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Synthesis of polyaniline nanostructures with controlled morphology by a two-phase strategy

Yongjun He [*], Jianhua Lu

Department of Chemistry and Chemical Engineering, Xi'an University of Science and Technology, Xi'an 710054, China

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Abstract

Polyaniline nanostructures with tubular, spherical, polyhedral, dendritic and belt-like morphologies were synthesized by simply tuning the preparation conditions in a two-phase medium. SEM, FTIR and UV–vis were applied for the characterization of the products. The results showed that the polarity of the organic solvents, the amount of ammonium peroxydisulfate (APS) and the concentration of the acetic acid influenced the morphologies of the polyaniline nanostructures. The difference in the polyaniline morphologies was attributed to the difference in the relative rate of interfacial nucleation to aqueous nucleation. The route reported here is expected to be applied for the controlled synthesis of various polymer nanostructures.

Keywords: Polyaniline; Nanostructures; Two-phase strategy

1. Introduction

Among the known conducting polymers, polyaniline is unique due to its electronic, magnetic, and optical properties similar to metals while retaining the flexibility and processibility of conventional polymers [1–8]. In recent years, polyaniline nanostructures have attracted intensive interest because of their potential applications such as chemical/electrochemical sensors, conducting molecular wires, light-emitting diodes, gas-separation membranes, etc. Various strategies including template synthesis, nanofiber-seeding, self assembly and interfacial polymerization have been developed for the synthesis of polyaniline nanostructures with different morphologies [9–14]. Among these reported approaches, interfacial polymerization exploited by Kaner group is the latest to chemically synthesize bulk polyaniline nanofibers, by which the polymerization of aniline is performed in an immiscible organic/aqueous biphasic system [15].

There were two kinds of nucleation processes in the interfacial polymerization: one is interfacial nucleation, and the other is aqueous nucleation. The interfacial nucleation favored the formation of polyaniline fibers, while the aqueous nucleation favored the formation of granular polyaniline particles [12,14,16]. We thought it is conceivable to obtain polyaniline nanostructures with transitional morphologies (between fibers and granules) by tuning the relative rate of the aqueous nucleation to interfacial nucleation. However, in the reported

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[*] Corresponding author. Tel.: +86 29 85583183; fax: +86 29 85583182.
E-mail address: yongjhe@yahoo.com.cn (Y. He).

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interfacial polymerization route, the effect of the aqueous nucleation on the morphologies of the products was often ignored.

In this communication, we prepared polyaniline nanostructures with tubular, fibrous, polyhedral, dendritic, spherical and belt-like morphologies in a two-phase medium. The products were characterized by SEM, TEM, FTIR and UV–vis. A possible mechanism for the formation of the polyaniline nanostructures with different morphologies was discussed.

2. Experimental section

2.1. Materials

Aniline (Tianjin Chem. Co.) was distilled under reduced pressure. Ammonium peroxydisulfate (APS, Shanghai Chem. Co.), acetic acid (Xi'an Chem. Co.), toluene (Xi'an Chem. Co.), 1-hexane (Beijing Chem. Co.), 1-hexanol (Tianjin Chem. Co.) and acetone (Xi'an Chem. Co.) were used as received without further treatment.

2.2. Synthesis

Standard synthetic process for the polyaniline nanostructures was as follows: 1.5 mmol of aniline was dissolved in 2 mL of toluene. 0.5 mmol of APS was dissolved in 8 mL of 0.2 mol/L acetic acid solution. The organic solution was added to the aqueous solution gently and with minimal agitation along the sides of the tubes. The resulting two-phase system was left undisturbed at 10 °C for 15 h. The polyaniline nanostructures were filtered, washed

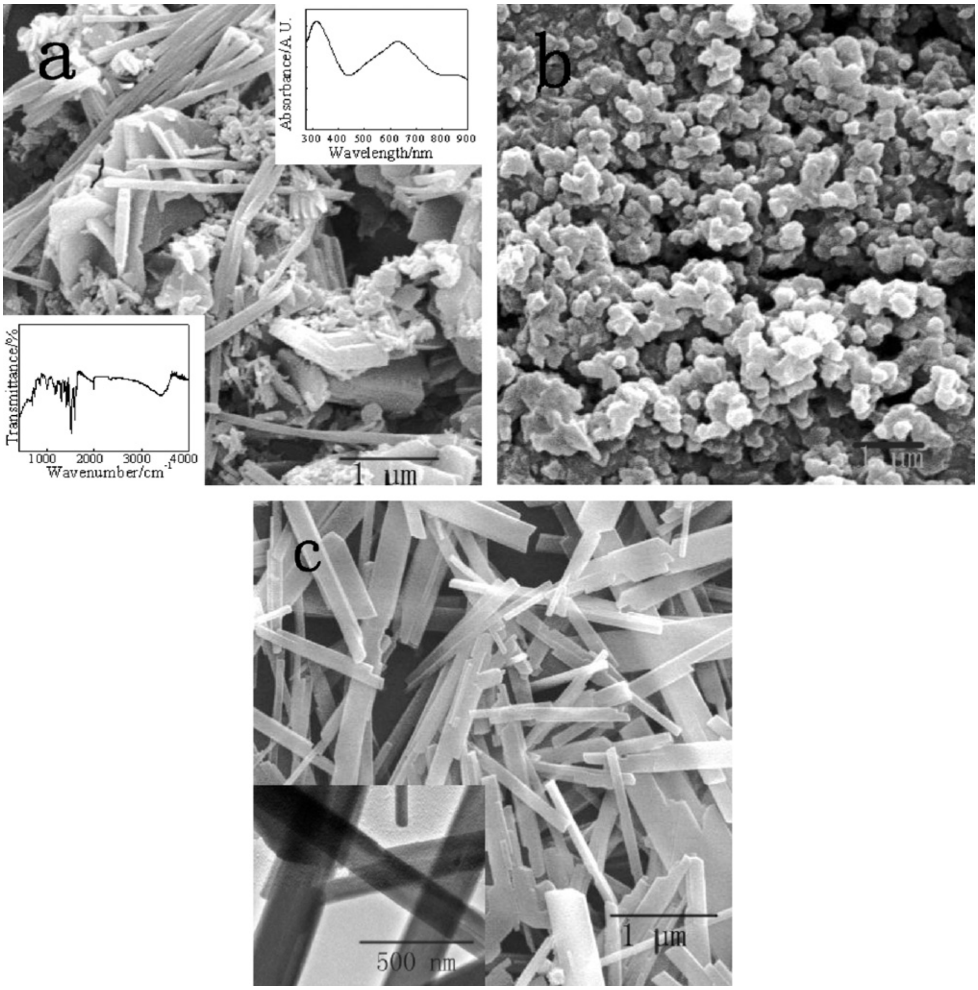

Fig. 1. SEM images of polyaniline nanostructures using (a) toluene, (b) 1-hexanol and (c) 1-hexane as organic phase. The insets in (a) are FTIR (left) and UV–vis (right) spectra of the samples. The inset in (c) is the TEM image of the polyaniline nanobelts.