Uses of Fats and Derivatives in Textile Processing*

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TEXTILE processing agents derived from fatty sources may be classified as follows:

1. Raw oils.
2. Soaps.
3. Sulphated oil products.
4. Sulphated and sulphonated alcohols.
5. Fatty esters.
6. Metallic insoluble soaps.

These products are used alone or in combination, depending upon the effects desired and the method of application.

The common characteristic of the fat derivatives is the possession of a hydrophile-lipophile complex. The use of any fat derivative is dependent either at the time it is applied, or at the time of removal from the fibre, upon its emulsifying properties.

Behavior and usage is dependent upon the lipophile-hydrophile ratio, electric charge of the globular particles, size of the globules, molecular size, pH of the emulsion, absorption, adsorption, and the kinetics of the system.

RAW OILS

Raw oils used alone or in conjuction with sulphated oils or other soluble compounds act as softeners, plasticizers, and lubricants.

Olive oil, teaseed oil, lard oil, and triple distilled oleic acid are the low titre oils most used, while tallow and coconut oil are the high titre fats adapted in large quantities to textile processing.

SOAPS

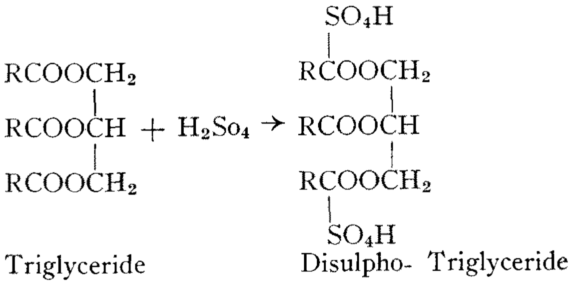
The detergent action of soaps is well known. Textile soaps should have good emulsifying action, freedom from hydrolysis in solution, non-rancidity, good solubility, peptizing ability, and excellent rinsibility.

Most favored are soaps made from olive oil or highly refined oleic acid. Inorganic chemicals such as the tetrapyro-phosphates and sodium hexa-meta-phosphate used as additives improve the rinsibility and prevent the formation of insoluble soaps and their subsequent absorption in the textile fibres.

SULPHATED OILS

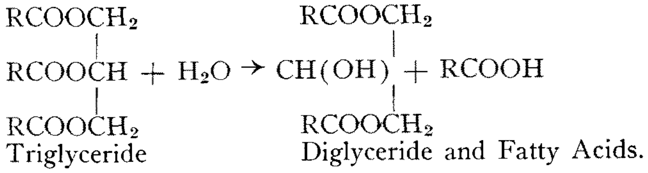
Sulphated oils are used for wetting, penetrating, plasticizing, impregnating and solubilizing as well as for the elimination of static electricity during winding and twisting of the fibres.

The colloidal and physical properties of these oils vary according to the raw oils used, amount of combined sulphuric anhydride and the method of processing. Sulphation is never carried to completion; so that they contain a certain proportion of sulphated glycerides, sulphated fatty acids, neutral oil and free fatty acids. During sulphation of castor oil the following reactions occur:



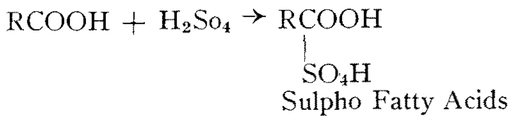
$$\begin{array}{l} RCOOCH_2 \\ \quad | \\ RCOOCH \\ \quad | \\ RCOOCH_2 \end{array} + H_2So_4 \rightarrow \begin{array}{l} SO_4H \\ \quad | \\ RCOOCH_2 \\ \quad | \\ RCOOCH \\ \quad | \\ RCOOCH_2 \\ \quad | \\ SO_4H \end{array}$$

Triglyceride — Disulpho- Triglyceride



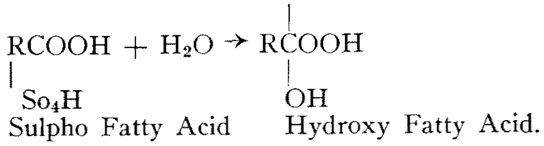
$$\begin{array}{l} RCOOCH_2 \\ \quad | \\ RCOOCH \\ \quad | \\ RCOOCH_2 \end{array} + H_2O \rightarrow \begin{array}{l} RCOOCH_2 \\ \quad | \\ CH(OH) \\ \quad | \\ RCOOCH_2 \end{array} + RCOOH$$

Triglyceride — Diglyceride and Fatty Acids.



$$RCOOH + H_2So_4 \rightarrow \begin{array}{l} RCOOH \\ \quad | \\ SO_4H \end{array}$$

