Corporation (13). This method has been described many times in the literature (14, 15), and results obtained on various fatty acid feed stocks have been widely published. Fundamentally, fractional distillation of fatty acids is carried out in the same manner as continuous simple distillation. The design of the main distilling column differs from simple distillation columns in that it is fitted with a plurality of bubble cap trays and means for removal of side streams of fatty acids and return of part of these streams as reflux. Pre-evaporator column and final stripping column are designed to remove odor cuts and residue from the system. Conventional condensers and vacuum systems are used.

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Commercial Uses of Fatty Acids

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THE total production of fatty acids in the United States has materially increased during the past decade. In 1941 approximately 225 million pounds were produced whereas in 1951 this amount increased to more than 400 million pounds. These figures do not include tall oil production, which has grown to be a very important factor in fatty acid uses, as indicated by the production of 90 million pounds of refined tall oil in 1948 and more than 141 million pounds in 1951. Production figures on refined tall oil are not available prior to 1948. This substantial increase in total fatty acid production is due to the development of a great many new uses as well as to a general increase in industrial production of established products in which fatty acids are used.

N. A. Ruston

The principal end-uses of fatty acids and fatty acid derivatives can be classified as follows: Soaps and synthetic organic detergents; Rubber compounding; Synthetic rubber polymerization; Paints, varnishes, and surface coatings; Plastics and plastic fabrication; Lubricating greases; Lubricating oils and oil additives; Cleaning compounds and polishes; Metal working and treating; Textile chemicals; Cosmetics and toiletries; Insecticides, disinfectants, and germicides; Candles; Paper and paper products; Inks and crayons; Ore flotation; Metallic soaps; and Food products.

These classifications are significant in that they emphasize the great diversification of industries and end-uses of products in which fatty acids are employed. There are few fields of manufacture or technology today which do not use fatty acids or their derivatives in one form or another.

Commercially produced fatty acids today are derived from naturally occurring animal, vegetable, and marine fats and oils. The majority of these raw materials occur in nature as complex mixtures of triglycerides, other esters, and alcohols. Some of the more common fats and oils used are beef tallow, pork greases, cottonseed, soya, coconut, palm, palm kernel, linseed, olive, menhaden, sardine, sperm, herring, and tall oils. Tall oil, of course, is not a true "oil" since it is actually a mixture of fatty acids and rosin acids, not occurring as a triglyceride. Both crude fats and oils and the "foots" from edible oil refining are used to produce the finished fatty acids.

The first step in fatty acid manufacture is the hydrolysis of the oils. This process produces crude fatty acids with glycerine as a by-product. The four most common methods are (1) autoclave, (2) Twitchellizing, (3) saponification with caustic followed by acidulation, and (4) high pressure continuous splitting. Although all four methods are still employed the trend is toward the last of thsee.

The next step is some form of purification of the crude fatty acid, usually a total distillation, which Although all four methods are still employed, the trend is toward the last of these.

By the preliminary steps of hydrolysis of the oils and purification of the acids, usually by distillation, mixed fatty acids having the composition of the original oil or fat are produced, which are suitable for many uses. To obtain properties required for other specific end-uses, separation into component fatty acids, or blends of component fatty acids having similar properties, is necessary. There is a trend in the fatty acid industry in the direction of producing relatively pure acids of each kind, and, as evidence of this, there are a number of fatty acids of 90-95% purity available commercially.

In order to provide "tailor-made" fatty acids which are more suitable for certain specific end-uses than the mixed fatty acids, further mechanical and chemical processing of the distilled mixed acids is necessary. Space will not permit a full discussion of these operations although, I believe, brief mention of some of the more important processes is necessary for a better understanding of the many types of commercial fatty acids and their end-uses.

Separation of liquid and solid fatty acids is accomplished by solvent separation or by hydraulic pressing. Examples are oleic and stearic acids. It should be noted that by this process fatty acids of the same chain length can be separated.

Fractional distillation produces fatty acids of 90% or better purity whenever the differences in boiling points permit such separation. In this case components must differ in chain length. Examples are 90% pure grades of palmitic, stearic, myristic, and caprylic acids.

