Seksjon for komplekse materialer

Water Electrolysis: Oxygen Production at the Anode Electrode

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Background

As the world moves towards a decarbonized energy infrastructure, hydrogen is considered to be one cornerstone of a sustainable economy. In particular, efficient, cost-effective and large-scale production of hydrogen with few impurities, based on renewable energy input, needs to be developed if the hydrogen economy is to succeed. Water electrolysis has the potential to meet these criteria.

Arguably, the most critical components in water electrolysis are the electrodes in which water is ultimately split into its elementary components, oxygen (at the anode electrode) and hydrogen (at the cathode electrode). In particular, the oxygen evolution reaction at the anode, which is rather inefficient, needs to be understood and improved so as to make water electrolysis a viable technology. As oxygen reaches super-saturation, small oxygen bubbles form which can have a large impact on the reaction kinetics. There exists very little research on these bubbles, a somewhat new phenomenon in physics.

Project Summary - Methodology

A simplified mass and charge transport model for an anode pore in PEM water electrolysis will be developed. Bubble formation and growth at predetermined nucleation sites will be modeled stochastically, where the probability of formation scales with local super-saturation of oxygen. The growth of spherical caps which represent the bubbles within the charged electrolyte, will be examined and how it relates to local current density (i.e. oxygen production). In this free-interface problem, a pressure mismatch drives the growth. The idea is to capture the variation of surface tension, as it appears in the Young-Laplace equation, with proton and oxygen concentrations in a model so as to match experimental findings on flat electrode surfaces.

A key question is whether stable bubbles can form, resulting from a self-stabilizing mechanism: growing bubbles increase catalyst shielding, thereby reducing catalytic activity and oxygen formation.

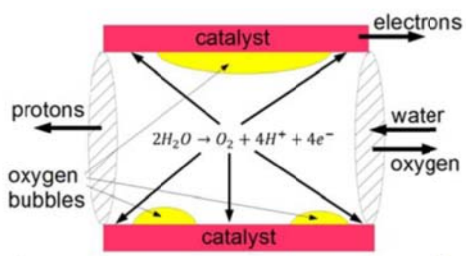

Figure 3a: Mass transport, pore wall reaction and bubble formation in anode catalyst layer pores. The pore liquid (water) contains protons and oxygen, the bubbles oxygen and vapour.

References

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