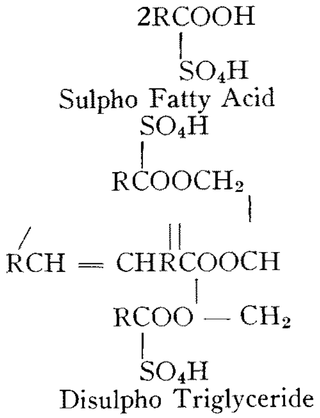
Sulpho Fatty Acids



$$\begin{array}{l} RCOOH \\ | \\ So_4H \end{array} + H_2O \rightarrow \begin{array}{l} \quad | \\ RCOOH \\ \quad | \\ OH \end{array}$$

Sulpho Fatty Acid — Hydroxy Fatty Acid.

The sulpho fraction of a sulphated olive oil has been shown to be:



$$\begin{array}{l} 2RCOOH \\ \quad | \\ SO_4H \end{array}$$

Sulpho Fatty Acid

$$\begin{array}{l} \qquad SO_4H \\ \qquad | \\ \qquad RCOOCH_2 \\ \qquad\qquad | \\ RCH = CHRCOOCH \\ \qquad\qquad | \\ \qquad RCOO - CH_2 \\ \qquad | \\ \qquad SO_4H \end{array}$$

Disulpho Triglyceride

The sulpho fraction consists of the above in the proportion of 2 parts sulpho fatty acids and one part of disulpho triglyceride.

These reactions illustrate the complex nature of the sulphated oils and their variety of possibilities, depending upon the proportions of the various reaction products.

Sulphated oils contain inorganic salts, principally sodium sulphate; which is another variable to be considered. Even a slight variation in the inorganic constituents may seriously alter the colloidal behavior of these products.

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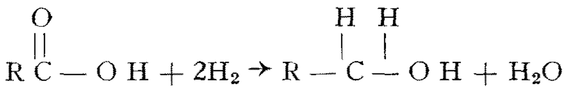
The sulpho glycerides and the sulpho acids are both oil and water soluble and determine the hydrophilic qualities of the sulphated oil. When these are present in sufficient quantities the sulphated oil has value as a wetting and penetrating agent. If the proportion of the combined free fatty acids and neutral oil is in excess the sulphated oil has value as a lubricant, softener and plasticizer. The emulsifying ability is determined by the relationship between the lipophilic unsulphated oil and the sulphated fraction, as well as the pH of the emulsion. Thus by varying the components sulphated oils may be adapted for a multitude of uses.

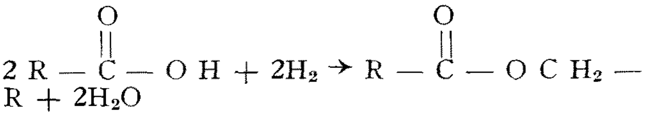
SULPHATED ALCOHOLS

By the process of hydrogenation of fats the carboxyl group is reduced to an alcohol if a specific catalyst is used.



$$R\overset{\overset{O}{\|}}{C}-OH + 2H_2 \rightarrow R-\overset{\overset{H\ \ H}{|\ \ |}}{C}-OH + H_2O$$

With only partial reduction of the acid, esters become the main products formed:



$$2\,R-\overset{\overset{O}{\|}}{C}-OH + 2H_2 \rightarrow R-\overset{\overset{O}{\|}}{C}-O\,C\,H_2-R + 2H_2O$$

Sulphates of these alcohols may be produced by means of sulphuric acid. In the case of cetyl alcohol the following reaction occurs:

$$C\,H_3\,(C\,H_2)_{14}\,C\,H_2\,O\,H \xrightarrow{H_2SO_4} C\,H_3\,(c\,H_2)_{14}-C\,H_2\,O\,So_2\,O\,H$$

Cetyl Alcohol — Sulphuric ester of Cetyl Alcohol

After neutralizing with NaOH the sodium salt is obtained.

$$C\,H_3\,(C\,H_2)_{14}\,C\,H_2\,O\,So_2\,O\,H \xrightarrow{NaOH} C\,H_3\,(C\,H_2)_{14}\,C\,H_2O\,So_2\,O\,Na$$

From sperm oil cetyl alcohol may be directly obtained and subsequently sulphated.

These sulphated alcohols contain perhaps even more variables than sulphated oils because of the differences in manufacturing treatment.

By varying the degree of sulphation, the proportion of free alcohol, free ester and percent of inorganic salt, sulphated alcohols may be adapted to many uses in the textile mill. The wetting ability of sulphated alcohols is very great and they have additional value because of their comparative stability in acid solution. As softeners they are very efficient, requiring only a small percent of the weight of the fibre to impart the necessary softness.

