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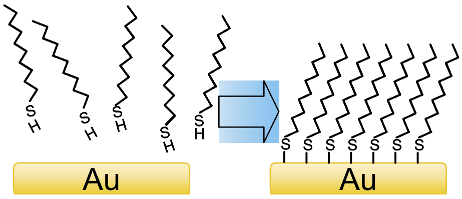
Electrochemical Fabrication of Nano-structured Interfaces

Applied Electrochemistry Group

Electrochemistry is a scientific field that deals mainly with the conversion between electric energy and chemical energy. For this reason, the design of the interface between a solid (electrode) and a liquid (or gas) at the nanometer scale is an important matter. Electrochemistry also provides a useful technique for the modification of solid surfaces at the nanometer scale. The current focus of our research group is on the development of an electrochemical technique for the fabrication of electrodes with suitable surfaces for effective energy conversion.

Alkylthiols dissolved in solution are strongly adsorbed onto metal surfaces and make a highly ordered monolayer called a self-assembled monolayer (SAM), as shown schematically in Figure 1. On the other hand, underpotential deposition (UPD) of metal is a useful means for preparing an atomic monolayer of metal on an electrode. Our recent studies have revealed that UPD occurs even on an Au electrode coated with a thiol SAM if the chain length of the thiol is relatively short, as shown in Figure 2. Based on such findings, we are trying to develop methods to facilitate the design of electrode surfaces at the nanometerscale.



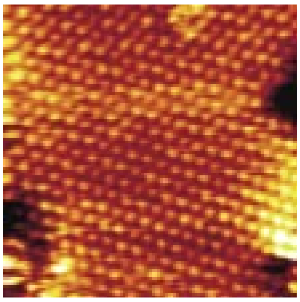


Figure 1 Self-assembled monolayer of alkylthiol molecules.

Design of Electrocatalysts at the Nanometer Scale

A combination of alkylthiol SAM and UPD of metal results in a unique technique that makes it possible to prepare islands of metal monolayers. An example of Pt monolayer islands deposited on an Au substrate is shown in Figure 3. Since the thiol SAM coated on the metal surfaces can be removed by electrochemical means, the exposed islands can be utilized as electrocatalysts. Materials such as these are very useful for investigating and elucidating the relationship between the physical properties of metals

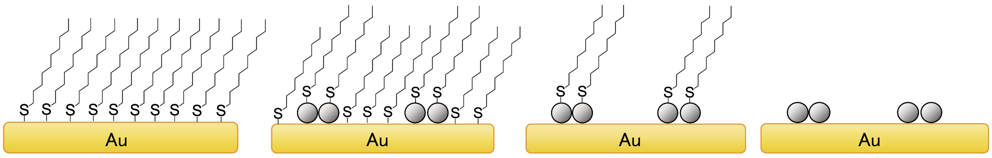


Figure 2 UPD on SAM-coated Au

and their electrocatalytic activities.

Electrodes Possessing Biochemical Activities

We have developed several methods to immobilize biomolecules such as glucose oxidase, cholesterol oxidase, cholesterol esterase, uricase, and amino acid oxidase on electrode surfaces, together with the appropriate electron mediators. To immobilize such biomolecules at the nanometer scale, thiol SAM, glutaraldehyde, and a bilayer of thiol SAM and phospholipid are used. The resulting electrodes exhibit useful properties as biosensors and specific electrodes facilitatingelectroorganic synthesis with high selectivity.

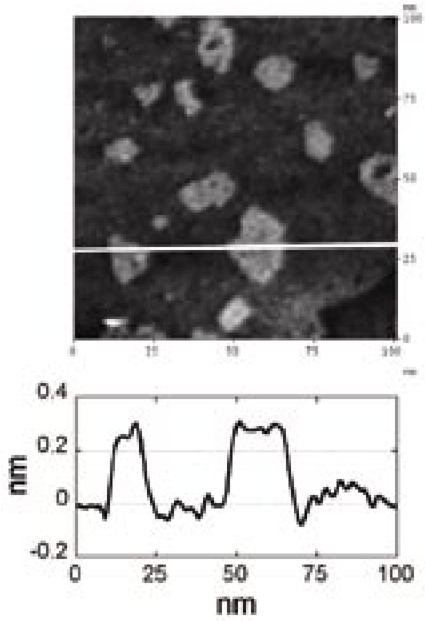


Figure 3 Islands of Pt monolayer deposited on an Au substrate.

Composites of Conducting Polymers and Inorganic materials

Electrochemical and chemical methods have been developed to prepare composites of conducting polymers and inorganic materials, especially metals and metal oxides. The resulting composite films and powders were found to exhibit interesting functions, which were derived by harmonizing the functions of the polymers and inorganic materials [involved]. Our current interest in this area focuses on the use of these composites as active materials for batteries and fuel cells.

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