Micro Ammonia Production System (MAPS)—Systems and methods for making nitrogen-based compounds (#8056)

High-yield, sustainable ammonia synthesis from air and water with unprecedented efficiency via gas-phase electrochemical system

This technology has been exclusively licensed for methods of forming nitrogen-based compounds

This MAPS ammonia production technology uses hollow hybrid plasmonic nanocages to create a highly effective electrocatalyst for ammonia synthesis from nitrogen (N_2) and water (H_2O) under ambient temperatures and pressure in the gas- and liquid-phase system. As a major energy carrier and a critical ingredient in producing fertilizers, ammonia is widely produced globally. To meet these ammonia demands, Georgia Tech researchers have developed this sustainable and environmentally friendly production method that enables a high ammonia yield rate with unprecedented Faradaic and energy efficiency. This technology decentralizes the production of ammonia while consuming significantly less energy than current methods, permitting local or on-site production with renewable electricity sources and long-term energy storage.

Benefits/Advantages

- **Higher yield and efficiency**: Uses hollow hybrid nanoparticles instead of solid nanoparticles for a three-fold enhancement in electrocatalytic activity due to the increased surface area and higher number of successful reactant collisions
- **Sustainable production**: Leverages renewable electricity sources and offers clean and sustainable ammonia electrosynthesis, unlike the current industrial method for ammonia production that is energy intensive and heavily relies on fossil fuels
- **Simplified process**: Enables production of ammonia via gas-phase system with few or no additional steps for separation and purification
- **Reduced carbon footprint**: Enables decentralized production so that farmers can make their own fertilizer on site, eliminating the need to transport it
- **Long-term energy storage**: Stored renewable energy in the form of liquid ammonia can be transported and delivered to end-users for various applications in the energy and transportation industries (e.g., back-up power, clean hydrogen fuel cells)

Potential Commercial Applications

This technology could optimize the production of ammonia for:

- Clean energy storage and power generation
  - Storage of surplus renewable energy in the form of ammonia fuel at times of excess supply in the grid (energy storage)
  - Clean power generation
  - Ammonia fuel cells
  - Hydrogen fuel cells
- Nitrogen-based fertilizers
- Pharmaceutical industry (e.g., cleaning chemicals, etc.)
- Marine industry

Background/Context for This Invention

Ammonia is the second most produced chemical in the world. The global production of ammonia approached approximately 146 million metric tons in 2015 and is projected to rise by 40% by 2050. In addition to fertilizers needed to increase food supply for the growing global population, Ammonia also holds great promise as a carbon-neutral liquid fuel for storing intermittent renewable energy when supply exceeds demand in the grid. It can also be used for power generation due to the compound’s high energy density and high hydrogen content. Ammonia can be utilized directly in ammonia fuel cells or indirectly in hydrogen fuel cells and plays a major role in the clean transportation sector.

Using the unique electrocatalytic activity of hollow hybrid plasmonic nanocages in a nitrogen reduction reaction, Georgia Tech created a new pathway to clean and sustainable ammonia electrosynthesis from N_2 and H_20 under ambient conditions using renewable electricity sources.

The method is a form of artificial synthesis that mimics the natural nitrogen enzymatic process. Georgia Tech researchers engineered the size and density of pores in the walls of the hollow plasmonic nanoparticles by tuning their peak localized surface plasmon resonance. In doing this, they enhanced the rate of electroreduction of nitrogen to ammonia. By increasing the temperature from 20?C to 50?C, an even greater electrocatalytic efficiency for ammonia synthesis is obtained.

Dr. Mohammadreza Nazemi
Postdoctoral Fellow - Georgia Tech School of Chemistry and Biochemistry

Dr. Mostafa El-Sayed
Regents' Professor- Georgia Tech School of Chemistry and Biochemistry

More Information

U.S. Application Filed - US20200255957A1

Publications

Using Nanotechnology for Electrosynthesis of Nitrogen-Based Fertilizer Under Ambient Conditions

, Science Trends, July 20, 2018

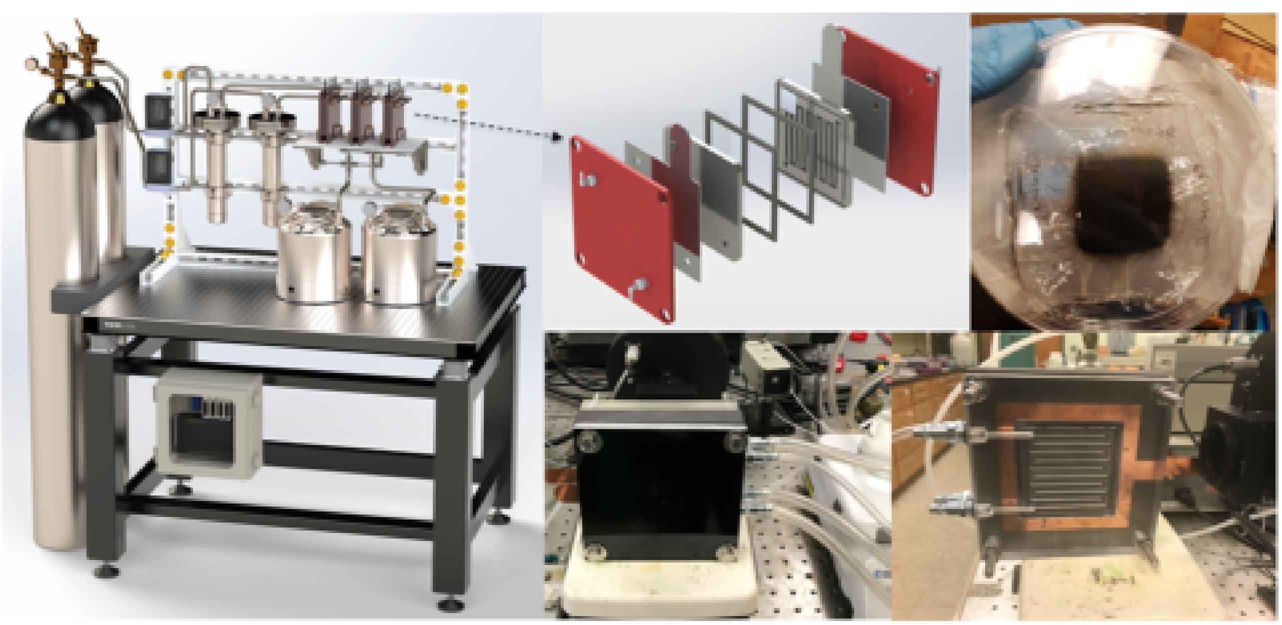
Enhancing the Rate of Electrochemical Nitrogen Reduction Reaction for Ammonia Synthesis Under Ambient Conditions Using Hollow Gold Nanocages, Nano Energy, July 20, 2018

Electrochemical Synthesis of Ammonia from N2 and H2O under Ambient Conditions Using Pore-Size-Controlled Hollow Gold Nanocatalysts with Tunable Plasmonic Properties, The Journal of Physical Chemistry Letters, August 23, 2018

Georgia Tech Ideas to Serve Competition 2020: FUEL THE WORLD, YouTube video, April 6, 2020

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/micro-ammonia-production-system-maps-systems-and-methods-making-nitrogen-based-compounds

Images:



Schematic of the gas-phase (photo) electrochemical cell for nitrogen fixation using hybrid plasmonic nanocages. (center top) In this setup, the catalyst materials are painted on both sides of the membrane surface, as shown in the top right image. Note that the generated ammonia in the gas form will be liquefied using the condenser as depicted on the benchtop.