Division of Multidisciplinary Chemistry
– Molecular Aggregation Analysis –

http://www.kuicr.kyoto-u.ac.jp/labos/is2/scope.html

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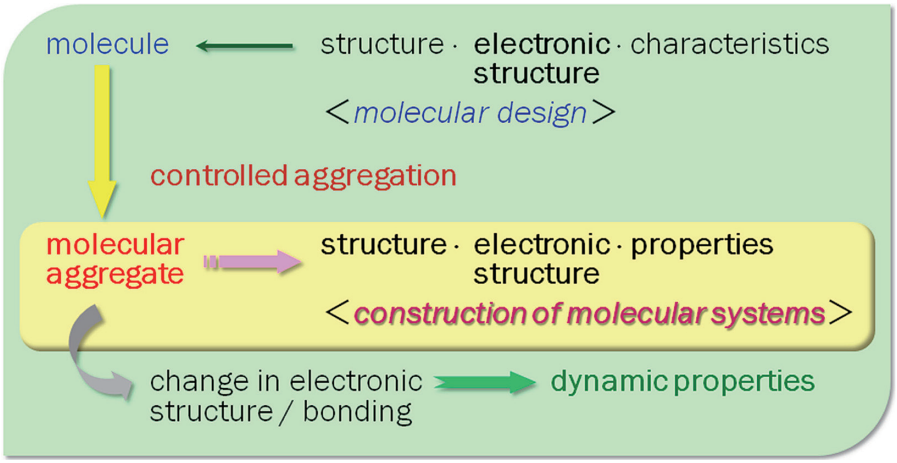
Scope of Research

The research at this subdivision is devoted to correlation studies on structures and properties of both natural and artificial molecular aggregates from two main standpoints: photoelectric and dielectric properties. The electronic structure of organic thin films as organic semiconductors is studied using photoemission and inverse photoemission spectrosocpies in connection with the former, and its results are applied to create novel molecular systems with characteristic electronic functions. The latter is concerned with heterogeneous sturcutres in mocrocapsules, boipolymers, biological membranes and biological cells, and the nonlinearity in their dielectric properties is also studied in relation to molecular motions.

KEYWORDS

Cultured Cell
Dielectric Monitoring
Photoinduced Decay
Surface Potential
Zwitterionic Molecule



Selected Publications

Tsutsumi, J.; Yoshida, H.; Murdey, R.; Sato, N., Decay Mechanism of Spontaneously Built-up Surface Potential in a Thin Film of a Zwitterionic Molecule Having Noncentrosymmetric Crystal Structure, *J. Phys. Chem. C*, **115,** 2356-2359 (2011).

Yoshida, H.; Sato, N., The Depth Profile of Core Energy Levels: Electronic Structure of Buried Organic/Metal Interfaces Examined by X-Ray Photoemission and Target Factor Analysis, *Chem. Phys. Lett.*, **511,** 146-150 (2011).

Murdey, R.; Sato, N., *In Situ* Conductance Measurements of Copper Phthalocyanine Thin Film Growth on Sapphire [0001], *J. Chem. Phys.*, **134,** [234702-1]-[234702-5] (2011).

Asami, K., Dielectric Properties of Microvillous Cells Simulated by the Three-Dimensional Finite-Element Method, *Bioelectrochemistry*, **81,** 28-33 (2011).

Asami, K., Design of a Measurement Cell for Low-Frequency Dielectric Spectroscopy of Biological Cell Suspensions, *Meas. Sci. Technol.*, **22,** [085801-1]-[085801-7] (2011).

