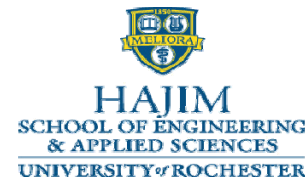


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Non-Precious Metal Oxygen Reduction Catalysts for Fuel Cells

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2:15 p.m.

101 Goergen Hall

With the growing awareness that the use of platinum needs to either be greatly reduced or completely eliminated from the polymer electrolyte fuel cell (PEFC), non-precious metal catalysts for oxygen reduction reaction (ORR) have received lots of attention in recent years as a possible replacement of Pt and its alloys at the fuel cell cathode. A successful cathode catalyst must combine high ORR activity with good long-term stability – a major challenge in the strongly acidic environment of the PEFC cathode. Since the early work of Jasinski in the 1960s [1] and of Yeager and co-workers [2] a significant progress has been achieved in the synthesis, performance improvement, and understanding of the ORR mechanism on non-precious catalysts [3-6]. The catalysts have been derived from macrocycle precursors, e.g. porphyrins, and other nitrogen-rich compounds, e.g. cyanamide and ammonia, usually subjected to a heat treatment in the presence of a transition-metal precursor. The most recent formulations include a number of well performing polymer-derived materials, synthesized with or without a heat treatment.

In this presentation, we will summarize the recent substantial progress in the development, performance testing, and characterization of non-precious metal oxygen reduction electrocatalysts at Los Alamos, obtained using both low- [3] and high-temperature [5] approaches. The main focus of this presentation will be on materials derived from heteroatomic organic compounds, including polypyrrole, as well as from polyaniline and cyanamide in the presence and absence of transition-metal salts as metal precursors. The catalysts have been studied using carbon and selected alternative supports, such as TiO₂. At present, the best non-precious metal ORR catalysts (at a high loading allowed by their low cost) trail Pt in the rotating disk electrode (RDE) experiments by no more than 40 mV, with similar performance difference maintained in the fuel cell at high voltages, i.e. in the range where PEFC performance is controlled by the oxygen reduction kinetics. Several catalysts also show much improved durability under both steady-state and potential-cycling conditions. An extensive characterization using electrochemical and non-electrochemical techniques allows for the correlation of high ORR activity with several different factors, which include the nitrogen precursor used in the synthesis and catalyst microporosity. In turn, the presence of graphene sheets can be strongly correlated with the most durable catalysts.

References

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