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ORIGINAL PAPER

Thin mesoporous polyaniline films manifesting a water-promoted photovoltaic effect

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Photovoltaic cells composed of thin mesoporous polyaniline films sandwiched between an indium–tin oxide anode and aluminium cathode have been fabricated. The cells show an increase in the photo-generated open-circuit voltage (V_{oc}) from 0.2 V to 0.6 V and stable-in-time V_{oc} generation following the addition of water containing highly hydrated ions, e.g. tap water. We explain the water-promoted photo-voltaic effect by the polarity of the water environment. Theoretical calculations show that increasing the solvent polarity increases the energy of the electronic transition related to the measured V_{oc}. The stable-in-time V_{oc} generation could be explained by the increase in the lifetime of the excitons as well as by their more efficient dissociation in the interpenetrating network of polyaniline and water. The penetration of water into the mesoporous polyaniline films is promoted by the presence of highly hydrated ions.

Keywords: polyaniline, morphology, photovoltaics, water, density functional theory

Introduction

Due to its synthesis in an aqueous medium, environmental stability, and low cost, polyaniline (PANI) is one of the conducting polymers attracting most interest (Chiang & MacDiarmid, 1986; MacDiarmid & Epstein, 1989; Gospodinova & Terlemezyan, 1998). However, PANI has never been regarded as a promising photovoltaic material. A limited number of publications describe its application as a hole-injecting layer in organic photovoltaic cells based on composites of an electron-donating conjugated polymer, such as poly(3-hexylthiophene) or poly(3-methylthiophene), and an electron-accepting fullerene-[6,6]-phenyl C61 butyric acid methyl ester (Bejbouji et al., 2010).

We previously showed that the presence of highly hydrated anions, such as formate, $HCOO^-$, leads to a weakening of the interactions between the water molecules and enhances PANI–nitrogen hydration. As a consequence, a regular water molecule intercalation between the growing polymer chains favours creation of the crystalline order in PANI (Gospodinova et al., 2009a, 2009b, 2011). We succeeded in obtaining mesoporous PANI films by the deposition of highly crystalline nano-fibrils on a glass support during synthesis. The propagation of PANI reduction by atomic hydrogen was observed during simple contact of such organised PANI films with a Fe-containing needle in an aqueous solution of highly hydrated ions (Gospodinova et al., 2009a, 2011). Therefore, the presence of highly hydrated ions promotes not only formation of the mesoporous morphology but also penetration of water into the PANI films and the reduction propagation.

In the present communication, we report the preliminary results of the influence of water containing highly hydrated ions, e.g., tap water, on the photovoltaic effect of thin mesoporous PANI films in

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