Sulphated alcohols and sulphated esters lower surface tension, and are used extensively in the dye vats as leveling and penetrating agents. They further assist dyeing, producing brighter and clearer shades and preventing bronziness and crocking.

Sulphonated alcohols increase scouring efficiency and impart to yarns and fabrics loftiness and desirable hand.

All wet processing of yarns, fibres and fabrics is enhanced by addition of this group of compounds.

FATTY ESTERS

Among the many other compounds classified as fatty esters used for various purposes in the textile industry are: alkoxyamines, amino salts, sulphated amines, quartenary ammonium compounds, sulphated or sulphonated amides, esterified and sulphonated amides, complex amines, fatty acid esters of glycols, and sulphated boro-phosphate fatty acid complexes.

If the hydrogen atoms of ammonium hydroxide or ammonium halide are replaced by suitable organic radicals, the resulting compound is cation active. These quartenary ammonium derivatives of fatty bases, by virtue of the positive charge at the effective part of the molecule, are of value in textile processing. They have merit as permanent finishes for cellulosic fibres, as assistants in stripping vat dyes and for rendering dyestuffs fast to washing. This latter is done by the formation of an insoluble complex by the reaction of the long chain cation of the quartenary ammonium compound with the long chain anion of the dyestuff.

The acylated nitrogen bases and alkylated pyridine derivatives act in much the same way. Stearyl amido methyl pyridinium chloride and cetyl pyridinium bromide are popular cation active compounds.

$C_{16}H_{33}Br$ Cetyl Bromide	+	Pyridine	Cetyl Pyridinium Bromide

FIGURE 1.

Weighting	Sulf. Alcohol—Stearyl Alcohol
Sizing	Sulf. Fats—Diglyco Myristate—Diglyco Palmitate —Diglyco Stearate Sulf. Oils
Boil-off	Sulf. Fatty Alcohols—Sulf. Oils—Soaps
Flame proofing	Sulf. Alcohols
Water proofing	Sulf. Tallow as Emulsifier with Wax and Aluminum Acetate
Anti foaming	High Molecular Fats—Mixed Fatty Alcohols —Sulf. Fats
Bleaching	Sulf. Long Chain Alcohols
Desizing	Sulf. Long Chain Alcohols—Sulf. Oils—Soaps
Printing	Fatty Alcohols
Dyeing	Sulf. Long Chain Alcohols—Sulf. Oils—Soaps—Sulf. Fatty Esters of Aliphatic Compounds—*Sodium Salt of Sulf. Lauryl Myristyl Collamide* —Tech. Nical Mixtures of Salts Quart. Ammon. Bases — Fatty Borosulfo Phosphate — Pridinium Compounds
Kier-boiling	Sulf. Alcohols—Sulf. Oils—Soaps—Sulf. Alcohol-*Amine Compounds*
Scouring	Sulf. Alcohols—Soaps—Sulf. Oils—Sulf. Esters of Aliphatic Compounds — Sulf. Lauryl Myristyl Collamide—Fatty Alcohol Borosulfo phosphate
Finishing	Sulf. Oils—Sulf. Tallow—Stearyl Alcohol—Sodium Lauryl Sulphate—*Sulf. Fatty Esters of Aliphatic* Compounds—Fatty Alcohol Borosulfo Phosphate Quart. Ammon. Compounds—Pyradine Salts containing B_{16} H_{33} Radical
Discharge printing	Sulf. Fatty Alcohols
Spotting	Diglyco-Laurate—Sulf. Alcohols
Degreasing	Diglyco-Laurate—Sulf. Alcohols—Sulf. Oils
Fulling	Sulf. Alcohols—Soaps—Sulf. Fats
Delustering	Sulf. Oils—Sulf. Fatty Alcohols—Soaps
Felting	Sulf. Alcohols—Sulf. Fats—Soaps
Carbonizing	Sulf. Alcohols
Mercerizing	Octy. Alcohol
Lubrication	Sulf. Oils—Raw Oils—Fatty Alcohols
Softening	Sulf. Oils—Sulf. Alcohols—Fatty Alcohols—Fatty Alcohol Borosulfo Phosphate — Quart. Ammon. Compounds
Dispensing and Emulsifying	Sulf. Oils—Soap Alcohols—Diglyco-Laurate—Di*glyco-Stearate — Glyceryl Mono Stearate* — Sulf. Fatty Esters of Aliphatic Compounds — Sulf. Lauryl and Myristyl Collamide—Fatty Alcohol Borosulfo Phosphate—Quart. Ammon. Compounds

Negatively charged colloidal rubber may be attracted to fibres by use of cationic compounds, resulting in satisfactory impregnation.

METALLIC SOAPS

The metallic soaps, such as stearates of aluminum, calcium and magnesium are used as waterproofing agents either alone or in mixtures with other waterproofing materials.

