Capacitive Electrolyzers for Membrane-free Water Splitting

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Green hydrogen production powering water splitting process with renewable energy sources is key for the decarbonization of the world economy. High cost, low durability, and fundamental issues to directly power the electrolyzers with renewable energy sources is key issues to be solved for a successful future hydrogen-based society. These challenges as well as membrane degradation and gas crossover during electrolyzer operation with partial load can be circumvented by decoupling the catalytic conversion on respective electrodes over space or time.

Today, all decoupled water electrolysis devices reported in the literature segregates the hydrogen and oxygen evolution over space where membranes are required to separate redox mediators from the two half-cells. We have developed a membrane-free decoupled hydrogen production process at KTH in a hybrid cell combining the standard electrocatalytic reactions of water splitting with a capacitive storage mechanism[1]. The hybrid cells can operate in both the acidic or alkaline conditions. Faradaic efficiencies over 99 % was achieved at 100 mA/cm^2 with stable hydrogen production for 20 h operation at a current density of 20 mA/cm^2 with no apparent electrode degradation.[2] We will introduce this process for hydrogen production using capacitive storage mechanism that is robust and offer increased flexibility of operation.

[1] Swedish Patent application No. SE 2151488-0 filed on Dec 7 2021, and a PCT Patent Application No. PCT/EP2022/084778, filed on Dec 7 2022

[2] Decoupled Supercapacitive Electrolyzer for Membrane-Free Water Splitting, Esteban Toledo-Carrillo, Mario García, Lorena Sánchez and Joydeep Dutta, Nature Communications (2023), under review