DEVELOPMENT OF SURFACE ACOUSTIC WAVE SENSORS INCORPORATING LANGMUIR-BLODGETT FILMS

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ABSTRACT

A sensitive surface acoustic wave (SAW) device has been developed by depositing phospholipids or stearic acid onto the channel of the device. For this purpose the Langmuir-Blodgett (LB) technique has been used to deposit an optimal number of layers which was found to be between 20 and 40. The affinity of alcohols to phosphatidylcholine coated channels increased with increasing chain length. The observed differences in mass loading, however, are rather small, which means that electrostatic and Van-der-Waals interactions rather than specific effects determine the binding.

INTRODUCTION

Since Sauerbrey /1/ found an empirical equation for the frequency shift of a quartz resonator in dependence on the mass of substance deposited on its surface, much attention has been paid to piezoelectric detectors /2,3/.

$$\Delta F = -2.3 \times 10^{6} F^{2} \, m/A$$

where ΔF is the frequency change (Hz) due to deposited mass, F is the resonant frequency of the piezoelectric crystal (MHz), m is the mass of the substance deposited on the surface (g), and A is the area coated (cm^2). This type of resonators has been applied to both liquid and gas phase analysis. The oscillation frequency of an AT-cut resonator is of the order of several MHz. The frequency for SAW devices is between two and three orders of magnitude higher. Therefore, an increase in sensitivity is expected for SAW resonators.

The first studies using SAW resonators as gas sensors were reported in 1979 /4/. The authors investigated SAW devices as gas chromatography detectors and proposed that a selective coating will lead to a more specific sensing. The aim of the present study is to improve the binding affinity of resonators by depositing phospholipids and fatty acids onto the surface of the device using the LB technique.

RESULTS

The 310 MHz SAW resonator used was fabricated on Y cut, X propagating quartz. The device was performed as a two port resonator. The space between the interdigital transducers was 65 μm in order to get the smallest insertion loss.

For the formation of monolayers phosphatidylcholine (PC), phosphatidylethanolamine (PE) and stearic acid (SA) were dissolved in chloroform (concentration 1 mM) and subsequently spread at 20 ^{o}C onto the water surface of the trough. The deposition of monolayers was performed by the horizontal lifting method (Langmuir-Schäfer method) at a surface pressure of 10 mN/m. The frequency shift obtained under these conditions increased linearly with the number of monolayers deposited up to about 50 monolayers.

The figure represents the monitoring of different alcohols by a PC coated SAW resonator. The frequency shift is linearly dependent on the concentration of alcohols. It is obvious that the same frequency shift will be obtained for butanol or propanol at different concentrations. These difficulties can be overcome by using different coatings.

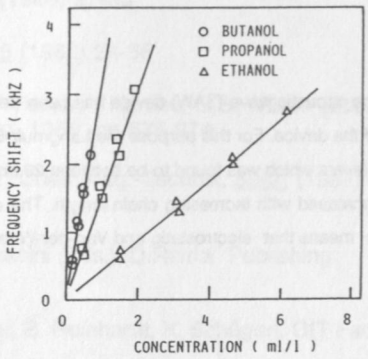

Fig. Correlation between the concentration of different alcohols and the corresponding frequency shift of a PC coated SAW resonator.

CONCLUSION

The LB technique is a suitable method for the reproducible coating of SAW devices. The phospholipids and stearic acid used for selective coating are qualified to differentiate between different odorants. The binding of alcohols increases with increasing chain length. This result is in agreement with data obtained by Nomura and Kurihara /5/ who found that the lowest concentration required for a measurable membrane potential change decreased linearly with increasing length of the hydrocarbon chain of alcohols.

These results reflect an equilibrium between the coated membrane and the gas phase. No specific mechanisms of reception occur in our experimental system. By increasing the number of lipids for coating the SAW devices it should be possible to identify odorants by a computerized pattern recognition algorithm.

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