

Rationalizing Catalyst Inks for Inkjet Printed PEMFC Electrodes based on Colloidal Interactions

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Polymer Electrolyte Membrane (PEM) fuel cell catalyst layer microstructure, thickness and platinum content depend upon electrode fabrication method. In this contribution, inkjet printing is investigated as an effective deposition method for PEM fuel cell electrodes. Our results show that inkjet printed electrodes can achieve thicknesses and Pt loadings as low as $1.5 \mu\text{m}$ and 0.025 mg/cm^2 respectively, present an evenly distributed micro-structure, and have a high repeatability of performance curves [1]. Pt utilization of these inkjet printed electrodes increased almost 8 times at higher current densities compared to a conventionally fabricated catalyst coated membrane (CCM) owing to a decrease in macro-scale mass and charge transport losses, as seen in Figure 1. Precise control over the deposition process enables this technique to fabricate thin electrodes and functionally graded electrodes. These advantages make this fabrication technique a viable option for large scale electrode fabrication process.

Catalyst ink dispersion and stability are a primary concern for inkjet printing technologies. Carbon particle agglomeration in the ink results in nozzle clogging during fabrication and larger Pt/carbon agglomerates in the layers, which are known to limit mass transport in the micro-scale [2]. Low stability limits the shelf-life of the ink cartridge which should be maximized to increase the applicability of this method. The type of solvent, ion concentration and pH dictate the ink stability and particle aggregate size which, in turn will dictate the applicability, jetting efficiency, and performance of the ink. In spite of being a major factor in the ink preparation process, the contribution of the solvent, ionic concentration and pH selection has seldom been studied and is still based on empirical observations [3]. Therefore, a detailed study of particle aggregation and solvent effects based on colloidal interaction models is presented in this article. We employ Derjaguin-Landau-Verwey-Overbeek (DLVO) based theoretical models of colloidal interactions to predict the stability of these particle dispersions in aqueous and non-aqueous solvents. Particle interactions studied are attractive van der Waals forces and repulsive electrostatic/Coulombic forces. A parametric study of the effect of ionic concentration, dielectric constant of solvents and zeta potential on ink stability was conducted. It was seen that solvents with a higher dielectric constant facilitated particle dispersion. Figure 2 shows a plot of interaction energy between the particles as a function of inter-particle distance for the solvents ethyl acetate, iso-propanol and deionized water. It can be seen that from the height of the energy barrier, catalyst particles are unstable in ethyl acetate and more stable in iso-propanol and deionized

water. Experimental observations agree with the theoretical predictions. The theoretical framework developed can be used to rationalize ink formulations.

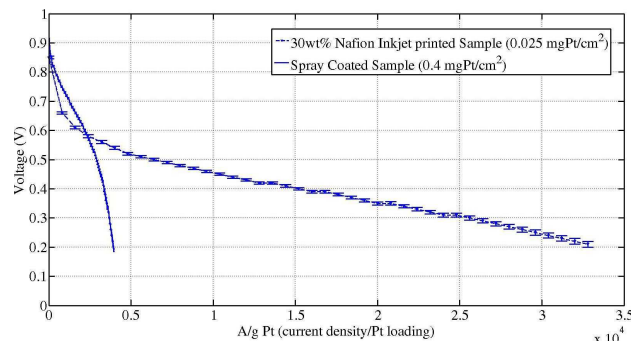


Figure 1. Pt utilization comparison of spray coated and inkjet printed CCMs (70% RH, 80 C). Error bars for the inkjet printed sample show standard deviation from 5 readings

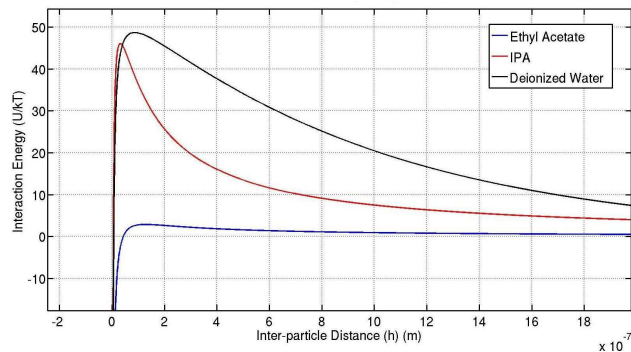


Figure 2. Effect of solvents ethyl acetate, iso-propanol (IPA) and deionized water on stability of 60 nm catalyst particles

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