Trends in Industrial Uses of Palm and Lauric Oils

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ABSTRACT

An attempt is being made to determine the importance of palm and lauric oil today and in the coming years of this decade whereby their industrial use in western Europe is considered outside the field of human and animal nutrition. The basic oleochemicals like fatty acids, fatty acid methyl esters, fatty alcohols and their most important derivatives are discussed as the essential products. Detergents are one of the most significant areas of application for basic oleochemicals and their derivatives. Changes in the application profiles of the final products are expected for the detergent industry in the coming years. These tendencies have been scrutinized with respect to their influence on future demand for palm and lauric oil. The competitiveness of natural oil-based oleochemicals versus ethylene- and paraffin-based synthetics is of great significance for the development of natural oils. It is attempted to elucidate the chances of natural oleochemicals in connection with petrochemical raw material developments.

INTRODUCTION

The industrial use of palm oil and lauric oils within the scope of this paper refers to their utilization outside the fields of human and animal nutrition, i.e., basically to their processing into oleochemical raw materials (fatty acids, fatty acid methyl esters, fatty alcohols) or into oleochemical derivatives in western Europe. Surfactants strongly determine the use of oils and fats (soaps), fatty acids, fatty acid methyl esters and fatty alcohols. Therefore, developments within trends in this category will be stressed in detail.

The name "lauric" is used when fatty acids, fatty acid methyl esters and fatty alcohols are discussed with regard to their origin from coconut oil and palm kernel oil. "Lauric range" refers to the C-chain range of the lauric oils and includes the comparable range of synthetic fatty alcohols. In the same way, "tallow/palm range" refers to the C-chain range of C_{16}-C_{18}.

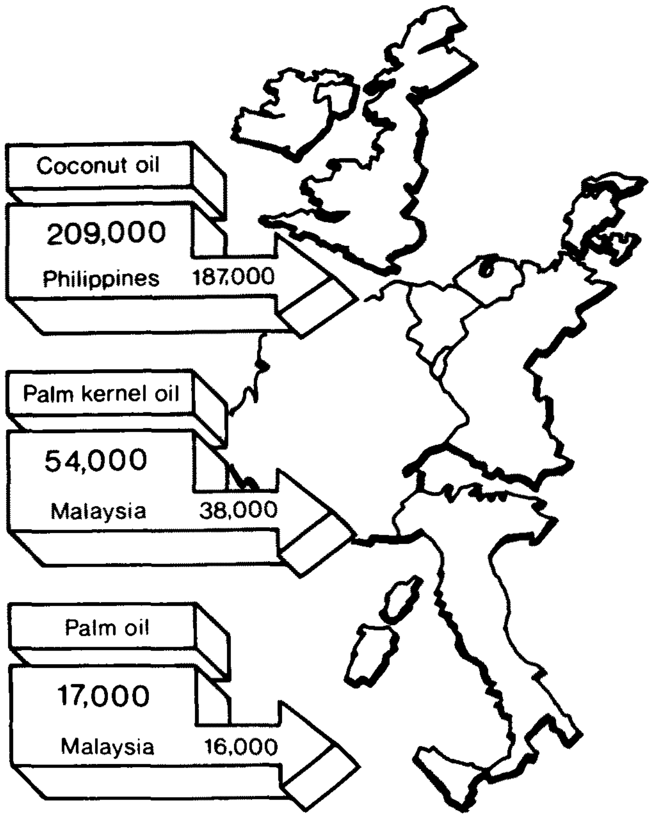

FIG. 1. Imports of lauric oil to European Economic Community nations for technical use during 1982.

IMPORTS OF LAURIC AND PALM OILS IN THE EUROPEAN COMMUNITY

280,000 t of these oils were imported in the EEC in 1982. Figure 1 depicts the amounts with respect to the most important exporting countries.

The proportions of oils used for technical processing are

Coconut oil	51%
Palm kernel oil	24%
Palm oil	<3%

(See Fig. 2.) Only direct imports are included in these figures. Possible resale of the oil mill industry to the chemical industry, e.g., the soap industry, is omitted.

The dominating position of the lauric oils in regard to their technical end use is reflected in the data for consumption, whereas palm oil only plays a minor role in the oleochemical industry. The 17,000 t of palm oil went equally into oleochemicals and for animal nutritive purposes. Besides palm oil, palm oil products such as fatty acid distillates, acid oils and above all palm stearin are imported. The latter is processed particularly for C_{16}-rich oleochemicals, for instance fatty acids and fatty alcohols.

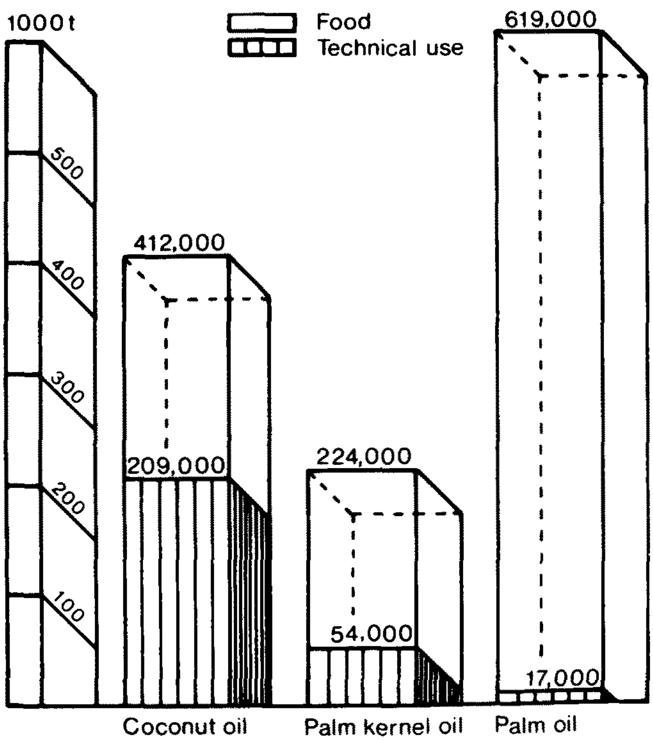

FIG. 2. Proportions of imported oils used for technical processing.

OLEOCHEMICALS IN WESTERN EUROPE

1,347,000 t of oleochemical raw materials were produced in western Europe in 1983 (Fig. 3). Glycerol is not considered here as it is not relevant to the assessment of the trends for the utilization of palm oil and lauric oils because it is a byproduct of these oils. Glycerol production figures

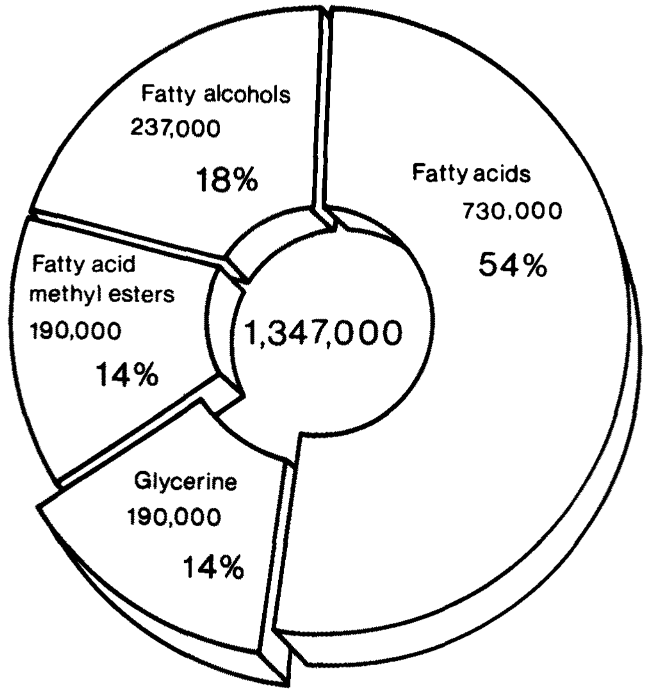

FIG. 3. Production of oleochemical raw materials in Western Europe during 1983.

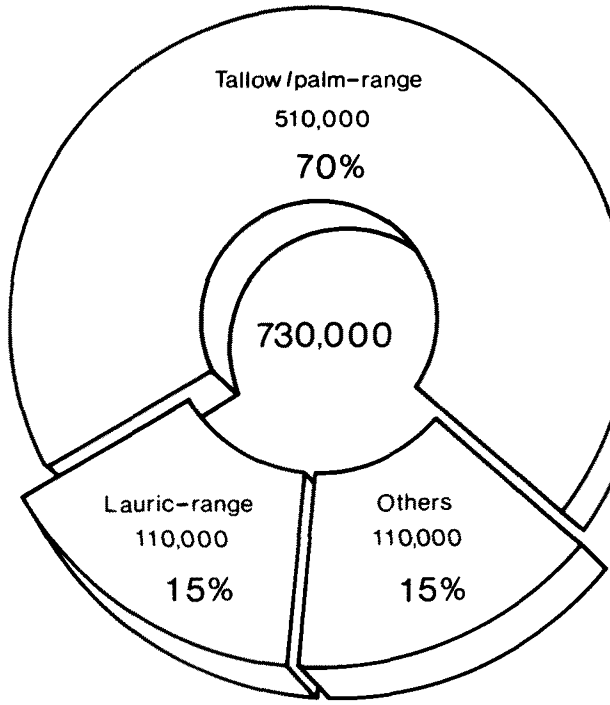

FIG. 5. Western European fatty acids, 1983.

