Abs. 264, 206th Meeting, © 2004 The Electrochemical Society, Inc.

Sensitization of Nanocrystalline Solar Cells with Phthalocyanine-Fullerene Composites

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In the last decade photovoltaic devices based on organic materials have undergone a very rapid development. They are widely used for fabricating solid state solar cells and for sensitizing wide bandgap inorganic semiconductors in nanocrystalline photoelectrochemical solar cells [1,2]. Among other molecular materials metal phthalocyanines, MePc (where Me = Cu, Zn etc.) are of special interest due to their low cost and potentially high photoelectronic properties. Till now the devices based on MePc dyes show poor conversion efficiencies that need to be improved. Meantime it was found that fullerenes (C_{60}) can increase the photoelectronic parameters of MePc via fabricating MePc:C_{60} composites [3].

In this contribution we present our studies of fabrication and examining the photoelectronic properties of ZnPc:C_{60} composites used for sensitizing TiO_2 based nanocrystalline solar cells. We have provided a comparative investigation of the optoelectronic properties of the appropriate single nanoscale layers prepared by vacuum evaporation technique. The promising composites were used for sensitizing nanocrystalline cells. We have also investigated the surface morphology of TiO_2 nanocrystalline during sensitization process using STM and AFM microscopy.

Fig. 1 shows the absorption spectra for sensitized TiO_2 nanocrystalline layer and for thin condensed layers of ZnPc (~100 nm), ZnPc:C_{60} composite and ZnPc in solution. The absorption spectrum of ZnPc in solution can be associated with the one expected for the monolayer absorbed on a TiO_2 surface. At the same time it differs much from the absorption characteristic of ZnPc sensitized electrodes. Fig. 2 shows the action spectra of photoconductivity obtained in DC mode for ZnPc:C_{60} (70:30 volume %) composite. It also presents the behavior of thin C_{60} and ZnPc single layers.

Fig 3 demonstrates the typical AFM images of TiO_2 nanocrystalline layer before and after sensitization. The result also supported by SEM data shows that the surface of TiO_2 nanocrystals seems to be covered with rather a thick layer of MePc:C_{60} composite. In this case fullerene molecules will improve the photosensitivity of a sensitizer in accordance with the mechanism observed in condensed layers. Finally we have investigated the photovoltaic properties of TiO_2-based nanocrystalline photovoltaic cell sensitized with ZnPc and ZnPc:C_{60}. It was found that the application of the composite resulted in the increase of the cell conversion efficiency.

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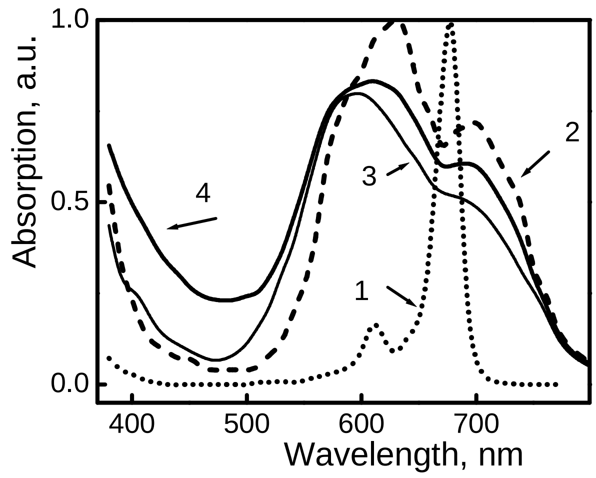

Fig. 1. Optical absorption curves: ZnPc in solution (1), condensed 100 nm ZnPc film (2), microcrystalline TiO_2 layer sensitized with ZnPc (3) and with ZnPc:C_{60} (4).

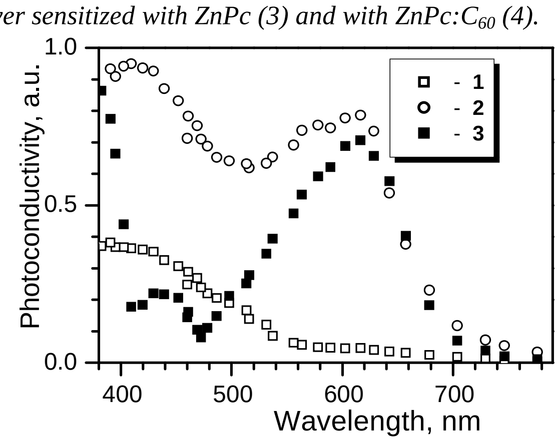

Fig. 2. Action spectra of photoconductivity for condensed layers of C_{60} (1), ZnPc:C_{60} composite (2) and ZnPc (3).

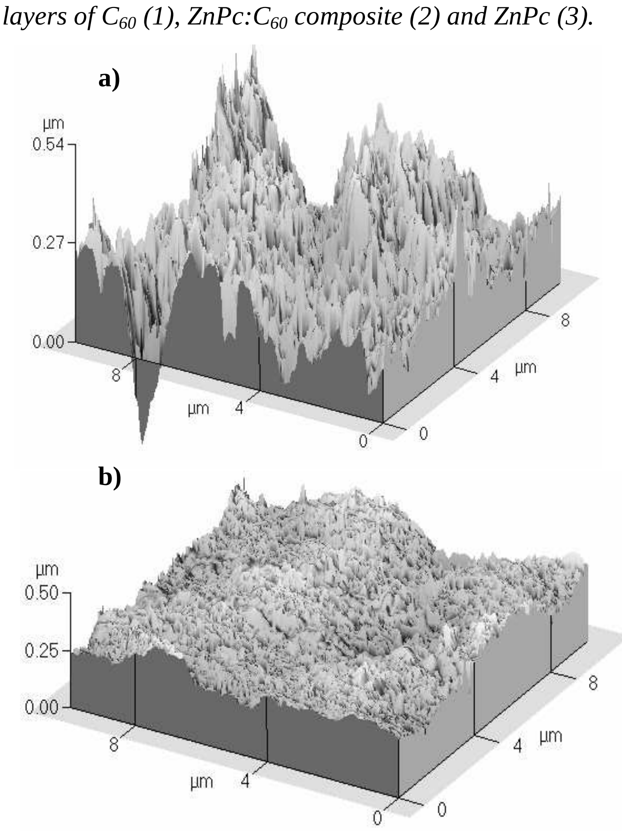

Fig. 3. AFM images of TiO_2 layer before (a) and after sensitization with ZnPc:C_{60} composite (b).