Enhanced dye absorption of high surface area carbonate-doped mesoporous TiO_2 nanospheres for dye sensitized solar cells applications

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1. Introduction

Dye-sensitized solar cell (DSSC) is one of promising candidates for harnessing solar power and alternatives to conventional silicon solar cells. DSSC has attracted widespread of attraction of scientist and industrial researchers because of its low cost, easy to fabricate and highly photon electron conversion. Photoanode of DSSC plays vital role in improvement of efficiency due to absorption of dye and transport of electrons. Major issue in DSSC is recombination of electrons with dye which decreases the efficiency. Since carbonate has high conductivity, doping of carbonate in TiO_2 is expected to increase electron transport and decrease recombination. The purpose of this research is to investigate the effect of carbonate on the property of DSSC.

2. Experimental method

Mesoporous TiO_2 nanoparticles were prepared by two steps. The amorphous nanosphere was synthesized via a sol-gel process. 0.9 g of hexadecylamine (HAD) was dissolved in 100 mL of ethanol, stirred well at room temperature. 2.5 mL of titanium-isopropoxide (TTIP) was added to the above solution and the milk-like solution was obtained. It was kept static for 24 h at room temperature.

The mesoporous TiO_2 nanospheres were obtained by solvothermal method by adding 0.64 g of amorphous nanosphere in 10 mL of ethanol and 5 mL of distilled water and stirred well for 30 min, then the above solution was transferred and sealed in 50 mL Teflon-lined autoclave. It was kept at 160 °C for 16 h.

Carbonate-doped mesoporous TiO_2 nanospheres were synthesized from appropriate amount of TiO_2 mesoporous nanosphere with thiourea and urea, which were grounded for 30 min and dissolved in 20 mL of DI water. It was kept static for 24 h and washed with ethanol and centrifuged. The product was dried and calcined at 400 °C for 4 h. The samples synthesized with different weight ratio were prepared and termed as CTO 1 (TiO_2: Thiourea: Urea=1 :0.25: 0.25), CTO 2 (1: 0.25: 0.50) and CTO 3 (1: 0.25: 1).

3. Results and discussion

Fig.1 a. shows the X-ray diffraction pattern of synthesized undoped and carbonated-doped mesoporous nanosphere. Carbonate-doped and undoped mesoporous TiO_2 exhibited a well crystalline anatase phase (JCPDS NO:21-1272). Fig.1 b clearly indicated that carbonate-doped mesoporous TiO_2 nanosphere (CTO 3) showed enhanced the efficiency of 5.4 % compared to P25 (2.4 %) and undoped TiO_2 (3.4 %). Almost similar V_{oc} (0.70±0.04 V) and FF (0.61±0.06) were obtained for all the carbonate-doped TiO_2 samples. Fig.1c showed IPCE analysis of undoped and carbonate-doped mesoporous TiO_2. All the photoanode showed maximum quantum efficiency at the wavelength of 520-560 nm Nearly 40 % of absorbance increased by doping carbonate. Impedance measurement (Fig.1 d) shows that resistance decreased from 197.2 to 97.4 Ω, which indicated that the electron transport increased by doping carbonate.

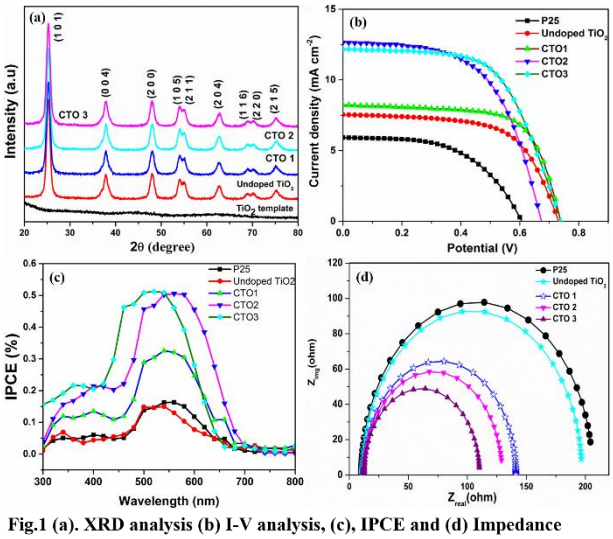

Fig.1 (a). XRD analysis (b) I-V analysis, (c), IPCE and (d) Impedance measurement of undoped and carbonate-doped mesoporous TiO_2

Conclusion

Carbonate doped mesoporous TiO_2 nanospheres enhanced photon to electron conversion compared undoped TiO_2 and enhanced efficiency of 5.4 % compared to undoped (3.4) and P25 (2.4 %).