Displacement Properties of Nano Structure Dendrimer

Jin-Won Song† , Kyung-Sup Lee*, Woo-Ki Lee*, Young-Il Choi, Suk-Am Yoon*** and Chung-Seog Choi******

Abstract - In the Langmuir-Blodgett (LB) technique, a monolayer on the water surface is transferred onto a substrate, which is raised and dipped through the surface. From this, multilayers can be obtained in which constituent molecules are periodically arranged. The LB technique has attracted considerable interest in the fabrication of electrical and electronic devices. Many researchers have investigated the electrical properties of monolayer and multiplayer films. Dendrimers represent a new class of synthetic macromolecules characterized by a regularly branched treelike structure. Multiple branching yields a large number of chain ends that distinguish dendrimers from conventional star-like polymers and microgels. The azobenzene dendrimer is one of the dendritic macromolecules that include the azo-group exhibiting a photochromic character. Due to the presence of the charge transfer element of the azo-group and its rod-shaped structure, these compounds are expected to have potential interest in electronics and ptoelectronics, especially in nonlinear optics. In the present paper, we give pressure stimulation to organic thin films and detect the induced displacement current.

Keywords: Displacement Properties, Langmuir-Blodgett (LB) technique

1. Introduction

In the Langmuir-Blodgett (LB) technique, a monolayer on the water surface is transferred onto a substrate, which is raised and dipped through the surface. From this, multilayers can be obtained in which constituent molecules are periodically arranged. The LB technique has attracted considerable interest in the fabrication of electrical and electronic devices. Many researchers have investigated the electrical properties of monolayer and multiplayer films [1-3].

Dendrimers represent a new class of synthetic macromolecules characterized by a regularly branched treelike structure. Multiple branching yields a large number of chain ends, which distinguishes dendrimers from conventional star-like polymers and microgels.

Azobenzene dendrimer is one of the dendritic macromolecules that include the azo-group exhibiting a photochromic character. Due to the presence of the charge transfer element of the azo-group and its rod-shaped structure, these compounds are expected to have potential interest in electronics and ptoelectronics, especially in nonlinear optics [4-8].

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Photoisomerization in monolayers of an azobenzene dendrimer was investigated for the first time by means of the absorption spectrum and Maxwell displacement current (MDC) technique. Dendrimers are well-defined macromolecules exhibiting a tree-like structure, first derived by the cascade molecule approach. According to the absorption spectrum, trans-to-cis conversion ratio was estimated to the azobenzene dendrimer generation. Charge with trans-cis isomerization was also measured by means of the MDC technique.

In the present paper, we give pressure stimulation to organic thin films and detect the induced displacement current.

2. Theory

Fig. 1 shows the model of a floating monolayer on a water surface. For simplicity, we confine our discussion to monolayers in the isotropic polar orientational phase. Briefly, the monolayer consists of rodlike polar molecules with length l. Each molecule has a permanent electric dipole moment μ in the direction along the molecular long axis, and it stands at a tilt angle θ away from the normal direction to the water surface. The motion of rod-like polar molecules is restricted within $0<\theta<\theta_A$, where $\theta_A = \sin^{-1}\sqrt{A/A_0}$ $(A_0 = \pi l^2)$. Here A is the molecular area and A_0 is the critical molecular area. The monolayer film is sandwiched between Electrodes 1 and 2.

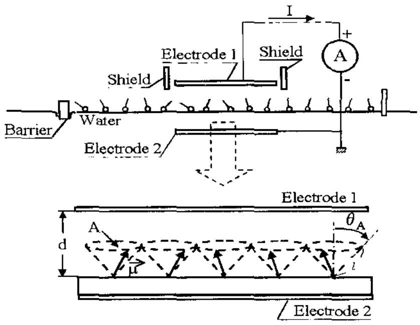


Fig. 1 Molecular model on the water surface.

In the MDC measurement, monolayers are compressed at a monolayer compression speed of α from the molecular area $A = A_i$. Electronic charges are induced on Electrode 1 due to the presence of polar molecules on the water surface, and the magnitude of these electronic charges by monolayer compression. As a result, MDC flows through an ammeter. MDC is expressed as

$$MDC = I = -K\frac{d}{dA}\left(\frac{S}{A} - \frac{S_{eq}}{A_i}\right) \quad (1)$$

with $K = \frac{\alpha\mu}{d}B$ .Here B is the working area of electrode 1.

