Efficient Hydrogen Evolution From Water via an Alloy Containing Aluminum Nanoparticles

Tech ID: 32779 / UC Case 2019-755-0

BACKGROUND

Few energy sources work well in "off the grid" applications such as laboratory fieldwork, military, and space exploration. Solar panels can be bulky and petroleum products are dirty as well as bulky. Traditional hydrogen gas used in fuel cells requires pressurized tanks of flammable material that are difficult to transport safely to remote areas.

A stable source of hydrogen gas that can be activated upon the addition of water would be a clean and safe energy source for these applications. Other such products exist, but they require water to be treated with e.g. alkaline chemicals before hydrogen can be released, or they might only work with purified water - not whatever water might be available in remote conditions.

Scale-up of such a stable source could result in decentralized, on-site production of hydrogen for additional, less remote applications such as the production of hydrogen fuel for vehicles in an area that lacks ready access to such fuels.

TECHNOLOGY DESCRIPTION

Gallium-rich gallium aluminum alloy forms at room temperature and releases hydrogen gas on contact with any water source

Hydrogen production from a gallium aluminum alloy containing aluminum nanoparticles in water

This technology is a gallium/aluminum alloy with a molar ratio of between 2:1 and 5:1 gallium to aluminum. The alloy is formed by combining aluminum (even waste aluminum foil or can lids) with liquid gallium at low temperatures (e.g. 40 degrees C or less). The aluminum forms nanoparticles that are suspended in the gallium and the alloy can be kept stable indefinitely by storing it in (for example) mineral oil or hexanes.

The reaction between the aluminum nanoparticles suspended in the gallium alloy and water results in a vigorous reaction that liberates nearly theoretical quantities of hydrogen in a very short period of time. There is no need to use purified or otherwise treated water in the reaction. Rain water, gray water, untreated tap water,

CONTACT

Jeff M. Jackson
jjackso6@ucsc.edu
tel: .



OTHER INFORMATION

KEYWORDS

hydrogen fuel, alumina, carbon free, catalytic hydrogen, aluminum waste, eco-friendly, green technologies, off-grid, remote field research, military applications, space exploration

CATEGORIZED AS

- Energy
  - Hydrogen

RELATED CASES

2019-755-0, 2023-938-0

and even salt water result in the rapid release of hydrogen.

Another eventual product of the reaction is aluminum oxide (Al_2O_3), also known as alumina. Aluminum oxide is an inert compound in the environment, but a useful commodity chemical with a wide number of applications. It is normally produced from the mineral bauxite by a process that results in significant, permanent pollution. Depending on the particle size and purity of the aluminum oxide, it can sell for a few dollars to potentially tens of dollars per kg.

The other product of the reaction is gallium - when the aluminum nanoparticles have reacted with the water, gallium is released. This gallium can be re-formed with aluminum and re-used indefinitely.

Separation of the three products happens readily in small scale when the alloy is reacted with an excess of water. The hydrogen gas bubbles out, the aluminum oxide forms a slurry, and the heavy gallium settles to the bottom.

The first US patent issued on April 2, 2024 and divisional applications on making the alloy and making hydrogen and aluminum oxide from the reaction are pending.

Refining the products of the reaction of the gallium/aluminum alloy in water into aluminum oxide

An additional technology (patent pending, international rights still available) describes the further refinement of aluminum oxide Al_2O_3 from the reaction. After the initial work on the reaction, the investigators discovered the surprising result that the actual byproduct of the reaction of the alloy with hydrogen at a temperature below 60 degrees was aluminum hydroxide, which in and of itself is a useful product.

If the reaction is carried out at a higher temperature (between 60 degrees and 100 degrees), aluminum oxyhydroxide is formed. Either aluminum hydroxide or aluminum oxyhydroxide can be heated to form aluminum oxide.

One potential use for the resulting aluminum oxide is to re-form aluminum. Any gallium remaining in the aluminum can be recovered and the aluminum can be recombined with gallium to re-form alloy, resulting in an entirely circular system.

APPLICATIONS

- ▶ Extremely clean "off the grid" hydrogen production, for e.g. field research, military, and space applications.
- ▶ On-site small scale production of hydrogen fuel for transportation
- ▶ Safe, inert hydrogen storage
- ▶ Laboratory hydrogen without pressurized gas storage
- ▶ Production of high grade clean aluminum oxide, aluminum hydroxide, aluminum oxyhydroxide, including gallium-doped versions of these.

ADVANTAGES

- Hydrogen fuel anytime, anywhere, just add water
- Safe, stable, low pressure hydrogen transport
- Aluminum oxide is an inert by product and a useful commodity chemical if recovered
- Hydrogen producing reaction can work with waste aluminum, untreated city water, gray water, rain water, and salt water
- Gallium/aluminum alloy forms at low temperature - about 20 degrees C to 40 degrees C - other techniques require heating to temperatures in excess of 700 degrees C
- Reaction happens fast
- Gallium can be readily recovered and re-used
- No electrical inputs
- No need to treat the water with acid or alkaline chemicals.

INTELLECTUAL PROPERTY INFORMATION

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,944,956	04/02/2024	2019-755
Australia	Published Application	WO 2025/155514	07/24/2025	2023-938
Canada	Published Application	WO 2025/155514	07/24/2025	2023-938
European Patent Office	Published Application	WO 2025/155514	07/24/2025	2023-938
United States Of America	Published Application	20250114770	04/10/2025	2019-755

Additional Patent Pending

RELATED MATERIALS

- Gallium Nanoparticle Formation and Doping of Nanocrystalline Alumina from a Ga–Al Liquid Metal Hydrogen Generating Reaction - 10/30/2023
- Easy aluminum nanoparticles for rapid, efficient hydrogen generation from water - 02/18/2022
- Aluminum Nanoparticles from a Ga–Al Composite for Water Splitting and Hydrogen Generation - 02/14/2022

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

Tel: 831.459.5415
innovation@ucsc.edu
https://officeofresearch.ucsc.edu/
Fax: 831.459.1658

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