

PETROCHEMICALS: FROM COMMODITIES TO SPECIALTIES FOR GCC COUNTRIES IN THE 1990's

Shawqui M. Lahalih and Ali G. Ma'adhah

Petroleum & Gas Technology Division
The Research Institute, King Fahd University of Petroleum & Minerals
Dhahran, Saudi Arabia

ABSTRACT. The chemical industry is a very big and very important industry to the world economy, in general, and to the GCC countries economy, in particular. However, due to its cyclic nature, overcapacity and other factors like environmental regulations, formation of economic blocks, new entrants and expansion, the commodity chemical industry faces serious problems that might result in drastic reduction of its profits, restructuring and diversification. Diversification into added value specialty products is one way to supplement the losses from commodity chemical products. This paper sheds some light into the possibility for GCC petrochemical companies to enter into this lucrative business. The chances for these companies to succeed are very good because they hold two key positions, namely: feedstock position and local market position and they need only to develop a strong R&D base in the third position which is technology development. Some suggested examples of specialty chemicals are provided for some key economic sectors in GCC like: agriculture, medicine and pharmaceutical, oil field, water management, construction and others. The suggested examples include: degradable mulches, soil stabilizers, concrete superplasticizers, drilling mud additives, dispersants, flocculants, analgesics and many others.

1. INTRODUCTION

Over the last decade the Arabian Gulf region has witnessed a noticeable degree of progress in the development of the petrochemical industry with its basic, intermediate, and final petrochemical products. In addition, some of these products have been used as raw materials in the downstream industry to produce an added value consumer products. However, due to the small and limited market in GCC countries, the decision was made to establish a highly export-oriented petrochemical industry with bulk commodity products. Consequently, heavy investment was made to establish this industry. It is estimated that 32% of total investment by GCC countries on industrialization, which reached about 37 billion US dollars between 1975 and 1990, was invested in the chemical and petrochemical industry. Today there are about 900 chemical and petrochemical companies established compared to over 5000 industrial companies established in the whole industrial sector of GCC countries [1].

A recent survey on the status and future prospects of petrochemicals worldwide revealed that the history of chemical industry is cyclic in nature[1]. Because of its huge market size and its interaction with many other industries, it has been influenced by many factors. Political, economic, and environmental issues are as important as production technology. These and other industrially-related factors like capacity additions, new entrants, technology developments and globalization in addition to supply and demand trends and the raw materials situations made this important industry very vulnerable in terms of its profitability and restructuring. While this drop in profitability and restructuring has profoundly affected the commodity part of the petrochemical industry, the specialty chemicals have flourished and have enjoyed a very healthy growth [2].

In view of this it becomes very essential for the industrialists of the chemical and petrochemical industry in GCC countries to have strategic plans to diversify their products line. This kind of diversification normally leads to more sophisticated and value added products that are normally referred to as "Specialty Chemical Products," as it was experienced in advanced industrial countries. These specialty products should help the GCC industry in completing its vertical and horizontal integration, and would also meet some of the local needs. In addition, they should also contribute to solving some of the local problems that face the GCC countries in the main economy sectors of medicinal, petroleum, agriculture, construction, water and many others.

However, to get into the specialty chemicals arena it is necessary to have a strong position in technology and know-how. Unlike the technology for commodity chemicals which is available for licensing, the technology for specialty chemicals is not available for licensing and is held captive in most cases. Furthermore, to succeed into this business, the petrochemical companies must have three strong positions, namely: a feedstock position, a market position, and a technology position. GCC countries have a strong stand on the first two positions, but they need to develop the third indigenously in order to enjoy healthy growth during the next decade. Internal development of new technologies, therefore, becomes a must since licenses for specialty chemicals are not available, as was pointed above.

Therefore, one of the objectives of this paper is to briefly review the status of the global and local petrochemical industry and point out the trends and problems it faces. Another objective is to provide an overview and perspective of the specialty chemicals and the chances for GCC countries to get into diversification of its petrochemical industry to meet the future challenges and problems of the commodity chemicals. The final objective is to provide some specific examples on the types of specialty chemicals that are needed in the region and can be developed locally utilizing locally produced raw materials and intermediate products.

2. GLOBAL STATUS OF THE PETROCHEMICAL INDUSTRY

The petrochemical industry is a very important industry. It plays a significant role in the world economy in general and to Gulf Cooperation Council (GCC) countries' economy in particular. Table 1 shows the market value of this huge industry along with the chemical and specialty chemical industries where they account for 12.2%, 24.3%, and 6.0% of world trade, respectively [3,4,5].

Table 1. Global Market Value of Chemicals, Petrochemicals, and Specialty Chemicals Industries as of 1991.

Business	Market Value(Billion \$)	% of GNP	% of World Trade
World GNP	20,400	100.0	584.0
World Trade	3,493	17.1	100.0
Chemical Industry	850	4.2	24.3
Petrochemical Industry	425	2.1	12.2
Specialty Chemicals	210	1.0	6.0

Because of its huge market and because of the reliance of many other industries on it, the petrochemical industry is tied in to the world economy. Therefore, the petrochemical industry is influenced by the economy recessionary and recovery status where these situations are influenced by many factors including political, economic, environmental, among others. These issues have created problems for the petrochemical industry like cyclicity and overcapacity that resulted in a drop in profitability and forced restructuring of the industry. Restructuring means the shut down of some plants to reduce capacity and elimination of weaker participants and the start of new specialty chemicals. The following is a brief account of the trends and problems facing this industry.

