



# Simplified, Single-Vessel Synthesis and Separation of Ammonia

**An apparatus and process for simplified, high yield production of ammonia using a single vessel, isothermal reactor.**

**IP Status:** Pending US Patent; **Application #:** 16/849,550

## Problem

The Haber-Bosch process, the standard synthesis technology to make ammonia, reacts nitrogen gas and hydrogen gas at high pressures and temperatures over an iron-based catalyst and then separates the ammonia from the reaction mixture by condensation. Major drawbacks of Haber-Bosch are the low yield of ammonia requiring recirculation of reaction gases, hazards, and cost of high pressure and temperature reaction conditions. These major drawbacks result in very large investments to build and maintain centralized ammonia production plants that are complex, costly and hazardous to operate.

## Solution

Researchers at the University of Minnesota have developed a reaction apparatus that combines catalyst and absorbents in a single vessel. When this vessel is charged with hot, compressed nitrogen and hydrogen, at low pressures, ammonia is formed just as it is in the Haber-Bosch process. However, unlike the Haber-Bosch process, ammonia production is much more efficient with higher conversion rates (75% vs. 20% in the Haber-Bosch process). In addition, as reaction and separation process takes place in a single vessel, the process is more energy efficient and reduces the capital and operating costs significantly. Furthermore, reducing the complexity and hazards opens up possibilities for smaller, decentralized plants for ammonia production.

## Phase of Development

Proof of concept: lab-scale reactor tested. Continuing to optimize absorbents.

## Features & Benefits

- 75% conversion rate of reactants to ammonia
- Simplified apparatus lowers cost of implementation
- Isothermal operation reduces production cost and time
- Scalable and energy-efficient process

## Applications

- Small and large scale production of ammonia

## Researchers

Edward Cussler Jr, PhD

*Professor Emeritus, Chemical Engineering & Materials Science*

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Alan McCormick, PhD

*Professor, Chemical Engineering & Materials Science*

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