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

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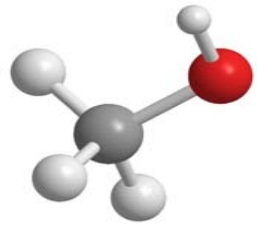
Abstract

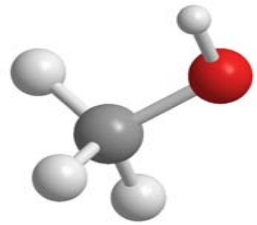
The use of Direct Methanol Fuel Cell (DMFC) is an electrochemical process without combustion as an alternative source of energy. A DMFC can produce energy constantly, unlike a Lithium battery which stores energy and after all energy is used up, a battery must be recharged for a long period of time. Since 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 40% 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.

Objectives



- To study the effect of methanol concentrations on the performance of DMFC.
- To compare the performance of graphite and metallic bipolar plates in a Direct Methanol Fuel Cell (DMFC).
- To investigate the effect of humidification on the performance of DMFC.

What is the DMFC?



- **Direct Methanol Fuel Cell (DMFC) is similar to the Proton Exchange Membrane Fuel Cell (PEMFC) in that it uses a polymer membrane as an electrolyte.**

- **DMFC is a device that converts a chemical energy to electrical energy with no combustion.**

- **The liquid methanol is fed directly to the cell; it is oxidized at the anode without reforming which make the DMFC an excellent candidate for very small & mid-size applications such as mobile phone.**

- **And as long as fuel and air supplied to the DMFC, it will continue to produce power, it does not need to be recharged.**

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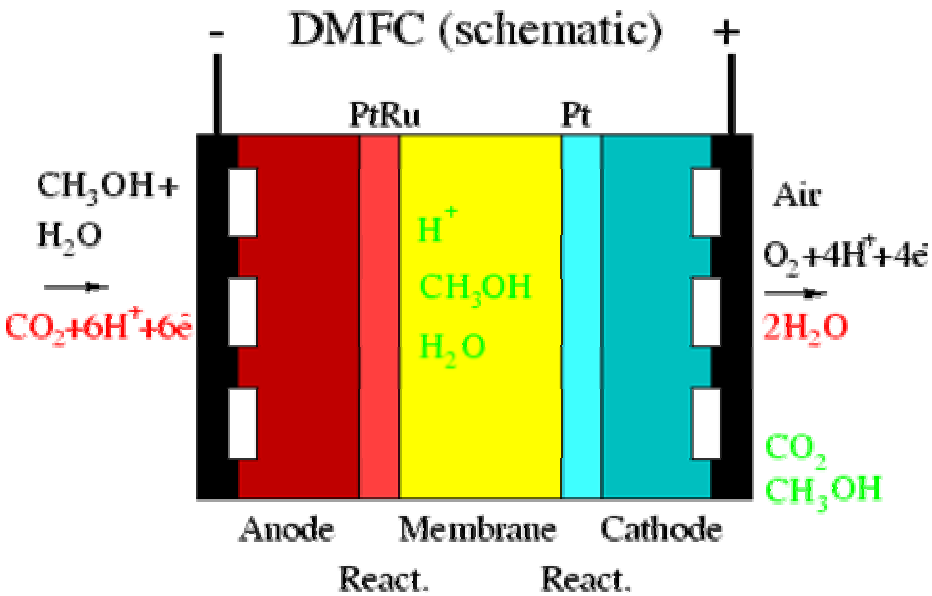
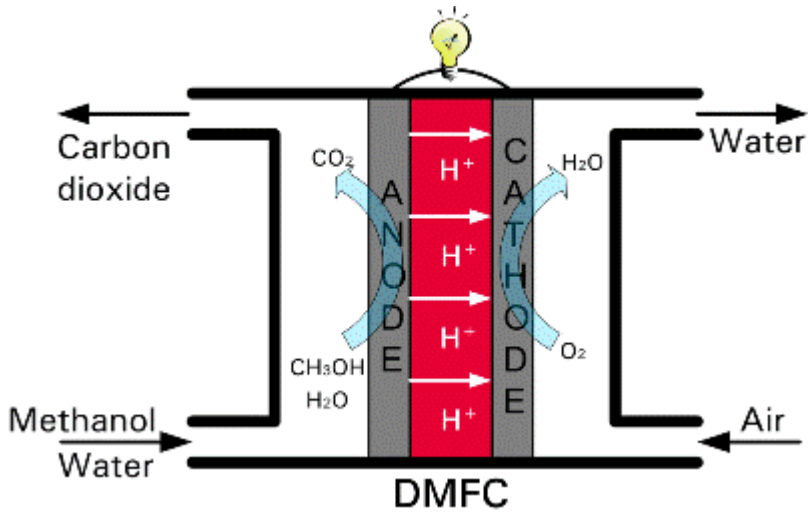
How Does DMFC Work?

