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DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN INDIA[1]

by

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India

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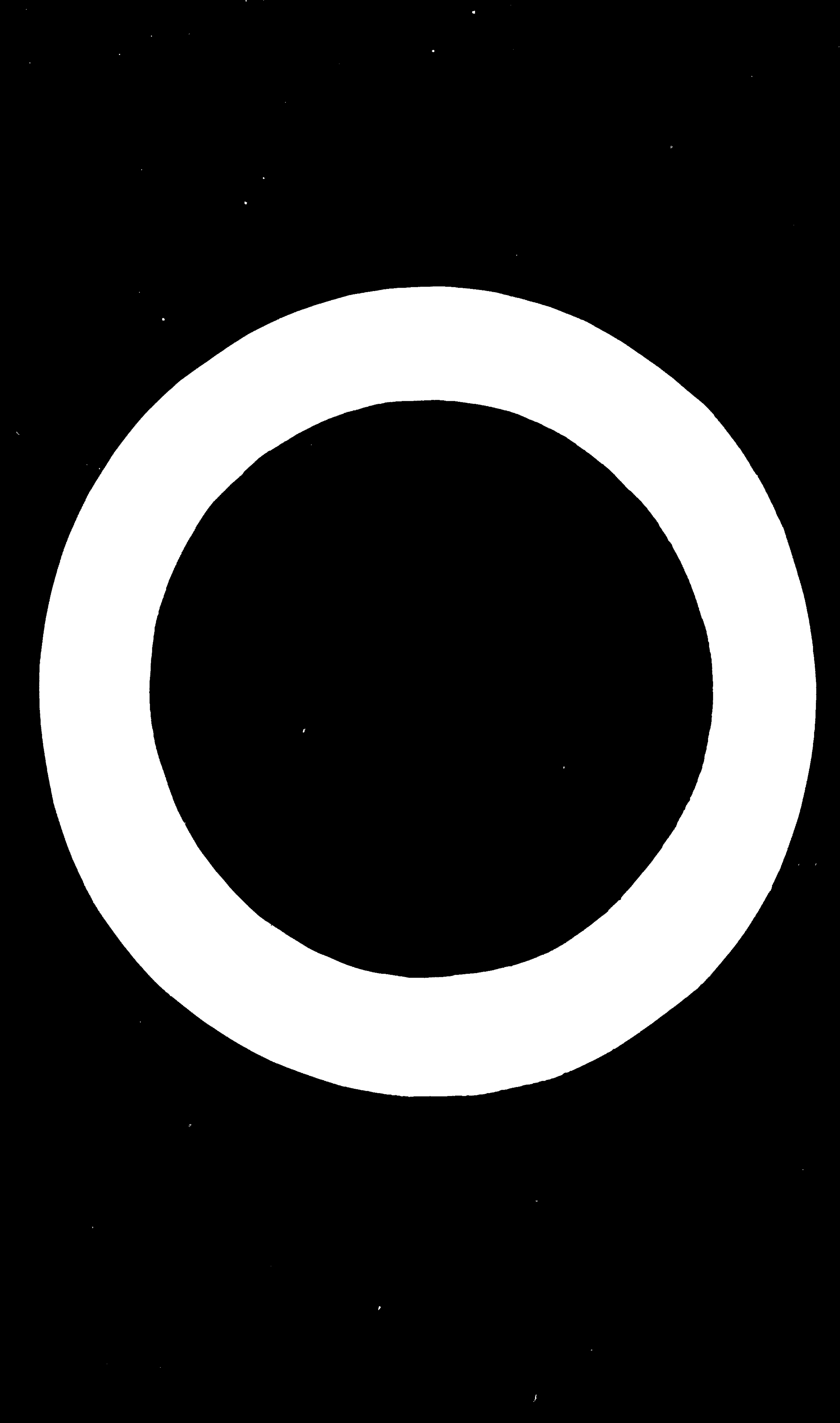

What are petrochemicals?

