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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 a specific model corrosion system, stainless steel, an iron alloy, was used, and 0.5 M NaCl solution was used as the electrolyte to simulate seawater.

In this study, a detailed analysis focusing on the main component, Fe, was performed using the electrode emersion method, which allows information on the electric double layer in solution to be retained even in vacuum. Photoelectron spectroscopy measurements and photoelectron emission microscopy observations were used to visualize the spatial distribution of the chemical state Fe species. This research method can be applied to the study of various corrosion processes, not only stainless steel, and is expected to accelerate the research and development of not only corrosion but also corrosion prevention based on various useful information on atomic and molecular scales that has not been obtained so far. Since the results obtained from this research grant show that the chemical state of stainless steel changes depending on the microscopic structure of the surface finish, we would like to develop this research into a systematic study using corrosion-resistant surface finishes (including chemical methods). Through a series of microscopic studies, we will explore the development of new research on corrosion and corrosion protection.