This presentation will provide an overview of the recent progress achieved at Los Alamos National Laboratory in electrocatalysis for polymer electrolyte fuel cells (PEFCs). The presentation will begin with a review of non-precious metal catalysts (NPMCs) for oxygen oxidation and conclude with a summary of the latest advancements in the oxidation of dimethyl ether (DME).

Since the early work of Jasinski in the 1960s [1], non-precious metal ORR catalysts have received much attention as a possible replacement of Pt-based formulations in both hydrogen and other types of polymer electrolyte fuel cells. Recent breakthroughs in the synthesis of NPMCs, achieved via the use of high-temperature approach (e.g., Lefevre et al. [2]; Wu et al. [3]) make replacement of Pt in ORR catalysts with earth-abundant elements, such as Fe, Co, N, and C, a realistic possibility. A successful ORR catalyst must combine high activity with good long-term stability – a major challenge in the strongly acidic environment of the polymer electrolyte cathode. The NPMC performance depends on the selection of precursors, synthesis chemistry, and catalyst nanostructure. Apart from possible direct participation in the active site, the transition metal is crucial to \( \textit{in-situ} \) formation of carbon nanostructures (nanotubes, onion-like structures, graphene) by catalyzing the decomposition of the nitrogen/carbon precursor at high temperatures (800-1000°C).

Dimethyl ether presents several advantages over some other alternative fuels for direct-feed fuel cells, such as methanol and ethanol. Unlike ethanol but similarly to methanol DME does not require C-C bond scission to be oxidized to CO\(_2\). DME is less toxic than methanol though and can be conveniently stored and transported using the existing infrastructure and storage technologies. Recently, our group demonstrated new DME oxidation catalyst [4] that not only outperforms DME oxidation catalysts reported to date [5] but also allows direct DME fuel cell (DDMEFC) to reach performance similar to that of the DMFC. Based on that result, we assumed that further improvement in the DDMEFC anode performance could potentially be accomplished by developing catalysts designed specifically for DME by accounting in particular for the differences in DME oxidation relative to methanol. In this presentation, we will summarize our efforts to date in the development of a “DME-specific” ternary PtRuPd/C catalyst, capable of (i) facilitating DME adsorption, (ii) lowering the activation barrier for the cleavage of O-C bond in the DME molecule, as well as (iii) accelerating oxidation and removal of CO intermediates.

References: