

Catalysis research in India and the role of the Catalysis Society of India

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1. Catalysis research in India

1.1. Historical perspective

The earliest recorded formal catalysis research in India is probably the work of Sir J.C. Ghosh of Dacca University (in the undivided India) on Fischer–Tropsch synthesis in 1924. After India achieved independence, the government established a number of higher educational and research centers, particularly the Council of Scientific and Industrial Research (CSIR) and the Indian Institutes of Technology (IITs), to build infrastructure and to encourage technical and scientific research in different areas of science. In the 1950s, the priority of the new nation was in the agricultural sector. Accordingly, catalysis research grew up with understanding and development of catalysts used in the fertilizer industry at the Projects and Development India Ltd (PDIL) of the government-owned Fertilizer Corporation of India (FCI) at Sindri. In the 1960s, research in catalysis flourished at different establishments, i.e., IITs at Kharagpur, Chennai and Mumbai, the Indian Institute of Science at Bangalore, the Jesuit Loyola Collage at Chennai and at the Regional Research Laboratory (RRL) at Hyderabad mostly on the fundamental aspects of catalysis, physical adsorption and chemisorption on different solid systems. During the 1970s, the rapid industrial growth of India required more relevant research in catalysis in the areas of petroleum refining, petrochemicals and coal at additional centers: the Indian Institute of Petroleum (IIP) at Dehradun, the Central Fuel Research Institute (CFRI) at Dhanbad, and the National Chemical Laboratory (NCL), Pune. During this period many industrial R&D centers also opened (Hindustan Lever Research Centre, Associated Cement Co., Alchemie Research Centre, Indian Oil Corporation, etc.). Due to the rapid growth in Indian per capita consumption of petroleum and petrochemical products during the 1970s, most of the laboratories initiated projects on the development of catalysts for petrochemicals and petroleum refinery processes with an emphasis on self-sufficiency and

indigenization rather than on innovation. The Indian Patent Law offered sufficient protection to Indian industries in pursuing novel methods of making catalysts and materials. Catalysis research soon expanded to cover topics such as synthesis and application of zeolites, molecular sieves, metallosilicates, novel materials, supported catalysts, electrocatalysis and photocatalysis.

1.2. Catalysis research in recent times

India opened its economy to outside investment during the early 1990s and the policy changes benefited the economy, created new jobs and provided sustained economic growth. (economic growth was 1.2% in 1991–92 and about 5.5% in 1994–95). These reforms and the resulting improvements for investment now attract more and more multinational companies to India to tap the huge Indian market. Companies like General Electric, USA; Unilever; and SABIC, Saudi Arabia, have now set up their own R&D centers in India. Indian catalysis research and development today is geared to serve the needs of the country on the one hand and the more challenging global requirements on the other. The research is focused, as elsewhere in the world, on innovative solutions to the problems of environmental pollution, safety in industrial practice and nil or low by-products formation (higher selectivities) in chemical reactions, with ways of saving energy. Catalysis R&D in Indian institutions (both at national and industrial R&D centers) now looks forward to the development of competitive catalysts and processes that are required to meet these challenges. The general areas of catalysis research in India and the organizations involved are presented in table 1.

1.3. Achievements of catalysis research in India

An early goal of catalysis research in India was the development of indigenous catalysts and processes to save foreign exchange and increase the self-reliance of the nation. This has resulted in many achievements in the fertilizer, petroleum refining and petrochemical

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Table 1
Catalysis research activity in India

