Indian Academia-Industry Collaboration in Developing Novel Process for Hydrazine Hydrate

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The process technology for Hydrazine Hydrate (HH) is highly desired in India. The CSIR-Indian Institute of Chemical Technology (CSIR-IICT) achieved a breakthrough in developing the HH technology indigenously in close association with a premier industry partner, Gujarat Alkalies and Chemicals Limited (GACL). The technology comes in the purview of Make-in India, Sashakt Bharat and Atmanirbhar Bharat initiatives.

Applications of Hydrazine Hydrate

Segment	Percentage
Polymerisation and Blowing Agents	35%
Agrochemicals	20%
Water Treatment	25%
Pharmaceuticals	8%
Others	12%

Import Substitution

Due to India's reliance on imports for 100% of HH, there was a pressing need to substitute this valuable chemical product with a domestic alternative. However, international collaboration was not an option, as the countries manufacturing HH were solely interested in selling the product and did not offer the necessary technology. Compounding the issue, the plant in India that previously produced HH through the urea route had ceased production and closed its operations.

In response, innovative solutions were developed to address knowledge gaps and overcome scientific and technical challenges in the creation of an eco-friendly process. By partnering with manufacturers of intermediates, who currently rely on imports, it is possible to achieve direct sales of up to 70% of the HH production capability (about 7000 tons).

Highlights

- The developed process differs from others in terms of its energy efficiency and environmental friendliness.
- Able to recover, regenerate, and reuse solvents and key raw materials without any loss in yield and conversion.

- High-purity product specifications meet international standards.
- Zero effluent generation.
- Commercially viable process.

Innovation

- HH technology is developed for the first time in India through an indigenous improved process route. Other manufacturers of HH are LANXESS, Arkema Group, Lonza, Weifang Yaxing Chemical Co. Ltd. and Otsuka-MGC Chemical Company, Inc.
- The process developed *via* the peroxide-ketazine route is novel and superior to other routes, such as the urea route, because it avoids hydrazine decomposition, consumes less ammonia, and produces high yields with minimal effluent generation.
- The process adopted a pressure reactive distillation for carrying out the hydrolysis reaction for the production of 40% HH, resulting in an 85% yield of high-purity product. The product was concentrated to 80% HH using simple distillation. The present route of production of 80% HH is a green process with any effluent water generated was treated chemically, biologically, and with membrane processes for reuse. The product meets international norms for impurities, making it marketable for export.
- Experiments conducted at bench scale – 100 g/h were successfully tested for yields, conversions, properties' data and operability. The process was scaled up to 12 kg/h. A pilot plant was designed and successfully commissioned/operated for more than a year. The pilot plant aided in data collection for the design and engineering of the 10000 TPA HH commercial plant, which is constructed at GACL Dahej Complex, Gujarat, in association with Larsen & Toubro (LTHE), Mumbai, which is the EPCM (Engineering Procurement Construction Management). Around 400 kg of HH was produced in the pilot plant, which was sent for seed marketing of the product that met international specifications.

Process Development

- The process was scaled up to a pilot scale of 12 kg/h. A pilot plant was designed and successfully commissioned/operated for more than a year.
- Around 400 kgs of HH was produced in the pilot plant, which was sent for seed marketing of the product that met international specifications.
- The pilot plant aided in exploring the design and engineering data generation for the 10,000TPA HH commercial plant.
- The commercial plant construction is completed at GACL, Dahej Complex, Gujarat, and process trial runs are in progress.

Scale–up

Scale-up was done for standardisation of process and steps, recoveries, recycle studies, data collection for the design of the commercial plant from lab to bench scale and bench scale to pilot scale and final commercial scale design.

Advantages

- The indigenous technology, the first of its kind in India, to have a commercial plant of substantial capacity.
- GACL leverages its in-house production of key raw materials, including hydrogen peroxide and ammonia from its sister company, giving it a competitive advantage.
- The technology developed is on par with global standards and practised by international players.
- The investment in the technology promises a reasonably attractive payback period of 5-7 years.

Patents

Joint Patents Granted, with our Industry Partner:

- Indian Patent No. 378643 Dated 05 Oct 2021 - An Improved Process For Production Of Hydrazine Hydrate; Applicants: Council of Scientific & Industrial Research, New Delhi (IN); Gujarat Alkalies and Chemicals Limited, Gujarat (IN).
- United States Patent No. US 11,225,413 B2 (45) Dated 18 Jan 2022 - Process For Production Of Hydrazine Hydrate; Applicants: Council of Scientific & Industrial Research, New Delhi (IN); Gujarat Alkalies and Chemicals Limited, Gujarat (IN).

Export potential

GACL's strategic location near Middle Eastern and African countries provides it with an advantage for exporting HH. The company can compete with manufacturers from China and Europe in terms of pricing and quality. However, at present, India needs all its HH production for domestic use, and there are no plans to export the technology.

Market Demand

- HH has a huge market demand, and the technology will open a new chapter in India for its usage, as the country has previously relied entirely on imports.
- The global HH market value is expected to grow rapidly and cross US$784 million by 2033.
- Asia-Pacific is one of the largest markets for HH, with the maximum consumption from countries, such as China, South Korea and India.
- The mandate to produce HH is also to meet the growing demand of manufacturing azodicarbonamide required as a foaming agent in the polymer and plastic industry.
- HH finds applications in the manufacture of pesticides and some value-added chemicals in the pharma industry.

The above factors are expected to drive the HH market in the next decade.

Commercial plant overall picture:

- Plant capacity: 10,000 tons per annum of 80% HH
- Annual Turnover: 300 crores per annum (@Rs. 300/- per kg of HH)
- The cost of the commercial plant is around Rs. 405 crores.
- ROI is 5–7 years.

Plant construction and mechanical commissioning are completed. Process trial runs are in progress. Commercial production is expected between March 2023 to June 2023.

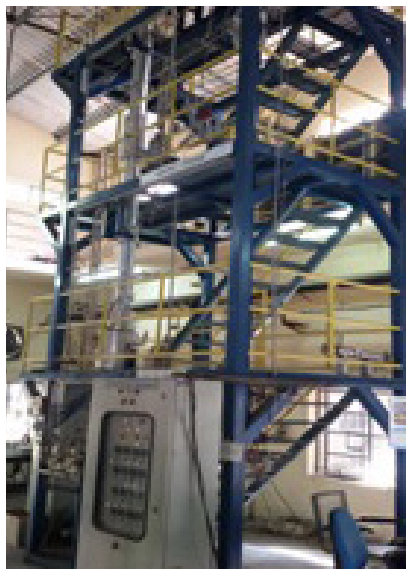
The development of HH process technology has received a couple of prestigious awards:

Golden Peacock Award 2020



FICCI R&D AWARD 2017



LAB/BENCH SCALE UNIT AT CSIR–IICT HYDERABAD	PILOT PLANT AT GACL DAHEJ COMPLEX GUJARAT
	
 HH COMMERCIAL PLANT SIDE VIEW	 HH COMMERCIAL PLANT NIGHT VIEW

HYDRAZINE HYDRATE COMMERCIAL PLANT

CENTRALISED DISTRIBUTED CONTROL SYSTEM

CONTROL ROOM

