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Nanocrystalline Anatase TiO_2 Prepared from Nanotubes for Dye-Sensitized Solar Cells

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Sol-gel synthesis of nanocrystalline TiO_2 is usually adapted for preparing the anode of dye-sensitied solar cells (DSC).[1-2] In the present work, commercial TiO_2 (Degussa P-25) was used as the starting material to prepare nanotubes by using hydrothermal treatment in NaOH solution. Uniform-size nanocrystalline anatase TiO_2 was then obtained by hydrothermally treating the nanotubes in water at different temperatures. Table I shows the surface area (S_{BET}) of the nanocrystalline TiO_2 obtained from different treatment temperatures. These samples are designated as H, followed by the treatment temperature in ^oC. It can be seen that the hydrothermally synthesized samples have smaller particle size and larger surface area in comparison with P-25. Fig. 1 shows the TEM images of H-180 and P-25 and reflects that the hydrothermally-synthesized sample has a smaller size. The XRD pattern in the Fig. 2 shows that the hydrothermally treated samples are made of anatase. These samples were proved to have high thermal stability, which is an important feature for film electrode preparation.

H-180 and P-25 film electrodes are formed using spin-coating with binder on ITO glass (10 Ω /cm^2, GemTech). After air-drying, electrodes were clacined at 450^oC for 30 mins in air and the process was repeated to increase film thickness. The electrodes were colorized with mercurochrome to become dye-sensitized electrodes. The I-V characteristics were recorded in a standard 2-electrode system with platinum on ITO as the counter electrode. The electrolyte was a mixture of 0.3M LiI and 0.03M I_2 in propylene carbonate. The light intensity employed was 83 $mWcm^{-2}$.

Fig. 3 shows the short-circuit current density (J_{sc}) of the solar cells made of H-180 and P-25 with different film thicknesses. In the thin film region (< 6 □m), J_{sc} of H-180 was higher than that of P-25. The efficiency is 1.45% at 2.9 □m (J_{sc}= 4.1 $mAcm^{-2}$, V_{oc}= 0.59, F.F.= 0.50). The high J_{sc} of the H-180 cell in comparison with the P-25 can be attributed to the high surface area of TiO_2 film. The present work has presented an option for preparing TiO_2 particles with high surface area and thermal stability.

Table I, Specific surface area and particle diameter of the hydrothermally-synthesized TiO_2

Sample	S_{BET} (m^2/g)	Diameter (nm)*
H-160	130	11.9
H-180	135	11.4
H-200	117	13.2
H-220	112	13.8
H-240	113	13.6
P-25	50	30.8

*determined from S_{BET}, assuming spherical particles.

References

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2. C. J. Barbe, F. Arendse, P. Comte, M. Jirousek, F. Lenzmann, V. Shklover, M. Grätzel, *J. Am. Ceram. Soc.*, **80,** 3157 (1997)

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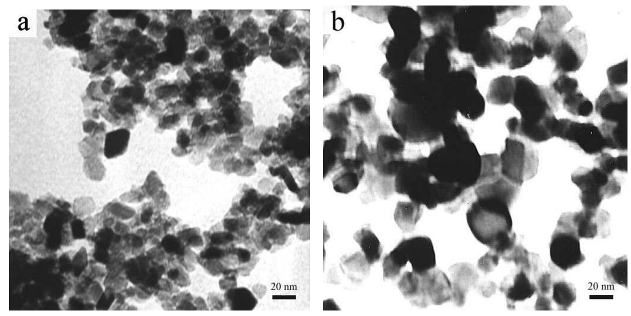

Fig. 1. TEM images of (a) hydrothermally-synthesized TiO_2 and (b) commercial Degussa P-25.

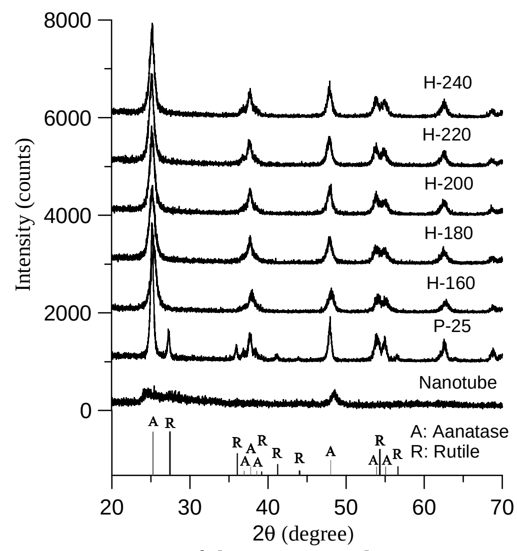

Fig. 2. XRD patterns of the TiO_2 smaples.

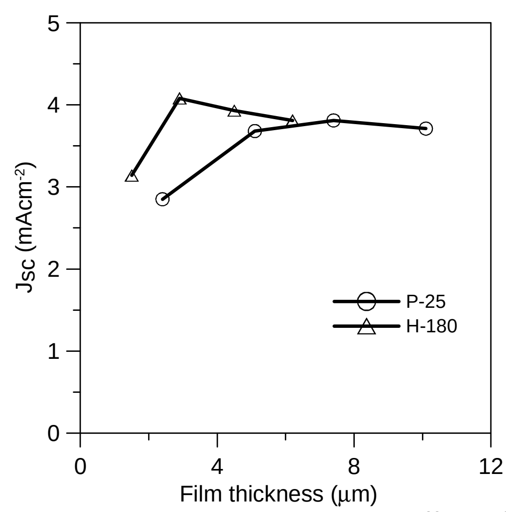

Fig. 3. Short-circuit current density, J_{sc}, at different film thicknesses under illumination of 83 $mWcm^{-2}$