

## FLAVIN/VILOGEN LB 막으로 구성된 MIM 소자의 광스위칭 현상

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### PHOTOSWITCHING CHARACTERISTICS OF FLAVIN/VILOGEN HETERO LB FILMS

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#### INTRODUCTION

In the initial process of biological photosynthesis, photoelectronic conversion occurs and then long-range electron transfer takes place very efficiently in one direction through the biomolecules.<sup>1,2</sup> It takes place on a molecular scale to the specific energy and electron transfer because to the redox potential difference as well as the electron transfer property of functional molecules, especially the electron-acceptor and sensitizer.<sup>3,4</sup> Various artificial molecular devices have been fabricated by mimicking biological photosynthesis.<sup>3,8</sup> The electrochemical photodiode consisting of Langmuir-Blodgett(LB) films or an aligned triad on the electrode which worked in electrolyte solution have been made.<sup>4-6</sup> Studies of electron transfer between A and excited dye molecules were carried out. Making use of a sensitizer(flavin) and an electron acceptor(phorphyrin), the Metal/Insulator/ Metal(MIM) structured device was fabricated and photo-induced electron transfer was investigated.<sup>3,7,8</sup> In the present paper, the MIM device was fabricated with the hetero-Langmuir-Blodgett(LB) film consisting of Viologen and Flavin derivatives, which are A and S respectively. Molecules of two functional materials were arranged on ITO glass regularly in space normal to the electrode surface, e.g. S/A, by the LB method. Finally by depositing aluminum on the hetero-LB film, a molecular device with MIM structure was constructed. Photocurrent properties of the MIM structured device were investigated to evaluate the direction of electron transfer and photoswitching function.

#### EXPERIMENTAL DETAILS

##### 1. Materials and Deposition of LB Films

Two kinds of functional materials were used. Viologen and Flavin were used as A and S unit, respectively. These two materials were synthesized. The measurement of surface pressure-area isotherms and the deposition of LB films were carried out with a circular Langmuir trough (Nima Tech., England).

##### 2. Cyclic Voltammetry

Cyclic voltammetry was carried out at 25 °C with a CV-75 potentiostat (BAS, Germany). The working (Pt plate), reference (Ag/AgCl) and counter (Pt plate) electrode was used. Aqueous solution with KCl for the cyclic voltammetry of A and S was used as the electrolyte solution. The working electrode was deposited with LB film of A and S for the measurement of redox potential.

##### 3. Photocurrent Measurement

A schematic diagram of the apparatus for photocurrent measurement is shown in Figure 1. An input exciting light of wavelength 460nm was generated with xenon lamp system. The photocurrent was detected through a current-voltage amplifier, A/D converter and personal computer. I-V measurement was carried out using Hewlett Packard 4145B

parameter analyzer.

