The Commission of the European Communities, however, forecasts that the exports of goods and services of the EC will rise by ca. 3% in real terms again despite these structural weaknesses. Together with the increase in fixed investments estimated at slightly more than 2 %, they would therefore provide the foundation for overall economic growth of ca. 1.5%. This figure results from the view of the Commission that private-sector consumption throughout the EC will go up only by little more than 1% and public-sector consumption by considerably less than 1%. Development in the individual member countries will display a very mixed picture in 1984, as it already has done in 1983. Real growth in the gross domestic product (GDP) is placed at somewhat more than 2% for the Federal Republic of Germany, the United Kingdom and Italy. As a result of badly needed adjustment measures, France, the Netherlands and Belgium will have to be satisfied with nothing more than a fractional gain in their GDP. The consequence of this trend will be an increase in the unemployment rate in the European Community next year to more than 11% due to unfavorable demographic conditions. On a brighter note, I might mention that the average rate of inflation within the Community could decline to less than 6%.

INNOVATION AS DECISIVE FACTOR

The world economy as a whole will most likely develop along somewhat more favorable lines next year than it is evolving in the current one. The outlook is most positive for the US economy, where the recovery which emerged in the first quarter of 1983 will stay on course. The prospects for Japan are also quite satisfactory – the only major industrial nation to weather the latest recession without a contraction of its gross national product. In Western Europe, the economic situation will continue to differ widely from country to country and improve only very slowly for the region as a whole. In a parallel development to the current year, the companies active in the service sector and the consumer goods industries can look forward to a somewhat better business year than the companies in the capital goods sector. Over the medium term, the outlook is best for those industries and companies which through innovative capabilities succeed in helping new technologies to achieve a breakthrough in the capital goods sector and generate new consumer demand and requirements by manufacturing trend-setting products. It is my firm belief that the oleochemical industry belongs to this group.

Challenges to a Mature Industry: Marketing and Economics of Oleochemicals in Western Europe

H.J. RICHTLER and **J. KNAUT**, Henkel KGaA, Oleochemicals Division, Postfach 1100, D-4000 Düsseldorf 1, West Germany

ABSTRACT

Basic oleochemicals are produced by splitting and further reactions of oils and fats: fatty acids, glycerine, fatty acid methyl esters, fatty alcohols and amines. The last two are included in the list of oleochemical raw materials, primarily because of their importance in the preparations of further derivatives. The wide range of derivatives of oleochemical raw materials such as fatty alcohol ethoxylates, fatty alcohol sulfates, fatty alcohol ether sulfates, quaternary ammonium compounds and soaps are summarized. Oleochemicals such as fatty alcohols and glycerine from oils and fats have equivalents on the basis of petrochemicals. Using the customary terminology, petrochemical products are referred to as "synthetics." They are included in the present discussion because in the application of oleochemical raw materials the origin of the material is often less important than the structure. Oleochemistry can be regarded as a mature branch of chemistry, with many applications for its products, but with few completely new fields. The challenge and the opportunities for oleochemistry today lie in the changing economic and ecological conditions. Availability and price development of oils and fats are discussed with particular reference to European conditions, for these are the prerequisites if oleochemicals are to be competitive and are to improve their chances in the marketplace. The importance and development of the oleochemical raw material fatty acids, fatty acid methyl esters, glycerine, fatty alcohols and amines are considered on the basis of historical data. In considering future developments of oleochemicals, the capacity, demand and the possible influence of petrochemistry or crude oil is discussed. The highly developed oleochemical raw materials industry is a flexible supplier of medium- to long-chain fatty alkyl groups. These facts, together with the well organized supply lines for raw materials and the considerable potential of these renewable raw materials, could provide the necessary conditions for the oleochemical raw materials industry to fulfil its future tasks on a larger scale. This could arise, for example, due to the partial substitution of petrochemical surfactants, if this should become necessary as a result of developments in the price and availability of crude oil, or on grounds of ecological factors.

Abbreviations: AE = fatty alcohol ethoxylate; AES = fatty alcohol ether sulfate; AS = alkyl sulfate; AOS = α-olefin sulfonate; DOP = dioctyl phthalate; ES = ester sulfonate; ESO = epoxidized soybean oil; LAB = linear alkylbenzene; LAS = linear alkylbenzene sulfonate; NPE = nonylphenol ethoxylate; SAS = secondary alkane sulfonate.

INTRODUCTION

Oleochemistry is a very old branch of chemistry. Some applications reach far back into history. Of course, soap made from fat and applied was the first cleansing agent in cosmetics. It is a well founded and well developed branch of chemistry in nonspeculative markets with a long tradition of exchange between supplier and user. Is there also sufficient scope for oleochemistry in the future? Most important, are new fields recognizable, are there new products or applications going beyond the traditional? And maybe even innovations? The competitiveness of oleochemistry and its greatest opportunities are doubtless determined by the economics. Availability and price of raw materials essentially determine oleochemistry's future. How will oleochemicals develop in an economic world of changing crude oil prices, ecological questions and surfactant alternatives? This is a new challenge for oleochemistry and this paper is an attempt to determine oleochemistry's position in Western Europe under these changing conditions.

Definition of Oleochemicals

"Basic oleochemicals" are produced by splitting and further reactions of oils and fats: fatty acids, glycerine, fatty acid methyl esters—and fatty alcohols and amines, i.e., the derivatives of fatty acids and their methyl esters. Products based on these oleochemicals are fatty chemical derivatives (see Fig. 1).

Omitting animal feed uses and tall oil, products to be discussed here for oleochemical application will be mainly those in the chain length range of C_{10} to C_{20}.

Some oleochemicals can be produced from petrochemicals. The distinction is that "natural" oleochemicals are derived from oils and fats, "synthetic" oleochemicals from petrochemicals, e.g., fatty alcohols from ethylene and paraffins, and glycerine from propylene. Synthetic oleochemicals are discussed since not the origin but price and application properties determine their value for the user. In some cases, synthetic oleochemicals are similar to the natural products. It is not possible to discuss here structural differences—e.g., more or less branching of the carbon chain and its possible influence on use properties (viscosities or solubilities of surfactants).

An overlap between synthetic and natural oleochemicals exists essentially only in the case of glycerine and shorter- and medium-chain length fatty alcohols. Synthetic detergent range fatty acids, i.e., above C_{10}, are of no importance in Western Europe. There are no economical manufacturing processes for the production of longer-chain synthetic fatty acids, e.g., of the C_{14}+ spectrum or unsaturated fatty acids or unsaturated fatty alcohols. Azelaic, pelargonic, undecylenic, isostearic and brassylic acids, which are derived from natural fatty acids, are not defined as "synthetic" in this context.

RAW MATERIALS

Oils and Fats: Volume

The most important oils and fats are shown in Table I. Tallow, palm, coconut and palm kernel oil are especially important for oleochemistry.

Worldwide, ca. 8 million tons, i.e., 14% of the total volume of oils and fats, are consumed in the oleochemistry business. In Western Europe, ca. 1.7 million tons are used, amounting to less than 3% of the total volume. This corresponds to about the same percentage of crude oil used in Western Europe for petrochemical derivatives, excluding plastics (Fig. 2).

Oils and Fats as Byproducts

The oleochemical industry relies on the large consumption of oils and fats in the nutritional domain for its needs. Since oleochemistry uses essentially nonedible oils and fats or byproducts of agricultural and food production, food requirements are not diminished (Table II). A special strength of the oleochemical industry is that it generates valuable products from nonedible or lower quality fats. By using these substances in a sensible manner it is thus operating a perfect recycling system.

Production Development

In the last 50 years, the world production of oils and fats tripled; soybean oil production increased almost 10-fold; and palm oil production increased almost 9-fold (Table III).

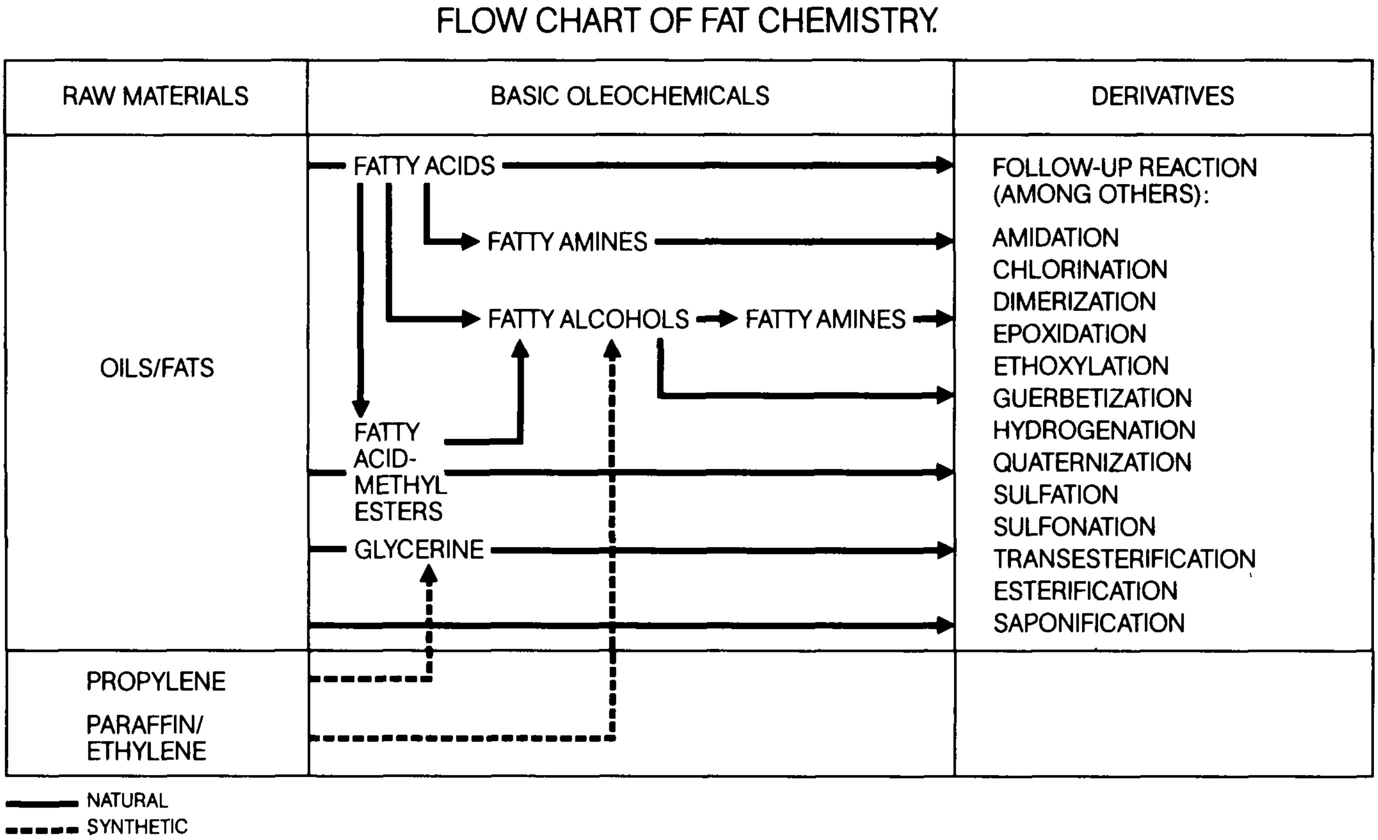


FIG. 1. Flow chart of fat chemistry.

