Performance Comparison Between Graphite and Metallic Bipolar Plates in Direct Methanol Fuel Cell (DMFC)

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Abstract

The use of Direct Methanol Fuel Cell (DMFC) is an electrochemical process without combustion as an alternative source of energy. A DMFC can produce energy constantly, unlike a Lithium battery which stores energy and after all energy is used up, a battery must be recharged for a long period of time. Since methanol is available in a liquid form, it requires minimum storage volume and is easy to transport. DMFCs have been used in different hand held applications such as cell phones and laptop computers. There are many parameters that have an effect on the performance of the DMFC such as the methanol concentrations, fluid and air flow rate, temperature, and the humidity level inside the air side of the cell. In this experiment a performance comparison between graphite and metal treated plates was studied with different methanol concentrations with and without humidification. Membrane Electrode Assembly (MEA) for DMFC with an active area of 2.54cm x 2.54cm, Pt/Ru catalyst in the anode side and Pt. catalyst in the cathode side, were used in two single fuel cells, one with graphite plates and the other with treated metal plates. The liquid methanol was fed to the cell at a rate of 6 ml/min. Methanol concentrations of 3%, 5%, 7%, and 10v% diluted in distilled water were used in both cells, under room temperature, 15psi air pressure, and an air flow rate of 1.0 SCFH. 3% and 5% methanol concentrations showed an optimum performance in graphite and metallic plates respectively. The 3% methanol concentration yielded 29% higher performance in the metallic bipolar plates and the 5% methanol showed 45 % higher performance in the metallic plates relative to graphite. Graphite Plates with 3% and 5% methanol concentrations with 30% humidity at the air side resulted in 16% and 21% improvement in performance respectively. While metallic plates with 3% and 5% methanol concentrations, after similar humidification was applied, showed 2%, and 9% improvement in performance respectively. Accordingly, it was concluded that the metallic bipolar plates showed higher performance than the graphite plates, and controlled humidification in the vicinity of 30% to 50% has positive influence on the performance of the cell. Humidification had more effect on the graphite plates than the metallic plates and was attributed to the surface energy of both materials. Future work will focus on optimization of the performance of the single cell and to build a stack of DMFC to power a mobile phone.

What is DMFC

- Direct Methanol Fuel Cell (DMFC) is a device that converts a chemical energy to electrical energy with no combustion; therefore, it reduces pollution in our environment.
- The liquid methanol is fed directly to the cell, it is oxidized at the anode without reforming.
- The only by products are water and some carbon dioxide CO2.
- And as long as there is fuel and air there will be power generated.

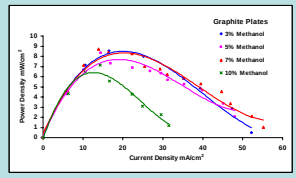
System Parameters

Cell Temperature = 22°C
Methanol Flow Rate = 6ml/min.
Air Flow Rate = 1.0 SCFH
Air Pressure = 15psi

Performance of Graphite Plates with Different Methanol Concentrations

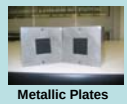

Graphite Plates

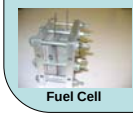

Fuel Cell

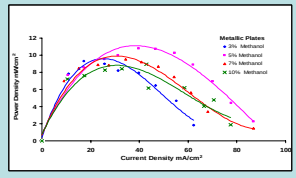


3% Methanol Concentration Exhibited the Highest Performance

Performance of Metallic Plates with Different Methanol Concentrations


Metallic Plates


Fuel Cell



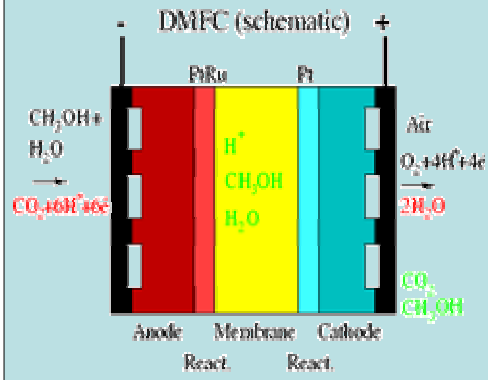
5% Methanol Concentration Exhibited the Highest Performance

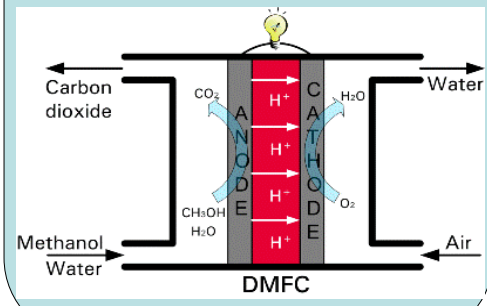
How Does DMFC Work?

