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PEM fuel cell performance in presence of trace concentrations of HCl and $C_4Cl_4F_6$ in hydrogen under automotive load cycling

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Polymer electrolyte fuel cell (PEM FC) is a promising energy conversion tool to be used in zero-emissions vehicles. The quality of hydrogen fuel have a direct impact on its cost and on a FC performance. The impact of halogen-containing compounds on a long-term performance of PEM FC is poorly investigated in case of hydrochloric acid [1] and there is no literature data on 1,2,3,4-tetrachloro-1,1,2,3,4,4-hexafluorobutane ($C_4Cl_4F_6$). The latter molecule was found in few hydrogen fuel samples from hydrogen refueling stations [2]. Therefore, investigation and understanding of possible impact of halogen-containing compounds on the performance of PEMFC is of high fundamental and practical interest.
In the present work the effect of 0.2 ppm of HCl and 0.2 ppm of $C_4Cl_4F_6$ in hydrogen fuel on a single cell performance was investigated. Complex test protocol included 2 constant load steps (0.6 A/cm^2) and 2 New European Driving Cycling (NEDC) steps with total duration of 1000 h. Figure 1 shows voltage degradation extracted from NEDC profiles at 0.6 A/cm^2 for the cells tested with pure and contaminated hydrogen.

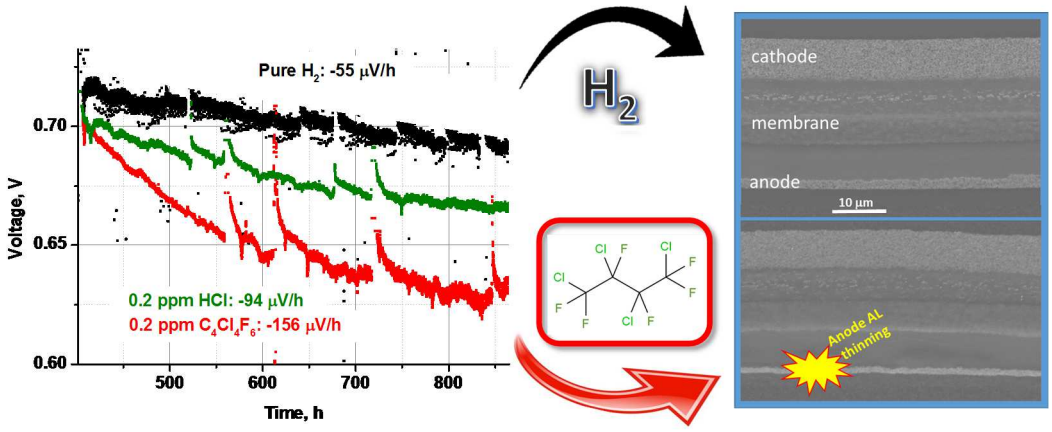

Figure 1: Voltage profiles and associated degradation rates for FC tested at 0.6 A/cm^2 in pure H_2 (black), H_2 + 0.2 ppm HCl (green) and H_2 + $C_4Cl_4F_6$ (red) on the left; SEM cross-section images for the cells after 1000 h operation in pure H_2 and H_2 + 0.2 ppm $C_4Cl_4F_6$ on the right.

Elevated reversible and irreversible voltage decay rates were observed in presence of impurities. $C_4Cl_4F_6$ provoked the most important FC performance degradation. Advanced electrochemical *in-situ* diagnostics, *ex-situ* microscopy observations together with other analytical techniques allowed to discover the causes for accelerated performance failure in presence of halogen-containing impurities in hydrogen.

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