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Surface Modification of Electrospun PAN Nanofibers and Its Application for Adsorption of Lead Ions

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Abstract

Surface modified PAN nanofibers were prepared by reaction between PAN electrospun nanofibers and hydroxylamine hydrochloride. The prepared nanofibers were used as matrix for lead ions adsorption. Micrographs of modified normal PAN fibers and PAN nanofibers were observed by Field Emission Scanning Electron Microscope (FESEM), and Fourier Transform Spectroscopy (FTIR) spectra of the surface modified PAN nanofibers were recorded. The adsorption capacity of modified PAN nanofibers and modified normal PAN fibers were calculated, and the adsorption isotherm of Pb^{2+} on the modified PAN nanofibers was studied. According to the results of experiment, surface modified PAN nanofibers had excellent adsorption capacity for lead ions.

Keywords: Surface Modified; Electrospun; Nanofibers; Adsorption

1 Introduction

Electrospinning is the most common technique for preparing nanofibers, the polymer jet is ejected when the electrostatic force applied to the polymer liquid overcomes the surface tension of the polymer solution. The charged jet is accelerated in the electrostatic field, solvent evaporation and deposition on a substrate at random [1, 2]. Nanofibers have gained a great deal of attention in recent decades due to such properties as remarkable high porosity, excellent structural mechanical strength, high surface area per unit mass, and so on. The expanding applications of nanofibers include filtration, enzyme immobilization, tissue engineering and biosensor. Especially nanofibers were applied for waste water treatment and recycling precious metals [3-6].

In recent years, plenty of researches have focused on surface modification of Ployacrylonitrile (PAN). PAN fibers have attracted much attention due to a variety of excellent characteristics, which include high strength, thermal stability, tolerance to most solvents, bacteria and photo irradiation, abrasion resistance. This would provide convenient diffusion channels and more reaction sites to adsorb metal ions.

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In this study, PAN nanofibers were electrospun. Amidoxime PAN normal fibers and amidoxime PAN nanofibers were prepared through treatment of normal PAN fibers and electrospun PAN nanofibers in hydroxylamine aqueous solution. Then, the amidoxime PAN nanofibers were applied for lead ions (Pb^{2+}) adsorption. The structures and properties of the modified normal PAN fibers and PAN nanofibers were characterized by Scanning Electron Microscopy (SEM) and Fourier Transformed Infrared Spectroscopy (FTIR). Additional, the absorbability was determined by Atomic Absorption Spectrophotometer (AAS).

2 Materials and Methods

2.1 Materials

Hydroxylamine hydrochloride, sodium carbonate, N, N-dimethylformamide (DMF), lead nitrate was purchased from Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China). Normal PAN fibers were produced by Daqing Petrochemical Company, PAN (Mw=79100 g/mol) was obtained from Aldrich and used without further purification. Water used in all experiments was de-ionized. All the chemicals were of analytical grade and used as received.

2.2 Methods

2.2.1 Preparation of PAN Nanofibers

PAN was dissolved in DMF at room temperature with stirring. The grounded collection roller covered with the aluminum foil was used to collect the nanofibers. The high-voltage supplier (DW-P503-4AC, Tianjin, China) was used to connect metal needles and the grounded collector for forming electrostatic fields. The parameters of electrospinning were set as follows: voltage 18 KV, collecting distance between the syringe needle tip and the grounded collector 18 cm, solution flow rate 1.0 mL/h. The solution flow rate was controlled by a microinfusion pump (JZB-1800D, Changsha, China), PAN solutions were placed in syringes with a 0.7 mm diameter spinner jet. Nanofibers were collected by roller for 24 h.

2.2.2 Surface Modification

0.5 mol/L hydroxylamine hydrochloride aqueous solution was prepared; the value of pH was adjusted to 6 by adding sodium carbonate solution. 0.25 g PAN nanofibers and 0.25 g normal PAN fibers were added to 80 mL hydroxylamine hydrochloride aqueous solution, the reaction was carried out at 70℃ for 2 hours and 4 hours respectively. Then, the nanofibers and normal fiberse taken from reaction medium were washed with distilled water and dried in a vacuum oven.

2.2.3 Conversion Rate of Amidoximation

The rate of amidoximation was calculated as follows:

$$\eta = \frac{(W_1 - W_0) \times 53}{W_0 \times 33} \times 100\% \quad (1)$$