Hydrogenation of fatty acids is employed to reduce or eliminate unsaturation. The usual procedure is to hydrogenate the oils first and then split off the glycerin to obtain the fatty acid. In some cases the fatty acids are treated directly with hydrogen.

Polymerization is a further means of purification. In this operation, known as "dimerization," polyunsaturated acids are polymerized, leaving the saturated and singly-unsaturated acids untouched. When the mixed fatty acids are treated under high temperature and pressure, polymerization of the polyunsaturates takes place and the monomeric acids are distilled from the polymer. Examples are high quality oleic acid and dimer acid produced from soya fatty acid. The following diagram illustrates the variety of products that can be obtained from tallow fatty acid as the basic raw material.

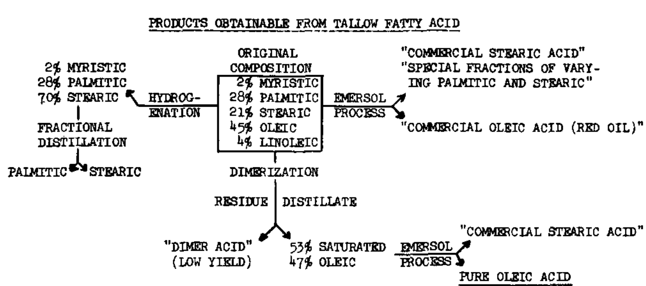

FIG. 1

Thus by these further processing methods the fatty acid manufacturer has been able to produce a series of basic materials possessing unique properties which are required for specialized end products and uses. The importance of this is indicated by the following example. A plasticizer manufacturer had one product based on commercial stearic acid which showed promise, but its compatibility with the resins for which it was designed was not adequate. When a fatty acid rich in palmitic acid was used, this difficulty was completely overcome.

During the past few years the greatest number of new uses for fatty acids have been developed in the field of synthetic organic derivatives. These products involve the reactions with the carboxyl group and in the carbon chain either at the double bond or elsewhere. Typical derivatives of this grouping are fatty alcohols, esters, amides, nitriles, amines, quaternary ammonium compounds, dibasic acids, and fatty acid halides.

Now we come to the specific uses of fatty acids in industry. Space will not permit a detailed description of each use, but I will attempt to give you an idea of the types of fatty acids and fatty acid derivatives which are applicable. It should be noted here that the selection of the particular fatty acid for each use is predetermined by its chemical and physical properties such as composition, titre, color, odor, iodine value, acid value, unsaponifiable content, polyunsaturate content, degree of reactivity, solubility in various solvents, detergency and sudsing qualities of its alkali metal soaps, and last but not least, its economic value.

The end-use classifications mentioned earlier in this paper will be the pattern for this discussion.

Soaps and Organic Synthetic Detergents. The use of fatty acids in soap making is the subject for another paper during this course so it will not be discussed here.

The synthetic organic detergents based on fatty acids are principally anionic or nonionic derivatives. The anionics comprise the fatty alcohol sulfates, most prominent of which is lauryl alcohol sulfate based on coconut oil. Other fatty alcohols such as oleyl and stearyl are also applicable.

The nonionic group are principally the ethyoxylated fatty acids and amides of tall oil, coconut, stearic, and oleic acids.

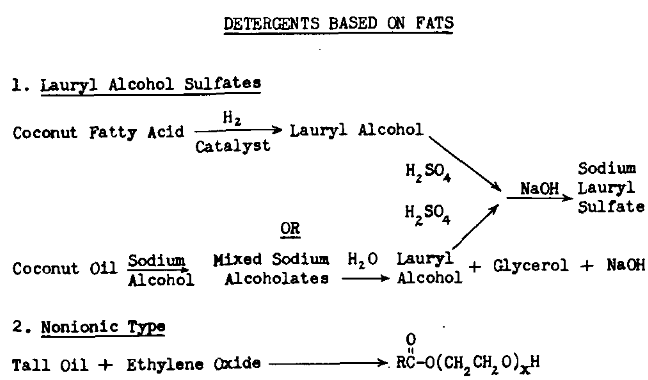

FIG. 2

Rubber Compounding. The principal use of fatty acids in both natural and synthetic rubber compounding is to activate the accelerators and to iron out variations in curing speeds. Stearic, tallow, cottonseed, oleic, and hydrogenated fatty acids are commonly used. Practically every type of finished rubber product contains approximately 2% of fatty acid, and this industry is next to soap in its consumption of fatty acids.

