OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

ph

05032

Distr.
LIMITED

ID/WG.158/8
7 June 1973

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on the Development
of the Synthetic Rubber Industry

Snagov, Romania, 25 - 29 June 1973

MANUFACTURING OF SYNTHETIC RUBBER IN ALEXANDRIA PETROCHEMICAL COMPLEX 1/

by

M.H. El Hifnawi
Nasr Petroleum Company
Alexandria, Egypt

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.73-4232

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

CONTENTS

Page

I INTRODUCTION

One may ask why Egypt should at all consider installing a synthetic rubber plant when it can buy natural rubber from other developing countries or import synthetic rubber from other developed ones. Egypt as well as other developing countries may be justified in considering such a project for the following reasons :-

a - A synthetic rubber project helps in the economy of a petrochemical complex as the one planned to be installed in Alexandria by providing an outlet for some of the products produced from naphtha cracking and which otherwise have to be burnt and valued as fuel oil.

b - The foreign hard currency required for importing rubber natural or synthetic is reduced or saved if locally available raw materials can be used.

c - Producing costs for some synthetic rubbers are normally lower than those of natural rubber.

d - A synthetic rubber has a uniform specified quality and does not suffer from frequent price fluctuations and interruption of supply like the natural rubber.

.../2

It can be said that new technical advances made in the production of stereo-regular rubbers have enhanced the acceptability of synthetic rubber in areas where natural rubber has maintained a prime position. It is clear that the developing countries will mainly install synthetic stereo-regular plants in future and the cis-polyisoprene, being one of the low cost synthetic rubbers that can be used interchangeably with natural rubber in heavy-duty tires, is bound to receive increasing attention from all the countries that are planning to install new rubber plants as Egypt.

II The petrochemical complex in Alexandria

Since naphtha is available in excess than what is required for the local market requirements of motor cars in Egypt, this naphtha could either be exported, burnt as fuel in furnaces or used as feedstock for petrochemicals. Both polyethylene and P.V.C. are badly required for the local market in Egypt for use in the following :-

a - Bags for fertilizers produced from existing fertilizer plants amounting to about one million tons per year.

b - Making P.V.C. tubes for domestic use as well as for irrigation purposes.

c - Use for shoes manufacturing.

d - Use for sheathing of cables.

e - Use in other different articles and services like tiles, pots, etc.

Since the required articles are either imported as finished products or raw synthetic material is imported and then fabricated to the different articles required for the local market, it was clear that the production of 45000 T/year of polyethylene and about 40000 T/year of polyvinyl chloride could be easily consumed in Egypt leaving no surplus available in few years soon after the start up of the petrochemical complex when the consumption will equal to 1 kg P.V.C. per capita which is still too low compared to the consumption in Lebanon which is 6 kg/capita & in other european countries reching about 35 kg. per capita.

It was also found that the consumption of different types of rubber in Egypt in 1975 and 1980 is estimated as follows :-

TABLE I

M. TONS IN YEAR 1975

	Natural R	S.B.R.	Polybutadiene	Butyl
Tyres Co.	4500	1900	2200	1370
Rubber articles Co's	750	750	-	-
Shoes Manufact. Co's	400	800	-	-
Cables Manufact. Co's	75	75	-	-
Others	575	522	-	-
Total	6300	4047	2200	1370

.../5

TABLE II

M. Tons in year 1980

	Natural R	S.B.R.	Polybutadine	Butyl
Tyres Co.	6500	2650	3400	2050
Rubber articles Co's	1000	1500	-	-
Shoes Manufact. Co's	500	1000	-	-
Cables Manufact. Co's	100	105		
Others	575	522		
Total	8675	5777	3400	2050

The exising production of tires in Egypt is as follows:-

Passenger cars tires	300,000 Pieces
Trucks tires	170,000 "
Inner tubes	600,000 "
Bicyle tires	500,000 "

The main reasons for such low consumption of tires are the following :-

a - The total number of motor cars in the country (excluding the army vehicles) is 130,000 cars and 45,000 trucks which is very low for a country with 35 millions inhabitants.

