Synthesis and Properties of Poly(N-(sulfophenyl)aniline) Nanoflowers and Poly(N-(sulfophenyl)aniline) Nanofibers/Titanium dioxide Nanoparticles by Solid Phase Mechanochemical and Their Application in Hybrid Solar Cell

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Abstract : Purpose/Objectives: The first purpose was synthesize Poly(N-(sulfophenyl)aniline) nanoflowers (PSANFLs) and Poly(N-(sulfophenyl)aniline) nanofibers/titanium dioxide nanoparticles ((PSANFs/TiO2NPs) by a solid-state mechano-chemical reaction and template-free method and use them in hybrid solar cell. Also, our second aim was to increase the solubility and the processability of conjugated nanomaterials in water through polar functionalized materials. poly[N-(4-sulfophenyl)aniline] is easily soluble in water because of the presence of polar groups of sulfonic acid in the polymer chain. Materials/Methods: Iron (III) chloride hexahydrate ($FeCl_3 \cdot 6H_2O$) were bought from Merck Millipore Company. Titanium oxide nanoparticles (TiO_2, <20 nm, anatase) and Sodium diphenylamine-4-sulfonate (99%) were bought from Sigma-Aldrich Company. Titanium dioxide nanoparticles paste (PST-20T) was prepared from Sharifsolar Co. Conductive glasses coated with indium tin oxide (ITO) were bought from Xinyan Technology Co (China). For the first time we used the solid-state mechano-chemical reaction and template-free method to synthesize Poly(N-(sulfophenyl)aniline) nanoflowers. Moreover, for the first time we used the same technique to synthesize nanocomposite of Poly(N-(sulfophenyl)aniline) nanofibers and titanium dioxide nanoparticles (PSANFs/TiO2NPs) also for the first time this nanocomposite was synthesized. Examining the results of electrochemical calculations energy gap obtained by CV curves and UV–vis spectra demonstrate that PSANFs/TiO2NPs nanocomposite is a p-n type material that can be used in photovoltaic cells. Doctor blade method was used to creat films for three kinds of hybrid solar cells in terms of different patterns like ITO│TiO2NPs│Semiconductor sample│Al. In the following, hybrid photovoltaic cells in bilayer and bulk heterojunction structures were fabricated as ITO│TiO2NPs│PSANFLs│Al and ITO│TiO2NPs│PSANFs /TiO2NPs│Al, respectively. Fourier-transform infrared spectra, field emission scanning electron microscopy (FE-SEM), ultraviolet-visible spectra, cyclic voltammetry (CV) and electrical conductivity were the analysis that used to characterize the synthesized samples. Results and Conclusions: FE-SEM images clearly demonstrate that the morphology of the synthesized samples are nanostructured (nanoflowers and nanofibers). Electrochemical calculations of band gap from CV curves demonstrated that the forbidden band gap of the PSANFLs and PSANFs/TiO2NPs nanocomposite are 2.95 and 2.23 eV, respectively. I–V characteristics of hybrid solar cells and their power conversion efficiency (PCE) under 100 $mWcm^{-2}$ irradiation (AM 1.5 global conditions) were measured that The PCE of the samples were 0.30 and 0.62%, respectively. At the end, all the results of solar cell analysis were discussed. To sum up, PSANFLs and PSANFLs/TiO2NPs were successfully synthesized by an affordable and straightforward mechanochemical reaction in solid-state under the green condition. The solubility and processability of the synthesized compounds have been improved compared to the previous work. We successfully fabricated hybrid photovoltaic cells of synthesized semiconductor nanostructured polymers and TiO2NPs as different architectures. We believe that the synthesized compounds can open inventive pathways for the development of other Poly(N-(sulfophenyl)aniline based hybrid materials (nanocomposites) proper for preparing new generation solar cells.

Keywords : mechanochemical synthesis, PSANFLs, PSANFs/TiO2NPs, solar cell
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