Synthetic Rubber Polymerization. The polymerizing agents used here have principally been partially hydrogenated tallow soaps and specially treated rosin soaps. A purified oleic acid is also now being used for production of high solids, rubber latices suitable for foamed rubber products and latex base paints. Oleic acid is also used as an emulsifying agent in the new oil extended rubbers.

Paints, Varnishes, and Surface Coatings. The largest use for fatty acids in this industry is in the manufacture of alkyd resins. The high iodine value acids, characterized by large percentages of linoleic and linolenic acids, and including refined tall oil, soya, cottonseed, linseed, and solvent-separated fractions are the principal products used in both air-drying and baking-type alkyds. Coconut fatty acids are also used extensively in baking-type alkyds where color retention is a prime requisite. Dimerized fatty acids also find application in alkyd resins as a partial replacement for phthalic anhydride and as a bodying agent in various varnish and enamel formulations.

In the emulsion type of paints and coatings, soaps of oleic, soya, and linseed fatty acids are used as the emulsifying agents.

Plastics and Plastic Fabrication. Unsaturated fatty acids provide convenient raw materials for the synthesis of three dibasic acids which are important in the manufacture of plasticizers and certain polyester and polyamide resins. Azelaic acid, the C_9 dibasic acid, is derived from oleic acid, and sebacic, the C_{10} homologue, from ricinoleic acid found in castor oil. In addition, the dimerized fatty acid previously referred to, a C_{36} dibasic acid, can be prepared by dimerization of polyunsaturated fatty acids.

Esters of sebacic and azelaic as well as oleic and ricinoleic acids find application as plasticizers in vinyl shower curtains, upholstery materials, raincoats, and so forth. The dibasic acids themselves are combined with polyhydric alcohols or polyamines to form the classes of plastic materials known as polyesters and polyamides, of which nylon is an example.

