Technology Development and Commercialisation of a Novel Sweetening catalyst –'Thoxcat ES™' for LPG and Lighter Petroleum Fractions

Sudip K. Ganguly[a,*], Sunil Kumar[a], Vivek S. Rathore[b], Bharat Newalkar[b], Atul Ranjan[a], Anjan Ray[a]

[a]CSIR-Indian Institute of Petroleum, Dehradun, Uttarakhand, India

[b]Bharat Petroleum Corporation Limited, Corporate R&D Centre, Greater Noida, Uttar Pradesh, India

E-mail: sganguly@iip.res.in

About Technology

The presence of mercaptans in petroleum products like liquefied petroleum gas (LPG), naphtha, gasoline, aviation turbine fuel (ATF), and kerosene is undesirable due to their foul odour and highly corrosive nature. In commercial practice, the lower molecular weight mercaptans present in LPG and light straight run naphtha (LSRN) are extracted with alkali and catalytically oxidised to disulfides with air. This process is termed extractive sweetening. The mercaptans in slightly heavier straight-run naphtha or light thermally cracked naphtha are converted to disulfides by a liquid-liquid sweetening process where both extraction and oxidation occur in the same vessel. In the absence of a sweetening catalyst, excess use of alkali solution makes the two approaches expensive and time-consuming.

In order to achieve import substitution, CSIR-Indian Institute of Petroleum (CSIR-IIP) in collaboration with Bharat Petroleum Corporation Limited (BPCL), has developed Thoxcat ES™, a liquid catalyst in a dilute alkaline solution, for use in processes that involve the oxidation of mercaptans found in LPG/lighter petroleum fractions. This catalyst is intended for use in the petroleum refining industry and has been licensed to M/s LONA Industries, Mumbai since 2007, with a royalty earning of 10% from the sale of the catalyst.

Around 50% of Indian refiners are using Thoxcat ES™ for sweetening LPG. As a way forward IIP-BPCL team has embarked since 2015 on commercialising the sweetening catalyst outside India. It was successfully trialled at Oman Refineries and Petro Chemicals (ORPIC), Oman, in 2016 and at Saudi Aramco in 2020. The product has been approved for regular consumption in its six units in Saudi Arabia.

As a way forward, IIP-BPCL plans to cover at least 10% of the global market in the next five years.

Bulk Production of Thoxcat ES™ at Lona Industries Limited

Lona was established in the year 1962 at Lonavala, Mumbai. It was identified for proven expertise in the production of phthalocyanines. Mr S.R. Dhote is the Chairman and Managing Director of the company,

with a turnover of roughly Rs 250 Crore per annum. The company is engaged in manufacturing metal phthalocyanine-based products exported to the international market, including countries like Canada, UK, Italy, Spain, the USA, Brazil, Turkey, Australia, Japan, Taiwan, Thailand, South Korea, Indonesia, and China.

Keeping in view Lona's potential expertise for producing metal phthalocyanine and its various derivatives, CSIR-IIP and BPCL management entered into an agreement with M/s Lona Industries Limited in September 2007 for regular production and supply of this catalyst, which is a metal phthalocyanine complex. The tripartite agreement was renewed in September 2017.

The production of Thoxcat ES™ at Lona gave employment benefits to around 20 skilled workforces of local origin, which helped in the economic upliftment of their families. We could fulfil the demand of about 25 tons of this catalyst of refinery users since 2007. Yearly production has nearly doubled after ME refineries accepted catalyst for regular use in 2020. The royalty model is 10% to our licensors CSIR-IIP and BPCL on sales realised.

Novelty of Thoxcat ES™

- Thoxcat ES™ demonstrates twice the activity of its competing commercial catalysts.
- The liquid form of Thoxcat ES™ does not gel during extended periods of storage.
- As cobalt phthalocyanine sulphonamide is insoluble in acidic mediums, its isolation is easier during preparation.
- Unlike conventional ones, preparing this catalyst does not require the use of oleum, a highly hazardous and corrosive substance.
- No carryover even in high mercaptide conditions, making it ideal for Middle East (ME) refineries.
- Thoxcat ES™ has a shelf life of 3 years and is cost-competitive.

