

DEVELOPMENT OF ANODE ELECTRO- CATALYST FOR DIRECT ETHANOL PEM FUEL CELL

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INDIAN INSTITUTE OF TECHNOLOGY DELHI
JANUARY 2015**

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DEVELOPMENT OF ANODE ELECTRO- CATALYST FOR DIRECT ETHANOL PEM FUEL CELL

by

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Submitted

in fulfillment of the requirements of the degree of

Doctor of Philosophy

to the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

JANUARY 2015

CERTIFICATE

This is to certify that the thesis entitled **Development of Anode Electro-Catalyst for Direct Ethanol PEM Fuel Cell** submitted by **Mrs. Jyoti Goel** to the Indian Institute of Technology Delhi, for the award of Degree of Doctor of Philosophy, is a record of the original bonafide research work carried out by her. She has worked under my supervision and has fulfilled the requirements, which to my knowledge, has reached the requisite standard for the submission of this thesis. The results contained in this thesis have not been submitted in part or full to any University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

I would like to thank the Indian Institute of Technology, Delhi and Department of Chemical Engineering for giving me an opportunity to pursue Ph.D on development of direct ethanol PEM fuel cell.

I would like to express my sincere gratitude to my supervisor Professor Suddhasatwa Basu for giving the opportunity to work in his lab and allowing me to participate in their research projects.

I want to thank Ministry of New and Renewable Energy (MNRE) and Department of Science and Technology (DST) for financial support of this research and Council of Scientific and Industrial Research (CSIR), and All India Council for Technical Education (AICTE) for Ph.D. fellowship.

I would like to thank all the members of fuel cell laboratory of Prof. S. Basu for providing a cooperative and friendly atmosphere for me to carry out my research.

I wish to thank my SRC members: Prof. K. K. Pant, Prof. S. K. Gupta, and Prof. A. K. Ganguli for their valuable suggestions and requisite guidance on technical issues.

I want to thank my family members especially my mother in law Mrs. Kanta Goel who is always there for me. I would also like to thank my husband, Mr. Sandeep Goel for his tremendous patience, continuous inspiration and encouragement to generate positivity and strength inside me.

(JYOTI GOEL)

ABSTRACT

State of the art Pt/C catalysts suffer from high cost and low catalytic activity towards ethanol oxidation, because of incomplete oxidation of ethanol in direct ethanol fuel cells (DEFCs). Ethanol is hard to oxidize completely into CO₂ and H₂O due to the difficulties in breaking the C-C bond at low temperature and the formation of CO-intermediates which poison the Pt catalyst. Thus it is necessary to develop catalyst with high selectivity towards ethanol oxidation reaction (EOR) in DEFC. The objective of this thesis is to study the performance and behavior of platinum based binary and ternary metal anode catalysts towards EOR. Binary Pt-Ir/C (20:20), Pt-Sn/C (20:20), Pt-Re/C (20:20) electro catalysts and ternary Pt-Ir-Sn/C and Pt-Re-Sn/C electro-catalysts with wt % (20:5:15), (20:10:10), (10:15:15) are prepared using co-impregnation reduction method. The prepared electro catalysts are physically characterized using scanning electron microscope (SEM), transmission electron microscope (TEM), energy dispersive X-ray spectroscopy (EDX) and X-ray diffraction (XRD) technique. XRD and TEM study reveals that the prepared nanoparticles are in the range of 10-20 nm. The prepared catalysts are electrochemically characterized by cyclic voltammetry (CV), chronoamperometry (CA), and linear sweep voltammetry (LSV) methods. Electrochemical characterization points out that small addition of third metal Ir or Re to Pt-Sn/C based catalysts enhances their activity towards ethanol oxidation.

DEFC results show that the ternary Pt-Ir-Sn/C (20:5:15) and Pt-Re-Sn/C (20:5:15) catalysts exhibit higher catalytic activity than binary Pt-Sn/C, Pt-Ru/C Pt-Ir/C, Pt-Re/C and Pt/C anode catalysts. The effect of various operating parameters like ethanol fuel concentration, ethanol flow rate, operating temperature, anode diffusion layer, and oxygen flow rate on

DEFC are studied using Pt-Re-Sn (20:5:15)/C metal catalyst. Analysis of products obtained by the oxidation of ethanol in DEFC shows that acetic acid and acetaldehyde are the major products.

To study the effect support material on EOR, mesoporous carbon nitride (MCN) and treated-multiwalled carbon nanotubes (t-MWCNTs) are prepared and tested. The physical properties of different support materials e.g., MWCNTs, t-MWCNTs and MCN are studied using TGA, TEM, FTIR and XPS technique. Using MWCNTs, t-MWCNTs and MCN as support, Pt-Re-Sn and Pt-Ru metal anode catalysts are tested in DEFC. The results suggest that Pt-Ru/MCN catalyst show a maximum power density of 63.2 mW/cm^2 , using 1 M ethanol as feed at 100°C .

A comprehensive one dimensional (1-D) steady state mathematical model is developed using tafel kinetic relations for ethanol oxidation and mass transport of different species throughout the cell. Overall polarization of cell is obtained by systematically addressing the various useful parameters such as ethanol cross over, mixed potential effect due to ethanol crossover, limiting current behaviour and variation in anode and cathode over-potential in the catalyst layer. The mathematical model developed for DEFC predicted well the experimental data of Pt-Re-Sn/MCN (20:5:15), Pt-Ru/MCN (20:20) and Pt-Re-Sn/C (20:5:15) anode catalysts.

Based on the experimental and theoretical analyses, Pt-Ru/MCN found to be most suitable anode catalyst for DEFC in terms of cell performance.

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