

BIOGRAPHICAL SKETCH

Gholamreza Mirshekari was born in Shiraz, Iran on September 21, 1989. He received his bachelor degree in Materials Engineering (Area of concentration: Industrial Metallurgy) from Shahid Chamran University in 2011, and master degree in Materials Engineering (Area of concentration: Identification, Selection & Manufacturing of Materials) from Isfahan University of Technology in 2014. In 2015, he entered Tennessee Technological University to receive his Ph.D. degree in Engineering. His research area focused on the fabrication and electrochemical characterization of non-carbon supported platinum electrocatalysts for oxygen reduction reaction in proton exchange membrane fuel cell (PEMFC) environment.

EDUCATION

Ph.D., Engineering

Tennessee Technological University, 2015-expected 2018

M.Sc., Materials Engineering

Isfahan University of Technology, 2011-2014

B.Sc., Materials Engineering

Shahid Chamran University, 2007-2011



College of Engineering

TENNESSEE TECH

The Department of
Mechanical Engineering
Announces the Dissertation Defense
of
Gholamreza Mirshekari
In Partial Fulfillment of the Requirements
For the degree of
Doctor of Philosophy
September 24, 2018
02:30 p.m.
Held in
307 Brown Hall
Tennessee Tech University

FIELD OF STUDY

Engineering-Electrocatalysis for PEM Fuel Cells

DISSERTATION TOPIC

CATALYTIC ACTIVITY AND DURABILITY OF NON-CARBON SUPPORTED PLATINUM ELECTROCATALYSTS FOR OXYGEN REDUCTION REACTION IN PROTON EXCHANGE MEMBRANE FUEL CELLS ENVIRONMENT

EXAMINING COMMITTEE

Dr. Cynthia Rice, Advisory Committee Chair

Associate Professor, Chemical Engineering

Dr. Stephen Idem

Professor, Mechanical Engineering

Dr. Jiahong Zhu

Professor, Mechanical Engineering

Dr. Jie Cui

Professor, Mechanical Engineering

Dr. Robert Glinski

Professor, Chemistry

ABSTRACT

Proton exchange membrane fuel cells (PEMFCs) offer numerous advantages such as high power output, high-energy conversion efficiency, low noise, and no environmental pollution which make them a promising technology for mobile and stationary power applications. Despite inherent advantages of PEMFCs, some economic and technical barriers impede their large-scale commercialization. One of the most important technical barriers is related to carbon nanoparticles, having widely been used as catalyst support for platinum in PEMFCs as it has a very high surface area, excellent electronic conductivity, low cost and good accessibility. Carbon supports, however, have a weak interaction with platinum and are susceptible to corrosion in the acidic environment of PEMFCs. Therefore, one of the significant challenges today is to determine if and to what extent novel catalyst supports with co-catalytic functionality can prevent or delay the degradation of the catalysts and improve both activity and durability of platinum group metal catalysts used in fuel cells.

To address the abovementioned PEMFCs technical barrier, the effects of particle size and metal oxidation state on the electrochemical behavior of TiO_2 , Mn_2O_3 , and Mn_3O_4 nanoparticles were investigated. The results showed some oxygen reduction reaction (ORR) activity for TiO_2 , Mn_2O_3 , and Mn_3O_4 nanoparticles strongly depending on particle size and metal oxidation state. The TiO_2 nanoparticles also showed remarkable durability in PEMFCs environment. Platinum nanoparticles were deposited on TiO_2 , TiN, and TiC supports nanoparticles used as the active and stable catalysts for PEMFCs. The results suggested that there is an increased support contribution with increased TiO_2 support size to improve Pt accessibility, thereby an increase in catalytic activity. Increasing the Pt loading from 12 wt% to 37 wt% on TiO_2 30 nm support, however, detrimentally affected stability. Among those three synthesized catalysts, the Pt/TiC catalyst had the highest stability and ORR performance. The ORR performance of the synthesized Pt/TiC catalyst was found to be promising with higher area specific activity of $252.6 \mu\text{A cm}_{\text{Pt}}^{-2}$ and almost identical mass specific activity of $0.16 \text{ A mg}_{\text{Pt}}^{-1}$ than that of the commercial Pt/C catalyst. Additionally, the Pt/TiC showed the outstanding stability with no reduction in ORR performance and 10.1% increase in electrochemical surface area after the accelerated stress test.