TECHBRIEF

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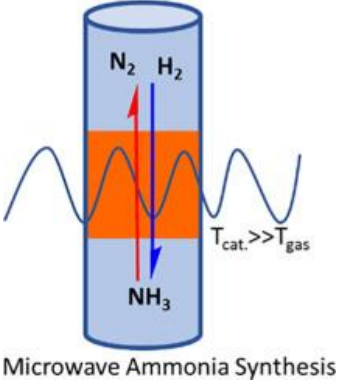

Microwave Ammonia Synthesis

Microwave-Assisted Catalysts for Ammonia Synthesis

Opportunity

Producing ammonia at smaller, distributed scales requires reaction pathways that are more responsive and energy-efficient than the high-temperature, high-pressure Haber–Bosch process. Researchers at the U.S. Department of Energy's National Energy Technology Laboratory (NETL), Battelle Memorial Institute, Florida State University (FSU) and West Virginia University (WVU) established a heterogeneous catalyst platform that leverages microwave energy to drive ammonia formation under significantly milder conditions. The catalysts consist of Group 7–11 metals, such as ruthenium, dispersed on metal oxide supports and optionally modified with alkali, alkaline earth or lanthanide promoters. Under microwave irradiation, these materials absorb energy volumetrically rather than through external heating, enabling rapid, localized activation of nitrogen and hydrogen at pressures as low as a few torr and up to 20 atm. This internalized heating mechanism enhances catalytic turnover at lower bulk temperatures while maintaining compatibility with modular, intermittently powered systems linked to renewable energy. The approach supports flexible, scalable ammonia synthesis outside of traditional Haber–Bosch infrastructure. This technology is available for licensing and/or further collaborative research from NETL in partnership with Battelle, FSU, and WVU.

Problems Addressed

- The conventional Haber-Bosch method is notoriously energy-intensive, consuming 1-2% of global energy due to its demanding operating conditions of high temperatures.
- The Economic viability of Haber-Bosch is largely confined to massive, centralized plants, making it incompatible with smaller, distributed energy sources, which produce limited power.

Potential Commercial Application

- Decentralized Ammonia Fertilizer Production: enables efficient, small-scale and distributed ammonia synthesis, perfectly suited for local fertilizer production in agricultural regions.
- Industrial Chemical Feedstock Production: offers a low-temperature, low-pressure, and energy-saving method for producing ammonia as a vital feedstock for various chemical manufacturing processes.

Competitive Advantages

- Lower Operating Conditions: microwave plasma catalytic process synthesizes ammonia at approximately 280°C and ambient pressure, significantly reducing the high temperatures (380–570°C) and pressures (150–250 atm) required by the traditional Haber-Bosch process.
- Enhanced Energy Efficiency: achieves over 30% energy savings compared to traditional processes by utilizing microwave energy to activate nitrogen molecules.

Intellectual Property Status

A U.S. patent (US10974969) was issued on April 13, 2021, and expires on September 11, 2038.

Publications

Y. Wang, et al. Microwave-enhanced catalytic ammonia synthesis under moderate pressure and temperature. Methods and compositions for microwave catalytic ammonia synthesis. (2021). Catalysis Communications. DOI: https://doi.org/10.1016/j.catcom.2021.106344.

Licensing

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