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Synthesis and characterization of AgI nanoparticles in β-CD/PAN nanofibers by electrospinning method

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ABSTRACT

AgI nanoparticles/β-cyclodextrin (β-CD)/polyacrylonitrile (PAN) composite nanofibers film were prepared via a new route which combined electrospinning technology with the reaction of solid–liquid process. In this article, AgI nanoparticles were successfully prepared in β-CD/PAN nanofibers which contained different concentration β-CD by the new route. Firstly, the $AgNO_3$–β-CD/PAN nanofibers were obtained via electrospinning method, then put the nanofibers into the solution of potassium iodide to prepare AgI–β-CD/PAN nanofibers. The morphology and structure of the composite nanofibers and nanoparticles have been investigated by scanning electron microscopy (SEM) and transmission electro microscopy (TEM). The existence of the AgI nanoparticles was proved by X-ray photoelectron spectroscopy (XPS) and X-ray diffractometer (XRD) patterns. The results of various characterizations indicated that the sample of AgI–β-CD (2 wt%)/PAN have the optimum morphology and structure.

1. Introduction

In the modern world, nanomaterials acted as an indispensable role in vast majority fields, thus, the research of nanomaterials has caused great interests. In addition, the preparation and study semiconductor nanomaterials have been also attracted the attention of most people due to its numerous applications. Recently, more and more researchers devote themselves to prepare semiconductor nanomaterials through many different methods in order to find potential application in different fields [1–4].

Silver iodide semiconductor nanomaterial possesses extensive applications in numerous fields, such as photographic materials [5], catalyst materials [6], and ionic semiconductor materials [7]. Over the past few years, much endeavor has been made to prepare AgI nanoparticles by many different methods, for example, mechanochemical reaction technique [8], chemical reaction [9] and sol–gel method [10], etc. However, in recent years, the research of organic and inorganic composite nanomaterials has also been arisen great interests; more and more people devote themselves to explore composite nanomaterials [11]. Meanwhile, a lot of people try to combine polymers with nanoscale inorganic particles, they have been realized that the composites would own dual nature of polymers and inorganic nanoparticles or may be obtain some new properties [12]. Kim and co-workers have been doped ZnO nanoparticles into poly(methylmethacrylate) microspheres by in situ suspension polymerization [13].

At the same time, electrospinning technology has been recognized as a simple and economical method of preparing polymers and inorganic nanoparticles blending composite materials. The main equipments of electrospinning technology contain high-voltage power supply, metal receiver and glass tube. During a typical process, a high voltage is applied between a droplet of a polymer solution, held at the end of a glass tube and a metal receiver. When the applied electric field surmounts the surface tension of the droplet, the polymer solution is ejected from the glass tube nozzle. With the fast evaporation of solvent and the tensile and split process, the droplets form nanofibers and deposit onto the receiver [14,15]. Xia and co-workers [16,17] synthesized composite nanofibers of TiO_2/PVP and SnO_2/PVP via electrospinning technology. Bai and co-workers have successfully prepared silver chloride nanoparticles in PVP nanofibers by electrospinning method [18].

In this article, we successfully prepare AgI nanoparticles/β-cyclodextrin (β-CD)/polyacrylonitrile (PAN) composite nanofibers film via electrospinning method and the reaction process of liquid–solid. The specific process is shown in Scheme 1. The products that we preparation are organic–inorganic composite nanofibers. To our knowledge, the method of we synthesized AgI nanoparticles in β-CD/PAN composite nanofibers has never been reported previously. We successfully obtained composite fibers with well-dispersed nanosized AgI particles. The morphology and structure of these composite nanomaterials have been investigated under various characterizations.

