

Fabrication of nano-polypyrrole Fibers using anodic aluminium oxide membrane technique

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1. Introduction

Polypyrrole (PPy) is one of the most important conducting polymers. Recently many papers pay attention to the nano-conducting polymer. It has been known two kinds of templates, nuclepore polymer template and anodic aluminium oxide (AAO) film, were used. The nanometer conductive polymer fibers have been fabricated in the pores of nuclepore polycarbonate templates by use of dc current deposition method [1,2]. In this paper, both the electrochemical method and chemical method are developed to produce nanometer sized PPy fibers by using anodic aluminum oxide films as the template.

2. Nano-PPy prepared using ac current method

Aluminum (99.9%) foil with thickness of 0.1mm was polished electrochemically under the voltage of dc 10V in a EtOH(95%) : HClO₄(70%) = 5:1 (V/V) solution for 2 minutes. After washing, the aluminum electrode was etched in 0.24M Na₂CO₃ solution for 1 min. to remove the native oxide layer. The aluminum foil was anodized in 0.5M H₂C₂O₄ solution at the voltage of dc 40V for 4-21 hours. Then the anodizing voltage was decreased stepwise in 5V intervals over a period of 5 minutes in order to reduce the thickness of barrier layer.

Pyrrole was polymerized electrochemically within the pores in anodized aluminum film on aluminum electrode in a solution containing 0.1M pyrrole and 0.2M LiClO₄ under ac 20V with frequency of 50Hz for 6 minutes. The electropolymerized nano-PPy fibers were obtained by immersing the PPy/AAO/Al foil in 0.1M NaOH solution at 40 for more than 5 minutes or in 0.5M H₃PO₄ solution containing 0.2M CrO₃. The SEM image of nano-PPy fibers in Fig.1 was measured for a partly dissolved sample, in which many paralleled nano-PPy fibers appeared. Fig.2 presents a piece of nano-PPy fiber obtained after the dissolution of alumina in 0.1M NaOH solution completely. The fiber presents a length of 3.4μm and with a diameter about 100nm. After being immersed in alkaline solution the nano-PPy fiber might be suitable for the use of switching material in the electronic devices as alkaline treated PPy film described in reference [3].

3. Nano-PPy prepared using chemical method

An anodic aluminum oxide (AAO) membrane was obtained by immersing the anodized aluminum foil in saturated HgCl₂ solution. The metal aluminium was dissolved via a replacement reaction of Al with Hg²⁺ ions. Therefore the AAO film could be peeled off. The AAO membrane with nanometer sized pore arrays was used as a nano-pores template.

The chemical preparation of nano-PPy fibers was carried out within a small two-compartment cell, which consisted of two plastic centrifugal tubes. An AAO membrane was placed in the center as the dividing separator. The solution containing oxidant reagent 0.2M (NH₄)₂S₂O₈ was added in one compartment while another compartment was full of 0.2M pyrrole solution. The polymerization of pyrrole took place in the nano-pores of AAO membrane where two

kinds of solution met together. The polymerization process was maintained for 5 minutes or longer.

Fig.3 presents the image of a PPy/AAO membrane after being immersed in 0.1M NaOH for 4 minutes. It can be seen that part of nano-PPy fibers with the diameter about 80nm are separated from the AAO. Part of AAO membrane appears on the button. The pore diameters of AAO membrane are similar with that of PPy fibers.

The properties of nano-PPy fibers were investigated.

Reference

[1] M. Nishizawa, V.P. Menon, C.R. Martin, Science. 268 (1995) 700.

[2] C. Jerome, D. Labaye, I. Bodart, Synthetic Metals. 101 (1999) 3.

[3] H. Xie, M. Yan, Z. Jiang, Electrochim. Acta. 42 (1997) 2361.

Fig.3 SEM image of partially dissolved nano-PPy fabricated by ac current method, polymerization voltage: 20V, time: 6 minutes

Fig2 SEM image of nano-PPy fiber fabricated by ac current method, polymerization voltage: 8V, time: 21 hours

Fig.3 SEM image of the partially dissolved AAO/PPy film fabricated by chemical method, polymerization time: 6 minutes