LSPR sensor modified by molecularly imprinted sol-gel for selective organic acid vapor detection

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1. Summary

Organic acid vapor detection is of great importance in medical diagnosis. Hence, this study explores the possibility of localized surface plasmon resonance (LSPR) sensor combined with molecularly imprinted sol-gel (MISG) layers to detect organic acid vapors selectively. AuNPs layers were fabricated on a glass substrate by ion vacuum sputtering method. MISG reaction solution was spin coated on the AuNPs layers. The results show that the change of transmittance at plasmon peak was affected by spin coating speed. When the speed was set as 3000 rpm, a better response was obtained. Besides, no nonspecific absorbance was observed in NISG coated samples. In addition, LSPR combined with MISG layers could be employed to detect hexanoic acid (HA) vapors selectively.

2. Experimental

The schematic of sensing mechanism is shown in Fig. 1. In this study, titanate sol-gel layer was prepared by dissolving 136 µL tetrabutoxy titanium as a precursor in 2 mL of iso-propanol and 50 µL HA was added as template. Besides, 24 µL 3-aminopropyl triethoxysilane (APTES) was added to enhance binding capacity between sol-gel MIP and AuNPs. 25 µL titanium tetrachloride was added to initialized the reaction. Then, the solution was prehydrolyzed at 70 °C for 1 h. The substrate was put into a quick coater for AuNPs deposition, and annealed in air atmosphere at 200 °C for 5 h. Titanate sol-gel layer was applied on the AuNPs film by spin coating 20 µL of solution at a spinning rate of 1000, 3000 and 5000 rpm, respectively. Then, samples were heated at 200 °C for 1 h to remove template molecules from the imprinted layer. The schematic of transmittance spectra measurement system was show in Fig. 2. Fatty vapors were generated by a calibration vapor generating equipment. In this study, the concentrations of propanoic acid (PA), HA and octanoic acid (OA) were 40.93, 21.05 and 11.23 ppm, respectively.

3. Results and discussion

To investigate the optimal thickness of MISG layer, the spectra and sensitivity of sensor samples at spin coating speed at 1000, 3000 and 5000 rpm were measured and analyzed. The real-time responses of MISG/NISG LSPR sensors to HA was shown in Fig. 3. It demonstrated that no responses were observed on all sensors coated with NISG. It indicated that there is no nonspecific absorbance in titanate sol-gel matrix. Hence, the adsorption capacity of MISG is mostly contributed by the unusual cavities in sol-gel layers. Considering the recovery time and response intensity of a sensor simultaneously, the spin coating speed at 3000 rpm would be the optimal condition for detecting HA vapors. Fig. 4 shows the real-time response of HA-MISG coated AuNPs sensors to PA, HA and OA vapors. The result demonstrated that the corresponding response signal of HA is larger than that of PA or OA. It indicated that HA-MISG layers would play a vital role in absorption of HA selectively.

4. Conclusion

In this study, an AuNPs film combined with MISG was successfully utilized for the determination of HA vapors selectivity. It also offers some useful technologies for developing sensors for fatty acid vapors. In addition, a sensor array constructed with MISG coated LSPR sensors would be developed for varieties of organic acid vapors.

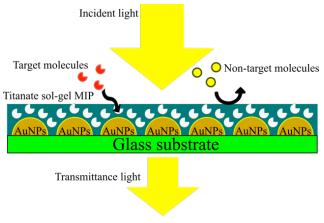

Fig. 1: Schematic diagram of MISG-coated AuNPs film

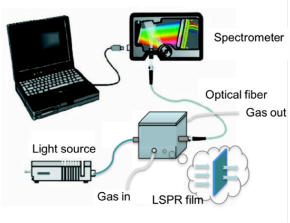

Fig. 2: Schematic diagram of spectra testing system

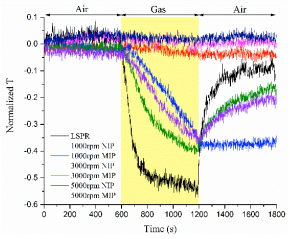

Fig. 3: Real-time response of MISG and NISG with different rpms to HA vapors

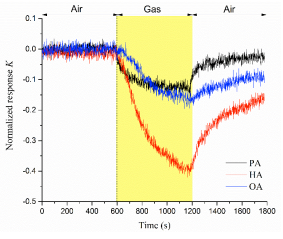

Fig. 4: Real-time response of MISG-LSPR sensor to 3 organic acid vapors.