P3HT/PMMA Fibers Fabricated by Electrospinning Technique for High Sensitivity Volatile Organic Compounds Sensor

Shih-Hsuan Chen[1], Shun-Hsiang Chan[1], Chun-Fu Lu[2], Wei-Fang Su[2] and Ming-Chung Wu[1,*]

[1]Department of Chemical and Materials Engineering, Chang Gung University, Taiwan
[2]Department of Materials Science and Engineering, National Taiwan University, Taiwan
*E-mail address: mingchungwu@mail.cgu.edu.tw

1. Introduction

Volatile organic compounds (VOCs) sensors are the imperative technology of modern life for environmental monitoring. In this study, we demonstrated a VOCs sensor chip adopting the proposed methodology that the optical property of poly(3-hexylthiophene)(P3HT)/poly(methyl methacrylate)(PMMA) blend is sensitive to VOCs vapor due to morphological evolution and hence can be served as an indication of the presence of VOCs.[1] Various VOCs, including toluene, chlorobenzene and acetone, was used to test the sensitivity of our P3HT/PMMA VOCs sensing chip[2-3]. The P3HT/PMMA served as a representative blend, and the sensitivity of the P3HT/PMMA blend was optimized with respect to P3HT/PMMA blending ratio, and blend concentration. The low cost and high sensitivity VOCs sensing chip developed in this study significantly extends the current VOCs sensing technology and can be extensively used to effectively prevent humans and the environment from potential damages of VOCs.

2. General Instructions

For the fabrication of VOCs sensing chips, the PMMA and various concentration P3HT were dissolved in chloro-benzene with continuous stirring for 48 h, respectively. Then, the P3HT solution was added to the stirred solution of PMMA in chlorobenzene. During the electrospinning process, the constant flow rate was fixed at 1.0 ml/h; the tip-to-collector distance was fixed at 7.0 cm and applied high-voltage 15.0 kV. The rotational speed of the metallic collector was 80 rpm. The extinction spectra of the P3HT/PMMA sensing chip exposed to various VOCs, in-cluding, toluene, chlorobenzene and acetone, for different time.The various VOCs sensing chips fabricated from P3HT/PMMA were prepared successfully by the electro-spinning technique in this study. Herein, we define the sen-sitivity, S, of the sensing chip according to the extinction spectra variation at different wavelength (Fig. 1(a)). The equation of S of the sensing chip at 560, 600 and 1020 nm are shown as below:

$$Sensitivity_{560} = \frac{E_{560after} - E_{560before}}{E_{560before}} \quad (1)$$

$$Sensitivity_{600} = \frac{E_{600after} - E_{600before}}{E_{600before}} \quad (2)$$

$$Sensitivity_{1020} = \frac{E_{1020after} - E_{1020before}}{E_{1020before}} \quad (3)$$

where E_{before} and E_{after} are extinction before and after VOCs vapor exposure, respectively.

The extinction spectra of P3HT/PMMA sensor chip exposed various VOCs for different time are shown in (Fig. 1(b)-(d)). These VOCs, including toluene, chlorobenzene and acetone, were chosen to test the applicability of the sensor, and the results reveal high performance. In addition, the P3HT/PMMA sensor chip exhibited the highest sensitivity for exposing chlorobenzene.

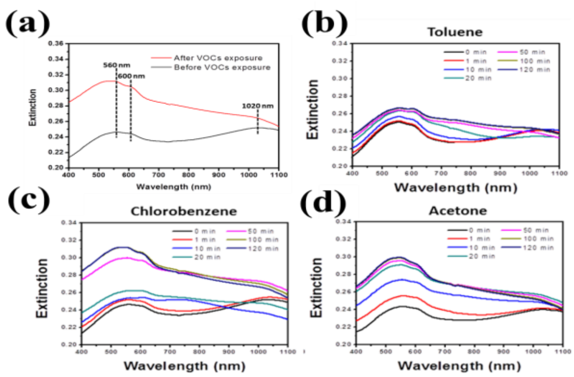

Figure 1 Extinction spectra of P3HT/PMMA sensing chip (a) before and after chlorobenzene vapor exposure for 2 h (b) exposed various VOCs for different time.

3. Conclusions

The VOCs sensing materials consisted of P3HT/PMMA blending were prepared successfully by electrospinning process in this study. A series of VOCs, e.g. acetone, toluene and chlorobenzene were chosen to test the sensitivity of P3HT/PMMA fibrous film. The P3HT/PMMA fibrous film can effectively detect the lower explosive limit for VOCs, and it even can achieve the detection limit of acetone, toluene at 500 ppm. This low-cost P3HT/PMMA fibrous film developed in the present work extends the current VOCs sensing technology. It can be extensively used to protect humans and the environment from VOCs potential risks.

Acknowledgements

The authors wish to acknowledge the financial support of the Ministry of Science and Technology and Linkou Chang Gung Memorial Hospital.

References

[1] X. Wang, C. Drew, S. H. Lee, K. J. Senecal, J. Kumar, L. A. Samuelson, Nano Lett. **2** (2002) 1273-1275.

[2] H.-C. Liao, C.-P. Hsu,M.-C. Wu, C.-F. Lu, W.-F. Su, Anal. Chem. 85 (2013) 9305-9311..

[3] M.-C. Wu, H.-C. Liao, Y. Chou, C.-P. Hsu, W.-C. Yen, C.-M. Chuang, Y.-Y. Lin, C.-W. Chen, Y.-F. Chen, W.-F. Su, J. Phys. Chem. B, **114** (2010) 10277-10284.