Materials & Chemicals

More Stable, Efficient Photocatalysts for Reducing Small Molecules

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WARF: P150202US01

Inventors: Robert Hamers, Di Zhu, Marco Torelli

The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing improved diamond electron emitters for catalyzing the reduction of nitrogen and other small molecules.

Overview

The reduction of small molecules such as nitrogen and carbon dioxide is extremely difficult because one-electron reduction processes often involve high-energy intermediates. Nitrogen reduction usually is coupled with the transfer of one or more protons to generate a more stable intermediate, but the energy level associated with this reaction remains relatively high.

UW–Madison researchers recently developed an improved photocatalyst based on hydrogen-terminated diamond (see WARF reference number P120070US01). They have shown that electrons emitted from the H-terminated diamond via light or electrical potential are capable of inducing a variety of reduction reactions (e.g., N_2 to NH_3; CO_2 to CO) under mild conditions, and without requiring the reactants to be adsorbed to the surface of the photocatalyst.

Building on their work, they continue to seek new ways to improve photocatalytic design and performance.

The Invention

The researchers have now developed amino-terminated diamond surfaces that can be used as electron emitters for catalyzing the reduction of small molecules, particularly inert gases. Compared to the previously designed H-terminated diamond surfaces, the amino-terminated surfaces exhibit superior electron emission and are significantly more chemically stable in the presence of UV light and water.

Reduction reactions that can be carried out using the new photocatalyst include but are not limited to: N_2 to NH_3 or hydrazine (N_2H_4); CO_2 to CO or organic molecules such as methane (CH_4), formaldehyde (H_2CO) or methanol (CH_3OH); and the reduction of nitrogen oxides (NO_x) to N_2. Other molecules that can be reduced include benzene ring-containing organic molecules such as substituted and unsubstituted benzene and naphthalene.

Applications

- Photocatalyst for the reduction of small molecules
- Ammonia production
- Water purification

Key Benefits

- More efficient and stable
- Excellent electron emission properties
- Use of diamond powder/grit may be less expensive than other catalysts.

Stage of Development

Amino-termination has been successfully achieved with ammonia plasma treatment and the new design demonstrates enhanced photoemission performance. Three different measurements were used to determine performance: transient light absorption experiments, UV photoemission spectroscopy (UPS) and surface photovoltage (SPV).

Results indicate better charge separation and much higher intensity in photoelectron emission in either air or vacuum. The amino-terminated diamond also resists oxidation substantially better than H-terminated diamond under continuous UV illumination, which helps to prolong the lifetime of diamond as a photoelectron emitter.

Additional Information

For More Information About the Inventors

- Robert Hamers

Related Technologies

- WARF reference number P120070US01 describes the researchers' improved photocatalyst based on hydrogen-terminated diamond.

Tech Fields

- Materials & Chemicals : Synthesis

For current licensing status, please contact Mark Staudt at mstaudt@warf.org or 608-960-9845