An institution is reborn—Indian Institute of Chemical Technology

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The origin of the Indian Institute of Chemical Technology goes back to the year 1944, when the Central Laboratories for Scientific and Industrial Research was set up by the erstwhile Hyderabad State. The main emphasis, at that time, was on optimum utilization of regional resources, which included coal, vegetable oils, ceramics, and paints, besides organic and medicinal chemistry. A major aim even then was to take the laboratory findings up to pilot-plant trials and ultimately make the technology transferable to industry. The building in which the institute is now housed was formally opened by Pandit Jawaharlal Nehru on 2 January 1954.

In 1956 the Central Laboratories came under the aegis of the Council of Scientific and Industrial Research (CSIR) and was renamed Regional Research Laboratory. In April 1989, in recognition of the institute's multidisciplinary activities and expertise in chemistry and chemical technology, the institute was rechristened Indian Institute of Chemical Technology (IICT) by the CSIR Review Committee. The main emphasis is on basic research in the chemical sciences leading to innovative processes for a variety of products necessary for human welfare, such as food, health and energy.

Earlier work

In the formative years, the institute, under Husain Zaheer (Director, 1948–62), laid emphasis on R&D related to coal, vegetable oils, drug development, paints and ceramics. It developed low-temperature carbonization of coal (LTC) for the production of solid fuel, useful as smokeless domestic fuel and as reductant in electrometallurgical operations. This technology was exploited by Singareni Collieries, a state government unit, to produce 900 tonnes per day of LTC coal.

In the area of oils, the institute has always been one of the premier centres for research. Its efforts to develop technology for castor products such as hydrogenated castor oil and fatty acids for greases, hard fat for soap making, stearic acid for the rubber industry and dehydrated castor oil for use in surface coatings have been recognized. In addition, the institute has developed technologies for processing oilseeds to obtain edible oils and flours, e.g. from cotton seed, sunflower seed and soybean.

IICT was one of the earliest institutes to initiate R&D in paints and organic coatings. Its early work focused mainly on the development of suitable organic coatings and polymers, including anti-corrosion chemicals and coatings for petroleum installations and petrochemical plants, and products based on cashew-nut shell liquid.

In the area of heavy chemicals and ceramics, completed projects include the development of bleaching aids, pesticide diluents based on indigenously available earths, wettable sulphur, silicon carbide, glass lining of equipment, pyrometric cones, microwave ferrites for X–C and S-band applications, and glass-to-metal seals. In addition, the institute's researchers have synthesized silicon carbide whiskers used to reinforce the metal and ceramic matrices used in aerospace engines and various defence applications.

It so happened that Zaheer and subsequent directors were organic chemists, and therefore emphasized the development of chemical technology. In the early years, organic chemistry research focused on the chemistry of heterocyclics, with a view to discovering new drugs. In fact, methaqualone, which is now used the world over as a restricted drug, was first synthesized in 1951 by Kakkar and Zaheer. Although many new molecules have since been synthesized and screened for their pharmacological properties nothing spectacular has emerged. Sidhu (director, 1963–81) was the first to give a new direction to the organic chemistry division, providing a major impetus to the development of pesticide technologies that were earlier exclusively imported into the country. Subsequently, the institute took up a mission-oriented programme involving chemists, chemical engineers and mechanical engineers to develop indigenous technologies for agrochemicals, resulting in process development for monocrotophos, butachlor, DDVP, and diazinon. The salient R&D tasks in the area of agrochemicals include: (a) development

of indigenous technology for identified pesticides of importance in current use and for future needs; (b) synthesis of novel organic compounds with potential pesticidal activity, (c) development of insecticidal and pesticidal formulations from plant and microbial sources, (d) development of formulations for pesticides, and (e) generation of toxicity data, which involves registration. The institute has also put together 'technology packages', which include process know-how, engineering design for commercial plants, and formulations of toxicological data.

Thus a research base was developed by the late seventies with the main focus on developing technologies for chemicals based on coal, vegetable oils, organic coatings and agrochemicals. In this process, the institute built a strong foundation for developing processes right from bench-scale operations to the pilot-plant stage, involving chemists, chemical engineers and mechanical engineers along with support groups such as analytical chemists, biologists, etc. This has resulted in successful transfer of technology from laboratory to industry.

