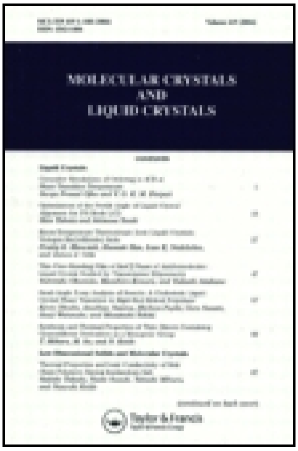

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Alternately Stacked Langmuir-Blodgett Film of Phospholipid and ZnO as an Olfactory Sensing Membrane

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ALTERNATELY STACKED LANGMUIR-BLODGETT FILM OF PHOSPHOLIPID AND ZnO AS AN OLFACTORY SENSING MEMBRANE

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Abstract Langmuir-Blodgett films of Phospholipid and ZnO were investigated as a sensing membrane to enhance the sensitivity of an olfactory sensor. The membranes were fabricated by alternate stack of dipalmitoylphophatidic acid (DPPA) and ZnO. Compared with the DPPA LB film, the alternately stacked film system showed higher sensitivity and faster response to gases. The chemical vapors used in this study were methanol, ethanol, and acetone.

INTRODUCTION

The sensitivity and selectivity of olfactory sensors mainly depend on the sensing film materials and the coating method. In this respect, many kinds of sensing film materials such as lipids, semiconductor metal oxides, GC packing materials, certain kinds of polymers, etc., have been studied.[1] All of these sensing materials were employed in the form of thin sorbent layers and were coated on various kinds of transducers. In these days the lipids and semiconductor metal oxides are most widely used as sensing materials in monitoring various types of gases. Previously we reported the phospholipid LB film coated quartz resonator sensor system,[2] but the sensitivity of the lipid sensing film was not so good. Inorganic semiconducting materials, such as oxides and catalytic metals, have been studied considerably. The oxide sensing materials utilize the concept of conductivity modulation and so they operate at elevated temperatures (e.g., 100-600 °C).[3] In this study we constructed a multi-layered film system of alternately stacked phospholipid LB films and ZnO films and coated the film on the quartz crystal microbalance (QCM) as the sensing membrane.

EXPERIMENTAL

The alternately stacked sensing membrane was deposited by successive repetition of LB technique (for DPPA) and dipcoating (for ZnO). ZnO particles(< 1 μm, purchased from Aldrich Co.) were suspended in DI-water (100 *mg* / 5 *ml*) and sonicated.

The deposition process was carried out according to the following steps:

(i) deposition of ten layers of DPPA LB film and then drying for 20 *min*.

(ii) dipping the DPPA LB film into the ZnO suspension for 10 *min* and then drying for 30 *min*.

The above steps were repeatedly performed to produce a multilayered film. The structure and uniformity of the film were analyzed by X-ray diffraction. A thin film X-ray diffractor with the Cu, Kα X-ray source, λ = 1.54 Å, was used. The monolayer thickness of the DPPA LB film has already been reported elsewhere.[4]

The apparatus and procedure for the sensor experiment and the conditions for LB film deposition were described in our previous paper.[2]

RESULTS AND DISCUSSION

The structure of the sensing membrane fabricated in this study is shown in Figure 1. Since ZnO particles are hydrophilic, the last deposition stroke of the DPPA LB film was downward to expose the hydrophilic part of DPPA to the surface.

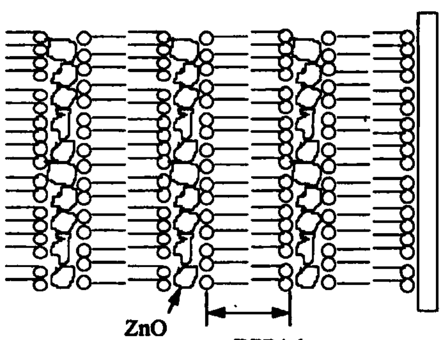

FIGURE 1 The structure of the sensing membrane used in this study

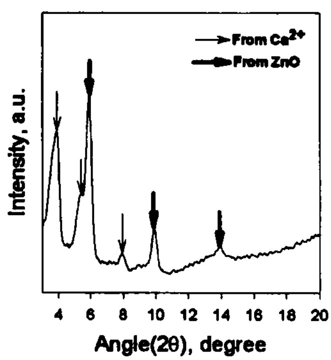

FIGURE 2 The X-ray diffraction pattern of the alternately stacked film.

