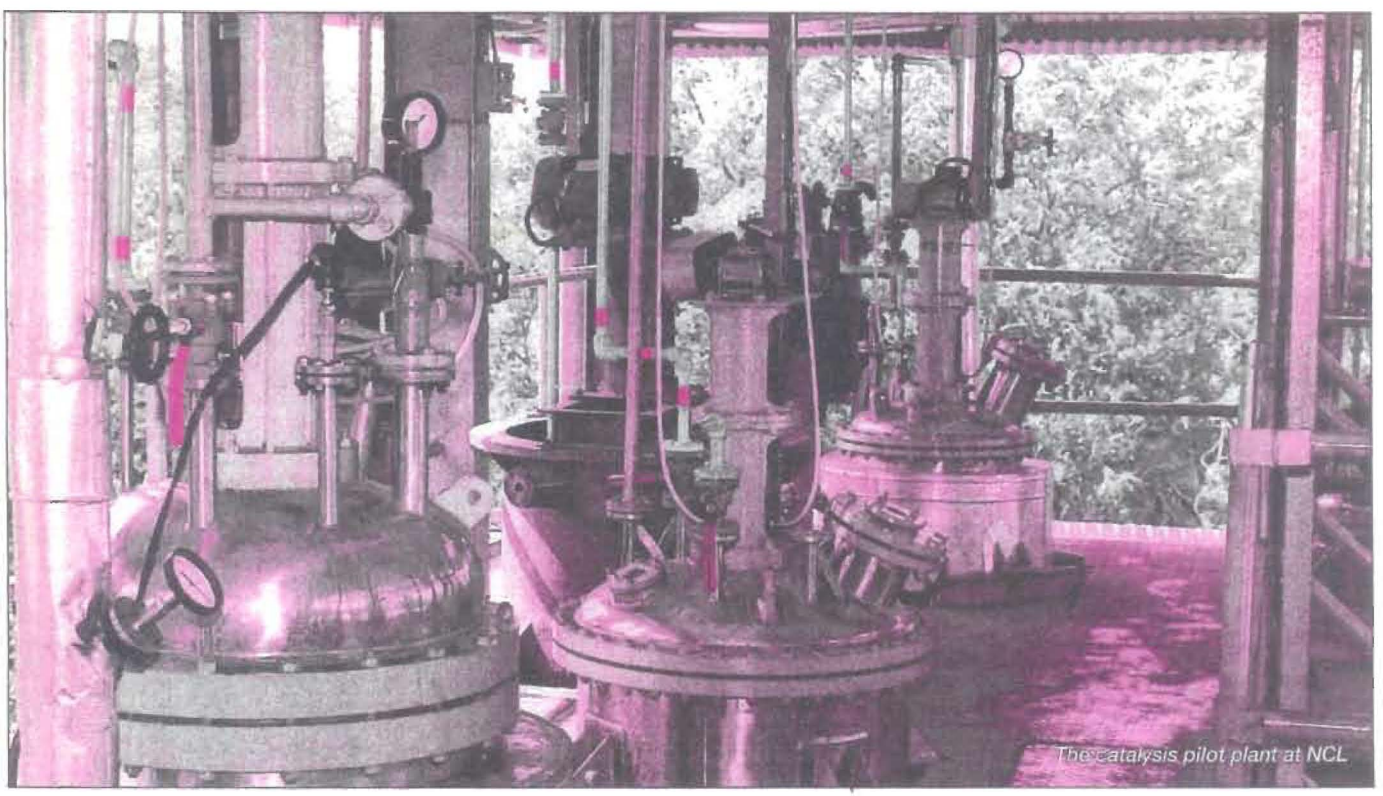
Sea change

It has been a time of intensive change for the National Chemical Laboratory as it has emerged as India's leading chemistry and chemical engineering laboratory. Susan Royse **reports on the developments**



The catalysis pilot plant at NCL

When *ECN* last visited the National Chemical Laboratory (NCL) in Pune, Maharashtra, in late 1991 (*ECN* 20 January 1992), the first waves of R&D globalisation and a more commercial culture were beginning to wash through the corridors.

Under the far-sighted vision of then director RA Mashelkar, NCL, India's foremost chemistry and chemical engineering laboratory, was beginning to emerge on the world stage, with international collaboration in fields ranging from industrial catalysis to plant tissue culture. Today Mashelkar has gained promotion to director general at the Council of Scientific and Industrial Research (CSIR), the umbrella organisation for India's network of 40-plus publicly funded laboratories, but the wheels he set in motion at NCL continue unabated.

CSIR, and within it NCL, began life in 1950 promoted by then prime minister Nehru with the aim of advancing knowledge to allow the newly independent India to 'stand on its own feet', explains Mashelkar. Technical development started in the 1960s and progressed through the 1970s with a strong emphasis on what Mashelkar terms 'reverse engineering', ie the development of new processes to produce copycat products aimed at self-sufficiency.

Through the 1980s the focus shifted to higher tech areas, catalysis and biotechnology for example, but Mashelkar recognised that acceptance of the new work in the home market was not guaranteed. At a time when high tariff barriers were driving import substitution initiatives, Indian companies appeared sceptical of genuine home-grown new technology. So Mashelkar decided to 'change the context' and make the laboratory's expertise available worldwide. By the time of the Indian government's liberalisation policies of 1991, Mashelkar was already encouraging his scientists to 'think ahead of the world'. Nine years on, his dream for India to become a global R&D platform is gaining momentum.

