CHEMICAL INDUSTRY—YEAR 2001: REGIONAL TRENDS*

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ABSTRACT

Chemical industry in developing and under-developed countries is of recent origin but the future is very bright as it is intimately connected with the basic needs of the society. Special features associated with countries having large and small population base will be discussed along with the availability and pricing of basic feedstocks.

The problems associated with the availability of trained manpower, economics of scale, upgradation of low into high value materials, protectionism, etc are very peculiar in developing countries. In countries like China and India there will be spectacular growth in the fertilizer industry.

INTRODUCTION

THE growth of the chemical industry in developing countries is crucial as it is so very intimately connected with the basic needs of the society for food, clothing, shelter and health. The perspectives for the chemical industry in developing countries like India, China etc having a large population base, are substantially different from those in Western Europe and U.S.A. The most striking difference with respect to European countries is that with respect to the manufacture of fertilizers. The second important difference arises out of large internal demand and lack of free foreign exchange to shop around the world. The third important difference arises out of small demand for motor gasoline but relatively large demand for middle distillates like diesel and kerosene. Further in countries like India very little fuel is used for internal heating in houses and offices. Lastly there is invariably a critical shortage of power.

The chemical industry, along with breakthroughs in agriculture, will play a major role in raising the standard of living in developing and under-developed countries. The pressure on land is so severe that there is no escape from getting much more out of the cultivated land and to divert a part of the land used for cotton to food crops. The problems faced by India are indeed gigantic and require a somewhat different approach. The shortage of housing is chronic and the backlog is extraordinarily large calling for immediate construction in India of at least five million houses. The life expectancy has increased dramatically in the last 10 to 15 years and this has led to further growth in population and larger demand for drugs.

HISTORICAL PERSPECTIVE

The establishment of chemical industry in India is a post-independence phenomena. Even the first set of refineries were built in early fifties which resulted in the availability of surplus naphtha. The first important fertiliser plant in India was conceived as late as in mid-fifties.

The existence of a large sugar industry led to a good demand for phosphatic fertilisers and made available large quantities of molasses which in the initial stages, ironically, was disposed of by paying a price to transporters to lift it from factories. India saw, through an imaginative policy of Govt. of India, growth of the organic chemical industry in the late fifties/early sixties based on alcohol in turn based on fermentation of molasses. However, this was a short-lived euphoria as soon alcohol was not available and today the future of alcohol based industries, to put it mildly, is very bleak. The crucial role of nitrogenous fertilisers for hybrid wheat, rice, maize, bazra, etc. was responsible for the support for fertiliser industry in a big way in early seventies. The availability of indigenous crude on-shore and off-shore has brought about a sea-change in the scenario.

FERTILISER INDUSTRY

Background: The Indian fertiliser industry has worked with practically all the available technologies

* Based on a lecture delivered at IUPAC Congress, Manchester, September 1985.

in the world: producer gas-based hydrogen; electrolytic hydrogen; coke-oven gas; naphtha; fuel oil; natural gas; coal gasification. We have seen cycles of surplus of naphtha to shortages of naphtha and again surplus of naphtha. Even today, we can see practically all the technologies working except that on producer gas. As of today we have an installed capacity of 7.5 million tonnes per annum of N, and 1.5 million tonnes per annum of P_2O_5. India has a limited supply of indigenous phosphate rock, located mostly in North Western and Central India, and hardly any potassium chloride is recovered from bitterns in salt works.

Future: The nitrogenous fertiliser industry has to grow in a spectacular way and by the year 2001 India should have a capacity exceeding 20 million tonnes annum of nitrogen and 5 mtpa of P_2O_5. Between now and 2001 at least an additional 7.5 mtpa of N will be based on natural gas and the rest of the need will be based on naphtha. It is highly doubtful whether fuel oil will be used in any future plants in the nineties and it is most unlikely that any new coal based plant will materialise. Since 1980 the emphasis has been on urea as a source of N which is probably a good proposition for anaerobic conditions prevalent in the cultivation of paddy—a crop which occupies a pivotal position in India. However, this emphasis ought to change and at least 30 to 40% of N in future should be supplied through ammonium nitrate based fertilisers. There is another reason why the nitric acid should acquire importance and this is concerned with the acidulation of phosphate rock.