2.1 Cyclicity

The petrochemical industry moves with the world economy, as was pointed out earlier. It has moved through one complete cycle since the middle of the 1980's where petrochemicals started to recover from a bad recession. It reached its peak in the late 1980's and started to decline in the early 1990's at the time world recession took place. The petrochemical industry started to recover again by the late 1994 and early 1995. It appears that the petrochemical industry reaches its lowest and highest peaks in a cycle of ten years. This means that it will continue to recover for the next few years but by the end of this decade it is going to plunge deeply again into recession forcing further restructuring and more loss of profits.

2.2 Supply/Demand and Overcapacity

In addition to the above mentioned factors, the supply of petrochemicals in the early 1990's has exceeded the market demand. This was due to the global expansion in various petrochemical products especially by new entrants from Third World countries. This resulted in a significant overcapacity which lead to huge profit losses. The new comers to this industry are mostly East Asian and South-East Asian countries in addition to some GCC countries. Table 2 summarizes the expansion by the Asian countries in ethylene where 17 to 19 new plants were added by the end of 1995 [6]. Table 3 shows the new addition in ethylene capacities by GCC countries. Similar expansions are also reported by other regions like Western Europe and North America.

Table 2. Asian Ethylene Expansions (Thousand of MT/Year) [6].

Asian Country	1990	1992	1995	New plant addition
Japan	5,976	6,326	7,226	3
South Korea	1,155	3,155	3,325	7
Taiwan	845	845	1,115	1 or 2
Thailand	315	315	665	1
Singapore	430	440	440	-
Malaysia	-	-	230	1 or 2
Indonesia	-	-	550	1
China	1,928	2,200	2,400	3
Total	10,649	13,281	15,951	17 or 19

Table 3. Announced Expansion and New Additions in Ethylene Capacities by GCC countries during 1990s.

GCC Countries	Additional Capacities(MT)
Kuwait	600,000
Oman	100,000
Qatar	200,000
Saudi Arabia	560,000
U.A.E.	300,000
Total	1,760,000

For polyethylene, the overall supply is going to exceed the demand by a significant margin. Table 4 summarizes the world supply-demand for LDPE, LLDPE, and HDPE for the year 1990 and the year 2000 [7], while Figure 1 shows the trend of polyethylene by the turn of the

century [8]. Table 4 and Figure 1 both show that there will be at least an average of 15% more supply of polyethylene than there is demand by the year 2000. Similar trends are expected for other commodity petrochemicals.

Table 4. World Supply-Demand for LDPE, LLDPE, and HDPE (Years 1990 and 2000) [7].

Countries	Supply/Demand Ratios					
	LDPE		LLDPE		HDPE	
	1990	2000	1990	2000	1990	2000
North America	1.30	1.23	1.62	1.36	0.87	1.06
Europe	1.20	1.20	1.29	1.56	1.03	0.98
Middle East	1.38	1.53	4.80	4.81	2.53	2.21
Japan	1.14	1.19	1.09	1.18	1.07	1.09
Far East	0.76	1.05	0.82	1.44	0.94	0.92
Rest of the World	0.89	0.83	0.78	1.55	0.81	0.85
World	1.14	1.15	1.40	1.50	0.97	1.01

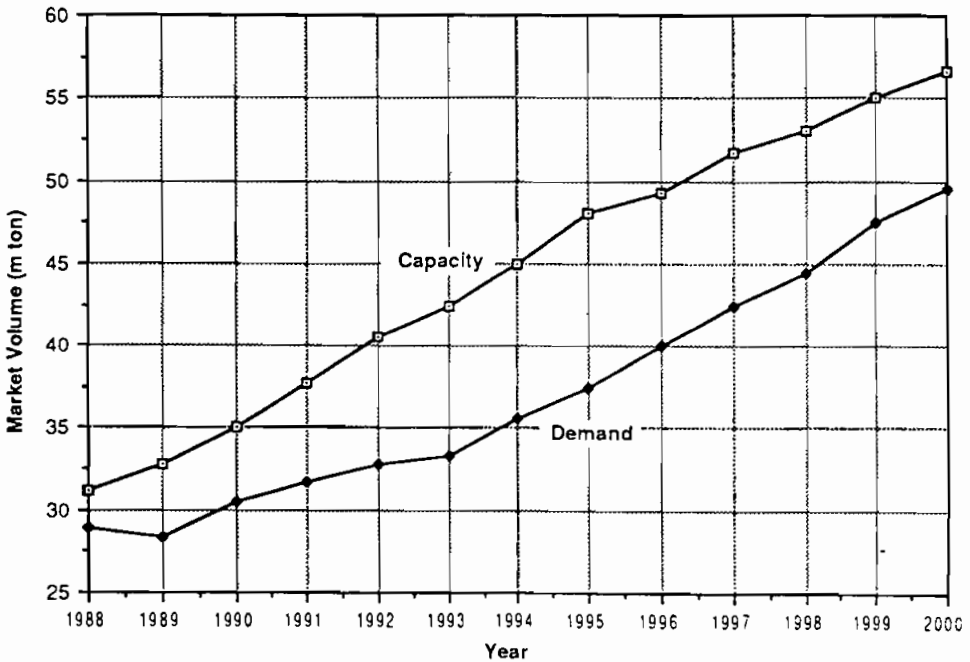


Figure 1. Global Polyethylene Capacity/Demand Curve [8].