.../6

b - The necessity of importing any type of rubber natural or synthetic in foreign hard currency prevents existing factories from extension and stops new factories from being erected. This naturally limits the production of new articles made from rubber or substituting other materials by rubber which is not easily imported.

c - The small number of motor cars produced by a single small car manufacturing company, at a higher cost than the imported ones. The high rate of customs dues imposed on the imported cars makes it very expensive for the majority of average persons to have their own cars.

d - The dramatically cheap fares of public transport especially the railway fares compared to the cost of running a car or using a bus.

However, the above consumptions of the different types of rubber illustrate that the installation of a synthetic rubber plant for Egypt is an attractive and economic preposition.

.../7

It was therefore decided because of afore mentioned consumption figures that it is possible to erect a petrochemical complex in Alexandria based on cracking about 256000 T/year of naphtha produced from Amriya Refinery nearby. This will produce about 80000 T/year of ethylene which will be used for the production of 45000 T/year of polyethylene and about 40000 T/year of P.V.C. The other products that will be available from the steam cracking are the C3 cut and the C4 cut. It is estimated that 38400 T/year of propylene and 24800 T/year of C4 cut will be produced and about 10600 T/year of Butadiene could be extracted from the latter. Table 3 indicates the intake and production figures for the complex & Table 4 shows the estimated investment cost for the different units.

.../8

III Pyrolysis of S.R. Naphtha

	M. T/year	% wt
Intake :		
S.R. Naphtha F.R.	256000	100
Production :		
H_2	6864	2.7
CH_4	36800	14.4
Ethylene	80000	31.2
Propane	3920	1.6
Propylene	38400	15.0
C_4 cut	24800	9.7
Gasoline	52936	20.6
Fuel Oil	12280	4.8
Chlorine required for P.V.C.	26400	

.../9

TABLE IV

ESTIMATED INVESTMENT COST FOR THE PETROCHEMICAL COMPLEX IN ALEXANDRIA

Stage A	T/year	LE. 10^6
Ethylene craking	80000	13.789
Polyethylene low density	45000	22.777
Venyl chloride monomer	43000	7.975
Polyvenyl chloride	40000	6.722
Butadiene extraction	10000	3.651
Stage B		
Polybutadiene	15000	5.907
Butadiene-Styrene (x)	15000	4.900
Ethylene glycol	10000	4.253
Polypropylene (x)	30000	8.738

(x) Under consideration.

III CHOICE OF SYNTHETIC RUBBER SUITABLE FOR EGYPT

The choice of any particular rubber will obviously depend on considerations of strict competetimeness and of economic consideration resulting from raw material availability, monomer synthesis cost and processing difficulties.

Although S.B.R. is one of the cheapest versatile compounds and oil extended S.B.R. is used for passenger car tires as well as footwear, conveyer belts, cable insulation, hose and foam products yet the main difficulty with S.B.R. tire compounds is its high heat generation under dynamic conditions. These compounds also have poorer hot tear resistance than natural rubber compounds. With the increase of tire thickness and size, releasing tires from moulds during manufacture and dissipation of heat in the running of the tires become difficult problems. In the developing countries where the greatest use of rubber is for large bus and truck tires, it is reported that S.B.R. is not a suitable substitute for natural rubber.

Of the conventional synthetic rubbers, butyl, chloroprene have established markets and their consumption is increasing. Butyl rubber a copolymer of a small

.../11

percentage of isoprene with isobutylene (and sometimes disyclopentadiene) is relatively impermeable to air and has good resistance to heat and oxygen. Virtually all inner tubes in U.S.A. & Europe are made from butyl rubber. However, butyl rubber consumption for tires did not increase well because of excessive tread wear.

IV STEREO REGULAR RUBBERS

Three groups of stereoregular synthetic rubbers have been developed and have shown great potential for rapid growth; these are : cis-polybutadiene, cis-polyisoprene and ethylene propylene rubbers. The latter will not be discussed in this paper since its consumption is still very limited.

