

Fabrication and Precise Evaluation of Model Heterogeneous Electrochemical Interfaces for Microscopic Elucidation of Corrosion Processes

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Summary

Since the electrolysis of water was reported more than 200 years ago, much research has been conducted on electrochemical reactions that proceed at the interface between a solid electrode and an electrolyte solution. Applications of electrochemistry include not only energy-related applications such as lithium-ion batteries and fuel cells, but also corrosion, plating, and various sensors. Important keyword common to all of these is the "electric double layer" that forms at the solid/liquid interface. The electric double layer is a layered region about 1 nm thick where anions are distributed near the positive electrode and cations are slightly more abundant near the negative electrode, resulting in a large potential difference at the interfaces. Various electrochemical reactions (oxidation-reduction reactions) involving electron transfer proceed using this potential difference. Advances in electrochemistry have led to the development of lithium-ion batteries and a variety of other devices that are indispensable to our daily lives.

On the other hand, although mankind has been using metals for a long time, microscopic understanding of corrosion is still limited. It is generally believed that corrosion is caused by the appearance of an anode and a cathode on a single metal surface due to some trigger, but the mechanism is not well understood. Therefore, the objective of this study is to establish a methodology to elucidate the microscopic mechanism of corrosion by fabricating a model corrosion electrode and precisely evaluating the interface states. As specific model corrosion systems, duralumin, an aluminum alloy, and stainless steel, an iron alloy, were used, and 0.5 M NaCl solution was used as the electrolyte to simulate seawater.

Electrode emersion technique was applied for the first time to the study of corrosion interfaces and X-ray photoelectron spectroscopy measurements revealed that, in the case of duralumin, information on the electric double layer in solution can be retained even in a vacuum. As a result, it was found that not only photoelectron spectroscopy but all precision measurement methods that require a vacuum environment can be applied, and it is expected that research and development on corrosion and corrosion protection will be accelerated based on various useful information that has not been obtained so far. On the other hand, in the case of stainless steel, it was found that a slight corrosion induction dramatically changes the surface condition, and it became clear that research under milder conditions, such as changing the electrolyte, was necessary. While devising sample systems, the usefulness of photoelectron emission microscopy has been suggested, and it is expected that a more detailed mechanism will be revealed through a spatial understanding of the chemical state.