PROBE SONICATION CONVERTING NITRATES TO AMMONIA IN WATER

IITM Technology Available for Licensing

Problem Statement

- **Ammonia is an essential raw material** in various industries such as fertilizers, textiles, and chemicals. There is hence a **demand for energy-efficient and eco-friendly production** of Ammonia.
- **Conventional catalyst based Haber–Bosch process** is energy-intensive as it relies on high temperature and pressure **resulting in CO_2 emissions.**
- Further, **alternative methods** such as photocatalysis and biochemical synthesis have **slow reaction rates, reproducibility issues, and expensive catalyst** limitations.
- There is a **need for a method to produce ammonia in ambient conditions without catalysts** while enhancing yield and sustainability compared to existing technologies.

Intellectual Property

- IITM IDF Ref 2692
- **IN 202341087398 Patent Application**

TRL (Technology Readiness Level)

TRL 4 Technology validated in Lab

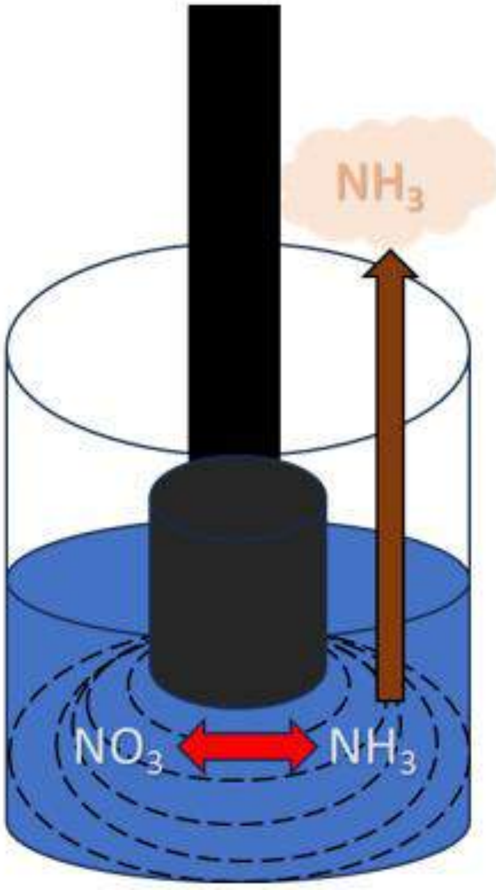
Technology Category/ Market

Category- Green Technology
Industry Classification:
Green Ammonia Production, Fertilizer manufacturing, Chemical manufacturing and Renewable Energy
Applications:
Green Ammonia production for use in fertilizer industry, refrigeration and use as hydrogen carrier for renewable energy.

Market report:
The global green ammonia market was valued at USD 0.29 Billion in 2024 and is projected to grow to USD 6.16 Billion by 2030 with a CAGR of 66%

Research Lab

Prof. Kothandaraman Ramanujan
Dept. of Chemistry



$$9H_2O \rightleftharpoons 9H^\cdot + 9OH^\cdot$$

$$K^+ + \boxed{NO_3^- + 8H^\cdot} + H^\cdot + 9OH^\cdot \rightleftharpoons NH_{3\,(aq)} + 7H_2O + KOH \rightarrow NH_{3\,(g)} \uparrow$$

Figure: Reaction pathway for the reduction of nitrate into ammonia during probe sonication. The inventors theorize that the ammonia is generated through a mechanism involving hydrogen radicals produced from the homolytic decomposition of H_2O.

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
ttooffice@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 9845

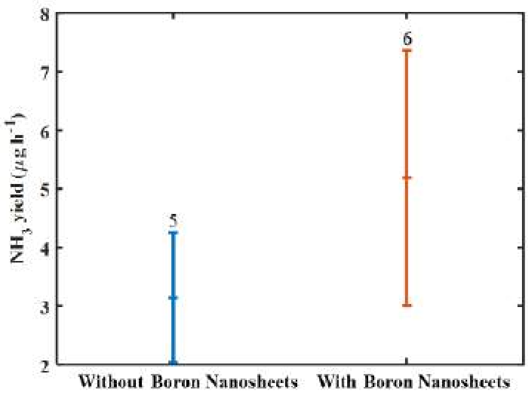


Figure: Depicts the variation in ammonia produced from 0.1 M KNO3 solution after 1 hour of sonication in the absence and presence of Boron nanosheets. Preventing the release of ammonia into the atmosphere is a method to increase the yield rate of ammonia. In this study, boron nanosheets were used as a matrix for the adsorption of NH3, which hindered its escape into the atmosphere. It was observed that the yield rate with boron nanosheets present was higher than the rate without it

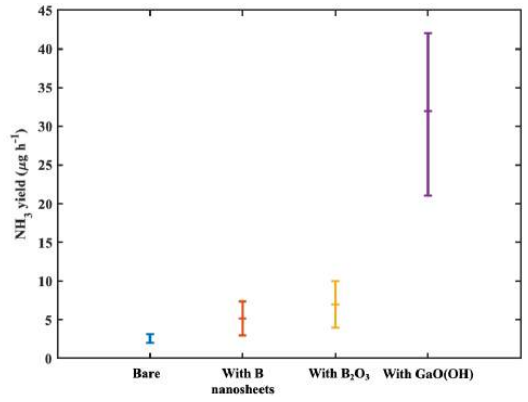


Figure: Depicts the yield rate of ammonia for the bare without any additive, with B nanosheets, with B2O3 and with GaO(OH). Upon the addition of B_2O_3, the yield is found to have doubled to 10 µg/h compared to an average value of 5 ug/h of Borophene. Whereas, with the addition of GaO(OH), the yield was found to have increased almost 3 times compared to that of the case with only 20 Borophene as an additive. The yield is found to be around 33 µg/h.

Technology

- The technology employs probe sonication in an aqueous nitrate solution to produce ammonia (NH_3) under ambient conditions, eliminating the need for high-pressure, high-temperature catalysts used in the Haber–Bosch process.
- **It generates hydrogen radicals via sonochemistry, which reduce nitrates (NO_3^-) to ammonia, and is compatible with various nitrate salts such as $NaNO_3$, KNO_3, or $LiNO_3$.**
- Process parameters include sonication power settings between 62.5 W and 250 W, temperature range from 25 °C to 80 °C (preferably ~35 °C), and sonication durations from 30 minutes to 24 hours.
- The invention supports both open and closed system configurations; closed systems minimize ammonia loss, and yield improvements are achieved using additives like boron nanosheets, B_2O_3, or GaO(OH).
- Ammonia detection uses an indophenol-blue method for precise quantification, while the process scales via intermittent sonication cycles, ensuring energy-efficient, sustainable production with broad industrial applications..

Key Features / Value Proposition

- The invented ammonia production method operates at ambient conditions (25–80 °C, ~1 atm), eliminating the high-pressure, high-temperature requirements of the conventional Haber–Bosch process and similar methods.
- Avoids the need for expensive and environmentally problematic catalysts, using probe sonication to generate hydrogen radicals that efficiently reduce nitrates to ammonia..
- The use of probe sonication accelerates reaction rates compared to alternative methods (photocatalysis, biochemical synthesis) which suffer from slow kinetics or reproducibility issues.
- Incorporation of additives (e.g., boron nanosheets, B_2O_3, GaO(OH)) apart from improving ammonia yield through adsorption and retention also minimizes losses while enhancing overall process efficiency.
- The energy-efficient, environmentally friendly approach reduces CO_2 emissions and is adaptable to both open and closed system setups, offering scalability and commercial viability for diverse industrial applications.

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
ttooffice@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 9845