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

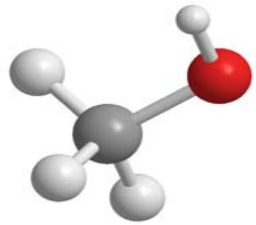
Cathode Reaction: $3/2\ O_2 + 6\ H^+ + 6e^- \Rightarrow 3\ H_2O$

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





What are the..



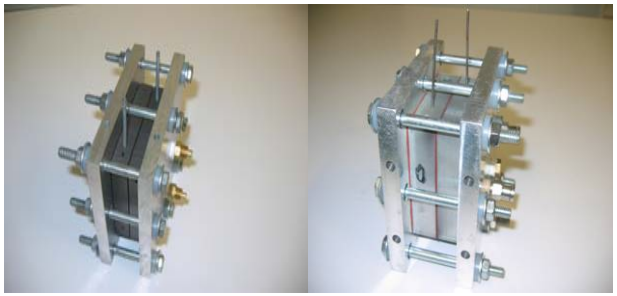
Advantages of Methanol?

- Since it is supplied in a liquid form, it is easy to store and transport.
- It is safer to handle than hydrogen.
- It can be made from renewable resources like biomass.
- It is relatively cheap.

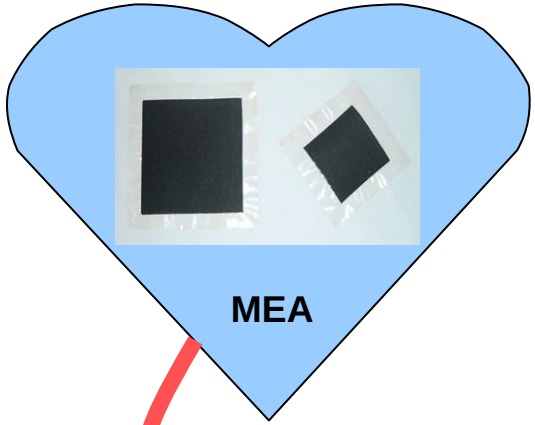
Disadvantages of Methanol Used in the DMFC?

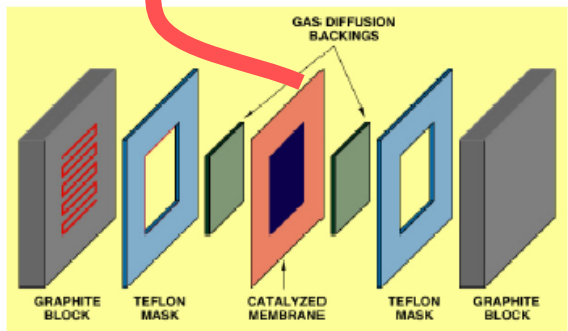
- **CO_2 is produced during power generation.**
- **Slow reaction.**
- **Lower performance than hydrogen fuel cell (PEMFC).**

