OPEN HOUSE

Department of Chemical Engineering

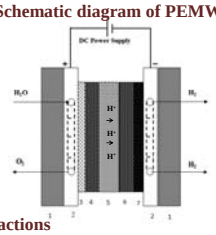
2014 IIT DELHI OPEN HOUSE

Development of High Temperature Proton Exchange Membrane Water Electrolyser for Generation of Pure Hydrogen and Oxygen

*Varagunapandiyan N and Basu S**

Introduction It is an electrochemical device used to split water electrochemically into pure hydrogen at the cathode and oxygen at anode with the application of electrical energy.

Schematic diagram of PEMWE



Reactions

At anode : $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$

At cathode : $2H^+ + 2e^- \rightarrow H_2$

Overall : $H_2O \longrightarrow ½O_2 + H_2$

Catalyst Synthesis

Precursors + 50 ml anhydrous ethanol+ 25 ml of sodium ethylate in ethanol

↓

Reflux the solution @ 80 ° C for 4-5 hours under N_2 atmosphere

↓

Resulting solution is allowed to cool

↓

Add 5 ml of 30% H_2O_2 to oxidize (stirring overnight)

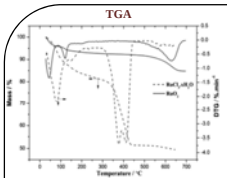
↓

Add 2-4 ml of NH_3 solution and 21-23 cm^3 of ethanol.

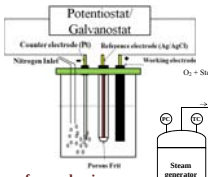
↓

Resulting powder is washed with distilled water, dried for 12 hrs and then calcined @ 400 °C for 4 hr