Chemicals derived wholly or partially from petroleum or natural gases are known as petrochemicals. Petroleum is not now only a specialized fuel burnt for its energy. It is a mixture of hydrocarbons which themselves when concentrated and purified are petrochemicals. Examples are ethane, propane, hexane etc. In addition to these, a large variety of petrochemicals are produced by one or more reactions based on petroleum products. Plastics and other synthetic resins used in paints, textiles, synthetic fibres, synthetic rubber, solvents and other heavy organic chemicals, detergent alkylates, pesticides, nitrogeneous fertilizers, are materials which are all classifiable under the term petrochemicals. It would thus be seen that modern civilization is intimately involved in petrochemicals. Every person in one way or the other uses some sort of petrochemicals daily.

Basic building blocks in petrochemicals

Naphtha or natural gases are generally cracked to isolate olefines, like ethylene, propylene, butadiene, butenes, and aromatics like benzene, toluene etc. These are the basic building blocks for diverse petrochemicals. In USA, natural gas has predominantly been used as primary raw materials, whereas in other countries, like Europe, Japan, Australia etc., naphtha is the preferred source.

Further steps in the petrochemical industries

The above-mentioned olefines, like ethylene, propylene, are further processed to produce useful products, like high polymers (poly-ethylene, polypropylene etc.), oxides (ethylene oxide) styrene, cumene, ethylene dichloride, isopropanol, butanol etc. The aromatics, like benzene, are further processed to important intermediates for the dyestuff industry and the polymer industry. Similarly C_4 streams are used in the manufacture of synthetic rubber, xylenes, etc. are further converted to phthalic anhydride, terephthalic acid etc., which are vital intermediates for synthetic resins, plasticizers, synthetic fibres, etc. Similarly, hydrogen derived from naptha is used in the manufacture of ammonia, an important source of fertilizers.

Inter-relation between classical processes and new processes in petrochemical industry

Ethylene, butadiene, acetylene, benzene, xylenes and other derived products had been earlier commercially produced from sources like fermentation alcohol, coal etc. Consequently, the products like styrene, polystyrene, butadiene, and synthetic rubber which are now commonly known as petrochemicals, are still obtainable from non-petroleum sources.

History of petrochemicals in India

As a result of the abundant world supply of petroleum, its fairly steady price and the economic process through which this raw material is converted into the most useful, mass consuming products, a new era in chemical technology had been ushered in. It started about forty years ago in USA followed by post-war development in Europe and other countries. In view of its fantastic growth in post war period throughout the western world and Japan and its wide potential in moulding the economic growth of countries, the planners in India seriously thought of schemes for its development in early sixties. The development of organic chemical industries themselves had started late in this country and it was in the early sixties, a few units of basic organic chemical industries, like acetic acid, butanol, styrene, and chemical products like plastics (PVC, polyethylene etc.), synthetic rubber, had been set up based on calcium carbide, coal carbonization products and fermentation alcohol. The manufacture of other synthetic resins based on imported raw materials had also started. Synthetic fibres like polyester, nylon etc. has also commenced based on imported basic chemicals. In 1961, the Government of India appointed a committee to "evolve a suitable pattern for development in India in the context of the integrated pattern of production of petrochemicals in advanced countries" and to "recommend the pattern of development of petrochemical industries in the country". The broad outline of programme for development of petrochemical industries in India was drawn up by the Petrochemicals Committee, whose report was published in 1962. This Committee recommended the setting up of four integrated complexes by 1971, each complex having a steam-cracker with a naphtha throughput of the order of 200,000 tonnes/year. The establishment of complexes rather than small scattered units, has been the basic approach, because such an approach results in an integrated development where all the intermediate products are utilized in units of economic size. The Committee also made estimates regarding demand for the more important organic and petrochemicals and the nitrogenous fertilizers and indicated the supply and demand position of naphtha for these. The Institut Français du Pétrole was commissioned in June 1962 by the Oil and Natural Gas Commission with the task of preparing a detailed report indicating time-phasing, location and order of investments for the development of petrochemical industry in India. This institute submitted a detailed report in February 1963. These reports were reviewed in the light of discussions in several panels appointed by the Planning Commission and in Development Councils. In the light of above, there have been considerable modifications on the original recommendations put up by the first Committee.

