IMPACT OF OPERATING CONDITIONS AND MEMBRANE DEGRADATION ON PERFORMANCES OF PEMFC

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From ecological and economical points of view, there is a strong urge to use sustainable energies and at the same time to decrease the pollution impact of human activities. Fuel cells by converting chemical energy (hydrogen) into clean electrical power can be part of the solution[1]. However, costs and performances of the polymer electrolyte found at the heart of the cell still have to be improved (durability[2], ability to withstand both higher operating temperatures and dryer gases…), and are the subjects of intense research.
Polyaromatic membranes, like sulfonated poly(Ether Ether Ketone) (sPEEK), used as polymer electrolyte for fuel cells offer a better thermomechanical stability than perfluorosulfonic membranes like Nafion (reference membrane) but a much lower chemical stability. Our goal was to understand the impact of fuel cell operating condition on the chemical stability of this alternative membrane and on the device performances.
In a first step focused on the impact of operating conditions on the device performances, we observed when increasing gas stoichiometries, a much important decrease of the performances for sPEEK than for Nafion, as illustrated in Figure 1. Electrochemical Impedance Spectroscopy (EIS) was used to understand the origin of the performances drop observed for sPEEK[3]. This technique highlighted a very high spatial heterogeneity of hydration and therefore of performance, due to slower water transport in the polyaromatic membrane. Chemical degradation was not responsible for the fast drop of performances observed after few hundreds of hours of operation, as we demonstrated that performance could be recovered, at least in part, after rehydration of the membranes. However a non-reversible

ageing was noticed through the slight decrease of the molecular weight observed for sPEEK 3/1.5, and the drop of the initial output voltage, not recovered after rehydration of the membrane.

In order to test the impact of chemical and structural modifications resulting from oxidative ageing (H_2O_2 can be produced during fuel cell operation) the second step of this study was focused on ex-situ ageing tests. These tests highlighted the correlation between a decrease of the sPEEK molecular weight observed during ageing and an improved swelling and conductivity of the modified membranes. In conclusion we have shown that a pre-oxidation of the membrane, using a H_2O_2 solution, improves sPEEK in-situ performances to such an extent that it could reach those of Nafion.

References

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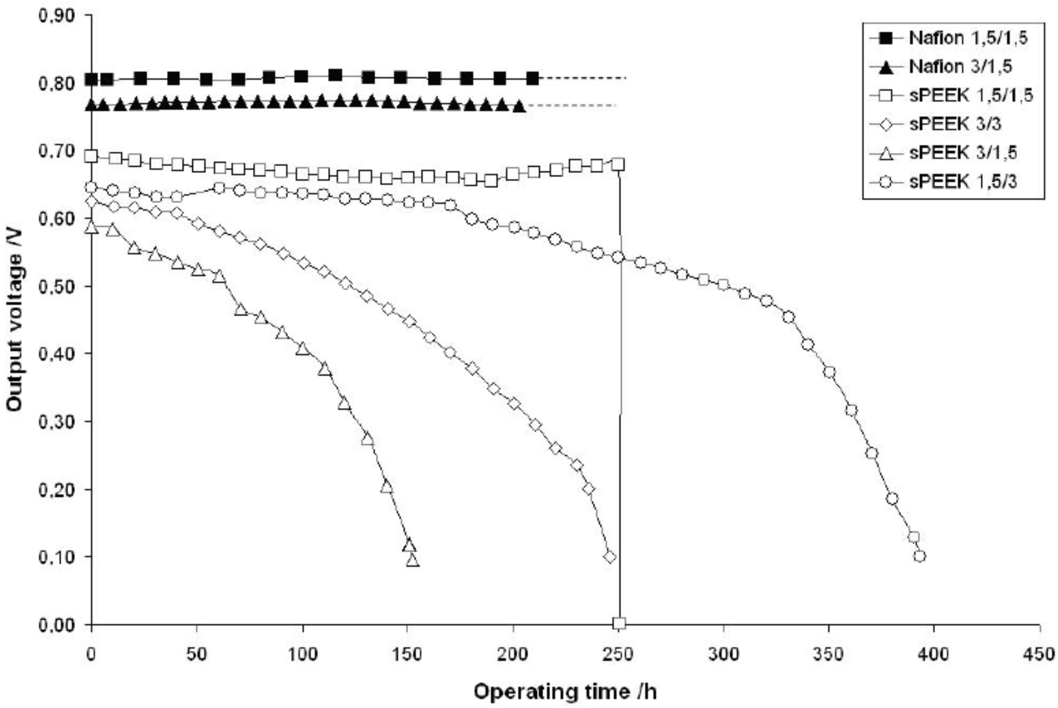

Figure 1: Evolution of output voltage as a function of operating time, for different gas stoichiometry configurations for both Nafion and sPEEK membranes.