01 Jan 2008

Polyaniline Nanofiber-Based Gas Sensors

Zhe-Fei Li

Frank D. Blum
Missouri University of Science and Technology

Massimo F. Bertino
Missouri University of Science and Technology

Chang-Soo Kim
Missouri University of Science and Technology, ckim@mst.edu

Recommended Citation

POLYANILINE NANOFIBER-BASED GAS SENSORS

Zhefei Li,[a] Frank D. Blum,[a] Massimo F. Bertino,[b] Chang-soo Kim[c]

[a] Departments of Chemistry and Materials Science and Engineering
[c] Department of Electrical and Computer Engineering and Biological Sciences
Missouri University of Science and Technology, Rolla, MO 65409
[c] Department of Physics
Virginia Commonwealth University, Richmond, Virginia 23284

Introduction

There has been recent interest in conducting polymers that have very promising chemical and electrical applications. Some of these polymers have shown great potential for use in sensors.[1] Polyaniline is one particular example of a prospective material.

In our laboratory, we have studied the synthesis of polyaniline nanofibers. We have carried out one-pot syntheses to obtain polyaniline nanofibers in aqueous solutions where the polymerization was influenced by γ-radiation[2] or UV-radiation.[3] This polymer can also be patterned with an appropriate photo mask.

In our present report, polyaniline nanofiber thin film sensors have been fabricated in one step by employing UV-irradiation and those sensors showed high sensitivity. Changes in conductivity were monitored with an electrometer as a function of time after the materials had been exposed to different gases. This simple gas sensing device can be used to detect many different gaseous types.

Experimental

Synthesis of polyaniline nanofibers. Polyaniline was synthesized by in-situ chemical oxidation polymerization of aniline with ammonium persulfate as the oxidant. Reactions were performed in 10 mL distilled water with 0.1 M aniline, 0.1 M hydrochloric acid (HCl) and 0.05 M ammonium persulfate (APS). Polyaniline nanofibers were prepared by exposing the precursor solution to UV light for 30 min.

Fabrication of polyaniline nanofiber sensors. Interdigitated gold microelectrodes were fabricated on flexible Kapton® substrates (Du Pont). The precursor solution, 25 μL, was dropped on the interdigitated microelectrodes and the solution was immediately irradiated with the UV light for 30 min. After the reaction, the film was washed with water and then dried at room temperature before measurement.

Instrumentation. Real-time current changes were monitored using a Keithley 617 programmable electrometer operated at 0.1 V. The morphology was characterized using a Hitachi S-4700 scanning electron microscope (SEM) operated at an accelerating voltage of 2 KV.

Results and Discussion

The SEM image for polyaniline nanofibers is shown in **Figure 1**. We observe that the polyaniline synthesized with UV-irradiation possesses a fibrous structure. In this case, the fibers seem to be laid down on the substrate as sort of a porous mesh. The high porosity and large surface area of the polymer should be an advantage for gas detectors.

Figure 2 displays the response of a polyaniline nanofiber thin film sensor to chloroform. For the interaction with organic solvent vapors, we believe that the electron carrier movement is interrupted by the adsorption of gases. Also, adsorbed gases might change the surface properties of polyaniline.[4] Vapor molecules can easily diffuse into the polyaniline nanofiber layer through the porous structures shown in **Figure 1**, causing the current decrease. The exponential decay time constant for chloroform is 25.2 sec. The response to other vapors may be much shorter.

The response to chloroform is reversible. The current will recover to its original value after exposure to chloroform is stopped. The recovery time constants are longer than the decay time constants. It is more difficult for the chloroform to diffuse out of the polyaniline layer, possibly because chloroform molecules are absorbed by the polymer chain.
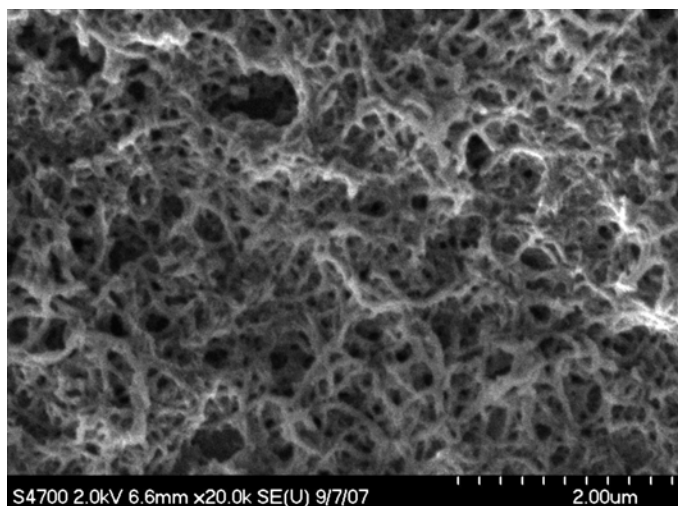

Figure 1. SEM image of polyaniline nanofibers on interdigitated microelectrodes.
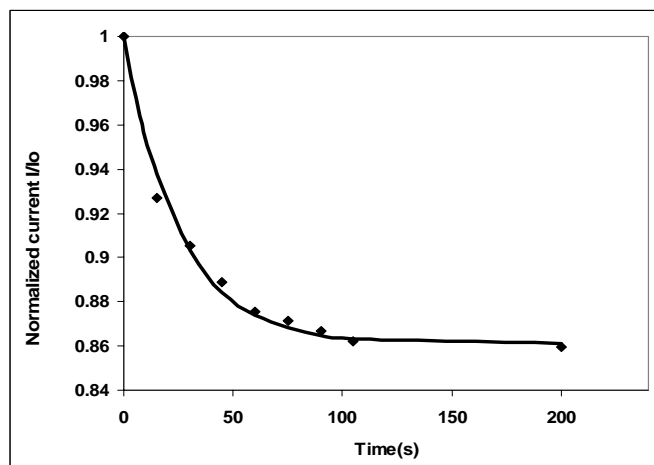

Figure 2. Response of a polyaniline nanofiber sensor to gaseous chloroform. The response is exponential with a time constant of 25.2 sec.

Conclusions

Polyaniline nanofiber-based thin film sensors can be fabricated with UV-irradiation. The material can be prepared from aqueous solutions, avoiding environmental problems. The SEM pictures show that the polyaniline produced has high surface area and porosity. These characteristics give sensors made from this material the potential for reasonably fast response times. The response to chloroform is reversible and this simple gas sensing device can be used as a gas detector.

References

(1) Virji, S.; Huang, J.; Kaner, R. B.; Weiller. B. H. Nano Lett. **2004,** 4, 491.
(2) Pillalamarri, S. K.; Blum, F. D.; Tokuhiro, A. T.; Story, J. G.; Bertino, M. F. *Chem. Materials*, **2005**, *17*, 227.
(3) Werake, L. K.; Story, J. G. ; Bertino, M. F. ; Pillalamarri, S. K.; Blum, F. D. *Nanotechnology*, **2005**, 16, 2833.
(4) Jin, G. R.; Ha, R H.; Joon, B Y.; Jeong, O L.; Jeung, S H. J. Macromolecular. Sci. A **2002,** A39, 1095.