Biotechnology: Application to oleochemistry

Rolf D. Schmid, formerly with Henkel KGaA, Düsseldorf, West Germany, and now working at the biotechnological institute of Braunschweig Technical University, Braunschweig, West Germany, gave the following talk, entitled "Application of Biotechnology to the Oleochemical Industries—Status and Perspectives," at last year's DGF/ISF meeting in Münster, West Germany.

In 1974, Cohen and Boyer described for the first time the expression of animal DNA in microorganisms (1). The enormous surge that the field of genetic engineering has experienced since becomes conspicuous by the fact that in 1985 alone, 445 molecular genetics-related patents were registered in the U.S.

In addition to spurring gene technology, new knowledge concerning the cultivation of animal and plant cells and advances in bioprocess engineering have resulted in biotechnology becoming a major field of international research both in industry and academia (2).

Potential applications of biotechnology to oleochemistry (3-8) can be found primarily in two areas. First, in plant breeding, both yields of oils and composition of triglycerides in seeds of oleaginous plants may be optimized by applying the methods of molecular genetics; second, biocatalysts (microorganisms or enzymes) might be applied to upgrade important intermediate products of oleochemistry such as fatty acids and glycerol.

A major factor limiting the scope of biotransformation in the oleochemical industry stems from the fact that intermediates as well as oleochemical specialist products usually are low-priced products. Fortunately, the past 10 years have seen significant improvements in bioprocess engineering (9), which in several cases have led to successful competition of biotransformation with established chemical processes in the commodity chemical area, as well as to new product opportunities (Table 1). Thus, some optimism is warranted that biotechnological processes also in the field of oleochemistry will eventually complement chemical methods.

TABLE 1

Bioreactors for Commodity Chemicals

Process	Biocatalyst	Status
Glucose isomerization	Immobilized glucose isomerase	Commercial
Ethanol from biomass (starch, cellulose)	Immobilized yeast	Several pilot plants
Acrylamide from acrylonitril	Immobilized bacteria	Commercial
Soap from palm oil	Lipase	Commercial

Oleochemistry and plant breeding

Fats and oils are important chemical feedstocks, as indicated in Figure 1 (10). Almost 90% of the global plant oil supply is used by the food processing industries. Since in this market most of such oils are interchangeable, prices of fats and oils for industrial use have remained essentially stable over the past decades (11) (Fig. 2).

However, a trend toward unlinking edible oils from industrial ones as a result of breeding measures has been observed recently. Thus, a new rapeseed variety that only contains small quantities of erucic acid and glucosinolates has been bred. This represents a major advance for the food industry (12-14). On the other hand, erucic acid is an important raw material for the production of foam-inhibiting fatty acid derivatives. This acid is now recovered from plants of the "old" rapeseed type. A more recent development with significant interest to oleochemistry is the breeding of

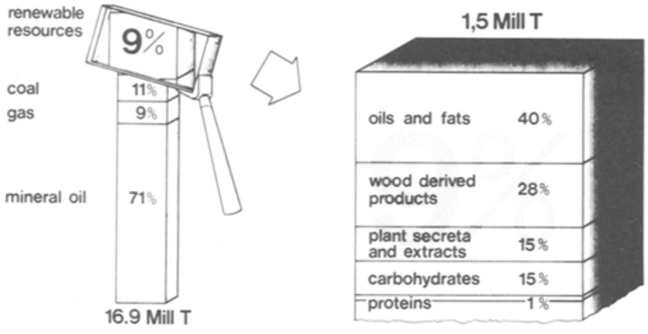


FIG. 1. Raw materials for chemistry in West Germany (1980).

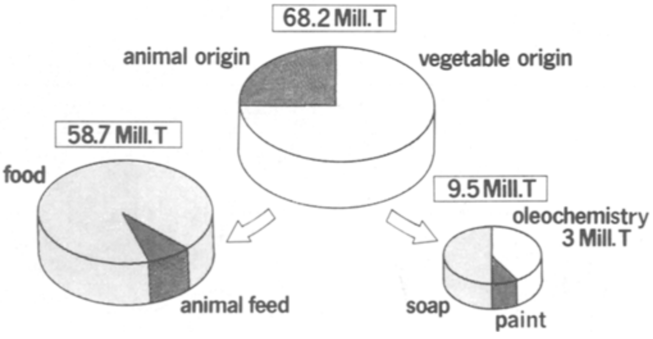


FIG. 2. World oil and fat consumption (1985).

a sunflower variety with an oleic acid content of 85% (15). Based on this new sunflowerseed oil, it is now possible for the first time to apply high-purity oleic acid to industrial synthesis (Table 2). The new biotechnological methods whose application for the breeding of oleaginous plants is currently being studied include primarily the methods of plant cell culture and plant genetic engineering (16).

Plant cell cultures

Plant culture techniques involve manipulation of cells extracted under sterile conditions from various parts of the plant (such as root, stem, leaf or apex). By appropriate phytohormone treatment, such cells develop into a "callus culture" that can be rapidly bred on a nutrient medium in a fashion similar to microorganisms. In many cases, a second hormone treatment reverses the transformation of such cultures, thereby allowing recovery of intact plants.

