Historical and Marketing Trends of Natural/Synthetic Fatty Acids[1]

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ABSTRACT AND SUMMARY

As long as a substantial portion of raw materials for natural fatty acids are relatively inexpensive by-products of other major industries, natural fatty acids should fulfill the world's projected needs at least through 1985. Production of synthetic fatty acids may also increase; however, at the present time the cost of their raw material and processing has made them largely noncompetitive, except in a few cases. Synthetic organic acid manufacturers currently supplying short chain products will continue their efforts to enter the detergent range fatty acid market area. We expect some breakthrough in synthetics during the life of our forecast. However, potential producers have yet to develop an economically competitive synthetic fatty acid as a replacement for natural fatty acids in the U.S. Petroleum-based products include odd, even, and branched chain acids whose performance must be proven. Finally, the petroleum base for synthetic fatty acids no longer has the price stability we have been accustomed to in the past. Recent changes in price of ethylene and forecasts are evidence of this trend for the future.

INTRODUCTION

Those of us with an involvement in the fatty acid business, either as producer or user, take a great interest in the continuing contest between natural and synthetic derived fatty acids for increased market position.

The long range resolution will, of course, depend upon a complex combination of factors that are purely speculative at this stage; i.e., raw material availability and economics, new synthetic technology or improvements in existing processes, and of course, changing market demands for specific types of products which in turn may dictate production techniques.

However, we can evaluate current technology, market requirements, and raw material status, with a considerable degree of accuracy. While this won't carry us to the turn of the century, it gives us a good basis for short-term prediction, say to 1985.

Disposition of Fatty Acid by Industry

In recent years considerable changes have occurred in the use of normal fatty acids due to expanded technology. This is reflected in the commercial use of such fatty acid modifications as dibasic and dimer acids, nitrogen derivatives, and fatty alcohols.

The last report compliled by the Fatty Acid Producers' Council was in 1965, and we believe this is now out-of-date due to product use changes. Table I shows the latest projection of disposition of fatty acid production from a recent compliation by Chem. Systems, Inc. Note the magnitude of the nitrogen use area.

The synthetic fatty acid manufacturer is primarily interested in the saturated fatty acid markets. Of immediate interest is group No. 2 shown in Table II. This five-year compilation by the Fatty Acid Producers' Council does not include use by the large independent soapers but does include the smaller fatty acid dependent soap maker and other applications.

[1]Presented at the AOCS Meeting, New Orleans, April, 1976.

RAW MATERIALS

Raw material sources represent a key element in our appraisal of the strength of fatty acids in the marketplace now and in the future. Naturally derived raw materials possess several unique and important differences as contrasted with petroleum feedstocks such as olefins and paraffins. I will refer to these differences in terms of by-product status, substitution, and expandable potential.

By-Product Status

If a raw material is a by-product, it has an economic advantage such as vegetable oils and animal fats which are by-products of protein manufacture. The use of soapstocks of coconut oil, palm, and other vegetable oils further enhances this aspect. Crude tall oil fatty acid is a by-product of sulfate kraft pulping in the paper industry.

Substitution

Substitution of common oil types is very important from an availability and economic standpoint. For example, coconut oil is the predominant lauric containing oil. We now have three sources of lauric oils completely independent of one another; i.e., babassu from Brazil which is in its infancy from the standpoint of growth potential, palm kernel from the conventional palm fruit, and the familiar coconut from the western Pacific area. For the longer chains such as C_{16} and C_{18}, tallow, palm, tall, soy, and corn oil are all substitute sources.

Expandable Potential

U.S. and world fats and oils situation: Table III outlines the expanding natural fats and oils industry worldwide from 1960 to 1974. Note, the U.S. has managed growthwise to remain at the consistent level of 24-26% of the expanding world production (1).

Interestingly, in the period 1960 to 1973 U.S. production of fats and oils increased 46%, while the world increase was 43%. U.S. population for this same period increased 17% and for the world it increased 27.5%.

