2차조화파를 이용한 모델생체막 표면현상 연구

Study on the Interfacial Phenomena at the Model Biomembrane by Optical Second Harmonic Generation

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The basic structure of cellular membrane consists of lipid bilayer on which many proteins or functional molecules are embedded.(1) Many biological phenomena occur on the cellular membrane, among which the transport of molecules across the membrane is one of the most important functions. Many organic ions having partial hydrophobicity can directly transport through the lipid bilayer without aid of protein channels or ionophore carriers. This passive transport of organic ions can be affected by the parameters such as the temperature or the chemical structure of the lipid molecule. The study of the molecular transport mechanism will be helpful for the basic understanding of the biological phenomena as well as the development of the effective way to control it.

We used a surface-specific nonlinear optical technique to study the adsorption and transport of organic hydrophobic ions across the model biomembrane consisting of lipid bilayer. The optical second harmonic generation (SHG) is the second-order nonlinear process, which is forbidden under inversion symmetry.(2) Therefore, it can specifically probe the interface of the liposome, the vesicle consisting of lipid bilayer, suspended in the water. Since the magnitude of second harmonic electric field is proportional to the difference of the numbers of adsorbates on the outer and the inner layer of liposome bilayer, we can monitor the adsorption and the transport of adsorbates in real time by measuring the time dependence of SH signal from the solution.(3)

The triphenyl cationic dye, Malachite Green (MG), was used as a model organic hydrophobic ion due to its large second-order hyperpolarizability. The unilamellar liposomes with size of about 140 nm were made by the extrusion technique using anionic lipids. 100 fs pulses at 840 nm wavelength from Ti:Sapphire laser was used as the input beam. MG and liposome solution were mixed in the temperature-controlled cuvette within 1 sec.

The effect of temperature and the chemical composition of lipids on the adsorption and transport of MG were investigated in the previous study.(4) The transport rate dramatically increased as the temperature increased, while the adsorption amount was not much

affected by the temperature. The chemical composition of lipid was also closely related to the transport rate. The dependence of the transport rate on the temperature and the chemical composition of lipid can be understood using the free area theory.

On the other hand, the transport of MGs from inside to outside of the liposome and the desorption of MGs from the outer layer of the liposome could be studied using the structural property of clay particles. Since a clay particle has a disk shape with very small thickness, the MGs adsorbed on the both sides of anionic disk planes cannot contribute to SHG signal due to the inversion symmetry. Because of this structure, it can rapidly drop the bulk concentration of MGs outside the liposome without affecting the total SH signal when mixed with the liposome solution.

In this presentation, the application of the SHG technique to the study of molecular transport across the liposome bilayer will be introduced and the several results will be discussed.

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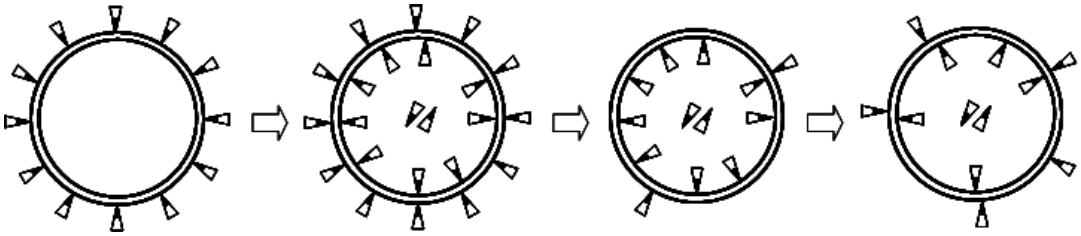

그림 1. Schematic: the adsorption and the transport across liposome bilayer

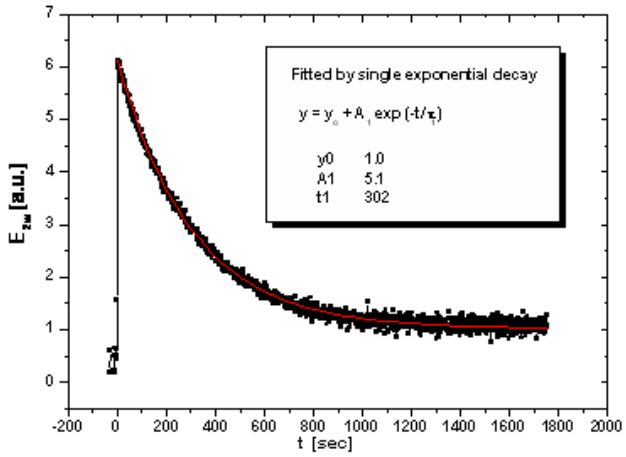

그림 2. Typical time dependence of SHG signal.