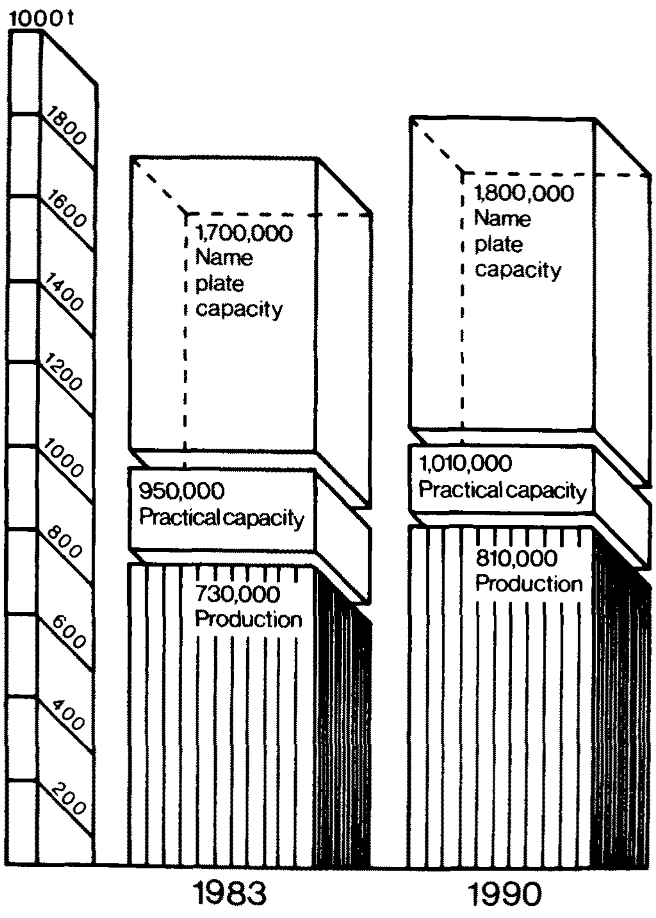

FIG. 4. Western European fatty acid capacities and production, 1983 to 1990. Difference between "name plate capacity" and "practical capacity": distillation performed more than once, operations not working continuously, a non-uniform product mix.

would be included in either case as a byproduct when shifts or competition of single oils are considered, e.g., "palm oil vs. tallow." The same is true when, for instance, glycerol-free or low glycerol palm/lauric derivatives would be imported into western Europe; the glycerol production would merely shift.

Fatty Acids

The production of fatty acids amounted to 730,000 t in western Europe in 1983. There is a very considerable overcapacity for fatty acids that will hardly be reduced before the end of the decade as a consequence of a slowly growing demand (plus 1-2% per year) (Fig. 4).

The individual C-chain ranges show the major share of 70% of long chains from the tallow range and only 15% of the lauric range (Fig. 5). The most important fields of application for lauric fatty acids are depicted in Figure 6.

An increased use of fatty acids of the lauric range is evident, for instance for fatty alcohols (obviously dependent on their ability to compete with synthetic alcohols) and amines, including quaternary ammonium compounds: the medium/short chain QAC may favorably find use for disinfecting agents, in particular. The share of lauric oils in amines is probably between 15 and 20%, at present. The classic areas of application for fatty acids such as metal soaps, auxiliaries for plastics (including lauroyl peroxide), amides and emulsifiers as auxiliaries for textile and leather manufacturing, are rather stagnant. Monoesters such as cosmetic oily components, reconstituted triglycerides such as suppository bases and so-called MCT-oils (medium chain triglycerides) for food additives, might still show possibilities for development.

The original very optimistically assessed application of short-chain fatty acids for polyol esters has not materialized. For instance, special lubricating oils that have been developed in the scope of energy conservation are still being produced in the conventional way, i.e., from mineral oils and not from esters (polyol esters, diesters).

For fatty acids, also those of the lauric range, there are applications aiming at the future: viz., specialty products for oilfield and mining chemicals (Fig. 7). On the other

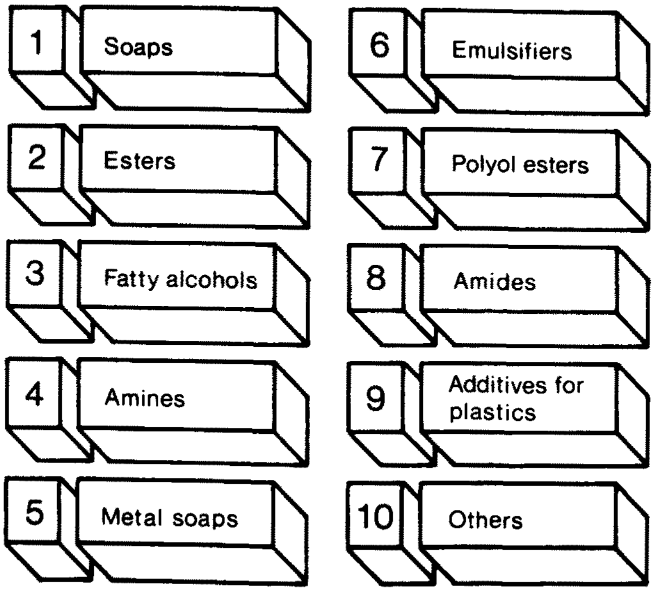

FIG. 6. The most important fields of application for lauric fatty acids in Western Europe.

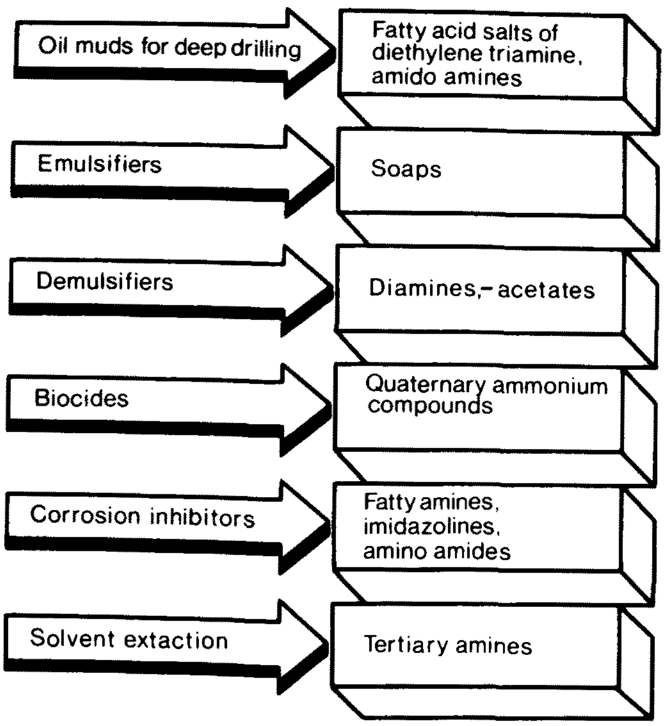

FIG. 7. Lauric acids for specialty products for oilfield and mining chemicals.

hand, auxiliaries for enhanced oil recovery (EOR) will not play an important role in western Europe in the near future. Otherwise, besides fatty alcohol sulfates and fatty alcohol ether sulfates, ethoxylated fatty acids (oleic acid) and soaps are mentioned as auxiliaries for EOR.

An interesting application is the solvent extraction, for instance of uranium ores with short-chain tertiary amines or QAC.

There are no signs that the use of fatty acids for soaps will increase. The major part of the soap production in western Europe will still be done directly from oils and fats. Palm oil fatty acids would certainly be a good alternative to tallow fatty acids as long as favorable cost conditions prevail. This would be the case in particular when tallow fatty acid is not produced on the site of the soap production.