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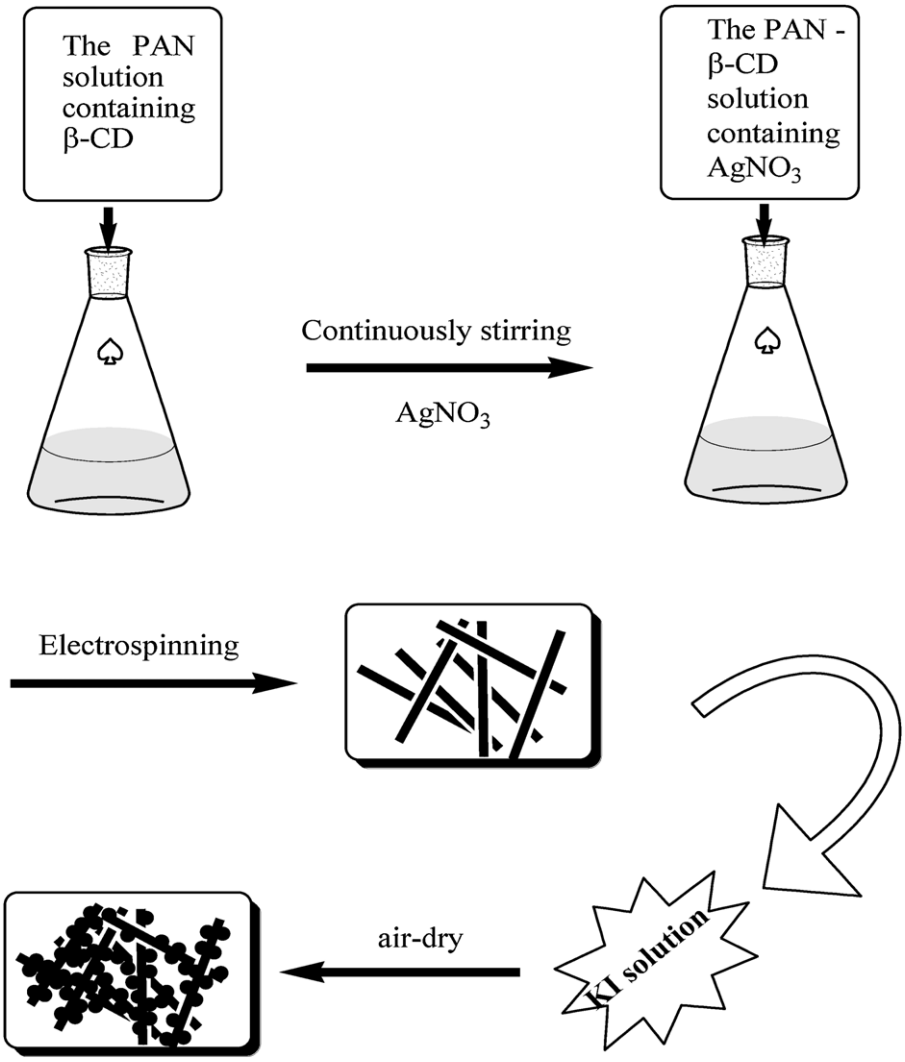

Scheme 1. Scheme of the procedure used to prepare the AgI–β-CD/PAN composite nanofibers.

2. Experimental

2.1. Materials

Silver nitrate ($AgNO_3$, AR, 99.8%) was provided by Tianjin Yingda Sparseness & Noble Reagent Chemical Factory. Potassium iodide (KI) and N,N-dimethylformamide (DMF) were supplied by Beijing Chemicals Co. (China). Polyacrylonitrile (PAN, Mw = 80,000) was purchased from Kunshan Hongyu Plastics Co. Ltd. (China). The above chemical reagents used were analytical grade and used without further purification.

2.2. Preparation of β-CD/PAN nanofibers containing $AgNO_3$ by electrospinning

It is essential to prepare solution before obtain β-CD/PAN nanofibers containing Ag ion. Thus, PAN and silver nitrate were dissolved in N,N-dimethylformamide (DMF), the mole ratio of PAN and $AgNO_3$ was 5/1. We prepared above solution three groups and keep stirring in the dark; the temperature was remained at zero degree by an external ice bath. After stirring 12 h, different mass percent of β-CD (2 wt%, 4 wt%, 6 wt%) was dissolved in above solution separately and continued stirring 12 h, the concentration of PAN was always kept in 10 wt%. The solution was injected in a glass tube with a sharp nozzle (the inner diameter was 1 mm). The glass tube was connected to the positive electrode by a copper wire twined it; a flat piece of aluminum foil, which was connected to the negative electrode, was used to collect electrospun fibers and the distance between the aluminum foil and sharp nozzle was 15 cm. The electrospinning was performed at 18 °C.

2.3. Preparation of AgI–β-CD/PAN composite nanofibers using KI solution

Potassium iodide was dissolved in deionized water; the concentration of KI was 0.4 wt%. At the same time, the obtained film was immersed in KI solution without illumination. About 24 h later, the reaction between $AgNO_3$ and KI was finished completely. The composite nanofibers were natural drying in the dark.

The AgI/PAN nanofibers film was also prepared using the similar procedure as described above.

2.4. Characterization

Scanning electron microscopy (SEM) (Hitachi, S-3400N, Japan) was used to observe the morphology and dispersion of AgI nanoparticles, and the samples were first coated with a thin