Most of India's phosphatic fertiliser is based on the reaction between phosphate rock and sulphuric acid. There is practically no worthwhile source of sulphur in India except through limited amounts of pyrites mined and roasting of sulphide ores of Cu, Zn etc. With ever-escalating sulphur prices and real danger of limited availability of sulphur in the world market, it will become imperative for India and countries similarly placed to go for large-scale manufacture of fertilisers through acidulation with nitric acid. A striking part of this strategy is that all N is usefully retained. Further, poor grade phosphate rocks can usefully be employed. The acidulation of phosphate rock is intimately connected with co-production of ammonium and calcium-ammonium nitrate. India even today produces more than 45 mtpa of wheat, in addition to 25 mtpa of bajra, jowar, maize, etc. This should provide an excellent opportunity to exploit this technology.

It is doubtful if K will be supplied in any form other than KCl but there are reasons to support supply of K as KNO_3 or phosphate.

There is considerable potential for application of fertilisers in growing better quality pastures for cattle feed. This is important in the context of a large cattle population and poor yield of milk, meat etc.

It is very likely that liquid fertlisers will grow in a substantial way; at the present moment very small amount of liquid fertiliser is used. Thus urea-ammonium nitrate and urea-diammonium phosphate blends may find a good market.

India will have to consider closing down old plants—a feature hitherto unknown for a variety of reasons. We have plants which consume 70 to 100% more hydrocarbon per tonne of ammonia compared to those from contemporary technology.

There is often a talk about the import of cheap ammonia from countries like Saudi Arabia, UAE, Kuwait, etc. as the feedstock in the form of base is taken at practically zero value. This is not likely to be important in the Indian context for several reasons. Firstly to the extent ammonia is converted to urea we simultaneously need CO_2. Secondly the cost of fertiliser delivered to a farmer is a more important criterion than the landed cost at the port. Thus countries like India would have to contend with ammonia manufactured indigenously.

RESEARCH POTENTIAL

There is an urgent need to gear up all resources to give a major thrust for developing technology better than the contemporary technologies. In lieu of India's large scale continuing needs this is all the more important. In particular new, energy efficient, ammonia and urea technologies need to be developed. We must concentrate on modifying urea to make it a slow-release fertiliser. India may well become one of the leading urea manufacturers in the world provided the requisite inputs and commitments to make investments in R and D are made now.

Energy efficient technology ought to be developed for nitrophosphate (NP) having more than 83–85% citrate solubility. In view of India's large scale need in this area coupled with the availability of large amount of poor grade phosphate rock and lack of sulphur this should become extremely important.

INDIA'S ROLE IN 2001

India is in a position to acquire a leading position in this vital sector of industry, covering all types of nitrogenous or phosphatic fertilisers, from preparation of project reports to supply of technology, erection of plants and running of plants on contract basis in any location in the world. There is a large reservoir of trained personnel in various sectors who are accustomed to work under adverse and sometimes hostile circumstances and are quite used to power failures. Developing countries in Africa, South-East Asia, Latin America, etc are likely to face problems of the type India has faced in the seventies and eighties and may well benefit from the Indian experience. China is very much expected to be in a similar position. Thus from technology to running plants, India and China may well emerge as serious contenders in the world scene.

India is expected to emerge as a country where the highest percentage of hydrocarbons consumed in any country will be earmarked for fertilisers and could approach figures like 20%. It may be emphasised that a very small percentage of hydrocarbons is used in India for warming of houses but then a lot of kerosene is used as a fuel for cooking and for illumination of homes.

India can meet a substantial percentage of hydrocarbons required from on-shore and off-shore fields. China is in a more comfortable position with respect to indigenous crude oil and gas production and probably will have some exports.