2.3 Other Trends and Problems

The petrochemical industry also faces other problems. Environmental issues and regulatory legislations are adding a heavy burden in terms of increased spending to reduce waste and eliminate toxic emissions from producing plants. The Clean Air Act that was passed in USA in 1990 is one example. Therefore, the trend is toward producing environment-friendly products. Recycling of plastic materials is also another problem. It is estimated that more than 30 million tons/year of plastics end up in waste worldwide. This is not surprising when one considers that the world annual production of plastics is about 80 million tons/year and about 10 million tons/year of plastics ends up in waste in U.S.A. alone [3]. The expected increase in

plastic consumption by developing countries is going to aggravate the environmental problem even further during the end of this decade.

Another problems facing the petrochemical industry are the formation of regional economic blocks like EEC, ASEAN, GATT, GCC, etc. and the joining of new entrants from Third World countries into this industry which are just examples on economically and politically driven new trends. Consequently these trends are expected to create stiff competition among petrochemical producers and may lead to overprotectionist policies. They can stimulate trade within the blocs themselves but if they restrict global movements of trade then it could cause danger to some petrochemical producers. This could lead to increased tariffs and restrictive trade legislations on imports. The best example is the imposed tariffs by EEC on some GCC petrochemical products, and the trade war that is going on now between USA and South East Asia and specially China.

It is evident from the above brief review of the status of the petrochemical industry that the market for this industry is becoming saturated with most of its commodity products. There are lots of expansions and large amounts of new capacities are added. Consequently, supply is exceeding demand and overcapacities are evident in most commodity petrochemicals.

3. DIVERSIFICATION AND SPECIALTY CHEMICALS FOR GCC COUNTRIES

In view of the above it becomes of paramount importance for GCC countries to establish new strategies for the petrochemical industry during the 1990s. One of these strategies could be to go into diversification of their product line to overcome the expected stiff competition during the 1990s.

And because most if not all of commodity polymers are reaching saturation, emphasis should be placed on new products, processes, and high technology to produce added-value specialty products. This includes engineering polymers, performance fibers and specialty petrochemical products and specialty rubbers to perform special functions in specialized applications. Specialty petrochemical products and advanced technologies will dominate during the 1990s, and these technologies will be monopolized by few technology holders and will not be available for public licensing simply because they are the safety margins for the producers of the commodity chemicals.

Before we can present some of the needed R&D to develop new added value products and/or processes in GCC countries, we would like to present a very brief overview and perspective of this fast growing and very lucrative industry.

3.1 Overview and Perspective of the Specialty Chemical Industry

Specialty chemical industry holds a significant share of the chemical industry in general. It is estimated that the worldwide production sale of specialty chemicals has reached about 200 billion US dollars a year serving over 31 industrial sectors. The decade of the 1980s witnessed a very rapid growth rate of specialty chemical sectors as a direct consequence of the restructuring of the troubled commodity chemicals. For example, US sales more than doubled from 28 billion dollars in 1981 to 60 billion dollars in 1991 [9].

The chief distinctions between specialty and commodity chemicals are their production volume and sale prices. Specialty chemicals are normally low volume production (e.g., under 10 thousand tons annually) while commodity chemicals are much higher. Also specialty chemicals are sold at much higher unit prices (e.g. over \$3 per kilogram) while commodity chemicals sell at much lower prices. Specialty chemicals are normally less capital intensive than commodity chemicals, hence they are less polluting than commodity chemicals. Table 5 summarizes the chief distinctions between the two groups of chemicals, namely, the commodity versus specialty chemicals.

Specialty chemicals industry normally enjoys high profit margins. The low production cost and high profits margin are characteristics of the specialty chemical industry. Unlike commodity chemicals industry, specialty chemicals are not prone to cyclicity. As was

mentioned above, the 1990s are going to witness an overcapacity and oversupply in commodity chemicals where profits are going to drop drastically. In addition stiff competition from third world countries in the 1990s and overcapacity might give specialty chemicals a more attractive investment opportunities.

Table 5. Distinctions Between Specialty and Commodity Chemicals.

Function	Commodity Chemicals	Specialty Chemicals
Production volume	> 10,000 tons	< 10,000 tons
Selling prices	< 1,000 \$/ton	> 3,000 \$/ton
Profitability	< 10-15%	> 10-15%
Capital intensive	High	Low
Value Added	Low	High
Cyclicity	More cyclic	Less Cyclic
Surpluses and overcapacity	Normally Yes	Normally No
Environment	More polluting	Less polluting
Innovations	Less dependent	More dependent
Life cycle	Long	Short
No. of products	Tens of products	Hundreds of products and thousands of formulations

In GCC countries the chemical industry has been mainly concentrated on producing commodity chemicals, where the chemical industry contribution to export accounted for 5.3% of their GDP in 1990 compared to only 0.4% in 1980. Thanks to the heavy investment by GCC governments in this important industry which totaled about 32% of total industrial investment which amounted to 37 billion dollars between 1975 and 1990 [5]. Today the GCC petrochemical industry capacity accounts for an average of 3% of world capacity for key petrochemical products [2,11].

