	Experiment title: Understanding Water Transport Dynamics in Anion Exchange Membrane Fuel Cell from Operando High Energy X-Ray Diffraction	**Experiment number**: CH6394
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Report:

The experiment was a success, as the proposed approach to detect water from X-ray diffraction (XRD) in a operating AEMFC was acchived. The experiment consisted in the following steps:

1. Scan the 'dry'cell + capillary filled with water
2. Determine the XRD signal of each one of the component: Water, GDL, Pt/C, PtRu/C, Gaskets, Membrane *etc*.
3. Measure the XRD scans of different membrane electrode assemblies (MEAs) under given AEMFC conditions.
4. Fit data from a scan with the different components (non-negative matrix factorisation and/or principal component analysis to extract water profiles.

Different commercial membranes were tested: AEMION membranes of 25,50 and 100 µm and a PIPERION membrane of 15 µm. For each membrane, various (unbalanced) relative humidities (R.H.) were applied and water profiles were investigated for different current densities produced by the cell.

As shown in **Figure 1.a** for the AEMION 100 µm MEA, the prelimenary non-negative matrix factorisation of the XRD scans from the different cell components reveals a component distribution without any artifacts, allowing the distinction between anodic/cathodic catalyst layers and GDLs. Especially, the so-extracted water profile during a z-scan in the dry cell indeed shows nearly no water (**Figure 1.b**).

Various water distribution profiles were obtained while operating the cell under hunidified conditions and at different current densities, as displayed in **Figure 1.c**. At low current densities below 200 mA cm^{-2}, liquid water is found mainly stored in the membrane, and at lower extents in anode and cathode catalyst layers. However, as the current is increased to 300 mA cm^{-2}, sharp changes are observed. Not surprinsingly, liquid water is globally produced, but the consumption of 2 water molecules at cathode *vs.* the production of 4 water molecules at anode for each 4 electrons exchanged lead to obvious anode flooding and only a minor increase at cathode (**Figure 1.c**). A complementairy measurement using humidity senors (**Figure 1.e**) at the gas outlets revealed that both anode and cathode increased in water content when a current was applied. This coupled with the XRD scans suggests that during normal operation the produced water is effectivley removed from the cathode, leading to no significant formation of liquid water, while there is a risk for flooding at the anode due to the significnat amounts of water produced.Comparing the measured water increase (black lines in **Figure 1.e**) to the expected one from the electrochemical reacions (blue lines in **Figure 1.e**) it can be seen that there is significant back-diffusion of water from the anode to the cathode, as almost 68 % of all produced water is transported from anode to cathode. Interestingly, XRD suggests this water flow toward the cathode does not prevent the catalytic layer loosing water.

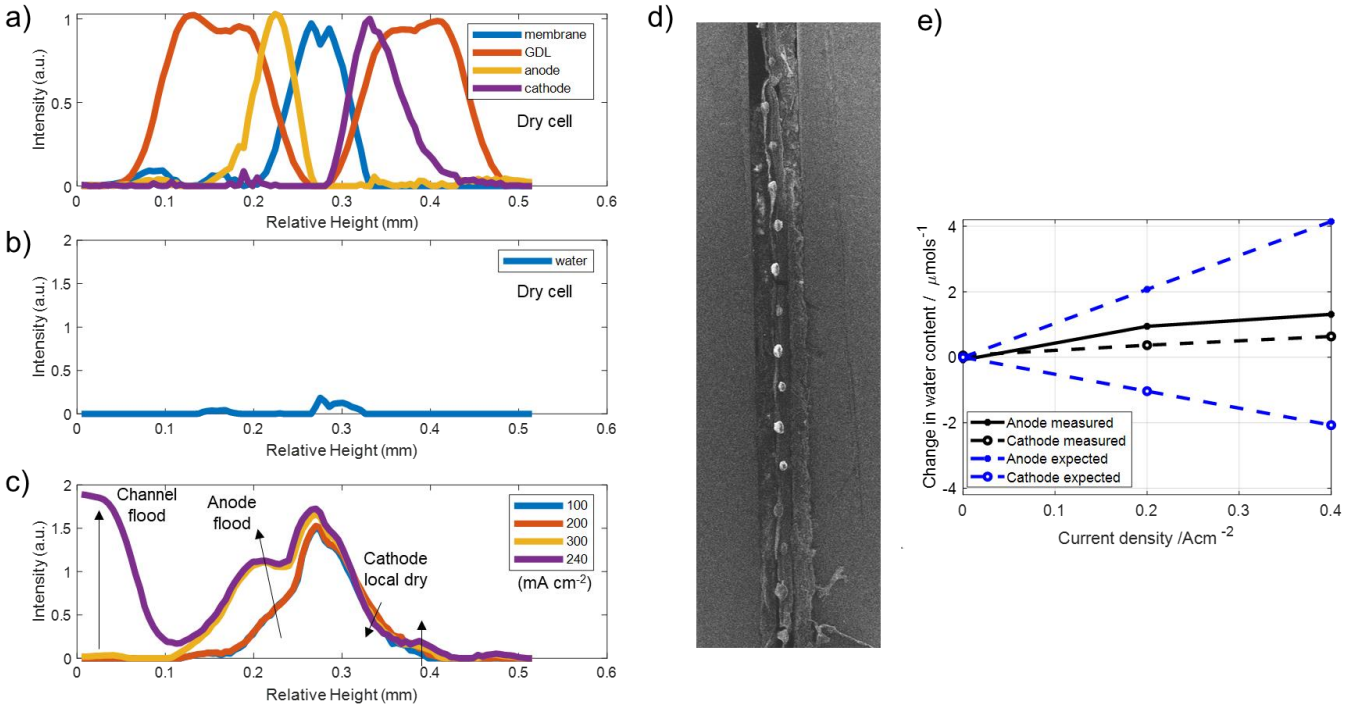

Figure 1: Prelimenary results on (a) different components distribution in the cell; (b) water profile distribution in the dry cell and (c) under different current densities; (d) SEM image of the AEMION 100 µm showing the presence of a reinforcement. (e) measured change in anode and cathode water using humidity senors.

From XRD and SEM images a reinforcement was detected (**Figure 1.a** and **1.e**), its placement was noted to be closer to the anode then the cathode. The exact effect of the reinforcement on the water distribution and if its placement matters is currently being investigated. Further analysis of the other datasets and parralel investigations on bulk water transport, and on the presence and position of a membrane reinformenet in AEM are ongoing. Overall it is noted that the XRD measurements have allowed for clarifty regarding the water distribution of the water in an active AEMFC.