Pesticides

Pesticides will play an important role as it is often said that per unit amount spent pesticides contribute to higher production compared to that based on application of fertilisers. In India, unlike the developed countries, bulk of the pesticides center around insecticides and even here the main targets are cotton crop and public health. We can anticipate real growth in the production of weedicides and herbicides, particularly for wheat and rice where it is often difficult to distinguish between the weed/herb and the main crop. There is also emphasis on no-tillage and this will give further boost to the use of weedicides/herbicides. It would be necessary to introduce new types of nematicides. Growth regulators, particularly for sugar and cotton are expected to become important.

Petroleum refining

The Bombay High crudes are rich in aromatics and give the kerosene fraction containing about 26% aromatics and thus do not meet specifications both for aviation turbine fuel and for illumination. New technologies will be developed and alternative options based on extraction and hydroprocessing will have to be considered. Petro-naphthalene may well be a reality. For maximising the production of middle distillates, which will continue to be in short supply, hydrocrackers will have to be designed. Here also new catalysts and new designs will have to be considered for the stated objective which is distinctly different from that calling for the maximisation of motor gasoline. Yet another difficult problem will be upgradation of feeds for lubricating oil and asphalt. There is a distinct possibility of introducing synthetic lubes on a modest scale.

Synthetic fibres

India has been known for decades for cultivation of cotton and in fact is one crop which takes up a major part of our new range of insecticides. The cotton crop covers 8 million hectares of which 28% is irrigated. We have cycles of surpluses and shortages and mismatch in requirements of types of cotton. We have to face realities associated with fairly high price of cotton and high cost of maintenance of cotton fabrics and shorter life of garments made from cotton. Further Indian ladies wear a sari which is usually of 5.5 m in length and users expect it to be wrinkle free. There is an urgent need in India, notwithstanding the expected improvements in plant breeding practices, to divert a substantial percentage of this land to other crops. India continues to import edible oils worth more than one billion dollars.

INDIAN ROLE

The Bombay High crude is light and rich in aromatics and provides naphtha ideally suited for the manufacture of BTX aromatics. India can embark on export of benzene and xylenes rather than exporting naphtha or swapping crude oils. Thus very large scale production of polyester fibres, which blend well with cotton in different proportions, is expected to be undertaken and India will probably occupy an important position in the world context.

There is a distinct possibility of India acquiring expertise from production of raw materials to polyester fibres to fabrics and emerge as an important exporter of know-how and products. The scale of production of polyester fibres, of different types, is expected to exceed 1.5 mtpa. New methodologies for spinning and blending of fibres are expected to emerge and non-woven fabrics may also become important. Even the demand for school uniforms, military uniforms, services personnel uniforms etc is very large. Bulk of the production is expected to be based on terephthalic acid and ethylene glycol. We expect a spectacular growth in this industry but do not share similar enthusiasm for polyamide fibres for apparel wear.

There is a real need to produce fibres which are ideally suited for tropical climate and have greater water absorbancy than the available fibres in the world. The sari market in India is most unusual in the context of the Western world and Japan.

The manufacture of acrylic fibres will make rapid strides due to small base at the present moment but the growth potential is limited due to climatic conditions.

The manufacture of regenerated cellulosics will probably witness negative growth due to poor performance characteristics of rayons and lack of availability of proper grades of pulps indigenously.

Thus a rapid growth of synthetic fibre industry in India is *sine quo non* for meeting primary requirements of clothing.

Speciality fibres

There is considerable potential for the production of elastomeric fibres and high performance polyamide fibres, based on terephthalic acid/isophthalic acid and phenylenediamines. At the present moment there are no production facilities for the above items.