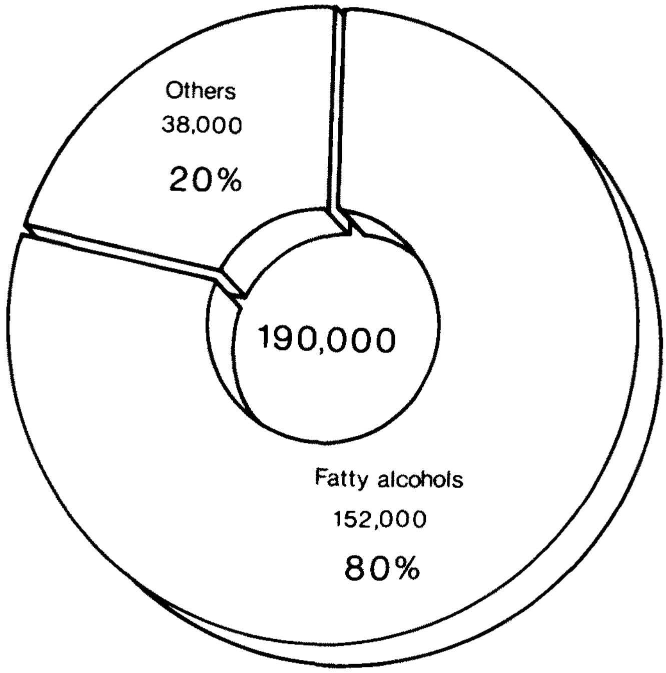

FIG. 8. Fields of application of fatty acid methyl esters in Western Europe during 1983.

Palm oil fatty acid could then offer advantages with regard to odor stability, though the lauric fatty acids in soaps are likely to show an advantageous development because the consumers' attention is – by the increased use of syndets – more and more drawn to higher foam and insensitivity against lime soaps. Fatty acids from palm kernel oil would certainly have preference over coco fatty acids in that the proportions of low cut fractions are smaller if the complete C-chain range is processed.

The use of soaps in western Europe has shown an overall decreasing tendency in the last ten years. This has been basically attributable to household soaps (1972 = 840,000 tons, 1982 = 776,000 tons). Toilet soaps have had a positive development: 1972 = 306,000 tons, 1982 = 364,000 tons.

It is to be assumed that this overall negative development will continue. Also in the classical "soap countries" of southern Europe, syndets in the form of cleaning agents for home care and shower/bath products or liquid soaps for body cleansing will increasingly replace the classic soap.

Fatty Acid Methyl Esters

Approximately 80% of the fatty acid methyl esters in western Europe are used for the production of fatty alcohols (Fig. 8). Although fatty acid methyl esters have several advantages in comparison with fatty acids, they have only been able to replace fatty acids in a limited way. The methyl esters have better storage stability, better fractionability due to their lower boiling points, lower energy costs in their production in comparison to fat splitting and are less corrosive. On the other hand, they require higher investments in comparison to fatty acid production.

Fatty acid methyl esters for fatty alcohols will show a development like the fatty alcohols, i.e., they will show a growth of 2-3% until 1990. A strong shift in the direction of laurics is expected. Particularly, palm kernel methyl esters would develop favorably when a price difference with coconut oil will continue to exist.

A substantial field of application is the production of fatty acid alkanolamides (super amides) from fatty acid methyl esters (Fig. 9). The overall sales of fatty acid

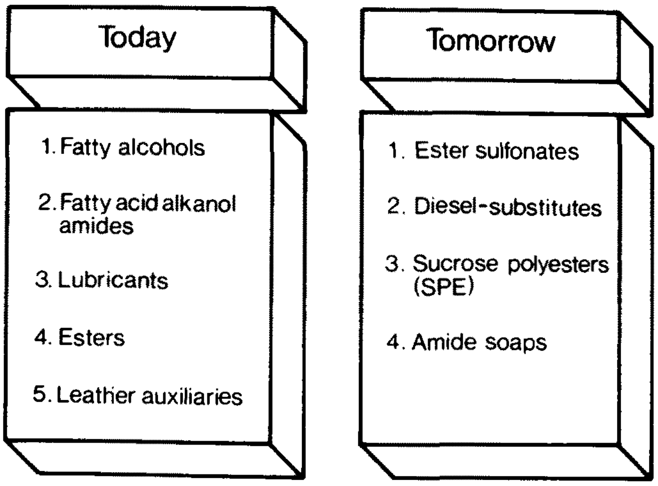

FIG. 9. Fields of application of fatty acid methyl esters in Western Europe currently and in the future.

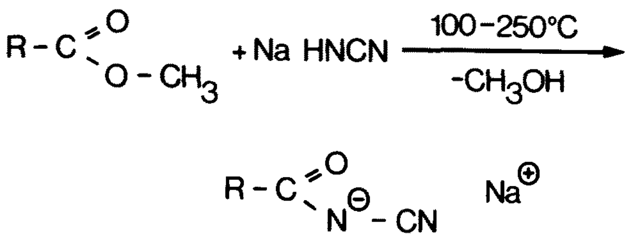

FIG. 10. Fatty acid cyanamides (amide soaps).

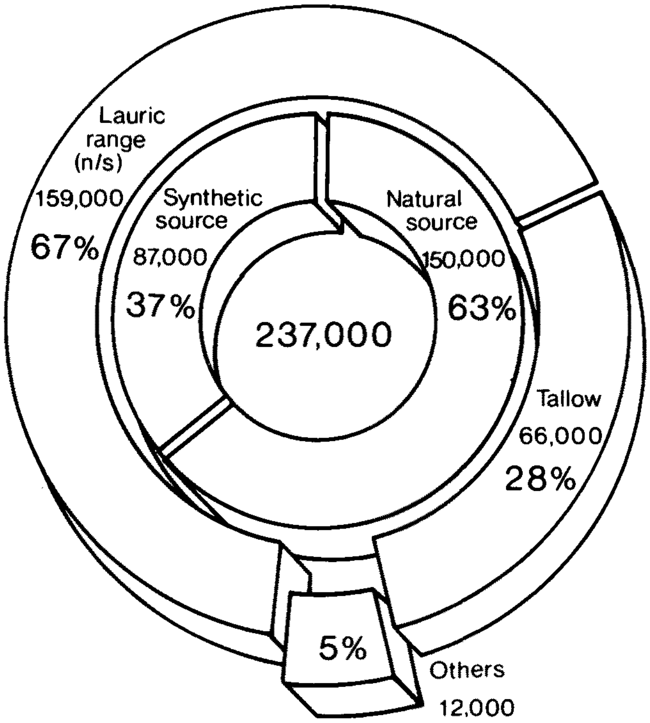

FIG. 11. Sources and types of Western European fatty alcohol production in 1983.

alkanolamides do, however, not show any growth. With a strong price pressure on the final products (shampoos, foam baths, light-duty liquids), the users are no longer willing to pay additional costs for additives, the more so as many an effect can be attained in substantially easier ways, e.g., increase of viscosity in alcohol ether sulfate-based shampoos and foam baths by using sodium chloride. A tendency to produce fatty alkanolamides directly from neutral oils is surely evident. The remaining glycerol does not interfere. On the contrary, it acts as a desired liquifier in the fatty acid alkanolamide.

The higher lauric prices have also led to the fact that other oils such as soybean oil are increasingly used as basic raw materials. However, lauric-based fatty acid alkanolamides will hold the greatest market share also in the future.

The other fields of application of methyl esters offer only moderate possibilities for growth from today's point of view. For instance, isopropyl myristate, produced with interchange technology from methyl ester, still holds a strong position in formulations for cosmetics. However, there are numerous other oily components as substitutes for isopropyl myristate.

The strongest possibilities for development of methyl esters can be seen in their processing into ester sulfonates. Tallow and palm oil or palm stearin are equally offered as raw materials. For the quality of α-sulfo fatty esters it is extraordinarily important to use pretreated special methyl esters in order to obtain lightly colored α-sulfo fatty esters.

Methyl esters as diesel substitutes do not play a role in western Europe due to the continuous oil glut. Methyl esters from vegetable oils could only gain importance in vegetable oil-producing countries and countries without crude oil, only when experiencing shortages and price increases for crude oil. There are still tests being conducted in western Europe, for instance in the automobile industry, but these receive low priority.

Sucrose polyesters (SPE) as low-caloric fat substitutes and cholesterol reducers are said to have an interesting future because of the excessive consumption of fat, particularly cholesterol containing fats. A considerable obstruction on the road to this development in western Europe will be the regulatory approval for nutriments. Attempts in this way are already further advanced in the USA; however, an official permit for their use in foods has not yet been given.

Amide soaps (fatty acid cyanamides) (Fig. 10) could become an interesting surfactant if an acceptable manufacturing process was developed. In particular, the availability of suitable sodium cyanamide would have to be resolved. Quite acceptable results have been obtained with amide soaps of the chain lengths C_{12}-C_{14}, C_{12}-C_{18} and C_{16}-C_{18} in detergency performance. The good lime soap dispersion power and the antiredeposition properties are striking. The C_{12}-C_{14} amide soaps indicate excellent cleaning performance in liquid all-purpose cleaners.

Fatty Alcohols

237,000 t of fatty alcohols were produced in western Europe in 1983. The lauric range, natural and synthetic, has a two-thirds share of the production (Fig. 11). The moderate growth of the fatty alcohols, 2% until approximately 1986, 3% from 1987 on, will reduce the overcapacities not before the beginning of the 1990s (Fig. 12). Substantial new fields of application for fatty alcohols are not in sight. Traditional applications are in the fields of surfactants that make up 75% of the use of fatty alcohols (Fig. 13). The product profile of detergents such as heavy-duty powders, heavy-duty liquids and light-duty liquids, also that of fabric softeners, as well as of cosmetic syndets (shampoos, foam baths, liquid soaps), and their sales will thus substantially determine the development of fatty alcohols in the future.

