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Impact of a chemical-mechanical *ex-situ* aging on PFSA membranes for fuel cells

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Abstract

Over the past decades, the proton-exchange membrane fuel cell (PEMFC) became one of the preferred technologies to promote hydrogen-based alternative energies. Although they are on the brink of being massively commercialized, PEMFCs still suffer from insufficient durability and reliability. In particular, the degradation of the polyelectrolyte membrane, as a consequence of the harsh mechanical and chemical stresses experienced during the operation of the fuel cell, has been identified as one of the main factors restricting the PEMFC lifetime [1,2].

An innovative chemical-mechanical *ex-situ* aging device was developed to expose the membrane at the same time to a mechanical fatigue and an oxidizing environment (*i.e.* free radicals) in order to reproduce conditions close to those encountered during the fuel cell operation. A cyclic compressive stress of 5 or 10 MPa was applied during several hours while a degrading solution – a 3 vol.% of H₂O₂ solution for mild conditions and a Fenton solution with 1 ppm of Fe²⁺ and 3 vol.% H₂O₂ for aggressive conditions – was circulated in contact with the membrane.

The results demonstrated that both composite Nafion™ XL and non-reinforced Nafion™ NR211 membranes are significantly degraded by the conjoint mechanical and chemical stress exposure (**Fig.1**). The fluoride emission rate (FER) was generally slightly lower with XL than with NR211, which could be attributed to the degradation mitigation strategies developed for composite XL. Nevertheless, an equal FER was obtained by increasing the pressure level or the aging duration, suggesting a limitation of the XL improved durability.

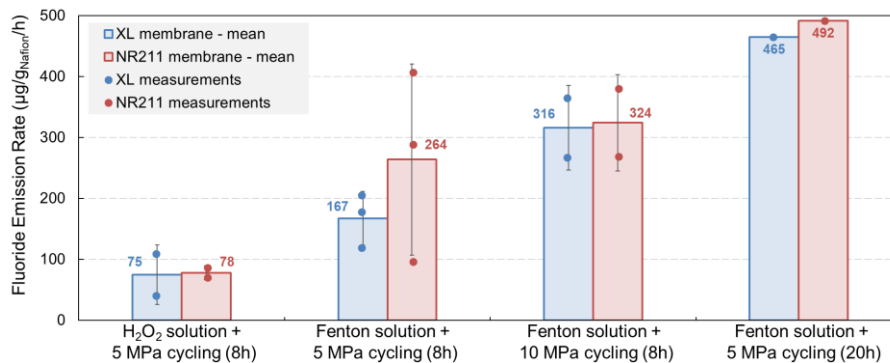


Figure 1: Evolution of the fluoride emission rate as a function of the severity of conjoint mechanical and chemical stress exerted on Nafion XL and NR211 membranes

[1] A. Kusoglu et al., *ECS Electrochem. Lett.* **3** (5), F33–F36, 2014.

[2] M. Robert et al., *Journal of Power Sources* **476**, 228662, 2020.