TABLE I

World Oil and Fat Production in 1981

WORLD OIL AND FAT PRODUCTION IN 1981.

OILS AND FATS	ESTIMATED VOL. IN MILL. T
SOYA BEAN OIL	12.2
TALLOW	6.0
PALM OIL	5.0
BUTTER	4.9
SUNFLOWER OIL	4.8
RAPE SEED OIL	3.8
LARD	3.8
COCONUT OIL	3.3
COTTON SEED OIL	3.2
PALM KERNEL OIL	0.7
OTHERS	9.1
PEANUT OIL, MARINE ANIMAL OIL	
OLIVE OIL, SESAME OIL	
LINSEED OIL, BABASSU OIL	
CASTOR OIL, TUNG OIL	
TOTAL	56.8

TABLE II

Oils and Fats: Nonedibles and Byproducts

OILS AND FATS: NON-EDIBLES AND BY-PRODUCTS.

BY-PRODUCTS	NON-EDIBLES OILS AND FATS
SOYA BEAN OIL = BY-PRODUCT OF SOYA BEAN PROTEIN PRODUCTION	CASTOR OIL
TALLOW = BY-PRODUCT OF MEAT PRODUCTION	LINSEED OIL
PALM KERNEL OIL = BY-PRODUCT OF PALM OIL	ANIMAL FAT
	ACID OILS
	NON-EDIBLE TALLOW

During the same time, the world population more than doubled and the per-capita consumption increased by ca. 25% (Table IV).

Conditions for a Production Enhancement

Conditions exist for increasing future oil and fat production, taking into account the special requirements of oleochemistry:

—cultivation practices and other measures:
  (a) new hybrids yielding bigger harvests (low stem coconut palms),
  (b) pollination by introduction of the Cameroon beetle ("weevil") into Malaysia,
  (c) new oil palm hybrids,
—activating agricultural reserves: cultivation of idle land,
—better fertilizer application,
—water desalination in dry regions,
—more effective plant protection,

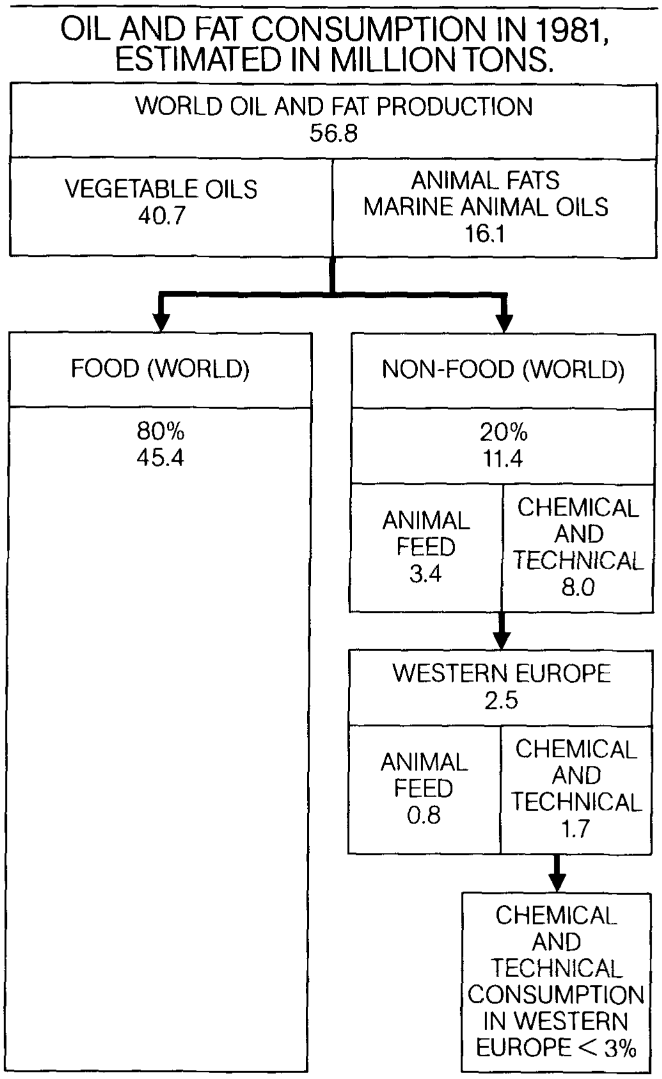


FIG. 2. Oil and fat consumption in 1981, estimated in million tons.

—new cultivation methods,
—plantations rather than wild growth (oil palms in Malaysia),
—improved harvesting conditions:
  (a) low stem palms and harvesting in plantations,
  (b) higher mechanization in agriculture,
—optimized oil production technology in the preparation of the oil fruits and the oil extraction.

Hybridization in particular holds the promise of considerable progress.

Other Influences on Oil and Fat Production

Agricultural production in developing countries may have other benefits as well: more than two-thirds of oils and fats produced are exported to countries with a high average per-capita income. These exports create and maintain work in developing countries. If Western oleochemical industry moves upstream into oil-producing countries this also means capital inflow in the form of investments.

The Geographical Distribution of Oil and Fat Production

Considerable amounts of oils and fats are produced in in-

TABLE III

World Production of Selected Oils and Fats as Raw Materials for Oleochemicals

WORLD PRODUCTION OF SELECTED OILS AND FATS AS RAW MATERIALS FOR OLEOCHEMICALS.

OILS AND FATS	1934/ 1938* MILL.T	1950 MILL.T	1960 MILL.T	1970 MILL.T	1981 MILL.T
SOYA BEAN OIL	1.3	2.1	4.0	6.1	12.2
TALLOW	1.7	2.2	3.6	4.4	6.0
COCONUT OIL	1.7	1.9	2.1	2.2	3.3
PALM OIL	0.6	0.9	1.1	1.7	5.0
PALM KERNEL OIL	0.4	0.4	0.4	0.4	0.7
OTHERS	15.9	16.1	20.9	25.3	29.6
TOTAL	21.6	23.6	32.1	40.1	56.8

*AVERAGE VALUES 1934/1938

TABLE IV

World Population, Per Capita Consumption, Oil and Fat Production

WORLD POPULATION, PER CAPITA CONSUMPTION, OIL AND FAT PRODUCTION.

YEAR	WORLD POPULATION MILL.	PER CAPITA CONSUMPTION KG	OIL AND FAT PRODUCTION MILL.T
1934	2,130	10.1	21.6
1950	2,400	9.8	23.6
1960	3,010	10.7	32.1
1970	3,615	11.1	40.1
1981	4,495	12.6	56.8

dustrialized countries with stable economic and political structures. In 1981, 19 million tons of oils and fats were produced in North America. Sixty percent of the tallow world supply and 75% of the world's soybean oil—expressed in oil equivalents—were produced in the USA (Fig. 3).

Dependence of the Western European Oleochemistry

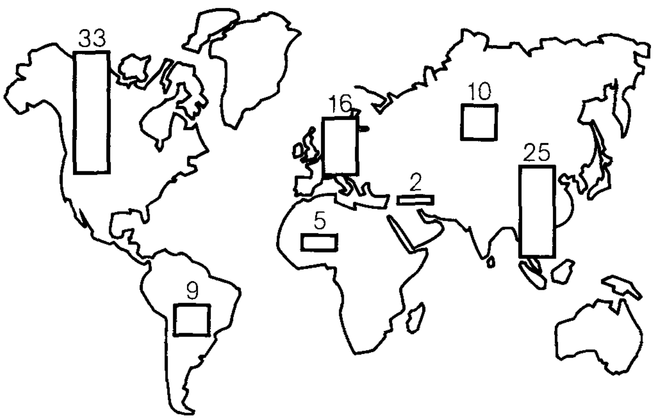
Although total European production—including Russia—amounts to only 9% of the world production, Western Europe nevertheless depends on the import of oils, fats and seeds. This dependence—at least for oleochemistry—will not change. Even if European production increases considerably (e.g., rape) or if the market situation (i.e., the price) facilitates using olive oil technically, the situation would only change a little: the lauric range constitutes the largest part of fatty alcohols. The situation is more favorable in the case of fatty acids which require only ca. 15% of products with lauric chain length (Table V).

An additional C_{16^+} range supply could only partially be used, because the required profile will, at least for important areas such as surfactants, demand medium- rather than longer-chain lengths: lauric soaps for liquid detergents; $C_{12/14}$ nonionics for detergent powders and liquids. Interesting exceptions could, however, develop: tallow acid methyl esters for ester sulfonates and tallow alcohol sulfate as LAS substitute, as well as behenic acid for amines, fatty alcohols and brassylic acid.

Until future developments such as cuphea and metathesis bear fruit, Western Europe has to live with the fact that the C_{16^+} chain length predominates in temperate and laurics in tropical zones.

The dependence of resource-poor Western Europe on external resources is nothing unusual. A similar situation prevails with respect to crude oil. The import of crude oil as a basis for the production of, e.g., synthetic fatty alcohols, has the same problem. The dependence on imports would remain—and fatty acids cannot economically be produced petrochemically.

WORLD OIL AND FAT PRODUCTION 1981, %.



REGION	OILS AND FATS MILL.T	REGION	OILS AND FATS MILL.T
USA/CANADA	19	USSR	6
SOUTH AMERICA	5	AFRICA	3
EUROPE	9	NEAR EAST	1
ASIA	14	TOTAL	57

FIG. 3. World oil and fat production 1981 (%).

TABLE V

Chain Length Distribution of the Western European Fatty Acid and Fatty Alcohol Production in 1982

CHAIN LENGTH DISTRIBUTION OF THE WESTERN EUROPEAN FATTY ACID AND FATTY ALCOHOL PRODUCTION IN 1982.

