Electrochemistry of Some Unique Interfaces

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In this talk I introduce two unique interfaces that exhibit characteristic electrochemical behavior implying new arena of electrochemistry and its applications. One is Silicon oxide and nitride surfaces, which are representative dielectric materials, being widely used as electrical insulators by semiconductor manufacturers, but poorly work when exposed to moisture. It allows significant ion current in protic solvent upon negative bias because cathodic condition can make the film unstable and protons possibly permeate through it. Not only size but density or crystallinity of silicon oxide and nitride are now possibly under control on nanometer scale, offering unprecedented opportunities to electrochemistry. Thermally grown thin film of high density SiO_x provides excellent proton-selectivity and well controlled defects for electron tunneling. In such insulating thin layers we can see burgeons of new electrochemistry. In this talk, we will discuss the charge transfer through a thin insulating layer of the dense SiO_x and its potential for unconventional electrochemistry on the dielectric surface.

The other interface in this presentation is what exists between solid electrode and redox active ionic liquid, specifically quaternary ammonium polybromide. Since the electrical double layer (EDL) is where heterogeneous electron transfer occurs, understanding the effects of the electrode-electrolyte interface structure on electrocatalysis is important. The strong electric field in the EDL offers unique environment for electrochemical reactions by altering the solvation structure and mass transport of redox species. Yet, it is challenging to evaluate the physicochemical properties of the matter within EDL, especially for the inner Helmholtz plane (IHP), where most electrochemical reactions occur. Herein, the microscopic environment in the IHP of ionic liquids (ILs) is investigated through the reorganization energy (l) reflecting the solvation structure. Exceptionally fast mass transport of Br_2 in N-methyl-N-ethyl-pyrrolidinium polybromide ($MEPBr_{2n+1}$) allows to obtain Br_2 reduction voltammograms in which the current plateau is governed by electron-transfer kinetic and to evaluate l based on the Marcus-Hush-Chidsey model. Regulating the potential of zero charge (PZC) of electrodes by surface modification and preparation of alloys with various elemental compositions, the surface charge sensitive-ionic structure in ILs is discussed. Furthermore, high-throughput investigations of the PZC of high-entropy alloy material library (HEA-ML) using the scanning electrochemical cell microscopy (SECCM) technique reveals the correlation between acidic HER activities on the HEA and its PZC. These highlight the surface charge-dependent EDL structure as one of the electrocatalyst designing principles.

Taek Dong Chung is a tenured professor in the Department of Chemistry at Seoul National University (SNU), Seoul, South Korea. He was born and educated in South Korea before earning his Ph.D. degree from SNU in 1997. After completion of this doctoral studies, Chung pursued postdoctoral research with Prof. Fred Anson at the California Institute of Technology, and at Oak Ridge National Laboratory in the United States. His independent research career began in 2002 when he established his research group at Sungshin Women's University. In 2007, he transferred to SNU and now holds the position of Department Chair. Chung's academic interests span a wide range of topics in electrochemistry, with a particular emphasis on developing new electroanalytical methods. He is one of the leading researchers of electrochemistry in nano-space and a pioneering figure in the field of Iontronics, which explores ionic circuitry operating on selective charge transport in aqueous media with potential to integrate with the human neural system. Chung's scientific contributions can be found in 200 international peer-review papers and numerous patents. He plays active roles within the academic community, notably serving as the Director of the Center for Electron Transfer and holding editorial and advisory board positions for a couple of journals, including the Journal of Electroanalytical Chemistry. Since 2022, he is the Secretary General of the Korean Electrochemical Society.

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