DMFC Setup

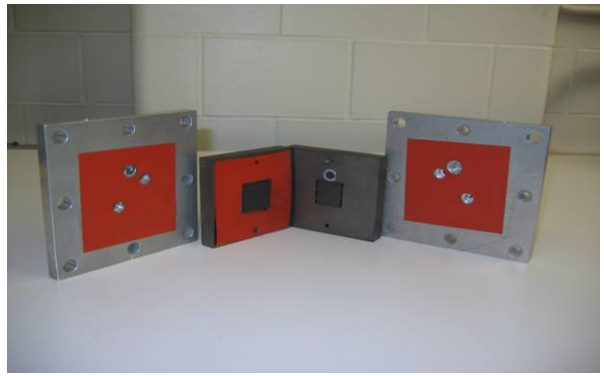


Graphite & Metallic Bipolar Plates Fuel Cells





Single Cell Structure



Components of DMFC

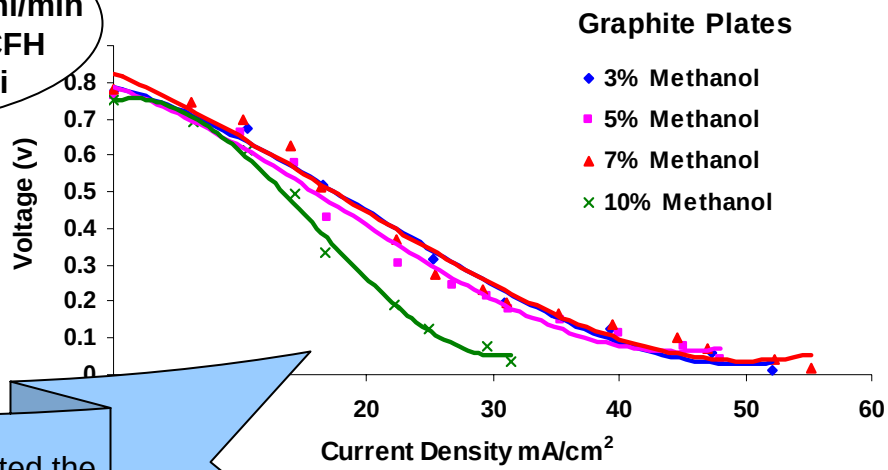
Making the Different Methanol Concentrations

Complete Assembly of DMFC

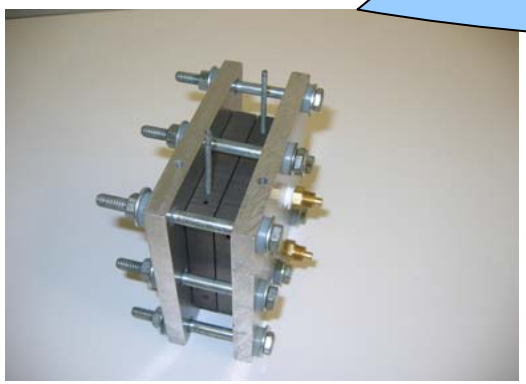
The Effect of Different Methanol Concentrations on the Performance of DMFC Using Graphite Plates

Cell Temp. 22ºC
Methanol Flow Rate = 6ml/min
Air Flow Rate = 1.0 SCFH
Air Pressure = 15psi

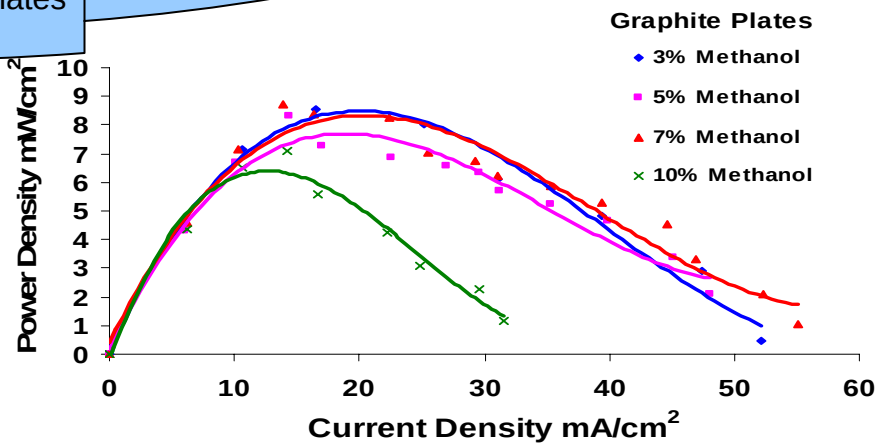
Graphite Bipolar Plates



3% Methanol Exhibited the Highest Performance Using the Graphite Plates



DMFC with Graphite Bipolar Plates



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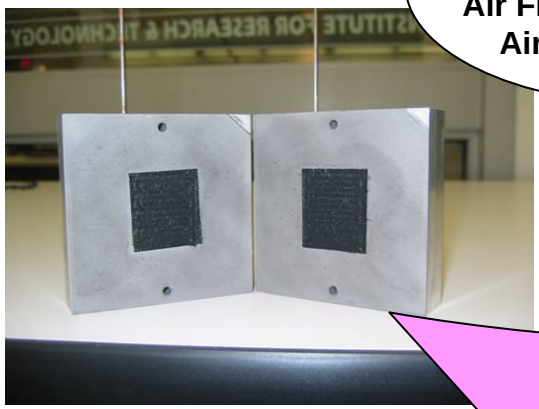
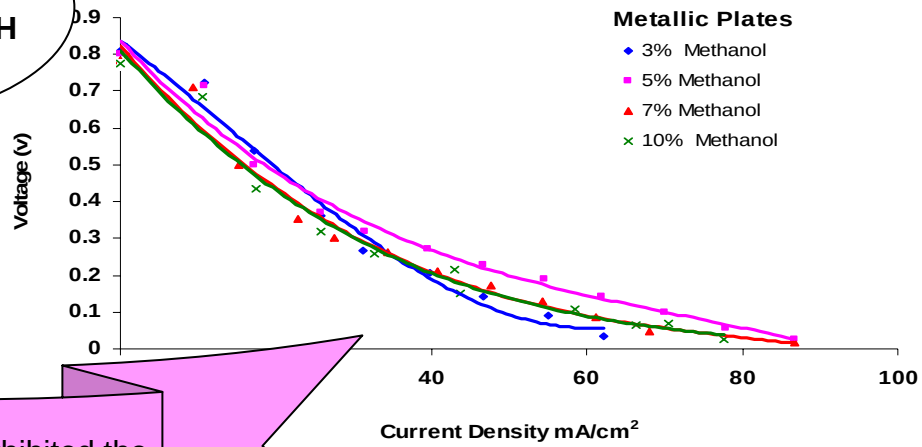
The Effect of Different Methanol Concentrations on the Performance of DMFC Using Metallic Plates