Current research

Chemical technology plays a crucial role in the overall development process and towards developing products for our daily needs. IICT's work is therefore very relevant to the economic growth of the nation. There is no doubt that no other industry in the country has grown as much as the chemical industry during the last two decades or contributed as much in terms of providing employment, and improving the health and nutrition of our citizens.

Since 1985, there has been a change in the institute's philosophy. As present director, I strongly believe that good science leads to good technology. A deliberate and conscious decision has been taken to strengthen organic chemistry and process technology. IICT has now built up expertise in relevant areas of chemistry, focusing on national needs. In fact, the institute's change in name reflects a sharpening of focus and intensifying of purpose. In the past five years the institute has acquired an international level of competence. At present, the areas of research the institute is engaged in are organic chemistry, drugs, pesticides, catalysis, coal, polymers, oils and organic intermediates.

Pharmaceuticals

In drug research, IICT believes in involving industry right from when a project is proposed or identified till it becomes commercially successful. Most projects are sponsored by the pharmaceutical industry. Some of the successful processes that have gone into commercial production include norfloxacin (antibacterial) and other quinolones, sulbactam (beta-lactamase inhibitor), flurbiprofen (analgesic and anti-inflammatory drug), azidothymidine (the only drug used for AIDS), timolol maleate (for glaucoma) and certain anticancer drugs (mitoxantrone and etoposide). Ongoing projects include ibuprofen and naproxin, based on the carbon monoxide insertion reaction; antibacterial agents, including beta-lactam antibiotics such as beta-methylthianemycin; beta blockers; antiasthmatics; antiulcerogenic compounds; and antiviral and anticancer agents. Besides, the laboratory is involved in a major way in developing technology for the production of vitamin A and vitamin E. Emphasis is also laid on anti-TB drugs, such as pyrazinamide by ammoxidation of methylpyrazine and chiral synthesis of 2-aminobutanol. Realizing the need to build a strong base for the production of drug intermediates, the institute has launched a programme in close collaboration with the chemical industry to develop technologies for phenylacetic acid and diethyl malonate based on carbon monoxide insertion reactions. We are also considering the production of various value-added intermediates starting from cyanogen chloride.

Chiral synthesis

In recent years, with better understanding of biological phenomena and their close relationship with molecular structure, chiral synthesis has become an important area. For instance, the beta-blocker activity of propanolol was found to be associated with the optically active *S*-isomer while the corresponding *R*-isomer is known to be a potential vaginal contraceptive. Chiral synthesis allows us to obtain an organic molecule as a well-defined stereochemical entity. Thus, chiral drugs which have biological specificity and fewer side-effects are increasingly entering the consumer market. IICT is the only institute in India that is engaged in a major way in developing technologies for chiral drugs. Two principal approaches are being used to synthesize target molecules: (i) homogeneous catalysis, and (ii) the chiron approach, utilizing inexpensive natural molecules with well-defined chiral centres, e.g. carbohydrates, hydroxy carboxylic acids and amino acids. IICT has launched an intensive programme to develop technologies for the production of such molecules, including *S*-ibuprofen, various beta blockers, diltiazem and beta-lactam antibiotics. It has built enormous credibility with industry by way of sponsored research not only for domestic requirements but also for the export of basic drugs worldwide. IICT also realized early on the need to look for synthetic vaccines. This is being done in close collaboration with the USSR Academy of Sciences.

Agrochemicals

IICT has provided technologies for various pesticides such as monocrotophos, butachlor, DDVP, etc. Last year the institute released its chlorpyriphos technology to several companies, including National Organic Chemical Industries (NOCIL) and Lupin. In addition, it has isolated and formulated the active principle responsible for insect antifeedant activity from neem oil/neem kernels. The product, known as Vepacide, is of low toxicity but prevents insects from eating the crop, causing them to starve and die. Vepacide is one of the safest natural pesticides and can be widely used for pest control on fruit and vegetable crops. Its potential for export is quite large and the process has been released recently to NOCIL for commercial exploitation.

Some other technologies under development include pirimiphos methyl, glyphosine, thiophanate, metalaxyl and chlorosulfuron. Further, IICT has also begun to develop technologies for a variety of pyrethroids such as S-fenvalorate and cyhalothrin. The institute's credibility with the pesticide industry is reflected in the annual sales of its products and the amount manufactured using IICT technology.