No.	Institution	Area of research	Commercialized catalysts/processes
National laboratories			
1	Central Electrochemical Research Institute, Karaikudi	Electrocatalysis	
2	Central Fuel Research Institute, Dhanbad	Liquifaction of coal and hydrotreatment, coal-derived chemicals	
3	Central Salt and Marine Chemicals Research Institute, Bhavnagar	Clays, metal complexes	Synthesis of zeolites
4	Indian Institute of Chemical Technology, Hyderabad	Supported metals and oxides for hydrogenation, ammonia synthesis, oxychlorination, catalysts for CFC substitutes	Benzene hydrogenation, manufacture of HFC, solid catalysts based on organic transformations
5	Indian Institute of Petroleum, Dehradun	Aromatization, FCC, HDS, hydrocracking, reforming, auto-exhaust catalysts	Bimetallic reforming catalysts, Merox catalysts, LPG from light naphtha
6	National Chemical Laboratory, Pune	Alkylation, CI chemistry, auto-exhaust catalysts, carbonylation, hydroformylation, dewaxing, FCC, isomerization, reforming, zeolites, selective oxidation, H ₂ production, Fischer–Tropsch synthesis	Ethylbenzene, <i>p</i> -diethylbenzene, formaldehyde, monometallic reforming, linear alkyl benzene (semi-commercial), xylene isomerization, zeolite synthesis, isomerization of <i>o</i> -dichlorobenzene
7	National Environmental Engineering Research Institute, Nagpur	Auto-exhaust catalysts, zeolite synthesis	Non-noble metal catalysts for exhaust purification
8	Regional Research Laboratory, Bhubaneswar	Catalysis by clays and minerals	
9	Regional Research Laboratory, Thiruvananthapuram	Clays, zeolites	Clay beneficiation
Industrial R & D centers			
1	Associated Cement Co., Thane	Alkylation, isomerization, auto-exhaust catalysts, zeolites	Diphenyloxide, reforming catalysts, catalytic converters, xylene isomerization
2	Alchemie Research Centre, Thane	Speciality catalysts	
3	Gujarat State Fertilizer Corp., Vadodara	Hydrogenation, dehydrogenation, selective oxidation	
4	Hindustan Lever Ltd, Mumbai	Hydrogenation of oils, FCC, zeolites	Supported Ni catalysts
5	Indian Oil Corporation, R&D, Faridabad	Auto-exhaust, FCC, hydrocracking, deep HDS, hydroprocessing	FCC catalysts, FCC additives
6	Indian Petrochemical Corp. Ltd, Vadodara	Alkylation, dehydrogenation, isomerization, reforming, transalkylation, zeolites	Dehydrogenation of alkanes, reforming catalysts, <i>p</i> -diethylbenzene, xylene isomerization, aromatics from LPG
7	Chennai Petroleum Corporation Ltd, Chennai	Petroleum-related catalysts Fertilizer-related catalysts	Almost all catalysts used in Indian fertilizer industry
8	Projects and Development India Ltd, Sindri		
9	General Electric (GEITC), Bangalore	Polymer/ related catalysts	
10	SABIC RRD, Vadodara	Petroleum refining-related research	
Universities/educational institutes			
1	Bhabha Atomic Research Centre, Mumbai	Various fundamental studies, supported metals	
2	Indian Institute of Technology, Mumbai, Kharagpur and Chennai	Various fundamental studies	
3	University Institute of Chemical Technology, Mumbai	Catalytic reaction engineering, fundamental studies, phase transfer catalysis	
4	Indian Institute of Science, Bangalore	Synthesis of microporous materials, modeling	
5	Universities at Mumbai, Chennai, Vadodara, Cochin, Guwahati and Goa	Mostly basic research; many areas	

sectors. For example, Projects and Development India Ltd Sindri has commercialized a number of catalysts used in the production of nitrogenous fertilizers at Fertilizer Corporation of India facilities and elsewhere. The Indian Institute of Petroleum has commercialized catalysts in secondary processing (catalytic reforming, mercaptan oxidation) while the Indian Petrochemicals Corporation Ltd and the National Chemical Laboratory have commercialized many catalysts and processes in the petrochemical and chemical sectors. Although most catalysts were developed for substitution in the existing processes, there have been improvements in selectivities and stability. In addition, a number of novel catalysts and processes have also been developed. The catalysts and processes developed by research in India are listed in table 1.