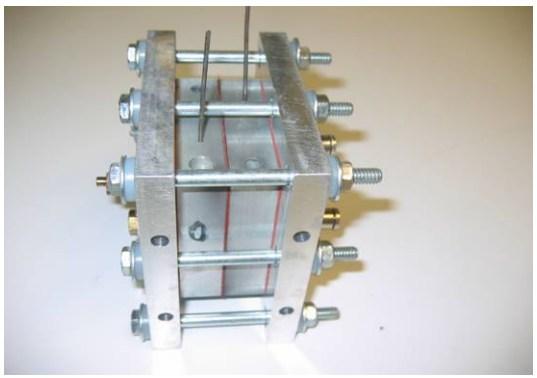
Cell Temp. 22ºC
Methanol Flow Rate = 6ml/min
Air Flow Rate = 1.0 SCFH
Air Pressure = 15psi



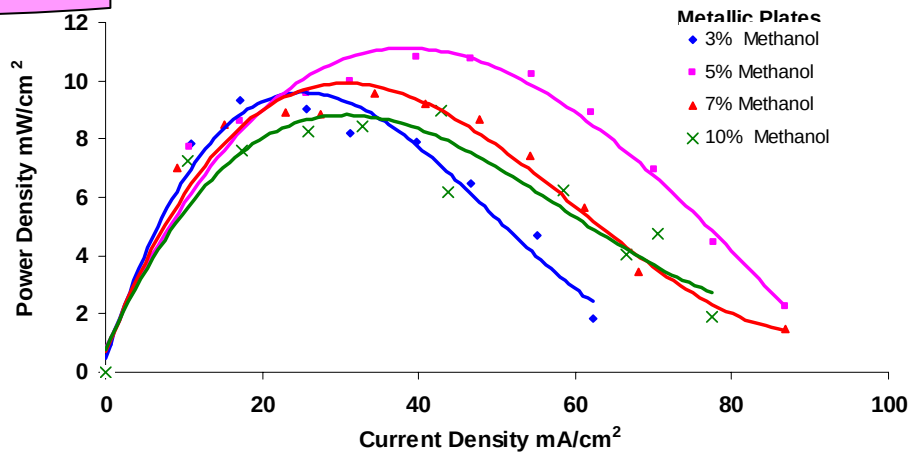
Metallic Bipolar Plates



5% Methanol Exhibited the Highest Performance Using the Metallic Plates



