

Conductive Thermoplastic Composites for Bipolar Plates in Polymer Electrolyte Membrane Fuel Cells (PEMFC)

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Introduction

Polymer Electrolyte Membrane Fuel Cells (PEMFC) are a very promising power generation option for the future of both stationary and transportation applications. Bipolar plates are a key component of PEM fuel cells. Thermoplastic bipolar plates have a high potential as a desirable alternative to current graphic plates for fuel cell manufacturing cost, weight, and durability.

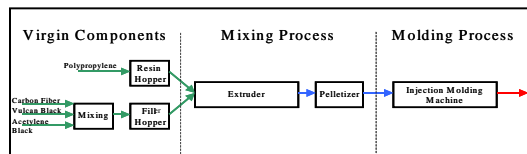
The Function of Bipolar Plates are:

- Conduct electrons
- Distribute flow of reactants
- Provide separation and containment of the anode and cathode gases
- Remove water and un-reacted gases
- Provide structural integrity
- Help regulate fuel cell temperature

Objective

To develop **highly conductive, lightweight, and low cost** materials for Polymer Electrolyte Membrane Fuel Cells

Experimental and Results



Polymer Matrix:

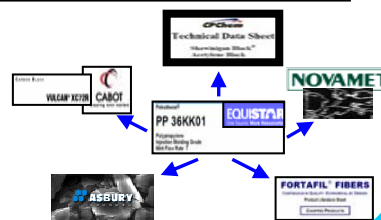
- Polypropylene

Conductive Fillers:

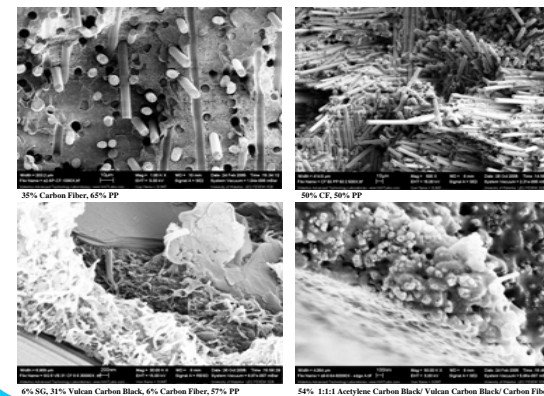
- Carbon Black
- Carbon Fiber
- Synthetic Graphite
- Ni-coated Graphite

Processing:

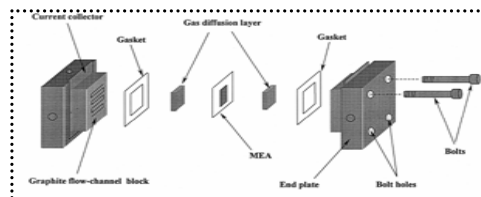
- Compression molding
- Injection molding



Scanning Electron Microscopy (SEM)



Background



Key Components of a PEM Fuel Cell:

- Membrane Electrolyte Assembly
- Gas Diffusion Layers
- Gaskets
- Bipolar Plates
- Current Collectors
- End Plates



Challenges for PEM Fuel Cells Commercialization:

- Hydrogen Storage and Distribution
- High Cost of Fuel Cells: Bipolar plates cost is 15-30%
- Durability
- Weight: >200 plates per fuel cell which account for ~80% total weight

For an Ideal Bipolar Plate:

- Conductivity > 10000 S/m
- Cost < \$10/kW (\$2-3/plate)
- Density < 5 g/cm³

Percolation Theory

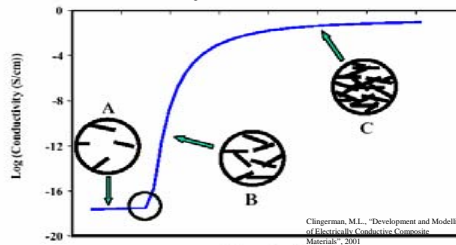


Figure 1: Percolation Theory for Conductive Composites

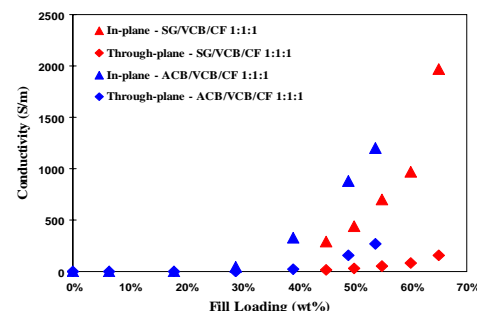


Figure 2. Conductivity of SG/VCB/CF 1:1:1 and ACB/VCB/CF 1:1:1 Composites Tested by Different Measurement Methods

Conclusion

- Filler types and properties have a great effect on composite properties
- Multiple fillers in composite showed significant synergetic effects compared to single filler composites
- 1:1:1 filler ratio in composites showed an optimal synergetic effect
- 220 S/m through-plane conductivity achieved when total 1:1:1 filler content reached 54 wt%
 - Carbon black, Acetylene CB and Carbon Fiber
- 1960 S/m In-plane conductivity achieved when total 1:1:1 filler content reached 65 wt%
 - Carbon Black, Synthetic Graphite and Carbon Fiber

Future Work

- Different Virgin Resins (PP, PE, Nylon....)
- GDL - Bipolar Plate Combination
- Metal Mesh Inserts Techniques
- Percolation and Synergetic Modeling
- Operational In-situ Fuel Cell Testing



GDL-Bipolar Plate Combination



Metal Mesh Inserts Techniques

Acknowledgements



Polymer Technologies



MMO & OCE