Substantial amounts of fatty alcohols are ethoxylated to nonionics and used as emulsifiers and as surfactants for detergents, or they are sulfated to obtain fatty alcohol ether sulfates. The use of fatty alcohol sulfates for the area of personal care has strongly decreased and is very limited to the field of mouth care and technical applications such

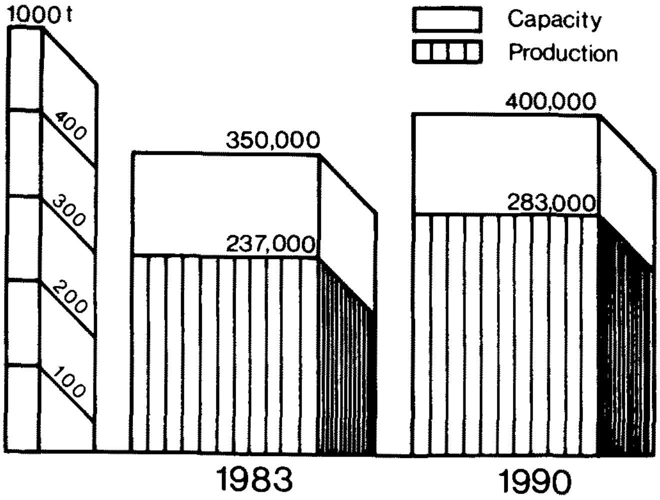

FIG. 12. Western European fatty alcohol capacity and production, 1983 to 1990.

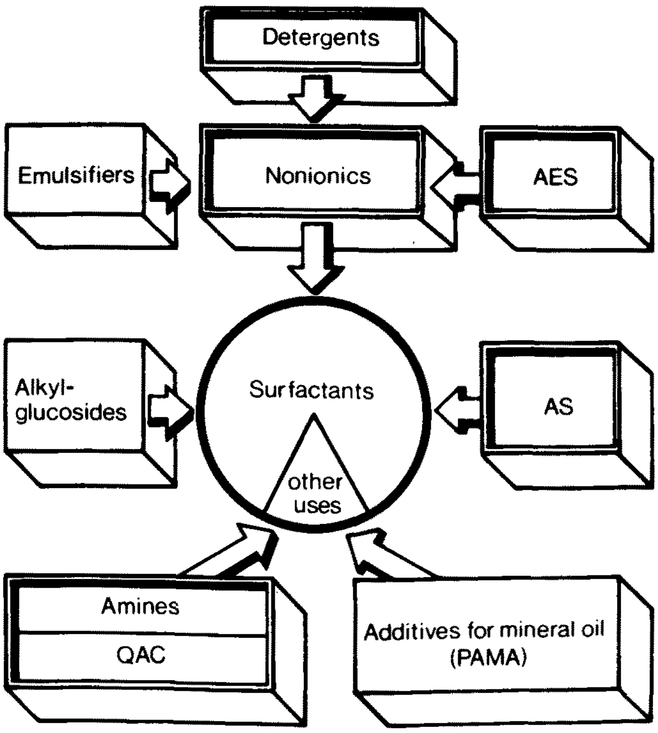

FIG. 13. Main fatty alcohol outlets in Western Europe.

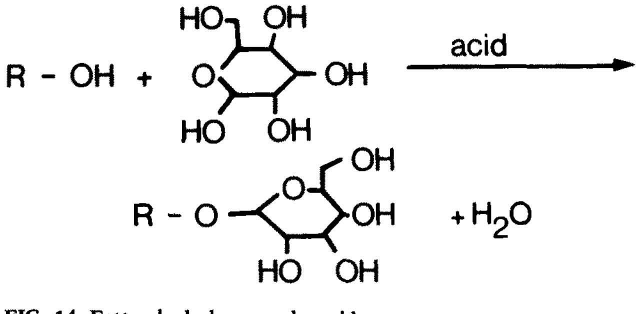

FIG. 14. Fatty alcohol mono glucoside.

as emulsion polymerization and auxiliaries for the textile industry. Only a 3% increase is expected in western Europe for personal-care products such as shampoos and foam baths, which will result in an increased use of fatty alcohol ether sulfates.

There are few starting points for new surfactants from fatty alcohols. However, an example of a new surfactant should be mentioned: alkyl glucosides (Fig. 14) which are built from natural starting materials. They are comparable to nonionics, for instance, C_{12}-C_{14} + 5 EO. The detergency performance is quite advantageous. Further investigations, in particular those involving antiredeposition properties, are yet to be carried out. Short-chain alkyl glucosides ($< C_{12}$) are usable solubilizers. The biodegradation behavior of alkyl glucosides is favorable. They have low aquatic toxicity.

In other fields of application, fatty alcohols have different prospects: in the area of lube oil additives, polyalkylmethacrylates show decreasing importance caused by, for instance, olefin copolymers. Also, fatty alcohols from lauric oils have to attain again their competitiveness with synthetic fatty alcohols in this field.

As far as amines are concerned, long chain products prevail when they are produced via fatty alcohols, particularly when they are converted to QAC, e.g., of the DSDMAC type. Tallow as a basis would be preferable with respect to its high proportion of long chain compounds, responsible for the softening effect. Amines (including amines via nitriles) are expected to increase at approximately 4% per year.

This paper deals with the substitution of petrochemical surfactants by naturally based surfactants. However, there has been recently an opposite development: the soaring coconut oil prices of the years 1983/1984 made fatty alcohols lose market shares and stimulated the development of synthetic fatty alcohols. In contrast the application profiles of nonionics for heavy-duty powders and heavy-duty liquids changed in that the medium-chain fatty alcohols with a branched alkyl chain were favored rather than retarded due to solubility. The trend toward synthetics indicates a substantial danger for the lauric oil-producing countries and, of course, also for the manufacturers of natural fatty alcohols, to lose volumes and markets.

SURFACTANTS

Influences on Detergents in Western Europe

Nonionics have a particular influence on heavy-duty laundry detergents (Fig. 15). Nonylphenol ethoxylates (NPE) are still used on a regional basis. At present they are being criticized. Possible substitutes could be fatty alcohol ethoxylates that can replace NPE in heavy-duty detergents without problems (more problematic would be their substitution in numerous other fields of application, for example, in institutional/industrial products such as cleansers). The tendency to use lower washing temperatures, the share of synthetic fibers in domestic laundry, and the introduction of heavy-duty liquid detergents have led to a higher share of nonionics and to a change of their application profiles: shorter alkyl chains and a corresponding lower degree of ethoxylation: C_{12}-C_{15} + 7 EO instead of C_{16}-C_{18} + 11/14/18/EO. The content of nonionics in the formulations has generally increased, though not to an extent as was originally expected. The use of nonionics in heavy-duty laundry detergents is not equally pronounced in western Europe. Depending on the detergent manufacturer its proportion lies between 3 and 8% in formulations. It depends, for instance, whether or not the better removal of fatty/oily soil will be stressed for a particular detergent.

In low phosphate or P-free formulations the content of

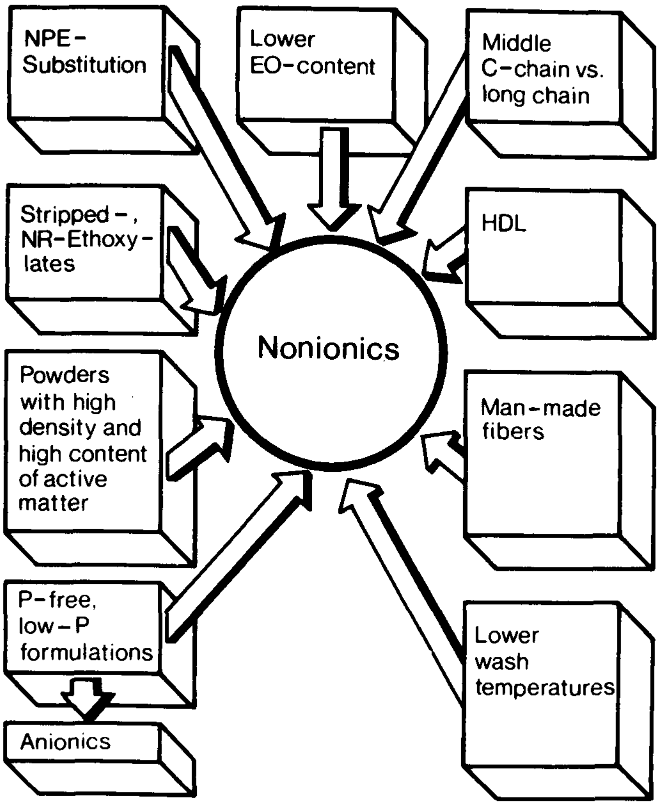

FIG. 15. Nonionics have a particular influence on heavy duty laundry detergents in Western Europe.

