# Reversible adapting layer produces a robust electrocatalyst

## Using in situ X-ray scattering to probe the active phase for water oxidation during gas evolution

Electrochemically converting water into oxygen/hydrogen gas is ideal for high-density renewable energy storage in which robust electrocatalysts for efficient oxygen evolution play crucial roles. Recent reports of highly economical and efficient electrochemical catalysts have significantly advanced this technology. However, the largest challenge concerning the reliability of the catalyst remains unconquered. A major reason for the slow progress of reliable catalysts for water oxidation is that the electrocatalyst contains most of the charge carriers during the harsh oxidization process because the OER normally occurs under a high anodic potential. To shed light on such complex surface reactions, we need a tool that allows in situ observation of the active phase of the metal centers under anodization and a novel strategy to protect electrocatalysts under such harsh conditions in order to achieve reliable catalysts for the OER. Under practical conditions, the OER occurs only within a several-nanometer region of the catalyst surface, and in situ studies within this limited region are essential and extremely challenging.

Recently, a team led by Prof. Chen at the Chemistry Department of National Taiwan University (NTU) utilized a novel in situ X-ray diffraction method to identify a strong correlation between the initialization of the oxygen evolution and the formation of an active metal oxyhydroxide phase. The lattice of the skin layer adapts to the structure of the active phase, which enables a reversible facile structural change that facilitates the chemical reactions without breaking the scaffold of the electrocatalysts. The single-crystal nanocube electrode exhibits stable, continuous oxygen evolution for 1,000 h. This robust stability is attributed to the complementary nature of the defect-free single-crystal electrocatalyst and the reversible adapting layer.

These results add to the understanding of the phase of the active metal centers on the electrocatalysts during the reaction and the advancement of the reliability of OER electrocatalysts.

X-ray techniques provide powerful tools for the investigation of the phases of surface active metal centers in electrocatalysis and can potentially be applied to probe other catalysis systems. In practical applications, solar water splitting or artificial photosynthesis devices can be achieved via the integration of a reliable catalytic system with a photovoltaic solar cell, which captures light energy to generate sufficient driving force for $H_2/O_2$ generation. Prof. Chen remarked, “This study can serve as a new strategy to realize the behaviors in liquid media and to design robust electrocatalysts for artificial photosynthesis that allow for the conversion of sunlight into oxygen and chemical fuels.”

Prof. Chen’s group is also currently working on developing novel in situ methodologies to realize the mechanisms behind the reactions. In the future, these strategies can be applied to achieve artificial photosynthesis.

**Reference**

Ching-Wei Tung, Ying-Ya Hsu, Yen-Ping Shen, Yixin Zheng, Ting-Shan Chan, Hwo-Shuenn Sheu, Yuan-Chung Cheng, Hao Ming Chen*. (2015). Reversible Adapting Layer Produces Robust Single-crystal Electrocatalyst for Oxygen Evolution. *Nature Communications*, 6:8106. DOI: 10.1038/ncomms9106

**Assistant Professor Hao-Ming Chen**
Department of Chemistry
*haomingchen@ntu.edu.tw*