On the other hand, the specialty chemical industry in GCC countries can be described best as a “formulated products industry.” Finished specialty intermediate products or active ingredients are imported and only mixing and blending of the various active ingredients are done locally. Therefore, no actual manufacturing of active ingredients or chemical intermediates is carried out in GCC countries. However, there are plans for a few specialty products licensed to be produced locally. These products include: linear alkyl benzene (LAB), some ethoxylates and few others that are planned to be produced in the future in GCC countries. At present a variety of “formulated products” are being produced in GCC countries. These include: adhesives, cleaners, detergents, oil field chemicals, some construction admixtures, pesticides, pharmaceuticals, cosmetics and others.

The specialty chemical industry is a diverse industry composed of hundreds of small markets served by thousands of companies. These companies serve about 31 business segments that account for 90% of specialty chemical markets. To mention just few of these segments, bulk medicinal chemicals, specialty surfactants, water-soluble polymers, plastic additives, catalysts, water management chemicals, oil field chemicals, lube oil additives, mining chemicals, corrosion inhibitors, some construction chemicals and some agricultural chemicals. Most of these business segments enjoy an average annual growth rate of more than 5%. Table 6 shows the market size and average growth rate of these specialty chemicals.

Table 6. U.S., Western European, and Japanese Market Size and Projected Growth Rates for Specialty Chemicals* [9].

Description	Market size (millions of dollars)			Average annual growth rate 1989-1994 (percent)
	1987	1990	1992**	
Bulk medicinal chemicals	11,900	12,680	13,089	1.6
Specialty ceramics	8,973	10,700	12,388	7.6
Specialty surfactants	7,700	8,324	8,745	2.5
Food additives	7,344	8,405	9,196	4.6
Electronics chemicals	6,557	8,192	9,626	8.4
Industrial and institutional cleaners	6,481	9,131	9,351	1.2
Pesticides	5,330	12,757	13,350	2.3
Flavors and fragrances	4,456	5,792	6,374	4.9
Cosmetics chemicals	3,637	4,032	4,319	3.5
Paper chemicals	3,387	3,748	4,007	3.4
Plastics additives	3,362	3,781	4,090	4.0
Water-soluble polymers	3,051	4,118	4,583	5.5
Automotive aftermarket chemicals	2,733	3,237	3,468	3.5
Reprographic chemicals	2,655	6,775	8,228	10.2
Catalysts	2,636	4,955	5,359	4.0
Water management chemicals	2,332	2,841	3,102	4.5
Textile chemicals	2,290	4,154	4,364	2.5
Adhesives and sealants	2,250	14,460	15,942	5.0
Oil field chemicals	1,871	2,830	3,090	4.5
Mining chemicals	1,770	1,824	1,861	1.0
Printing inks	1,581	5,568	6,045	4.2
Antioxidants	1,546	1,684	1,783	2.9
Photographic chemicals	1,500	3,059	3,302	3.9
Specialty coatings	1,486	2,652	2,759	2.0
Rubber-processing chemicals	1,350	1,391	1,444	1.9
Biocides	1,260	1,541	1,635	3.0
Membrane materials	1,116	1,611	1,800	5.7
Flame retardants	834	1,098	1,143	4.1
Corrosion inhibitors	569	593	615	1.8
Lube oil additives	390	3,401	3,580	2.6
Specialty polymers	310	2,699	3,570	15.0
Total	102,660	158,033	172,208	4.25

*This represents 90% of total market.

**Estimated from SRI Data.

3.2 Opportunities in Specialty Chemicals and Needed R&D for GCC Countries

A brief investigation of the market size of five sectors in GCC countries revealed some significant market size for some consumed specialty chemicals as shown in Table 7 [1]. We believe that some of these high added value products can be prepared from local raw materials. However, a significant amount of R&D is needed to be carried out before any of these products can be realized. As was mentioned above the technology for these specialty chemicals is not easily accessible and more often is not available for licensing, but is rather being held captive. Therefore, we see very good opportunities for GCC countries to start their own in-house R&D and develop indigenous technologies to convert some of their relatively cheap commodity chemicals into high added value specialty products to meet the needs and demands of the local market. We believe that the market size potential is significant for some of these specialty products in addition to the fact that GCC countries have a very strong feedstock position.

The following are some examples on the type of specialty chemicals that are needed locally and can be developed from local raw materials to solve some of the problems facing GCC countries in various sectors of the economy.

3.2.1 Agricultural Sector: In this area production of specialty chemicals to improve soil fertility, conserve water consumption, and improve crops yield like the use of soil additives as conditioners and slow release fertilizers is needed. Reducing plastic waste and its effect on environment by producing degradable plastics is also needed. One example is the production of degradable agricultural plastic mulches [14]. Elimination or reducing soil erosion by wind and water by producing an effective and economical water-based and not organic-solvent-solvent-based soil stabilizers is also another example [15]. Environment-friendly insecticides, herbicides and pesticides are also other opportunities. Figure 2 shows some of these specialty products and the suggested route for their preparations from methane-based derivatives. Figure 2 also shows the basic, intermediate, and final commodity chemicals like urea, melamine and formaldehyde that are being currently produced in the Kingdom and the possible conversion of these relatively cheap chemicals into high added value specialty products like superplasticizers for construction, drilling mud additives for oil wells and soil stabilizers, and mulches for agricultural purposes. Market volumes for some of these is shown in Table 7.