Thermoplastics

This is a vital sector of petrochemicals industry and more so in India as we really do not have alternatives. We even have serious constraints in increasing our paper production in a big way; a bright spot here is the utilisation of bagasse in a major way as a source of pulp. From energy consumption point of view products based on thermoplastics are very well placed compared to other alternatives. Thus a large scale expansion of polyethylenes, polypropylene and polyvinylchloride is badly needed. Our past experience clearly reveals that demand has consistently outstripped production. An example, which is quite unique in the world context save China, may be cited for the requirement of woven HDPE/polypropylene for packing of more than 20 mtpa of urea in 50 kg bags by 2001.

Polyethylene films will undoubtedly have a high potential. Flexible PVC requirements will be large and here there are no serious competitors. The growth of polystyrene will be limited. It is most unlikely that any new thermoplastic will be introduced but the existing ones will witness improvements in several contexts. New polymer alloys are likely to be introduced.

The critical shortage of housing in India, and countries similarly placed, makes it imperative to utilise thermoplastics and fibre glass reinforced and filled plastics in a big way. We can expect large scale consumption of thermoplastics based products in housing where the backlog runs into at least 10 million houses. In this connection thermoset resins will also contribute substantially.

Engineering plastics

The growth of this industry is crucial for transport sector and engineering industries. India has a relatively large base for a variety of engineering goods and it is imperative to move on to high performance engineering plastics in diverse applications from gears to sophisticated parts. The bicycle, two-wheeler and automobile sectors have unbelievably large potential; the production of bicycles and two-wheelers should cross 15 million per annum mark by 2001. Innovations in design of bicycles may well result in large consumption of engineering plastics in this sector.

Engineering plastics like polycarbonate and polybutylene terephthalate will find extensive application in street light illumination, banks, post offices, etc. There is considerable scope for evolving new blends. There is a growing market in electronic goods and computers.

Polymers for cement-concrete

As repeatedly emphasised the housing and construction industry has to grow in a massive way. It is very likely that to impart highly desirable properties associated with setting time, strength, resistance to environment etc, polymeric additives based on acrylates, styrene-vinyl acetate, etc will be used in a big way. The cement industry in India is expected to grow in a manner that will take production to a level exceeding 90 million tonnes per annum by 2001.

Bulk drugs

The production of bulk drugs should rise in a spectacular way for various reasons. In particular drugs for tropical diseases like enteric fever, apart from pain killers, will have to grow in a major way. Even the production of vitamins particularly A, C, and E will increase substantially.

BIOTECHNOLOGY

India has considerable background in this area. With the recent constitution of the National Biotechnology Board the Government of India will provide support on a very large scale for the promotion of this new exciting and potentially rewarding area. We can expect a major thrust in R and D. We can also expect more inputs in separation processes. It is doubtful whether technology for production of any bulk chemical will become important excepting alcohol by fermentation where we hopefully would improve our processes in a major way. Chemicals for diagnostic purposes particularly hepatitis and enteric fevers and synthetic insulin may emerge as successful ventures.

Production of edible proteins, to supplement normal source of protein for large vegetarian population, may emerge as an important industry.

RENEWABLE VS NON-RENEWABLE RAW MATERIALS FOR ORGANIC CHEMICAL INDUSTRY

This is a very popular subject all over the world. India's organic chemical industry was born on the renewable raw material alcohol, which in turn is based on sugar cane molasses. It is ironical that before 1956 sugar companies used to pay to transport contractors to lift molasses from their factories to avoid pollution problem. Today we have no molasses to offer – every tonne is mopped-up. Absolute alcohol was used in admixtures with petrol for several years in India in automobiles. The initial production of even polyethylene and polystyrene was based on alcohol. It has now performed the vanishing trick – there is hardly any alcohol available for chemical industry and even imports have taken place. The demand for potable alcohol seems to be remarkably high.

The demand for foodstuff itself is so high that even in the case of sugar hardly any amount is available as an industrial raw material. There are also competing claims for different crops; sugar cane crop is of long duration of about 11–12 months. Thus alcohol as a feed-stock, based on molasses or starches, holds no future in India. Only high value added products such as citirc acid, fumaric acid, bio-polymers based on molasses, will have a bright future. Sugar can be imaginatively used for value added products and there is a good potential for polysaccharides.