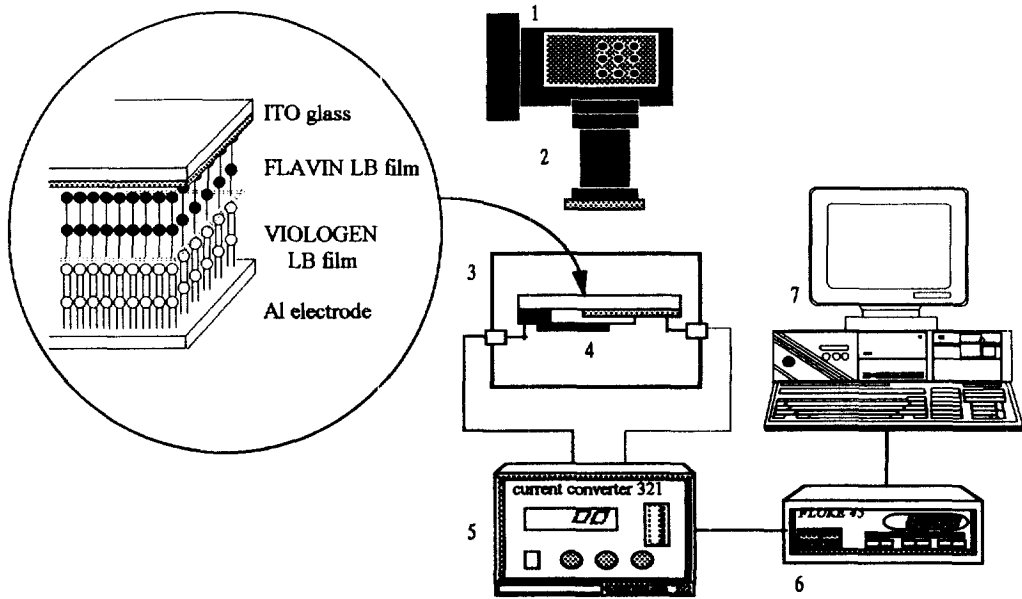


FIGURE 1 Schematic illustration of a hetero-type cell and experimental setup: 1, 150W Xe lamp; 2, 460nm filter; 3, shield box; 4, MIM device; 5, current-voltage converter; 6, A/D converter; 7, personal computer.

## RESULTS AND DISCUSSION

### 1. Surface-pressure Area Isotherm

The  $\pi$ -A isotherm of each materials are shown in Figure 2.. The isotherm of the monolayer of S has two condensed regions at 20mN/m and 40mN/m. The monolayer is more stable at 40mN/m and the limiting area per molecule is  $24 \text{ \AA}^2$ .

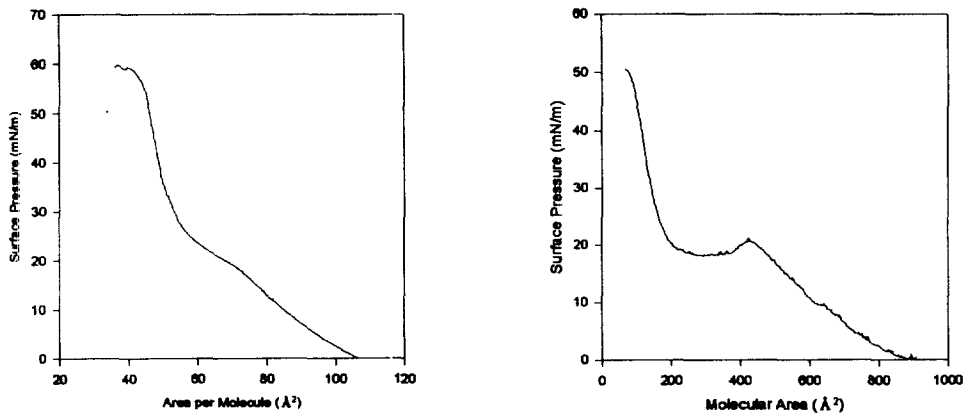


FIGURE 2 Surface pressure-area isotherm of functional materials: (a), A; (b), S.

In contrast, the expanded and condensed regions are clearly observed for the monolayer of A. At a surface area less than  $60 \text{ \AA}^2$  molecule, there is an abrupt increase of slope. This is clearly also due to a phase change and represents a transition to ordered solidlike arrangement of the two-dimensional array of molecules. The limiting area per molecule is  $60 \text{ \AA}^2$ .

## 2. Analysis of Cyclic Voltammograms

The cyclic voltammograms of A and S are shown in Figure 3. During positive potential sweep, the anode currents reaches a maximum at  $-0.15\text{V}$  and  $-0.16\text{V}$ . This indicates that the concentrations of oxidized A and S are maximized at  $-0.15\text{V}$  and  $-0.16\text{V}$ . When the cyclic direction is reversed, the oxidized forms of A and S are reduced back to the original starting material at  $-0.44\text{V}$  and  $-0.5\text{V}$ . Thus the redox potential of A is  $-0.36\text{V}$ . The redox potential of S is about  $-0.41\text{V}$ .<sup>7</sup>

