Synthesis and properties of bismuth oxide nanoshell coated polyaniline nanoparticles for promising photovoltaic properties

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INTRODUCTION

The science of organic/inorganic nanocomposites is extremely promising for applications in light-emitting diodes[1,2] photodiodes[3,4] photovoltaic cells[5,6] smart microelectronic device[7,8] and gas sensors among others.[9,10] The properties of hybrid nanocomposites can be easily adjusted by varying the composition. Their fabrication shares the same advantages of organic device technology such as low cost production and the possibility of device fabrication on large area and flexible substrates. Solar cells composed of hybrid conjugated polymers and metal oxides nanocrystals can combine attractive characteristics of bulk inorganic materials with the solution processability and low temperature chemical synthesis of polymers[11,12] so have been extensively studied in recent years.

Conjugated polymers derive their semiconducting properties from having delocalized π-electron bonding along the polymer chain. The π bonding and π* antibonding orbitals form delocalized valence and conduction wavefunctions, which support mobile charge carriers. One important approach is to construct heterostructure architectures, with two polymers used to transport either electrons or holes, with recombination forced to occur close to the heterojunction.[12,13] There has also been much work on the improvement of the process of charge injection at the two electrodes, and devices which retain the simple single-semiconductor-layer architecture can also show very high efficiencies.[13] To obtain high efficiency, it is necessary to have an interpenetrating network of electron-accepting and hole-accepting components within the device. Ideally, the microphase domain size should not exceed the exciton diffusion length, which is about 5–10 nm for most polymers.

In the present contribution, a new method was developed to prepare polyaniline nanoparticles coated by Bi2O3 nanoshell. Conducting polymers with function groups can act as self-assembling complex polymer to control disperse and crystal growth of Bi2O3. For the purpose, polyaniline was chosen as functional conjugated polymer, whose –NH groups at side chains could complex inorganic ions. In the process, bismuth salt and a polyaniline/PEG precursor aqueous solution were mixed to issue the complex reaction between Bi3+ ion and –NH of the PANI precursor. After addition of concentrated aqueous ammonia and subsequent heating treatment, polyaniline nanoparticles coated Bi2O3 nanoshell were obtained. This PANI/Bi2O3 hybrid heterojunction material can possess a high interface area for effective separation of excitons. The photoluminescence (PL) properties of the composite and application in photovoltaic devices are discussed.

EXPERIMENTAL

Materials

Aniline monomer was distilled under reduced pressure, ammonium peroxi-disulfate (NH4)2S2O8, hydrochloric acid (HCl), aqueous ammonia, ammonium hydroxide, nitric acid, urea, polyethylene...