Once a suitable method of selection has become available, this technique opens up the possibility of reducing the development of new crops by many years. In the case of oil-bearing plants, this method was first used to enhance yields of oil palms (17). After a project life of some 10 years, thousands of palm trees that are the result of breeding via plant cell cultures are contributing to palm oil production in Malaysia. Although the difficulties involved in this method have not all been overcome, preliminary results concerning increased oil content and improved fatty acid composition are quite encouraging.

Similar experimental techniques are being applied to other oleaginous plants, one example being the generation of coconut callus cultures (18).

Recombinant DNA application

Since the first successful introduction of "foreign" DNA into plants through a vector derived from plant-pathogenic microorganisms, molecular plant breeding has been extensively studied. It has proved possible to increase the resistance of plants to herbicides by inserting foreign "resistance genes" (19). The upgrading of seeds for planting in brackish-water areas or for arid regions is also being intensively studied.

Current experiments with oil-bearing seeds aim at changing the fatty acid composition by means of recombinant DNA technology (20). A starting point for such work consists in the finding that fatty acid biosynthesis in plants is rather simply structured in a manner similar to procaryotic microorganisms. In contrast to fatty acid synthetase (a multienzyme complex found in animals or eucaryotic microorganisms), separate plant enzymes form a reaction chain that activates acetate and transforms it into fatty acids (21). By varying the concentration of these enzymes, it may become possible to selectively influence the fatty acid composition as well as the triglyceride yields of plants. A further topic of current research consists in cloning thioesterases which specifically liberate medium chain fatty acids (22). However, all such experiments must take into account that biosynthesis of triglycerides in plants is compartmentalized, taking place in particular organs and organelles (for example, in the proplastides of seeds) (23). At the moment, no processes exist to selectively express "foreign" genetic information in particular organs or organelles. Furthermore, the regulation of triglyceride biosynthesis in plants is not yet completely understood. Thus, changing the fatty acid composition of oleaginous plants by means of molecular genetics must be considered a long-term objective.

Medium chain fatty acids

Due to the excellent cold-water solubility and emulsification power of C_{12}-alcohol derivatives (24), the supply of appropriate raw materials is of prime importance to the oleochemical industry (11,25) (Fig. 3). To satisfy the needs of this market, pathways starting from oleochemicals as well as from petrochemicals have been worked out, leading to excellent products (25). Coconut oil, the most essential pertinent raw material derived from oleochemical feedstocks, is subject to considerable price variations as a result of large changes in the harvest size of coconuts in the Philippines, the major producer of coconut oil.

Considerable effort has been directed at stabilizing the supply of medium chain fatty acids by new procedures (31). Some examples are summarized in Table 3. One example is the enzymatic formation or

TABLE 2

Fatty Acid Composition of Traditional and SVO Sunflowerseed Oil

	% Contents in seed triglyceride	
	Sunflowerseed oil	SVO sunflowerseed oil
C16:0	6	3.5
C18:0	4	3.5
C18:1	28	85
C18:2	61	7

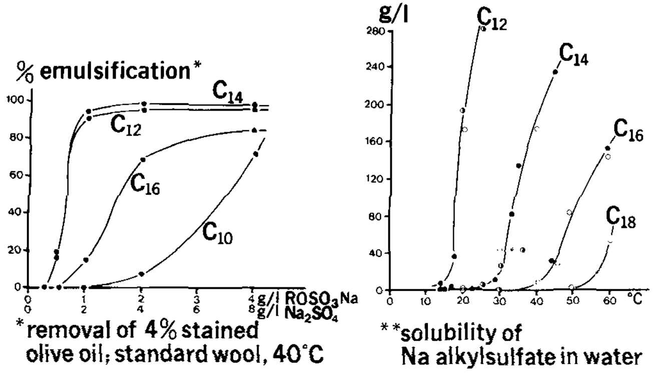


FIG. 3. Alkylsulfate homologues: washing properties and cold water solubility.

agricultural production of petroselinic acid, the major component of triglycerides in coriander seeds, and its subsequent ozonolytic cleavage to lauric acid (26) (Scheme 1). While this route is technically feasible, it leads to the equimolar formation of adipic acid as a coupled product, creating separation and marketing problems.

As a further agricultural alternative, breeding of the Cuphea plant family has been actively pursued for the last 15 years. This family of plants, discovered as early as 1964 during an extensive screening program of the U.S. Department of Agriculture for potential new agricultural crops, features a large number of species whose dominant fatty acids and seed lipids lie in the C_8-C_{14} range. Breeding studies on the Cuphea family have been supported by the oleochemical industry over the past 10 years (27,28). The current situation is summarized in Table 4; experts are optimistic and expect that seed material for the agricultural production of medium chain triglycerides by cuphea will become available within the next 10-20 years.

Other fatty acids

While oleic and linoleic acids account for 70%, and only six natural fatty acids for 95%, of the world supply in fatty acids, considerably more than 1,000 different fatty acid structures have been described, primarily for taxonomic purposes. Among these are numerous species that dominate in the seed of individual plants (12,21,29,30). Their technological potential is unclear. For research purposes, it is therefore desirable to make larger quantities of such oils available for chemical studies (Fig. 4).