Also, the world per capita production of fats and oils in 1960 was 22.47 lb, and in 1973 it expanded to ca. 25 lb. The U.S. per capita production in 1960 was 88.76 lb, increasing to 111.68 lb in 1973.

Of a total U.S. production of fats and oils of 24.5 billion lb in 1973, the U.S. government reported that 2.0 billion lb, or 8% of the total, was used for fatty acid manufacture. Let us look at the principal raw materials on which the U.S. manufacturer of fatty acids depends.

U.S. tallow: U.S. Tallow production in 1950 was 2.3 billion lb, and increased to 5.2 in 1971. USDA forecasts it will reach 6.7 billion by 1980. 38-45% of this tallow production has been exported each year. When you consider the anticipated 1.5 billion lb gain by 1980 plus a possible decline in exports of 3% per year due to expanding rendering capability in developing countries, it would make available over 2.0 billion lb of tallow annually, which is sufficient to fulfill our 1985 projection in excess of three times based on the projected consumption pattern of fatty acids. U.S. projected production is illustrated in Table IV (2).

Palm oil: Palm oil has gained prominence but still has a long way to go volume-wise. Figure 1 shows anticipated expansion from 2.4 billion lb in 1973 to 4.2 by 1980 and is projected to exceed 5.0 billion lb by 1985 (3). The U.S. is a healthy importer of palm oil for both food and non-food purposes.'

Palm kernel, babassu, and coconut oils: Palm kernel, babassu, and coconut oil production is 6.6 billion lb a year with worldwide expansion underway.

Tall Oils: A growth factor of 3-5% per annum is expected of the pulp and paper industry. Thus, tall oil supply should be adequate for our projection.

Soybean oil: Soybeans, already a very strong crop in the U.S., will see increases not only domestically but in other countries, mainly Brazil. Soy demand will continue to increase to satisfy the world need for protein.

Raw Material Position

We expect the growth of the world supply of fats and oils experienced in the last two decades to continue, unless economic conditions blunt their demand. Since fatty acids use less than 10% of fats and oils production, we see no supply problem within the period of our forecast to 1985.

FATTY ACID INDUSTRY

Growth of the Fatty Acid Industry

1960-1974 Growth (total disposition): The total disposition of unsaturated, saturated, and tall oil fatty acids covering the period of 1960 to 1974 grew from 281.6 to 1,157.0 million lb.

For all practical purposes, one can say the industry has doubled fatty acid output in 15 yr (1960-1974). The growth overall was 5% per year during this period. Note that during the years of 1973 and 1974 use level declined due to two main factors; i.e., export of crude tall oil and decline in pulp and paper industry.

Trends – total disposition of fatty acids (1975-1985): Past growth and use per capita are basic ingredients in our assessment of trends shown in Figure 2. The spread indicated in each forecast shows, at best, unabated growth at the 1960-1974 per annum rate projected to 1985. The bottom line of each projection reflects the economic dip of 1975 with anticipated 1976 recovery to 1973 level. The projection from 1976 to 1985 reflects a conservative 60% of the growth rate per capita which we experienced during the 1960-1974 period. This is the pessimistic side of our projection due to general economic decline, possible fuel use reduction, and technological changes due to the automotive industry switching to small cars. This impact will be felt by every supplying industry, not only automotive, but rubber, plastic, textile, steel, lubricants, protective coatings, etc.

Charles Aldag, vice-president and general manager of Ashland Chemical Company's Chemical Products Division, in his paper, "Fatty Acids – Review and Forecast," presented at the C.M.R.A. meeting in New York on May 9, 1975, used disposable personal income as a guide to project future trends of fatty acids to 1985. Total optimal demand calculated to 1.672 billion lb compared to our projection of 1.626 billion lb. With additional background now available on the impact of our economic conditions, we have projected also a minimal requirement of 1.517 billion lb.

Manufacturing Capability of the Fatty Acid Industry (1975-1985)

The question we now may ask is, "Does our industry possess sufficient production capability to handle the projection we have made to 1985?" The Fatty Acid Producers' Council annually reports the manufacturing capacity of its members. Table V shows the capacity reported for 1975 which represents ca. 80% of the industry.