In Figure 2, the lattice spacing of the sensing membrane is shown. There are two groups of reflection peaks shown in the figure. One is from the Ca^{2+} ions which were adsorbed on the DPPA head groups to enhance both LB film transferability and X-ray peak intensity, and the other is from the ZnO layer. From the Bragg's equation, the lattice spacing of one DPPA layer was 22.3 Å, and the lattice spacing of the ZnO layer, i.e., every 10 layers of DPPA film, was 224 Å. From these results we infer that the sensing membrane was deposited very uniformly.

Figure 3 shows the response curves from such alternate films with different numbers of layers and from DPPA LB film. As the number of layers increased, frequency change increased linearly. The sensing membranes were all exposed to the gaseous methanol for 180 sec. In the case of alternate films the output signal peaks (total frequency change) were much higher and the initial slopes of the response curve, which mean the speed of adsorption, were much steeper than those of a DPPA film, even for an alternate film of two layers.

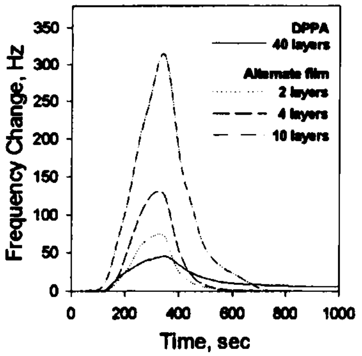

FIGURE 3 The response curves of different type of sensing membranes (for methanol at 7500 *ppm*).

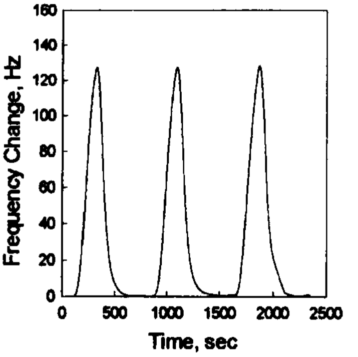

FIGURE 4 Reproducibility of the frequency change pattern (an alternate film four layers for methanol at 7500 *ppm*).

In order to check the reproducibility, the adsorption-desorption process was repeatedly perfomed. In a sequential test shown in Figure 4, when the exposure to methanol gas was stopped and the inert gas (N_2) was blown, the initial frequency was recovered very fast. The dependence of the signal output on the methanol concentration is illustrated in Figure 5. The signal output is related linearly to the gas concentration so that the quantification of gases is possible if only the frequency change is known. The elapsed time for the adsorption-desorption process was irrelevant to the gas concentration.

In Figure 6 the response characteristics of an alternate film and DPPA LB film to three different chemical vapors are shown. The alternate film showed high affinity for ethanol and the DPPA film for acetone. When used as a sensing membrane, the alternate film was much better than the DPPA film in differentiation of the gases because the differences in frequency change for different gases were much greater.

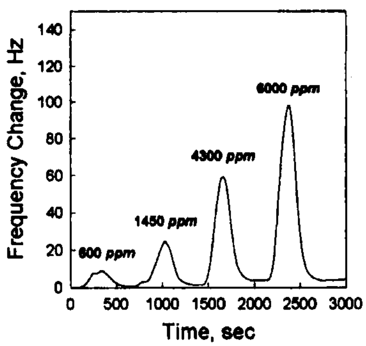

FIGURE 5 The concectration denpendency of the frequency output (methanol, alternate film of four layers).

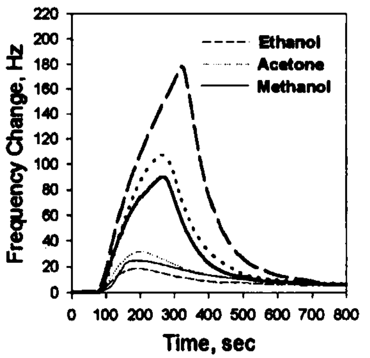

FIGURE 6 The response characteristics for three chemical vapors (6000 *ppm*) of an alternate film of four layers (thick line) and a DPPA LB film of 40 layers (thin line).

CONCLUSION

A multilayer film system of alternately stacked ZnO films and DPPA LB films was fabricated and it's gas sensing characteristics were investigated. The gas sensitivity of the alternate film was much better than that of the DPPA film. The alternate film showed fast adsorption-desorption property and very good ability for gas discrimination.

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