Decoupling beam damage from electrochemical degradation in hydrogen fuel cells using correlative spectromicroscopy

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Polymer electrolytes such as perfluorosulfonic acid (PFSA) are key to a variety of electrochemical and clean energy applications, including batteries, fuel cells and electrolyzers. Unfortunately, these materials are exceptionally sensitive to electron and X-ray radiation, which often destroy up to 80% of the sample during data acquisition.[1] It is important to understand the chemical, physical, and spectroscopic changes that occur due to radiation damage. Soft X-ray damage to PFSA was characterized using a combination of scanning transmission -ray microscopy (STXM), X-ray absorption spectroscopy (NEXAFS), infrared spectroscopy, fluorescence imaging, and atomic force microscopy. X-ray exposure induces substantial and selective loss of fluorine, preferential cleavage of the side chains, and physical ablation of the polymer. The combination of multiple imaging and spectroscopy modalities provides detailed insight into radiation damage mechanisms.

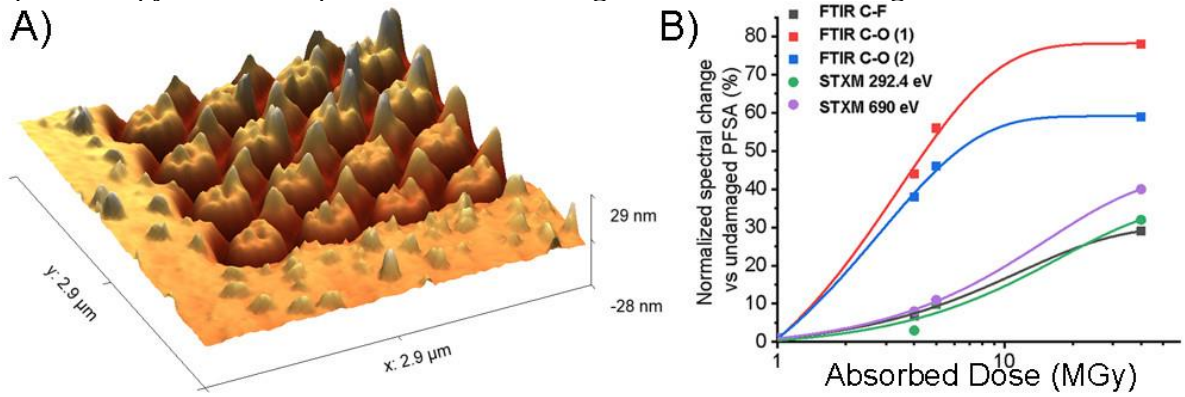

Figure 1: A) Atomic force microscopy image of damaged polymer film after exposure to 310eV beam in scanning transmission X-ray microscope. B) Dose damage dependence of different functional groups inside the polymer, determined using infrared and X-ray microscopy.

An optimized, low-dose strategy was then used to probe the nanostructure of the polymer electrolyte at the electrode interface inside a hydrogen fuel cell. The influence of the X-ray beam can be quantitatively deconvoluted from the electrochemical degradation of interest, without any compromise to image resolution or signal-to-noise quality.

References

[1] - Martens, I., Melo, L.G., Bizzotto, D., Wilkinson, D.P., Hitchcock, A.P.H., J. Phys. Chem. C., 123, 16023 (2019)