Nitrogen Fixation using Reactions in Aqueous Microdroplets

Nitrogen gas makes up approximately 80% of the air on Earth, yet our ability to capture and fix it into commercially significant compounds is limited. Ammonia (NH3), for example, is among the most important nitrogen-containing chemicals and commodity chemicals in general due to its use in fertilizers, but its synthesis is dependent on the energy-intensive, century-old Haber-Bosch process. In the face of increasing sustainability and energy-use concerns, it is now necessary to develop innovative new ways to fix nitrogen. Researchers at Purdue University have developed an alternative to the outdated Haber-Bosch process that capitalizes on nitrogen found in the air. In their process, gaseous nitrogen is converted into ammonia using reactions in aqueous microdroplets. By spraying a solution containing a specific blend of chemical reagents in a mist of fine droplets, they create an in situ chemical reaction that can be captured and collected on a prepared surface. In applied uses, the sprayers can be multiplexed, added together to increase the yield of the final product. This method is also not limited to producing ammonia. Following the initial nitrogen-capture reaction, the products can be modified to produce a variety of new compounds. With its low cost, reliance on environmentally friendly reagents, and simple and convenient methodology, this novel nitrogen fixation process is a promising alternative to traditional methods.

Technology Validation:

Direct analysis of the sprayed solution post-reaction by mass spectrometry showed production of ammonia with a specified catalytic reagent, indicating the presence of ammonia in the spray. This product is also observed when the spray is directed at a conducting or non-conducting surface and the collected material is analyzed offline from the surface. The chemical identification was confirmed by tandem mass spectrometry using data for the authentic compound as a reference.

Advantages:

Technology ID

2024-COOK-70581

Category

Agriculture, Nutrition, & AgTech/Precision Agriculture & Smart Farming
Chemicals & Advanced Materials/Green & Bio-Based Chemistry

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-Much faster and less energy intensive than traditional methods, such as Haber-Bosch

-Utilizes nitrogen from air

-Scalable via multiplexed sprayers

-Relies on environmentally sustainable chemical reagents

Applications:

Production of commercially significant Nitrogen-containing compounds such as:

-Ammonia-based fertilizer

-Cleaning supplies

-Energetic materials

-Pharmaceuticals

-Cold storage and refrigeration systems

-Waste water treatment

-Various manufacturing industries (leather, rubber, paper, cosmetics, etc.)

TRL: 5

Intellectual Property:

Provisional-Gov. Funding, 2024-02-21, United States

PCT-Gov. Funding, 2025-02-18, WO

Keywords: Sustainable nitrogen fixation,Alternative ammonia synthesis,Low-energy nitrogen conversion,Microdroplet reaction chemistry,Green ammonia production,Post-Haber-Bosch process,Air-derived nitrogen utilization,Scalable chemical synthesis,Ammonia for fertilizer production,Environmental chemical manufacturing