Biotransformations

The number of oleochemical intermediates is quite limited (31) (Fig. 5). Important intermediate products such as fatty alcohols can also be synthesized from petrochemical starting materials. As indicated in Figure 6, severe competition exists between petrochemical- and oleochemical-derived intermediates (32). With respect to biotransformation, oleochemicals may have an edge over petrochemical feedstocks, due to the fact that nature provides a wide range of enzymes, acting upon natural compounds such as triglycerides, fatty acids or fatty alcohols.

TABLE 3

Routes to C_{12} Alcohols

Status
- Hydrogenation of coconut/palm kernel fatty acid methyl esters
- Oligomerization of ethylene (SHOP process, oxo process)
- Oligomerization of ethylene (Ziegler process)
- Oxidation of paraffins

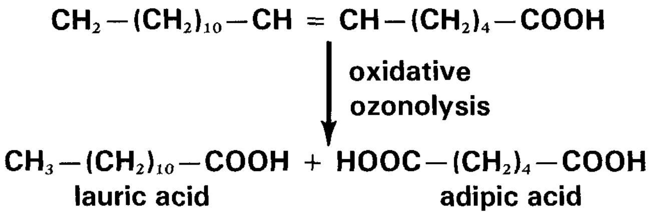
Projects
- Increased harvest of coconut/palm kernel oil
- Breeding cuphea into a crop
- Breeding of petroselinic acid plants/ozonolysis
- Genetic modification of C_{16}/C_{18} plants
- Monoterminal oxidation of dodecane

TABLE 4

Developing Cuphea into an Agricultural Crop

Hopes
- Interesting fatty acid composition
- Potential for high yields
- High genetic diversity
- Forms stands naturally
- Adapted to arid climates with irrigation

Drawbacks
- Dormant seeds
- Sticky glandular hairs on stems and flowers, preventing easy harvesting
- Indeterminate flowering
- Early seed shattering



$$CH_2-(CH_2)_{10}-CH=CH-(CH_2)_4-COOH \xrightarrow{\text{oxidative ozonolysis}} \underset{\text{lauric acid}}{CH_3-(CH_2)_{10}-COOH} + \underset{\text{adipic acid}}{HOOC-(CH_2)_4-COOH}$$

SCHEME 1

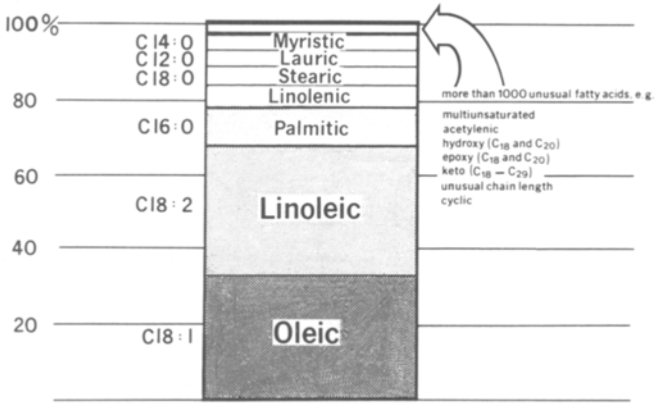


FIG. 4. World distribution of major fatty acids.

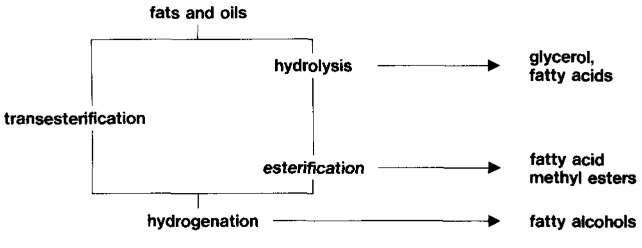


FIG. 5. Unit processes in oleochemistry.

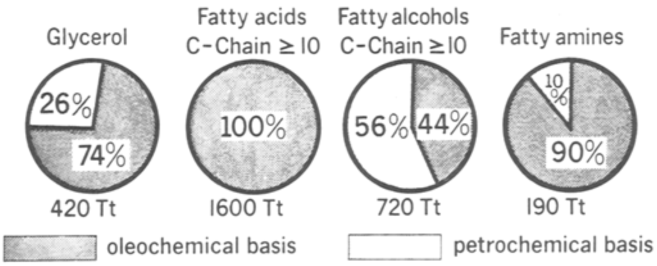


FIG. 6. World production of oleochemistry-related chemicals in 1983.

Lipases

Lipases are a class of triglyceride-hydrolyzing enzymes whose activity depends on the occurrence of an oil-water interface. They occur widely in animals, plants and microorganisms (33). Although a number of lipases, especially those in microorganisms, have been well characterized, knowledge of their structure-activity relationships is still sparse, and so is information about the three-dimensional structures of lipases (34).

Different lipases may show differing specificities as far as the cleavage of various bonds, chain length and structure of cleaved fatty acids are concerned (Table 5) (34,35). The suggestion that lipases might be used to industrially hydrolyze fats and oils was first made in 1902 (36). Similarly, the observation that ester syntheses can be catalyzed by lipases was also already reported at the turn of the century (37). In 1937, H.P. Kaufmann published a series of papers on thermodynamic aspects of fat splitting. These studies reveal that the difference in free energy involved in triglyceride hydrolysis is on the order of 0 kcal/mol (38). It is thus easy to understand that lipases not only can be used for the cleavage of fat, but also for interesterification and ester synthesis (3,7,39).