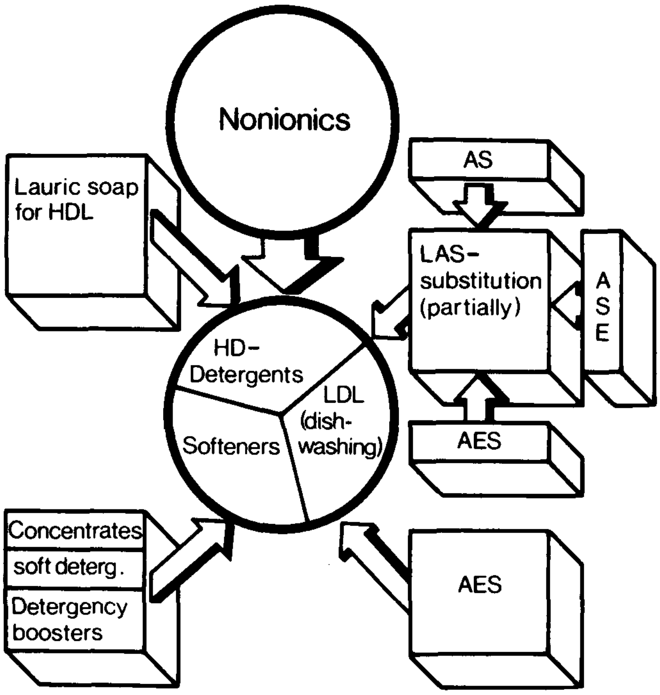

FIG. 16. Western European influences on detergents and softeners.

surfactants altogether would be higher, but not necessarily in favor of nonionics. Also the anionic component (LAS, tallow alcohol sulfate) will contribute to the decreased dispersion power of particulate soil due to the smaller or non-existing content of phosphate.

The interest in condensed powders, for instance with bulk-densities of from 500 to 600 g/l, is increasing. Also, medium and highly concentrated powders with bulk density up to 700 g/l are being tested, following a development in the USA. Should this trend continue, nonionics would profit from it. For example, concentrated heavy-duty powders contain approximately 20% nonionics of the medium C-chain range. In moderately concentrated powders, tallow alcohol sulfate can be used as well.

By the increased use of nonionics the specific utilization properties of this class of products are extended: *stripped* or *narrow range ethoxylates (NRE)* improve the properties (e.g., odor, low pluming, etc.). Basically, the lauric-derived ethoxylates are quite favored by these developments as long as they are competitive with synthetic fatty alcohol ethoxylates.

A new field of application (Fig. 16) for lauric fatty acids are *soaps* for heavy-duty liquid detergents. Their development in western Europe is still slow. It is not expected, in the near future, that they will reach market shares near to those of this detergent category in the USA.

For the substitution of LAS in heavy-duty detergents mainly the following raw materials are available:

- Long-chain fatty alcohol sulfates, e.g., based on tallow (or palm oil, too?);
- Long-chain α-sulfo fatty acid esters, e.g., based on tallow or palm oil;
- Long-chain fatty alcohol ether sulfates, e.g., based on tallow.

There would be a great interest in using fatty alcohol ether sulfate of the chain length C_{12}-C_{14} at an increased extent in light-duty liquids when its price is justifiable. Its superior cleaning action in synergistic mixtures, its excellent skin compatibility, and the optimal biodegradability would be appreciated. An increase of the use of fatty alcohol ether sulfates is expected, should the prices of lauric oil attain again their previous normal levels.

The market for raw materials for fabric softeners and of softeners themselves has started to move: higher concentrated softeners have found acceptance in the market. This is not only attributable to a substitution of already existing products but has brought additional sales. Whereas double and triple concentrates can still be formulated in a "classical" way with DSDMAC, plus emulsifier (e.g., ethoxylated amine), imidazolinium compounds have to be used for decuple concentrates.

The market for so-called "soft detergents", i.e., laundry detergents with incorporated fabric softener, is still too young to be judged. There are several ways to formulate soft detergents. Oleochemicals would be favored by this development when, for instance, purely nonionic powders plus cationic would be used as a basis or, for instance, tertiary amines (tallow, coco-chain length) combined with anionics. Likewise, laundry boosters in the form of water-insoluble substrates that are impregnated with QAC of the type dodecyl-/tetradecyl trimethyl ammonium bromide are still being introduced to the market.

Ester Sulfonates and Alcohol Sulfates as LAS Substitutes and Surfactants for Cosmetic and Technical Applications

In high-foaming detergents for washing by hand or detergents for top-loading washing machines that play a part outside western Europe (Asia, South America, Africa), ester sulfonates of the lauric range would be able to substitute LAS by one third (however, fatty alcohol sulfate of the lauric range would have an even better foaming power). This could be of particular importance to those countries that produce lauric oils but have to import alkylbenzene (Fig. 17). The foaming power is dependent on the water hardness and the concentration, more or less comparable

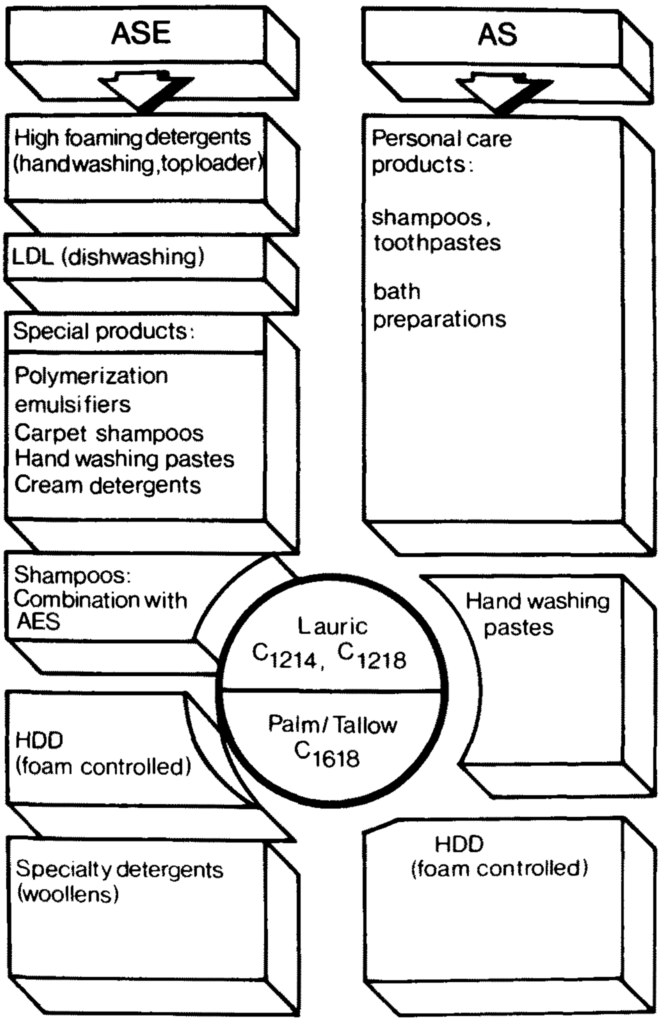

FIG. 17. ASE and AS as LAS-substitutes and surfactants for cosmetics and technical application.

with LAS. It is an open question to what extent lauric ester sulfonates will be price competitive.

In light-duty liquids only a few percent of LAS could be substituted by lauric ester sulfonates. They do not bring synergisms like fatty alcohol ether sulfates, secondary alkane sulfonates or α-olefin sulfonates. This is also true for household cleaners.

Medium- and long-chain ester sulfonates have been investigated also with regard to other fields of application outside laundry detergents and dishwashing and cleaning agents, e.g., as polymerization emulsifiers for the manufacture of PVC, where fatty acid ester sulfonates give increased thermal stability, a generally improved stabilization of the PVC (independent of the type of stabilizer) and better gelation properties for the manufacture of PVC plastisols. In ethyl acrylate/acrylic acid copolymers, fatty acid ester sulfonates attain nearly the fine dispersion of lauryl alcohol sulfate.

In shampoos, fatty alcohol ether sulfates can be substituted by lauric ester sulfonates by one third. The decrease of viscosity and the transparency can be compensated by fatty acid alkanolamides. Tallow/palmester sulfonates are generally to be considered as surfactants with good hard-water detergency performance, with sufficient biodegradability, good foam control and excellent detergency performance in heavy-duty powders. A slightly lower detergency performance with respect to polyester fibers can be compensated for in formulated products without problems, e.g., by nonionics.

Particularly in foam controlled heavy-duty powders, LAS can be substituted by long-chain α-sulfo fatty acid esters to a proportion of up to 50% when conventional foam depressors are used, for instance, long chain soaps. Palm/tallow ester sulfonates can be characterized as "foam-proof". There is some progress in obtaining a paste concentration higher than 30%: the paste concentration can almost be offered at a level of active matter equal to LAS.

