Novel Non-Platinum Group Metal Cathode Catalyst for Fuel Cell Electric Vehicle Application

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Due to the tremendous contribution of CO_2 emitted by fossil fuelled vehicles into the total amount of green-house gases produced, all major automobile manufactures have recently announced plans to accelerate commercialization of zero-emission fuel cell vehicles [1-3]. In a strategic cooperation with Nissan, Daimler, and Ford, an agreement has been signed to accelerate the commercialization of fuel cell electric vehicles (FCEV). Nissan, Daimler and Ford combined have more than 60 years of cumulative experience in developing FCEVs and have logged more than 10 million kilometres in different test drives [3]. For successful commercialization of FCEVs the amount of platinum in the stack should be substantially reduced or alternative, non-platinum group metal (non-PGM) catalysts should be implemented. UNM group introduced the sacrificial support method (SSM) based on templated synthesis of both PGM [4, 5] and non-PGM [6-11] catalyst for several fuel cell configurations.

Herein, we report on the design of a novel, highly active and durable Fe-N-C catalyst which can be a potential catalyst for future automotive application. This novel catalyst was synthesized from iron and charge transfer salt materials using a modified sacrificial support method.

After optimization of heat treatment conditions, a large batch (~5g) of Fe-NCB catalyst was synthesized and tested at Nissan Technical Center North America in order to validate the high performance and durability of this promising catalyst under automotive performance and durability cycling that simulate actual fuel cell stack conditions.

Figure 1 represents RRDE data for Fe-NCB catalysts.

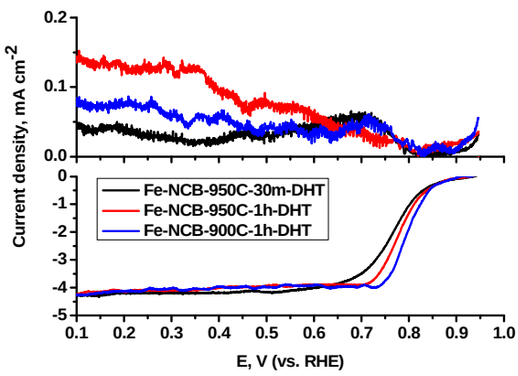

Figure 1. RRDE data for Fe-NCB catalysts. Conditions: 0.5M H_2SO_4 saturated with O_2, 1200RPM, 5 mV s^{-1}, catalyst loading 0.6mg cm^{-2}.

MEAs were fabricated and evaluated at Nissan Technical Center North America. Figure 2 shows the MEA performance of the Fe-NCB catalyst under the recommended DOE conditions: H_2/O_2 operation, 100%RH, and 1.5 bar total pressure or 0.5 bar_g backpressure. Three MEAs with the same catalyst loading of 4 mg cm^{-2} and different Nafion content were investigated. The open circuit voltage (OCV) was 0.92V and did not change with increasing Nafion content.

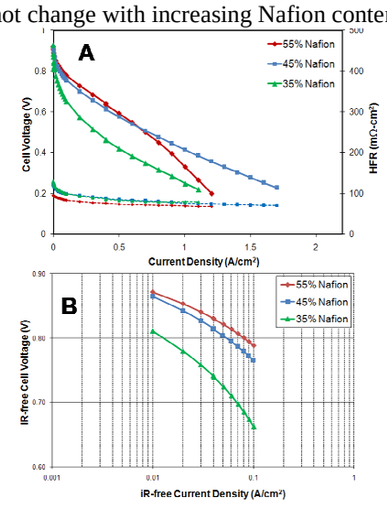

Figure 2. MEA performance (A) and kinetic current densities (B) of Fe-NCB catalyst with varying Nafion content. Conditions: Tcell=80°C, 100% RH, 0.5 bar back pressure.

In summary, it can be concluded that a highly active and durable non-PGM cathode catalyst was designed which can be a promising catalyst candidate for future automotive application. The start-stop durability needs to be improved. High kinetic current densities and overall performance was observed in both RDE and MEA tests. The Fe-NCB catalyst was found to be extremely durable under different independent test protocols which simulate actual vehicle driving conditions, including that recommended by the US Department of Energy Durability Working Group and Nissan load cycling protocol. The high performance and excellent durability is independently validated at Nissan North America's Fuel Cell and Battery Laboratory.

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