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Camphor sulfonic acid doped polyaniline-tin oxide hybrid nanocomposites: Synthesis, structural, morphological, optical and electrical transport properties

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Abstract

Camphor sulfonic acid (CSA) doped PANi–SnO_2 hybrid nanocomposites were synthesized by solid-state synthesis route with varying amounts (10–50%) of CSA. X-ray diffraction studies have proven the successful incorporation of CSA into the polyaniline–SnO_2 hybrid nanocomposites and the results are also supported by microstructural analysis. UV–visible and Fourier infrared spectroscopy studies have provided insight into the electronic interaction between the CSA, polyaniline, and SnO_2. The room temperature dc electrical conductivity of CSA-doped PANi–SnO_2 hybrid nanocomposite films were observed to depend on the amount of CSA doping and the morphology.

Keywords: C. Electrical properties; C. Optical properties; PANi–SnO_2 hybrid composites; Structural properties

1. Introduction

In recent years, conducting polymers such as polyaniline, polythiophene and polypyrrole have received much attention because of their potential applications in chemical and biological sensors, electronic devices, as well as efficient and low cost solar cells, due to their remarkable mechanical and electrical properties such as low operating temperature, low cost, flexibility and easy processability and so on [1–7]. However, there are also some disadvantages such as low chemical stability and mechanical strength that are unfavorable for conducting polymer-related applications.

Metal oxides can adopt a large variety of structural geometries with an electronic structure that may exhibit metallic, semiconductor, or insulator characteristics, endowing them with diverse chemical and physical properties. Therefore, metal oxides are the most important functional materials used for chemical and biological sensing and transduction. Moreover, their unique and tunable physical properties have made themselves excellent candidates for electronic and optoelectronic applications. Nanostructured metal oxides have been actively studied due to both scientific interests and potential applications [8–13].

Polyaniline is one of the many interesting conducting polymers used in gas sensing, solar cells and supercapacitors [1–7]. Polyaniline can exist in three different oxidation states and the intrinsic redox reactions it can undergo, results in different electrical properties that vary easily with doping, making it suitable for gas sensing application [1–7]. However, an important drawback with polyaniline is its limited mechanical strength. Doping of polyaniline with various acids influences the optoelectronic properties by changing the chemical/structural nature of the polymer and also creating more active sites [14,15]. Potential dopants for polyaniline include camphor sulfonic acid, *p*-toulene sulfonic acid, hydrochloric acid, sulfuric acid, tannin sulfonic acid, lignin sulfonic acid, etc. Among these different dopants camphor sulfonic acid doped polyaniline have enhanced chemical stability and thermal degradation properties and have performed as better anti corrosion materials than polyaniline itself [16,17].

Organic–inorganic (conducting polymer–metal oxide) hybrid materials are currently of great interest for exploring enhanced sensor characteristics, due to their synergetic or complementary behaviors that is not available from their single counterparts [18,19]. The syntheses of PANi–SnO_2 hybrid

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nanocomposite with different combinations of the two materials have attracted more and more attention, since they have interesting physical properties and potential applications. These particles not only combine the advantageous properties of SnO_2 and PANi, but also exhibit many new characteristics that single-phase materials do not have.

In this article, we report the preparation of CSA-doped PANi–SnO_2 hybrid nanocomposites films by spin coating technique and effect of CSA doping on their structural, morphological, optical and electrical transport properties.

2. Experimental methods

2.1. Materials

Aniline, ammonium peroxydisulfate ($(NH_4)_2S_2O_8$, APS), ammonia (30%), methanol, hydrochloric acid (34%) of analytical reagent grade were used as received from Sd Fine Chem. Ltd., Mumbai. Stannic chloride pentahydrate (Thomas Baker) was used as received and camphor sulfonic acid of 99.9% purity was purchased from Sigma-Aldrich chemicals.

2.2. Preparation of PANi–SnO_2 nanocomposites

PANi–SnO_2 hybrid nanocomposite was prepared by solid-state synthesis route. The details of the synthetic procedure have been published elsewhere [20,21].

2.3. Preparation of CSA-doped PANi–SnO_2 hybrid nanocomposites

Camphor sulfonic acid (CSA) doped polyaniline–SnO_2 hybrid nanocomposites were prepared by adding CSA (10–50%) into polyaniline–SnO_2 nanocomposite matrix. For thin film formation, CSA doped PANi–SnO_2 hybrid nanocomposites were dissolved in m-cresol and stirred for 11 h. Thin films of the CSA doped PANi–SnO_2 hybrid nanocomposites were prepared on glass substrate by using spin coating technique at 3000 rpm for 40 s. and dried on hot plate at 100 °C for 10 min. Fig. 1 shows the flow diagram of synthesis and deposition of CSA doped PANi–SnO_2 hybrid nanocomposites.

