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The Effect of Incorporation of Mixture of TiO_2 Crystallites from P25 and P90 in Photoanode towards the Efficiency Enhancement in Dye Sensitized Solar Cells

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Abstract

Dye-sensitized solar cells (DSSCs) are emerging as promising candidates to replace expensive silicon solar cells because of reasonably high efficiency and lower production cost. Photoanodes of these DSSCs generally have TiO_2 particles having the diameters in the range of 15-25 nm, which facilitate the enhanced dye adsorption due to their large specific surface area. In this research work, mixtures of P25 TiO_2 powder (particle size ~22 nm) and P90 TiO_2 powder (~14 nm) with different weight percentages were used to prepare the photoanodes for DSSCs. Powder sample mixtures were analyzed by the XRD to identify the ratio of the anatase and rutile phases present in the above photoanodes. DSSCs fabricated with above photoanodes were characterized with I-V measurements. Electrical Impedance Spectroscopic measurements were used to characterize the interfacial resistance of the different interfaces in the DSSC. The DSSC with the highest power conversion efficiency of 7.0% was fabricated by using a photoanode fabricated with 70:30 ratios of P25:P90 composite. Factor of 10% efficiency enhancement is achieved by using this modified photoanode when compared with the conventional P25 photoanode. The best DSSC showed a short circuit current density of 13.91 $mAcm^{-2}$, open circuit voltage of 743.9 mV, and a fill factor of 68%. Observed enhancement in the dye adsorption of the best photoanode would have contributed to the increment in the photocurrent generation. Therefore, the occupation of the inter-grain spaces in the P25 matrix by smaller nanoparticles of P90 would have increased the surface area of the photoanode leading to this efficiency enhancement. Further, this occupation leads to lower the interfacial resistance between the TiO_2 nanocrystallites and the electrolyte from 13.5 Ω to 3.75 Ω. Possible reduction of trap states due to this occupation would also have contributed to this efficiency enhancement by lowering the electron recombination dynamics of DSSC.