Catalysis

During the period of the Seventh Five-Year Plan, the inorganic and physical chemistry division was regrouped, and catalysis received the main emphasis. Technologies using both homogeneous and heterogeneous catalysis are being developed. The institute is now engaged in collaboration with Indian Petrochemicals (IPCL), in the development of catalysts for oxychlorination, and, with Indian Drugs and Pharmaceuticals (IDPL), for ammoxidation. The group working on homogeneous catalysis has developed various carbon monoxide insertion reactions that can be exploited for synthesis of drugs and drug intermediates. It has also developed an elegant approach for the manufacture of phenylalanine, an intermediate required in the synthesis of the sweetening agent aspartame. Basic studies form an integral part of catalysis development for both present and future growth. These include synthesis and characterization of new catalysts for possible applications in petrochemicals, pharmaceuticals and other chemical industries.

Synthetic organic chemistry

In the past five years, IICT has made many contributions to organic chemistry. Its publications cover synthesis of antitumour agents, Sesbanimide, Fredricamycin A, beta-lactams, hydroxy fatty acids and other natural products with biological activity. It has built a strong foundation in photochemical research and synthesis of chiral compounds using chiral substrates. In addition, enzymatic reactions for the transformation of organic substrates to value-added products is being actively pursued.

Polymers, coal, oils

Resins and polymers play an important role in national economy as they are extensively used in construction and other industries in the form of organic coatings and structural adhesives. To meet the rising demand, the institute has initiated a programme to develop low-priced materials as substitutes for wood and other building materials. It has developed interpenetrating polymer plastic composite panels to be used as a partial substitute for wood in building materials, and polymers for specific purposes. The programme includes the development of structural adhesives such as anaerobic and cyanoacrylates for high bond strength, polysulphide adhesives, and sealants. Some of the technologies for adhesives have already been released to entrepreneurs. In addition, researchers at the institute are working to develop synthetic membranes, biodegradable plastics, and polymer matrices for slow release of pesticides and other bioactive materials.

In the area of coal, one of the projects relates to the gasification of Indian coals with high ash content, with a view to setting up a demonstration plant for combined-cycle power generation. This work is being supported by the Department of Coal of the Government of India.

IICT continues to associate with the vegetable-oil industry in developing value-added products from fatty acids. One of its recent contributions is rice bran stabilization, which is being introduced at various rice mills.

Research for industry

Over a period of two decades the chemical engineering division has evolved a series of well-connected activities which serve a range of large- and medium-scale industries. These include process-development and pilot-scale studies for value-added chemical intermediates such as glyoxal, *m*-phenoxybenzaldehyde, sodium azide and cyanuric chloride. Computer-aided process design of chemical equipment and commercial plants increases the success rate of transfer of technology. Mathematical modelling and simulation of complex chemical transformations involving heat and mass transfer ensure optimum utilization of resources. Production of ammonia at a scale of half a million tonnes per annum and transportation of natural gas through complex networks stretching over hundreds of kilometres have been optimized with this technique, resulting in considerable saving of materials and energy.

