119d Graphite-Filled Liquid Crystal Polymer Composites for Fuel Cell Bipolar Plates

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One emerging market for thermally and electrically conductive polymer resins is for bipolar plates for use in fuel cells. The market for fuel cells is expected to reach nearly $3 billion by 2005, with a dramatic increase projected by 2010. Bipolar plates require high thermal and electrical conductivity, low hydrogen permeability, and good dimensional stability.

Fundamental and applied research is needed for the development of cost effective fuel cells for stationary and transportation applications. The proton exchange membrane fuel cell (PEMFC) is one of the most promising alternative fuel technologies to power cars and buses. Hydrogen is the fuel which reacts with oxygen (from the air) to produce DC electricity to power motors and auxiliary equipment for the vehicle. The byproducts of the reaction are heat and water.

Bipolar plate technology plays a key role in fuel cell technology. The bipolar plate separates one cell from the next, with this plate carrying hydrogen gas on one side and air (oxygen) on the other side. The bipolar plate must be made of gas impermeable material. Otherwise, if the hydrogen and oxygen gases mix, electrons pass directly from the hydrogen to the oxygen and these electrons are ‘wasted' since they cannot be sent to an external circuit to do useful electrical work. In addition, the bipolar plate must be electrically conductive to minimize ohmic losses and thermally conductive to conduct the generated heat (reaction byproduct) away. Ideally, the bipolar plates should be as thin as possible to minimize electrical resistance and to make the fuel cell stack as small as possible.

In this study, two different synthetic graphite particles and one natural flake graphite were added to Vectra A950 RX (liquid crystal polymer) and the resulting composites were tested for thermal conductivity. Currently, graphite/liquid crystal polymer composites are being considered for bipolar plates in fuel cells. The first goal of this work was to compare the through-plane thermal conductivity using the guarded heat flow method and the transient plane source method. The results showed that both test methods give similar through-plane thermal conductivity results for composites containing 40, 60, and 70 wt% graphite. The advantages of using the transient plane source method are that the in-plane thermal conductivity is also measured and the experimental time is shorter than the guarded heat flow method. The second goal of this work was to develop and utilize a detailed finite element analysis to model heat transfer within the graphite filled liquid crystal polymer composite sample for the transient plane source method and compare these results to actual experimental results. The results show that the finite element model compares well to the actual experimental data. The finite element model can be used in the future as a design tool to predict the dynamic thermal response of different composite materials for many applications.