I - POLYBUTADIENE RUBBER

Great confidence has been expressed in the future for P.B. and proof of this lies in the large number of plants that are planned. Compared with 100% SBR, PB has better wear, heat build-up and groove crack resistance. The only falling off is noticed in resistance to chipping. This may be improved with more knowledge about its compounding and blending with natural rubber in 50-50 for heavy duty tires and in 25-75 blends with SBR for passenger tires.

Lithium and organolithium compounds seem to be different from other alkali metals and produce polybutadiene with ca 35% cis 1-4 and 50% trans 1-4 stnucture. After the introduction of the Zeigler type catalyst such as Aluminium triethyltitanium tetraiodide it wqs possible to produce polybutadiene with more than 90% cis 1-4 structure. When this was blented with 20-25% S.B.R. it showed improved abrasion and crack resistance in tire treads. Cis 1-4 polybutadiene is characterized by high abrasion resistance, low temp. properties and good resistance to ageing. Blends with more than 50% cis 1-4 Polybutadiene with S.B.R. produce problems in tread tearing, chipping, skid resistance and general ride quality. Its consumption could therefore be estimated by assuming that about 25% of rubber in all automobile tire treads can be of cis-polybutadiene and that tire tread constitute about 60% of the weight of the rubber in a tire. Thus if 50% of the new rubber goes in automobile tires, then 8-10% of the total new rubber could be assigned to cis-polybutadiene. The solution polymerization technique for cis polybutadiene using Zeigler type catalyst is similar to thqt for cis polyisoprene.

.../13

2 - POLYISOPRENE

This rubber is the best known to use in tire side walls and footwear. Cis-polyisoprene which resembles natural rubber was obtained by polymerizing a sol. of isoprene in a solvent with either a lithium base catalyst or a Zeigler type catalyst such as aluminium trialkyl-titanium tetrachloride. In 1961 Shell produced cis-isoprene rubber with a cis content of 90-92% and in 1962 Goodyear's Natsyn produced its rubber with 95-96% cis content.

Studies have shown that polyisoprene rubber gives vulcanizates very similar to those of natural rubber. The vulcanizates have high resilience and low heat built up. Moreover it is a synthetic material of good prosessability and could be used after minor modifications and recipe in conventional rubber processing equipment. P.I. has the potentional of being of excellent uniformity and it is finding applications in areas previously held by natural rubber particularly where good mould flow, excellent colour and purity of polymer are of importance. Following table 5 gives the typical properties of natural rubber & polyisoprene vullanizates.

.../14

TABLE V

TYPICAL PROPERTIES OF POLYISOPRENE & NATURAL RUBBER VULCANIZATES

	Tires Tread Compound		Carcass Compound	
Natural rubber (No 1 smoked sheet)	100	-	100	-
Polyisoprene (natsyn 200)	-	100	-	100
ISAF black	50	50	-	-
Sulphur	2.25	2.25	3	3
Tensile strength (psi)	4300	4200	4775	4400
Elongation (%)	550	650	740	800
300% modulus (psi)	1800	1300	675	475
Shore A hardness	68	67	55	54
Rebound at 212°F (%)	76.4	74.6	84.5	83.5
Heat build up (°F)(Goodrich Flexometer)	54	54	29.0	30.5

These compounds contain conventional amounts of Zinc oxide, Stearic acid, antioxidants and accelerator.

Published tests indicate that polyisoprene is fully equivalent to natural rubber in gum rubber formulations. It is reported that cisisoprene is chemically identical with natural rubber and also almost duplicate the compounded physical properties of natural rubber; it has the advantage of being cleaner more uniform in quality than natural rubber available. It can be charged to the mill without size reduction or premastication and usually require less mixing time than premasticated natural rubber.

Oil extended polyisoprene is a good prospect on economic grounds and its latexes may well proove to be one of the most important outlets for polyisoprene.

