New catalyst for hydrogen production is a step toward clean fuel

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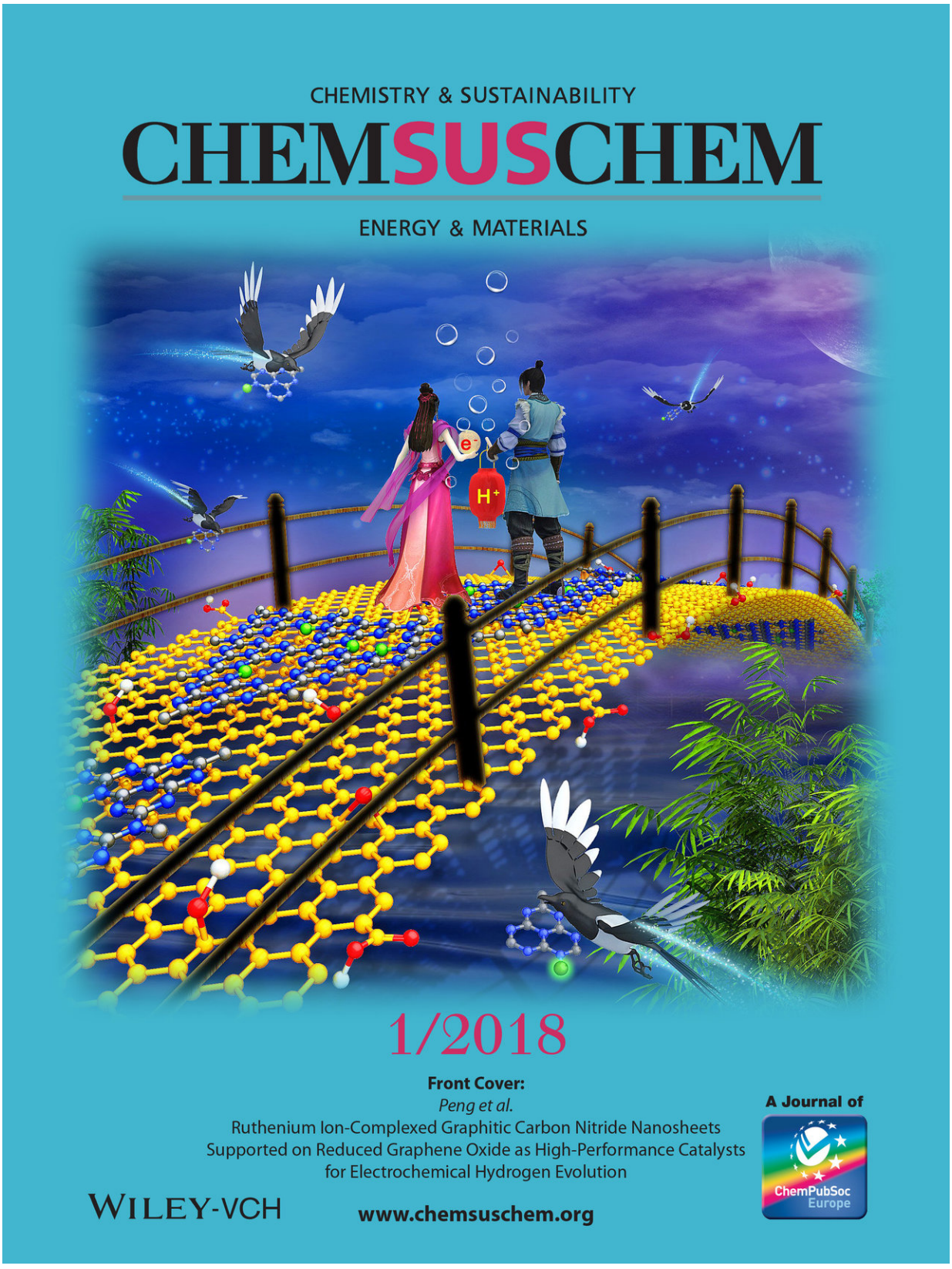
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Front Cover:
Peng et al.
Ruthenium Ion-Complexed Graphitic Carbon Nitride Nanosheets
Supported on Reduced Graphene Oxide as High-Performance Catalysts
for Electrochemical Hydrogen Evolution
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The Front Cover shows the production of hydrogen gas when electrons and protons meet on ruthenium ion-complexed graphitic carbon nitride nanosheets supported on graphene surface. The image is based on an ancient Chinese legend of Niulang and Zhinü. Niulang was a human cowherd and Zhinü was a fairy from heaven. They fell in love with each other. Yet their love was banned by the fairy's queen, who forcefully separated them by the Silver River. The lovers were only able to see each other once a year, on the 7th day of the 7th lunar month, with the help of a flock of magpies that formed a bridge. More information can be found in the Full Paper by Peng et al on page 130 in Issue?1, 2018 (DOI: 10.1002/cssc.201701880). Credit: Yi Peng/*ChemSusChem*

A nanostructured composite material developed at UC Santa Cruz has shown impressive performance as a catalyst for the electrochemical splitting of water to produce hydrogen. An efficient, low-cost catalyst is essential for realizing the promise of hydrogen as a clean, environmentally friendly fuel.

Researchers led by Shaowei Chen, professor of chemistry and biochemistry at UC Santa Cruz, have been investigating the use of carbon-based nanostructured materials as catalysts for the reaction that generates hydrogen from water. In one recent study, they obtained good results by incorporating ruthenium ions into a sheet-like nanostructure composed of carbon nitride. Performance was further improved by combining the ruthenium-doped carbon nitride with graphene, a sheet-like form of carbon, to form a layered composite.

"The bonding chemistry of ruthenium with nitrogen in these nanostructured materials plays a key role in the high catalytic performance," Chen said. "We also showed that the stability of the catalyst is very good."

The new findings were published in *ChemSusChem*, a top journal

covering sustainable chemistry and energy materials, and the paper is featured on the cover of the January 10 issue. First author Yi Peng, a graduate student in Chen's lab, led the study and designed the cover image.

Hydrogen has long been attractive as a clean and renewable fuel. A hydrogen fuel cell powering an electric vehicle, for example, emits only water vapor. Currently, however, hydrogen production still depends heavily on fossil fuels (mostly using steam to extract it from natural gas). Finding a low-cost, efficient way to extract hydrogen from water through electrolysis would be a major breakthrough. Electricity from renewable sources such as solar and wind power, which can be intermittent and unreliable, could then be easily stored and distributed as hydrogen fuel.

Currently, the most efficient catalysts for the electrochemical reaction that generates hydrogen from water are based on platinum, which is scarce and expensive. Carbon-based materials have shown promise, but their performance has not come close to that of platinum-based catalysts.

In the new composite material developed by Chen's lab, the ruthenium ions embedded in the carbon nitride nanosheets change the distribution of electrons in the matrix, creating more active sites for the binding of protons to generate hydrogen. Adding graphene to the structure further enhances the redistribution of electrons.

"The graphene forms a sandwich structure with the carbon nitride nanosheets and results in further redistribution of electrons. This gives us greater proton reduction efficiencies," Chen said.

The electrocatalytic performance of the composite was comparable to that of commercial platinum catalysts, the authors reported. Chen noted, however, that researchers still have a long way to go to achieve cheap

and efficient hydrogen production.

More information: Yi Peng et al, Ruthenium Ion-Complexed Graphitic Carbon Nitride Nanosheets Supported on Reduced Graphene Oxide as High-Performance Catalysts for Electrochemical Hydrogen Evolution, *ChemSusChem* (2017). DOI: 10.1002/cssc.201701880

Provided by University of California - Santa Cruz