Therefore the following relation is easily obtained by integrating the MDC with respect to the molecular area

$$\frac{S}{A} - \frac{S_{eq}}{A_i} = -\frac{1}{K}\int_{A_i}^{A} IdA \quad (2)$$

Substituting Eq. (2) into Eq. (1), the following equation is obtained

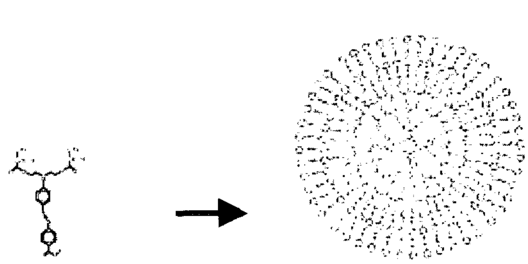
$$I = \frac{1}{\tau\alpha}\int_{A_i}^{A} IdA + K\frac{S_f}{\tau\alpha} - \frac{1}{A}\int_{A_i}^{A} IdA \quad (3)$$

Assuming $S_{eq}(A_i) = 0$. It should be noted here that rod-like polar molecules lie on water surface at the molecular area $A>A_0$, due to the Coulomb attractive force working between polar molecules and the water surface. That is $S_{eq}(A_i) = 0$ for $A>A_0$. Usually in the MDC measurement, monolayer compression starts at $A=A_i>A_0$.

At the molecular area $A=A_m$ MDC reaches its maximum, therefore $dI/dA=0$ at $A=A_m$. The dielectric relaxation time τ(A) of monolayers can be determined as a function of the molecular area [9-12].

3. Experiment

The chemical structure of AZ-G4 monomer is presented in Fig. 2. Monolayers of AZ-G4 were spread from diluted chloroform solutions onto the surface of pure water.



G1 G4

Fig. 2 Molecule structure of AZ-G4

The working area of Electrode 1 was 45.6[cm^2]. The distance d between Electrode 1 and the water surface was 1 mm. The displacement current I was measured by an electrometer (Keithley 6517).

AZ-G4 was spread on pure water (pH 6.0, 18.2 MΩ cm) and maintained at 20[℃]. Once a monolayer was rested for 5 minutes, the monolayer was compressed at a compression speed of 40[mm/min]. MDCs were measured during monolayer compression. Irradiation with UV light (λ_1=365nm) and visible light (λ_2=450nm) regions occurred at AZ-G4 monolayers. The absorption spectra was measured using a UV-visible recording spectrophotometer (Hitachi U-3501 spectrophotometer).

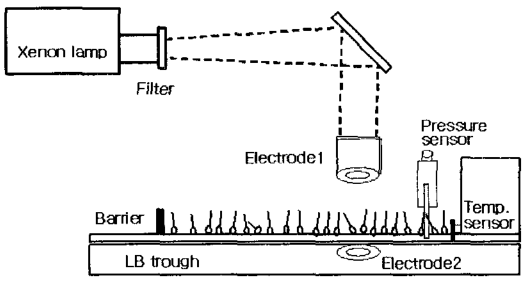


Fig. 3 Displacement current measuring apparatus according to light stimulus transfer on water surface

4. Results and Discussion

Fig. 4 indicates the current generated from AZ-G4 molecules during compression with a constant barrier velocity in the area per molecule ranging from 5900[Å^2] to 1800[Å^2]. Surface pressure-area isotherm is also shown in the Fig.. A current peak appears in the range of molecular area A between 4900[Å^2] and 1800[Å^2] by monolayer compression. The Absorption spectrum of AZ-G4 is indicated in Fig. 5. From this we know that expressing peak in 440[nm], 340[nm], and maximum value of absorption ratio appears to be 340[nm] near in 200[nm]-800[nm].