V Methods of Isoprene production

Of the several methods used for the manufacture of isoprene (1, 2) two routes have been used commercially propylene dimerization (Goodyear S.D.) and dehydrogenation of isopentane (Houdry or Shell). The latter is similar to the well known dehydrogenation process for butadiene production from n-butane or n-butene. Butane or butene being structurally simpler can be dehydragenated to butadiene more selectively than isopentane or isopentene can to isoprene. Also n-butane is more plentiful than isopentane. The isopentane route is likely therefore to produce isoprene at a higher cost than the normal butane-butene route for butadiene.

.../16

In the goodyear S.D. process propylene is dimerized to 2 methyl-1 pentene in the presence of tripropyl aluminium catalyst; the former is isomerized to 2-methyl-2-pentene, which is then cracked in the presence of vapour phase catalyst to obtain isoprene and methane. This crude is then fractionated to yield a monomer of exceptionally high purity.

VI CHEMISTRY OF ISOPRENE

It is obtained from propylene 99.9% pure free from water & sulphur & other reactive substances in 3 reaction steps :-

1 - Demerization of propylene to 2-methyl pentene-1.

2 - Isomerization of 2-methyl pentene-1 to 2-methyl pentene-2.

3 - Pyrolysis of 2-methyl pentene-2 to isoprene & methane.

1 - $2\ CH_2 = CH{-}CH_3 \xrightarrow[200^\circ C]{3000\ p.s.i} CH_2 = C(CH_3){-}CH_2{-}CH_2{-}CH_3$

propylene 2 methyl pentene-1.

In the liquid phase & catalyst is tri-n-propyl alumium. It is an exothermic reaction = -23 Kcal. Selectivity is 90%. Trimer is the principal by product.

.../17

2 - Isomerization is in vapour phase at atmospheric pressure & $100^{o}C$, over special silica alumina catalyst.

$$CH_2 = \overset{CH_3}{C} - CH_2-CH_2-CH_3 \longrightarrow CH_3-\overset{CH_3}{C} = CH-CH_2-CH_3$$

2 methyl pentene-1 $\quad$ 2 methyl pentene-2

= 1.5 Kcal exothermic

equilibrium coversion is = 85%

3 - $$CH_2 = \overset{CH_3}{C} - CH_2-CH_2-CH_3 \longrightarrow CH_2 = \overset{CH_3}{C} - CH = CH_2 + CH_4$$

2 methyl pentene-2 $\quad$ isoprene

= 15 Kcal endothermic

It is conducted at $660^{o}C$ & atmospheric pressure, steam as diluent & HBR as a catalyst.

VII <u>PRODUCTION COST OF ISOPRENE</u>

Production cost estimates based on propylene price of 1.5-2.5 ¢/lb show that isoprene can be produced from propylene to complete with butadiene, which is a well established chemical selling at 11-13 ¢/lb.

The following tables illustrate the elements of operating cost for a 20,000 T/year plant for isoprene production from Isobutylene or propylene. The use of propylene for the manufactures of synthetic rubber in

.../18

Egypt will eleminate the necessity of installing a polypropylene unit whose product is not essential for Egypt and thus will save the polypropylene plant investment which is estimated to be 8.738 million pounds for a capacity of 30000 T/year. (Refer Table 4).

TABLE VI

ELEMENTS OF OPERATING COST OF 20,000 T/YEAR ISOPRENE PRODUCTION

BASED ON ISOBUTYLENE & PROPYLENE

MANUFACTURING COST AND SELLING PRICE

Variable charge	Unit cost $	Isobutylene Annual Quantity	Isobutylene Annual cost (10^3 $)	Propylene Annual Quantity	Propylene Annual cost (10^3 $)
Raw material					
Isobutylene (tons)	24	21800	520	-	-
Methynol (tons)	50	19800	990	-	-
Propylene (tons)	50	-	-	31000	1550
Byproducts Residols(tons)	10	(9200)	(-921)	-	-
Investments in 10^6 $			5.6		8.6
Utilities					
Electricity (10^6 Kwh)	10	6350	63	$ 135000/y.	
Steam (tons)	1.6	208000	333		
Cooling water (10^3M^3)	6	2780	17		
Process water (M^3)	0.2	64000	13		
Fuel produced (10^6 Kcal)	1.5	(1600)	(-2)		
Catalyst and chemicals			150		90
Labour men/shift			7		7
Salaries & wages (men/year	500	28	140	28	140