Considering tall oil does not require hydrolysis (unlike tallow or vegetable oils) fat splitting and distillation should be adequate for our 1985 projection. There could be some weakness in separation and hydrogenation depending on the product mix, fuel, and hydrocarbon supply as we go into the 1980-1985 area. In other words, hardware appears adequate.

The ever increasing interest on the part of the synthetic

TABLE I

Typical Disposition of 1973 Production of Fatty Acids (End-Use Consumption of Fatty Acids in the U.S.)

Industry	Percentage[a]	In mm. of lbs[b]
Surfactants – soaps	33	392
Fatty nitrogens	18	214
Rubber industry	10	119
Surface coatings	10	119
Grease – heavy metal soaps	5	60
Textile industry	5	60
Plasticizers	4	48
Food additives	1	12
Cosmetic	1	12
Pharmaceuticals, export and other	13	154
Total Disposition[c]	100%	1,190

[a]Chem Systems Inc.
[b]Process evaluation by Ashland.
[c]FAPC Total Disposition of Fatty Acids (1973).

TABLE II

5-Year Average Disposition of Saturated Acids[a]

Fatty acid area	%	Principal use area
No. 1 Capric-Caprylic	2.7	Synthetic lubricants and plasticizers
No. 2 Lauric-Myristic	15.9	Surface active wetting agents
No. 3 Palmitic-Behenic	81.4	Universal use
	100%	

[a]Compiled from FAPC Annual Data 1970-1974.

TABLE III

U.S. and World Production of Fats and Oils in M of Metric Tons

Year	World	U.S.	% of World
1960	29,561	7,273	25 25
1965	35,091	8,435	24
1970	39,329	10,327	26
1971	41,551	10,441	25
1972	42,862	10,370	24
1973	42,212	10,656	25
1974[a]	45,993	11,986	26

[a]Forecast. Ref. 1.

TABLE IV

U.S. Tallow Projection

Year	Metric tons
1950	1.04
1973	2.36
1980	3.04

[a]Ref. 2.

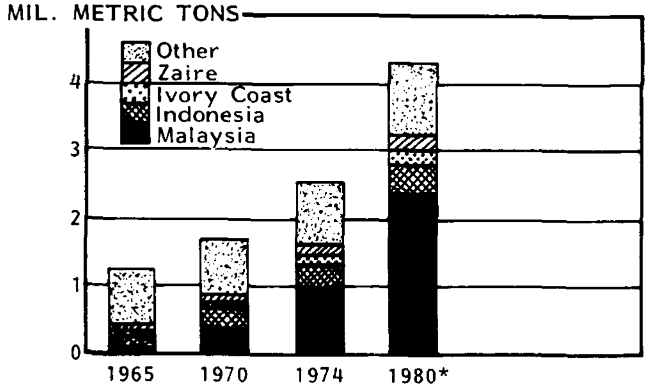

FIG. 1. World palm oil production.

fatty acid proponent is of concern to the natural producers. His interest surfaces with greater frequency as time passes. We liken this to the Loch Ness Monster. He raises his head at propitious moments when an opportunity appears economical, but so far has retreated into the depths to disappear once more, not liking the market situation for permanency. When will the next surfacing occur?

SYNTHETIC FATTY ACIDS

Synthetic Fatty Acid Process Review

Within a relatively short period of time, a number of developments and new processes have subverted Mother Nature. Notably these include the advent of synthetic fibers as replacements for wool, cotton, and silk, and a similar situation between synthetic rubber and natural rubber. Each one of these has created economic and sociological change.

In our own industry we have witnessed the development of synthetic glycerine as a replacement for the natural product. The natural glycerine survival is due to favorable economics, since it is a by-product of fatty acid manufacture.