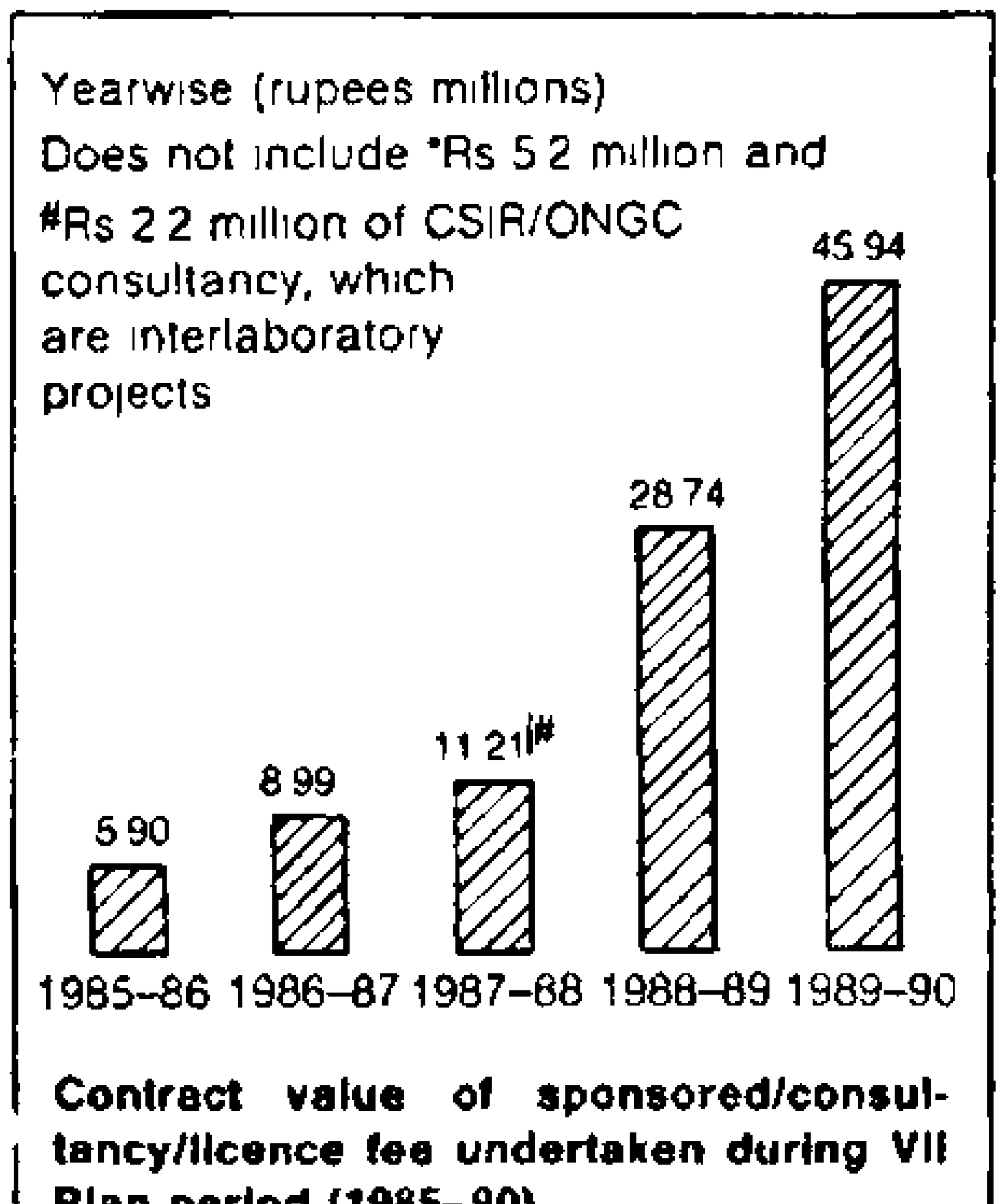
Hazard identification and quantitative risk assessment in various operations provide valuable information to the chemical industry for the protection of plant personnel and environment. IICT's activity in this area is based upon vast experience in design and operation of chemical plants. Using appropriate computer software and with relevant databases, it is possible to predict the causes and frequency (probability) of untoward-release scenarios. The petrochemical industry and one natural gas processing complex have already availed of the institute's expertise in this area.

IICT has also developed expertise in engineering design for process plants for the manufacture of agrochemicals and organic intermediates. A measure of this activity is the number of detailed engineering assignments handled by this division in the past five years. This division is in a unique position because of its close interaction with process-development and process-engineering groups The institute has built a computer-aided design and drafting facility which is being utilized for drafting process flow diagrams, equipment-arrangement drawings, etc. In addition, the division caters to the specific requirements of a particular unit operation in a chemical process.

Facilities

Pilot plants at IICT are made use of by a number of chemical industries to standardize and optimize process parameters to improve productivity. The pilot-plant facility is known for its high level of sophistication and maintenance and the availability of all necessary equipment and accessories under one roof.