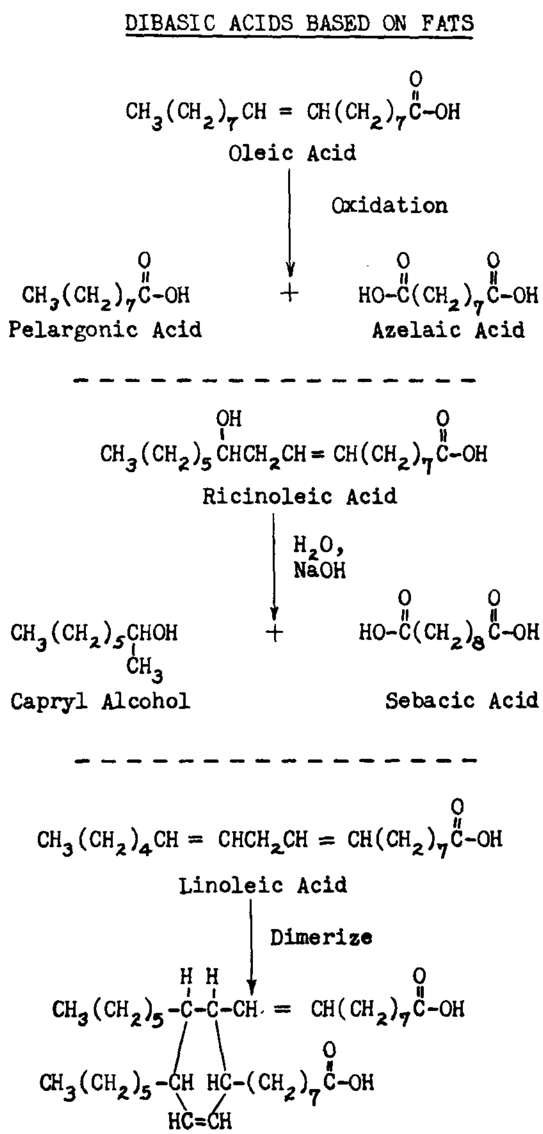

FIG. 3

Lubricating Greases. Of the many types of lubricating greases available, those made with metallic fatty acid soaps as the gelling base account for the major consumption. In preparing greases, lithium, calcium, aluminum, sodium, and barium are combined with such fatty acids as stearic, oleic, tallow, cottonseed, and hydrogenated acids. Petroleum oils, of course, are the other principal components.

Since World War II the use of "all purpose" type lithium soap greases has steadily increased. Today both petroleum and synthetic types are available. Hydrogenated castor oil fatty acid (12-hydroxystearic acid) lithium soaps form the base of these greases.

Lubricating Oils and Oil Additives. Synthetic oils and greases composed principally of sebacate and azelate esters are used in instrument and aircraft lubrication by our Armed Forces. The unique property of these esters for this use is their extremely low pour points.

Fatty acid derivatives are the basis for many oil additives used as oil detergents, viscosity index improvers, corrosion inhibitors, extreme pressure compounds, etc. Such products as chlorinated stearic acid, lauryl methacrylate polymers, fatty amines, mono- and polyhydric alcohol esters of oleic acid and their sulfurized derivatives are widely used.

Cleaning Compounds and Polishes. Cleaning compounds refer to specialty products, such as metal cleaners, and steam cleaning compounds. The basis of these products is alkali metal soaps of tall oil, tallow, cottonseed, soya, oleic, and stearic acids.

In the emulsion type of furniture and shoe polishes, liquid floor wax and metal polishes, fatty acid soaps are principally used as the emulsifying agents for the various waxes. Oleic, stearic, fractionated tall oil, and hydrogenated fatty acids, also the nonionic and sulfated esters of these acids, are commonly employed.

Metal Working and Treating. This grouping includes soluble grinding and cutting oils, metal powder manufacture (aluminum and bronze), carbon removal compounds, anti-corrosion, buffing and foundry parting compounds. For these products a great variety of fatty acids and derivatives find use.

Textile Chemicals. The various textile applications for fatty acids are textile soaps, fabric softeners, fiber processing lubricants, sizing compounds, dyeing assistants, waterproofing agents, mildewproofing agents, and sanforizing assistants. Some of the products applicable to these uses are oleic acid and its esters (in some cases sulfated), quaternary ammonium compounds, aluminum stearate, and copper oleate and linoleate.

Cosmetics and Toiletries. In this classification we have shaving creams, shampoos, talcum powder, hand lotions and cleansing creams. Highly refined fatty acids and derivatives are a requisite and include stearic, palmitic, myristic, lauric, oleic, and coconut fatty acids, sulfated lauryl alcohol, zinc stearate, glycerol, and ethyoxylated esters. There is a tremendous amount of stearic acid consumed in the manufacture of shaving creams, both brushless and lather types. Stearic acid is saponified, often in conjunction with coconut fatty acids, to yield the white, creamy emulsion with which everyone is familiar.

Insecticides, Disinfectants, and Germicides. In insecticides and disinfectants the principal use of fatty acids and their derivatives again involves emulsifying agents. Oleic acid soaps, sulfated esters, and polyglycol esters are often used.

The quaternary ammonium compounds based on lauric acid are themselves excellent germicides.

Candles. Stearic and hydrogenated fatty acids are used with paraffin wax in candle manufacture to impart whiteness and rigidity.

Paper and Paper Products. The principal fatty acid used is stearic acid in coatings. In addition, oleic acid finds use as a defoamer in paper manufacture.

Inks and Crayons. An example of the use of a fatty acid as a solvent is the application of oleic acid with Victoria Blue B Base, a dye employed in inks for carbon paper, typewriter ribbons, and similar products. In crayons and lead pencils stearic acid functions as a wax and lubricant.