Enzymatic fat cleavage

The current industrial method of fat cleavage using superheated steam is successfully applied to the hydrolysis of most fats and oils. An important prerequisite for any application of lipases to industrial fat splitting thus is the availability of a nonspecific lipase that cleaves indiscriminately all ester bonds in triglycerides of varying origin. The most intensively studied enzyme for this purpose originates from a yeast, *Candida cylindracea*. However, the past few years have also seen the development of lipases from other (e.g., thermophilic) microorganisms for the same purpose (8). While lipases that split all three ester bonds in a triglyceride at a similar rate are indeed available, their hydrolysis rate, unfortunately, depends on both the melting point and the chain length distribution of the substrate. Whereas low-melting oils such as olive and soybean oil are generally cleaved easily, enzymatic hydrolysis of beef tallow or coconut oil under the same conditions is slower and incomplete. Improving the substrate emulsification (40), employing organic solvents (41) or simply increasing the enzyme concentration can largely increase hydrolysis rates of such glycerides, water-immiscible as indicated in Figure 7 for beef tallow. However, these measures lead to an incremental increase in production costs, rendering the enzymatic process less competitive.

Various experimental setups for enzymatic fat cleavage have been described (42–45).

From the viewpoint of economics, a large volume-time turnover with low biocatalyst cost is of major

TABLE 5

Lipase Data

Organism	Available from	Specificity	Temperature optimum (C)	Specific activity (U/mg lipase)
Aspergillus niger	Amano	Regio 1,3	25	9.02
Candida cylindracea	Meito Sangyo	Unspecific	45	53.22
Chromobacterium viscosum	Toyo Jozo	Unspecific	70	22.75
Geotrichum candidum	—	Cis-Δ9-unsaturated fatty acids	40	14.2
Humicola lanuginosa	Amano	Unspecific	60	5.16
Mucor spec	Amano	Regio 1,3	35	0.39
Mucor miehei	NOVO	Regio 1,3	40	3.25
Pancreatic	Sigma	Regio 1,3	—	4.08
Penicillium cyclopium				
A Lipase		Unspecific	35	0.09 (A+B)
B Lipase		Unspecific	40	—
Pseudomonas spec	Amano	Regio 1,3	47	7.80
Pseudomonas fluorescens	Amano	Regio 1,3	50–55	3.05
Rhizopus arrhizus	Sempa	Regio 1,3		16.08
Rhizopus delemar	Amano	Regio 1,3	35	2.20
Torulopsis emobii	—	—	—	1.75

[a] Olive oil.

importance. An acceptable setup consists of a one- or two-stage stirred reactor, whose enzymatic-containing two-phase system is separated, after the reaction has been completed, into crude fatty acid and glycerol water by means of one separator for each reaction stage. Through suitable ultrafiltration equipment, the lipase can be separated from the glycerol-water and then be recycled. A rough cost estimate for this process is detailed elsewhere (42); it indicates that critical factors are cost of the catalyst and choice of the equipment. Though the cost structure of such a process might be considerably improved by developing less expensive lipases (e.g., through cloning procedures and increase of the catalyst lifetime by immobilization), the economic advantage compared to triglyceride cleavage with superheated steam is marginal at best. It is often heard that enzymatic processes result in considerable savings of energy. This appears questionable in view of the very efficient energy recycling system that is presently used for steam cleavage and subsequent fractional distillation of the fatty acid mixture. Benefits from enzymatic fat cleavage might only be derived if complete hydrolysis is not required (for example, in industrial soap production) (46), or if the selective cleavage of fatty acids leads to a specialty product of high added value. One such example is enzymatic fat cleavage applied to the production of pure, unsaturated fatty acids (47).

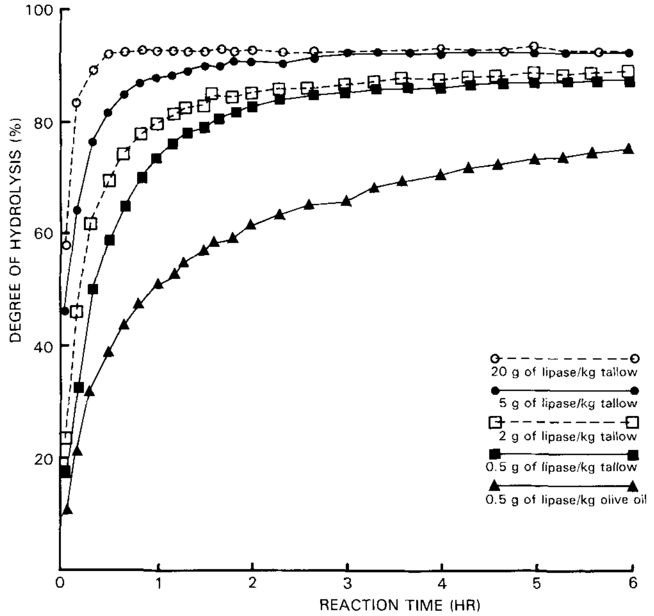


FIG. 7. Hydrolysis of tallow vs lipase concentration: 1200 g fat, 30% (w) buffer pH 5.8, 50 C, 1800 rpm.