Decay Mechanism of Spontaneously Built-up Surface Potential in a Thin Film of a Zwitterionic Molecule Having Noncentrosymmetric Crystal Structure

The photoinduced decay of spontaneously built-up surface potential was investigated for a vacuum-deposited polycrystalline thin film of a zwitterionic molecule, pyridinium 5,7-dihydro-5,7-dioxo-6*H*-cyclopenta[*b*]pyridin-6-ylide (4N-PI) (Figure 1). The excitation energy required to induce the decay lies above the energy gap of 2.2 eV in accordance with the photoconduction threshold. Using fixed excitation energy of 2.8 eV, the decay rate was examined for two films for which different crystallinity was observed and it turned out to increase with increasing film crystallinity. Besides, photoinduced decay of the surface potential has also been observed for Alq_3. However, two different mechanisms are proposed to explain this behavior. One is the relaxation of preferentially ordered molecular dipole moments by photoinduced molecular rotation, and the other is cancellation of the built-up potential through the displacement of photogenerated charge carriers. To our knowledge, there is no conclusion to this controversy, especially with due consideration of the high molecular symmetry of Alq_3. In this work the current-voltage relationship obtained from the surface potential decay for 4N-PI is found to be explained by a combination of an ohmic behavior at low voltages and a trap-limited space-charge-limited-current conduction at high voltages. The electrical parameters derived from the fitted *I-V* curves trend appropriately with the change in film crystallinity. We therefore conclude that photogenerated carriers, rather than molecular rotations, contribute essentially to the disappearance of the surface potential of 4N-PI films under illumination.

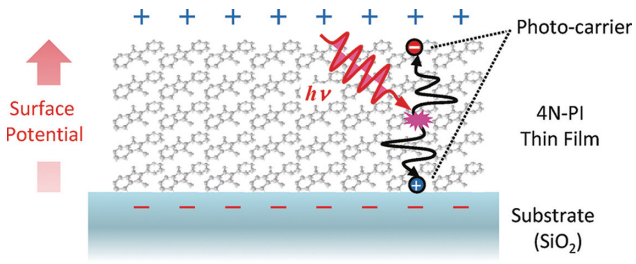


Figure 1. Schematic of photoinduced decay of spontaneously built-up surface potential for a vacuum-deposited polycrystalline thin film of pyridinium 5,7-dihydro-5,7-dioxo-6*H*-cyclopenta[*b*]pyridin-6-ylide (4N-PI).

Dielectric and Optical Monitoring of Animal Cells Cultured on ITO Transparent Electrode

Cultured cells are commonly used for screening of toxicants and medicines. The screening requires high sensitive, high throughput and inexpensive sensing techniques. Dielectric spectroscopy would be a feasible tool for the screening because it is sensitive to the morphology and electrical properties of cells as well as a label-free and noninvasive method. In this study, we have developed a real-time dielectric monitoring system where cells are cultured on ITO-coated glass plates, which permit simultaneous observation of cells by optical microscopy. Electric admittance between the ITO electrode and the Pt electrode placed in the culture medium was measured at a regular interval. With the confluent monolyers of Mardin-Darby canine kidney cells, which are connected to each other with tight junctions, effects of apoptosis inducers (camptothecin (CT), actinomycin D (AD) and cycloheximide (CH)) were examined (Figure 2). Several hours after the dosage, the conductance of the cell monolayer increased, accompanied by appearance of gaps between cells, i.e., opening of tight junctions. At the final stage, all cells became spherical and separated from the ITO electrode, being electrically invisible. The results suggest that the dielectric monitoring technique is a promising tool for sensing the morphological changes of cells in response to toxicants and medicines.

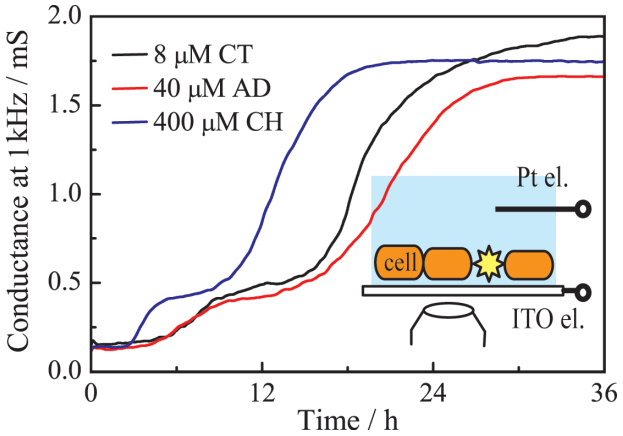


Figure 2. Conductance changes of the cell culture system (inset) after dosage of apoptosis inducers.