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V_2O_5 Incorporated Nano-Structured TiO_2 Photo-Anodes for Solar Cells and Sensor

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Abstract

Many studies have been conducted to increase the effectiveness and efficiency of solar cells using low cost materials. This field of research is highly important due to the increasing demand for energy and environmental pollution caused by energy resources used today. In an attempt to replace dye in photo-electrodes of DSSCs by other materials, organic inorganic perovskite solar cells emerged. Recently, such organic- inorganic perovskite solar cells obtained revolutionary advancement. However, the use of organic compounds causes stability issues, though such cells exhibited efficiencies above 20%. Therefore, search for new stable completely inorganic photo-electrode capable of harvesting sunlight is highly important. The present study is focused on improving light harvesting properties of TiO_2 based electrode by incorporating V_2O_5 nanoparticles. The photo-electrodes were prepared by adding 0, 5, 10, 15, 20% mass fractions of V_2O_5. The fabricated photo-electrodes are characterized by analysing XRD, SEM, UV visible absorption spectrum, Mott-Schottky plots and Tauc plots. The peaks in the XRD spectrum are used to calculate the crystallite size and dislocation density. For the TiO_2 film the crystallite size and dislocation density are about 31.6 nm and 9.98×10^{14} m^{-2} while those of V_2O_5 are about 52.6 nm and 3.62×10^{14} m^{-2} respectively. Table 1 shows the bandgap values obtained using Tauc plots for all the photo-electrodes investigated.

Table 1 Bandgap and Flat band potential for the photo electrodes the photoelectrodes

Sample	V_2O_5 mass fraction/%	Band gap (eV)	Flat-band potential *(V)
a	0	3.49	-0.69
b	5	3.11	-0.54
c	10	3.06	-0.64
d	15	2.84	-0.66
e	20	2.75	-0.71

* Relative to Pt electrode

Photo-electrochemical cells are assembled by sandwiching a gel polymer electrolyte between TiO_2/V_2O_5 photo-anode and Pt counter electrode. The energy conversion efficiency of these dye free solar cells improved from 0.006 to 0.083 % with increasing amount of V_2O_5. .