LO – H2 Project n°4

Title: Effect of different catalysts on the performance of membrane-less water 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.

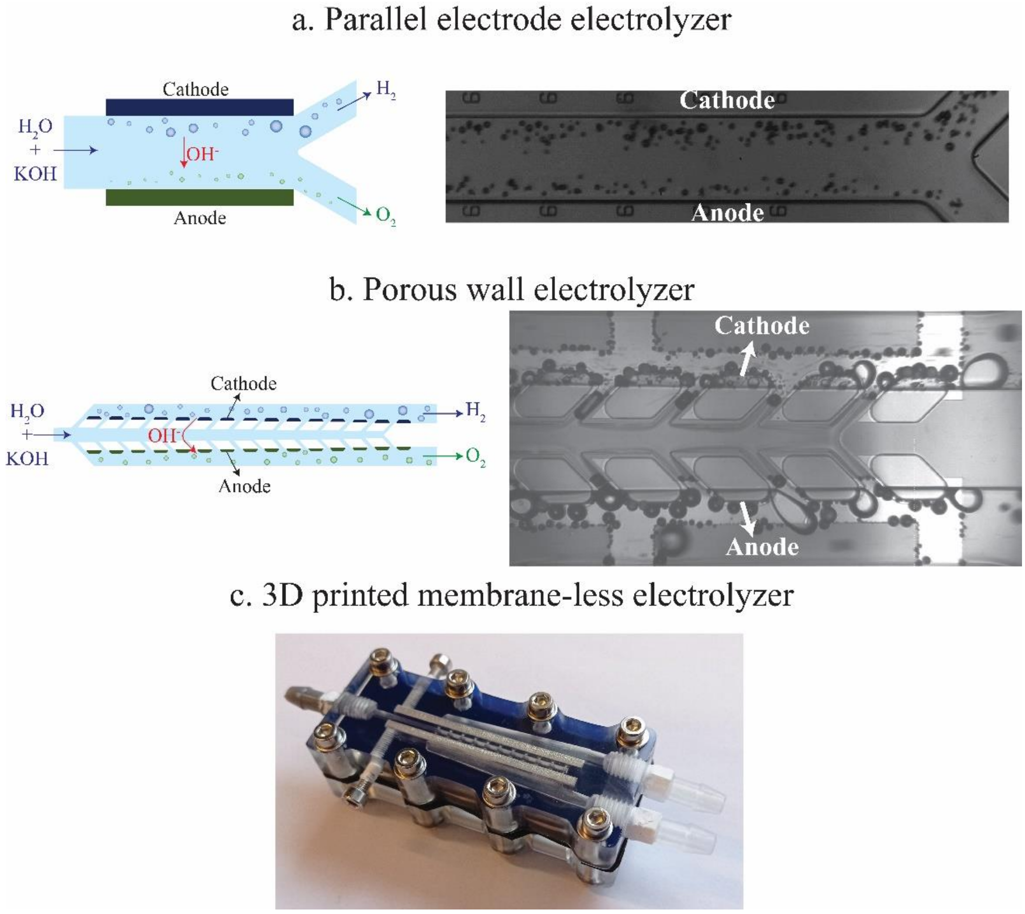

Figure 1. Membrane-less electrolyzers developed at LO: a) Parallel electrodes electrolyzer relies on the fluidic flow to separate the oxygen and hydrogen bubbles, b) Porous wall electrolyzer utilizes fluidic flow and geometrical topographies to achieve highly pure hydrogen production, c) a picture of 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 material and design of catalysts strongly affect the performance of the water electrolysis. The electrode material, the surface area, and the surface structure are among the main parameters that can be fine-tuned to achieve better electrochemical performance. In this project, you will determine the best potential catalysts that can be used in membrane-less electrolyzers. Afterwards, you will fabricate the electrodes and incorporate them in 3D-printed membrane-less electrolyzers. You can fabricate the test devices using the 3D printing facilities available in LO and EPFL. The performance of each electrode can be evaluated by conducting linear sweep voltammetry measurements and tracking bubble evolution and detachment size at the surface of the electrode. The best electrodes will be used in a complete electrolyzer system to measure its performance in larger systems and its stability over long runs. This project provides an exceptional opportunity to learn or improve your knowledge and expertise in CAD designing, 3D printing technologies, and electrochemistry