The present position of petrochemical industry in India

In consequence of the initial planning of petrochemical industry in the early sixties, the following units have come into operation in the mid sixties. Due to several favourable factors, petrochemical industry has made considerable headway in the Bombay region. In December 1966, the first naphtha cracker in India with a throughput of 60,000 tonnes per annum was commissioned. Ethylene is used for the production of 9,000 tonnes of polyethylene. Propylene and benzene (4,500 tonnes per annum) are sold to another unit for conversion to cumene (14,500 to 22,000 tonnes per annum). From cumene are derived phenol (10,000 to 15,000 tonnes per annum) and acetone (6,000 to 9,000 tonnes per annum). Part of the acetone is converted into di-acetone (2,000 to 5,000 tonnes per annum). In addition, one of the units is also producing acetylene black from the cracker's products (total capacity 900 tonnes per annum). The other unit is also manufacturing phthalic anhydride (6,000 tonnes per annum) out of imported ortho-xylene, and 3,000 tonnes of phthalates plasticizers.

A much bigger steam-cracker with an annual throughput of 225,000 tonnes of naphtha has also been commissioned in the same region. This is an integrated complex where the different streams from the cracker are converted to a number of petrochemicals in fairly large size plants. The total investment is estimated to be well over 500 million Rupees. The production of the intermediate products and their subsequent conversion to final products are illustrated as follows:

Table I

			tonnes
	$-C_1$ (methane 2,700 tonnes)	+ hydrogen	
		- vinyl chloride	30,000
steam cracker		(-for PVC 20,000 t	
		-for sale 10,000 t)	
		- ethylene dichloride	3,000
225,000 tonnes		- ethylene	21,000
		(-for polyethylene 20,000 t)	
naphtha	$-C_2$ (ethylene 60,000 tonnes)	- ethylene oxide	12,000
		ethylene glycol	10,000
		diethylene glycol	600
		- polyethylene glycol	1,000
	$-C_3$ (propylene 35,000 tonnes)	- acetone	11,000
		- isopropanol	1,500
		- diacetone	2,800
		- M.I.B.K.	3,700
	-Oxo process	- butanol	5,000
		- isobutanol	800
		- 2-ethyl hexanol	8,000
	$-C_4$	butadiene	7,200
	$-C_5$	dicyclopentadiene	700
	$-C_6$	benzene	14,000

About 21,000 tonnes of ethylene are sold to another unit which is producing high-density polyethylene 20,000 tonnes per annum.

The methanol unit with a capacity of 33,000 tonnes per annum has also been commissioned in the same area along with a fertilizer unit based on naphtha. In the same petrochemical area, another unit is likely to be commissioned within a year or two for the production of ethanolamines (3,000 tonnes) based on ethylene oxide available from one of the units referred to earlier. A carbon black unit (18,000 tonnes) has also been commissioned in the same area. A project for the manufacture of methylamines in the fertilizer complex near that area is also coming within two to three years.

A PVC unit with a small capacity based on acetylene from carbide is likely to be expanded to 20,000 tonnes per annum based on a small cracker producing ethylene. This scheme is likely to materialize within three years. Many other subsidiary products based on the primary products obtainable from the crackers are likely to be commissioned in the same area over the next five years. A public sector project producing a number of products based on benzene and toluene is under implementation in the Bombay area. This project will mainly concentrate on producing items required for dyestuff and allied industries. The products to be manufactured in this unit are indicated below:

Table II

Organic chemicals	tonnes/annum
1. mono-chlorobenzene	3,500
2. o-dichlorobenzene	300
3. p-dichlorobenzene	600
4. acetanilide	2,000
5. nitrobenzene	11,000
6. o-nitrotoluene	1,900
7. p-nitrotoluene	1,150
8. m-nitrotoluene	125
9. di-nitrobenzene	350
10. o-nitrochlorobenzene	820
11. p-nitrochlorobenzene	1,520
12. di-nitrochlorobenzene	1,500
13. aniline	6,000
14. nitrobenzene sulphonic acid	2,060
15. metanilic acid	1,935
16. meta-amino phenol	750

It may be mentioned in this connexion that the development of this petrochemical complex has been possible in the Bombay area due to the presence of two refineries in the same place.

In Gujerat where there is a refinery based on indigenous crudes, already one petrochemical unit has come up for the production of 3,000 tonnes of benzene and 13,000 tonnes of toluene based on Udex process. A caprolactam project (18,000 to 20,000 tonnes) in the adjacent fertilizer project is also under implementation.

The position regarding development of synthetic fibres is indicated below.