There are strong reasons to believe that a substantial part of the consumption of cane sugar will be diverted to high fructose corn syrup (HFCS), as here a short duration starch crop can gainfully be employed to provide a value added product. In many locations in India fallow land can be utilised for the production of high yielding variety of tapioca. Further the manufactured food industry is rapidly growing.

The conversion of cellulosic material to alcohol, after about 75% loss in weight, holds no promise in India for a variety of reasons associated with the capital and recurring costs.

There is one commodity – bagasse which holds a bright future if corrective measures are taken. The size of cane crop will continue to be fairly large and we can count on more than 100 million tonnes per annum of wet bagasse. The most obvious outlet is for writing paper and subsequently newspaper and India can possibly emerge as an exporter of writing paper. The involvement of chemical industry in this sector is heavy.

India is fortunate in having ethane and propane in the natural gas and can support more than 1.5 million tonne per annum ethylene from this source alone; naphtha is expected to be a surplus commodity and can provide a valuable source of chemicals.

Coal based chemicals

India has experimented with coal based fertiliser plants and our experiences are not rewarding. First of all, capital costs are very high and reliability of uninterrupted operation is not high. For reasons given elsewhere in the text no new fertiliser plant is expected to be based on coal upto year 2001. The use of synthesis gas based on coal for chemical industry is also most unlikely for similar reasons. However, gasification of coal for power industry, possibly with combined cycle, is exceptionally bright in view of large scale demand for power and high ash in India coals approaching values as high as 25 to 30%. Yet another distinct possibility is exploitation of very large underground deep deposits of coal – some of them in areas far removed from the coal mines. The *in-situ* gasification of coal, which is a difficult subject, is expected to emerge in a big way particularly in North Gujarat in Western India.

Soaps and Detergents

With the improvement in the standard of living the demand for personal care soaps and detergents should grow in a spectacular way. India and perhaps China face peculiar problems in this context. India continues to have a deficit in edible oils and as of today imports are at a level of one billion dollars per annum. Thus the use of edible oils for toilet and laundry soaps is ruled out, notwithstanding expected breakthrough in plant breeding and large-scale use of fertilisers and pesticides. Further in most locations in India, we have hard water and a lot of soap is simply wasted in taking care of hardness of water. We continue to have shortage of middle distillates and to a great extent this situation will persist even after new hydrocrackers and additional cat-crackers are installed. Thus the availability of the kerosene fraction for making linear alkyl benzenes (LAB) is expected to be uncomfortable but does not offer insurmountable situation. It is in the toilet soap sector where LAB sulphonate cannot be used that we face serious problems.

It seems most likely that our problems can be got over to a great extent by adopting alpha olefin sulphonates (AOS) in a big way. Alpha olefins will be based on ethylene whose potential availability is very good. The potential for alpha olefins (C_4 to C_{20}) is at least 400,000 tpa in India by 2001. Even for laundry detergents AOS holds a good potential. With the use of synthetic fabrics in a major way synthetic fatty alcohol (in C_{13}–C_{15} range) ethoxylates are also expected to become important. Lauryl alcohol (C_{12} alcohol) is unusually expensive in India in view of the high coconut oil prices (almost three times the international price).

A considerable amount of a variety of surfactants will be used in the secondary and tertiary recovery of oils.

Chlorine-based chemicals

There is a very good potential for chlorosolvents, like carbon tetrachloride and perchloroethylene, to be produced on a large scale and India can consider exports of 2,50,000 tpa of these materials as the cost of chlorine is really low in the international context. This apparently paradoxical situation arises out of a peculiar situation, which will persist, where unlike the Western world, the loading of cost is on caustic soda and chlorine is usually an unwanted by-product. The textile industry does consume a fairly large amount of caustic soda besides paper and detergent industries. Further with the growth of the large alumina plants which are export oriented, additional imbalances will be created. India can convert this liability into an asset and additionally consider large-scale, port based, bleaching powder plants for export markets. For large plants the total energy concept is expected to be adopted.

