APPLICATION OF QUARTZ CRYSTAL OSCILLATOR TO ATMOSPHERIC MOLECULE SENSOR

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Abstract: **The quartz crystal oscillator, which has a stable natural frequency, has been applied to an atmospheric molecule sensor. The frequency shifts with the micro-weight-change of crystal with adsorbed molecules. Experiments were performed with various combinations of the coated membrane and the vapor chemicals. The designed system has enough sensitivity to detect atmospheric molecules in the vapor.**

Keywords: **Quartz crystal oscillator, Natural frequency, Adsorption, Membrane, Coating**

Introduction

The quartz crystal [1] has been applied to an oscillator, which has a stable natural frequency. The frequency shifts with the micro-weight-change of crystal. In this study, a sensor system was designed with the quartz crystal to detect atmospheric molecules, and experiments were performed with various combinations of the coated membrane and the vapor chemicals.

Materials and Methods

The quartz crystal oscillators with a natural frequency of 10.7386 MHz (Fig. 1) were applied to the sensing system. The oscillator was vibrated with an electric circuit. The surfaces of crystal were modified to hydrophilic with the silane-coupling reaction, or to hydrophobic with ozonation. An electric counter was designed to measure the vibrating frequency, so that the variation of 1 Hz can be detected.

The surfaces of the crystals were coated with various organic molecule membranes: palmitic acid, stearic acid, arachidic acid, Japanese lacquer, polyvinyl alcohol, or cellulose acetate. The Langmur-Brodget (LB) technique was applied to the coating of palmitic acid, stearic acid, and arachidic acid, and the relations between the shift of the natural frequency and the number of the layers coated on the crystal were measured during LB coating process. The dipped and dried method was applied to the coating of Japanese lacquer, polyvinyl alcohol, and cellulose acetate. The membrane of Japanese lacquer was fixed on the crystal in 130 degrees C for 30 minutes.

The coated crystal was put in a cubic chamber of 20 cm. The variations were made about the atmosphere in the chamber with the vapor of chemicals: acetone, ethanol, undecanol, an ammonia solution, benzyl acetate, anisaldehyde, citral, water, methyl acetate, and octanol. A cup (1 ml) of each chemical in the liquid state was placed in the corner of the chamber, in which the vapor was stirred with a fan. At 25 degrees C, the shift of natural frequency of the oscillator was measured for 15 minutes exposure to the vapor, and for successive 5 minutes in the fresh air.

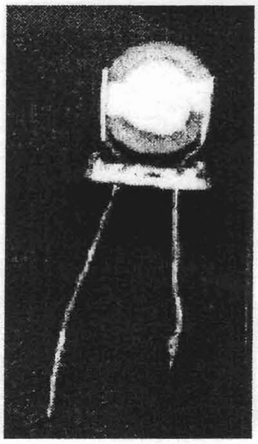

Figure 1: The quartz crystal oscillator

Results

The natural frequency linearly decreased with the number of accumulated membrane layers, when the LB membrane was accumulated on the quartz crystal oscillator. Figure 2 exemplifies the relationship between number of LB layers of palmitic acid and frequency shift. The results were similar about stearic acid and arachidic acid. The rate of decrease in the natural frequency was proportional to molecular weight of the acid.

In the experiment with the chamber, the natural frequency decreased with adsorption of atmospheric molecules and saturated within 15 minutes. Figures 3 and 4 exemplify the frequency tracings with arachidic acid and with Japanese lacquer. The shifts of frequency varied up to 700 Hz. The shifts depended on combination of the coated membrane and the vapor of chemicals.

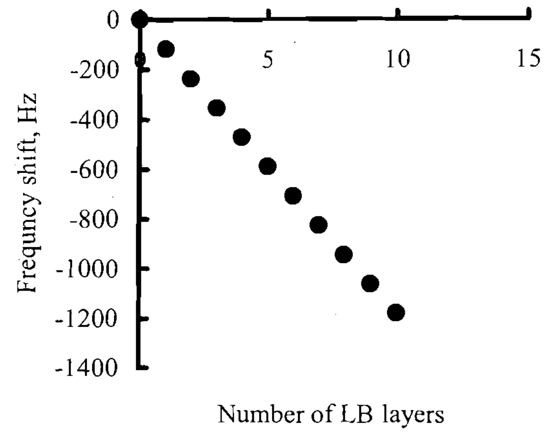

Figure 2: The relationship between number of Langmur-Brodget layers of palmitic acid and frequency shift of the oscillator

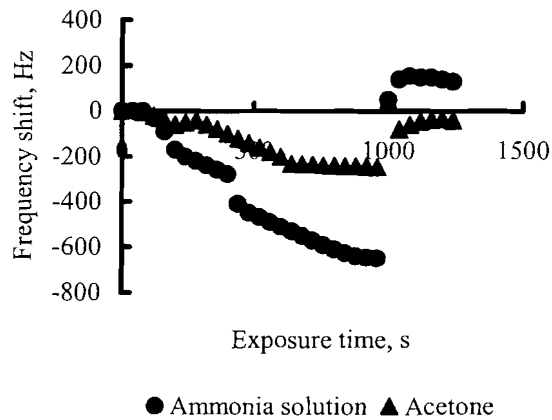

Figure 3: The frequency shift of the oscillator coated with three layers of arachidic acid

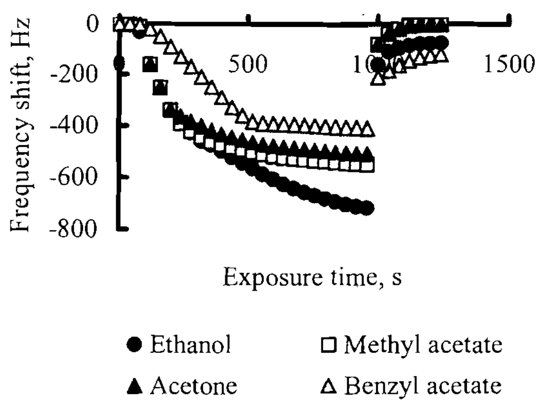

Figure 4: The frequency shift of the oscillator coated with Japanese lacquer

Discussion

LB technique had been applied to modify surface chemical properties in biosensors [2]. The technique was effective to certify the proportional shift of frequency with the decrease of mass of oscillating quartz crystal. The natural frequency of quartz crystal oscillator tends to return to original value after removal of vapor. The recovery means reversible adsorption of chemical molecules to the surface of quartz crystal oscillator. The coating of Japanese lacquer was most effective to gain wider shift of frequency with adsorption of atmospheric molecules. The selective adsorption can be applied to smell sensors.

Conclusions

The designed system has enough sensitivity to detect atmospheric molecules in the vapor. The sensitivity can be controlled with the coated membrane. The present study shows the availability of quartz crystal oscillators for the sensor for atmospheric molecules.

Acknowledgements

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