Clean Technology

Method and Electrocatalyst to Efficiently Produce Hydrogen Fuel over a Broad, Acidic pH Range

View U.S. Patent No. 8,956,525 in PDF format.

WARF: P110007US02

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an electrocatalyst to enable water oxidation over a broad, acidic pH range.

Overview

The desire to store renewable energy such as solar or wind energy in the form of hydrogen gas, which could substitute for non-renewable fossil fuels, is driving the development of effective water oxidation catalysts. Existing technologies that generate oxygen and hydrogen are inefficient and commercially impractical. The electrolytic production of hydrogen involves the transfer of four protons and four electrons with the formation of an oxygen-oxygen bond, and the high energy barrier associated with this transfer makes the reaction particularly challenging. This high energy barrier produces an overpotential, or loss of energy, when the reaction is conducted at a usable rate.

Previous efforts to reduce the overpotential have improved the process, but barriers to effective commercial use still exist. Many catalysts degrade under the reaction conditions required, while others are too expensive or do not sufficiently reduce the energy barrier. A recently developed electrocatalyst consisting of cobalt oxide and fluoride ions (see WARF reference number P100096US01) is a significant advance toward effective water oxidation, but the use of fluorides requires specialized and expensive plastics in the surrounding electrochemical cell. Furthermore, these cells operate optimally around pH 3.5. Electrocatalysts are needed for use in electrochemical cells made of conventional materials that enable electrolysis over a broad, acidic pH range.

The Invention

UW-Madison researchers have developed an improved method for generating oxygen and hydrogen with a cobalt-oxide electrocatalyst that uses fluorophosphate or a similar anion electrolyte as the electrolytic buffer in the electrolysis reaction. Using this method, an anode and a cathode are placed in an aqueous solution containing water, a cobalt cation and the anion electrolyte. Then an external source of energy (potentially derived from solar, wind or other renewable energy) drives the electrolysis reaction to generate oxygen and hydrogen. Alternatively, a catalyst containing cobalt, oxygen and the anion electrolyte can be deposited on the anode of the electrochemical cell prior to electrolysis in cobalt-free conditions.

This cobalt-oxide catalyst enables efficient oxidation of water at room temperature over a more favorable pH range. The reduction in overpotential makes it easier and less expensive to split water into hydrogen and oxygen, while the expanded pH range allows water oxidation to be coupled with desirable reactions such as reduction of carbon dioxide at the cathode. In addition, the electrolyte buffers are compatible with conventional materials used in electrochemical cells. The hydrogen gas output of this process can be collected and

Applications

- Storage of renewable energy as hydrogen fuel
- Electrochemical synthetic reactions

Key Benefits

- Enables oxidation of water over a broad pH range
- Allows use of electrochemical cells made of conventional materials

Additional Information

For More Information About the Inventors

- Shannon Stahl

Related Technologies

- For more information about improved electrolysis with electrocatalysts formed from cobalt and fluoride, see WARF reference number P100096US01.

Related Intellectual Property

- View Divisional Patent in PDF format.

Publications

- Gerken J.B., Landis E.C., Hamers R.J. and Stahl S.S. 2010. Fluoride-Modulated Cobalt Catalysts for Electrochemical Oxidation of Water under Non-Alkaline Conditions. ChemSusChem. 3, 1176-1179.

Tech Fields

- Clean Technology : Biobased & renewable chemicals & fuels
- Clean Technology : Energy storage, delivery & resource efficiencies

For current licensing status, please contact Jennifer Gottwald at jennifer@warf.org or 608-960-9854