	PRODUCTION T	RANGE	
		MEDIUM CHAIN LENGTH (LAURICS)	LONG CHAIN LENGTH (TALLOW/ PALM ETC.)
FATTY ACIDS	730,000	110,000	620,000
FATTY ALCOHOLS (NATURAL)	150,000	85,000	65,000
TOTAL		195,000	685,000

The "Sensitive" Coconut Oil

Agricultural products are subject to a multitude of influences such as weather, climate and possible natural castastrophes. Likewise, concentration of crops in a few geographical areas could render them subject to special political influences. In the case of the oils and fats discussed, poor harvests or conflict situations have not resulted in bottleneck situations for many years. The strong dependence of the main coconut oil consumers on the main producer, the Philippines, as an especially sensitive point has been discussed many times. Indeed, the Philippines are, with 45-50% of the world production and 70% of the world export, the most important producer. However, problematical situations have not arisen for many years. The Philippines depend on the export of coconut oil as an extremely important source of foreign currency. They will, under all foreseeable circumstances, maintain the export of coconut oil. Of the world coconut oil production, 80% is used for human and animal consumption and only 20% for chemical and technical purposes. Coconut oil today is not absolutely necessary for the food industry. New technologies, e.g., transesterification, have made it possible for the margarine industry to use other oils when extreme price developments or supply shortages arise. Remember the high price situation in 1979/80 which the margarine industry was able to overcome by substituting lower priced coconut oil. The volumes required by oleochemistry are, with certainty, also available in case of short supply, since the food industry withdraws from this market in high price situations. Furthermore, sunflower oil has become more important for the appearance and the profile of many margarine brands—at least in Western Europe.

The coconut situation will also be influenced by the considerably increased production of palm oil; the composition of its byproduct, palm kernel oil, is very similar to that of coconut oil. The idea to eliminate palm kernels by hybridizing measures will not be realized in the near future—especially since the coconut alternative is valued in Malaysia.

The often quoted speculative influence also has diminished. The producing countries know that a high price policy is dangerous. They are conducting a realistic marketing policy which takes long-term demands into account. Coconut oil has to maintain its competitiveness with the other leading oils in order not to lose its market. Furthermore, coconut oil can only be stored for a limited time. This pertains to many other oils and fats as well. Their cultivation cannot be interrupted at will and neither can they be stored indefinitely.

To accord coconut oil an especially "dramatic" role seems, after the crude oil upheavals and crises which had quite different dimensions, certainly unjustified.

Future Oil and Fat Demand

How will consumption develop during the remainder of the present decade? Will there be a sufficient supply of oils and fats for nutritional purposes with enough left over for oleochemistry—even though the portion required by the latter is quite small and a considerable part of this is unsuited or only conditionally suited for nutrition?

There is a supply and demand balance. A larger increase in demand in the highly developed countries is improbable. Even increasing incomes will exert only a very minor influence. Changing eating habits—reduced fat consumption—will have their effects. Increased demand could only occur in undeveloped and developing countries if income there increases and results in higher fat consumption.

Oil production for nutritional purposes could be increased by depending more on palm oil and soybean oil. A short-term adjustment to higher demands can only be achieved with one-season plants, e.g., soybean, rape, sunflower, etc. The USA, the large oil and fat producer furnishing one-third of the world supply, has, in this respect, considerable capabilities at its disposal. Especially in the case of soybean cultivation, reserves could be activated. This year the PIK (payment-in-kind) program was effective for the first time in the USA. However, here it has to be kept in mind that soybean oil is the byproduct: because of the "meal to oil" interdependence, an increased soybean oil production requires higher consumption of meal.

It is certain that oleochemistry will obtain its raw materials—even in the case of higher demand—since it is only the small brother of the big food oil production. The oils relevant for oleochemistry will probably develop as shown in Table VI to the end of the present decade.

TABLE VI

World Production Prospects for Selected Oils and Fats until 1990

WORLD PRODUCTION PROSPECTS FOR SELECTED OILS AND FATS UNTIL 1990.

OILS AND FATS	1981 MILL.T	1990 MILL.T	GROWTH RATE % P.A.
SOYA BEAN OIL	12.2	15.9	3.0
TALLOW	6.0	7.2	2.0
PALM OIL	5.0	8.6	6.2
LAURICS*	4.0	5.2	3.0
RAPE SEED OIL	3.8	7.0	7.0

*COCONUT AND PALM KERNEL OIL

Soybean oil has, after larger increases of nearly 7% p.a. in the years 1960-80, reached a plateau. Cultivation areas are neither increased nor decreased as in former years, since demand is stagnating. However, soybean oil is so far hardly processed in oleochemistry. It is considered a "leading indicator oil" in the world fat market.

Tallow's growth rate is, with ca. 2% p.a., expected to be modest since breeding measures with the objective of producing lean meat are concluded. Meat consumption will hardly increase in the industrialized countries. A considerable buying power increase in the developing countries resulting in an enhanced meat consumption appears unlikely. Tallow is, however, cheap. It is, contrary to palm oil, mostly nonedible, and is almost exclusively processed for technical purposes. Tallow, thus, still constitutes *the* raw material for oleochemistry which, however, could be supplemented by the C_{16} source, palm oil.

Palm oil from Malaysia—in 1981, ca. 55% of world production—should be of special interest for oleochemistry. Its growth amounted to almost 8% p.a. during the past 20 years. A favorable development is also expected for the future.

Malaysia is an example that illustrates how other developments exert their influence on the cultivation of oil plants. Low rubber world market price, a consequence of the manufacture of synthetic rubber, resulted in a shift to oil palm cultivation from 1960 forward.

Palm oil is a partial substitute, or supplement, for tallow in the case of increased demand. The somewhat different spectrum of fatty acids has to be taken into account: palm oil contains more C_{16}, tallow more C_{18}.

Coconut oil will probably experience a considerably stronger growth since the Philippines' recultivation program and the hybridization will bear fruit toward the end of this century: the Philippines intend to double their coconut production by the year 2000.

A growth of 3% per year would, in the case of laurics (coconut oil, palm kernel oil; without babassu), result in more than 5 million tons in 1990. Thus oleochemistry could command more than 1 million tons for chemical and technical purposes if it uses them to the same extent as today (only ca. 20%). To declare laurics a bottleneck and to favor, on these grounds, petrochemical syntheses shows a gross misunderstanding of the supply situation.

Considering availability and nutritional demand trends, no shortfall is recognizable in this decade but, on the contrary, it is an abundant supply situation. The average growth of oleochemically important raw materials is assumed to amount to 4% annually, while nutritional oils and fats will increase by ca. 3%. Sufficient reserves can be expected especially for soybean, palm, rapeseed oil, and under long-term perspectives also for coconut oil. Oleochemistry will have available more raw materials than it can absorb.

Price Developments

The two most important oleochemical raw materials, coconut oil and tallow, were selected for a price development consideration and scrutinized in this respect for a 20-year period. A price comparison at the beginning and end of this period has little meaning since the intermittent peaks would be missed. Therefore, average prices were calculated for successive 5-year periods and superimposed over the actual price development.

The average coconut oil price increased from DM 111/100 kg in the 1962/66 period to DM 143 in the 1977/81 period. This amounts to an increase of 1.3% per year. Over the total period the average price increased from DM 93/100 kg in 1962 to DM 128.14/100 kg in 1981 (Fig. 4).

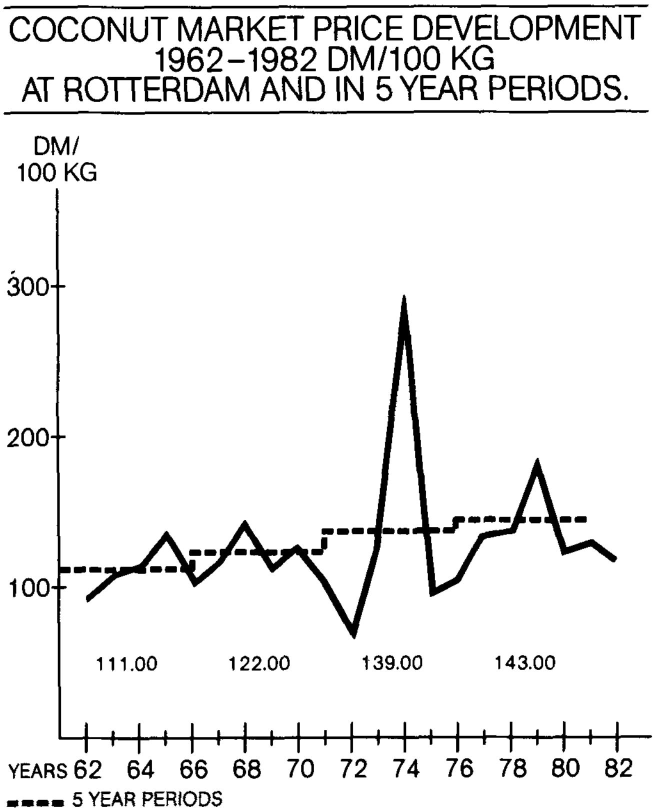


FIG. 4. Coconut market price development 1962-1982 DM/100 kg at Rotterdam and in 5-year periods.

The average tallow (fancy) price increased from DM 68/100 kg in 1962/66 to DM 101/100 kg in 1977/81. This corresponds to an increase of 2.0% per year. With respect to the total time period, the average price increased from DM 56 in 1962 to DM 80.35 in 1981 (Fig. 5).

There are probably few raw materials whose price development during a 20-year period was comparably stable. This is especially obvious when comparing it with the crude oil price development, taking 1970 as a reference point.

Figure 6 gives a comparative compilation of indexed prices of crude oil, ethylene, coconut oil and tallow. The real price development during this period is depicted in Table VII.

Prognosis

A long-term price prognosis for oils and fats, e.g., coconut oil and tallow, can only be made on the assumption that the historical development of the past decade will continue since there are no indications that the implications and the situation will change essentially.

- —Fat and oil consumption for nutritional purposes remains stable, in the long run.
- —Broad distribution of oil and fat production alleviates the impact of poor harvests and other mishaps.
- —Interchangeability of many fats and oils amongst each other exerts a stabilizing influence on prices.
- —Oleochemistry will develop without creating speculative demand.

Summary: "Oil and Fats"

- —Oils and fats are produced from agricultural, i.e., renewable, sources.
- —Production of oils and fats is sufficient.
- —There are sufficient reserves for an increased oleochemical demand.
- —Raw materials important for oleochemistry enjoy a special status as byproducts of oil and fat production for nutritional purposes.

