LO – H2 Project n°3

Title: Dissolved gas separation from liquid electrolyte for membrane-less electrolyzers

Project: Master project / Semester project

Introduction:

Renewable energies have been developed significantly in the last decade in an effort to reduce the need for hydrocarbon fuels. Consequently, the cost of energy from renewable sources is becoming competitive compared to fossil fuels. However, the renewable energy sources are intermittent and a storage mechanism is required to compensate for their intermittency. Energy storage in the form of hydrogen has been regarded as one of the primary storage strategies due to the high energy density of hydrogen. Water electrolysis is the major technology for clean hydrogen production. However, hydrogen produced through water electrolysis is too expensive due to the high capital and operating costs of electrolyzers. Technological innovations are required to improve the performance of water electrolyzers and reduce the cost of hydrogen production.

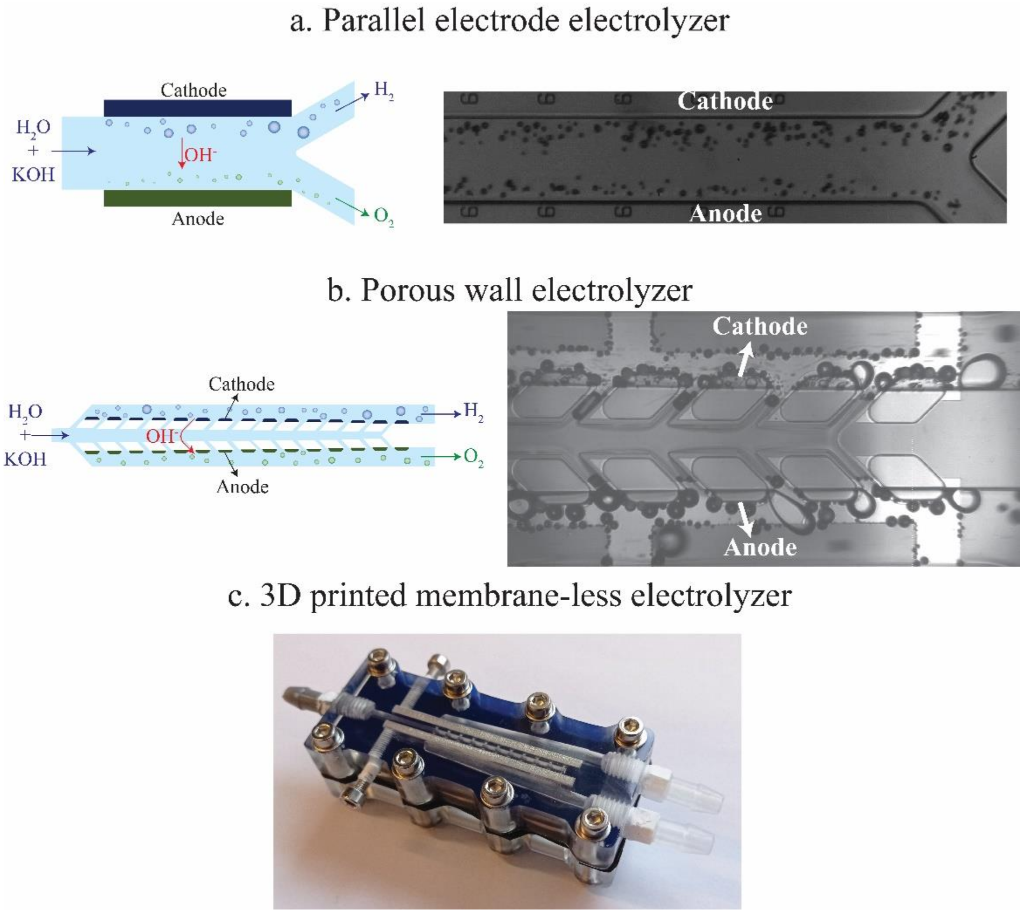

Figure 1. Membrane-less electrolyzers developed at LO: a) Parallel electrodes electrolyzer relies on the fluidic flow to separate the oxygen and hydrogen bubbles, b) Porous wall electrolyzer utilizes fluidic flow and geometrical topographies to achieve highly pure hydrogen production, c) a picture of the 3D printed membrane-less electrolyzer.

A water electrolyzer requires catalysts to split water molecules into hydrogen and oxygen and an ion-conducting medium (electrolyte) to conduct ions between the catalysts. The products of water electrolysis are in gas form. Therefore, we need a mechanism to separate hydrogen and oxygen bubbles. Commercial electrolyzers use a membrane or a separator to keep hydrogen and oxygen bubbles separated. This gas separation mechanism can limit the operating conditions of the water electrolyzer and increase the hydrogen production costs. Optics Laboratory (LO) is developing a novel flow-based electrolyzer called "**membrane-less electrolyzer**" that resolves many technological issues of commercial electrolyzers.

A membrane-less electrolyzer utilizes flow to separate the bubbles and eliminates the need for the membrane. Figure 1 shows two membrane-less electrolyzers. Figure 1.a shows the parallel electrodes membrane-less electrolyzer where the electrolyte flow applies inertial forces on bubbles to keep the two streams of oxygen and hydrogen bubbles separated. Figure 1.b depicts the porous wall membrane-less electrolyzer that separates the oxygen and hydrogen bubbles using electrolyte flow and geometrical topographies. Figure 1.c shows a picture of 3D printed membrane-less electrolyzer.

Project description:

The products of water electrolysis initially dissolve in the electrolyte. The bubbles nucleate when the gas concentration surpasses the saturation point. Therefore, we always have some products dissolved in the electrolyte. We use a phase separator after the electrolyzer to remove the collect gaseous products for storage. This process can work efficiently for bubbles due to their density difference from the liquid. On the other hand, the collection of dissolved gas in the liquid is a challenging task since we cannot rely on buoyancy force for the separation. In this project, you will investigate different methods for the dissolved gas separation from the liquid electrolyte. Some potential solutions for the dissolved gas separation from the liquid are 1) mechanical rotation of the liquid, 2) using a hydro-cyclone to swirl the liquid at large velocities, and 3) utilization of ultrasound irradiation to force bubble nucleation. Figure 2 shows a picture of dissolved gas separator currently under development at LO. You can use numerical simulations to design and 3D printing to fabricate the dissolved gas separator. Afterwards, you can implement this separator in an electrolyzer system to measure and quantify its performance. This project provides an exceptional opportunity to learn or improve your knowledge and expertise in CAD designing, 3D printing technologies, electrochemistry, numerical simulations, and fluid mechanics.

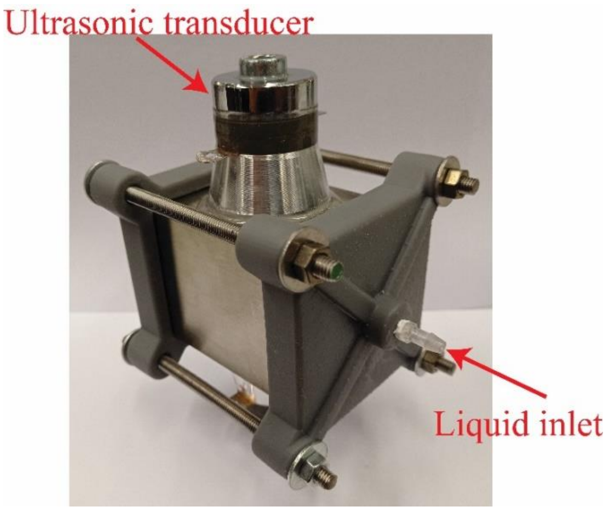

Figure 2. Dissolved gas separator using ultrasound irradiation.