Perchlorate Reduction Catalysts: Challenges, Rationales, and Solutions

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Abstract
Perchlorate ($\text{ClO}_4^-$) is a pervasive toxic anion that can cause thyroid gland malfunction. In California, perchlorate in groundwater is an ongoing challenge for drinking water supply and site remediation. The detection of perchlorate on Mars also triggers new interests in developing perchlorate reduction catalysts. However, aqueous perchlorate is highly inert. For example, most electrochemical systems use $\text{ClO}_4^-$ as the background electrolyte to adjust ionic strengths. Therefore, unique design rationales and working mechanisms are necessary to reduce aqueous $\text{ClO}_4^-$. In my PhD study, I developed a heterogeneous catalyst using palladium (Pd) to activate $\text{H}_2$ and rhenium (Re) to abstract the oxygen atom from $\text{ClO}_4^-$. The Re–Pd/C configuration achieved the rapid and clean conversion $\text{ClO}_4^- + 4\text{H}_2 \rightarrow \text{Cl}^- + 4\text{H}_2\text{O}$. However, the original Re complex had a series of issues, especially (i) the short lifetime due to hydrolytic decomposition and (ii) the high cost of this rare metal element.

In this seminar, I will present our recent findings, including (i) the discovery and elucidation of the surprisingly increased lifetime of Re sites upon simple modification of the organic ligand and (ii) the switch from Re to other abundant metals to obtain even higher activities. I want to show that (i) the commonly thought “fragile” molecular catalyst can be very stable and (ii) the bioinspired catalysts can perform “better” than microbes in specific aspects. Most importantly, we want to highlight the amazing power of coordination chemistry to develop exciting environmental technologies.

Background
Jinyong Liu received his Bachelor’s degree in Chemistry and Master’s degree in Environmental Science at Tsinghua University and his Ph.D. degree in Environmental Engineering at the University of Illinois at Urbana-Champaign (advisors: Prof. Timothy Strathmann and Prof. Charles Werth). He joined the Department of Chemical and Environmental Engineering at the University of California Riverside in 2016. Current research topics in his lab include (i) innovative and practical methods for PFAS degradation, (ii) catalytic reduction of oxyanions such as perchlorate, chlorate, and bromate, and (iii) developing bioinspired transition metal species for environmental pollutant degradation. He is the recipient of several American Chemical Society awards: Environmental Science & Technology Letters Excellence in Review Award, C. Ellen Gonter Environmental Chemistry Award, and Graduate Student Award in Environmental Chemistry.