Quality Control & Hand Holding

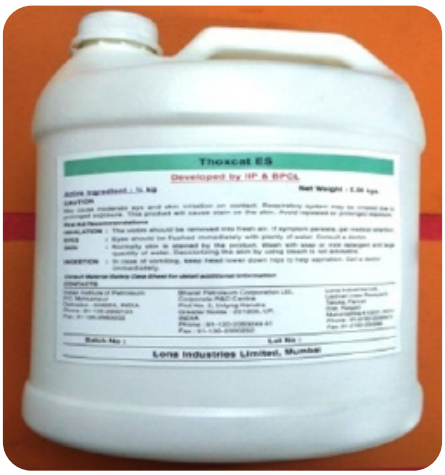
Before supplying to refineries, CSIR-IIP conducts rigorous quality control tests on each batch of produced samples to ensure their clearance. In case of any variation in quality, the BPCL team works closely with CSIR-IIP to identify corrective measures and modifications in the synthesis strategy. They also keep regularly updating on the product's upgrade strategies. Additionally, CSIR-IIP provides hands-on assistance in the form of plant visits during trial productions for new formulations.



Lona Factory



Thoxcat ES™ Product Bottle



Lona Production Facilities

Commercialisation in India

The refinery trial performance proved lower catalyst consumption than another commercial catalyst for similar conversion, validating the catalyst's higher activity. Successful industrial trial runs reflecting its consistent higher activity and lower consumption rates formed its basis for commercialisation. The first successful commercialisation occurred in December 2007 in BPCL Mahul Refinery. Subsequently, the catalyst was commercialised in nine other Indian refineries, namely, HPCL (Mumbai), HPCL (Visag), BORL (Bina), HMEL (Bhatinda), MRPL (Mangalore), IOCL (Digboi & Paradip), RIL (Jamnagar) and BPCL (Kochi). **Today, nearly 50% of the Indian Refinery demand for LPG sweetening catalysts is being met by Thoxcat ES™**.

Commercialisation Challenges in the Middle East & Reformulation for its Solution

During the trial runs at ME refineries, it was observed that the plant configurations were different from those in Indian refineries. One significant issue that arose during the trials was the higher tendency for foaming, which was tentatively attributed to high and fluctuating mercaptide levels in the oxidiser feed. This unique design challenge had not been encountered in Indian refineries before. Additionally, the higher ambient temperatures in the ME region throughout the year were also hypothesised to contribute to this foaming behaviour. In response to this challenge, CSIR-IIP and BPCL R&D conducted a detailed parametric study to reformulate the catalyst and improve its foam control feature, ensuring a competitive edge over alternative sweetening systems. The reformulated catalyst was successfully trialed and accepted for regular use in ME refineries. ***This is the first instance in CSIR-IIP that a CSIR-developed catalyst has been marketed abroad***.

Way Forward

The current catalyst is a co-invention of **"CSIR-IIP"** and **"BPCL,"** which is in line with the present concept of "**Make in India**." The invention is protected by nine patents, including two in the USA, two in the UK, two in France, and three in India. The catalyst has been successfully demonstrated and commercialised in ten Indian refineries and two refineries in the ME.

The efforts put into inventing, developing, and commercialising the novel cobalt phthalocyanine sulphonamide catalyst have been recognised by four national awards, including the prestigious CSIR Technology Award for "**Innovation**" in 2007 and the **"Most Significant CSIR-Technology Award**" in 2015 for the development and commercialisation of Thoxcat ES™ LPG sweetening catalyst.

Being techno-economically superior, the catalyst has been successfully implemented in 10 out of 23 refineries in India and 2 refineries in the Middle East. Kochi Refineries Limited is presently conducting trials for their Coker LPG units, while Nayara plans to initiate trials soon. It has the potential to replace the existing commercial catalysts the world over. CSIR IIP-BPCL targets commercialising "Thoxcat ES™" in 25 refineries within two years, focusing on ME refineries and in 70 refineries globally over the next five years.