The impact of trace concentrations of NH_3 in hydrogen on polymer electrolyte membrane fuel cell performance under automotive load cycling

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Polymer electrolyte membrane fuel cells (PEMFCs) are very promising and highly efficient energy conversion tools for developing hydrogen transportation. The problem of fuel purity is closely related to the process and the cost for hydrogen production and to durability of fuel cell stack. Understanding and quantification of impact of impurities in real operating conditions is necessary to optimize requirements to fuel purity. Ammonia is one of common gas impurities, which can come from fuel reforming process. Its level should be <0.1 µmol/mol in hydrogen fuel according to the present standard ISO 14687-2, which is quite tough. There are limited reports in literature on the effect of ammonia as potential impurity in air and in fuel streams in FCs [1, 2]. In most of the studies high concentrations of NH_3 (>10 ppm) were investigated during constant current stationary operation mode of FC. This protocol allows clearly observe measurable effects of the fuel contaminant on FC electrochemical characteristics. However, these results may not be representative for lower NH_3 amounts in fuel and for dynamic cycling protocol, which better simulates a FC vehicle operation mode.

In the present work the impact of low concentrations (< 3 ppm) of ammonia in H_2 on a PEMFC performance was investigated under new European driving cycle (NEDC) conditions. Performance and durability of membrane electrode assemblies (MEAs) with low-loaded anodes (~0.1 mg_{Pt}/cm^2) were evaluated over ~600 h cycling tests with and without NH_3 impurity in H_2 flow. In addition, short-term tests at a constant current load were conducted to understand the impact of cycling protocol on the kinetics of FC contamination with ammonia. Significant influence of a test protocol on FC voltage was observed during operation under contaminated hydrogen. A detailed electrochemical characterization using polarisation curves, cyclic voltammetry, EIS was conducted at different steps of the tests to monitor MEA components degradation. Efficiency of various in-situ MEA cleaning techniques was probed. Finally, recommendations on the acceptable content of NH_3 in hydrogen fuel as well as on mitigation strategies of the impurity effect were given.

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[1] T. Lopes et al., J. Electrochem. Soc., 161, (2014), F703-F709.

[2] F. Uribe et al., J Electrochem. Soc., 149, (2002), A293-A296.