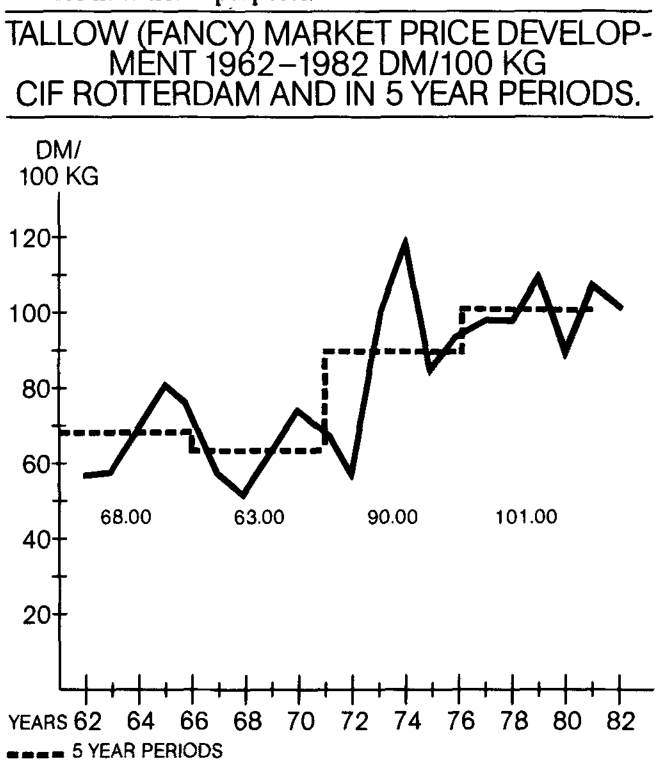


FIG. 5. Tallow (fancy) market price development 1962-1982 in DM/100 kg, CIF Rotterdam and in 5-year periods.

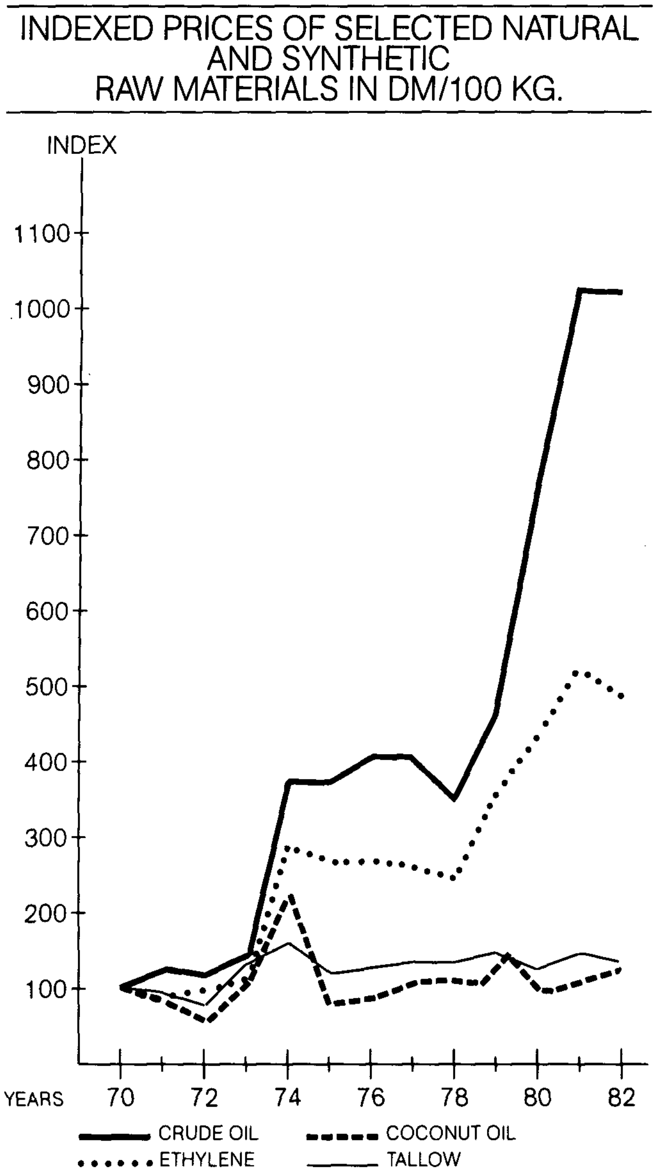


FIG. 6. Indexed prices of selected natural and synthetic raw materials in DM/100 kg.

—Price development of important oils and fats was modest.
—There are no indications that the future price development will differ from that in the past.

THE BASIC OLEOCHEMICALS

Basic oleochemicals will be considered in some detail. The compilation in Figure 7, which shows a limited number of the fatty chemical possibilities, illustrates the great importance of the basic oleochemicals for derivatizations.

Fatty Acids

In the context of the present discussion, fatty acids are defined as distilled fatty acids of animal or vegetable origin and their modifications, e.g., hydrogenated and separated (stearic/oleic acid), as well as fractionated acids.

After World War II, the fatty acid industry in Western Europe began to develop as it had in the USA.

The advantage that this industry could supply defined, pure, and homogeneous fatty acids at low cost—contrary to the triglycerides so far available—generated a large demand and resulted in an explosive growth of the fatty acid business up to, and well into, the 1970s (Table VIII). Unfortunately, this trend did not continue. During recent years the business stagnated somewhat while capacities were further enlarged. Considerable excess capacities in Western Europe caused a number of problems (Table IX).

The difference between nameplate and practical capacity is due to the following reasons:-

—many companies do not work continuously,
—distillations are often performed more than once because of various raw materials,
—the product mix is not uniform but changes considerably because of varying raw material prices and qualities.

The most important fatty acids, according to their raw material origin, are listed in Table X. It is obvious that lauric fractions constitute only a minor share. The production, according to product group, is shown in Table XI.

The consumption, according to application, is shown in Table XII.

Generally speaking, the fatty acid industry in Western Europe is in as difficult a position as is the total chemical industry. This situation is caused largely by considerable excess capacities.

The difficulty of the situation is enhanced by the large capacities presently being established, especially in Asia, without an adequate market. These additional volumes will seek their markets in Europe, the USA and Japan. The European fatty acid industry will have to face this challenge and will indeed meet it.

The production in the raw material producing countries such as Malaysia is viewed more as a supplement to the European business which has to restrict itself to certain base products.

The fatty acid business has become increasingly complex. It does not suffice to manufacture certain products. Their marketing constitutes the main problem. The further

TABLE VII

Market Price Comparison of Selected Natural and Synthetic Raw Materials in DM/100 kg

MARKET PRICE COMPARISON OF SELECTED NATURAL AND SYNTHETIC RAW MATERIALS IN DM/100 KG.

YEAR	TALLOW (FANCY)	COCONUT OIL	CRUDE OIL	ETHYLENE
1970	74.00	127.00	6.01	30.00
1971	69.00	105.00	7.67	29.00
1972	57.00	71.00	7.22	29.00
1973	97.00	130.00	8.22	34.00
1974	118.00	291.00	22.39	85.00
1975	85.00	97.00	22.30	80.00
1976	94.00	105.00	24.36	80.00
1977	98.00	135.00	24.39	79.00
1978	98.00	140.00	21.18	73.00
1979	110.00	186.00	27.88	106.00
1980	90.00	124.00	45.60	130.00
1981	107.00	130.00	61.90	156.00
1982	102.00	118.00	61.60	145.00
1983*	97.00	111.00	57.30	130.00

*ON A HALF YEAR BASIS

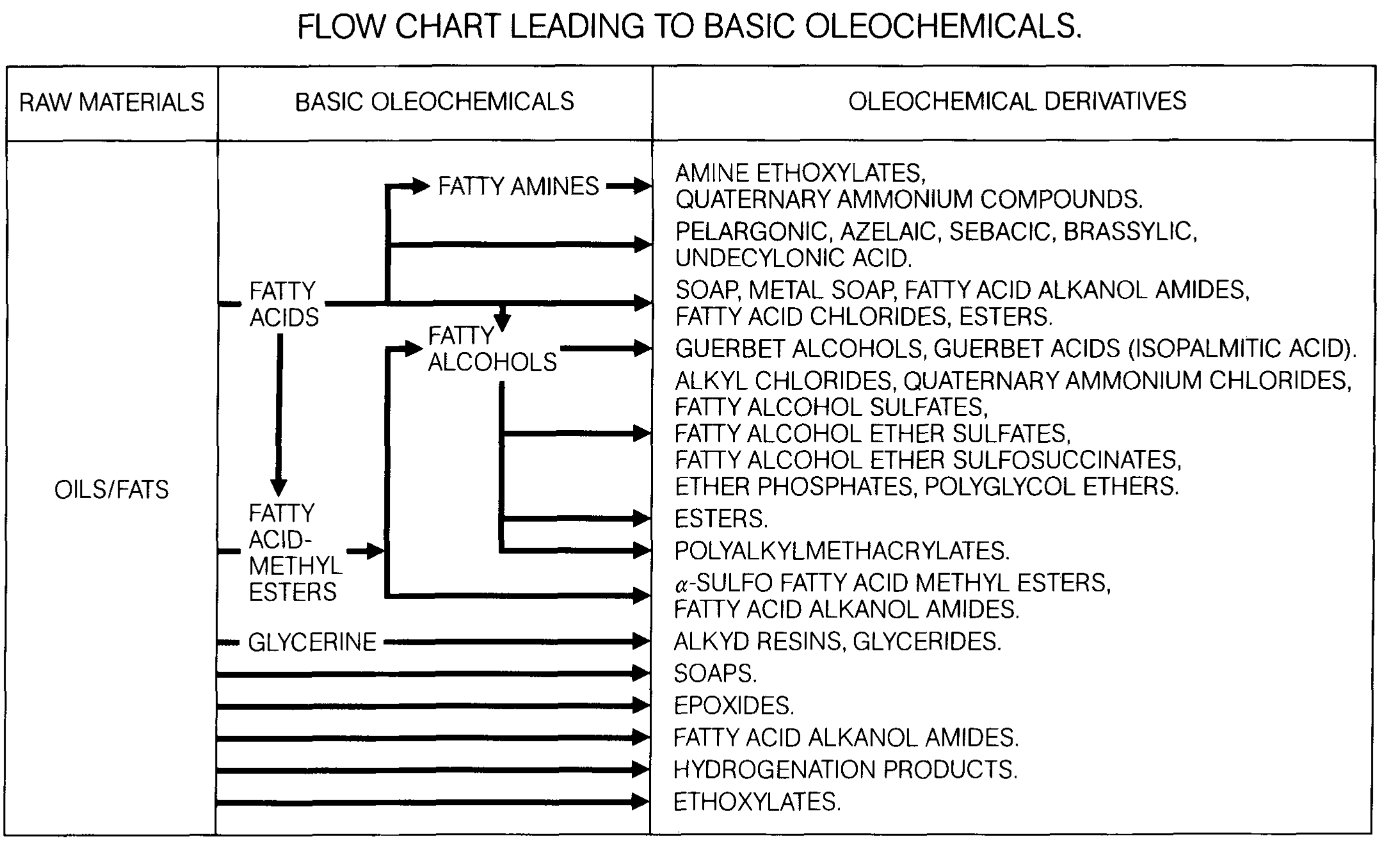


FIG. 7. Flow chart leading to basic oleochemicals.

