Electrochemical Tools in Materials Research: From Fundamentals to Applications

Electrochemical tools are widely applied in materials research such as corrosion, electrowinning (metal production), and rechargeable batteries, fundamentally rooted in electrochemical systems. The disciplines of electrowinning and corrosion are governed by the same fundamental thermodynamic processes (metal oxidation)—differing in that electrometallurgy seeks to maximize reaction kinetics to efficiently produce metals, while corrosion research aims to minimize reaction kinetics to prevent material degradation. Efficient electrowinning and rechargeable batteries are similarly related by the same need for facile reaction kinetics; however, batteries further demand chemically reversible processes. Furthermore, the application of electrochemical tools ranges from fundamental thermodynamic studies to the development of electrochemical processes: molten oxide electrolysis (MOE) and liquid metal batteries (LMB). MOE is a carbon-free, electrochemical technique to decompose a metal oxide directly into liquid metal and oxygen gas. From an environmental perspective what makes MOE attractive is its ability to extract metal without generating greenhouse gases. The feasibility of iron-making by MOE is demonstrated in lab-scale set-up. Liquid metal batteries are characterized by liquid metal electrodes and a molten salt electrolyte, which self-segregate into layers based upon density and immiscibility. These batteries boast fast electrode kinetics due to liquid-liquid interfaces allowing fast charge/discharge characteristics, impressive current densities resulting from high ionic conductivity of the molten salt electrolytes, long cycle life enabled by continuous annihilation and creation of liquid electrodes (i.e., no solid-state electrode degradation mechanism), and the utilization of low-cost materials.

Biography:

Dr. Hojong Kim is a research scientist at MIT, where he is leading efforts to develop electrode materials for use in liquid metal battery technology. His research interests include electrochemical energy conversion and storage, environment-friendly electrometallurgical processes, high-temperature corrosion, and materials for energy storage and conversion. Previously, he worked as a senior research scientist and project lead at Samsung Corning Precision Glass Co. Ltd to improve the process yield for thin film transistor liquid crystal display (TFT-LCD) glass manufacturing. Kim received his Ph.D. in the Uhlig Corrosion Laboratory at MIT under Professor Latanision (2004) and B.S. in Materials Science and Engineering from Seoul National University in South Korea (2000).