Ester interchange

From the quantities of materials involved, the most important transesterification process in oleochemistry is the production of fatty acid methyl esters. These serve as raw materials for further chemical transformations and as starting materials for fatty alcohol production. Although esterification of fatty acids with methanol through lipase catalysis is a fast process resulting in high yields, it is quite costly to shift the reaction equilibrium toward quantitative ester yields, e.g., by removing reaction water (50). Compared to present chemical methods, an enzymatic synthesis of fatty acid methyl esters does not offer any economic advantage.

A more favorable situation is found in the case of edible fat production. Thus, the preparation of cocoa butter by means of lipase-catalyzed ester interchange has attracted a great deal of attention in recent years (48–53) (Scheme 2).

Developments have already reached pilot-plant scale. A certain drawback is that cocoa butter produced by biotransformation is legally considered a food substitute and thus is faced with tough competition from native cocoa butter.

A second attractive application of enzymatic ester interchange is in the hardening of vegetable oils without the usual high-pressure hydrogenation. For this purpose, triglycerides of different melting points are subjected to ester interchange in the presence of lipase. The resultant product shows butter-type properties (50,51). The use of appropriate immobilization procedures extends the lifetime of the lipase biocatalyst to a period of many months (50).

Ester synthesis

Wax esters (50,51,57), monoglycerides (59,60,62), isoprenoid esters (54–56,60) and sugar esters (62,63) are but a few examples of activities in this field (55,57,61). The use of lipases for ester synthesis has been rediscovered and intensively studied in the past two decades. It turned out during these investigations that lipases from different origin show a markedly different potential for the synthesis of esters. Although the choice of the right enzyme and the optimization of the reaction conditions often leads to high yields, economic needs require advantages over competing methods of chemical ester synthesis, the latter usually being very straightforward. Such advantages could lie, for instance, in a higher positional or enantiomeric selectivity. Another plus might be derived from the mild reaction conditions for enzymatic ester synthesis in the case of sensitive substrates. One such example is the synthesis of 2-methylpentanoyl-prenylester, a black currant aroma component whose fragrance quality seems to depend upon the presence of a Δ3-cis double bond (64) (Fig. 8).

In base-catalyzed synthesis of this ester, the aroma quality is slightly impaired, probably due to a partial

$$\text{palm oil + stearic acid methyl ester} \xrightleftharpoons{\text{lipase}} \text{"cocoa butter" + oleic acid methyl ester}$$

SCHEME 2

migration of the double bond. In contrast, under the mild conditions of the lipase catalysis, a pure-formula product is obtained. Immobilization of the lipase on kieselguhr permits this reaction to proceed in high yields over many months, without any significant decrease in enzyme activity (56).

It is thus to be expected that enzyme-catalyzed ester synthesis will eventually develop into an economically viable complementation of classical procedures in such cases where selectivity or mild reaction conditions are required.

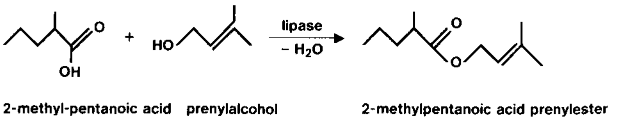
Biotechnological fatty alcohol production

Natural fatty alcohols occur widely as components of waxes. In general, their biosynthesis takes place via biochemical reduction of activated fatty acids (65). In some cases, ω-hydroxylation of alkanes to fatty alcohols has been implied.

Bioreduction of activated fatty acids to fatty alcohols requires three steps catalyzed by membrane-bound enzymes. In addition, several expensive cofactors such as NADH, CoA and ATP are involved in the pathway (Fig. 9).

Since isolation of the appropriate enzymes and development of cofactor regeneration systems would render this process uneconomical, industrial-level bioreduction of fatty acids to fatty alcohols is only feasible with intact microorganisms.

To evaluate the industrial potential of such biotransformation, a cooperative project among several universities was carried out in which the individual enzymes from various microorganisms and plants were partially purified and their turnover numbers determined. It was thought that should high enzyme activities be observed, it would be possible to produce a technically suitable biocatalyst complex by means of microbial optimization or, where necessary, to increase individual enzyme activities by cloning techniques. However, during the course of this work it became apparent that turnover numbers of the enzymes involved were several orders of magnitude lower than would be necessary for an industrially feasible process (66).



$b.p._{(0.07)}$ 38°C

$n_D^{20} = 1.4370$

^{1}H-NMR ($CDCl_3$) $\delta = 5.33$ (1H,m)

$\delta = 4.58$ ppm (2H,d)

"black current", "flower of elder", "juniper"

FIG. 8. Lipase-catalyzed synthesis of 2-methylpentanoic acid prenylester.

Fatty acids biotransformation

The industrial transformation of native fatty acids so far is focused primarily on transformations of the carboxyl group and on some reactions at double bonds or hydroxyl groups (25). In contrast, biotransformation reactions open up the possibility of attacking non-activated positions of the fatty acid chain (3).

An interesting example is the biochemical oxidation of the terminal carbon atom of fatty acids, leading to dicarboxylic acids, important starting materials for the synthesis of polyesters and other polymers.