The fibre industry is distributed over wide area. At present, most of these units are producing the fibre based on imported monomers like caprolactam, and chemicals like DMT, acrylonitrile etc.

Table III

Synthetic fibres	The present installed capacity (tonnes)
nylon (textile yarn)	6,800
polyester fibres	4,500
acrylic fibre	300

High polymers for plastics

As indicated earlier, the production of polymers for the manufacture of plastics had started almost ten years back in this country. The present position regarding high polymers for plastics based on petrochemicals is indicated below:

Table IV

	(tonnes)
polyethylene (low density)	10,000
polyethylene (high density)	20,000
PVC	20,000
polystyrene	12,000

Nitrogenous fertilizers

The present installed capacity of nitrogenous fertilizers based on naphtha and natural gas is 752,000 tonnes (N) against a total installed capacity of 1,144,000 tonnes (N). About 126,000 tonnes (N) is based on natural gas. Further capacity to the extent of 858,000 tonnes (N) is under implementation. An additional capacity of 924,000 tonnes (N) has also been approved. Thus a total capacity of 2,415 million tonnes of N has already been established and approved. The total naphtha requirement for this capacity would be of the order of 0.66 million tonnes. The above mentioned capacity is likely to be established by 1975/1976. Further fertilizer capacity may have to be established based on other feedstocks like heavy oil, L.S. heavy stock etc., if naphtha is not available from indigenous sources by that time

As indicated earlier, development of the plastics industry has taken place in this country based on coal carbonization etc. The position regarding the major plastics polymers already set up in this country based on these sources is given below:

Table V

	tonnes	remarks
low density polyethylene	12,000	(based on alcohol)
PVC resins	17,500	(based on acetylene from carbide and ethylene from methanol)
polystyrene	10,000	(based on ethylene from alcohol)
urea formaldehyde resins (adhesives)	8,000	
U.F. and M.F. moulding powder	4,450	
phenolic moulding powder	6,700	
polyester resin	1,300	

Similarly the position regarding organic chemicals based on non-petroleum sources is given below:

Table VI

	Capacity intalled tonnes	remarks
acetid acid	16,000	based on alcohol (fermentation)
acetic anhydride	7,000	"
acetone	1,500	"
butanol	4,000	" (another 5,000 tonnes capacity based on alcohol under implementation)
butyl acetate	4,500	based on alcohol (fermentation)
ethyl acetate	4,500	"
chloroethylenes	8,400	based on acetylene from calcium carbide
mono-chloro acetic acid	2,500	
butadiene	22,500	based on alcohol

Table VI (cont'd)

	Capacity installed tonnes	remarks
styrene	18,000	another 10,000 tonnes under implementation
ethylene	25,000	based on ethylene from alcohol
phenol	2,000	coal carbonization
benzene	54,000	" "
toluene	9,000	
naphthalene	12,000	
ethanol	286,000	
2-ethyl hexanol	2,500	

Table VII

synthetic rubber (SBR)	30,000 tonnes	based on non petroleum sources

The present position of petrochemicals derived both from petroleum and other sources are given in the following tables:

Table VIII

Plastics
(total capacity established both from petroleum and other sources)

low density polyethylene	22,000 tonnes
high density polyethylene	20,000 "
PVC	40,000 "
polystyrene	20,000 "
U.F. resin	8,000 "
U.F. moulding powder	4,450 "
P.F. moulding powder	6,700 "
polyester	1,300 "
cellulose acetate	3,000 "

Table IX

Organic chemicals
(total established capacity both from petroleum and other sources)

acetic acid	16,000 tonnes	
acetic anhydride	7,000 "	
acetone	18,500 "	
butanol	9,000 "	
butyl acetate	4,500 "	
butadiene	30,000 "	
benzene	106,000 "	
chloro ethylenes	5,400 "	
carbon black	54,000 "	
acetylene black	1,000 "	
diacetone	5,000 "	
ethylene	96,000 "	
ethyl acetate	4,500 "	
ethanol	286,000 "	
2-ethyl hexanol	10,500 "	
ethylene oxide	12,000 "	
ethylene glycol	10,000 "	
ethylene dichloride	5,000 "	(excluding captive capacity from vinyl-chloride)
formaldehyde	26,000 "	
isobutanol	800 "	
isopropanol	1,500 "	
mono chloro acetic acid	2,500 "	
M.I.B.K.	3,700 "	
methanol	33,000 "	
napahthalene	12,000 "	
phenol	18,000 "	
propylene	40,000 "	
polyethylene glycol	1,000 "	
phthalic anhydride	12,000 "	