.../20

Supervision at 25% of salaries and wages	35	35
Total variable charges	2167	1950
Fixed charges	1290	1970
Manufacturing cost	3457	3920

SELLING PRICE	Isobutylene Annual cost 10^3 $	Propylene Annual cost 10^3 $
Net cash flow at 20% of total investment	1120	1720
Depreciation provides	700	1070
Net income after taxes	420	650
Net income before taxes at 50%	840	1300
Manufacturing cost	3457	3920
Isoprene sales	4297	5220
Isoprene selling price $ /ton	215	260
	or ¢/lb 9.8	or ¢/lb 11.8

.../21

VII ISOPRENE TOTAL CAPITAL INVESTMENT

	$
Process units investment	5613000
Tankage & utilities	1293000
Total	6906000

Dimerization section	1521000
Isomerization section	707000
Pyrolysis section	1955000
Recovery section	1064000
Purification section	1659000
Total process & Utilities cost	6906000
General service facilities at 15% of above	1036000
Total fixed capital	7942000
Interest on constmetion loan at 7% year (x)	556000
Start up cost 10% of total process & utilities cost	794000
Working capital	750000
Total capital investment not including land	10042000

(x) Construction period of 24 months financed loan of $ 7.942 million for average of half of construction period assumed.

.../22

VIII PRODUCTION COST FOR 80 MILLION LB/YR AT 0.9 STREAM FACTOR

Direct opert. cost		Basis or unit cost	¢/lb
Labour :	Operating	6 men/shift at 4.4$/men-hr	0.29
	Maintenance	3.8% of process unit invest.	0.26
	Control Lab.	20% of operating labour	0.05
	Total labour		0.60
Material :	Raw & process		
	Propylene	3.0 ¢/lb	6.85
	Tri-n-propyl aluminium	98.0 ¢/lb.	0.93
	HBR	65.0 ¢/lb.	0.02
	NaOH	3.0 ¢/lb.	
	Maintenance	3.8% of process unit invest.	0.26
	Operating	10% of operating labour	0.03
Total Material			8.09
Total utilities			0.95
Total direct cost			9.64
Plant overhead			0.48
Taxes & insurance			0.20

.../23

Plant cost		10.32
C & A		0.39
Cash expendition		10.71
Depriciation		0.99
Interest on working capital		0.06
Total production cost		11.76

<u>By-product credit</u>

Propane-propylene	2.5 ¢/lb.	(-0.06)
Methane & others	0.7 ¢/lb.	(0.56)
Other	1.5 ¢/lb.	(0.67)
Net production cost		10.47

.../24

IX UTILITIES SUMMERY

	Dimerz. Sect.	Isomery. Sect.	Pyrol. Sect.	Recov. Sect.	Purif. Sect.	Total
Water (1000 gal/hr) cooling	69.2	99.5	241.0	55.8 (x)	142.5	608.0
Make up (steam plant)	0.8	3.3	3.4	1.4	4.7	13.6
Make up (cooling water)	1.4	2.0	4.8	1.1	2.8	12.1
Steam lb/hr	5970	25600	26800	11350	36500	106220
Elect. power (KW) process	500	8	17	590 (x)	3	1118
Utilities	28	62	104	31	88	313
Fuel (10000 cu.ft/hr)	20.4	--	55.3	--	--	75.7

(x) Includes requirements for refrigeration.

..../25

VII STEREOSPECIFIC POLYMERIZATION COST

Polymerization manufacturing cost is quite similar for the 3 stereo regular rubber : PB, PI & EPR.

Next table 7 gives the elements for a 20000 T/year plant starting from Butadiene or isoprene or ethylene and propylene. The manufacturing cost for such a plant, including profits and taxes is given in table 4.