Tallow range α-sulfo fatty acid esters show a good detergency performance on *wool* and, hence, would be an alternative for *specialty detergents.* α-sulfo fatty acid esters based on palm oil or tallow are excellently biodegraded. Tests to detect stable metabolites showed that the biodegradation takes place without any residue. It remains to be investigated whether the good detergency performance of the pure ester sulfonates in the presence of electrolytes will bring advantages in formulated products, for instance with respect to their performance in phosphate-free systems.

Lauryl alcohol sulfates have been established in personal-care products of all kinds for many decades. Details with respect to their excellent performance need no longer be discussed. Combinations of lauryl and tallow range alcohol sulfates are used as active material for hand-washing pastes in western Europe.

In foam-controlled heavy-duty detergents up to 50% of LAS can be substituted by tallow alcohol sulfates. The foam depressing agent has yet to be adapted to this system. Tallow range alcohol sulfates show synergistic effects in combination with LAS.

INFLUENCES ON PALM OIL AND LAURIC OIL

Compared to the nonedible tallow, palm oil will always demand a premium because of its prevailing use for nutritive purposes in the shade of nutritive oils like soybean oil. This becomes evident when prices for both raw materials are considered over a longer period. (Figs. 18,19).

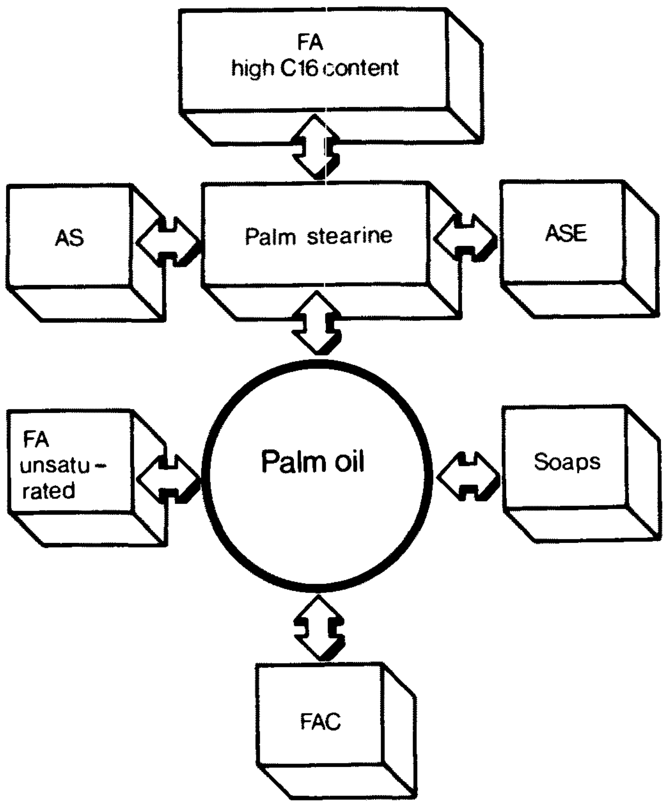

FIG. 18. Palm oil: Influences and outlets.

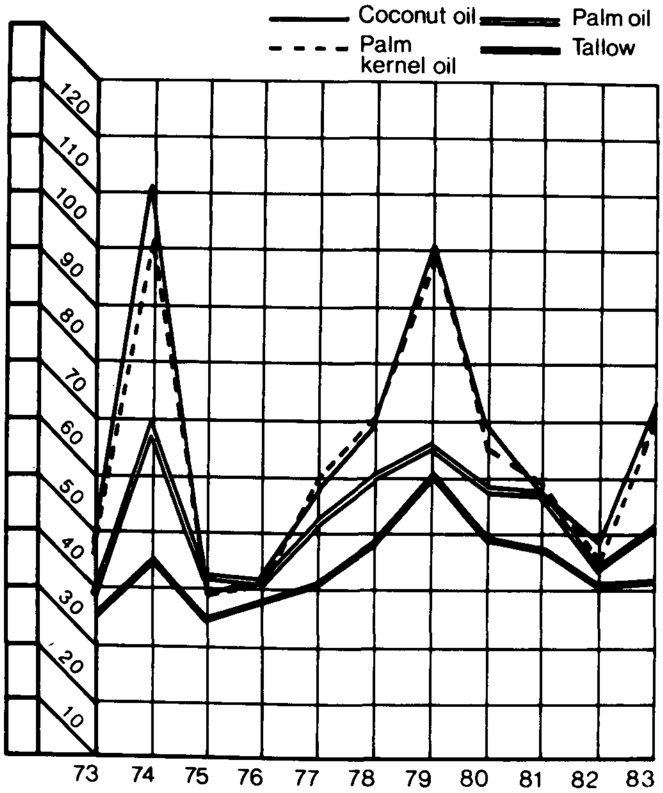

FIG. 19. Price development of natural oils, CIF Rotterdam.

Before the interest in palm oil for oleochemicals will become greater, a narrowing of the prices would have to take place first by a continuous price increase of tallow: for example, when the volume of tallow as a byproduct of red-meat production would markedly decrease. Although the production of tallow shows only moderate growth (approximately 2% per year), its availability is assumed to be sufficient. The production of palm oil has very much increased, as has its use for nutritive purposes.

Palm oil could be used as raw material for unsaturated fatty alcohols. For instance, partially unsaturated fatty alcohols with a medium iodine value could be produced from palm oil fatty acid methyl ester with special catalysts. It remains to be tested whether ethoxylates of such partially unsaturated palm oil fatty alcohols bring advantages with respect to odor and better solubility in comparison with alcohol ethoxylates based on unsaturated fatty alcohols from tallow. Ethoxylates of such partially unsaturated fatty alcohols are excellent detergent raw materials, for instance as nonionic component in heavy-duty detergents. They indicate partially better detergency performance in the 60 C wash cycle than ethoxylated oxoalcohols with a shorter C-chain such as, for example, $C_{1212/1415}$. The consumer will, however, accept such unsaturated ethoxylates only when their prices are comparable with tallow-based alcohol ethoxylates. Additionally, these ethoxylates based on natural alcohols are in an extremely hard competition with the comparable alcohol ethoxylates based on synthetic fatty alcohols, e.g., oxo-alcohols.

Palm oil-based unsaturated fatty alcohols with higher iodine values (IV $>$ 95), however, are problematic because the processing industry attaches great importance to a most possible high proportion of oleyl alcohol that is higher due to the basic raw material tallow. The proportion of linoleyl alcohol due to the presence of linoleic acid in palm oil is mostly undesired because of its higher instability to oxidation. Saturated palm oil fatty alcohols are of interest because of their high content of cetyl alcohol. In addition, they do not contain C_{17}-fractions like tallow and are easier to produce.

Fatty acids from palm oil, e.g., palm oleic acid, did not find the acceptance as expected. Most consumers, as for instance the textile industry, were too much oriented towards the application profile of tallow oleic acid. A higher content of linoleic acid and the content of palmitoleic acid have not always been desirable, although the product has advantages with respect to odor and color. This could be interesting, otherwise, for certain cosmetic esters such as oleyl oleate.

Palm stearin, or the palm stearic acid methyl ester which is preferred from a viewpoint of import, would have substantial better possibilities for development in the future than palm oil as long as the price is competitive with tallow. Of course, the price advantage must not be outbalanced by import duties. With increasing demand of cetyl alcohol for cosmetic purposes, palm stearin is a good basic raw material for fatty alcohols. This basis would also be interesting for use in cosmetics with respect to its odor unless coconut oil heavy ends, i.e., another product of vegetable origin as well, are used for this purpose.

It also depends on the structure of the oleochemical plant whether processing of palm stearin on a larger scale is possible. When the production is oriented to a separation of tallow fatty acid by wetting agent techniques, for instance, only limited amounts of palm stearin could be fed into the product flow because otherwise the basis for the production of the olein would fail.

