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Same beginning, different ends: new tailored catalyst activation protocols improve reliability in green hydrogen generation

A team of international researchers unveil the importance of designing tailored activation protocols to prevent catalyst degradation in water electrolysis. Their approach, which monitors the material's evolution in real-time, leads to catalysts with higher durability, stability and reproducibility compared to those achieved through traditional protocols.

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Decarbonization technologies are increasingly deployed to fight climate change. Many of these technologies involve electrochemical reactions to generate clean fuels and chemicals powered by renewable electricity (for example, green hydrogen). However, such reactions are often inefficient on their own and require an electrocatalyst to accelerate them.
The predictive design of active catalysts is challenged by their chemical and structural transformation during reaction, which also exacerbate degradation and limit stability. This effect is especially prominent in the oxygen evolution reaction (OER) within water electrolysis - the half reaction needed to produce green hydrogen.
Typically, though, the initial material is not yet fully optimized for catalysis; it is said to be in a precatalyst form. To improve its ability to drive the electrochemical reaction, a so-called activation process is needed. ï¿½Think of precatalysts as hidden talents and activati
n protocols as the training programs that turn them into their own champions. The rig
t activation protocol will make them thrive; the wrong one may waste their talentï¿½, expl
ins Dr. Lu Xia, ICFO and former Jülich researcher who is studying how to exploit electrochem
stry for energy storage application. Conventionally, though, activation processes are overl
oked and standard regardless the starting precatalyst mate
ial. Now, a joint effort between the Forschungszentrum Jülich (led by Dr. Meital Shviro, now at NREL), University of Bayreuth, and ICFO researchers, **Dr. Lu Xia**, **Dr. Kaiwen Wang**, **Tengyu Chen**, **Dr. Kaiqi Zhao**, **Ranit Ram**, **Dr. Barbara Polesso**, **Dr. Anku Guha**, led by **Prof. Dr. F. Pelayo Garcia de Arquer**, has shown that the role of tailored activation protocols is, in fact, critical. **The team has proposed an activation protocol that offers real-time control over**

deterioration and has demonstrated that it improves the reliability, activity and stability of those catalysts employed in the OER of water electrolysis. Importantly, this was implemented **at industrially relevant conditions.** On the other hand, they have shown that inappropriate activation protocols lead to irreversible catalyst degradation, complicating control and reproducibility. In the study, published in Nature Materials, many other international institutions have collaborated, namely the Chongqing University, Norwegian University of Science and Technology, Beijing University of Technology, Zhejiang Ocean University, ETH Zurich, Freie Universitat Berlin, Tsinghua University and University of Electronic Science and Technology of China.

The multidisciplinary collaboration in the team was key to the success of the study. For instance, Forschungszentrum Jülich focused on the design and characterization of catalysts Chongqing University was responsible for the theoretical simulations to predict the activatio behavior, and ICFO played a central role proposing and leading the precatalyst programmin strategies as well as the experimental monitorization of how catalysts changed during th activation protocols. ï¿½This multidisciplinary synergy enabled an in-depth understanding of the precatalyst behavior, driving the development of a tailored strategy for high performa ce electrolysisï¿½, shares Dr. Lu Xia, first co-author of the s

An appropriate activation protocol leads to higher performance catalysts

In the end, the observations validated the theoretical models, which had accurately predicted the precatalyst evolution during operation. Compared to traditional techniques, **the combination of theory and experiment enabled higher control over the oxidation process, minimal dissolution of the catalyst and longer-term stability of the material.**

In particular, researchers benchmarked their method with promising materials for OER in a water electrolyser operating at industrial-relevant settings. After hundreds of hours of activity, they observed a threefold improvement in the duration of the catalyst before completely dissolving when using their activation protocol instead of the standard one. ï¿½The two approaches are fundamentally different, which explains why the outcom s differï¿½, explains Dr. Xia. ï¿½Conventional activation, like cyclic voltammetry, i duces uncontrolled surface changes, degrading catalysts and impairing stability. In our ca e, we leverage a precatalyst platform, guided by theoretical models and operando insigh s, to precisely control activation, minimizing dissolution and ensuring reliable performancei ?½, h

adds. Overall, this approach bridges the gap between theoretical understanding and ractical application, enabling the development of highly reliable catalysts for water electro ysis and rising awareness on the importance of activation protocols to ensure optimal ac ivation, stability and reproducibility. The natural next step would be to apply the protocol to other electrochemical reactions and investigate how it impacts them. Another research irection would be to refine the protocol to take into account larger material areas, ransport phenomena and other subtleties surrounding water electrolysis. That would llow for extending the strategy to larger-scale electrolyzers, bringing the ultimate goal f device commercialization one ste

Reference:
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