Impact of Structural Plastics as Balance of Plant Components on Polymer Electrolyte Membrane Fuel Cell Performance

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Structural plastics are a primary class of material used for integrating the balance of plant (BoP) components into a fuel cell system that is both compact and robust for automotive applications. It has been approximated that the cost of the BoP is roughly 50% of the total cost to a fuel cell system[1]. Therefore, it is critical to select grades of structural plastics that meet the mechanical properties and cost targets for automotive system and do not negatively impact the performance or durability of the fuel cell stacks.

The integration of BoP components to feed the reactant and coolant streams to the stacks creates a significant amount of wetted surface. Hence, GM has developed a series of screening protocols to assess the compatibility of prospective BoP materials in a fuel cell system[2-4]. The objective of these series of experiments is to understand if a perspective BoP material adversely affects the fuel cell electrode or the membrane and whether these effects are recoverable under normal automotive operating conditions. These experiments include soaking BoP materials at temperature in de-ionized (DI) water to extract a 'soup' of potential contaminants from the material. This 'soup-like' extract solution is then used to screen the material. Membrane and electrodes are screened for adverse interactions with membrane conductivity and cyclic voltammetry (CV), respectively. Next the extract solution is infused into an operating fuel cell to measure the impact on performance. Additionally, the extract solution is characterized analytically to understand the component species. Ultimately, the screening procedure was successful in providing a rapid screening tool to determine if these materials can adversely affect the performance of a fuel cell[3-7].

While these protocols are effective to screen out bad grades of material, increased effort is needed to quantify the impact of relatively good grades of plastics on the fuel cell performance. Figure 1 shows impact of contamination by infusing an extract solution from a structural plastic of polyamide 610 (Nylon 610) at a fixed current density of 0.2 A/cm^2. In Zone (I), DI water was infused into a 50 cm^2 fuel cell system via a nebulizer. The infusion rate is equivalent to the amount of water vapor feed rate with 65% RH, 0.2 A/cm^2 at stoichiometry of 2. This assures the cell voltage is stable under DI water infusion. In Zone (II), the extract solution was infused into a fuel cell system at the same feed rate. It is observed that the cell voltage decays as the extract solution starts to infuse into a fuel cell system. Zone (III) is the same as Zone (I) but attempted for cell voltage recovery. It appears that the cell voltage has partially recovered after 7 hours of continuous DI water infusion. The approximate one hour delay in voltage change at the beginning of Zones (II) and (III) is due to the residue remaining inside of the fuel cell system.

In this work, we will focus on understanding the sensitivity of the observed voltage loss to operating conditions and elucidate the source of the voltage loss observed. Detailed parametric studies of platinum (Pt) loadings on cathode electrode and various operating conditions including RH, current density (CD), temperature, and extract solution concentration on PEMFC performance will be investigated.

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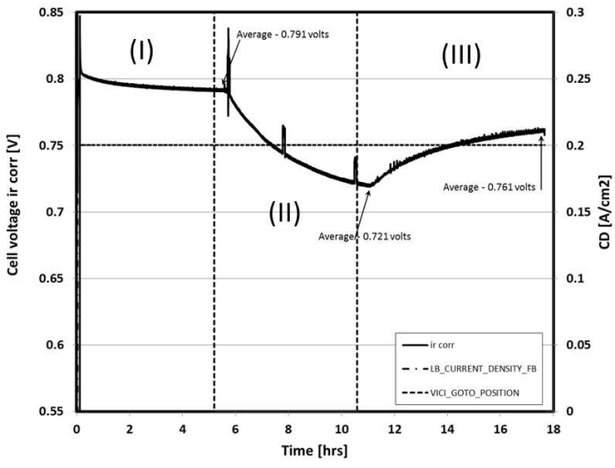

Figure 1. Extract solution infusion test profile: (I) DI water infusion; (II) extract solution infusion; (III) DI water infusion. Test conditions: cell temp.: 80 °C, An./Ca. RH: 65%/65%, An./Ca. stoi. = 2, current density = 0.2 A/cm^2, Ca. catalyst loading = 0.4 mg/cm^2 Pt/Vulcan.