Currently, the dicarboxylic acids most important to industry are produced from petrochemical feedstocks. Chemical pathways to medium and long chain dicarboxylic acids are, however, quite limited (Table 6).

In contrast, biochemical ω-oxidation of long chain alkanes or fatty acids is well documented in the literature. Thus, the "diterminal microbial oxidation" of alkanes has been extensively studied (67,68). As a result of this work, fatty acids were shown to be intermediate products of this metabolic chain (67) (Fig. 10).

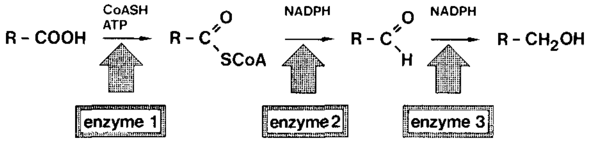


FIG. 9. Biosynthesis of fatty alcohols. Enzyme 1, fatty acid-CoA-synthase; enzyme 2, acyl-CoA-reductase; enzyme 3, aldehyde-reductase.

TABLE 6

Technically Important Dicarboxylic Acids

Dicarboxylic acid	Chain-length (C)	Application	Raw material	Price (DM/kg)	Market size (Tt)
Adipic acid	6 9	Polyester plasticizer	Butadiene	2.20	2000
Azelaic acid	9	Polyester plasticizer	Oleic acid	8	28
Sebacic acid	9	Polyester plasticizer	Ricinoleic acid	9	9
Dodecanoic acid	12	Polyester bleach	Butadiene	11	5
Brassylic acid	13	Polyester fragrance	Erucic acid	15	<1

TABLE 7

Biochemical ω-Oxidation of Fatty Acids

Starting material	Product	Yield g/l	Yield Hr	Organism	Company/author
C_{16} n-alkane	C_{16}-DC	20	48	*Candida spec*	Ajinomoto, 1971
C_{12} n-alkane	C_{12}-DC	4	91	*Corynebacterium*	Du Pont, 1973
C_{15} n-alkane	C_{15}-DC	87	180	*Candida spec*	Shen et al., 1977
C_{16} n-alkane	C_{16}-DC	61	68	*Candida spec*	Ajinomoto, 1978
C_{13} n-alkane	C_{13}-DC	45	84	*Candida tropicalis*	Nippon Mining, 1980
9c $C_{18:1}$-acid	9c $C_{18:1}$-DC	2	48	*Candida tropicalis*	Daicel Chem. Ind., 1980
9t $C_{18:1}$-acid	9t $C_{18:1}$-DC	39	96	*Candida tropicalis*	Bio Res. Center, 1982
Coconut oil	C_{12-18}-DC	10	96	*Candida tropicalis*	Bio Res. Center, 1982
Akylchloride	ω-Chloro-$C_{12}/_{18}$-acid	0.2	72	*Arthrobacter, Nocardia*	Kao Soap, 1982
C_{14-18} n-alkanes	C_{14-18}-DC	92	96	*Candida tropicalis*	Huels AG, 1984

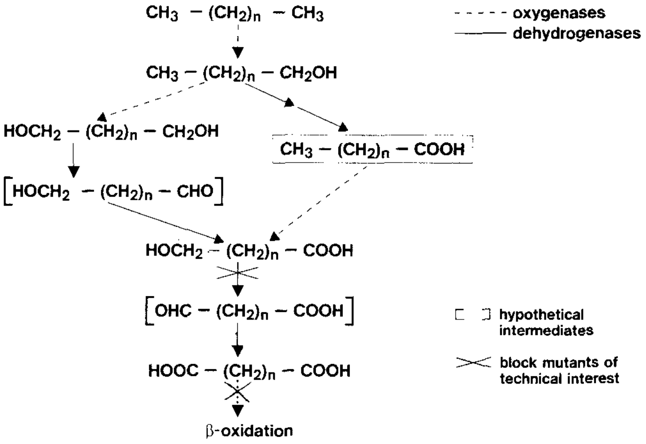


FIG. 10. Microbial oxidation of alkanes to dicarboxylic acids.

TABLE 8

Research Association "Bioreactors for the Oleochemical Industry"

Targets	Company
Symmetrical triglycerides	Mitsubishi Chem. Eng. Meito Sangyo Asahi Denka
Food oils with functional properties	Ajinomoto Amano Nihon Kihatsuyu
Improved soy lecithin	Yakult Niigata Steel
Meat-related flavors	Unitika Itoh Ham Shibahara Hasegawa Fragrances
Food from fish oil	Nippon Oils and Fats Toyo Joozo Sanki Engineering

Guidance: Ministry of Agriculture, Forestry and the Fisheries, Tokyo.

Thus, development of microbial strains that can oxidize terminal carbons of fatty acids but have lost the ability to further degrade dicarboxylic acids via β-oxidation is rather straightforward. Unfortunately, the development of an economic fermentation or bioreactor process for terminal functionalization of fatty acids is not that simple, mainly due to the low water solubility of the substrates. Nevertheless, at least in the case of alkane oxidation, initial technical success already has been achieved. As an example, brassylic acid, produced by terminal oxidation of tridecane, has entered the market (69), and more recently, the microbial production of low-cost adipic acid was reported (70) (Table 7).