Anode
Reaction: $CH_3OH + H_2O \Rightarrow CO_2 + 6H^+ + 6e^-$

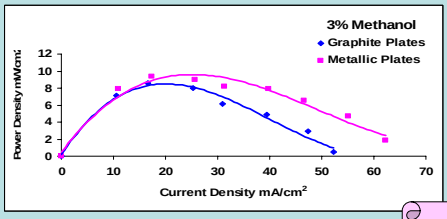
Cathode
Reaction: $3/2\ O_2 + 6\ H^+ + 6e^- \Rightarrow 3\ H_2O$

Overall Cell
Reaction: $CH_3OH + 3/2\ O_2 \Rightarrow CO_2 + 2\ H_2O$

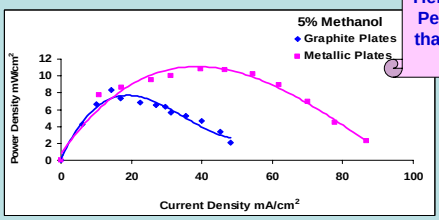




Power Density Performance Using 3% & 5% Methanol Concentrations



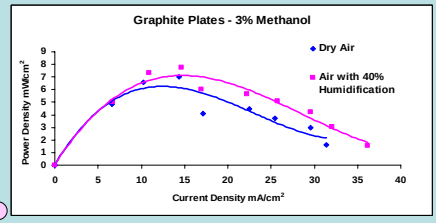
Power Density Showed 29% Higher Performance Using Metallic Plates



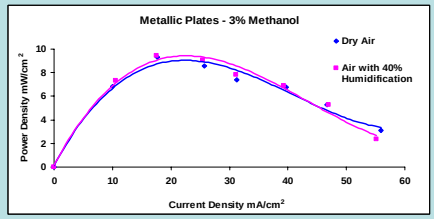
Power Density Shoed 45% Higher Performance Using Metallic Plates

Metallic Plates Yielded Higher Performance than Graphite Plates

Power Density Performance with & without Humidification

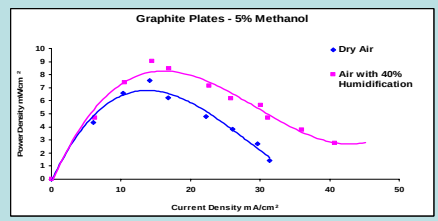


Power Density Showed 16% Higher Performance with Humidification Using Graphite Plates

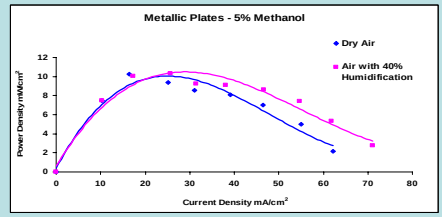


Power Density Showed 2% Higher Performance with Humidification Using Metallic Plates

Power Density Performance with & without Humidification



Power Density Showed 21% Higher Performance with Humidification Using the Graphite Plates



Power Density Showed 3% Higher Performance with Humidification Using Metallic Plates

Conclusions

- 3 & 5% Methanol concentrations showed an optimum performance using graphite and metallic plates respectively.
- Metallic plates showed 29% higher performance than graphite plates with 3% methanol concentration.
- Metallic plates showed 45% higher performance than graphite plates with 5% methanol concentration.
- Humidification using graphite plates with 3 & 5% methanol concentrations yielded 16% & 21% improvement in performance respectively.
- Humidification using metallic plates with 3 & 5% methanol concentrations, showed 2% & 9% improvement in performance respectively.
- Humidification showed more influence on the performance of the graphite plates than the metallic plates.

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