

Ex-situ Evaluation of Degradation-Mitigating Additives for Proton Electrolyte Membrane Fuel Cells

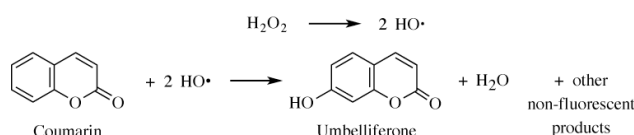
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Various types of additives like hydrogen peroxide decomposers or radical scavengers have been described in the literature to inhibit radical attack and to improve the durability and lifetime of proton exchange membranes (PEMs).¹ The effect of CeO₂ and ZrO₂ on membrane durability are widely discussed in the literature and their effectiveness in reducing chemical degradation has been shown in-situ.^{2,3}

However, understanding why and how additives work, and which effect they have on the membrane properties is not fully understood.

Ex-situ tests allow screening and ranking of a variety of additives in a short time for their degradation mitigation capability and their effect on the membrane properties. In this work, two sets of experiments are performed. In the first set, CeO₂ and ZrO₂ additive particles are dispersed in separate aqueous solutions containing H₂O₂ and coumarin as radical trap. The thermal decomposition of H₂O₂ at 80 °C leads to the formation of HO radicals and the formation of fluorescent umbelliferone (Scheme 1).



Scheme 1: Reaction of coumarin with HO radical and formation fluorescent umbelliferone.

The amount of formed umbelliferone and hence measurable fluorescent intensity is dependent on the presence and type of additive material (Figure 1).^{4,5}

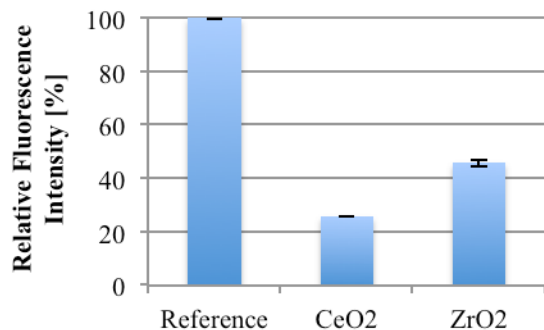


Figure 1: Fluorescence intensity at 455 nm (excitation at 366 nm, pH 9) using additive particle dispersions.

For the second set of experiments, Nafion[®] DE2020 was co-cast with up to 3 wt% of CeO₂ or ZrO₂ particles. The membranes were then degraded using H₂O₂ and Fe²⁺ catalyst (Fenton's reagent).⁶

Proton conductivity, water sorption, ion exchange capacity and chemical structure of untreated and degraded membranes were determined and the effect of particles on polymer durability was discussed.

Additive particles have also been examined for their size, distribution, and composition in order to correlate results from the fluorescence experiments to their effect of prohibiting chemical degradation in PEMs.

References:

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