

[Request Information](#)[Permalink](#)

# Carbon-Doped NiO Catalyst For Hydrogen Evolution Reaction

Tech ID: 33000 / UC Case 2020-273-0

## BACKGROUND

Water electrolysis represents a sustainable and environmentally friendly method to generate hydrogen fuel. Since a proton rich environment is favorable for hydrogen adsorption on a catalyst surface, an acidic medium is preferable for hydrogen evolution reaction (HER).

However, performing HER in an acidic medium limits catalysts to platinum group metals. In addition, a corrosive acidic fog generated by the acidic electrolyte not only contaminates the produced hydrogen gas, but also causes severe chemical corrosion of the catalysts.

These factors add significant cost for hydrogen generation and pose barriers for constructing large-scale electrolyzers.

Alternatively, the use of alkaline electrolytes, which have a low vapor pressure and result in a relatively mild chemical environment could avoid these issues. Non-platinum group metals such as Ni can be used as electrocatalysts or electrodes with alkaline electrolytes. A major challenge for alkaline water electrolysis is the requirement of an additional water dissociation step (i.e., the cleavage of the strong H–OH bond) for generating the essential H atom intermediates for HER.

The high activation barrier of water dissociation makes HER very sluggish in alkaline medium. For example, Pt typically exhibits two orders of magnitude lower exchange current density in alkaline solution than that in acidic solution. It is therefore critical to develop alkaline HER catalysts that contain both hydrogen adsorption sites as well as water adsorption and dissociation sites.

## TECHNOLOGY DESCRIPTION

Transition metal oxides such as NiO are promising alkaline HER catalysts. Since Ni sites in NiO possess incompletely filled d orbitals, Ni sites have been reported to serve as active sites for water adsorption and dissociation in alkaline electrolytes. Nonetheless, the performance of NiO is still not comparable to Pt-based catalysts. One of the possible reasons is lack of hydrogen adsorption sites relative to Ni and Pt.

This invention creates hydrogen adsorption sites for NiO through heteroatom doping, particularly carbon doping. Carbon doping creates under-coordinated active Ni sites that are highly favorable for hydrogen adsorption. Experiments show that Carbon-doped NiO achieves an ultralow overpotential of 27 mV at the geometric current density of 10 mA /cm<sup>2</sup>, and a low Tafel slope of 36 mV /dec, representing the best performance among the state-of-the-art NiO catalysts.

## CONTACT

Jeff M. Jackson  
[jjackso6@ucsc.edu](mailto:jjackso6@ucsc.edu)  
tel: .



## INVENTORS

- ▶ Chen, Mingpeng
- ▶ Kou, Tianyi
- ▶ Li, Yat

## OTHER INFORMATION

### KEYWORDS

Electrolytic hydrogen production,  
Alkaline Hydrogen Evolution  
Reaction, NiO electrode

### CATEGORIZED AS

- ▶ **Energy**
- ▶ Hydrogen

### RELATED CASES

2020-273-0

APPLICATIONS

Clean hydrogen production by electrolysis in alkaline medium

ADVANTAGES

Best performing NiO catalyst in alkaline medium

Cheaper than platinum electrodes

Longer lasting electrodes and a cleaner reaction than acidic media

INTELLECTUAL PROPERTY INFORMATION

Country	Type	Number	Dated	Case
United States Of America	Published Application	<a href="#">20210220803</a>	07/22/2021	2020-273

RELATED MATERIALS

- ▶ [Carbon doping switching on the hydrogen adsorption activity of NiO for hydrogen evolution reaction - 01/30/2020](#)

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ [Zinc-Iodine Battery with improved Coulombic efficiency](#)
- ▶ [Z-Scheme Microbial Photoelectrochemical System \(Mps\) For Wastewater-To-Chemical Fuel Conversion](#)
- ▶ [Hydrogen-Treated Semiconductor Metal Oxides For Photoelectrochemical \(PEC\) Water Splitting](#)
- ▶ [Self-Biased and Sustainable Microbial Electrohydrogenesis Device](#)
- ▶ [Three-Dimensional Hierarchical Porous Carbon Foams For Supercapcitors](#)

University of California, Santa Cruz  
Industry Alliances & Technology Commercialization  
Kerr 413 / IATC,  
Santa Cruz,CA 95064

Tel: 831.459.5415  
[innovation@ucsc.edu](mailto:innovation@ucsc.edu)  
[officeofresearch.ucsc.edu/](http://officeofresearch.ucsc.edu/)  
Fax: 831.459.1658

© 2022, The Regents of the University of California  
[Terms of use](#)  
[Privacy Notice](#)