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Fabrication and Scale-up of Highly Durable Heavy Duty Fuel Cell MEAs

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Abstract

Medium and heavy-duty PEM fuel cells operate under much harsher conditions than light duty fuel cells and are expected to last 30,000 hours in the field. These systems must therefore operate successfully in the presence of impurities, starting and stopping, freezing and thawing, humidity and load cycling. Therefore, materials, components, and interfaces used in such systems need to be highly resistant to severe mechanical and chemical stress.

In a PEM fuel cell, the catalyst ink formulation and mixing processes control catalyst layer coating quality, electrode morphology, and the resulting fuel cell performance and durability. Catalyst ink properties are a result of complex solvent-catalyst-ionomer interactions that depend on the mixing method employed. Here, we will compare the performance and durability of electrodes made from bath sonicated inks for ultrasonic spray coating vs. ball milled inks for Meyer rod coating. Ink rheology and catalyst particle size will be used to correlate ink properties to electrode morphology and structure and ensure consistency from batch to batch, and from small lab scale to subsequent scale-up.

Novel, highly active stable Pt and ordered PtCo intermetallic nanoparticles with well-controlled particle size and composition have been synthesized on a highly efficient PGM-free single metal active site rich carbon, to maximize their synergistic effects for enhanced performance and durability. These catalysts were integrated with a variety of ionomers (Aquivion, Nafion, and high O_2 permeability ionomer (HOPI)) to further improve fuel cell performance and achieve >600 mA/mg_{Pt} at 0.9 VIR-free with a mass activity loss less than 30% after 150k square wave accelerated durability cycles; and > 600 mA/cm^2 (~65% efficiency) at 0.8 V, with a performance loss < 40 mV after 150K cycles (0.6 to 0.95 V). So far no other group has reported comparable MEA durability.

This work provides a comprehensive understanding of interactions between Pt, PtCo, carbon, ionomer, membrane, and GDLs and their impact on electrode structure, fuel cell performance and durability, as well as considerations for scale up to a R2R fabrication process. The attained information will be used to improve fuel cell electrode design, fabrication and scale-up.

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