CHEMISTRY SEMINAR

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Thursday, August 1, 2019, 1:00 – 1:50 p.m.  
Room C2004 (Chemistry/Physics Building)

Title: Carbon-free fuel cell catalyst supports with enhanced electronic conductivity

Abstract:

Polymer electrolyte membrane fuel cells (PEMFCs) are a clean energy technology with potential application in automotive and station power systems. However, the high cost of Pt catalyst and long-term durability of electrode materials hinders market penetration. The support material greatly influences electrocatalytic activity and durability of the Pt nanoparticle catalysts. Carbon black has been the primary catalyst support in fuel cells over the last 30 years due to its high surface area and high electronic conductivity. However, carbon corrosion occurs readily during start-up/shutdown conditions. Therefore, more advanced support materials are needed to address this issue.

Many low-cost metal oxide materials like as TiO₂, NbOₓ, WOₓ, and MoOₓ have high oxidative and thermal stability. As such, there has been a growing interest to exploit these materials in fuel cell catalysts layers. However, the potential benefits of adding these metal oxides to the catalyst layer are often negated by their inadequate electronic conductivity. Recently, there has been a growing interest in designing metal oxides with sufficient electrical conductivity to be a practical catalyst support. Significant attention has been paid to titanium suboxides (TiₓO₂₋ₓ) materials since they possess acceptable electronic conductivity. Furthermore, the addition of a dopant can further enhance electronic conductivity by creating oxygen vacancies within the lattice structure. Recently, Esfahani and co-worker have reported a process of modifying TiO₂ with Mo to form Mo-doped titanium suboxide (Ti₃O₅-Mo). While this has been shown to be a promising fuel cell catalyst support, the support still had a sizable band gap of (2.6 eV).

We have hypothesized that the introduction of a second dopant could further reduce the electronic band gap and enhance conductivity. Specifically, we have examined the use of Si as the second dopant. We have synthesized a dual-doped metal oxide support material with a composition of Ti₃O₅Mo₀₂Si₀₄ (hereafter referred to as TOMS). The TOMS support displays a remarkably low band gap of 0.31 eV, leading to significantly higher electronic conductivity compared to other metal oxide supports. We have prepared fuel cell catalysts by depositing Pt nanoparticles onto the TOMS support. The resultant catalysts show remarkable stability and electrocatalytic activity. In this presentation, I will describe how doping alters the conductivity of metal oxides. In addition, we will demonstrate the electrocatalytic active of Pt/TOMS for fuel cell relevant reaction as well as its stability under several accelerated stress test protocols.