Polyisoprene and Polybutadiene selling prices may be estimated as follows :-

Monomers selling price (Isoprene & Butadiene) 220 $/ton or 10 ¢/lb.

Polymerization manufacturing cost including profits and taxes at 50% 265 $/ton or 12 ¢/lb. Polymer selling price 485 $/ton or 22 ¢/lb.

.../26

TABLE X

20,000 TONS/YEAR STEREOSPECIFIC POLYMERIZATION PLANT

ELEMENTS OF OPERATING COST

Investment (MM$) (including start up expenses, laboratories, inital catalyst & chemical charges and paid up royalities).	8
Utilities requirements :	
Electricity (10^6 Kwh/year)	25300
Steam (tons/year)	136000
Cooling water (10^3 M^3/year)	7300
Process water (M^3/year)	450000
Nitrogen (10^3 M^3)	8600
Chemicals and catalysts ($)consumption	1,260,000
Labour men per shift	20

.../21

TABLE XI

MANUFACTURING COST INCLUDING PROFITS AND TAXES

Unit	Unit cost \$	Annual Quantity	Annual cost 10^3 \$ /year
Utilities			
Electricity (10^6 Kwh)	10	25,300	253
Steam (tons)	1.6	136,000	218
Cooling water (10^3 M^3)	6	7,300	44
Process water (M^3)	0.2	450,000	90
Nitrogen (10^3 M^3)	2	8,600	17
Chemicals and catalyst			1,260
Labour			
Salaries and wages (men/shift)	5,000	80	400
Supervision at 25 percent of salaries & wages			100
Total variable charges			2,402
Fixed charges			1,840
Total manufacturing cost			4,242
Net cash flow at 20 percent of total investment			1,600
Depreciation provides			1,000

.../28

Net income after taxes	600
Net income before taxes at 50%	1,200
Total manufacturing cost	4,242
Manufacturing cost including profits after taxes at 50 percent	5,442
Manufacturing cost including profits ($/ton)	272
	(or ¢/lb) 12.3

<u>N.B.:</u> Manufacturing cost for a 40,000 tons/year plant is estimated at 11 ¢/lb.

IX - STYRENE - BUTADIENE RUBBER

This is the main synthetic rubber produced all over the world and it is made by one of the following processes.

A) Emulsion process at 122 oF (hot process)

B) Emulsion process at 41 oF (cold process)

C) Solution process using alkyllithium catalyst

D) Alfin (Alcohol & olefin) Solution process using complex sodium salt.

It is reported that in U.S.A. about 90% of all solid S.B.R. is made by a cold emulsion polymerization process.

Solution process using lithium catalysts and producing random copolymers is in commercial use. Alfin process is not widely used yet. Compared to emulsion S.B.R., solution S.B.R. has a narrower molecular distribution and a higher cisdiene content.

Solution S.B.R. requires lower amounts of an accelerator to obtain a given modulus and hardness than emulsion S.B.R. does, therefore when used in tires gives lower heat build up, higher resilience and better blowout resistance. Solution S.B.R. gives poorer mill binding, rougher extrusions and generally more difficult to process. By proper balancing however solution S,B.R. as presently made has significantly better properties than emulsion S.B.R. and is still not too difficult to process.

Alfin S.B.R. has a narrow molecular weight distribution, It is specially free from the low molecular weight portion and it has

./..

a diene configuration of 69 % trans and 31% vinyl. Dut to high trans contact, it requires a higher milling temperature than other S.B.R. . Performance of alfin S.B.R. should be between that of emulsion and that of solution S.B.R.

It is reported that in 1980 world market will contain more solution S.B.R. than emulsion S.B.R. by about 50% .

