Small-Scale Catalytic Ammonia Production Technology

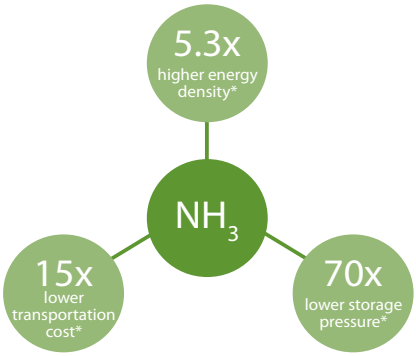
Innovation and Impact

- Development of a breakthrough ammonia synthesis catalyst for faster kinetics, enabling operations at lower temperatures and thereby simplifying the ammonia loop, potentially lowering power consumption by ~35%
- Novel ammonia loop control under intermittent loads lowering gas and energy storage needs
- Optimized and scalable advanced, low-cost technology for air separation and polishing for theproduction of fast-response, high-purity nitrogen

Importance and Challenges of Ammonia

Ammonia is an attractive storage medium for connecting remote, intermittent renewable energy sources with end-use demand. Integration of key innovations with state-of-the-art technologies will enable cost-effective scaling down of the ammonia synthesis required for coupling with intermittent energy sources. Small-scale ammonia, necessitated by the size of renewable energy sources, introduces other challenges:

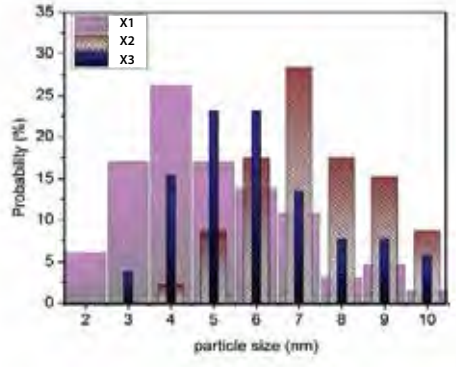
- Simplification of the ammonia loop for energy and cost-effective scale-down
- Management of fluctuations in temperature and loss of reactants resulting from the variability of renewable power
- Low volumes of high-purity nitrogen at lower cost

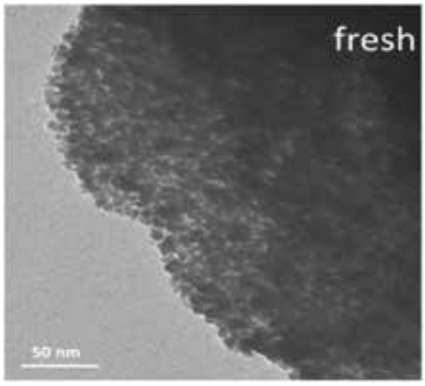


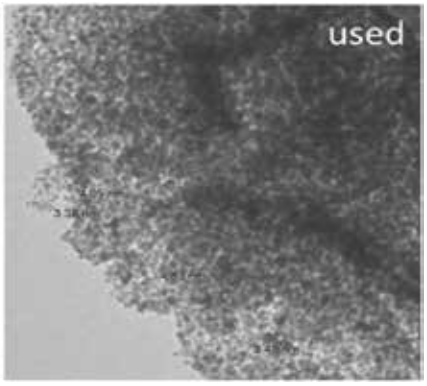
*Compared to liquid H_2 from electrolysis, the simplest carbon-neutral liquid fuel

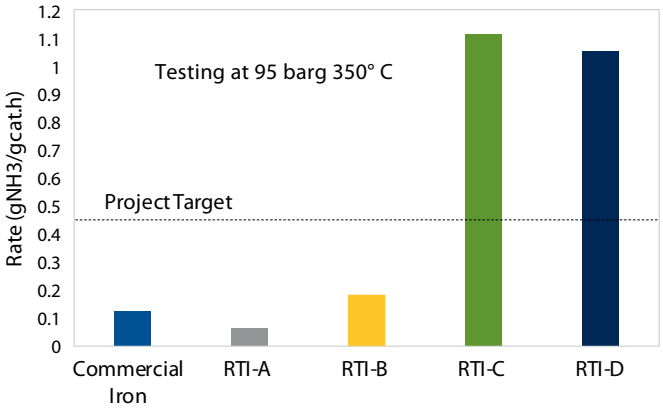
Innovations in Materials Development

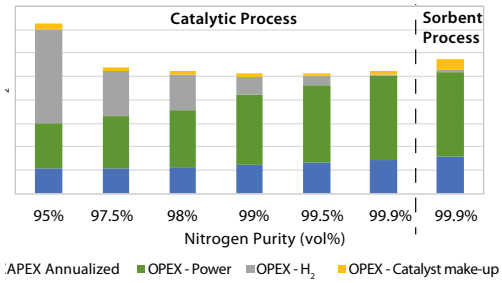
RTI International is developing a novel, patent-pending metal organic framework (MOF)–based ruthenium catalyst for ammonia synthesis. Our optimized approach has led to the development of synthesis methods that offer fine control over particle size and surface area. RTI's catalysts are robust and have shown much higher activity than commercially available iron catalysts, enabling us to significantly reduce reactor operating temperatures. Additional catalyst development and testing will focus on further dropping operating temperatures from ~450–500 °C seen in traditional processes to 300 °C, which will result in benefits in process design and integration.











Innovation in Process Design and Development

Air Separation and Optimization

RTI is evaluating non-cryogenic air separation methods to determine appropriate nitrogen purity levels, sizes, and costs. Along with experimental validation of nitrogen polishing to bring contained oxygen down to <10 ppm, we are developing an optimized high-purity nitrogen supply with low delivered costs and fast response to intermittent loads.

Variable Load Ammonia Loop

RTI is also working to demonstrate a patented philosophy for ammonia plant control when subjected to irregular loads. Loss of or reduction in electricityleads to reduced feed volume, which often results in temperature runaways from increased rates of reaction and fatigue failure of vessels from associated pressure changes. The demonstration of the patented concept will achieve up to 90% turndown at a 10 kg/day NH_3 scale.

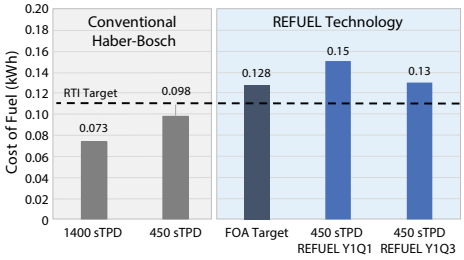
Integrated Process Development

RTI aims to demonstrate the innovations developed in this project in an integrated system producing 10 kg NH_3/day. This will involve scaled-up production of advanced MOF–based catalysts, nitrogen polishing, and advanced plant controls. A robust operation of at least 500 hours on-stream, with at least five instances of scheduled intermittencewith 90% turndown, is planned.

Technology-to-Market Assessments

RTI's technologies are well on their way to meeting cost targets. RTI is investigating two strategies for entry-to-market of the technologies developed in this project:

- Advanced high-performance ammonia synthesis catalysts suitable for plant retrofits
- Entire value chain of the process for greenfield opportunities



More Information

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Renewable Energy to Fuels through Utilization of Energy-Dense Liquids (REFUEL)

ARPA-E's REFUEL program focuses on the development of scalable technologies to produce carbon-neutral liquid fuels using only air, water, and renewable electricity as input streams.

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