Unproven routes to commercial development are shown in Table VI. Within the last eight years we have examined a number of samples of synthetic fatty acids from foreign as well as domestic sources. Yet there are no commercially produced counterparts to the natural fatty acids in the U.S. marketplace today. It is interesting to note in the case of glycerine that both the natural and synthetic have survived. Does this foretell the fatty acid situation? A number of interesting routes to the synthetic fatty acids have come to our attention, but to date none has proved commercially successful in the U.S.

Companies as potential supplies: A number of companies in our country have offered synthetic fatty acids and after a period of time have withdrawn from the market place presumably due to unfavorable economics. These include Conoco, Gulf Oil, Ethyl, Shell, and Texaco. We will discuss Texaco later in our report.

Companies active in commercial development: Three companies currently active in the market development of synthetic fatty acids on a commercial scale are Liquichimica, Monsanto, and Emery.

Liquichimica has announced a 220 million lb plant (annual basis) slated for 1977. This plant process is described as oxidation of oxo aldehydes prepared from normal olefins (10% alpha); therefore, the main product stream is suspected to be heavily branched.

Monsanto is now market sampling a mixture of C_{11} to C_{13} synthetic fatty acids reported to contain 55% straight chain terminal carboxyls with the balance a mixture of 2-3-4 branch carboxyl groups. In addition, they are reported to be market testing 90% or better straight chain with terminal carboxyl. These synthetic fatty acids, we believe, correspond to some Monsanto patents covering the oxo approach by the addition of carbon monoxide and water to random olefins.

Emery Industries is sampling a synthetic fatty acid numbered 4117D which is a C_{29} plus, alpha branched acid. 4117D is reported to be a free radical addition of acids to olefins to make the high molecular weight branched product.

Prominent Commercial Processes – Synthetic Acids

We wish to comment briefly on the two processes for

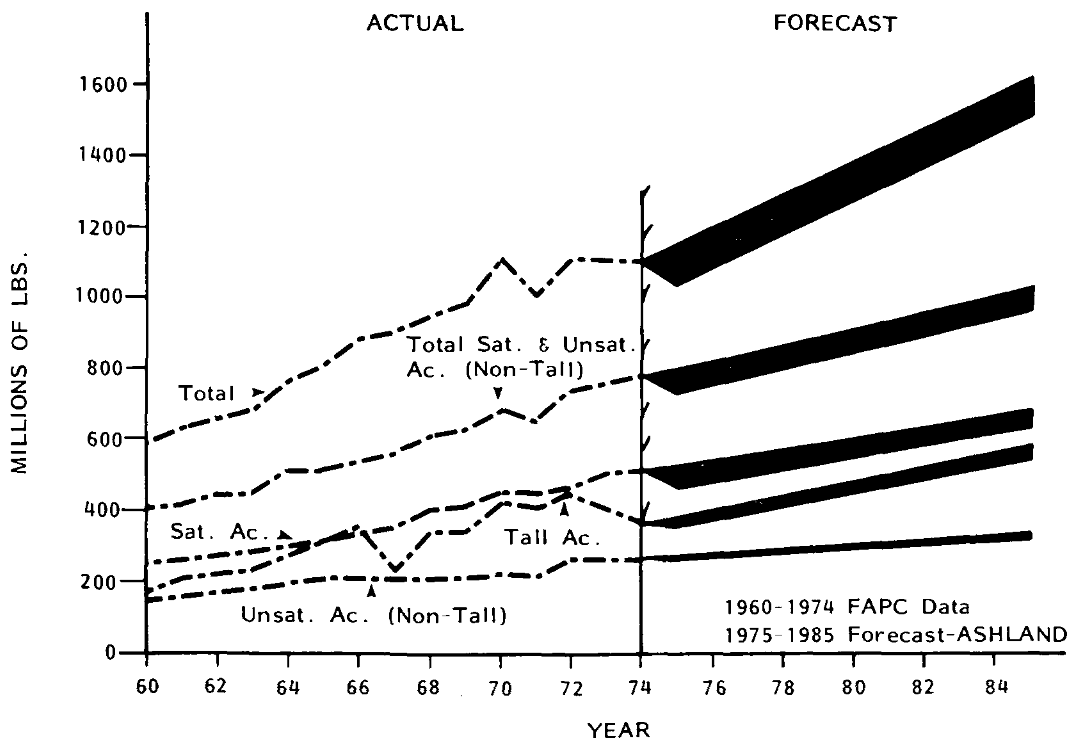

FIG. 2. Total disposition of fatty acids.

synthetic fatty acids which have been most widely used and discussed; i.e., the oxidation of the paraffins and the oxo process.