Summary and outlook

The application of biotechnological methods to oleochemicals must be evaluated against established chemical procedures. In addition, competition from the agricultural development of new specialty oils has to be considered. Despite such obstacles and limitations resulting from the low price levels of most oleochemical products, niches for the application of biotechnology become increasingly apparent.

Rewarding goals have been defined in the breeding of plants that produce triglycerides containing scarce or new types of fatty acids. In the field of biotransformation reactions, ester interchange of triglycerides and ω-functionalization of fatty acids are notable examples. International competition has become strong in many of these areas. Several companies and industrial research associations have set targets, for example, for developing lipases for industrial applications (6,71). An interesting example is a comprehensive industrial project guided by the Japanese Ministry of

Agriculture (72). The goals involved, which are supported by 14 associated companies, are shown in Table 8.

Finally, new incentives to transform sugars into valuable fatty acids through fermentation processes have appeared. Thus, the first industrial manufacture of the diet foodstuffs and cosmetic product γ-linoleic acid using mold cultures has been announced (73).

These developments illustrate that the new methods of biotechnology are at the point of developing into opportunities in the field of oleochemistry.

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Henkel's R&D

Henkel KGaA, a $5-billion West German manufacturer of specialty chemicals and consumer products, has opened a new research center in Santa Rosa, California.

Called Henkel Research Corp., the center is the only Henkel research facility outside of the company's Düsseldorf headquarters. Research activities at Henkel's former technical center in Minneapolis, Minnesota, have been integrated into the Santa Rosa facility. The new facility will employ 90 persons.

In addition to conducting experimental research, Henkel Research Corp. will seek to establish links with U.S. universities and companies, particularly with biotechnology and science-based firms based in the San Francisco Bay area of California. Kenneth D. MacKay is president and research director of Henkel Research Corp. According to MacKay, activities will include molecular genetics, enzyme biochemistry and exploratory research in oleochemistry as well as analytical, polymer and extraction chemistry.

Projects at the new center will be coordinated by Juergen Falbe, executive vice-president and chief technical officer of Henkel KGaA, and Arnold Heins, vice-president and head of the Henkel Research Division in Düsseldorf.

Exxon agreement

Exxon Chemical Co. has signed a series of agreements with CdF Chimie of France to assume worldwide marketing of Cdf Chimie's synthetic acids and oxo alcohols. Under the agreements, Exxon also has exclusive rights to production at the CdF Chimie plant at Harnes, France, and an option to buy the facility.

The products covered by the agreements include oxo alcohols and synthetic acids in the C_7 to C_{10} range, used in such applications as coatings, surfactants, synthetic lubricants, plasticizers and polymerization chemicals.

Phosphate ban

Virginia's General Assembly has approved a ban on the use, sale and distribution of detergents containing phosphates. The measure, which passed in February, has been supported by governor Gerald Baliles, who is expected to sign it once he receives it.

The ruling, however, does allow dairy and beverage processors to use detergents containing phosphates. They also are allowed in industrial sanitizers, metal cleaning and conditioning and in commercial laundries that cater to hospitals.

It is expected that a similar bill will be introduced in North Carolina during this legislative session. Phosphate bans already are in effect in Maryland and Washington, DC.

Dial reorganizes

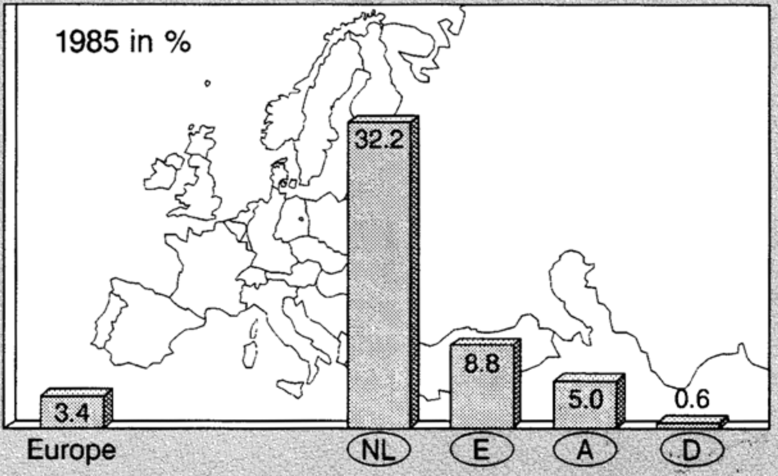
Dial Corp. has reorganized its consumer products line into three divisions: personal care, food and household. A fourth division has been established for international operations.

Richard Lies, former manager of the company's Aurora, Illinois, plant, heads the personal care division. The head of food products is Paul Lustig, former vice-president of marketing. Dave Morrison, former vice-president of manufacturing, leads the household and laundry products division. W.T. Bennett, president and chief executive officer of Armour International, leads international operations.