TABLE VIII

Fatty Acid Production

FATTY ACID PRODUCTION.

T	1950	1960	1970	1982
WESTERN EUROPE	230,000	410,000	620,000	730,000
WORLD	550,000	1,100,000	1,400,000	1,600,000

TABLE IX

Western European Fatty Acid Distillation Capacities in 1982

WESTERN EUROPEAN FATTY ACID DISTILLATION CAPACITIES IN 1982.

NAME PLATE CAPACITY PRACTICAL CAPACITY	1,700,000 T 950,000 T
CAPACITY UTILIZATION	~ 75%
PRODUCERS	35

TABLE X

Western European Fatty Acid Production According to Source in 1982

WESTERN EUROPEAN FATTY ACID PRODUCTION ACCORDING TO SOURCE 1982.

FATTY ACID SOURCE	%
TALLOW/PALM	70
COCONUT/PALM KERNEL	15
OTHERS	
SOYA BEAN AND SUNFLOWER OIL	8
FISH OIL AND OTHERS	7

TABLE XI

Western European Fatty Acid Production According to Fractions in 1982

WESTERN EUROPEAN FATTY ACID PRODUCTION ACCORDING TO FRACTIONS IN 1982.

FATTY ACID FRACTION	T	%
LOW CUTS	15,000	2
FRACTIONS	70,000	10
SATURATED FATTY ACIDS (STEARIC ACID)	250,000	34
UNSATURATED FATTY ACIDS (OLEIC ACID)	70,000	10
OTHER DISTILLATES	325,000	44

TABLE XII

Western European Fatty Acids—Fields of Application in 1980

WESTERN EUROPEAN FATTY ACIDS – FIELDS OF APPLICATION IN 1980.

APPLICATIONS	%
FATTY ALCOHOLS, AMINES, ESTERS, METAL SOAPS, PLASTICS	35–40
DETERGENTS, SOAPS, COSMETICS	30–40
ALKYD RESINS, PAINTS	10–15
RUBBER, TIRES	3–5
TEXTILE, LEATHER, PAPER	3–5
LUBRICANTS, GREASES	2–3
OTHERS (CANDLES)	2–5

internal or external use of the stockpiled coupled products and their storage can only be successfully coped with by the raw material producer located near the place of consumption. The difficult fatty acid business situation prompted more and more producers during the past years in Europe as well as in the USA to give up.

To find new applications for fatty acids and the further development of fatty acid derivatives constitutes a special challenge for the European fatty acid industry. This is most important because the growth rate will be only between 1 and 2% until 1990.

To adjust capacities to the market may be viewed as a further challenge and in the short term perhaps the most important one. This important challenge of the total chemical industry pertains especially to the European fatty acid industry. Only in this manner will it be possible to maintain, under long-term conditions, a healthy oleochemical industry capable of investing in new technologies and products.

Fatty Acid Methyl Esters

A considerable fraction of fatty acid methyl esters is hydrogenated to fatty alcohols. Methyl esters are in this context to be viewed as intermediates and are used captively.

Table XIII reviews world and Western European fatty acid methyl ester production since 1950.

Parallel to the development of fatty alcohols, large volumes of fatty acid methyl esters were available at low cost. Therefore, it appeared interesting to search for additional areas of application for these products. The essential advantage is that methyl esters are, compared with the corresponding fatty acids, transported more easily since they have a low or melting point and are less corrosive. Finally, their color is generally more stable during storage.

TABLE XIII

Fatty Acid Methyl Ester Production

FATTY ACID METHYL ESTER PRODUCTION.

T	1950	1960	1970	1982
WESTERN EUROPE	25,000	50,000	80,000	190,000
WORLD	70,000	100,000	180,000	390,000

Oleochemistry succeeded in developing interesting derivatives from methyl esters. Alkanolamides, metal working agents, and especially sulfo-fatty acid methyl esters, generated by direct sulfonation, have to be mentioned.

These esters are interesting as surfactants. It is expected that fatty acid methyl ester development will be determined by the expansion of fatty alcohols. This would result in a growth rate of 3%. A partial substitution of LAS via ester sulfonate could result in additional gain of ca. 5%. The use of fatty acid methyl esters as a partial diesel substitute could be a further interesting field of application for countries with a favorable agricultural structure and few or nonexisting crude oil reserves—but presently not for Western Europe. This depends strongly on the crude oil price development. However, a greater independence from crude oil imports with corresponding savings of scarce foreign currencies could constitute an incentive.

Methyl esters, so to speak "masked fatty acids," should have a future as basic oleochemicals. They can be produced in large amounts at low cost. Oleochemistry and especially application research must be concerned more with this raw material of the future.

Fatty Alcohols (Table XIV)

Two-thirds of the fatty alcohols produced in Western Europe are of natural origin. The ratio is reversed in the world production. Two-thirds of the world fatty alcohol production is synthetic.

TABLE XIV

Fatty Alcohol Production

FATTY ALCOHOL PRODUCTION.

T		1950	1960	1970	1982
WEST. EUROPE	NATURAL	15,000	35,000	73,000	150,000
	SYNTHETIC	–	–	27,000	80,000
	TOTAL	15,000	35,000	100,000	230,000
WORLD	NATURAL	75,000	125,000	225,000	260,000
	SYNTHETIC	–	–	200,000	420,000
	TOTAL	75,000	125,000	425,000	680,000

In 1982, the Western European production amounted to only 58-66% of the nameplate capacity of 350,000-395,000 tons. Yet, fatty alcohols displayed during the past years a noteworthy growth as a consequence of an increased consumption of their derivatives (fatty alcohol ether sulfates, cosmetics, lubricant additives, etc.). Only 5% are used directly as pure fatty alcohols (Fig. 8). The production development was very positive from 1970 to 1982 with 7% per year.

This development was, in 1979/80, assumed to continue to the end of the 1980s with growth rates of 5-7% per year depending on the forecasting source. This optimism has in the meanwhile been quenched, or the expectation for a positive development has been projected farther into the future. Reduced growth rates have to be expected.

Influences are as follows.

Detergents:

- Far higher substitution of LAS on the basis of fatty alcohol ethoxylates had been expected in heavy-duty powders.
- Higher market shares had been expected for heavy-

AREAS OF APPLICATION FOR FATTY ALCOHOLS IN 1982.

95%	FATTY ALCOHOL DERIVATIVES
5%	PURE FATTY ALCOHOLS (CONSISTENCE FACTORS FOR COSMETIC AND PHARMACEUTICAL APPLICATIONS, EMOLLIENTS, SOLUBILIZERS, STENCILS, LUBRICANTS, METAL WORKING AGENTS)

70–75%	SURFACTANTS
13–18%	CHEMICAL AND TECHNICAL APPLICATIONS (RAW MATERIALS FOR AMINES, CHLORIDES, PHOSPHATES, ALDEHYDES, THIOPROPIONIC ACID ESTERS AND OTHER ESTERS, TEXTILE, LEATHER, PAPER AUXILIARIES, STENCILS)
8%	MINERAL OIL APPLICATIONS (VI IMPROVER, FLOW IMPROVER)
4%	COSMETICS (WITHOUT SURFACTANTS AND EMULSIFIERS)

FIG. 8. Areas of application for fatty alcohols in 1982.

duty liquid detergents with high nonionics contents.

- —Further LAS price increases were expected resulting in higher substitution by tallow alcohol sulfate. However, the LAS price has stabilized.
- —The use of extenders in textile softeners and imidazolinium derivatives.
- —Limited growth of the total detergent market (2% p.a.).

Cosmetics:

- —The cosmetics market, so far considered a growth market, may have reached, at least in case of some product groups, its growth limit (e.g., shampoos, bubble baths).

Chemical and technical products:

- —Partial markets like that of viscosity improvers on the basis of polyalkylmethacrylate are diminishing (less demand, substitution by olefin copolymers).
- —The demand for intermediates (amines chlorides, thiopropionic acid esters).

Fatty alcohols will experience a phase of lesser demand during the coming years since the market will not expand as expected, and will enjoy moderate growth rates from the middle of this decade until its end. Until 1985/86, the growth rate could be 2% per year and then increase to ca. 3% until the end of the decade. This means that present capacities would be more than sufficient and would be used to the extent of only 70-80% of present nameplate capacity in about 1990.

New markets are not easily recognizable. Applications such as EOR (enhanced oil recovery) are, in the present oil price situation, not as interesting as before. Furthermore, there would be little prospect for such surfactants on the basis of fatty alcohols in Western Europe.

The competitiveness of natural vs synthetic fatty alcohols has been and is still being discussed. The dependence of raw materials on the process is of importance in this context; processes requiring large raw material volumes react more sensitively to raw material price variations. The production of natural fatty alcohols requires smaller amounts of raw material than do some synthetic processes. The energy requirement for the production of natural alcohols is considerably lower, and the necessary capital investment for a new petrochemical plant is higher. It is probably, furthermore, essential whether a fatty alcohol plant fits into an existing system and is operated as an integrated production. The purchase of intermediates, e.g., fatty acids, on the market may already question the competitiveness, although the sale or use of coupled and byproducts (glycerine, low cuts) is eliminated. An integrated production is in a position to make optimal use of less valuable fractions, e.g., by derivatization. However, broad derivatization possibilities also entail high capital investment requirements for the follow-up processes such as ethoxylation, sulfation, esterification, etc., and the sale of specialties demands a considerably enhanced marketing effort.

The main problems are the ethylene and partially *n*-paraffin price developments. Due to the low consumption of ethylene and its derivatives, and the large volume expected from the Near East, the ethylene price will probably increase only moderately. It is, furthermore, anticipated that the price hikes for oils and fats will be lower.

Considering the competitiveness of some processes, the sequence from higher to lower economics is: (i) natural fatty alcohols, (ii) Ziegler process (with high byproduct credit), (iii) ethylene oligomerization/olefin metathesis, and (iv) Ziegler process (with low byproduct credit).