Oxidation of the paraffins: The Russians, using the oxidation of paraffins, manufacture over a billion pounds of synthetic fatty acids annually. In fact, the number of plants within the communist bloc is currently reported to be in the area of twenty. Oxidation of the paraffins is followed by saponification, separation of unsaponifiable, hydrolysis of the soap, and fractionation of the crude fatty acids to yield the final fatty acid products. A typical analysis of the acids reported from Russian production is shown in Table VII. Feedstock in this instance is n-paraffins, essentially C_{18} through C_{30}.

Oxo process: The oxo process is very important to the chemical industry providing us with a number of essential chemical products; i.e., aldehydes and short chain alcohols. Oxo chemistry begins with the addition of carbon monoxide and hydrogen to olefin feedstock. The source of olefin may vary; it can be from ethylene, from cracked paraffin, or from the dehydrogenation of n-paraffins. The olefin may be random or alpha and may range from ethylene to triacontene. The nature of the finished acid will depend on the nature of the feedstock; i.e., odd, even, or branching.

Oxo organic acids which are currently manufactured are outlined in Table VIII. Included are several naturally derived fatty acids such as capric/caprylic from the lauric oils, heptanoic from castor, and pelargonic from oleic. The market size for the short chain organic acids has been recently reported at 70-80 million lb annually.

The synthetic producer would now like to add the coconut oil range of fatty acids to the short chains already being marketed. Coconut oil used in fatty acid manufacture and in conventional soap in 1973 was some 276 million lb. Since synthetic fatty acids would potentially contain odd and even chains and branching, performance must be proven to capture the market.

Detergent range fatty acid comment: The natural fatty acid producer, particularly in 1973-1974 was faced with a dramatic increase in coconut oil price, actually exceeding $0.60/lb. This was a stimulus for the synthetic producer, but today's price is ca. $0.16/lb West Coast. In the period of 1952-1973 (some 22 yr) the average price of coconut oil was $0.145/lb, which is not an encouraging level for the synthetic producer. The synthetic fatty acid producer for the first time is faced with uncertain raw material costs for both ethylene and paraffin feedstock, which depend on petroleum economics.

Natural versus synthetic fatty acids – Texaco's process: Chem. Systems, Inc. reported some interesting background which we would like to share with you on Texaco's process for entry into the synthetic fatty acids. Ethylene was Texaco's choice of raw material for alpha olefins to be followed by carbonylation. The technology required to make synthetic fatty acids via the ethylene route is much more sophisticated than the process required to make them from natural fats and oils.

TABLE V

July 1975 Fatty Acid Processing Capacity[a]

	Million lbs
Fat splitting	1,687
Distillation	1,966
Separation	529
Hydrogenation	741

[a]FAPC Survey of Fatty Acid Capacity 1975 (July).

TABLE VI

Potential but Unproven Routes to Synthetic Fatty Acids

1. Oxo carboxylation of olefins
2. Oxidation of olefins and paraffins
3. Oxidation or carboxylation of ethylene growth intermediates
4. Oxidation of alcohols or aldehydes
5. Ozonation of olefins
6. Telomerization of ethylene with formic or acetic acids, esters, and amides
7. Telomerization of ethylene with chloroform
8. Telomerization of various dienes with acrylates
9. Olefins or Diolefins plus HCN to make nitriles for acid or amine conversion
10. Fermentation of paraffins

TABLE VII

Typical Analysis of Russian Synthetic Fatty Acids

Chain length	Weight %
C_5 - C_6	3
C_7 - C_9	10
C_{10}- C_{16}	40
C_{17} - C_{20}	25
C_{21} and up, including still residues	22

Plant investment required for synthetic fatty acids has been reported to be up to ten times greater than that for conventional hydrolysis of fats and oils. Plant write-off is a major problem. Base raw material costs for the long range will be deciding factor and will determine whether natural fatty acids or synthetic will win out in the marketplace.