Table IX (cont'd)

Organic chemicals

(total established capacity both from petroleum and other sources)

phthalate plasticizers (DOP, DBP, DEP, DMP, etc.)	12,000 tonnes
styrene	18,000 "
toluene	22,000 "
vinyl chloride	50,000 "

Table X

Synthetic Rubber

SBR (dry and oil extended)	30,000 tonnes

Outlook for future

The future production of heavy organic chemicals and nitrogenous fertilizers will be mainly based on naphtha or natural gases in India.

Regarding nitrogenous fertilizers, the likely position till 1975 has already been indicated. For period beyond 1975, the position to date is still fluid as the planning in this line will depend mostly on availability of additional naphtha from indigenous sources (from enhanced capacity of refineries) as well as from alternate feedstocks like heavy oil, L.S. heavy stock etc.

Other organic chemicals and chemical products

In Gujarat near the refinery site, a project for the manufacture of ortho and paraxylenes (capacity 2[illegible] and [illegible] tonnes respectively) and mixed xylenes to the extent of [illegible],500 tonnes along with DMT (20,000 tonnes) is now under implementation. The project cost would be of the order of 130 million Rupees. The scheme is likely to be implemented by 197[illegible].

A decision has been taken to erect a cracker based on naphtha derived from indigenous Gujarat crude with a throughput of 323,000 to 42[illegible] tonnes of naphtha. Ethylene (100,000 to 130,000 tonnes), propylene (about 50,000 to 65,000 tonnes including 1[illegible],000 tonnes of polymer grade), benzene (1[illegible] to 25,000 tonnes) would be available for further processing. The capacity for butadiene has not yet been finalized as it might be necessary to set up a separate synthetic unit coupled with extracted butadiene from the cracker. This project will be in the public sector. In addition, several down stream units have been planned based on the products available from the cracker.

They are:

Table XI

1.	low density polyethylene	40,000 - 45,000	tonnes
2.	(a) styrene	30,000	"
	(b) polystyrene and co-polymers	16,000	"
3.	vinyl acetate/polyvinyl acetate and alcohol	30,000	"
	(by-product acetic acid)	13,000	"
4.	polypropylene resins (including 3,000 tonnes of fibres)	15,000	"
5.	acrylonitrile	17,000 - 24,000	"
6.	synthetic rubber (general purpose polybutadiene/SBR)	30,000	"

There is a likelihood of certain changes in the downstream units. The total investment in this project including downstream units is likely to be of the order of 1,200 million Rupees.

Future petrochemical complexes in other areas are still now in the planning stage. They would be taken in hand only after reviewing the progress made in the Gujarat complex.

Barauni area

It is intended to implement the project in two phases. The production pattern envisaged is as follows:

Table XII

		tonnes (1)	tonnes (2)
1.	benzene	41,400	56,500
2.	cyclo hexane	19,000	30,000
3.	ortho xylene	7,000	15,000
4.	para xylene	-	25,000

In this area, there is another project under advanced consideration for the manufacture of detergent alkylates (dodecylbenzene) (20,000 to 28,000 tonnes) along with other olefins from C_2 - C_6 based on wax cracking. The possibility of setting up a DMT and a naphthalene plant is also under study.

Other petrochemical complexes are likely to be set up in Madras and Haldia (near Calcutta) later.

Table XIII

Future capacity of synthetic fibres
(already approved)

nylon textile yarn	8,500 tonnes
nylon industrial yarn	8,800 "
acrylic fibres	11,500 "
polyester fibres	19,900 "

Table XIV

Estimated demand of plastics and synthetic rubber
(provisional)

	1973/1974	1978/1979
	tonnes	
PVC	80,000	175,000
polyethylene (LD)	58,000	150,000
polyethylene (HD)	23,000	45,000
polypropylene	7,000	15,000
polystyrene and co-polymers	35,000	70,000
phenolic moulding powder	6,500	9,000
phenolic resins	13,000	22,000
UF (moulding powder)	3,500	7,000
UF (resins adhesive)	12,000	24,000
acrylic resins	5,000	10,000
polyester resins	1,400	3,200
epoxy resins	750	1,500
melamine formaldehyde moulding powder	1,000	2,000
phthalate plasticizers	18,000	38,000
synthetic rubber (SBR polybutadiene)	60,000	108,000