Glycerine

Thirty years ago, the glycerine market experienced continuous price alterations caused by changes in demand and limited availability.

Earlier, glycerine yielded considerable profits for the soap producers. Therefore, the soapers were very interested in this lucrative business and enlarged it. The large soap and detergent producers are consequently still among the most important producers of natural glycerine.

The picture changed when synthetic glycerine entered the market in the 1950s and 60s. This surmounted the production bottleneck and the market development depended thereafter essentially on demand.

The production of other, relatively low cost polyols led to a substitution of glycerine by polyols such as sorbitol, TMP and other glycols in the 1960s and 70s, resulting in a low growth of the glycerine market. Simultaneously, the production of natural glycerine increased disproportionately. A reason for this development was, among other things, a tendency toward natural fatty alcohols. If this trend continues worldwide, the total glycerine demand can be satisfied with natural glycerine by the end of this decade.

Since natural glycerine is a coupled product which amounts to ca. 10% when natural oils and fats are processed, it will command price advantages as compared with the synthetic product.

The considerable quality improvement of natural glycerine is eroding the competitive edge which the synthetic material enjoyed in this respect. Therefore, the trend that producers of synthetic glycerine will stop production may continue. The development in the USA, where some plants closed down in the past few years, should be mentioned.

Table XV shows world glycerine production since 1950, and Table XVI shows its most important areas of application in Western Europe.

Glycerine, an important byproduct, will continue to constitute an important raw material on the oleochemical market. If methyl esters grow rapidly, large volumes of glycerine will be generated. This could result, due to price decreases, in a resubstitution of other polyols which had substituted for glycerine in the past.

TABLE XV

Glycerine Production

GLYCERINE PRODUCTION.

T		1950	1960	1970	1982
WEST. EUROPE	TOTAL	60,000	110,000	150,000	190,000
WORLD	NATURAL	180,000	200,000	220,000	310,000
	SYNTHETIC	20,000	90,000	140,000	110,000
	TOTAL	200,000	290,000	360,000	420,000

TABLE XVI

Western European Fields of Application of Glycerine in 1982

WESTERN EUROPEAN FIELDS OF APPLICATION OF GLYCERINE IN 1982.

GLYCERINE APPLICATIONS	%
PHARMACY, COSMETICS	28
ESTER, FOOD	22
RESINS	21
CELLULOSE	6
POLYOLS, POLYURETHANE	5
TOBACCO	3
NITRATION	4
OTHERS	11

TABLE XVII

Fatty Amine Production

FATTY AMINE PRODUCTION.

T	1972	1982
WESTERN EUROPE	55,000	110,000
WORLD	145,000	300,000

Fatty Amines

Fatty amines (Table XVII) in Western Europe are manufactured from fatty acids and, to a lesser extent, from fatty alcohols. Syntheses via olefins are insignificant. The average yearly growth amounted to 7% from 1972 to 1982. The available capacity of 145,000 tons is in excess of demand: the nameplate capacity is only utilized to the extent of 75%.

Sales of primary amines are stagnating while secondary and tertiary amines are being increasingly derivatized. Ca. 25% of the amines are used as such (e.g., in road building, for anticaking) and ca. 75% in the form of derivatives (quaternary ammonium compounds, amine oxides, amine-EO-adducts): see Table XVIII.

Growth rates are estimated to be 4% per year. Development of softeners, which account for 45% of sales, will be important. Reservations are still seen in the softener market. Consumption in Western Europe varies by country (Table XIX).

TABLE XVIII

Western European Fatty Amines—Fields of Application in 1981

WESTERN EUROPEAN FATTY AMINES – FIELDS OF APPLICATION IN 1981.

APPLICATIONS	%
SOFTENING AGENTS	45
MINING/ANTI-CAKING AGENTS	12
ROAD BUILDING	10
BIOCIDES	10
TEXTILES, FIBERS	8
MINERAL OIL INDUSTRIES	4
DYES/PIGMENTS	3
OTHER USES	8

TABLE XIX

Softener Per Capita Consumption in 1981

SOFTENER PER CAPITA CONSUMPTION IN 1981.

COUNTRY	KG	COUNTRY	KG
WESTERN GERMANY	6.4 -	GREAT BRITAIN	1.9
DENMARK	3.7	SPAIN	1.4
BELGIUM	3.7	ITALY	1.1
SWITZERLAND	3.3	FINLAND	0.8
NETHERLANDS	2.6	IRELAND	0.7
AUSTRIA	2.6	GREECE	0.3
FRANCE	2.2	PORTUGAL	0.1

The consumption of softeners is determined by various factors:

—ratio "machine:hand wash,"
—tendency toward concentrated preparations,
—utilization of raw materials (dialkyldimethylammoniumchloride, imidazoline derivatives),
—use of extenders,
—success of multifunctional detergents or soft detergents (detergent plus fabric softener).

The area of application of amines is, besides this important sector, decidedly determined by specialties which are very characteristic for this basic oleochemical.

Growth markets for specialties are seen in:

—mining/flotation (utilization of poorer ores, e.g., iron ores, liquid extraction),
—cosmetics (quaternary ammonium compounds in conditioning agents),
—corrosion inhibitors,
—oil field additives (demulsifiers, biocides).

THE CHALLENGE: PROBLEMS AND OPPORTUNITIES

Features of Oleochemistry

How can oleochemistry be characterized?

- –assured position of mature industry,
- –processes have been optimized over the years,
- –a multitude of products (basic oleochemicals and derivatives) with numerous applications,
- –flexible product mix by starting with chain length-specific oils and fats: the building blocks of specific carbon chains can be produced by selection of raw materials,
- –relatively simple processes facilitate a broad product spectrum,
- –the production is, by nature of the materials, environmentally compatible. The handling of oleochemical materials is controllable and does not burden the environment. Residues can be utilized or destroyed without problems.
- –there are chances especially for medium-scale operations, e.g., for oleochemical intermediates, derivatives,
- –assured, renewable and (probably) stable-priced raw materials available worldwide through a well established logistic system.

Problems

These positive features are counteracted by problems:

- –considerable excess fatty acid, fatty alcohol and amine capacities (as well as in certain derivatives such as fatty alcohol ether sulfates),
- –increasing tendency to downstream of oil producing countries in South-East Asia,
- –few prospects for "new" products.

Excess Capacities

After an average growth of ~3% in the 1970s, oleochemistry will have to be satisfied with further increases of below 2% per year, i.e., a modest growth due to a slow recovery. Lower crude oil prices should enhance buying power; however, they should also diminish the above average growth rate of natural products at the expense of petrochemical products in some areas. The excess oleochemical capacities will thus be reduced only gradually since additional large volume applications are not recognizable. Certain streamlining measures in the sense of an adjustment of existing capacities should therefore be considered. However, it is especially necessary that the need for new capacities is carefully scrutinized before they are established.

Downstream

A tendency toward downstreaming is recognizable in some oil-producing countries. The emerging countries do not want to export only raw materials but want to satisfy the demand for basic materials and derivatives as well.

Due to the weak development of the oleochemical business and large capacities the sales situation in Western Europe will worsen. In the sense of a Thünen model one might argue that the production of fatty materials away from the market is advantageous in that the production costs decrease more steeply with distance than transportation costs increase. However, the specific situation of Western European oleochemistry has to be taken into account.

In a typical integrated business, byproducts can only be marketed effectively and flexibly at the location of production, i.e., in Western Europe. It is entirely unthinkable that the well functioning Western European oleochemical economy could adjust to generally altering these conditions. The demand concentration and the established connection to the converters are already too well developed and advanced. Nevertheless, Western European oleochemical industry has to adjust to the prospect that basic oleochemicals will be pushed onto the Western European market. Does a sensible cooperation solve the problem, e.g., in the form of joint ventures, accompanied by a technology transfer?

"Old Products"

The established place of oleochemistry in the market and the widespread application of its basic materials and derivatives constitute its strength. Its success was essentially determined by its derivatives such as fatty alcohol sulfates, ether sulfates, nonionics, fatty acid esters and quaternary ammonium compounds.

Most of these applications are now proven and established. They have to be viewed as "old products for old applications." Their development is probably determined more by economical and ecological than by technological factors. However, if economical factors (price increases for petrochemical derivatives such as ethylene and alkylbenzene) changed, a return of old products toward old applications–e.g., surfactants in detergents–would result. A change of ecological requirements would exert a similar influence: either through legislative measures or emphasis on problems, i.e., greater public awareness. New scientific findings on the ecological behavior and effects could lead to the prohibition or a voluntary ban for certain compound classes (NPE).

The close contact of derivative producer with the market is an advantage of oleochemistry. New applications may certainly be found for "old" products, e.g., fatty acids in deep oil well drilling, lauric acid soaps in heavy-duty liquids, imidazolinium salts as softeners, ether sulfates in new surfactant formulations with an improved dermal compatibility, nonionics in heavy-duty liquids. The borderline between "old" and "new" products is certainly not strictly defined. There are numerous tasks–solutions in small steps, optimizations–which may open new applications for established products: highly concentrated fatty alcohol sulfate pastes for powdered detergents, nonionics with a narrow EO number spectrum, fatty alcohol ethoxylates instead of NPE for chemical and technical applications.

Coupled products such as glycerine and low cut alcohols and fatty acids present a continuous challenge. A derivatization beyond present possibilities which would give the coupled products a high-added-value would be a continuing task of application research (e.g., glycerin chemistry).

"New" products are probably a weakness of oleochemistry. Oleochemicals and oleochemical derivatives have developed stepwise over decades with wide branching and with an intensive scrutiny of the substances and their applications. It appears that the basic oleochemicals fatty acids, fatty alcohols and especially glycerine would hardly yield anything new: there is nothing to be found and nothing to be researched anymore. They are considered to be indeed "mature" in the sense of being "beyond their apex." It would seem to be especially urgent to stop this thinking. This suspicion is not as noticeable in the case of amines and fatty acid methyl esters: they appear "younger."

Product type	Implications/ partner	Can be influenced?
Old products Old applications	Economical/ecological situation	Hardly
Old products New applications	Application Research	Yes—continuous challenge
New products for old/new applications	Research/technology	Conditionally future task

New Products?

Oleochemistry has concentrated its efforts for decades on the ester function. Reactions with the double bond are the exceptions (epoxides, dimerizations, ozonolysis). More than 90% of fatty chemistry is realized by reacting the classical ester group and only a few percent by reacting the double bond.

Does interest turn now more toward the functionalization of the long alkyl chain? Will now rather the double bond function in the alkyl chain be utilized?