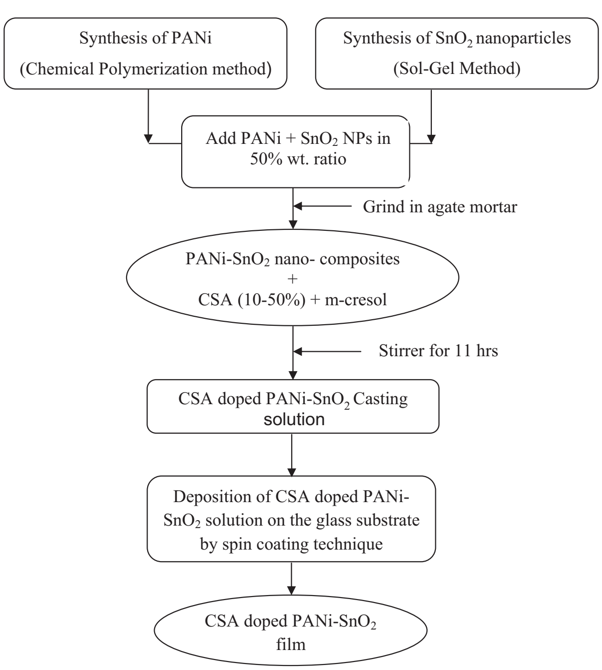
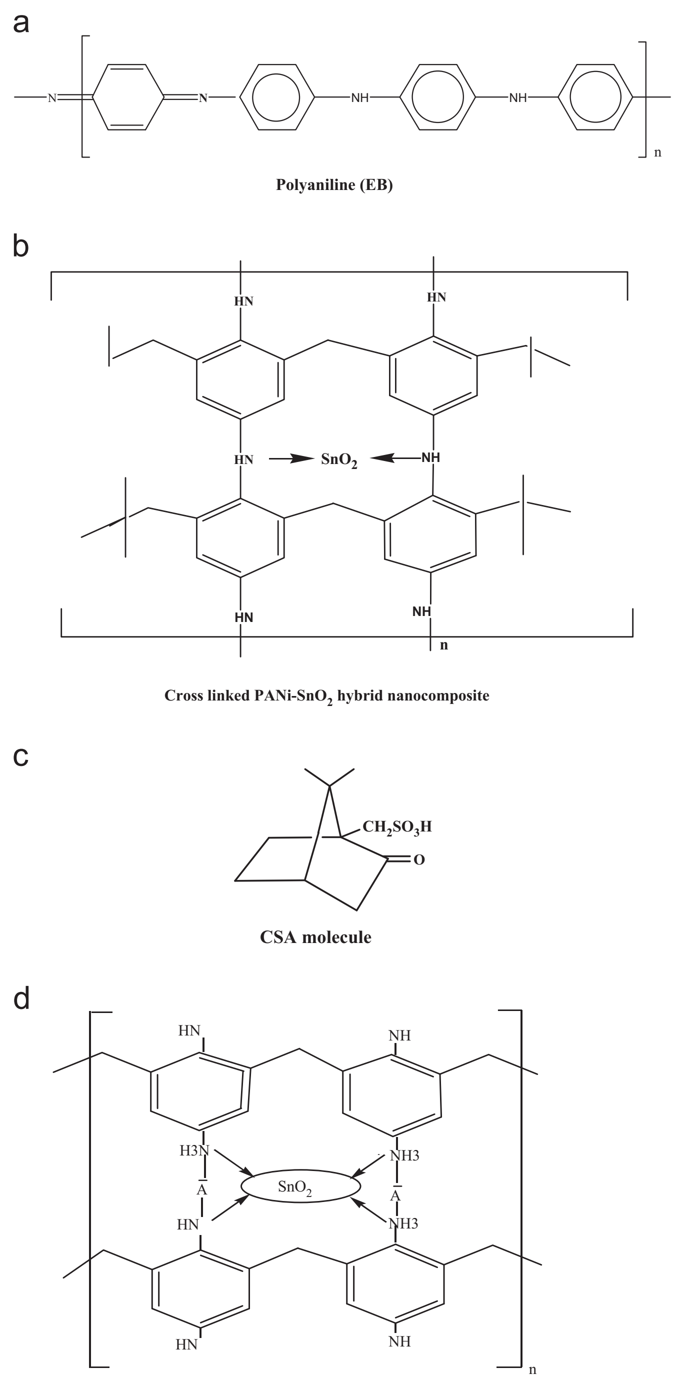


Fig. 1. Flow diagram of synthesis and deposition of CSA doped PANi–SnO_2 hybrid nanocomposites.



Scheme 1. Reaction mechanism of CSA doped PANi–SnO_2 hybrid nanocomposites; (a) formation of PANi (EB), (b) formation of PANi–SnO_2 hybrid nanocomposite, (c) molecular structure of CSA and (d) formation of CSA doped PANi–SnO_2 hybrid nanocomposite.