Docket #: S18-281

Environmentally-friendly, localized ammonia and ammonium nitrate/fertilizer production

Researchers in Prof. Thomas Jaramillo's laboratory have developed an electrochemical method for local production of ammonia that simultaneously solves an environmental problem while also producing a valuable chemical product with a massive global market. This technology employs a highly selective electrocatalyst to produce ammonia and ammonium nitrate from recycled waste nitrates using water as a hydrogen source. This could reduce both production and distribution costs because does not rely on the standard Haber-Bosch process (which currently requires over 1 % of the entire global energy supply and 3-5 % of the natural gas supply for pre-requisite hydrogen production). On-site, low volume production of fertilizer also maximizes nitrogen utilization efficiency. Furthermore, the process can be directly coupled to renewable electricity to further lower environmental impact. Ammonia produced with this technology could be used as a chemical precursor, exploited as a fuel alternative or directly converted into fertilizer for agricultural use.

Stage of Research
The inventors have demonstrated that a titanium electrocatalyst for this reaction can achieve over 80% faradic efficiency toward ammonia. They are planning to develop a prototype.

Applications

- **Electrocatalytic ammonia and ammonium nitrate production** from water and nitrate for use as:
    - fertilizer
    - fuel alternative for energy storage from intermittent renewable sources (wind, solar, etc.)

    - chemical precursor to many nitrogen-containing chemicals (e.g., hydrazine, nitrous oxide and nitric acid)

Advantages

- **Energy efficient** - uses water rather than molecular hydrogen as a hydrogen source for the reaction, which could reduce overall fossil fuel and energy consumption for ammonia synthesis
- **Environmentally friendly:**
    - converts waste (nitrate runoff) into useful product (ammonia or ammonium nitrate)
    - can be directly integrated with wastewater treatment (nitrate salt capture and concentration) technologies currently under development for water purification
    - can be coupled with renewable energy to lower carbon dioxide emissions
- **Localized production** - does not require large, centralized plants, enabling on-site production of ammonia and fertilizer:
    - lowers distribution costs
    - increases utilization efficiency when fertilizer can be directly applied to crops
    - allows end-users to control their own supply
- **Lower cost infrastructure** - could operate at significantly lower pressures than the Haber-Bosch, potentially lowering equipment and operational costs

Publications

- J.M. McEnaney, S.J. Blair, A.C. Nielander, J.A. Schwalbe, D.M. Koshy, M. Cargnello and T.F. Jaramillo Electrolyte Engineering for Efficient Electrochemical Nitrate Reduction to Ammonia on a Titanium Electrode *ACS Sustainable Chem. Eng.* February 14, 2020.

Patents

- Published Application: WO2020028570

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