The functionalization of the alkyl chain could gain significance, especially in case of higher prices for petrochemical derivatives. It is, after all, an advantage of natural products that their hydrocarbon chains possess double bonds at defined locations. Thus, the molecule offers special points for chemical attacks. These unsaturated compounds, uniform with respect to chain length and double bond position, yield uniform products, contrary to petrochemically produced olefins which constitute broad chain length mixtures which have to be separated and which are accompanied by coupled, less desirable chain lengths. Thus, one can functionalize natural products accurately toward a given aim. There would be new opportunities for oleochemistry in terms of new product ideas and new processes which, by present means, cannot be solved yet but which are already being realized by petrochemistry in other areas —through catalyst development and higher purity educts: the metathesis reaction which is used with olefins on a large scale. Metathesis should be interesting if one considers that almost 90% of oils and fats contain C_{14}+ fatty acids.

Peripheral processes such as separation and selective hydrogenations should yield high purity fatty acids such as oleic and erucic acid serving as a basis for fatty chemical polymers, e.g., through functionalization toward suitable monomeric building blocks. It should be possible to generate high purity, unsaturated compounds in oleochemistry also. Processes or compounds linking fatty chemistry with petrochemistry could also be of interest:

- —epoxidation of unsaturated fatty materials and ring opening reactions with petrochemical reagents,
- —hydroformulation of unsaturated fatty materials to diols, triols, etc.

Even though ozonolysis has shown only limited value in practice, it has to be carefully watched to see if there are more cost effective and modern processes and application possibilities for this interesting and selective cleavage reaction.

Fatty acids and fatty acid methyl esters of important oils and fats could especially serve as a basis for such efforts:

- —soybean oil (fatty acid, fatty acid methyl ester) since it constitutes the largest volume,
- —palm oil (fatty acid, fatty acid methyl ester) since it enjoys great growth rates,
- —tallow (fatty acid, methyl ester) since it is readily available for chemical purposes,
- —rapeseed oil (fatty acid, fatty acid methyl ester) since it is produced in close proximity to the processing industry.

Technology

Oleochemistry improved its processes years ago. Considerable progress has been achieved. Nevertheless, optimizations are possible

- —through new mixed catalysts,
- —through special energy concepts, e.g., energy-optimized distillation processes,
- —through detailed instrumentation improvements,
- —through computer-assisted process control.

Although oleochemistry consumes little energy compared with petrochemistry, the last steps nevertheless require some energy. New biotechnological work-up procedures are being investigated to reduce costs for splitting and oil recovery: splitting of fats by enzymes and enzymes for the preparation of oilseeds. There are further improvement possibilities in the sulfation and sulfonation processes (ester sulfonates, highly concentrated fatty alcohol sulfates and fatty alcohol ether sulfates).

The "Green Revolution"

The preliminary stage of oleochemistry, the biological influence upon oil-producing plants, deserves special attention. Much is expected from hybridizing techniques even without taking into account future possibilities such as gene manipulation. Resistant plants with higher yield and the hybridization of certain carbon chain length preferences hold promise: some cuphea hybrids *(C. parsonsia)* yield >80% C_{12}. It may, however, take some time before this annual plant is utilized agriculturally in Europe.

The accomplishments of past hybridizing measures are already noteworthy:

- —an increase of the fat content in sunflower kernels from 20-40 to 60%,
- —low erucic acid rape varieties,
- —low stem palms with 4- to 6-fold yields,
- —low growing peanut plants with creeping shoots.

A success was also realized in Malaysia with palm trees cloned by tissue culture techniques.

It is certainly important that oleochemistry strives at an early stage for its raw materials as a biological research subject at the appropriate scientific institutions.

The Market

The multitude of applications of oleochemical derivatives requires derivative producers with marketing specialization. The producer maintains proximity to the market and develops speciality products. He is in close communication with the user, e.g., leather, textile, paper, and rubber auxiliaries products for the cosmetic and pharmaceutical or detergent industry. This position of the derivative producer is of the utmost importance for the industry producing basic oleochemicals which cannot adequately fulfill this function. The applications of oleochemicals are numerous and diverse and require specialists for each area.

Some producers are integrated, i.e., they produce basic oleochemicals as well as derivatives. The reason may be the attempt to optimize utilization of coupled products and byproducts. Fierce competition in the field of basic oleochemicals, due to large excess capacities, may lead to decreasing prices and attempts are made to compensate this through high-value-added products. It requires careful planning to bring the higher value in balance with the higher marketing effort for the derivatives. The latter includes toxicological and ecological safeguarding of products, especially for cosmetic, pharmaceutical and detergent application. Expensive R&D effort and marketing through qualified staff are also involved (Fig. 9). A number of previous specialities matured in the course of time, and became commodities because of competition leading to decreasing prices (ether sulfates, alkanolamides, quaternary ammonium compounds for textile softeners).

Oleochemistry appears to be an easily understandable industry which, due to its attractive raw materials, has a beautiful and secure future.

One does not diversify easily into oleochemistry anymore. The companies operating successfully in this field do so as a result of a long-term adjustment and selection process. It is a field for specialists with the knowhow—it may be permitted to use this reference—to play the "oleochemical piano."

In the present situation it seems questionable whether new integrated producers could start from the very beginning and be successful.

The Resubstitution

Why did oleochemistry not capitalize on possibilities in the times of most horrid crude oil price increases and scarcity? Oleochemistry simply remained restricted to its traditional areas since there were no possibilities. There would have to be a suppressive competition, e.g., the substitution of petrochemical by fatty alcohol based surfactants or natural fatty acid esters instead of crude oil on a broad scale in lubricants or fatty alcohol phthalates or triglyceride epoxides, respectively, instead of DOP, etc. A broader push of oleochemical products would essentially only be facilitated via prices or via a longer-term scarcity. However, the prices for petrochemical derivatives have experienced an adjustment, and scarcity was changed into excess because of recession and lower demand. Supply disturbances for petrochemicals were insufficient for a continuing resubstitution and the prices for crude oil products were still low enough. Besides that, the moment of inertia is great. The processor was used to his petrochemical raw materials. Changes often demand long and expensive experiments. After all, petrochemistry delivered its products for decades without problems.

Surfactants

Surfactants predominate the consumption of oleochemicals. The same pertains to additives and specialities in the detergent area (fatty acid alkanolamides, glycerine monostearate, quats, etc.).

It therefore appears logical to treat surfactants in detergents and cleaning agents separately. Four parameters are decisive for these applications: performance, raw material availability, toxicology/ecology, and economy (price).

Performance

Anionics. Essential differences are not recognizable. In theory, powdered detergent formulations are producible with all the customary surfactants (LAS, AS, AES, SAS, ES, AOS) with the exception of special formulations. LAS, AES and SAS still constitute the major surfactants for liquid light-duty detergents. A trend toward an increased use of AES is not noticeable. Combinations, especially with LAS, are preferred because of synergistic effects.

Nonionics. The amount of nonionics of the fatty alcohol ethoxylate type in powdered detergent formulations is increasing (synthetic fabrics, lower phosphate content, lower wash temperature). However, this development is slower than had been anticipated. A tendency towards higher surfactant contents is seen in low phosphate formulations, however, not necessarily of the nonionic type. The development varies according to the markets in Western Europe and the product philosophy of the producer. The phosphate reduction—with zeolite or without—will not necessarily result in a trend toward nonionics. There is no general movement toward phosphate-free detergent formulations in the main markets.

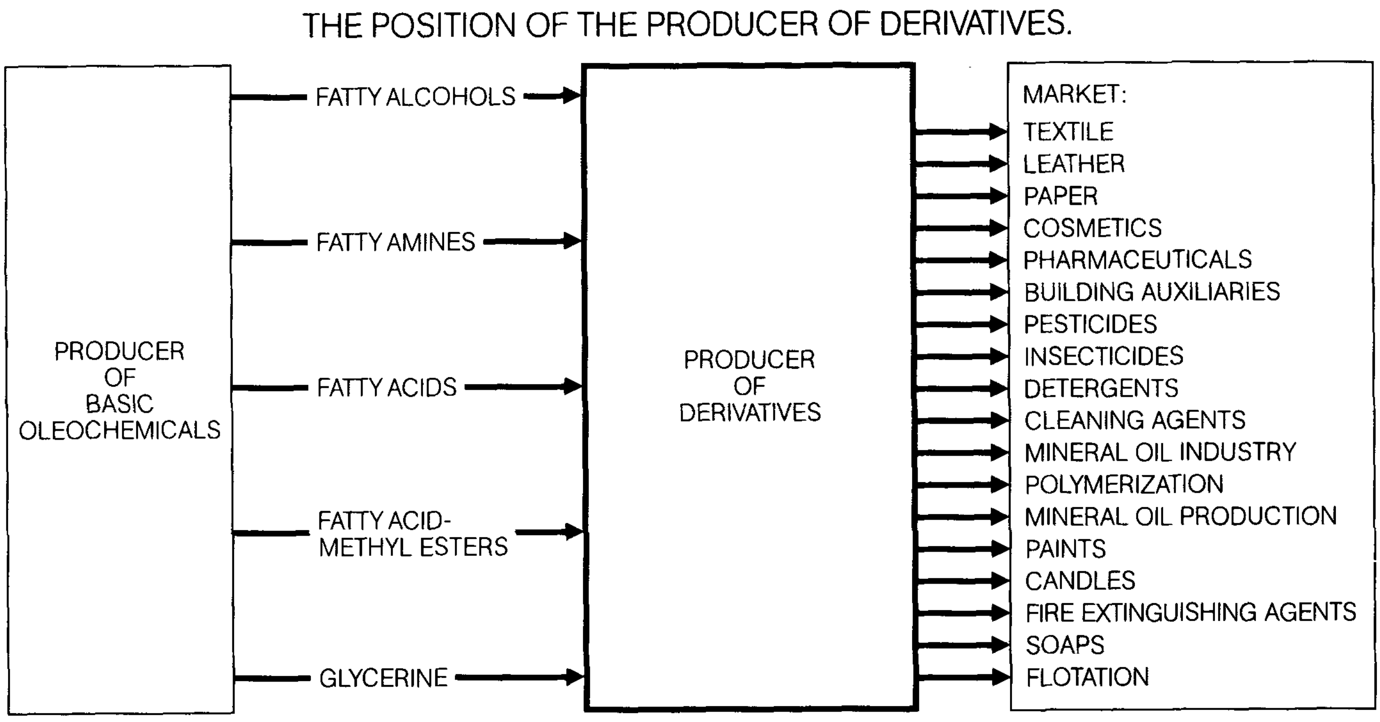


FIG. 9. The position of the producer of derivatives.