1.4. Manufacture of catalysts

Many of the catalysts used in the production of nitrogenous fertilizers were developed and commercialized by PDIL in the early 1960s and 1970s. These developments were unique in that these catalysts were probably the very first indigenous ones to be put into commercial use in India, as agriculture was the primary concern for the country soon after independence. These catalysts are for steam reforming, shift conversion, desulfurization and methanation. Subsequently, some of these catalysts were even exported. PDIL was the first in India to set up catalyst manufacturing and testing facilities.

The important catalyst manufacturers in India are PDIL, IPCL, SCIL (Süd Chemie India Ltd) and HLL. IPCL possesses a facility at Thane for the production of adsorbents and catalysts. In addition to making a variety of molecular sieve-type adsorbents, the catalysts developed at the IPCL R&D center at Vadodara are scaled up at this facility. SCIL is a subsidiary of Süd-Chemie and has facilities at Cochin and Vadodara to manufacture a wide variety of catalysts used in the fertilizer, petroleum and petrochemical industries. SCIL has recently began the manufacture of catalytic converters for automotive emission control. Auto-exhaust converters are mainly manufactured by Engelhard and Johnson-Mathey. Hindustan Lever Ltd at Mumbai manufactures Ni-based hydrogenation catalysts for the production of oils and fats and markets its catalysts in India and abroad. Other catalyst manufacturers are Catalysts India Ltd, Mumbai (V_2O_5 -based oxidation catalyst) and Indian Explosive Ltd, Kanpur (fertilizer catalysts). Limited catalyst production facilities are also available at Associated Cement Co., Thane, and at NCL, Pune.

1.5. Future trends in catalysis research in India

1.5.1. Globalization

With the opening up of the Indian market for global business, catalysis research aimed at the indigenization

of catalysts has lost relevance. The focus of research has now shifted towards globally competitive catalysts and processes which can be exported to other countries. As a result of this approach, a few novel catalysts/processes have been developed in niche areas. Typical of these are IIP's adipic acid process, IPCL's *p*-xylene from toluene process and NCL's LAB and phenol hydroxylation processes. Again, globalization has resulted in many partnerships between Indian and foreign organizations. For example, a large amount of catalysis research carried out in CSIR laboratories such as NCL, IIP and IICT is in collaboration with multinationals. Based on these activities, many catalysts/processes developed in India are expected to go global in the next few years.

1.5.2. Environmental catalysis

Worldwide, catalysis is now not only perceived as the route to economic benefits, but also as a means of saving raw materials and prevention of ecological damage. The development of green processes and pollution abatement catalysts has acquired great importance. Recently, IOC (ACC) introduced catalytic converters for mopeds. NEERI, IIP, NCL and Bharat Heavy Electricals have also been working on auto-exhaust catalysts for many years.

1.5.3. Catalysis in organic chemistry

Today, the most wasteful operations are carried out in the organic chemicals and pharmaceutical industries. Many of the synthesis and reaction steps used in these industries are based on discoveries made many decades ago when environmental concerns were absent. It is believed that highly selective eco-friendly catalysis based organic transformations will become important in the fine chemical and pharmaceutical industries in the near future. Many eco-friendly processes have reportedly been developed recently for alkylation, nitration, acylation and halogenation reactions at NCL and IICT.

Again, catalysis in the synthesis of chiral compounds is expected to grow rapidly. Other areas of importance are the heterogenization of many homogeneous catalysts in industrial practice, the immobilization of enzymes and the synthesis of enzyme mimics. The last mentioned area assumes importance as enzymes are by far the most efficient catalysts known, nature having taken millions of years to design them.

