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Effect of N2-cold Plasma Treatment of Carbon Supports on the Activity of Pt3Pd3Sn2/C Towards the Dimethyl Ether Oxidation

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Abstract : Dimethyl ether (DME) possesses several advantages over other small organic molecules such as methanol, ethanol, and ammonia in terms of providing higher energy density, being less toxic, and having lower Nafion membrane crossover. However, the absence of an active and stable catalyst has been the bottleneck that hindered the commercialization of direct DME fuel cells. A Vulcan XC72 carbon-supported ternary metal catalyst, $Pt_3Pd_3Sn_2$/C is reported to have yielded the highest specific power density (90 mW mg-¹PGM) as compared to other catalysts tested fordirect DME fuel cell (DDMEFC). However, the micropores and sulfur groups present in Vulcan XC72 hinder the fuel utilization by causing Pt agglomeration and sulfur poisoning. Vulcan XC72 having a high carbon sp^3 hybridization content, is also prone to corrosion. Therefore, carbon supports such as multi-walled carbon nanotube (MWCNT), black pearl 2000 (BP2000), and their cold N2 plasma-treated counterpartswere tested to further enhance the activity of the catalyst, and the outputs with these carbons were compared with the originally used support. Detailed characterization of the pristine and carbon supports was conducted. Electrochemical measurements in three-electrode cells and laboratory prototype fuel cells were conducted.$Pt_3Pd_3Sn_2$/BP2000 exhibited excellent performance in terms of electrochemical active surface area (ECSA), peak current density (jp), and DME oxidation charge (Qoxi). The effect of the plasma activation on the activity improvement was observed only in the case of MWCNT while having little or no effect on the other carbons. A $Pt_3Pd_3Sn_2$ supported on the optimized mixture of carbons containing 75% plasma-activated MWCNT and 25% BP2000 ($Pt_3Pd_3Sn_2$/75M25B) provided the highest reported power density of 117 mW mg-1PGM using an anode loading of1.55 mgPGMcm^{-2}.

Keywords : DME, DDMEFC, ternary metal catalyst, carbon support, plasma activation
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