3.2.2 Medicinal and Pharmaceutical Sector: In this area the cost of active ingredients or chemical intermediates used in bulk medicinal chemicals in GCC countries account for a very significant portion of production cost of pharmaceuticals (i.e., about 75%). These active ingredients are imported and take a significant portion of the profits. Therefore production of specialty chemical intermediates from local raw materials of benzene, propylene and butane would be needed to produce drugs like ibuprofen and acetaminophen. Chemical intermediates like p-aminophenol and isobutyl benzene are the precursors for acetaminophen and ibuprofen respectively and can be prepared from above basic raw materials. Figure 3 show the flow diagram and possible preparation procedure for these analgesics from butane and benzene-based derivatives. In addition, styrene-butadiene latex is heavily used as a backing material for carpets and mucates, which are being currently manufactured locally as shown in Table 7. Most of the intermediates like isobutylene, ethylbenzene, styrene and butadiene are being produced in the Kingdom. Market volumes and values are shown in Table 7.

3.2.3 Oil Field Chemicals: More than 150 million dollars worth of chemicals are used annually in GCC countries for oil field operations. Most of these are used in oil well drilling, cementing and production. Production of chemicals like drilling mud additives as viscosifiers and as dispersants would be highly desirable. In addition because of environmental regulations, the production and use of water-based chemicals would be preferred over organic solvent-based chemicals. One possible dispersant is sulfonated urea-melamine formaldehyde [12]. The flow diagram and synthesis scheme for these specialty dispersants are shown in Figure 2. The amounts that are being consumed annually is shown in Table 7.

3.2.4 Water Management Specialty Chemicals: Production of polymeric coagulants and flocculants in GCC countries would be needed to handle industrial and municipal sludges and wastes. Anionic and cationic-based polymers could be prepared from local raw materials. Table 7 shows that currently polyacrylamides are used in significant amounts. Polyacrylamides are very versatile specialty products and can be used as flocculants to treat municipal and industrial waste waters and they can be used as fluid loss additives in oil well drilling. Polymethacrylate, polyacrylates and polyacrylic acid have great market value as antiscaling agents in water cooling towers and as dispersants in detergents, coatings, etc. as can be seen from Table 7. Figure 4 is a flow diagram showing the preparation of these products from propylene derivatives.

3.2.5 Construction Chemicals: Because of the severe environmental conditions in the GCC countries, the production of certain construction chemicals is recommended. Examples include the production of concrete admixtures melamine-based or naphthalene-based

Table 7. Estimated Consumption of Some Specialty Chemicals in GCC Countries, 1991 [1].

Sector	Specialty Chemicals		Total Estimated GCC Consumption	
	Function	Commercial products Currently Used	MTY	Million Dollars
1. Oil Field	Weighting Agent Viscosifier:	Barite	51,328	22.5
		Bentonite	29,502	11.5
		CMC	1,227	4.3
		Others ¹	1,738	8.5
	Fluid Loss Add.:	Polyacrylamide	1,400	6.2
		Others ²	7,081	6.9
Dispersants:	Lignosulfonates	261	0.9	
	Others ³	2,047	7.0	
2. Water Management	Flocculants:	Polyacrylamide (Cationic & Anionic)	3,567	15.7
	Antiscaling:	Polymethacrylate and Polymaleic-based ⁴ and Phosphonate-Acrylate	15,647	39.10
3. Carpet and Mucate	Backing Material	SB-Latex ⁵	23,000	34.50
4. Construction	Admixtures: Plasticizers Superplasticizers:	Lignosulfonates	9,210	31.54
		Lignosulfonate	1,420	6.80
		Naphthalene-based	3,680	25.2
		Melamine-based ⁶	1,980	20.34
5. Bulk Medicinal Pharmaceuticals	Analgesics:	Acetaminophen (p-Aminophenol)	926	7.4
		Ibuprofen (Isobutyl benzene)	127	3.2

1. Other significant viscosifiers include natural products like x-anthan gum and starch most of which can be replaced by carboxymethyl cellulose (CMC).
2. Other significant amounts of fluid loss additives include starch most of which can be replaced by CMC and/or polyacrylamides.
3. Other significant amount of other dispersants could include phosphorylated urea formaldehyde [12].
4. SMA is styrene-maleic anhydride co-polymer which can be used as antiscaling agent when sulfonated.
5. SB-latex can also be used as pigment binder in paper and in paints.
6. Sulfonated melamine-urea formaldehyde [13].

superplasticizers. These specialty chemicals improve the strength and durability of concrete structures. It is estimated that the market value of the consumed superplasticizers in concrete in GCC countries amounts to about 80 million dollars annually as shown in Table 7. Sulfonated urea-melamine formaldehyde can be manufactured from urea, melamine, formaldehyde and other commodity chemicals that are being produced currently in GCC countries [13]. The flow diagram of Figure 2 shows the synthetic route for the properties of these powerful dispersants.

3.2.6 Other Specialty Sectors: Other specialty chemical intermediates are also needed in other industrial sectors in GCC. These include existing industries such as: paints, adhesives and sealants, cleaners, detergents, cosmetic, textiles, and carpentry and many others.