Palm stearin would also be a very good basic raw material for ester sulfonates. Tests with various methyl esters showed that methyl esters with a C-chain distribution of C_{16}-C_{18} = 1:1 behave comparable to the tallow cut with the relation C_{16}:C_{18} = 1:2. Apart from this, it would lead to a higher yield of oleic acid when there would be an

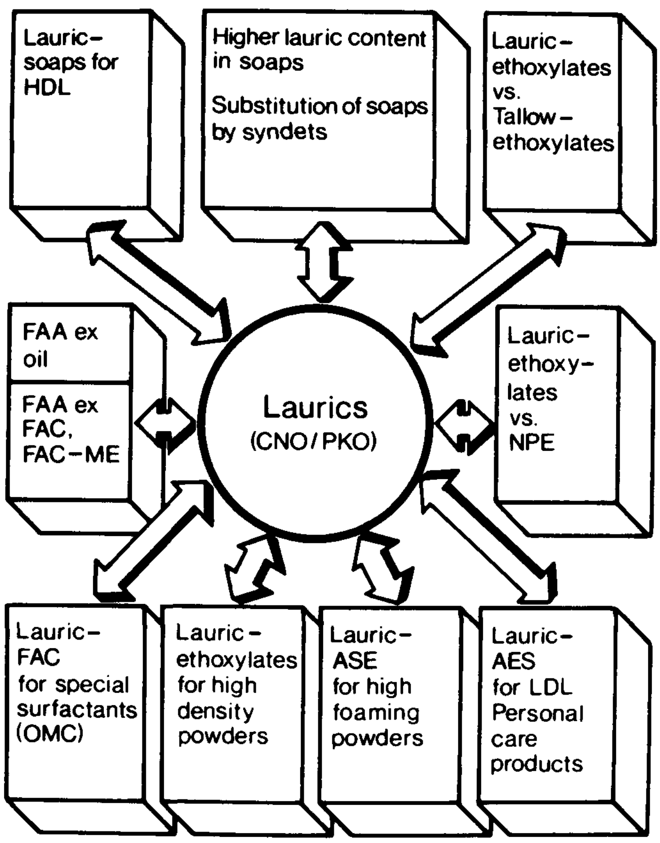

FIG. 20. Laurics: Influences and outlets.

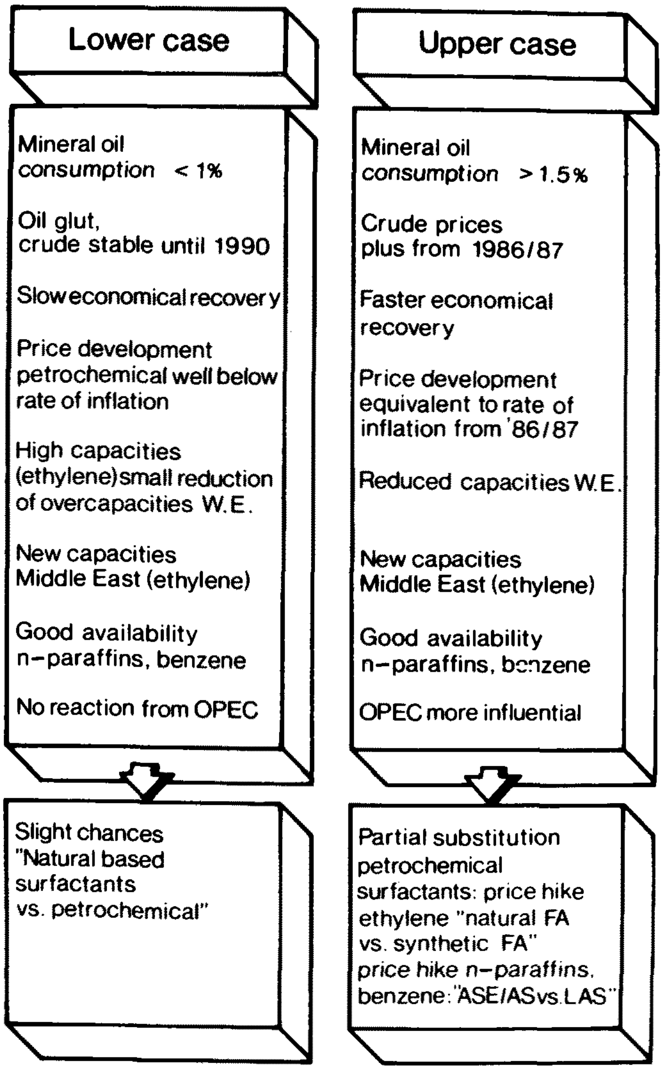

FIG. 21. Crude oil/petrochemical scenarios.

increased demand of C_{16}-18 methyl esters for ester sulfonates and with a coupling of C_{16}-C_{18} fatty acid production with the recovery of oleic acid ex tallow. Palm stearin methyl ester would be a good alternative to tallow assuming that the price is competitive. It also remains to be investigated whether fatty alcohol sulfates ex palm stearin in comparison to tallow alcohol sulfate would offer advantages in application (paste viscosity, solubility) for heavy-duty powders or hand-washing pastes because of its shorter chain.

A light tendency to C_{16}-rich stearin is seen with regard to certain applications, for instance, for metallic soaps. Due to the higher acid value more metal can be incorporated. (Fig. 20).

Laurics directionally, show a *good* development over the whole spectrum of oleochemicals. This assessment is based on the assumption that lauric oils will move again on a reasonable price level for a longer period and that the competitiveness of lauric-dependent fatty alcohols is not adversely affected by synthetic fatty alcohols.

The increasing production of palm oil with a corresponding growth of palm kernel oil and the additionally observed increase of the number of palm kernels as a consequence of the weevil effect improves the highly accepted availability of palm kernel oil as an alternative to coconut oil. However, for the derivative manufacturing industry there has also to be a price incentive in comparison to coconut oil, because the low content of light ends and the higher content of C_{18} are not optimal for production of fatty alcohols. A higher proportion, for instance, of stearyl alcohol is a burden because there are not sufficient marketing possibilities for stearyl alcohol. Low cuts are no more seen as undesirable co-products by derivative producing plants but as the basis for derivatives (polyol esters, monoesters, short-chain QAC).

THE SUBSTITUTION

Surfactants are the "flywheel" for oleochemicals such as fatty alcohols, fatty acids and fatty acid methyl esters. However, surfactants are also produced to a considerable extent from petrochemical raw materials. Surfactant number one is still LAS. The future demand for surfactants will not take a linear course. It is characterized by numerous interdependences. One of the most decisive factors is the "cost/performance ratio". It is excellent with respect to LAS.

Whether this will continue will depend on the price development of the feedstocks. Will petrochemical products increase in price in the future and when? Do natural feedstocks such as tallow, palm, coconut oil and palm kernel oil continue to be worth their money as they have been in the past (except for this year)?

As a general principle, raw materials that are replenished by nature are a reasonable solution with respect to securing raw material sources on a long term; for a given situation, however, it is also a question of the moment. For instance, many procedures to recover crude oil under difficult, i.e., expensive conditions have been pushed into the background or are no more pursued with equal intensity. This is a consequence of today's oil glut. This also is a question of the moment.

It may be assumed that the historic price development of the most important oils and fats for oleochemicals will also be valid for the future. A very moderate price increase is expected that will clearly stay below the inflation rate. Unfortunately, periods with soaring prices will keep being exceptions to this viewpoint.

With respect to the question of the development of petrochemical feedstocks two scenarios may be possible (Fig. 21):

1. Prices for crude oil and its derivatives will remain stable until the end of the decade, with good availability.
2. The other assumption is an increased use of petrochemicals from 1986/1987 on, which could lead to price increase equal to that of the inflation rate. In a certain way the consumers' shortcomings in learning would come to light here: with a regenerating world economy the consumption increases and measures taken formerly with respect to energy savings are not regarded anymore that serious. An example of this is the trend to faster and bigger automobiles.

Extreme changes should be excluded since they cannot be projected. Scenario two could mean a gradual long-term substitution of petrochemical surfactants. The fact that changed application profiles of detergents have a strong influence, is indicated by the shift of surfactants in the USA where the total volume of alcohol-based surfactants was bigger than LAS in 1982.

It is anticipated that a series of complicating conditions from other areas could oppose the above-mentioned substitution. Some of these are: sluggishness of the systems such as internal logistics; considerable capacities of LAB/LAS; an understandable resistance of the user to change formulations with a "cost/performance" relation, which is at the

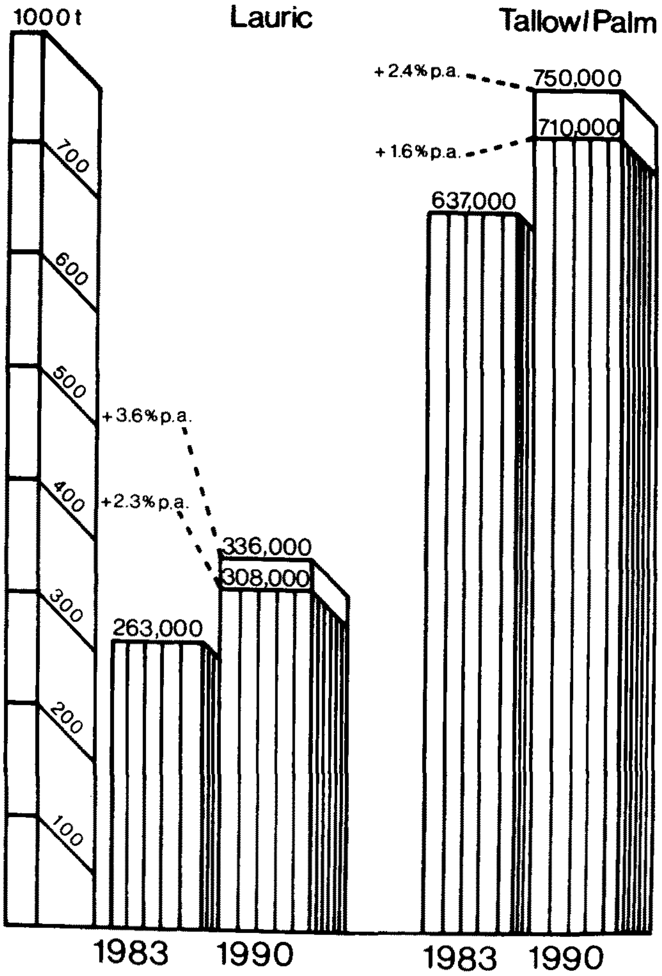

FIG. 22. Development of lauric oils and tallow/palm oil in Western Europe until 1990.

borderline of a clear superiority of the alternate surfactants.