Product seminar

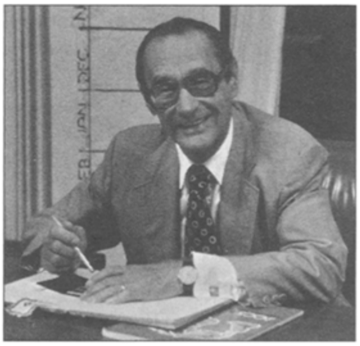
The AOCS Southwest Section's sixth annual seminar on product development drew nearly 100 participants interested in technology for the soaps and detergents industry. The all-day symposium was held Feb. 18 at the Buena Park Hotel, Buena Park, California.

Share of Concentrated Detergents in Total Laundry Detergents



Consumers in the The Netherlands are virtually the only Europeans to heartily adopt the use of concentrated detergent powders. Overall in Europe, the concentrated powders account for about 3.4% of sales. The chart shows market share of the concentrated powder in The Netherlands, Spain, Austria and Germany. The generally slow acceptance is attributed to consumer resistance to change.

—From "The Detergent and Cleanser Market in Europe," presented by Hans-Dietrich Winkhaus, executive vice president of Henkel KGaA, Düsseldorf, West Germany, during the Second World Conference on Detergents, Oct. 5-10, 1986, Montreux, Switzerland.



Honored

AOCS member Helmut Stupel, who retired March 1 after 28 years with the Shell group of companies, was recognized for his contributions to the soap and detergent industry at the recent Soap and Detergent Association (SDA) convention. The SDA awarded Stupel with a large plaque for his service to the association and to the industry. Shell Chemical, honoring him at its SDA party, presented him with a leather-bound copy of his first book, *Synthetic Detergents,* published in 1954.

Six speakers made presentations, which included some new formulations and trends in processing technology. Talks included the following: Review of Agglomeration Technology, by Mike Dolan, Monsanto Co.; Nonionic Surfactants Containing Propylene Oxide, by Carter Naylor, Texaco Chemical Co.; New Development in Formulating Rinse Cycle Fabric Softeners, by James Fuller, Sherex Chemical Co.; Development of a Nonionic Surfactant-Based High Density Laundry Powder, by Connie Merrill, Shell Chemical Co.; Alkyl Polyglycosides, Unique Nonionic Surfactants, by Ken Scott, Horizon Chemical; and New Alkanolamide for Hard Surface Cleaners, by Joe Drozd, Stepan Co.

Those serving on the seminar committee were Frederick Shook of Pilot Chemical Co., general chairman; Henry Reich of Lonza Inc., program chairman; Ron Rawding of Pilot Chemical Co., publicity; Larry Copeland of Pilot Chemical Co., registrar; Don DuRivage of Pilot Chemical Co., treasurer; and Bob Dearstyne of Lonza Inc., Southwest Section president.

Supplier's day

The New York chapter of the Society of Cosmetic Chemists will hold its 8th annual Supplier's Day May 21, 1987, at the Aspen Hotel, Rte. 46 West, Parsippany, New Jersey, from 3 to 7 p.m. The general public is admitted free.

A dinner will follow at 7 p.m. The speaker will be Herman Brown of Finetex Inc., who will speak on "Product Development: A Synergistic Approach." For more information, contact Anthony Latella at BASF, telephone 201-263-5589.

British research

The United Kingdom's Science and Engineering Research Council (SERC) has agreed to fund a six-year program to encourage the use of new techniques for studying catalysis under realistic conditions. This initiative is aimed at studies of single crystal surfaces and high-area catalysts, the role of promoters and poisons in catalysts and the synthesis of new catalysts.

Meanwhile, the British Ministry of Agriculture, Fisheries and Food has patented a new method of degrading lignin. According to J.H. Utley of Queen Mary College, London, one of the developers of the process, the next step will be to break down the lignin into intermediate size molecules useful to the chemical industry as surfactants and sequestering agents.

News briefs

AOCS member **Lynn Lander** has been named director of technical services for **Lever Brothers Co.** He formerly was development manager.

Thomas E. Breuer has been appointed director of product technology in the **Humko Chemical Division of Witco Corp.**

Akzo Chemie America has appointed **Nicholas H. Sommers** international manager of advertising and public relations, and **M.E. Morrison** vice-president.

James E. Schorr, formerly president of Enron Chemical Co., has been appointed to the new position of president of the **National Distillers & Chemical Corp. (NDCC)** and president of **USI Chemicals Co.** Enron Chemical Co. was purchased by NDCC in late 1986 and is being consolidated with NDCC's USI Chemicals.

PQ Corp. has appointed **L. Sue Madding** and **Michael T. Skelly** as sales representatives in its industrial chemicals division.

Elliot A. Vogelfanger has been named manager of investor relations for Vista Chemical Co.

PPG has acquired **Mazer Chemicals** surfactant manufacturer and marketer based in Gurnee, Illinois.

Obituary

JAMES BURN

AOCS has been informed of the death of AOCS member James Burn in June 1986. At the time of his death, he was vice-president and general manager of The Dycho Co. Inc., Niota, Tennessee.

Burn joined AOCS in 1968. He earned his masters degree from the University of Tennessee in 1944. He first worked at the University of Tennessee as a chemistry instructor, then went on to work for Socony-Vacuum Oil Co. He did doctorate work at Columbia University during 1949-1952, then became technical director and chemist at The Dycho Co. in 1954. His work there centered on detergents, oils and textile specialties.

He is survived by his wife, Martha Anne, and two children, Jack and Rose Anne.