4. CONCLUSIONS

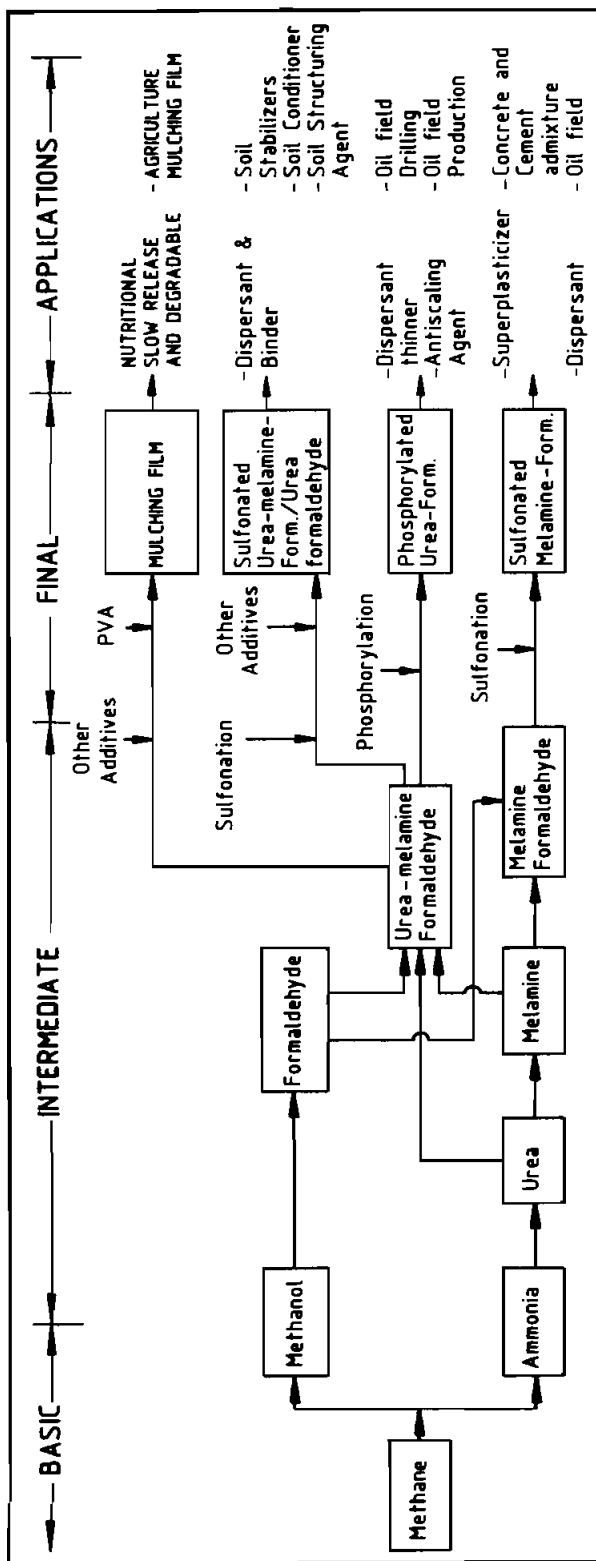
The chemical industry is a very big industry and it accounts for a big portion of the world economy in general, and to GCC economy, in particular. However, the commodity chemicals part of this industry faces lots of problems in terms of overcapacity and market saturation. The cyclic nature of this industry makes it prone to world recession. Cyclicity, overcapacity and surplus of some of these commodity chemicals will result in profit drop. To stay in this competitive business, chemical companies must diversify their products line into specialty chemicals. To succeed in this lucrative business of specialty chemicals that are needed to supplement the existing commodity chemical business, chemical companies need to have strength in: feedstock position, market position and technology position. GCC countries need to have an in-house strong base in technology development since they already have strong market and feedstock positions. This paper gave some examples on how GCC countries can start to diversify their product line and enter into this lucrative added value specialty business in order to convert some of their relatively cheap commodity chemicals into added value products and address and solve some of the problems facing GCC countries.

ACKNOWLEDGEMENT

The authors would like to thank the Research Institute, King Fahd University of Petroleum and Minerals for the support of this work.

REFERENCES

- [1] Lahalih, S. M., "Possibility of Producing Specialty Chemical Products in the GCC Countries," Study Report, Gulf Organization for Industrial Consulting, Doha, Qatar, 1993.
- [2] Lahalih, S. M., "Petrochemical industry: status, trends and growth prospects in the 1990's," *Al Ta'awon Al Sina'e*, No. 53, 3-18, 1993.
- [3] Vergara, W., "Petrochemicals in Developing Asia," *Chemical Engineering Progress*, 52-59, July, 1991.
- [4] Philpot, J., "Where in the World is the Industry Going?," *Chemical Systems Limited*, 1-8, May, 1992.
- [5] Industrial Data Bank (IDB), Gulf Organization for Industrial Consulting (GOIC), Doha, Qatar, 1992.
- [6] "Asian Ethylene Expansions," *Chemical Week*, February 12, 1992.
- [7] Oxley, D.F., "Global Supply/Demand Patterns," Presented at the International Polyethylene Conference, England, 1-18, 1992.
- [8] Walker, M., "Polyethylene Producers Face Competitive Future," 23-24, June 20, 1994.
- [9] Stanford Research Institute (SRI), Specialty Chemicals Reports, 1991.
- [10] Prospects for the Petrochemical Industry in the Arabian Gulf Countries, GOIC, 1992.
- [11] *Petrochemicals Industry Data Book*, Economic and Research Division, Research Institute, King Fahd University of Petroleum and Minerals, Dhahran, 1994.
- [12] Lahalih, S. M., "Mud Drilling Fluids, Additives and Process for Making the Same," U.S. Patent 5,094,762, 1992.
- [13] Lahalih, S. M. and Halabi, M.A., "Process for the Synthesis of Highly Stable Sulfonated Melamine-Formaldehyde Condensates as Superplasticizing Admixture in Concrete," U.S. Patent 4,677,159, 1987 and U.S. Patent 4,845,888, 1989.
- [14] Lahalih, S. M., Akashah, S., and Hajjar, F., "Degradable Agricultural Plastic Mulches," U.S. Patent 4,686,790, 1987 and U.S. Patent 4,845,888, 1989.
- [15] Lahalih, S.M., "A Method and Composition to Stabilize Soil and Process of Making the Same," U.S. Patent Application on File, 1995 and U.S. Patent 4,793,741, 1988.



