A Novel Ammonia Synthesis Catalyst Promoter for the Haber-Bosch Process

Our novel ammonia synthesis catalyst:

- 200% increase in activity compared to conventional industrial catalysts;
- Produces the same amount of ammonia at reduced synthesis temperatu
- Produces the same amount of ammonia at reduced synthesis pressure;
- Has good stability using non-purified nitrogen and hydrogen precursors.

Warwick Ventures has available for licence a novel catalyst promoter for improving the efficiency of ammonia synthesis using the Haber-Bosch process. Researchers at Warwick have demonstrated a 200% increase in catalyst activity compared to conventional industrial Fe-based catalyst.

The increased activity is achieved at a lower temperature than conventional Fe catalysts, offering potential for significant savings in energy consumption and costs compared to current processes. The new catalysts also have excellent tolerance to oxygenate impurities in the feed gases, with demonstrated stability over 200 hours with continuous feeds of 99.995% pure N_2 and H_2. This property can reduce the necessity for advanced purification stages, thus reducing the design, operating and maintenance costs of new ammonia plants.

The new catalyst promoter would be of interest to companies involved in ammonia synthesis through conventional Haber-Bosch process, typically for the production of nitrogen fertilisers such as ammonia, ammonium bicarbonate, ammonium sulphate or urea. It is also suitable for small scale ammonia synthesis reactors using renewable electricity as the energy sources via electrolysis of water for hydrogen production and air separation for nitrogen generation, to be used as the precursors for ammonia synthesis. We also consider capital investment to set-up a company to mass produce this novel catalyst.

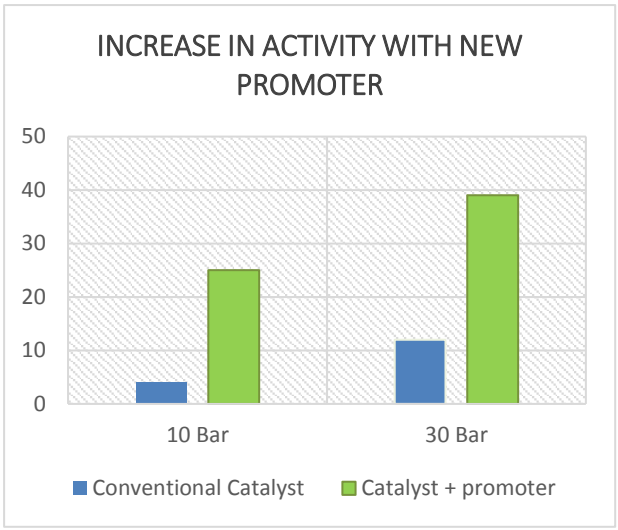

Figure 1: Ammonia production (mmol g^{-1} h^{-1}) at 450° C

BACKGROUND

Ammonia is the second most produced inorganic chemical in the world, with an annual production of 150 million tons. The production of ammonia also accounts for approximately 1% of the world's energy consumption, 4% of the world's consumption of natural gas, and contributes approximately 1% of global CO_2 emissions. Ammonia synthesis is dominated by the Haber-Bosch process, named after the two key inventors who won Nobel prizes in chemistry. The current Fe-based catalyst invented by Fritz Haber is excellent but the requirements of high temperature and high pressure demand significant energy (and cost) inputs which dominate the environmental impact of new plants and limit the adoption of ammonia as a cost-effective energy storage medium. For both centralised and de-centralised Haber-Bosch processes, a catalyst which allows for the operation of this

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reaction at reduced temperature and pressure is desirable to lower the cost of the reaction and increase the efficiency. Low tolerance of oxygenates is another issue of conventional ammonia synthesis catalysts. Our catalyst has an excellent tolerance to oxygenates as good stability has been observed when cylinder nitrogen and hydrogen were directly used as the precursor for ammonia synthesis without further purification.

INVENTION

Researchers at the University of Warwick have developed a novel ammonia synthesis catalyst promoter which, when blended with conventional Fe-based catalysts, delivers much higher activity compared to the conventional commercial Fe-based ammonia synthesis catalyst alone. The optimised operating temperature of the Warwick catalyst is 450 °C which is about 50 °C lower than the commercial Fe-based catalyst. At 450 °C, the activity of the Warwick catalyst is approximately five and three times of that of the bench mark industrial Fe-based catalyst at both 10 and 30 bar respectively (Figure 1). The activity of the Warwick catalyst at 400 °C is about 150% of that for the industrial catalyst at 500 °C, which means our catalyst can be operated at much lower temperature. At 450 °C, the activity of our catalyst at 10 bar is about twice of the activity of commercial catalyst at 30 bar indicating ammonia can be synthesised at much lower pressures. A stability test of 200 hours has been carried out when no further purified cylinder nitrogen and hydrogen were directly used as the precursors for ammonia synthesis.

We anticipate that our catalyst can be directly integrated to existing plants with minimum modification. This will save both energy and operating costs. Further operating costs may be possible for new build plants by reducing the requirement for complex purification stages due to the tolerance of oxygenates.
450 °C

KEY FEATURES

Our novel ammonia synthesis catalyst:

- Has increased activity, typically a 200% increase over conventional industrial catalysts;
- Produces the same amount of ammonia at reduced synthesis temperature;
- Produces the same amount of ammonia at reduced synthesis pressure;
- Drop-in technology – no requirement to modify existing plant (but further cost savings possible for new plants)
- Good stability using non-purified nitrogen and hydrogen precursors;
- Suits both centralised and de-centralised Haber-Bosch processes.

PROOF OF CONCEPT DATA

The scientists have generated significant proof of concept data, the details of which are available under a Confidentiality Agreement. Below is a summary of the results:

- The activities of the catalyst at 10 and 30 bar and different temperatures;
- Primary long term stability of the catalyst using cylinder nitrogen and hydrogen without further purification.

IP POSITION

A UK patent application (GB 1806687) has been filed on the new catalyst promoter technology. The patent and the associated intellectual property are available for licence through Warwick Ventures. We also welcome investors to discuss on potential investment of a new company for mass production of this family of novel catalyst.

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