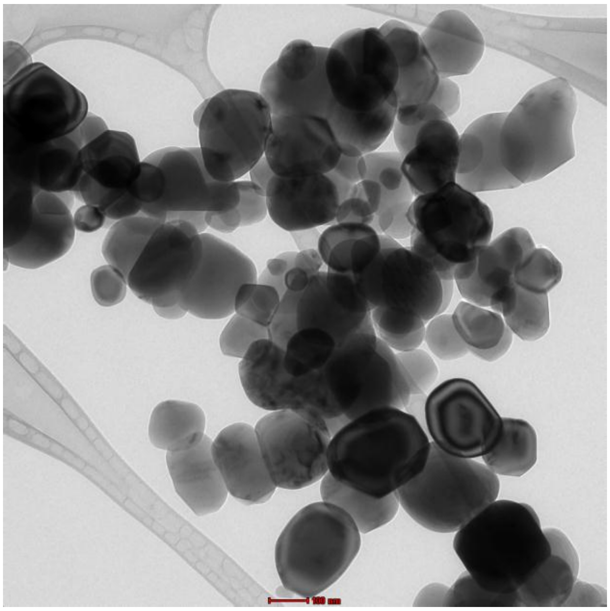

Figure 3. transmission electron microscopy (TEM) pattern of nanocrystalline thin film TiO_2

Table 1: Photoelectrochemical data of the DSC

Electrolyte	J_{sc} **(mA/cm²)**	V_{oc} **(mV)**	*FF*	η (%)
KI	6.12	611	0.512	1.914

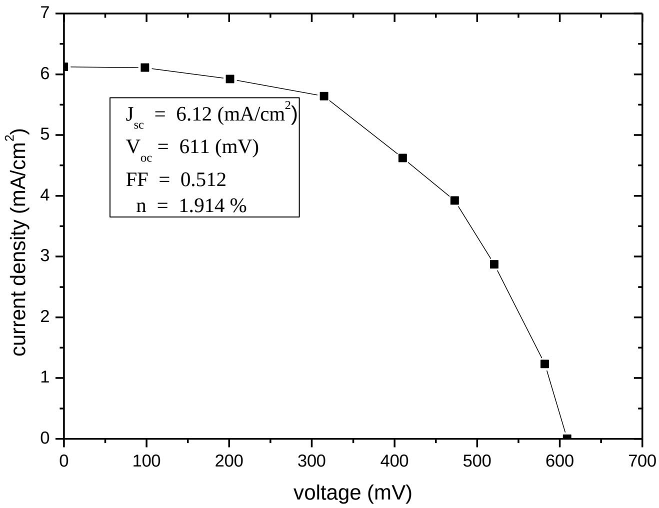

Figure 4. current density and voltage curves (J-V) for dye-sensitized solar cell (DSC) fabricated by using the polymer gel electrolyte containing the iodide salt potassium

Figure 4. and table 1. Shows the photocurrent-photovoltage characteristics curves (J-V) of dye-sensitized solar cell (DSC) based on the polymer gel electrolyte by adding these iodide salt potassium (KI) : iodine (I_2). The mixture with the ratio of KI:I_2 was 10:1. The open- circuit voltage (V_{oc}), the short-circuit current density (J_{sc}), fill factor (FF) and overall light to electrical energy conversion efficiency (η) value of the dye-sensitized solar cell (DSC) with the polymer gel electrolyte of KI are 611 mV, 6.12 mA/cm^2, 0.512, 1.914 %, respectively.,

4. Conclusions

In this work, we synthesis TiO_2 by sol-gel method with doctor blade technique for dye sensitized solar cell (DSC). XRD identified the phase formation for anatese structure , SEM magnification of as 80,000 and TEM images level that the thin film nanocrystalline structures size 100-200 nanometer (nm). Composed of polymer gel electrolyte of were prepared by adding iodide salt potassium (KI) and iodine (I_2). The mixture with the ratio of $KI:I_2$ was 10:1. The system was optimized and the maximum ionic conductivity of polymer gel electrolyte was 2.37 mS/cm at 30 °C. The results showed that energy conversion efficiency of light to electricity were 1.914 %, under irradiation of 100 mW/cm^2.

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References

[1] Bin L, Liduo W, Bonan K, Peng W, and Yong Q. *Sol. energy mater. sol.cells* . 2006; 90 : 549-573.
[2] Nazeeruddin M. K, Kay A, Rodicio I, and Grätzel M. *J.Am.Chem.Soc.*1993; 115 : 6382.
[3] Nazeeruddin M. K, Pechy P, and Grätzel M. *J.Am.Chem.Soc.*2001;123 : 1613.
[4] Kambe S, Nakade S, and Kitamura T. *J.Phys.Chem.B.* 2002; 106 :2967.
[5] Gregg B.A, Chen S.G, and Ferrere S. *J. Phys.Chem.B.* 2003; 107 : 3019.
[6] Diamart Y, Chen S.G, Melamed O, and Zaban A. *J.Phys.Chem.B.* 2003; 107 : 1977.
[7] Barbe C.J, Arendse F, Comte P, and Grätzel M. J. *Am.Ceram.Soc.* 1997; 80 : 3157.
[8] Smestad G. *Sol. energy mater. sol.cells.* 2003; 76 : 17.
[9] Grätzel M, *Prog. Photovolt. Res.* 2000; 8 : 171.