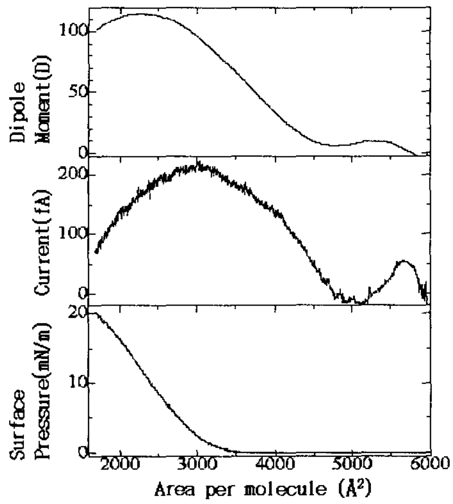


Fig. 4 Displacement current of barrier compress

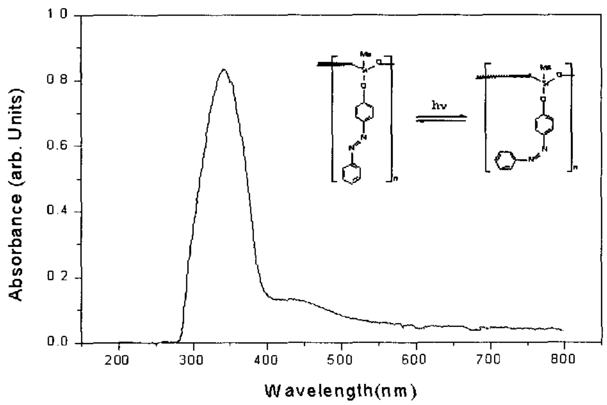


Fig. 5 Absorption of AZ-G4

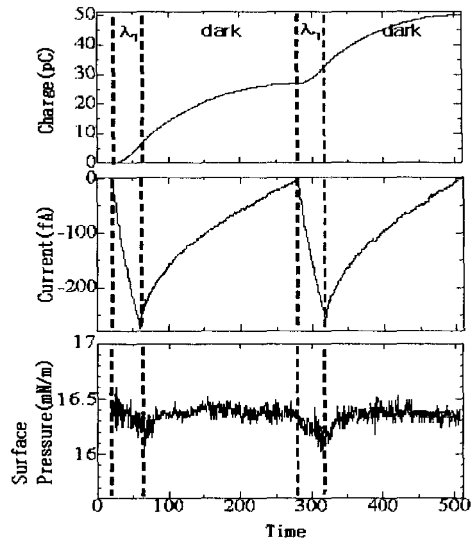


Fig. 6 hotoirradiation of AZ-G4(λ_1=365[nm])

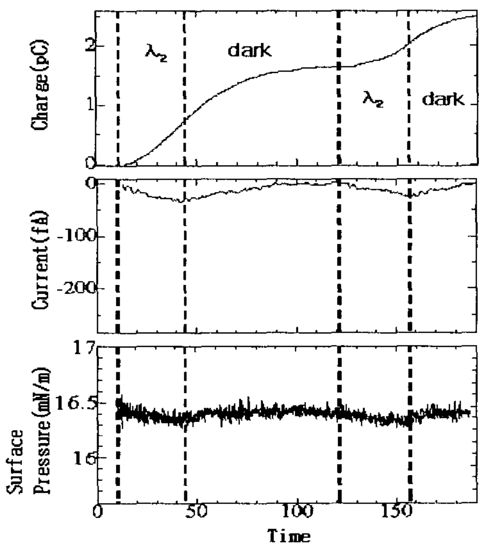


Fig. 7 hotoirradiation of AZ-G4(λ_2=450[nm])

In addition, by irradiating the ultraviolet light (λ_1= 360[nm]) and visible light (λ_2=450[nm]) region at the AZ-G4 organic monolayer known as cis-trans structure the displacement current in accordance with light stimulus were detected and compared.

Fig. 6 and 7 show typical results of MDC measurements of the AZ-G4 monolayers with estimated induced charge. MDC current is generated with alternating 365[nm] and 450 [nm] photoirradiation and the direction of the current is alternated.

Photoirradiation was permitted for 30 seconds, following examination for 30 seconds after displacement current amounted to 0. When photoirradiation was 365[nm]'s, displacement current occurred roughly at - 280 [fA] and it took 3 minutes to reach 0. When irradiation was 450nm's, displacement current occurred roughly at - 45 [fA], and displacement current amounted to 0 after approximately one minute. We discovered that displacement current appears more significantly in 365[nm] with absorption ratio indicating a maximum value in 340[nm] as demonstrated in Fig. 5.

Also, in the case of photoirradiation, surface pressure changed, and with the size of ensued displacement current at 365[nm], we could know that at 450[nm], surface pressure change shows more noticeably. The charge amount began to increase after photoirradiation, and the charge amount demonstrated that increase continuously occurred during dark conditions. This is considered by did not irradiation 250[nm] previous that can look cis-trans feedback. Also, is proportional in displacement current of 365[nm]'s photoirradiation and could know that the bigger charge amount happen.

5. Conclusion

We have investigated the photoisomerization phenoenon in an azobenzene dendrimer by means of the absorption spectrum and MDC technique. We showed the current generated from AZ-G4 molecules during compression with a constant barrier velocity in the area per molecule. When photoirradiation was 365[nm]'s, displacement current occurred roughly at - 280 [fA] and it took 3 minutes to reach 0. When irradiation was 450[nm]'s, displacement current occurred roughly at - 45 [fA], with displacement current amounting to 0 after about one minute. Also, in the case of photoirradiation, surface pressure changed, and with the size of the ensuing displacement current at 365[nm], we could know that at 450[nm], surface pressure change appears more drastically.

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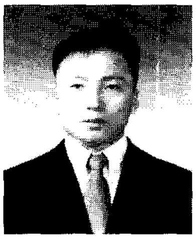

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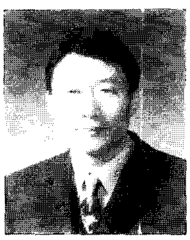

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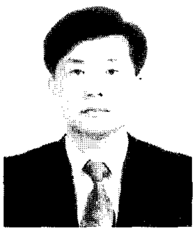

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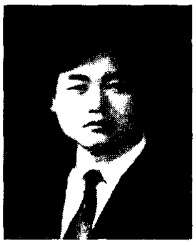

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