DMFC with Metallic Bipolar Plates



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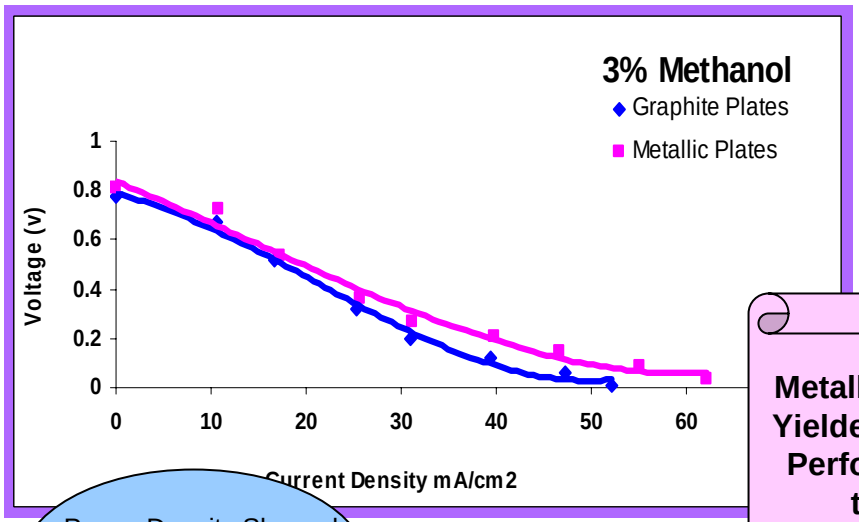
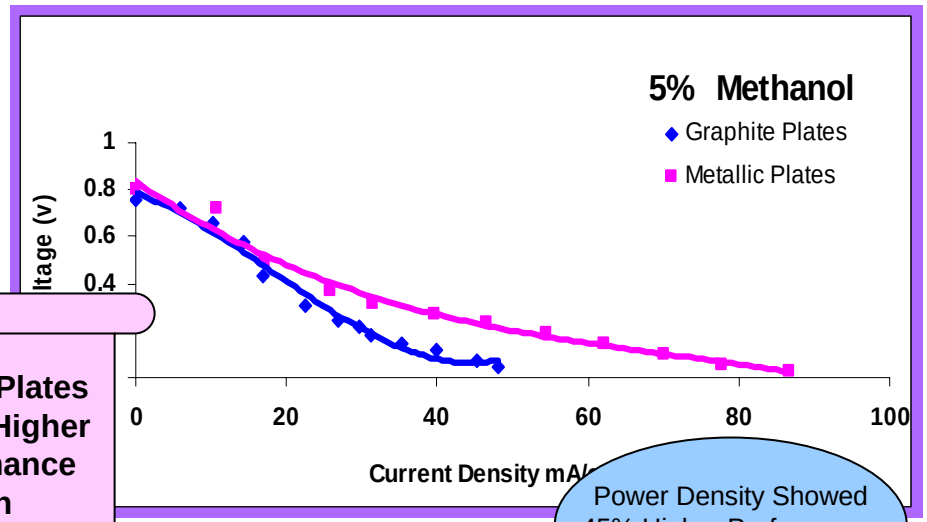
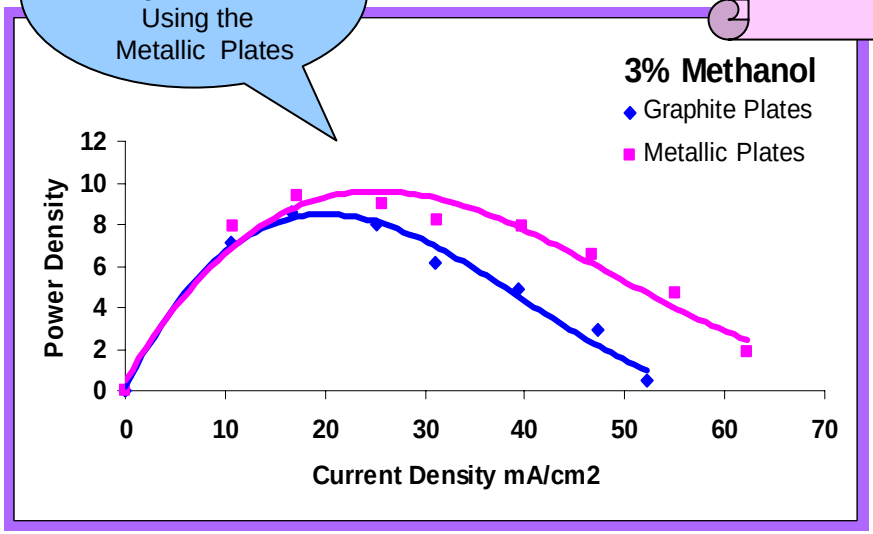
Comparison Between Graphite and Metallic Plates At 3% & 5% Methanol Concentration



