

변위전류에 의한 DMPE, DLPE 지질막의 수면상 거동 연구
[A study on the movement of Liquid DMPE and DLPE monolayer
on a water subphase by Maxwell Displacement Currents]

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Abstract

Maxwell displacement current clearly shows the onset of a first order phase transition from gaseous to gaseous-fluid phase, and polar ordering of liquid molecules in the solid phase coexisting with fluid. For further monolayer compression in the fluid/solid phase transition, the condensation of domains was suggested.

1. Introduction

Monolayers of lipids on a water surface have attracted much interest as models of biological membranes, also as precursors of multilayer systems promising many technical applications. They exhibit very interesting physico-chemical properties as two-dimensional and interfacial systems. Until now, many potential methodologies have been developed in order to obtain a better understanding of the relationship

between the structure and function of the monolayers. For the past few years, we have developed a novel technique which allows to prove molecular motions in monolayers to be probed in the entire range of molecular covering-area by measuring the Maxwell displacement-current-measuring technique. It is effective in the detection of phase of monolayers, and suitable for observing fast potential changes generated due to the phase transitions. The technique can give an essential information on the polar orientation order in monolayers, which is defined by $S = \langle \cos \theta \rangle$, θ is the tilt angle of permanent dipoles away from the normal direction of the monolayer, and $\langle \rangle$ denotes a thermodynamic average.

In the present investigation, we studied the phase behavior of phospholipids on the air-water surface by means of the Maxwell displacement-current measuring technique and the film balance technique.

2. Experimental

The lipids used here are L- α -dilaurylphosphatidylethanolamine(DLPE) and L- α -dimyristoylphosphatidylethanolamine(DMPE), whose chemical structures are shown in Fig. 1.

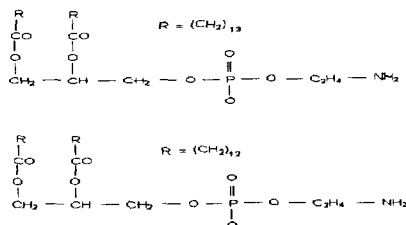


그림 1. Chemical structures of DMPE and DLPE.

They were purchased from Sigma and then used them as received.

Figure 2 shows the Langmuir-trough used in the present study. Briefly, the trough has a rectangular shape and its area is $1,050\text{cm}^2$. Above the water surface electrode 1 is placed at the center of the trough parallel to the surface. The working area(B) of the electrode is 44.2cm^2 , and the distance between electrode 1 and the water surface(d_1) is $1.0 \pm 0.05\text{nm}$.

The lipids have one phosphatidylethanolamine head group(hydrophilic group) and two long alkyl chains with a carbonyl group(hydrophobic group). Monolayers of these lipids are spread

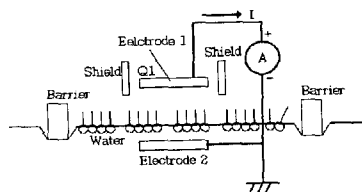


Figure 2. Measuring system of displacement current.

from chloroform solution onto a surface of pure water in the trough using a microsyringe. The monolayers on the water surface are compressed from both sides of the trough with the aid of two moving barriers at room temperature.

The monolayers between the two barriers are compressed with constant speed $a(\text{cm}^2/\text{min})$. As a result, the displacement current is generated from the monolayers. Displacement current-area(π -A) isotherm is measured during the compression of the monolayer. Charge flowing through the ammeter ($:\Delta Q_1$) is also monitored with current-area(I-A) isotherm.

3. Results and Discussion

Figure 3 shows the displacement current generated from DMPE molecules during the compression with a constant barrier velocity of $50.0\text{mm}/\text{min}$ from $A = 300\text{\AA}^2$ to 60\AA^2 . Displacement current is initiated to flow at $A=170\text{\AA}^2$, and it continuously flows with monolayer compression, although the surface pressure is immeasurably low in the range $85\text{\AA}^2 < A < 170\text{\AA}^2$. Based on these experimental results, we divided the I-A and

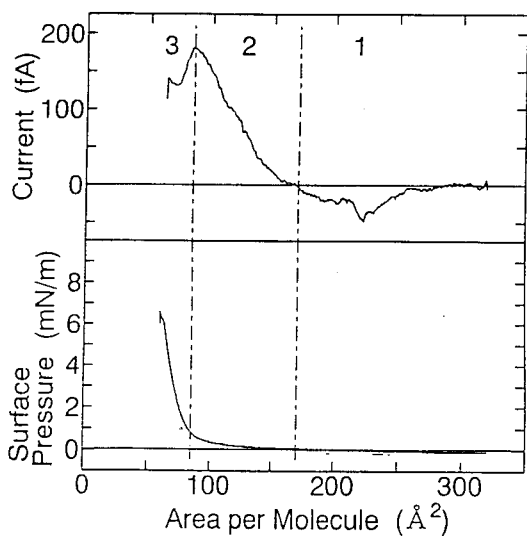


Figure 3. Displacement current in the range of immeasurably low surface pressure of DMPE.