Preparation Procedure

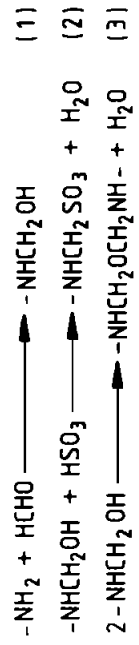
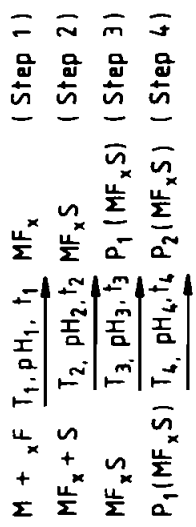


Figure 2. Flow Diagram of Some Opportunities in Specialty Chemicals Based on Methane Derivatives and Suggested Route for Their Preparation in GCC Countries.

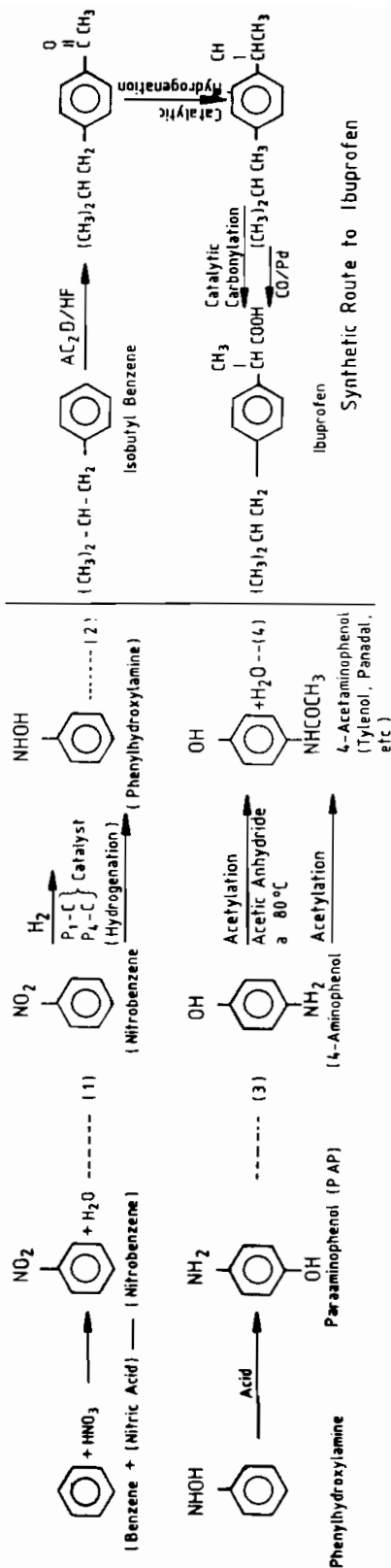
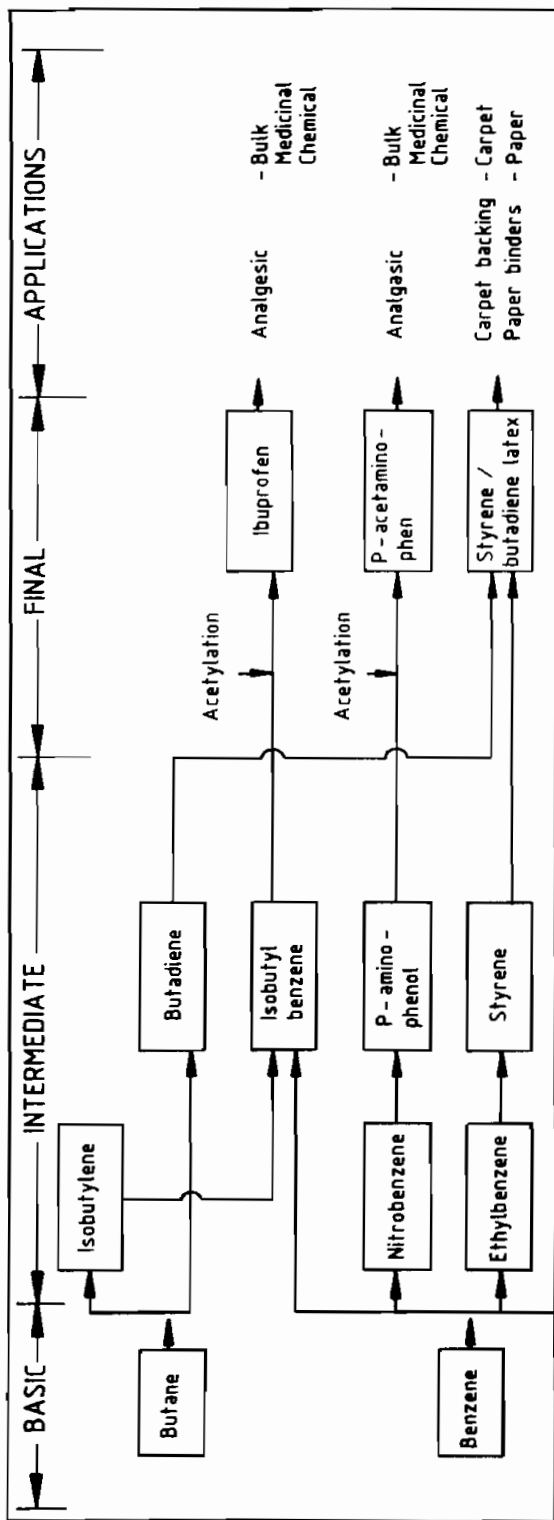
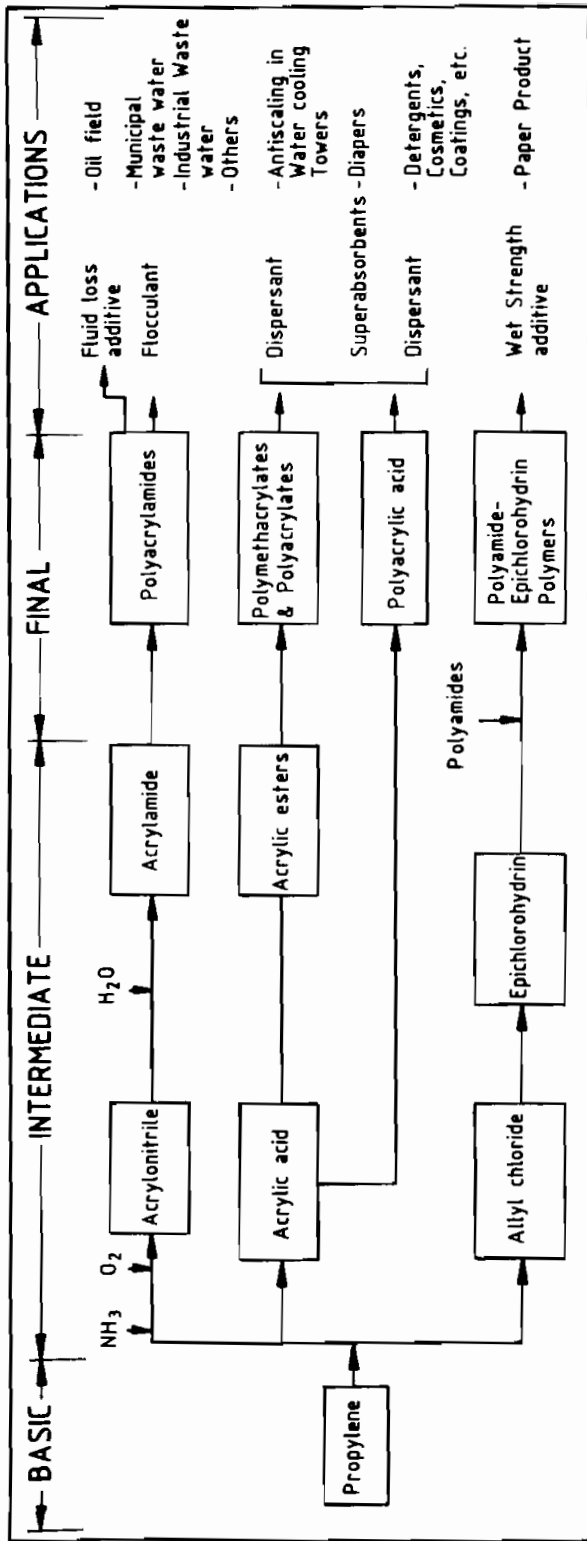


