Economical Fruit Dye Sensitized Nanocrystalline TiO_2 Photoanode for Solar Cell Fabrication

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Abstract: Dye sensitized solar cell (DSSC) proposed by O'Regan and Grätzel has attracted considerable interest in research since 1991. In present work, solar cell characteristics of pomegranate fruit dye sensitized TiO_2 photoanode is presented. The TiO_2 powders were prepared by using titanium tetra-isoproxide (TTIP) as Ti precursor at temperatures of 300, 400 and 500 °C. As-prepared powders were characterized by using X-ray diffraction (XRD), UV-visible spectroscopy and field emission scanning electron microscopy (FESEM). The effect of annealing temperature on structural and optical properties of TiO_2 powders was studied. The pomegranate fruit dye sensitized solar cell (DSSC) characteristics of TiO_2 thick films deposited on FTO coated glass substrates by using Doctor's Blade method were studied by using solar simulator and with polyiodide as an electrolyte. The characterization studies revealed that as-prepared TiO_2 powders were nanocrystalline with anatase phase symmetry. The crystalline sizes of as-prepared TiO_2 powders obtained at 300 and 500 °C were found to be 12 and 18 nm respectively. The optical band gap of as-prepared TiO_2 powders obtained at 300 and 500 °C were found to be 3.34 and 3.22 eV respectively. The absorption coefficient of resultant was noted to be of the order of 10^4 cm^{-1}. The morphological analysis of resultant powders using SEM revealed spherical TiO_2 particles with sizes between 10 to 50 nm. The pomegranate fruit dye sensitized TiO_2 photoanode showed the solar properties: short circuit current (I_{sc}) = 0.412 mA, open circuit voltage (V_{oc}) = 0.628 V, fill factor (FF) = 39.11 % and photo-conversion efficiency (η) = 0.139 %.

Index Terms - Nanocrystalline, Anatase TiO_2 film, TTIP, DSSC, Pomegranate fruit dye.

1. INTRODUCTION

A new type of solar cells: dye-sensitized solar cells (DSSCs) developed by O'Regan and Grätzel in 1991 have been attracting much attention over last decade as potential low-cost alternative to the commercial silicon based solar cells due to their ease of fabrication and high photo-conversion efficiencies [1],[2],[3]. Titanium dioxide is one of the most promising materials for photochemical energy conversion processes. However, its wide band gaps of 3.0 eV and 3.2 eV for the rutile and anatase phases respectively require UV light for the excitation of electron-hole pairs. This limits its applicability to efficient solar energy conversion because only 5-7 % of the solar spectrum lies in the UV range accessible by pristine TiO_2. TiO_2 nanoparticles explicit the following special properties: (i) greatly enhanced surface area giving effective exposure to light and facilitates the photochemical reactions on the surface, and (ii) enhanced photoinduced charge transport useful for harvesting and donating of photo induced electrons [4],[5]. In literature, the conversion efficiencies are reported in the range of 0.06 to 0.09 % by using natural dye for different materials and no depletion layer formation on the surface, which profoundly changes the photo electrochemical properties [6],[7]. In view of this, the main objective of present work was to fabricate DSSCs based on TiO_2 films and pomegranate and strawberries fruits dyes for their better photovoltaic performance. For this purpose, the nanocrystalline TiO_2 powders were synthesized by simple hydrolysis route followed by annealing treatment. The nanocrystalline TiO_2 powders were characterized by using XRD, Raman spectroscopy, FESEM and UV-Visible spectroscopy. TiO_2 films of these powders were prepared on Indium tin oxide (ITO) substrates by using Doctor's Blade method. The resultant films were used as photoanodes for pomegranate and strawberries fruits dyes sensitized solar cell applications. The results obtained with respect to the above mentioned objective are presented in this paper. The data pertaining to this is presented in this communication.