Fabrication and Characterisation of Hydrogen Fuel Cell Membrane Electrode Assemblies

M. K. Mathe*, S. Hietkamp, M. Rohwer, R.M. Modibedi, C. Masuku, T. Masombuka and M. Mohlala

Council for Scientific and Industrial Research, CSIR Materials Science and Manufacturing, PO Box 395, Pretoria 0001, South Africa, www.csir.co.za

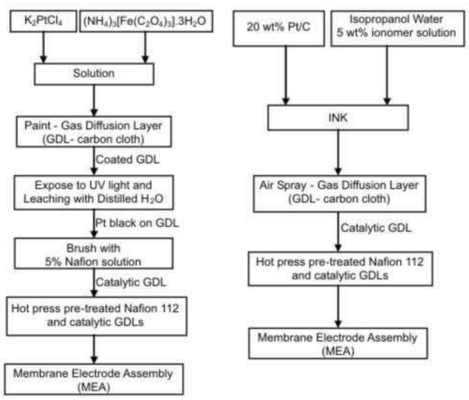
*kmathe@csir.co.za

INTRODUCTION

Fabrication of Membrane Electrode Assemblies (MEAs) is a key research area that will help in the eventual commercialisation of the Proton Exchange Membrane Fuel Cell (PEMFC). The main objective is to develop a working fuel cell system with a minimum amount of catalyst loading; whilst maintaining performance and subsequently reduce the cost of fuel cells in general. The effect of ionomer content on PEMFC performance was also investigated.

EXPERIMENTAL WORK

MEA Fabrication



K_2PtCl_4
$(NH_4)_3[Fe(C_2O_4)_3].3H_2O$
Solution
Paint - Gas Diffusion Layer (GDL- carbon cloth)
Coated GDL
Expose to UV light and Leaching with Distilled H_2O
Pt black on GDL
Brush with 5% Nafion solution
Catalytic GDL
Hot press pre-treated Nafion 112 and catalytic GDLs
Membrane Electrode Assembly (MEA)
20 wt% Pt/C
Isopropanol Water 5 wt% ionomer solution
INK
Air Spray - Gas Diffusion Layer (GDL- carbon cloth)
Catalytic GDL
Hot press pre-treated Nafion 112 and catalytic GDLs
Membrane Electrode Assembly (MEA)
Paint Method
Air Spray Method

Hot pressing conditions: 110°C, 1.8tons for 3min

Figure 1:MEA fabrication

Figure 2:Testing station

RESULTS

Structural Characterisation

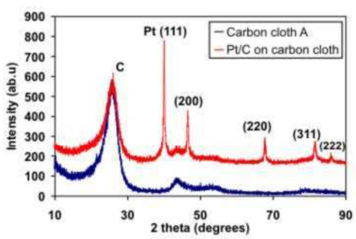
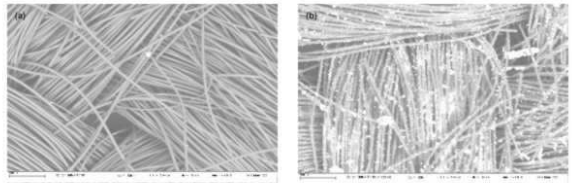


Figure 3: XRD spectra, Cu-Kα source



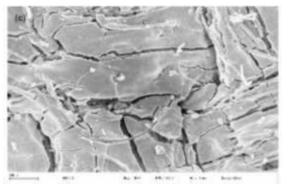


Figure 4: SEM micrographs (a) carbon cloth, (b) Pt on carbon cloth – paint method, (c) Pt/C on carbon cloth- air-spray method

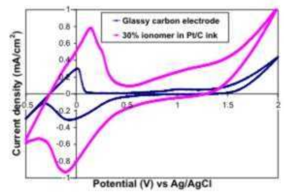


Figure 5: Cyclic Voltamogrames of Pt/C ink on glassy carbon electrode, 0.5M H_2SO_4 at ambient conditions and sweep rate 50mV/s

Performance

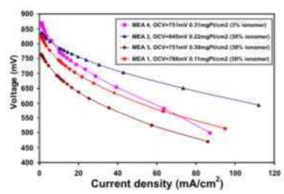


Figure 6: Polarization curves electrode area, 7.5cm², H_2/O_2, 20°C

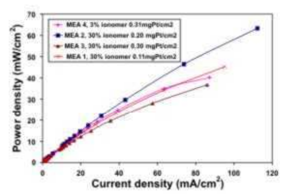


Figure 7: Power density curves electrode area, 7.5cm², H_2/O_2, 20°C

MEA	Pt loading mg/cm²	Ionomer content %	Ionomer loading mg/cm²	OCV mV	V mV	J_{max} mA/cm²	P_{max} mW/cm²
MEA 1	0.1	30	0.22	828	476	94.93	45.19
MEA 2	0.2	30	0.43	845	564	112.27	63.32
MEA 3	0.3	30	0.61	751	428	86.00	36.81
MEA 4	0.3	3	0.03	751	460	87.20	40.11

Table 1: Summary of results

- For MEAs 3 and 4 both with approximately similar Pt loadings of 0.3 mg/cm² but different ionomer contents of 30% and 3%, results indicated that the overall performance of MEA 4 was higher compared to MEA 3.
- Highest power density of 63 mW/cm² was observed in MEA 2 with a Pt loading of 0.2 mg /cm². Compared with other MEAs of similar ionomer content of 30%, it is obvious that MEA 2 Pt loading could be taken as optimal for these MEA fabrication architecture.

CONCLUSION

- Pt supported on carbon gave higher performance than Pt black on carbon cloth. Pt deposition using the paint method showed a poor morphology for electrolyte diffusion.
- XRD results showed presence of Pt metal without any evidence of Pt oxide.
- Preliminary CV studies carried out on Pt/C ink in 0.5M H_2SO_4 on a glassy carbon electrode showed atypical anodic and cathodic peaks. Reasons for this anomaly will be subject for future work which will include detailed electrochemical studies on the relation between performance, ionomer and Pt loading.

REFERENCES

[1] A.Lindermeir, G.Rosenthal, U.Kunz,U.Hoffmann, J. Power Sources 129 (2004) 180-187
[2] P. Hurley, "Build your own fuel cell", Wheelock Mountain Publications, 2002
[3] X-ray Spacing, Dale Minerals International, [ONLINE], Available: http://www.webmineral.com/X-Ray/shtml5)
[4] M. Parasanna, E. A. Cho, H.-J. Kim, T.-H. Lim, et al, J. Power Sources (2006) (IN PRESS)

our future through science