Analytical instrumentation services at IICT are run in the form of a mini test house. Besides meeting international analytical needs, the institute undertakes analytical assignments from different industries, universities and government



Contract value of sponsored/consultancy/licence fee undertaken during VII Plan period (1985–90)

Estimated returns from technologies developed up to March 1990 and projections for the period 1990–1995
(Rupees millions)

Product (No. of licencees in parenthesis)		Estimated value of production up to March 1990	Premia on processes released up to March 1990 (includes design fees)	Estimated royalty up to March 1990	Estimated value of production from April 1990 to March 1995	Estimated royalty for the period April 1990 to March 1995
Monocrotophos	(10)	1161 7	9 471	7 600	2550	18 800
Butachlor	(6)	175	4 566	950	492 5	4 650
DDVP	(4)	115	1 683	.500	480	600
Diazinon	(1)	40 0	.438	.800	50	1 000
Quinalphos*	(1)	134 4	.250	1 152	—	—
MBC	(1)	363 0	.120	7.260	375	—
Chlorpyriphos	(4)	—	7.200	—	1500	6 000
Vepacide	(1)	—	.500	—	650	—
	(29)	1989 1	24 228	18 662	6097.5	31 050

*Jointly with RRL, Jorhat

departments on nominal charges. Instrumentation facilities include NMR (400, 300, 200, 90, 80 and 60 MHz) spectrometers, mass spectrometers, atomic absorption spectrometer, and facilities for X-ray crystallography. IICT has its own toxicology unit for evaluating the toxicity of various agrochemicals. Its entomology group works closely with the organic division in evaluating new and known pesticides. Screening of chemical formulations for insecticidal and insect antifeedant and growth-regulator activity forms an important part of the work of this group.

IICT collaborates with the Centre for Cellular and Molecular Biology (CCMB) to provide library and documentation facilities for biological and chemical literature. The library is considered to be among the best in the world. The institute has a planning and coordination division, which coordinates with other institutions, government departments and agencies, and is also involved in marketing the knowledge base and in technology transfer. It interacts with clients right from project identification up to transfer of technology.

Applied research, direct gains

The philosophy of involving the chemical industry right from when a project is identified and maintaining a close relationship till project completion has resulted in enormous gains: the institute signed agreements worth Rs 45.9 million in 1989-90 alone. In fact, today, IICT enjoys the confidence of the chemical industry, being practically the only institute in the country with the capability of developing technologies for various products.

International collaboration

In the past four years, IICT has initiated programmes to work in close collaboration with some well-known institutes in the world. IICT is actively engaged in work on organic synthesis and synthetic vaccines in collaboration with the Zelinsky Institute of Organic Synthesis under the Indo-USSR integrated long-term programme. A collaborative programme with the US National Cancer Institute will develop synthetic anticancer drugs based on biological leads. There is a proposal to collaborate with the Institute of Natural Product Chemistry of the French Centre National de la Recherche Scientifique (CNRS). IICT is also associated with the Netherlands Organisation for Applied Scientific Research (TNO) in work on risk analysis, and with some institutes in the UK in work on carbon monoxide-based chemicals and on some aspects of chemical engineering. In addition, under the CSIR collaborative programmes with various countries, IICT is closely associated with many institutes in a number of European countries.

Recognition, role

IICT is today known for its strength in basic research in chemical sciences and its involvement with industry by way of developing and transferring various technologies to the chemical industry.

The institute's strength lies in its research activity and its relevance to the world of commerce and industry, as summed up by S. Varadarajan, chairman of the research council of the institute: 'Hyderabad today is the key headquarters of medium fine chemical industry and many things are happening here. . . . Hyderabad has produced many entrepreneurs in the chemical industry. This network has spread to all parts of India and, as a result, it is fair to name an institute associated with this network as the Indian Institute of Chemical Technology. The change of name is not an imposed one but a recognition of realities.'

Scientific capability depends on how we nurture our young scientists and encourage them to take on challenging problems relevant to national needs. IICT recognizes the need to strengthen its activity by inducting young people from within the country and abroad. In recent years, the institute has attracted many CSIR fellows, especially in the areas of organic chemistry and catalysis. In addition, a number of young, talented, well-trained chemists from the USA and Europe have joined the institute. This is borne out by the fact that the CSIR Young Scientist award in chemical science has gone to a researcher at IICT in the past four years. I hope that the many young PhDs from the institute working as postdoctoral fellows in some of the best-known schools in the US will return and join India's national institutes and contribute towards building science and technology.

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