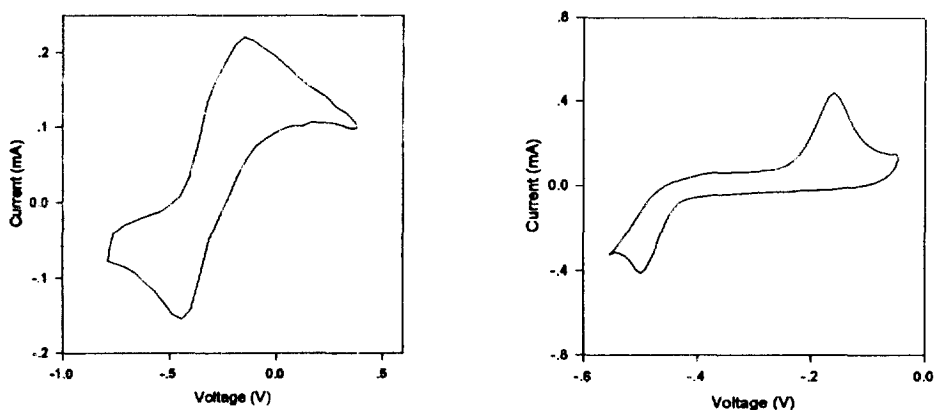


FIGURE 3 Cyclic voltammograms of A, S.

## 3. Photocurrent Response

Figure 4. shows the photocurrent-time response with the irradiation of a  $460\text{nm}$  monochromatic light by a xenon lamp. When a forward bias is applied in accordance with the energy level profile in the MIM device, a stable photocurrent is generated. With repeated step illumination, the reproducible photocurrent is generated accordingly. The photocurrents are very stable and level of responses is consistent during the repeated cycle over 30 minutes. The results indicate that the photoswitching function of the MIM device is achieved. When reverse bias is applied, photocurrent is much smaller than that of forward case. In the proposed molecular device, the photo-induced unidirectional flow of electrons could be achieved due to the redox potential difference as well as electronic coupling between the functional molecules. It is also observed that the intensity of the photocurrent is dependent on the external bias voltage. The external bias voltage being increased, higher photocurrents are generated. Data is not vision.

As shown in Figure 5., the rectifying characteristic is observed from the measurement of photocurrent(I)-voltage(V).

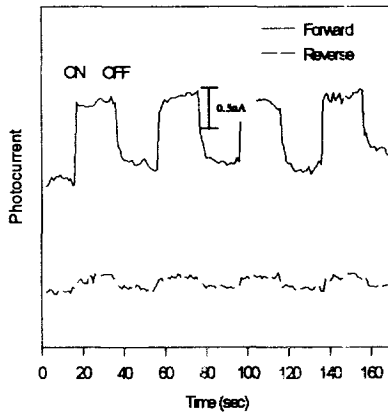
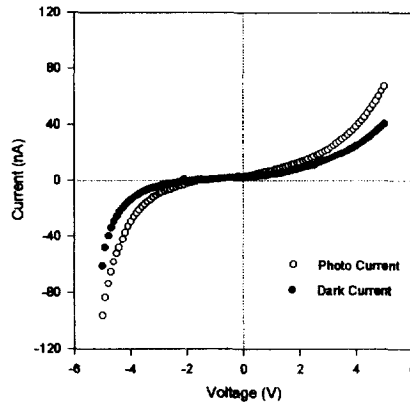


FIGURE 4 Photocurrent-time curve of MIM device: The applied bias was 2.5V.  
 FIGURE 5 I-V characteristics for the MIM device. (460nm Xe lamp)



### CONCLUSIONS

A molecular device with MIM structure was fabricated by the LB multilayers consisting of A and S. By depositing aluminum on the hetero-LB film, a molecular device with MIM structure is constructed. When the forward bias voltage is applied in accordance with the energy level profile in the MIM device, stable photocurrents are generated. With repeated step illumination, the photoswitching function of the MIM device is achieved. Photocurrent flows in the direction of the energy profile of constituted LB films on illumination by light which can be absorbed by the sensitizer. Since the rectifying characteristic is observed in the I-V curve, a molecular device fabricated has the feasibility to be used as a photodiode.

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