1.6. Publications and patents

The total number of publications from India in the area of catalysis is probably less than 200 per year. About 100 publications are from NCL alone. Among the well-cited papers, many are from NCL published in prestigious journals such as *Nature*, the *Journal of the American Chemical Society*, *Science* and *Angewandte Chemie*. Until recently, there has been a lack of

awareness of intellectual property rights (IPR) and the need to patent one's inventions. The situation is fast changing with the introduction of new patent laws in India and global competition. The total number of patents filed in catalysis based on research in India is probably about 60–70 per year. About 30 patents are filed every year from NCL alone in catalysis. NCL has been granted so far about 50 US patents in catalysis.

1.7. Funding catalysis research

No exact figure is available for in-house research in the industrial sector. CSIR laboratories together probably spend about US\$5 million per annum in this area. Much less is known about funding for catalysis research in university departments. The major funding agencies for catalysis research in India are governmental agencies such as CSIR, DST (Department of Science and Technology), CHT (Centre for High Technology) and the departments of environment and atomic energy.

2. The Catalysis Society of India

The Catalysis Society of India (CSI) was founded in March 1973 at Banaras with Prof. S.K. Bhattacharyya as the president and Prof. J.C. Kuriacose as the secretary. The main mandates of the CSI are to encourage catalysis research in India, to organize professional meetings between researchers, to enhance mutual interactions and to encourage cooperation between industry and academia.

The growth of the membership of the CSI is a measure of the growth of catalysis research activity in the country. The present membership of the society is in excess of 750 compared to 75 in 1974. At the time of the founding of the CSI, the major centers of research in catalysis were just a handful, the IITs at Madras and Kharagpur, PDIL at Sindhri, IIP (Dehradun) and IPCL (Vadodara). Catalysis research activity has spread to many more organizations during the past 25 years (table 1).

During the last two decades, the catalysis community in India has made significant strides both in applied and fundamental research. Many catalysts and processes have been developed and commercialized, notably by IIP, IPCL, NCL and ACC in petroleum refining and petrochemicals manufacture and by PDIL in fertilizers production. In basic research also, members of the society have made important discoveries in catalysis

resulting in publications in prestigious journals such as *Nature* and *Science*.

In catalysis education only the IITs and a few universities were active during the 1970s, whereas today Ph.D. students can be found in nearly all the organizations mentioned. The CSI organizes (in collaboration with the Department of Science and Technology, New Delhi) annual workshops lasting three weeks for graduate (Ph.D.) students in catalysis.

The CSI organizes national symposia and workshops on catalysis on alternate years jointly with host organizations. So far, the CSI and host organizations have jointly organized 15 national symposia and 10 workshops. These meetings are well attended with about 300–500 participants. The 16th National Symposium is being organized by the Indian Institute of Chemical Technology in February 2003 at Hyderabad. Besides, meetings (short symposia) are also arranged by the local chapters of the society for various reasons either alone or in collaboration with other agencies/societies. All these meetings have contributed enormously to the development of catalysis research in India.

Another important activity of the CSI is the publication of the *Bulletin of the Catalysis Society of India* (a peer reviewed journal from 2002) on a bimonthly basis. Original research articles and reviews submitted by CSI members are published along with news-briefs covering the activities of the individual members, organizations and zonal chapters. The bulletin acts as a window to the activities of the various research groups in India and is also a source of information on the recent happenings in catalysis in India and abroad.

The CSI encourages catalysis research through its awards: the Eminent Scientist Award for senior researchers, the Young Scientist Award for those below the age of 40 years and the L.M. Yeddanapalli Award for very young researchers (below 35 years of age). These awards are normally presented during the national symposia.

The activities of the society are managed by an executive committee of nine members who are elected for a two-year term by the members. The committee members elect among themselves the office bearers of the society, i.e., the President, the General Secretary, the Treasurer and the Joint Secretary. The present (2001–2003) President and General Secretary of the society are, respectively, Dr. A.V. Ramaswamy, from NCL, Pune, and Prof. B. Viswanathan from IIT, Madras, Chennai.