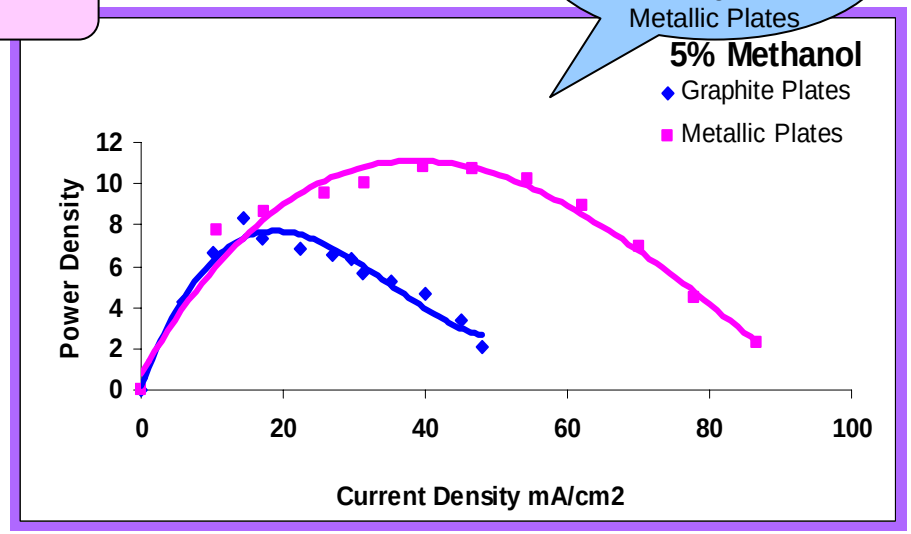


Metallic Plates Yielded Higher Performance than Graphite Plates

Power Density Showed 29% Higher Performance Using the Metallic Plates



Power Density Showed 45% Higher Performance Using the Metallic Plates



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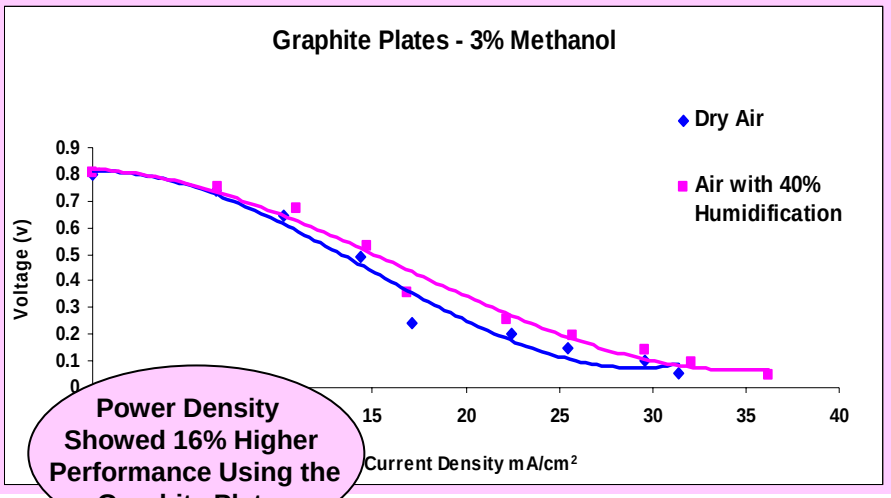
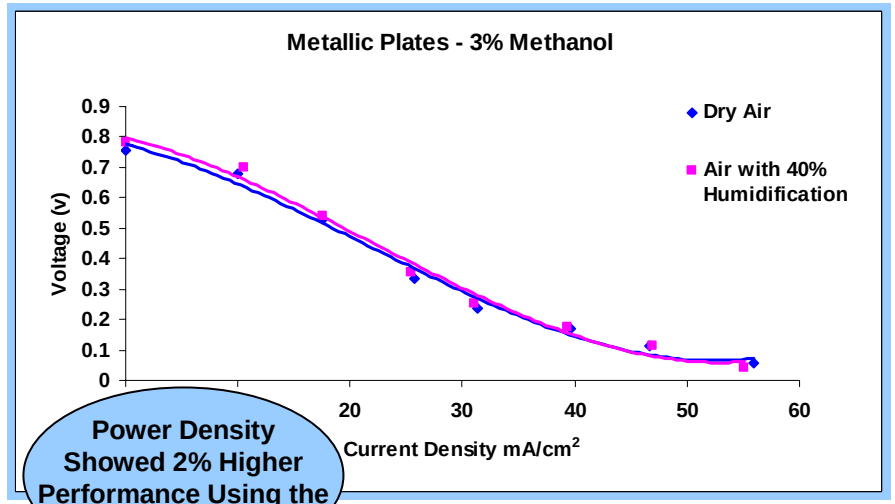
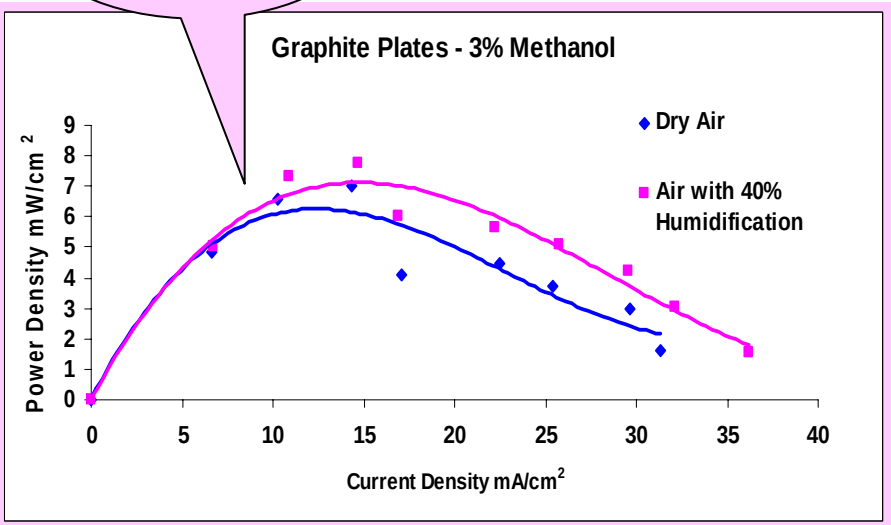
Comparison Between Graphite and Metallic Plates with 3% Methanol Concentration Before and After Humidification