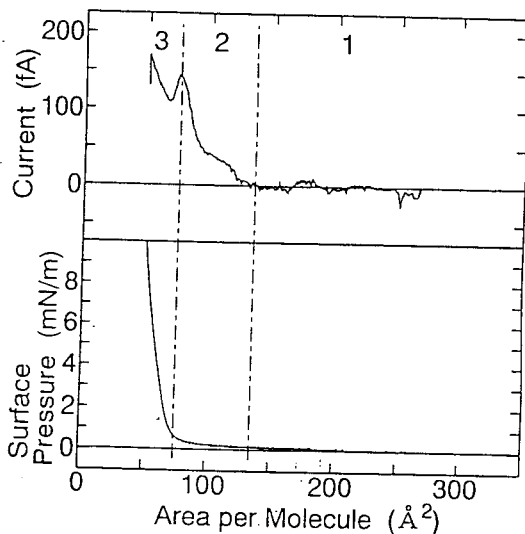


Figure 4. Displacement current in the range of immeasurably low surface pressure of DLPE.

Similar experimental results were obtained for DLPE molecules as shown in Fig. 4, where the displacement current is generated at $A=135 \text{ \AA}^2$. Fig 5 shows the displacement current generated from DMPE molecules during the compression with a constant barrier velocity of 50.0 mm/min in the range of $A=160 \text{ \AA}^2$ to 30 \AA^2 . Judging from the trace of displacement

current, we divided the I-A and π -A isotherms as indicated in the figure.

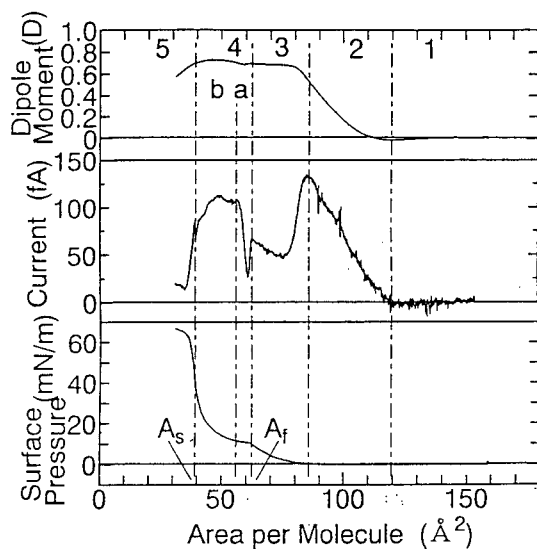


Figure 5. Displacement current generated from lipid monolayers on a water surface, surface pressure-area, displacement current-area, and dipole moment-area isotherms from the top of DMPE.

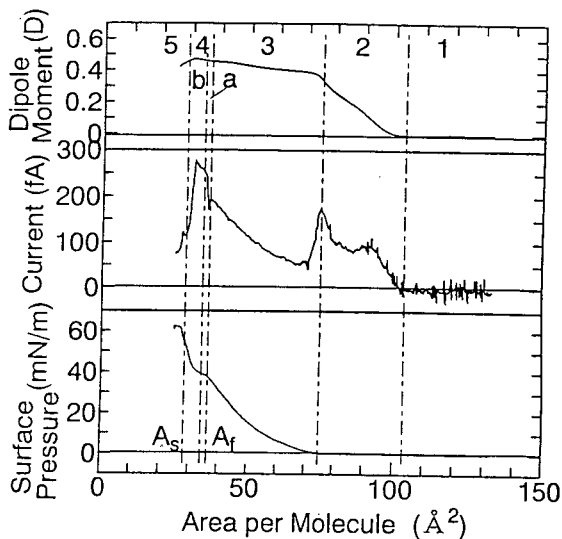


Figure 6. Displacement current generated from lipid monolayers on a water surface, surface pressure-area, displacement current-area, and dipole moment-area isotherms from the top of DLPE.

Similar experimental results were obtained for DLPE molecules, as shown in Fig. 6. One of the main characteristics of the I-A isotherm is that the current shows a distinguished change at the onset of the transitions even where the change in π -A isotherm is very small, e.g., transition from region 4 to region 5. As described above, the I-A isotherm is effective in the detection of phase transitions.

4. Conclusions

We have investigated the phase behavior of phospholipids on the air-water surface by means of the Maxwell displacement-current measuring technique and the film balance technique. In the range at immeasurably low surface pressure, the onset of the solid phase transition has been detected. Polar ordering in the solid phase coexisting with the fluid was concluded from the generation of displacement current. Further monolayer compression in the fluid/solid phase transition to \AA^2 , suggests the condensation of domains. Finally, we concluded that the phase transition of phospholipids is clearly distinguished by the displacement current.

Reference

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