From the standpoint of ecology there will be no influence that would force a substitution of LAS. This surfactant is sufficiently biodegradable even when the formation of persistent metabolites or components cannot be excluded.

What could a partial substitution of LAB in western Europe mean? If:

- Petrochemical prices increase from 1986/1987 on,
- Natural feedstocks stay competitive, particularly lauric oils,
- The application profile of detergents develops as mentioned,

a substitution in the order of magnitude of approximately 25% can be imagined for heavy-duty detergent powders. A large substitution of LAS, for instance in light-duty dishwashing liquids, for example, by fatty alcohol ether sulfates is not taken into consideration because this would only be conceivable under very favorable assumptions for fatty alcohols, which will occur partially. A substitution of other uses of LAS has not been considered because the substitutes mentioned have been optimized in heavy-duty detergent formulations only. In addition, the substitution of nonylphenol ethoxylates in heavy-duty detergent powders and a slight substitution of synthetic fatty alcohols of the lauric range has been assumed. Figure 22 shows in comparison, what effects these assumptions would have on the possible demand for raw materials (fats and oils).

Lauric oils

One possibility is the assumption of a moderate development, i.e., with a 2% growth for fatty acids, 3% for methyl esters for fatty alcohols, a stagnant development of methyl esters for other purposes. With this conventional assumption the raw material demand would change by approximately + 2.3% per year. With the other progressive assumption a substitution of nonylphenol ethoxylates in laundry detergent and a moderate replacement of synthetic fatty alcohols of the lauric range with the premise of their improved competitiveness is considered. This could be reflected in an additional demand of approximately 30,000 t of lauric oil per year from 1990 on and in a growth of approximately 3.6% per year.

Tallow/Palm-Range

The conventional development of long-chain fatty acids, fatty acid methyl esters and fatty alcohols would give an approximate 1.6% per year growth of raw material (tallow, palm), whereas with the mentioned substitution of approximately 25% LAS in heavy-duty detergent powders by ester sulfonates or fatty alcohol sulfates, approximately 40,000 t of raw material would be additionally required, and this would constitute a 2.3% growth per year.

How the chances for palm oil or palm derivatives (palm stearin, etc.) versus tallow could develop is strictly a question of the market price. Even if, under conventional considerations, the basic oleochemicals in western Europe will show a very moderate development until the end of this decade, it can be positively stated that an additional demand exists of palm oil/tallow and, particularly, for lauric oils for industrial use. It does not appear speculative when a development in the direction of this potential is assumed.

Abbreviations

AE	fatty alcohol ethoxylate
AES	fatty alcohol ether sulfate
a.m.	active matter
AS	fatty alcohol sulfate
ASE	α-sulfo fatty acid ester
CNO	coconut oil
DSMDAC	distearyl dimethyl ammonium chloride
EOR	enhanced oil recovery
FA	fatty alcohol
FAA	fatty acid alkanolamide
FAC	fatty acid
FAC-ME	fatty acid methyl ester
HDL	heavy-duty liquid
HDD	heavy-duty detergent
HDP	heavy-duty powder
HF	high foaming detergent
LAB	linear alkylbenzene
LAS	linear alkylbenzene sulfonate
LDL	light duty liquid
OMC	oilfield and mining chemicals
NPE	nonylphenol ethoxylate
N	natural
NRE	narrow range ethoxylate
PAMA	polyalkyl methacrylate
PKO	palm kernel oil
QAC	quaternary ammonium compound
S	synthetic
TAS	tallow alcohol sulfate
WE	Western Europe

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Processing for Industrial Fatty Acids - I

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ABSTRACT

Palm kernel and coconut oils are particularly important to the fatty acid industry because they are the major sources of lauric acid. This paper describes the processes used to convert these oils to their fatty acids. These in turn may be fractionated into saturated/unsaturated acids and to specific chain lengths by winterization, panning and pressing, fractional distillation, solvent crystallization and hydrophilization methods. The products are important raw materials for the soap, detergent and oleochemical industries.

INTRODUCTION

Palm oil, palm kernel oil and coconut oil are very significant parts of the economies of the ASEAN countries. These oils are also very important in the world's supply of vegetable oils. Coconut oil and palm kernel oil are particularly significant to the fatty acid industry and its customers, because they are the largest of a very few commercially available sources of lauric acid. Considerable research is being funded to find domestic sources of lauric acid in the largest consuming countries, but success of this research will not come before the AOCS meeting.

Let's look at the availability of coconut oil and palm kernel oil for the year 1983/84 (1) as presented in Table I. Coconut oil and palm kernel oil represent major raw materials for the manufacture of fatty acids and glycerine.

TABLE I

World Production of Major Vegetable Oils[1]

(1000 Tons)	1983/1984 (Estimated)
Soybean Oil	13,361
Palm Oil	5,724
Sunflower Oil	5,703
Rapeseed Oil	5,279
Cotton Oil	3,056
Coconut Oil	2,387
Palm Kernel Oil	782
Total	36,292

[1]Source: *Oil World*

THE OILS

Table II shows that coconut and palm kernel oils have similar fatty acid chain length distribution. Both contain chain lengths from C_6 (caproic acid) to C_{18} saturated (stearic acid) and C_{18} unsaturated (oleic and linoleic acids). Both contain approximately 48% lauric acid. The major differences between the two oils are at the extremes of the chain length distribution. Coconut fatty acids have approximately 14.5% of the C_8 plus C_{10} fractions, compared to only 7.5% for the palm kernel oil fatty acids. The palm kernel acids contain 15% oleic acid versus 5% for the coconut fatty acids. These differences may lead to different desired processing steps to yield economically derived products for specific end-use applications.

TABLE II

Compositional Differences (%)

	Carbon Chain Length								
	C_6	C_8	C_{10}	C_{12}	C_{14}	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$
Coconut Oil	<1	7.5	7.0	48.0	16.5	8.0	4.0	5.0	2.5
Palm Kernel Oil	<1	4.0	3.5	48.0	15.5	8.0	2.0	15.0	2.5

HYDROLYSIS

The first important step in processing these oils is splitting or hydrolysis of the triglyceride to yield glycerine plus a mixture of fatty acids. The hydrolysis reaction can be done batchwise according to the Twitchell process (2) or continuously at high temperature and pressure using the Colgate-Emery process. This continuous countercurrent method takes from one to three hours to accomplish a 99% conversion. Today, almost all fatty acid manufacturers use the continuous process as shown in Figure 1. Also, of more recent interest is the enzymatic hydrolysis of triglycerides. Lipase enzymes from *Aspergillus niger*, *Candida rugosa* and *Rhizopus arrhizus* can be effectively used to split these oils;

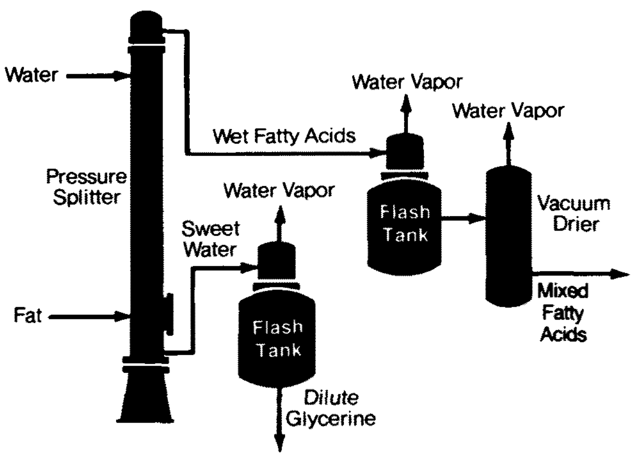

FIG. 1. The Colgate-Emery process of hydrolysis. Almost all fatty acid manufacturers use this continuous process today.

however, the enzymes are expensive and require longer reaction times (72 hours) to completely hydrolyze the oil (3). On the other hand, for comparison, Twitchell splitting may require 24 hours to realize an 85% split.

GLYCERINE

The glycerine obtained from the hydrolysis may be refined to a high purity (greater than 95%) by processing the sweet-