Etching Effect on Electrospun Ag/QR/PMMA Freestanding Film for Volatile Organic Compounds Detection

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1. Introduction

The excessive volatile organic compounds (VOCs) in chemistry workspace and indoor usually threatens human's health. Three-dimensional structured materials show a strong potential for sensing applications such as detecting VOCs in threaten threshold. The electrospun technique is a facile and quick process to create various nanostructures or submicron structures. Moreover, combining the quantum nanomaterials with optical sensing materials usually directly changes their optical behavior. Herein, we prepare a hybrid material consisting of CdSe/CdS quantum rods (QD), silver nanoparticles, and poly(methyl methacrylate) (PMMA) by electrospinning technique. The hybrid Ag/QD/PMMA sensing material is deposited on metal frame substrates and presents freestanding fiber film. In case of CdSe/CdS existing in the ordered-arrangement fibers, it can greatly increase the light absorption of the sensing material and provide the polarization property toward the light scattering. Furthermore, silver nanoparticles also improves the light response due to the surface plasma resonance. [2] After UV-ozone etching treatment, we further investigate the correlation between the sensitivity and etching time. Finally, we summarize the response of Ag/QD/PMMA sensing material versus various VOCs with different concentrations and study the polarized properties.

2. Results and Discussion

Ag/QD/PMMA sensing fibers deposited on the hollow metal frame was treated with double-sided UV/ozone etching as shown in **Fig. 1(a)**. The procedure of double-sided etching is that the film surface is etched on one side firstly with a specific time. After that, the other side of the film is also etched with the same etching time. In this study, the best etching time is treated 15 min for each side. Because of the ordered fiber arrangement which caused polarized property of light scattering, we rotated counterclockwise every 30° as a step (**Fig. 1(b)**). When the rotation angles reach 90°, optical extinction shows the strongest response due to the strong polarization. It might be attributed to QDs orientation which is coherent to fibers ordered arrangement and coupled with the specific rotation angle. To evaluate the response toward VOCs, we defined the maximum extinction change (ΔE_{max}) as their related response. The definition is presented as follow:

$$\Delta E_{max} = E_t - E_{t0}$$

In order to ensure that the sensing material is not affected by any disturbance in general ambient condition, we set an ambient disturb threshold based on the blank test result and further studied the responses toward various VOCs with 10,000 ppm. Among various VOCs detection in **Fig. 1(c)**, as Ag/QD/PMMA material exposed to n-butanol of 10,000 ppm, it exhibits the highest response in 5 min. Even more, we detected the sensing limit of n-butanol with gradually descended concentration ranged from 10,000 ppm to 100 ppm, as shown in **Fig. 1(d)**. Even in 100 ppm, Ag/QR/PMMA still presents a distinguished extinction change. Therefore, it gives obvious evidence for the great sensitivity of Ag/QR/PMMA sensing material toward n-butanol with low concentration.

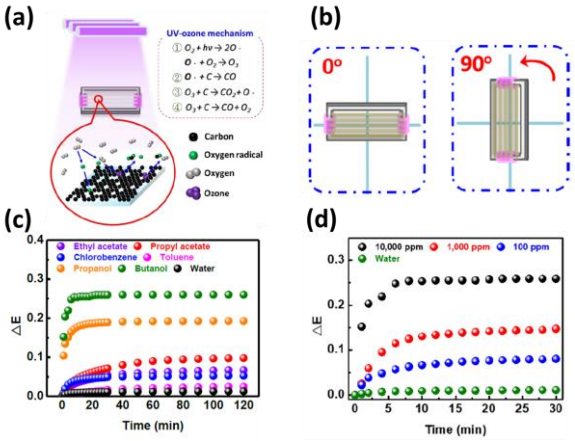

Fig. 1. (a) Mechanism of UV-ozone etching, (b) scheme of rotation procedure, and extinction change of sensing material toward (c) various VOCs and (d) n-butanol in different concentration.

3. Conclusions

In this study, Ag/QR/PMMA sensing fibers were successfully prepared by electrospinning and deposited on hollow metal frame substrate which treated with the double sides etching to improve the response due to the increased surface area. The polarization test revealed that the extinction change became lager when the rotation angle reached 90°. Exposing to various VOCs with 10,000 ppm, Ag/QR/PMMA sensing material shows outstanding responses, especially toward n-butanol. The detection limit of n-butanol can reach 100 ppm.

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References

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