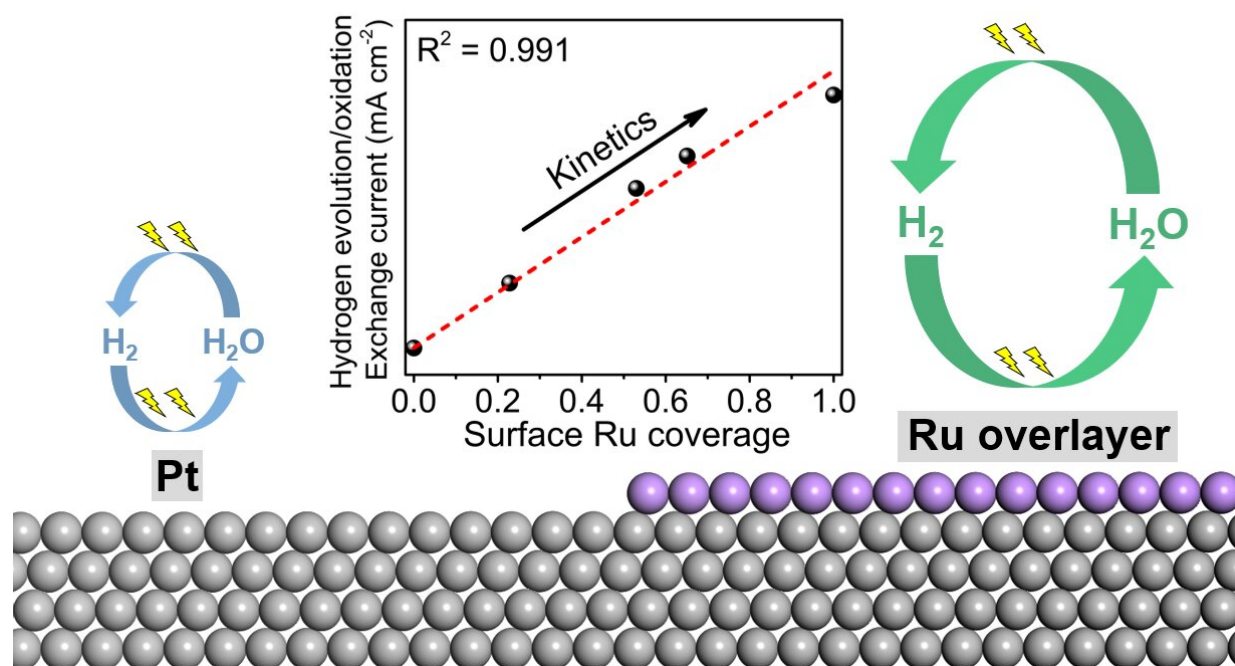


New mechanisms of activity improvement on bimetallic catalysts for hydrogen generation and fuel cells

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Ruthenium atoms supported on platinum are extremely active to produce hydrogen. Credit: HKUST

A group of researchers at the Hong Kong University of Science and Technology (HKUST) and Xiamen University has revealed new understandings of how surface ruthenium atoms can improve the hydrogen evolution and oxidation activities of platinum. This discovery

opens a new venue for rational design of more advanced catalysts for electrolyzer and fuel cell applications.

Hydrogen is a clean energy carrier that does not contain carbon. It is believed to play an essential role in our future sustainable society. Hydrogen can be produced from water via the [hydrogen evolution reaction](#) (HER) in an electrolyzer by using renewable energies, and consumed via a [hydrogen](#) oxidation reaction (HOR) in a fuel cell to generate electricity. Unfortunately, these two reactions are well-known kinetically sluggish in alkaline media, even on the most active platinum catalysts. The slow reaction rates limit the efficiencies of these two electrochemical devices and hinder their wide adoption. It has been known that the reaction rates of HER/HOR on platinum can be improved by surface modification or alloying with ruthenium. However, the mechanisms for this promotion have been under debate for over decades. Part of the reasons is a lack of direct observation of behaviors of [hydrogen atoms](#) on the surfaces of catalysts.

To reveal the enigma of high HER/HOR activities on platinum-ruthenium bimetallic catalysts, a research team led by Prof. Minhua Shao, Department of Chemical and Biological Engineering and Energy Institute at HKUST, recently applied the powerful surface-enhanced [infrared absorption spectroscopy](#) (SEIRAS) to directly monitor the binding strength of the important reaction intermediate, hydrogen atoms on various surfaces. Through the combined electrochemical, spectroscopic, and [theoretical studies](#) they confirmed the surface ruthenium atoms interacted with the sub-surface platinum is one order of magnitude more active than platinum, i.e., the ruthenium rather than platinum atoms are main active sites in this system.

"Previous works mainly used conventional electrochemical and characterization techniques, which cannot directly monitor the adsorption behavior of hydrogen reaction intermediates. In this work, we

use the powerful surface-enhanced infrared absorption spectroscopy, which is among the very few techniques that can directly "see" surface hydrogen atoms, and provides us more straightforward information on how ruthenium improves the activity" said Prof. Shao. "This work rules out the most widespread theory that the bifunctional effect on the interface between platinum and ruthenium is the cause of increased activities, and opens new directions on future design of more advanced HER/HOR catalysts, which can consequently reduce the usage of precious metals in both water electrolyzers and hydrogen fuel cells."

This work is part of the newly founded Collaborative Research Fund project led by Prof. Shao "Development of high-performance and long-life alkaline membrane fuel cells," and constitutes an important subsection of fundamental research to this whole project. Following works on the development of practical and high-performance bimetallic [platinum-ruthenium](#) electrocatalysts based on these findings is in progress.

This study was recently published in *Nature Catalysis* entitled "The Role of Ruthenium in Improving the Kinetics of Hydrogen Oxidation and Evolution Reactions of Platinum."

More information: The role of ruthenium in improving the kinetics of hydrogen oxidation and evolution reactions of platinum, *Nature Catalysis* (2021). [DOI: 10.1038/s41929-021-00663-5](https://doi.org/10.1038/s41929-021-00663-5) , www.nature.com/articles/s41929-021-00663-5

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