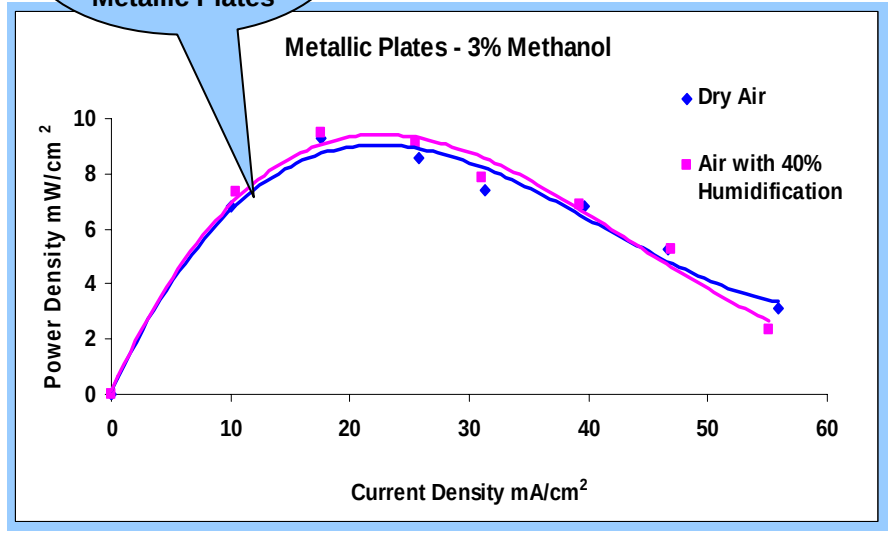


Power Density Showed 16% Higher Performance Using the Graphite Plates



Power Density Showed 2% Higher Performance Using the Metallic Plates





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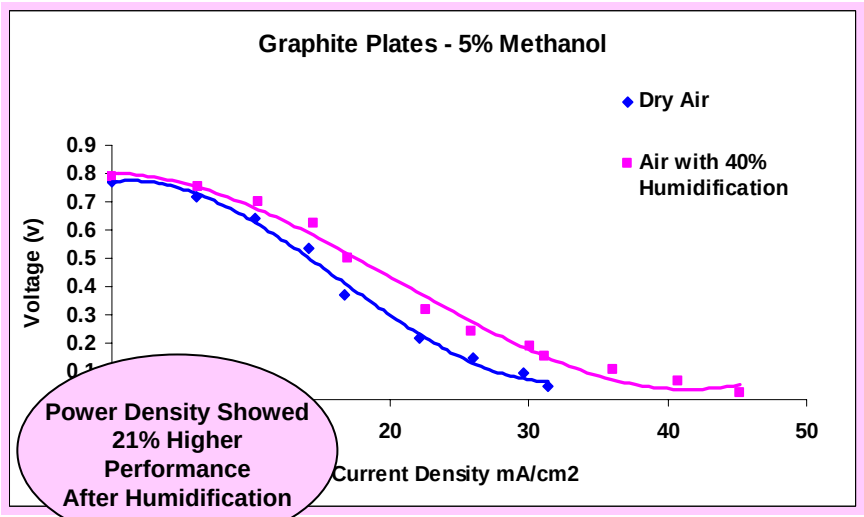
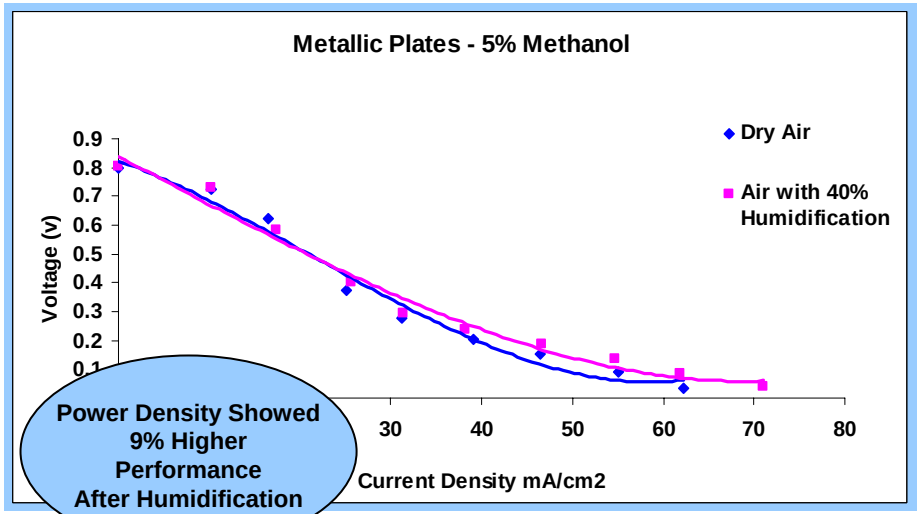
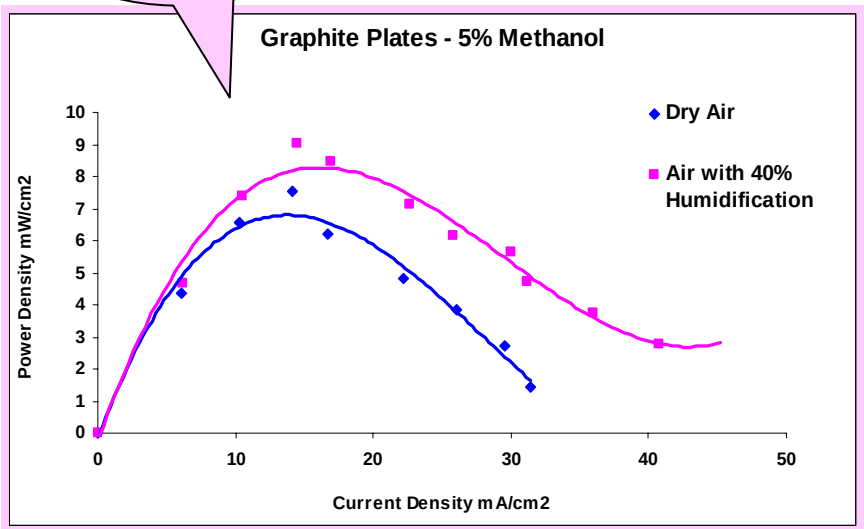
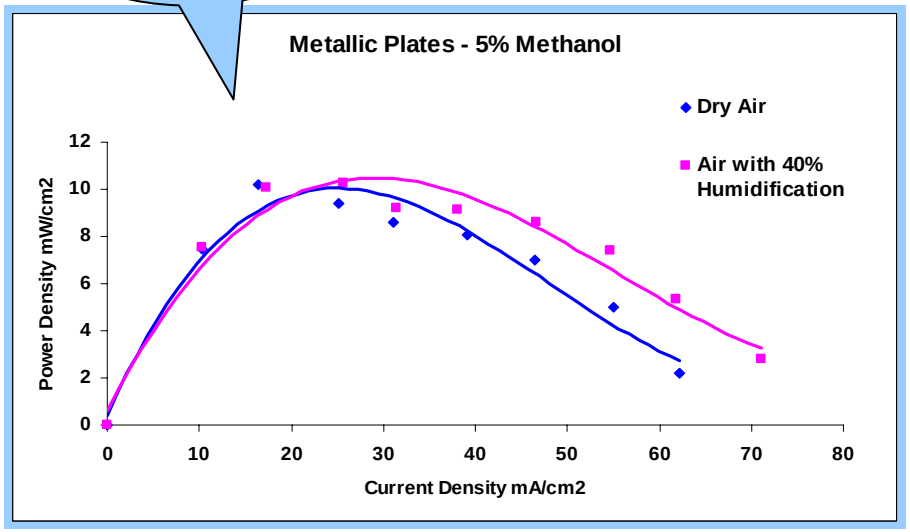
Comparison Between Graphite and Metallic Plates with 5% Methanol Concentration Before and After Humidification









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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.

Future Work

- To optimize the performance of the single cell.
- To build a stack of Direct Methanol Fuel Cell to achieve the performance required to power a mobile phone.

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