Raw Material Availability

Tight supply situations are neither foreseeable for petrochemically or oleochemically based surfactants. Certain external problems (wars, political developments), of course, cannot be foreseen. They could lead to a global disturbance. In general, i.e., for large-scale purposes, the availability of LAB/LAS, AES, AE, AS and NPE is viewed as being better assured than for SAS and AOS (capacity). The production facilities for ES are presently being established.

Toxicology/Ecology

Anionics. There are no medium-term prospects for legal changes. The question of the ultimate biodegradability of surfactants is, however, being discussed. Additional legal requirements are, though, not expected for the near future.

Nonionics. NPE could again become the focal point of discussion since biodegradation intermediates display a higher fish toxicity than do the parent compounds. Their—perhaps stepwise—substitution would be ecologically desirable. A strong growth of heavy-duty liquids is not anticipated for the near future, i.e., this will not focus attention on nonionics.

Economy (Price)

The price development of the basic surfactants will largely determine the choice of these materials. According to the preceding considerations of the subject matter "natural raw materials" one might expect lower price increases for them than for comparable petrochemical products. On the other hand, an extensive resubstitution is not to be expected either, considering the implications: a lower demand for crude oil products, a pressure due to existing and future petrochemical capacities (Near East), a hesitant world economic recovery, the need of the oil-producing countries to sell. These reasons could lead to a scenario of the "least possible price increases for petrochemical products.".

It is, furthermore, hard to imagine that LAB producers with large worldwide capacities (>1.5 million tons) would simply succumb to competition. This would be contrary to all past experience. A partial and slow substitution would, for the reasons discussed, appear the maximum which can be realized. A certain moment of inertia might be a further reason for this drawn-out substitution, e.g., established logistics systems, caution in changing the formulations of brand-name products, etc. This assumption would appear to be especially pertinent if an explosive development of petrochemical raw materials is not anticipated.

A partial substitution of the workhorse LAS to the extent of 20-25% appears maximally possible on the grounds of the scenario outlined above, stable or slightly decreasing crude oil prices up to 1985/86, followed by an upward trend until 1990, but below the average inflation rate. It is possible that the processors take an earlier opportunity to use substitutes in order to test alternative products on a large scale. The following LAS substitutes offer themselves.

Anionics.

(a) Ester sulfonate/tallow alcohol sulfate: ES and TAS are probably the most interesting alternatives. The capacity reserves would allow a partial substitution, i.e., excess capacities could be reduced. In this context it is also important that existing sulfonation and sulfation facilities could be used. Long-chain ester sulfonates are principally suitable for powdered detergents. They have proven to be a suitable, e.g., 50%, substitution in heavy-duty powders.

Tallow and palm fatty acid ester sulfonates are, however, unsuitable for liquid products, e.g., light-duty liquids. Investigations with solubilizers, combinations with other surfactants or shorter-chain ester sulfonates would have to be conducted.

If there were a considerable price rise of ethylene oxide, medium-chain length alcohol sulfates would constitute a proved possibility for light-duty liquids.

(b) AES: These are usually not formulated into heavy-duty powders in Western Europe—contrary to the USA. However, they would be an excellent LAS alternative for light-duty liquids—with the possibility of introducing these materials which have hitherto, for cost reasons, been used only on a small scale in formulations.

Nonionics.

(a) Fatty alcohol ethoxylates: Even if an above-average increase of the nonionics content in specialities seems possible, anionics should remain necessary. Various reasons speak against an unusual nonionics growth (no universal but special washing performance [oily soiling], product storability).

A further displacive "natural vs synthetic fatty alcohol ethoxylates" competition is improbable (low ethylene price growth). Ethoxylates on the basis of natural fatty alcohols would be favored by larger price increases for petrochemicals since an ethylene price hike would express itself in the alcohol as well as the ethoxylate part of synthetic nonionics.

(b) NPE: NPE are unimportant for powdered detergents. They find numerous technical and chemical applications. Fatty alcohol ethoxylates would have to be optimized for these applications.

Availability of the fatty chemical raw materials has been discussed: in case of a possible substitution of 20-25% LAB and NPE, the necessary fatty materials in a volume of ca. 100,000 tons would be available in the time period under consideration, as well as the capacities, without any addition. If such volumes of oleochemicals substituted for petrochemical surfactants, there would be no trouble in making use of the coupled products, low cut alcohols and glycerine.

If one wanted to be a little provocative, one might even claim that oleochemistry could obtain its raw materials in such amounts as would be necessary to substitute the total Western European demand for petrochemically based surfactants. Of course oleochemistry would have to adjust its capacities for basic oleochemicals in advance.

(c) Soap is in tune with today's ecological concerns. Presently, there is no indication that soap could regain a major role in powdered detergents. In spite of builders, pure soap detergents would not meet the demands to which modern detergents are subjected. However, shorter-chain soaps are experiencing something of a comeback in combination with anionics and nonionics in builder-free heavy-duty liquids where they contribute to the washing performance of these products. Furthermore, long-chain soaps are important as foam regulators in powdered detergents.

Fat chemistry was once the big loser, i.e., when detergents changed from soaps to synthetic surfactants. Will oleochemistry regain lost ground—through its oleochemical derivatives, such as methyl ester sulfonates or alkyl sulfates? It would change the overall growth rate for basic oleochemicals from 2% to a modest 3%. But, of course, for the product group, fatty acid methyl esters or fatty alcohols, it would be most significant.

(d) Nonsurfactants: The substitution of petrochemical derivatives is not limited to surfactants. Examples for nonsurfactant applications are:

- –ESO (epoxidized soy oil) as a partial substitute (10-15%) for DOP. This would depend on the 2-ethylhexanol price development and would, at 1-1.2 million tons of DOP in Western Europe, yield a theoretical potential of 100,000 tons ESO.
- –ESO has so far only been applied as a costabilizer. Perhaps the future will yield more use possibilities in order to reduce certain heavy metal stabilizers.
- –*n*-DOP (basis: *n*-C_8 or *n*-C_8/*n*-C_{10} mixtures) instead of DOP: better compatible plasticizers with a better low temperature stability and lower volatility. This constitutes a higher potential which could be activated if 2-ethylhexanol prices were increased.

These examples have been quoted to demonstrate that excess volumes of low cut alcohols, which would be generated in case of production of larger volumes of oleochemically based surfactants, are manageable.

Oils and Fats and Oleochemicals, Respectively, as Gasoline Substitutes

Not too much hope should be invested in all those areas which were selected with euphoria during the crude oil crisis. Even alternatives to conventional energy sources were being discussed since the term "renewable resources" gives such a nice contrast to the term "finite" connected with crude oil. Irrespective of the fact that opinions on crude oil reserves diverge widely, the raw material volumes, ca. 2,800 million tons of crude oil vs 57 million tons of oils and fats, demonstrate clearly the limitations. In addition, 80% of oils and fats are needed for nutritional purposes.

Little will change in the future in this respect. If all the utilized renewable energies such as water, sun, wind, plants and biomass were tripled by the change of the century—and that would indeed be an enormous achievement—then this would not even constitute 10% of the total energy demand. And oils and fats would again only be a small fraction of this contribution.

There may be regional exceptions: "coco diesel" in the Philippines, soybean methyl ester in Brazil, and other methyl esters, e.g., peanut acid methyl ester in other countries. Greater ventures in this direction would generate considerable problems: large monocultures, activation of idle land, byproducts such as glycerine and—in the case of soybean oil—the main product, meal, would be generated in very large volumes.

The present crude oil situation has stopped some alternatives for the solution of the gasoline problem and has slowed down others.

Anyhow, these areas of application are less relevant for Western Europe than for countries with a favorable agricultural structure and little or no crude oil reserves. This would, in the final analysis, be a political decision.

"Oleochemicals vs Petrochemicals?"

This is certainly not the question. Already, the orders of magnitude put the problem into the proper perspective. But today's availability of raw materials, the possible price development, the appropriateness of dealing with these resources, would appear to necessitate a new determination of oleochemistry's position. It cannot be oleochemistry *or* petrochemistry, but oleochemistry *and* petrochemistry. Oleochemistry offers some noteworthy, great opportunities. They will not easily be realized.

In oil glut times—when oil was cheap—it seemed sensible to cut the long hydrocarbon chains, with energy expenditure, into little pieces and to build from them, with energy expenditure, fatty chemical materials. Perhaps, it would today be more sensible to perform such operations only where it is rational and advantageous from the structural point of view.

In the same sense, it would not be meaningful to produce higher olefins or ethylene from fatty materials. Why should new processes be developed to produce fatty acids and fatty acid methyl esters from olefins by hydrocarboxylation and hydrocarboxymethylation, when nature prepares (in fats) fatty acids much more elegantly, with much less energy, with much less noise, and further, those raw materials are plentiful?

Fatty chemistry's great advantage is that it maintains building blocks of the molecules, synthesized biochemically, and their energy content. The energy balance is in favor of natural, oil-derived chemicals. The principle of the "least change in the structure of the raw materials" is maintained in oleochemistry. The following quotation could also be applied to oleochemistry.

"A preserving chemistry and a new set of instruments which is more sensitive and more appropriate to the material possibilities of the substrate is required if the molecular order of biogenic matter given by nature and optimized by evolution is to be exploited. An example is that of nature itself, in which synthesis reactions, rearrangement reactions and degradation reactions proceed under the mild conditions of vegetable and animal life with a level of selectivity which is beyond the reach of petrochemistry" (1).

ACKNOWLEDGMENTS

Many colleagues in the Henkel company helped me prepare this presentation. Special thanks to Mr. Fochem of the purchasing department for compilation of data on "oils and fats."

REFERENCES

1. Hofmann, P., and C.H. Krauch, Naturwissenschaften 69:518 (1982).

GENERAL READING

Albrecht, W., Chemiefasern Textilind., Jan. 1983.
Barth, H., Fette, Seifen, Anstrichm. 84 (1982).
Berth, P., J. Heidrich, and G. Jacobi, Tenside Deterg. 17 (1980).
Gander, K.F., Z. Lebensm. Technol. Verfahrenstechnik, ZFL 31: 3 (1980).
Hofmann, P., Fette, Seifen, Anstrichm. 85 (1983).
Holz, A.E., Fette, Seifen, Anstrichm. 80 (1978).
Klimmek, H., Chem. Ind. XXXIII, Mar. 1982.
Stein, W., Fette, Seifen, Anstrichm. 84 (1982).
Vogel, W.J.B., Soap, Cosmet. Chem. Spec. Mar. 1983.
Werdelmann, B.W., and R. Schmid, Fette, Seifen, Anstrichm. 84 (1982).