Table XV

Estimated demand of major organic chemicals
(provisional)

	1973/1974	1978/1979
	tonnes	
acetic acid	30,000	60,000
ethanol	300,000	400,000
ethylene oxide	16,000	30,000
methanol	45,000	80,000
isopropanol and derived solvents	23,000	35,000
butyl-isobutyl alcohol	16,000	18,000
2-ethyl hexanol	[illegible]3,000	50,000
phthalic anhydride	24,000	60,000
phenol	17,000	30,000
aniline	6,000	10,000
detergent alkylates	15,000	40,000
chlorinated ethylenes	10,000	20,000
ethylene glycols	14,000	30,000
styrene	50,000	75,000

The main constraints in the development of petrochemicals in developing countries

Petrochemical industries, which are new to this country, have certain special features about them. They are highly capital intensive and when the production is trebled, economies in capital investment ranging from 20 to 45 per cent are possible depending on the type of production. Economy in the cost of production results from reduction in unit costs in labour and capital. In the production of ethylene, for example, while the capital investment per tonne is around US$570 for a plant of [illegible]0,000 tonnes per year capacity, it comes down to about US$250 for a plant of [illegible]0,000 tonnes per year capacity.

This type of industry needs a high proportion of skilled labour including technicians and scientists, but the labour requirement is small. While this is so in the case of petrochemical intermediates, the next stage, i.e. the processing of these intermediates into finished products, is labour intensive.

This is an industry with a high rate of technological changes and obsolescence. This is due to large-scale organized research and development on which a substantial amount of money is being spent in the U.S.A., European countries and Japan.

Yet another feature of this industry is the need for setting up of complexes because of inter-dependence of the industry.

From our experience in India, we have come across the following facts:

If any petrochemical complex is planned based purely on the present indigenous demand and its likely expansion over a limited period of 4-5 years, the chances of setting up minimum economic units are very remote. An active participation in export trade for these chemicals is essential to avoid selling in a limited market and thereby incurring loss over a long period. Thus the necessity of a well organized marketing division which would look after the highly competitive international trade is essential.

In view of the limited resources of both internal currency and foreign exchange at the disposal of the developing countries, a very thorough project evaluation is essential before setting up petrochemical industries. Simultaneously, a high risk has to be taken consciously to set up these units keeping in view the wide potential of these industries in ameliorating the economic conditions of the general population.

There should be no illusion regarding its limited effect in employment potential particularly so far as basic industries are concerned. As stated earlier, it is only at the ultimate stage, viz., finished fibres and the apparels made thereof or the plastic process industries, that there could be scope for wider employment of labour.

The shortage of skilled technicians in developing countries who could be entrusted in setting up as well as running these sophisticated activities is well known. A well planned training programme is thus essential before going ahead with petrochemical industries.

An infrastructure of engineering industries (fabrication of plant and equipment) and an experienced consultancy organization (looking after detailed drawings and designs, co-ordinating the various activities connected in this sort of projects) is essential for smooth development of petrochemicals in a developing country as otherwise there would be chronic shortage of foreign exchange and other con-committant troubles affecting the smooth growth of these industries. In fact, without these facilities, the generation of confidence among the technicians of the developing countries would be sufficiently handicapped that any real benefit to the country would be in doubt.

An industry with such high rate of technological changes and obsolence requires well organized research institutions and departments both in industry and outside to cope with this sort of problem. Establishment of these should almost be compulsory to avoid future troubles.

UNIDO assistance

Fortunately, in India thanks to sagacious planning, the infrastructure of engineering industries and consultancy organizations have been established and it is on these lines, viz., by providing her experts for UNIDO's activities abroad, India can claim to assist other developing countries desirous of setting up petrochemical industries.

In the field of international marketing particularly by public sector units, where no permanent collaboration with foreign parties exist, UNIDO could be of much assistance in offering technique of export of manufactured products and development of marketing techniques.

Similarly in organizing research and development departments in industries themselves could be well assisted by UNIDO.

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