Ore Flotation. The principal products used in this industry are tall oil, fatty amine salts, and oleic acid. Among the many minerals treated with these reagents are phosphates, fluorspar, feldspar, and limestone.

Metallic Soaps. Manufacture of metallic soaps accounts for a substantial consumption of fatty acids. End-products in this group are used in a great many of the finished materials produced by other industries indicated in this discussion. Among the more common are aluminum, calcium, zinc, barium, and iron stearate, lithium 12-hydroxystearate, copper oleate and linoleate, and cobalt, calcium, and manganese linoleates. These products find use in lubricating greases, waterproofing compounds, cosmetics, flatting agents, paint driers, and mildew proofing compounds.

Napalm used by our Armed Forces as a gelling agent for gasoline contains the aluminum soaps of oleic and coconut fatty acid. A similar product developed during the past few years is used in the Hydrafac process, which takes advantage of the gel-forming properties of aluminum fatty acid soaps in reviving the flow of spent oil wells.

Food Products. Certainly one of the most interesting fields involving stearic, oleic, and palmitic acids is the use of monoglycerides and ethylene oxide condensates as bread fresheners, anti-spattering agents for cooking fats, and food emulsifiers. Much publicity has been given these products in recent years in connection with studies by many organizations on chemicals in foods so their composition and use are well known.

Earlier in this discussion I mentioned that there are few fields of manufacture or technology today which do not use fatty acids or their derivatives in some form or other. I trust now you can see the truth of this statement.

The multitude of new types of fatty acids and derivatives which research has developed for specific industrial uses during the past few years is phenomenal. This work still continues at such a rapid pace that the next decade will undoubtedly see many new products commercially available which at present have not even reached the test tube stage.

Evaluation at the Consumer Level

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CONSIDERATION of Consumers' Research should probably begin with a brief outline of its background and origins. It was the outgrowth of public response to a book entitled "Your Money's Worth" written by Stuart Chase and myself. Published in 1927, this book had the distinction of being the first of several best-sellers in the field of consumer problems that reflected the information and point of view of Consumers' Research. It was a pioneering book in the sense that it discussed by brand name a considerable number of well-known, widely-advertised products and freely mentioned their unfavorable as well as favorable aspects, a practice which had hitherto been taboo in books for the general reader. It still is taboo in proceedings of nearly all professional and technical societies.

F. J. Schlink

Perhaps I should qualify the term "pioneering" a bit because much information having to do with patent medicines came from a remarkable group of books and pamphlets issued by the American Medical Association for the information of physicians. These were the work of the director of the A.M.A.'s Bureau of Investigation, the late Dr. Arthur J. Cramp, who set an example of courage, initiative, and public service which has never been equalled in American professional societies. (Others who in earlier years had made great contributions to exposure of frauds in misrepresented foods or patent medicine were Samuel Hopkins Adams with his series of "muckraking" articles in popular magazines, Mark Sullivan, and Dr. Harvey Wiley, physician, chemist, and first head of the Federal Food and Drug Administration. The pioneer in state activity in exposure of adulteration of foods, drugs, and other consumer products and in the protection of the consumer through specifications and standards was Prof. E. F. Ladd of North Dakota. His successors have been Culver S. Ladd and R. O. Baird.)

"Your Money's Worth" served to whet the appetite of its readers for more information on specific products, and the demands were so insistent that in a little more than a year's time Consumers' Research was set up to obtain information to handle these requests. In the beginning it had a small subsidy from a philanthropist and functioned largely as a clearing-house for information obtained from professional societies such as the A.M.A., American Dental Association, a few of the more active state departments of health, certain state experiment stations (such as North Dakota and Connecticut) and other governmental departments which carried out research or tests of one sort or another, college professors and graduate students carrying out research or investigations with a bearing on consumers' problems, and college and municipal purchasing departments.

Contacts were made with commercial laboratories and college teachers and research men to carry on test-