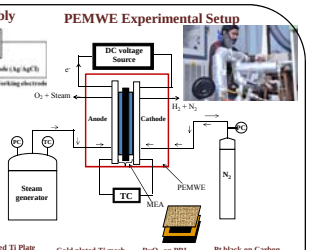
TGA



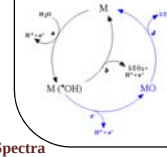
Three electrode Assembly



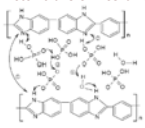
PEMWE Experimental Setup

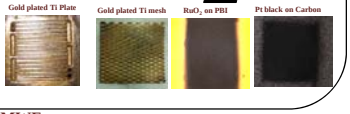


OER Mechanism



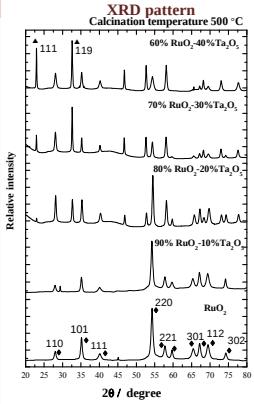
Proton transfer mechanism



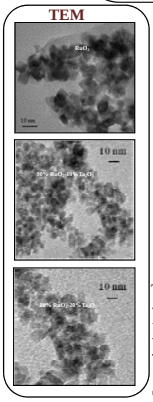


XRD pattern

Calcination temperature 500 °C

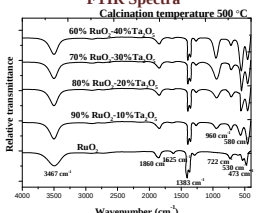


TEM

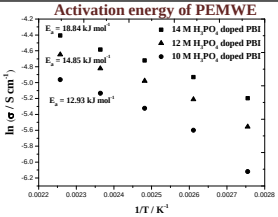


FTIR Spectra

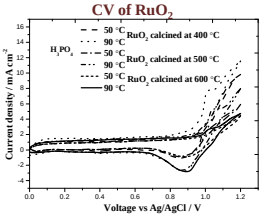
Calcination temperature 500 °C

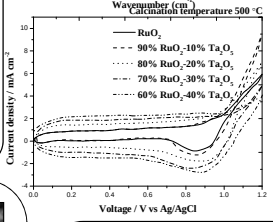


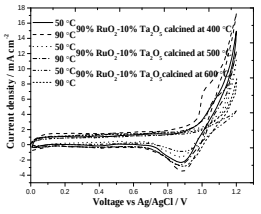
Activation energy of PEMWE

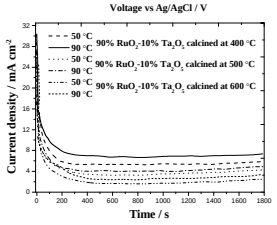


CV of RuO_2

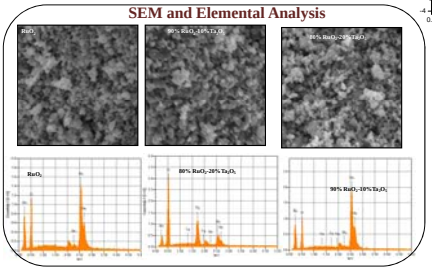




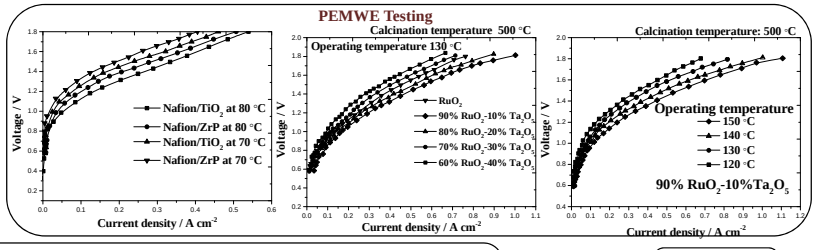




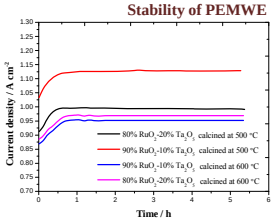
SEM and Elemental Analysis



PEMWE Testing



Stability of PEMWE



Summary

- Anode RuO_2 and RuO_2-Ta_2O_5 electrocatalysts were successfully prepared by sol-gel procedure with different compositions and different calcination temperatures for OER.
- Presence of RuO_2 and Ta_2O_5 crystallite phase were confirmed by XRD. Crystallite size increased with increase in calcination temperature.
- Oxygen-metal bond formation was observed in FTIR spectra and the peak intensity was increased with increase in calcination temperature.
- SEM shows uniform surface morphology and EDX shows required composition.
- Electrochemical activity increased with increase in electrolyte temperature and decreased with increase in calcination temperature.
- The maximum performance is obtained for 90%RuO_2-10%Ta_2O_5 with current density of 17.15 mA cm^{-2} at 1.2 V for OER.
- Activation energy of 14 M H_3PO_4 doped PBI electrolyte membrane calculated as 18.84 kJmol $^{-1}$ and the conductivity is 0.012 S cm^{-1}

Publications

[1] Varagunapandiyan N, Basu S and Keith Scott. Effect of treatment temperature on the performance of RuO_2 anode electrocatalyst for high temperature proton exchange membrane water electrolysers, Int J Hydrogen Energy 2013;38: 16623-16630.

[2] Puthiyapura VK, Pasupathi S, Basu S, Wu X, Su H, Varagunapandiyan N, Pollet B, Scott K. $Ru_xNb_{1-x}O_2$ catalyst for the oxygen evolution reaction in proton exchange membrane water electrolysers. Int J Hydrogen Energy 2013;38: 8605-8616

[3] Varagunapandiyan N and Basu S. Ruthenium Oxide-Tantalum Oxide Anode Electrocatalyst for High Temperature Proton Exchange Membrane Water Electrolyser. Int J Hydrogen energy (submitted)

Acknowledgment

- CSIR
- ISRO
- All fuel cell lab members