

Title:

Design and In Situ Investigation of Electrocatalysts for Enhanced Performance in Water and Seawater Electrolysis

Abstract

Meeting the global imperative to decarbonize energy-intensive industries requires scalable technologies for producing clean fuels and chemical feedstocks. Proton exchange membrane (PEM) electrolysis offers high efficiency and compatibility with renewables, but its acidic operating conditions demand oxygen evolution reaction (OER) electrocatalysts that remain active and stable while minimizing reliance on scarce noble metals like iridium and ruthenium. Direct seawater electrolysis offers a complementary route to decarbonization, but chloride ions drive a competing chlorine evolution reaction (CER), which reduces OER selectivity and accelerates catalyst degradation.

This talk presents two catalyst design strategies developed to address the activity-selectivity-stability trade-off. The first is a support engineering strategy using bimetallic transition-metal nitride supports (TiTaN, TiZrN), in which tensile strain at the IrO_x support interface tunes the OER intermediate adsorption energetics, yielding higher activity, lower overpotentials, and suppressed iridium dissolution, with benefits that persist under seawater-relevant conditions. The second is oxide encapsulation, in which ultrathin SiO_x or TiO_x overlayers on ruthenium oxide thin films suppress chloride transport to the buried catalytic interface, with SiO_x outperforming TiO_x due to lower chloride permeability and higher resistivity.

Together, these strategies reveal fundamental trade-offs among activity, selectivity, and stability, pointing to promising directions for catalyst design across acidic and seawater electrolysis environments.