

## ABSTRACT

Nowadays, DMFCs are very attractive device and one of the promising trends of the future technology which are extremely desirable power sources for stationary and portable applications. The liquid organic molecules of methanol have been proposed as fuel which is fed directly into the anode compartment without any chemical modification, which simplifies the overall system. The use of liquid methanol helps to overcome the main problems that have been identified with the use of gaseous  $H_2$  in a PEMFC configuration, i.e., production, transportation, refilling and storage. Despite the benefits of DMFCs, its advancement to being commercially functional is hindered by a number of crucial factors. These factors are often associated with the lack of appropriate catalyst development, synthesis techniques, catalyst coating and manufacturing. Whilst most research efforts have been directed towards developing more active catalysts and minimum utilization of noble metals in the active catalyst.

With the ultimate goal of achieving better overall performance of the DMFC i.e. 'low cost high energy density fuel cell'. This research work has been concerned with an exploration of new high performance anode electrocatalyst development for the Methanol Oxidation Reaction (MOR). First of all, Pt nanoparticles have been deposited on  $NiTiO_3/C$  nanoparticles and the resulting nanocomposite catalyst has been compared with Pt/C in terms of the electrochemical activity for the MOR using CV, SSP, and CA techniques. XRD and TEM have been used for characterizing phase purities and morphologies of prepared materials. The results demonstrate that  $NiTiO_3/C$  has significant promotion effect on the electrocatalytic activity and stability for the methanol electro-oxidation although  $NiTiO_3/C$  by itself does not catalyze the MOR. Furthermore, it is of interest to evaluate the performance of Pt-Ru- $NiTiO_3$  nanoparticles dispersed on Vulcan carbon for the MOR compared with Pt-Ru/C (conventional catalyst). The results demonstrate that the superior

electrocatalytic performance of Pt-Ru-NiTiO<sub>3</sub>/C is attributed also to the synergistic effects of NiTiO<sub>3</sub>. Such higher catalytic activity is due to the promotional effect exhibited by surface Ru oxide and NiTiO<sub>3</sub>. On the other hand, it promotes the reaction increasing the current density and shifting the onset potential to even more negative values, suggesting that it also participates in the bi-functional mechanism along with Ru.

Finally, the performance tests of the conventional and new catalysts are conducted on 5 cm<sup>2</sup> active area with various operating conditions like cell operating temperatures, methanol/water molar concentrations and reactant flow rates. Experiments are conducted with the combination of four different electrocatalyst materials on the anode side (Pt/C, Pt-NiTiO<sub>3</sub>/C, PtRu/C, Pt-Ru-NiTiO<sub>3</sub>/C) and with commercial 20 wt. % Pt/C on the cathode side. 0.5 mg<sub>pt</sub>/cm<sup>2</sup> loading is maintained on both sides. Best performing operating conditions have been optimized. The maximum peak power densities attained are 13.30 mW/cm<sup>2</sup> (26.6 mW/mg<sub>pt</sub>) and 14.60 mW/cm<sup>2</sup> (29.2 mW/mg<sub>pt</sub>) for Pt-NiTiO<sub>3</sub>/C and Pt-Ru-NiTiO<sub>3</sub>/C at 80°C respectively, with 0.5 M concentration of methanol and fuel flow rate of 3 ml/min (anode) and oxygen flow rate of 100 ml/min (cathode). Besides, 5 h short term stability tests have been conducted for PtRu/C and Pt-NiTiO<sub>3</sub>/C.

The overall results suggest that the incorporation of NiTiO<sub>3</sub>/C supportive material to Pt and Pt-Ru appears to make a promising anode electrocatalysts for the enhanced DMFC performances