Chem. Systems' analysis of the Texaco process in Figure 3 depicts the comparative economics of natural and synthetic fatty acids in a graphic form. Ethylene, coconut oil, and finished fatty acid values are compared. Note the effect of efficient catalyst recovery or its impact on process costs for the synthetic route.

If coconut oil remains at an average of $0.18/lb and the corresponding fatty acid transfer value is in the $0.21 to $0.22 range, ethylene with catalyst recovery of 99.9% must be priced at less than $0.05/lb to compete. Ethylene is reported now at the $0.10 level and may possibly reach

TABLE VIII

Short Chain Organic Acids Manufactured in the U.S.

Organic acid		Process	Major end uses
Valaric acids	C-5	Oxo	Synthetic lubricants
n-Caproic	C-6	Oxo	Synthetic lubricants
n-Heptanoic	C-7	Ex Castor	Synthetic lubricants
n-C_8 & C_{10}	C-8/C-10	Nat'l acids Via fractionation	Synthetic lubricants, plasticizers and peroxides
2-Ethyl hexanoic	C-8	Oxo	Driers-Stabilizers
Neo-Decanoic	C-10	Koch	Polymers, driers, stabilizers
Versatics	C-7/C-9 C-11	Koch	Driers and stabilizers
Pelargonic	NC-9	Ozonolysis	Synthetic lubricants, plasticizers and coatings

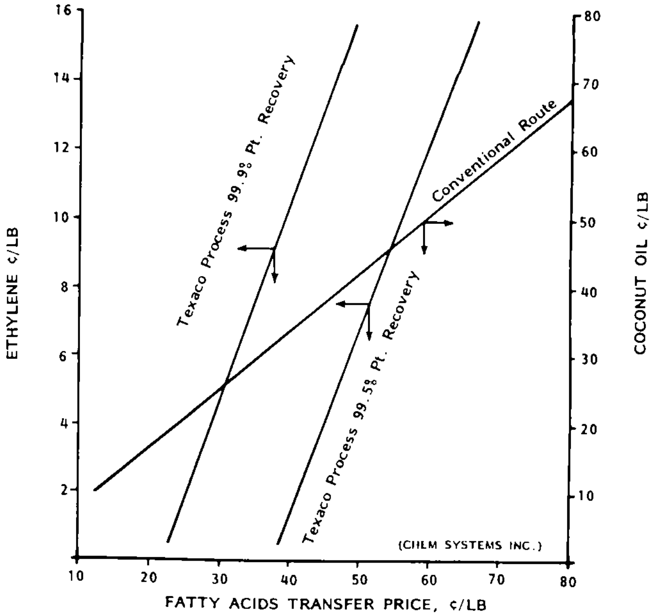

FIG. 3. Linear fatty acid production economics, Texaco process vs. conventional technology vis coconut oil.

higher levels within the near future. This virtually eliminates ethylene as a source for competitive detergent range fatty acids, unless future economics can be improved.

Comment: It remains to be seen if olefins from cracked paraffins can be economically converted to fatty acids via either the carbonylation or carboxylation route. Very little information is available on possible success of current research and development in this area. We do know that Shell has announced it is adding 1.5 billion lb of ethylene capacity at Deer Park, Texas, and 100 million lb of alpha olefins. Economics will be interesting. Current olefin sales price is in the low $0.20/lb range.

Within our forecast period it is expected that synthetic fatty acids will achieve some breakthrough due to the heavy investment in research. Likely some unique properties will emerge from certain synthetic fatty acids which will result in product sales outside an area currently served by natural fatty acids.

ACKNOWLEDGMENTS

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