TABLE XII

CAPITAL INVESTMENT IN 1000 DOLLARS FOR STYRENE- BUTADIENE RUBBER BY COLD EMULSION PROCESS

Plant capacity 77.4 Million pounds/year

Stream factor 0.9

	Raw Material preperation	Polymerization	Monomer recovery	Coagulation & drying	
Battery limit investment	665	1,914	2436	2249	7284
Utilities & tankage investment	369	656	158	1511	2694
Total	954	2570	2594	3760	9878
General service facilities at 15% of above					1482
Total fixed capital					11360
Interest on construction loan at 9.5% x					1079
Start up costs					800
Total depreciable capital					13239
Working capital					800
Total capital investment not including land					13739

x For one half the assumed construction period of 24 months.

- - - - - -

TABLE XIII

STYRENE BUTADIEN UNITS OPERATING COST
IN 1000 $ / YEAR

	Raw Material Preparation	Polymerization	Monomer Recovery	Coagulation and drying
Total labor	117.4	105.3	157.4	415.7
Total Material	24.6	7760.8	142.8	1048.7
Total Utilities	20.2	104.0	44.8	131.0
Total direct operating cost	162.2	7970.5	328.7	1596.0

TABLE XIV

PRODUCTION COST FOR STYRENE - BUTADIENE RUBBER

BY COLD EMULSION PROCESS

	Basis or Unit cost	Total cost 1000 $/year ¢ / lb	1000$/year
Labor operating	12 men/shift, 4.90 $/man hr.	0.66	513.6
Maintenance	2.5% yr of battery limit cost plus 1.5% of refrigeration cost	0.24	185.7
Control lab.	20% of operating cost	0.13	102.7
Total labor		1.03	802
Material (x) chemicals	etc.	11.30	8739.6
Material Maintenance	2.5% yr of buttery limit cost	0.24	185.7
Materials operating	10% of operating labour	0.07	51.4
Total Materials		11.61	8976.7
Utilities			
Cooling water	2¢/1000 Gal	0.02	12.9
Steam	55¢/1000 lbs	0.08	60.2
Power	1¢/Kwl	0.27	207.6
Inert gas	15¢/1000 ScF	-	1.8
Deionized water	35¢/1000 gal	0.02	17.5
Total Utilities		0.39	300.0
Total direct op. cost		13.03	10,073.0
Plant overhead	80% of total labour	0.82	641.6
Taxes & Insurance	20% yr of fixed capital	0.29	227.2
Plant cost		14.14	10,941.8
Research etc.	10% of Sales price	2.00	1,548.0
Cash expenditure		16.14	12,489.8
Depreciation	10% yr of fixed capital	1.47	1,136.0
Interest on working capital	6% / year	0.06	47.5
Total Production cost		17.67	13673.3

N.B. Plant capacity 77.4 million lbs/year & 0.9 stream factor.

TABLE X V

COMPARISON BETWEEN DIFFERENT TYPES OF SYNTHETIC RUBBER

	% Used in Tires year 69 -- 75	10^3 Tons in 1975	Rate of market increase %	Price ¢/lb. as in 1971
S.B.R.	58 -- 55	1.135	4.5	13.5--15.6
Polybutadiene	72 -- 70	260	7.7	20.5--22.0
Polyasoprene	89 -- 66	230	22.3	23 --23.9
E.P.T.	10 -- 5	95	31.0	30
Batyl	84 -- 81	153	6.3	25.3--27.2
Polychlorprene	1.2--1.2	126	7.7	- -

CONCLUSION

The choice of type of synthetic rubber plant in a developing country like Egypt is a difficult problem. The 2 alternatives of either building a Styrene Butadiene plant which can produce at the sametime polybutadiene or building a polyisoprene plant using available propylene for isoprene production. The latter alternative will make use of the available propylene produced from the naphtha cracking process istead of building a polypropylene plant to meke use of such product. A high density polyethylene plant could be made to give the material required for the articles need to be made from the polypropylene unit especially when it is known that the low density polyethylene produced is much higher than what is required for the local market.

No doubt that the final judgement will depend on the outcome of economic, commercial and technical factors which will become more clear when the different offers for the different units are received by us in the second half of the current year.

[redacted]

12. 8. 74