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Hydrothermal growth of high surface area mesoporous anatase TiO_2 nanospheres and dye sensitized solar cells performance

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[Introduction]

Dye sensitized solar cells (DSSCs) are considered to be an inexpensive solar cell in the modern era. The morphology of the photoanode plays an important role in determining the properties of charge transport. The mesoporous TiO_2 as photoanode materials with uniform pore size has a great attention due to their special function where the open pores in the mesoporous structure will speed up the electron transport and will facilitate more adsorption of the dye molecules since it has the internal surface area. In this work, ordered mesoporous TiO_2 spheres were successfully synthesized by template free hydrothermal method. The effect of growth periods on the morphological properties was investigated. To analyze the potential application of DSSCs, the photoanodes with mesoporous TiO_2 spheres prepared at different growth periods were constructed. The effect of mesoporous TiO_2 spheres as a scattering layer over P25 active layer in the photoanode was also investigated.

[Experimental method]

Titanium (IV) isopropoxide (TTIP 97 %), 1-Butanol (CH_3 $(CH_2)_2CH_2OH$) were purchased from WAKO chemicals, Japan and used as received without further purification. TTIP (0.5M) was added to 200 mL in butanol. The solution was maintained at room temperature under vigorous stirring for 30 minutes and 60 mL of deionized water was slowly added to the above solution and stirred for 1 h. Then the white color solution was transferred to the 50 mL Teflon -lined stainless steel autoclave at 150°C and the hydrothermal growth was varied for 15, 20 and 25 h, respectively. Finally, the resultant products were collected and annealed at 350°C.

[Results and discussion]

The surface area and pore size of the samples were obtained from the Barrett-Joyner-Halenda analysis. The surface areas of the samples were 168.46 m^2g^{-1} (15 h), 178.44 m^2g^{-1} (20 h) and 188.40 m^2g^{-1} (25 h). The surface area was higher for the mesoporous TiO_2 spheres grown at 25 h when compared to that of the samples grown at 15 and 20 h. Fig.1 depicts the I-V characteristics for mesoporous TiO_2 sphere with the thicknesses of 3, 7, 12, 16 and 23 μm. The associated energy conversion efficiencies (η) were 0.56, 2.80, 4.50, 7.02 and 4.07 %, respectively. It was found that the maximum efficiency was achieved for the layer thickness of 16 μm. The mesoporous TiO_2 spheres were used as a light scattering layer on top of the P25 active layer and the device performances were studied using N719 dye. Fig.2 indicates the I-V characteristics of the P25 titania coated DSSC sensitized with N719. It shows an efficiency of 5.23 %. Whereas, the light scattering layer of mesoporous TiO_2 spheres coated device showed an increased efficiency of 5.91 %. The enhancement of the efficiency was due to the collection of more number of photons from the internal reflections by the scattering effect of mesoporous TiO_2 spheres.

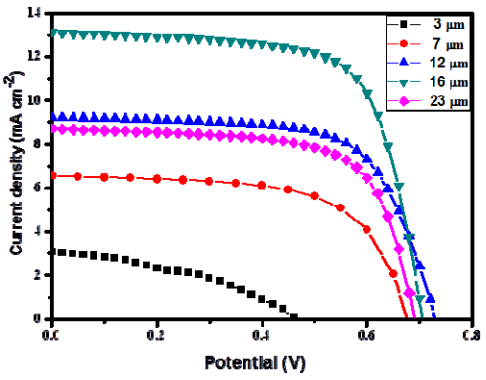

Fig.1. I - V characteristics of mesoporous TiO_2 spheres for various thickness.

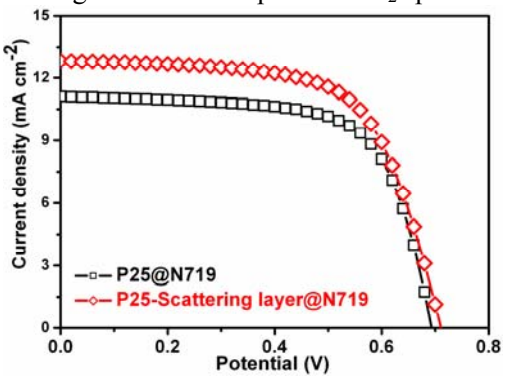

Fig.2. I - V characteristics of P25coated cell and mesoporous TiO_2 nanospheres coated cell on P25 sensitized with N719 dye.

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