Decoupled Water Splitting: Reshaping Water Electrolysis

Avner Rothschild[a,b]

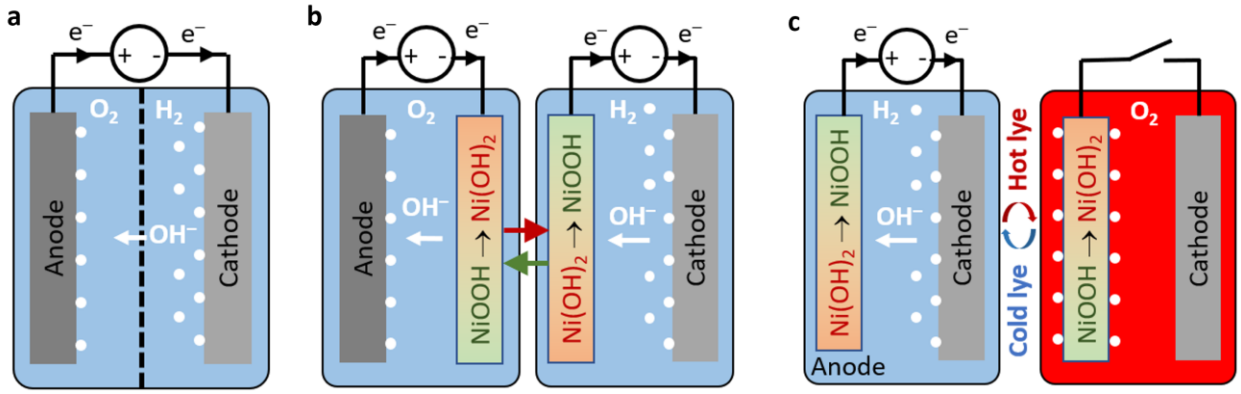
[a]*Technion – Israel institute of Technology, Israel;* [b]*H_2Pro, Israel*

Email: avnerrot@technion.ac.il

Abstract

The present water electrolysis technologies present challenges to increase their economic competitiveness, scale up and performance. These challenges arise from the co-production of H_2 and O_2 in the same cell and from energy losses. To prevent H_2 and O_2 mixing, the electrolytic cell is divided by a membrane into cathodic and anodic compartments (Fig. a). This membrane architecture complicates the electrolyzers construction by adding gaskets and compression sealing to prevent H_2/O_2 crossover. This adds substantial costs and limits operation at high pressures and low-purity water. In addition, substantial energy losses, mostly due to the difficult oxygen evolution reaction (OER), increase the cost of energy in this energy intensive technology. These drawbacks give rise to high cost of green hydrogen.

To overcome these challenges, we developed alternative processes that decouple the generation of hydrogen and oxygen into two cells (space separation, Fig. b),[1] or two consecutive stages (time separation, Fig. c),[2] avoiding the need for membrane and sealing. In addition, we divided the OER, a difficult electrochemical reaction that requires four electrons and protons to generate an O_2 molecule on a single atomic reaction site, into two sub-reactions that occur on four sites, thereby enabling facile reactions and reducing the energy losses in water electrolysis. An ultrahigh efficiency of nearly 99% was demonstrated at lab scale,[2] and we expect reaching above 90% at system scale. To bring this breakthrough process to reality we established H_2Pro, an Israeli startup company that aims to produce green hydrogen at $1/kg by the end of this decade, based on our invention.



1. Landman et al., *Photoelectrochemical water splitting in separate oxygen and hydrogen cells*, Nature Materials 16, 646–651 (2017).

2. Dotan et al., *Decoupled hydrogen and oxygen evolution by a two-step electrochemical – chemical cycle for efficient overall water splitting*, Nature Energy 4, 786–795 (2019).