Hydrometallurgy

Apart from its applications in nuclear industry, we can visualise a bright future for its adoption in the recovery of copper, nickel, cobalt, tungsten, molybdenum, vanadium, etc. from lean ores. India is seriously lagging in the production of copper and nickel. This would call for simultaneous production of oxime type of extractants.

High purity silicon for solar power

The production of high purity crystalline and amorphous silicon will be undertaken on a decent scale. The potential is very high in view of very favourable climatic conditions and the perennial shortage of power which is also of high cost.

Production of titanium

It is a pity that in spite of titanium being very versatile and basic raw material available, we do not, at the moment, see any sign of a commercial plant. We can expect one or two large plants for the production of titanium metal and this will call for production of stoichiometric amount of Mg/Na metal.

NUCLEAR POWER

The chemical industry is very intimately connected with the nuclear power industry. In India we have a very uncomfortable situation in many parts, notably Western India and Southern India, where we do not have coal reserves. Further large scale transportation of coal from Eastern and Central Indian coal fields poses problems. It is essential to have large scale growth of this sector of power industry and India is aiming at generation of 10,000 MW by year 2001, which would be less than 10% of the total power generation. Thus plants for heavy water, additional production of uranium, fuel reprocessing, etc. will come-up in a major way. At the present moment our generation of nuclear power is less than 1000 MW.

Speciality Chemicals

Speciality chemicals, including so-called fine chemicals and high purity chemicals for electronics, hold a bright future. Many of these chemicals can be produced on a small scale and in view of large trained man-power and existence of a well organised small scale industry we can expect major contributions. Intermediates as well as finished products for plastics, rubbers, fibres, pesticides, drugs, electronics etc. will be produced in a major way for domestic consumption and for exports.

INDIA VS DEVELOPED COUNTRIES

There is a distinct possibility that India will have a prominent place in fertilisers, synthetic fibres and speciality chemicals. However, in relation to developed countries the petrochemical industry, including primary and end-products as high polymers, will continue to be relatively small. India may emerge as a strong contender in providing a variety of services.

INDIA VS OTHER DEVELOPING COUNTRIES

In many respects countries like India and China will have parallel situations. It is likely that some countries in South America, notably Brazil, may emerge as important centers for chemical industry in some well defined areas.

Research and Development as a Tool for Rapid Growth

Chemical Engineering attracts very talented students for the first degree course. Postgraduate education in engineering and technology commenced in a systematic way about 20 years ago and Government support is powerful. However, as if now, careers in research are not very rewarding. Notwithstanding this limitation, a number of good students are staying on for postgraduate work and a good market for Ph.D's in Chemical Engineering now exists.

R & D in industry is a relatively recent phenomenon and there are limited number of success stories. The Government of India, through the Department of Science Technology, has provided a number of incentives. Now it is common to find a short para on R & D in Director's report and Chairman's speech. However the potential of contributions from R & D is high.

We have a large reservoir of well trained, intelligent and motivated scientists in most of the disciplines. However, research as a career does not still appear to be very rewarding and hence the number of talented scientists who gravitate towards this is limited. We should look into this matter and devise means to make this career not only intellectually exciting but also professionally rewarding. There is a capability to take complicated processes from bench scale to full plants. In some cases we do have an integration between R and D and project engineering. We also have a highly talented crew for commissioning and running plants under adverse climatic and operating conditions.

Our main strength stems from a large demand base and in most cases marketing is not a serious constraint. Our recent experiences, even in consumer electronics, have shown that demand is abnormally high. This would have a major impact on fertilisers, clothing, housing and drugs. There are many situations which call for innovative processes and products consistent with the social ethos.

We expect in the coming years a situation where technology in many sectors will not be freely available and in some cases may not be available at all. It would be prudent to recognise this reality.

