Robust Mesoporous Nife-Based Catalysts For Energy Applications

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SUMMARY

UCLA researchers in the Department of Chemistry and Biochemistry have used selective dealloying method to produce novel high-performance, robust, and ultrafine mesoporous NiFeMn-based metal/metal oxide composite oxygen-evolving catalysts.

BACKGROUND

Electrochemical and photoelectrochemical decomposition of water into oxygen and hydrogen gas is thought to be a promising approach to generate hydrogen fuel. The most challenging half-reaction in water electrolysis is the oxygen evolution reaction, which has slow kinetics and requires an electrocatalyst to lower the reaction barrier and the overpotential. For large-scale applications, the electrocatalyst should be made of inexpensive, abundant, and highly corrosion-resistant materials, which are able to oxidize water at high current densities and low overpotential.

The existing state-of-the-art oxygen-evolving catalysts supported on commercially available three-dimensional nickel foams exhibit exceptionally good catalytic activities. The high intrinsic electrical conductivity of the nickel foam allows it to act as an effective current collector for the catalyst. The porous architecture of open cell nickel foams favors effective mass transfer of both ionic species and gas molecules at the catalyst/electrolyte interface. However, the specific surface area of these commercially available open cell nickel foams with pore sizes in the submillimeter and millimeter range is very low, meaning the total effective interface surface area is small.

Although transition metal oxides have demonstrated as promising catalysts, delivery of high current densities by these catalysts can only be achieved under extreme pH conditions. Therefore, further improvement of these metal oxide catalysts is necessary for the development of efficient water electrolysis devices.

INNOVATION

Researchers at UCLA have synthesized high-performance, robust and ultrafine mesoporous NiFeMn-based oxygen-evolving catalysts with pore sizes on the order of ~10 nm by selective dealloying. The open porosity facilitates effective mass transfer at the catalyst/electrolyte interface, and the small size of the ligaments and pores in the described mesoporous catalyst yields a high BET surface area and therefore a high density of oxygen-evolution catalytic sites per unit mass. The high bulk electrical conductivity of the mesoporous catalyst also allows for effective current flow through the electrocatalyst, making it possible to use thick films with a high density of active sites. In 1 M KOH solution, $Ni_{60}Fe_{30}Mn_{10}$-alloy based metal/metal oxide composite thick film catalyst exhibits a catalytic activity towards water oxidation of 500 mA/cm^2 at 360 mV overpotential and is stable for over eleven days.

APPLICATIONS

Commercial alkaline electrolyzers

ADVANTAGES

Scalability: simple, cost-effective synthesis procedure that can be easily extended to large-scale applications without using expensive and complex lithography or templating techniques.

Durability: better corrosion resistance performance comparing to existing oxygen evolution catalysts

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OTHER INFORMATION

KEYWORDS

Electrocatalyst, catalyst, electrolyzer, water splitting, oxygen-evolving catalyst, hydrogen fuel

CATEGORIZED AS

- **Energy**
  - Hydrogen
- **Materials & Chemicals**
  - Composites
  - Nanomaterials
- **Nanotechnology**
  - Materials
- **Engineering**
  - Other

RELATED CASES

2016-289-0

High current density: delivers high current densities (of the order of 500 mA/cm^2 or higher) under moderate pH conditions and at relatively low overpotential (360 mV)

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,680,231	06/09/2020	2016-289

RELATED MATERIALS

- Detsi, E., Cook, J. B., Lesel, B. K., Turner, C. L., Liang, Y. L., Robbennolt, S., & Tolbert, S. H. (2016). Mesoporous Ni 60 Fe 30 Mn 10-alloy based metal/metal oxide composite thick films as highly active and robust oxygen evolution catalysts. Energy & Environmental Science, 9(2), 540-549.

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Space Confined Polymer-Based Field Effect Transistors
- Nanoporous Tin Powder For Energy Applications

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