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Short Communication

Dye-Sensitized Solar cell using extract of *Punica Granatum L.* Pomegranate (Bedana) as a Natural Sensitizer

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Abstract

The extract of Pomegranate (Bedana), Punica Granatum L. was used as a natural sensitizer of a wide band gap semiconductor ZnO based in Dye-sensitized solar cells (DSSC). It is one of the most promising devices for the solar energy conversion due to their low production cost and environmental friendly. ZnO nanorods were fabricated using sol-gel spin coating technique. The synthesis and performance study of ZnO nanorods based DSSC is reported in the present paper.

Keywords: Absorption spectra, DSSC, efficiency, natural dyes, ZnO nanorods.

Introduction

DSSCs are modern devices for the conversion of visible light into electricity based on sensitization of wide band-gap semiconductors[1,2]. The sensitization approach enables the generation of electricity with irradiation energy lower than the band-gap of the semiconductor. The mainprogress of such devices occurred after the development of nanostructured porous semiconductor films onto which light absorbing dye molecules are adsorbed. Synthetic inorganic dyes, such as ruthenium(II) complexes with carboxylated polypyridyl ligands, are commonly employed as molecular sensitizers in such cells[3,4,5]. Other approaches, such as the use of natural extracts have also been reported[6-13]. This study reports the use of extract of Pomegranate (Bedana), as a natural sensitizer in dye-sensitized solar cells.

Normally TiO_2 nanostructures were used to fabricate DSSC. However, ZnO has shown a great deal of research interest in DSSCs due to some of its fascinating properties. ZnO is often utilized as a photo anode material in DSSCs due to its attractive properties such as large exciton binding energy, wide direct band gap (3.27 eV), which is generally used in organic solar cells[14-16]. ZnO is also highly transparent, which allows for greater light penetration. Finally, 1-D single crystal structure formation is possible with ZnO, enabling a higher surface-to-volume ratio for greater dye loading.

To increase the conversion efficiency of ZnO nanorod-based DSSCs, it would be desirable to eliminate the interface between ITO and the ZnO nanorods[17-20]. Some researchers have recently taken up this concept by growing ZnO nanorods on a ZnO film using a two-step method[21]. In this work we grew ZnO nanorods on an ITO coated glass using sol-gel spin coating technique.

Effective conversion of visible light into electricity was achieved with the use of extract of Bedana as the semiconductor sensitizer in dye-sensitized solar cells. The use of a natural product enables a faster, simpler and environmentally friendly solar cell production without the requirement of all steps involved in the preparation and purification of natural dyes. Nevertheless, stability and long-term operation are fundamental issues for the development of such devices and further studies are in progress.

Methodology

Bedana is the fruit of a well-disseminated tropical tree, commonly found in Nepal and India. The violet and light red juice extracted from the fresh fruit shows intense broad bands in the visible region of the electronic spectrum (figure 1). The morphology of the samples was observed using a scanning electron microscope (SEM) with a field emission gun operating at 200 kV. Figure 2 shows hexagonal shapes of ZnO thin film. The thickness of ZnO film was around ~2 μm.

ZnO nanorods were fabricated using sol-gel spin coating process[6,22]. The use of a natural dye, obtained from Bedana extract, as the molecular sensitizer of nanostructured ZnO films results in red and voilet colored photoanodes, which were employed in dye-sensitized solar cells. The experiments were carried out in sandwich type dye-sensitized solar cells, consisted by a photoanode, a counter-electrode and an electrolyte mediator layer in between. Both electrode substrates are glasses covered by a conducting film: ITO (Idium doped Tin Oxide) for photoanode and carbon dust for counter-electrode. The mediator layer is the KI_3 liquid. The transparent photoanode was prepared by the deposition of a ZnO semiconductor film, prepared from zincacetate, followed by the sintering of its particles at 350°C and having the dye adsorbed on the surface of nanosized oxide. Fruit extracts was obtained by squeezing fresh Bedana fruits.

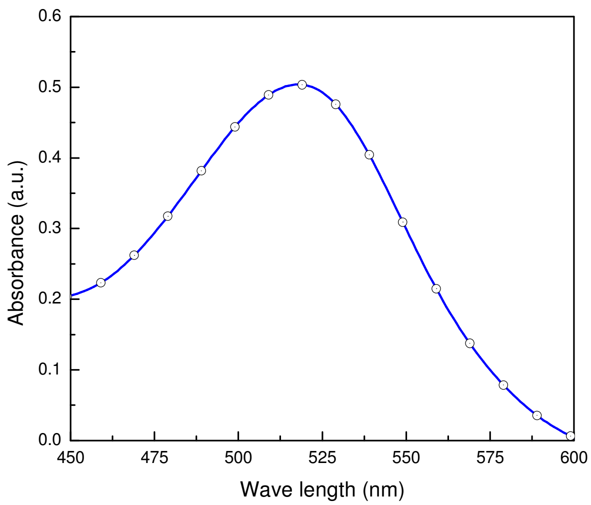

Figure-1
Absorption spectra of Bedana Juice

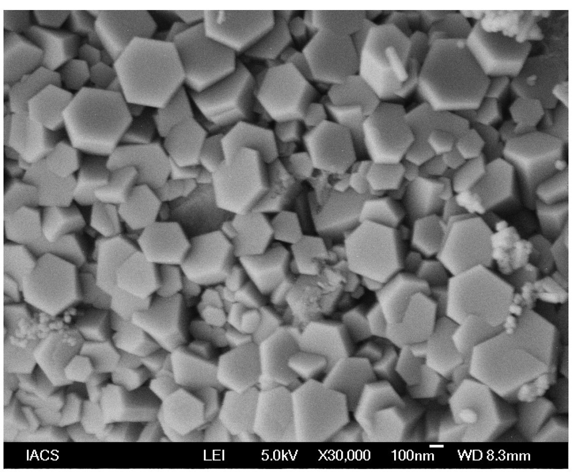

Figure-2
Scanning electron microscope (SEM) picture of ZnO nanorod used in the dye-sensitized solar cell

Results and Discussion

The performance of this natural dye as the semiconductor sensitizer was monitored through the current and voltage output upon light irradiation of a dye-sensitized solar cell with an effective area of 4 cm^2. Photocurrent and photovoltage values as high as 1.55 mA and 550 mV, respectively, were obtained with overhead projector light irradiation. Such values are similar to those obtained employing traditional synthetic dyes[1].

The role of the dye in DSSC consists in acting as a molecular electron pump. It absorbs the visible light, pumps an electron into the semiconductor, accepts an electron from the redox couple in the solution, and then repeats the cycle.To be suitable for application in DSSC, the dyes must present, among other characteristics, a strong absorption in the visible range; high stability and reversibility in the oxidized, ground and excited states; and a suitable redox potential in relation to the semiconductor conduction band edge as well as in relation to the redox charge mediator in the electrolyte, to ensure efficiency in the charge injection and regeneration processes[23,24]. The results show that the extract of Bedana, adsorbed onto the semiconductor surface, acts as a good sensitizer and efficiently promotes electron transfer across the dye/semiconductor interface.

Conclusion

Dye-sensitized ZnO solar cells are a successful combination of materials, usually consisting of a dye-sensitized nanocrystalline ZnO film, an electrolyte with an KI_3 redox couple and a carbon dust counter-electrode. In addition to practical interests, as an alternative energy source, these devices are also very fascinating systems from a scientific point of view, in which light can be converted to electrical energy through complex energy and charge transfer processes.The overall efficiency in energy conversion depends critically on the individual properties of the constituents of the DSSC cell.

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