As emphasised earlier the R and D costs are really low and infrastructure exists. We have a few success stories in fine chemicals, drugs, pesticides, dyestuffs, etc. to buttress our hopes and aspirations. However, so far, we have not made any impact on our core industry and, as stated earlier while discussing fertilisers, synthetic fibres, thermoplastics, petroleum refining, etc., we can plan in a concerted way to acquire an important position in the world scenario.

MAJOR CONSTRAINTS

The most important constraint, which is likely to persist for some years-perhaps upto year 2001, is the shortage of power and in addition interruptions in power supply and fluctuations from the standards. This has been very detrimental.

A possible solution, partly or wholly, in many chemical plants, is to adopt the total energy concept so that steam requirements and power demands are matched properly. There is great scope in industries like fertilisers, soda ash, crackers for olefins, etc. There is considerable scope in improving sulphuric acid plants and apart from surplus power generation in these plants, imaginative use of export steam can be made by proper integration with other plants. We have made some progress in this direction but we ought to do much more.

It is sometimes argued that we will run into serious problems of financing projects in the chemical industry. We do not support this contention as is evident from case histories of recent capital issues. It seems very likely that in coming years a large number of companies will fall upon public to subscribe to equity, convertible and non-convertible debentures, etc. Thus, as long as the dogma of putting plants in the Public Sector (i.e. Govt. undertaking) does not bug the industry we do not expect problems.

CONCLUDING REMARKS

Chemical industry will definitely play a pivotal role in raising standards of living in countries like India. The Indian chemical industry can catapult itself into one of the leaders in some selected sectors of chemical industry, notably all types of fertilisers, synthetic fibres and speciality chemicals. R and D in India is expected to make an impact in the world scenario. India is expected to enter in the world market in an important way to design, commission and operate chemical plants and provide services on a decent scale. Investment in chemical and allied industries, excluding oil and gas production, between 1985 and 2001 may easily exceed 50 billion dollars.

ACKNOWLEDGEMENTS

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ANNOUNCEMENTS

INDIAN NATIONAL SCIENCE ACADEMY (INSA) MEDALS

The Aryabhata Medal – 1986: Instituted in the year 1977, the award is given once in three years. Prof. S. Ramaseshan, Visiting Professor at the Raman Research Institute, Bangalore, has been awarded the Aryabhata Medal for 1986.

The Viswakarma Medal – 1985: This medal has been awarded to Prof. M. M. Sharma of Bombay University, for his contribution to Chemical Technology.

The Srinivasa Ramanujan Medal: This medal has been awarded to Prof. C. S. Seshadri of the Institute of Mathematical Sciences, Madras for his work in mathematics.

The T. R. Seshadri 70th birthday commemoration medal: This medal has been awarded to Prof. D. K. Banerjee, former Director, Indian Institute of Science, Bangalore, for his contribution to organic chemistry.

Raman Research Professorship of INSA: The Indian National Science Academy has selected Prof. M. G. K. Menon, Planning Commission Member for the INSA-C. V. Raman Research Professorship for his contribution to science and technology. The Professorship carries Rs. 3,500 a month for five years in addition to a contingency grant and allowance at Central Government rates.

PROFESSOR SANTI RANJAN PALIT MEMORIAL AWARD FOR THE YEAR 1987

Nominations are invited for the award of Professor Santi Ranjan Palit Memorial Award for the year 1987.

The award of Rs. 10,000/- value is instituted in the year 1985 by the Indian Association for the Cultivation of Science, in memory of late Prof. Santi Ranjan Palit. The Award is given biennially by Indian Association for the Cultivation of Science Calcutta (IACS), to distinguished scientists for outstanding research contribution made in India during the ten years preceding the year of the Award, in the fields of Physical Chemistry and/or Polymer Science.

The last date for the receipt of the nominations is **30th April 1986.**

Further particulars may be had from: Prof. A. K. Barua, Director, Indian Association for the Cultivation of Science, Calcutta 700 032.