'Today we look on NCL not as a national laboratory but as an international research centre carrying out research because it is challenging in itself not because it is needed in the neighbourhood', echoes Mashelkar's successor at NCL, Paul Ratnasamy, formerly the laboratory's head of catalysis.

NCL now boasts a client list including the multinationals Dow, DuPont and GE Plastics, as well as the Indian majors Reliance Industries, IPCL and Indian Oil. It employs some 350 scientists and engineers, of whom around 200 are PhDs, and 300 doctorate students. Last year it amassed a total of 95 Indian patents (66 filed and 29 granted), more than any other Indian organisation, and 29 US patents (12 filed and 17 granted). Funding is a 55:45 mix of CSIR allocation and external earnings. Some 42% of the external earnings come from foreign industry and a further 27% from Indian private industry.

Research is concentrated in five major areas: catalysis, polymers, organic chemical

technology, biotechnology and advanced materials. The laboratory is striving to maintain a healthy balance between client-driven contract research and curiosity-driven basic research. And, as with so much industrial R&D around the world, the emphasis is increasingly on 'green' technologies.

The catalysis division's first major success came in 1985 with the commercialisation at IPCL's Baroda facility of a xylene isomerisation catalyst, an alternative to the imported Mobil ZSM-5 zeolite catalyst. 'This was the turning point in catalysis in India', says AV Ramaswamy, NCL's head of the catalysis and inorganic chemistry division. Not only that, Ramaswamy claims a world record: some 15 years later the catalyst has not been replaced. The second process to be commercialised was the *Albene* process, a one-step catalytic route from fermentation alcohol, of which India is one of the largest producers, to ethylbenzene. This was adopted by Hindustan Polymers in 1989.

A wide array of further processes of significant industrial potential are now at various stages of development. At the pilot-scale level is a patented process for the alkylation of ethylbenzene offering a selectivity to para-diethyl benzene of greater than 99.5%. NCL is negotiating the supply of the catalyst to an undisclosed company, says Ramaswamy. Other processes at the pilot-scale level are: the isopropylation of benzene to cumene, which Ramaswamy expects to go commercial this year; the disproportionation of C9-C10 alkyl aromatics to xylenes; the production of LAB using a solid zeolite catalyst, piloted with Reliance Industries since 1995; the hydroxylation of phenol to catechol and hydroquinone using hydrogen peroxide – two packages have been sold, says Ramaswamy, but none is yet commercially available; and the selective ortho-methylation of catechol to guaiacol avoiding the use of dimethyl sulphate.

Still on trial are new catalysts for the ammoximation of ketones to oximes, the direct oxidation of benzene to phenol, an improved iron-molybdenum catalyst for the production of formaldehyde and an improved vanadium-molybdenum catalyst for the production of maleic anhydride.

The latest investment at the 700 acre NCL site is a new Rupee10m ($225 000) multipurpose pilot plant, set up with a World Bank loan. The plant, currently being commissioned, has been designed to accommodate a wide range of chemical processes and operations up to 250-litre semi-commercial batch sizes. The plant houses a series of stainless steel batch reactors of 65 litre and 250 litre capacity plus a 250 litre gas induction reactor, together with glass-lined reactors of 35, 50 and 100 litre capacities, associated equipment for a number of downstream unit operations and a dedicated laboratory. Negotiations for use are ongoing with a couple of sponsor organisations, reveals Hemant Joglekar, head of the new pilot plant.

NCL's Paul Ratnasamy... the laboratory needs to follow the four 'Ps' of success: publications, patents, PhDs and prosperity

In the polymers division, work covers a broad spectrum of activities including synthesis, characterisation, molecular simulation, reaction engineering and micro-encapsulation. Here divisional head S Sivaram emphasises the integrated interdisciplinary nature of the research supported by a 'tremendous network' of overseas academic collaborators . As examples of the emerging work he cites a fundamental new method for the formation of nanoparticles (100nm size) of materials such as polyurethane. The work is covered by several US patents, the most recent granted in February. The group is also looking at catalytic options for making syndiotactic polystyrene, he reveals.

The majority of the organic chemistry division's effort is drug related. Given India's disrespect of international patents, much of NCL's work with Indian pharmaceutical companies has traditionally focused on the development of new processes for FDA approved drugs, for example taxol. Internationally, it has collaborated on more fundamental research, for example, work with the National Cancer Institute of Maryland has culminated in the discovery of a family of compounds of potent anti-HIV activity for which a joint patent has been taken.

However, it was the plant tissue culture group that was responsible for one of the first truly international breakthroughs of the laboratory. Back in March 1990, the group received worldwide attention with the publication in *Nature* of its success in getting bamboo to flower after just six months. Normally it takes many years before the bamboo flowers – and it flowers just the once, a 'suicidal flowering' after which the plant dies. Further, the flowering is unpredictable. As a result, little work had previously been done on the crop despite its economic significance.

During the past decade NCL's tissue culture group has built on its breakthrough. 'We are continuing work to investigate the basic phenomenon of flowering, seeking the chemical responsible, and trying to raise hybrids,' explains Rajani Nadgauda, head of the tissue culture pilot plant.

Field trials are now under way at a number of different locations across India, in Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu, and in Nepal. Other economically important tree species also being investigated in 'genetic gardens' include teak and eucalyptus.

As NCL enters the 21st century, Ratnasamy points to four criteria for success – the 'four Ps' as he puts them: publications, patents, PhDs and prosperity. Although the laboratory has yet to produce a globally competitive technology, on all four of Ratnasamy's counts it would appear to be on the right track. ■