Figure 3. Flow Diagram of Some Opportunities in Specialty Chemicals Based on Butane and Benzene Derivatives and Suggested Route for Their Preparation in GCC Countries.



Production from basic raw materials

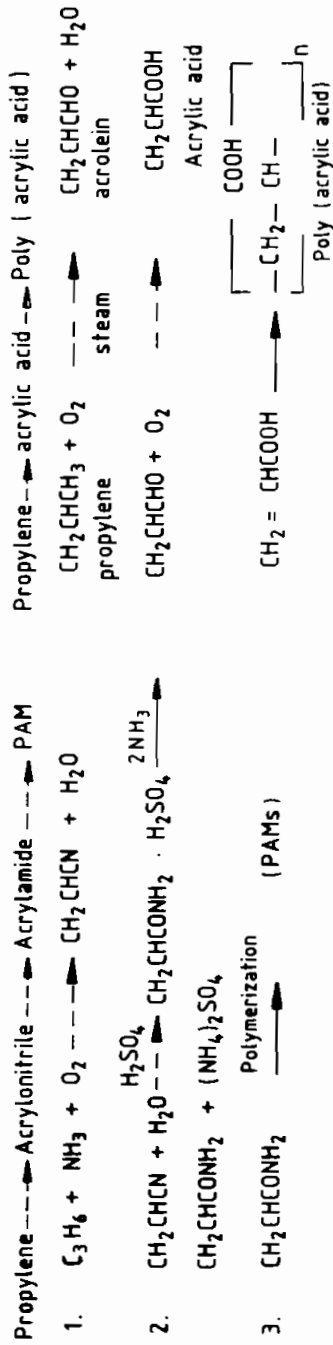


Figure 4. Flow Diagram of Some Opportunities in Speciality Chemicals Based on Propylene Derivatives.