WOOL PROCESSING

Wool, which arrives at the mill in a very dirty condition must first be scoured. A soap made from a low titre fat insures good solubility and so an olive oil or oleate soap is preferred. Together with limited amounts of soda ash, the soap solution dissolves the suint, emulsifies the grease and removes some of the dirt and extraneous matter. Wetting agents increase the effectiveness of the scour.

Before the wool can be oiled for working it must be further purified by burring and carburizing. Burring involves the beating out of impurities by a machine. Organic impurities are removed by an acid soak known as carburizing. Wetting agents in the acid solution increase the penetration of the acid solution with consequent increased removal of organic matter.

Lubrication of wool stock is to give the wool fibre more softness and elasticity as well as to preserve its soundness and staple length, and prevent fly and waste in carding and spinning.

The kind of lubricant, the amount used and its method of application are of importance if later difficulties in carding and spinning are to be avoided. During spinning the greatest benefit from lubrication is the increased facility with which the fibres slip by each other and allow the draft and twist to be more evenly inserted in the yarn.

The oil used is determined by the grade of wool being worked and the intended use of the finished textile product, as well as the policy of the particular mill. Wool oils are usually mixtures of raw and sulphonated oils to which mineral oil may be added. Often a hygroscopic material such as glycerine or diethylene glycol is of advantage.

A good wool oil should have the following properties: (1) be easily removed; (2) freedom from discoloration; (3) ability to increase strength of the fibre; (4) good lubricating value; (5) freedom from tendency to cause spontaneous combustion; (6) non-corrosive; (7) non-rancidity.

Wool oils are applied by spraying, soaking, or splashing. Varying quantities are used, but for wool spinning a forty per cent emulsion is frequently used.

Soap and wetting agents are again used when the wool is backwashed after spinning.

During the processing of felts, soaps, sulphated oils and sulphonated alcohols are used in considerable quantities. In the past soaps made from sulphated oils were used because of the diminished tendency of hydrolysis and the formation of insoluble soaps.

During fulling it is necessary to make the wool fibres draw together in a felting action, by the application of moisture, heat and pressure. Fulling agents in the form of palm oil soaps and sulphonated alcohols increase the swelling of the fibres. This swelling and applied pressure force the fibres to move in one direction because the scale formation of the wool fibre prevents backward slippage. Thus the fibres become entangled and ultimately felted.

PROCESSING OF SILK

Most textile mills receive silk in the form of raw silk in skeins. The sericin or outer gum coating is removed from the fibroin by treating the silk at temperatures of about 200° F in soap solutions which have been augmented with sulphated oils or alcohols. After subjection to this degumming treatment, the silk emerges lustrous and with a smooth feel.

Degumming is followed by boiling-off. Boil-off compounds are variable but are mixtures of the wetting agents, emulsifying agents, mild alkalis and water softeners which give insurance of high solvency, good rinsibility, and excellent fibre conditioning.

After the boil-off, the silk is allowed to absorb 11% moisture, and is then ready for throwing which consists in twisting and winding the strands to make the proper sized threads, having the needed elasticity and tensile strength. Before throwing silk must be oiled, for the following reasons: (1) To increase tenacity and tensile strength; (2) To diminish static electricity; (3) To make the yarn soft and supple; (4) To prevent breakage and abrasion during twisting; (5) To coat, and bind the filaments together; (6) To make the yarn less sensitive to atmospheric conditions.

Silk throwing oils are very often mixtures of sulphated oils made from olive, teaseed, or neatsfoot oils to which raw coconut oil is added to the extent of about forty per cent.

Preparatory to finishing and dyeing, the silk yarns or knit goods must be thoroughly cleaned which calls for another detergent bath wherein the same principles of textile cleaning are demanded, as before described.

SYNTHETIC FIBRE PROCESSING

Synthetic fibres like silk must be oiled before winding and twisting and in general are treated in much the same manner as silk. The oil used must fill the following requirements: (1) Must not stain or discolor; (2) Must be easily scoured out and hence readily soluble in warm water; (3) Must be chemically neutral(pH 7); (4) Must be picked up readily and retained by the yarn; (5) Must not oxidize or turn rancid over a period of time; (6) Should have little odor and should not develop one.

COTTON PROCESSING

At the cotton mill the cotton bales are broken, the bale breaker picks the compressed cotton apart and delivers it in tufts on a belted conveyor to openers which reduce the size of the bunches. The bunches are conveyed to the picker room, where the pickers beat out some of the impurities and deliver the cotton in rolls of batting called laps.

In the picker room the cotton is oiled for further processing. After oiling the cotton is conveyed to the carding machines which remove some of the impurities and separate the fibres from their matted structure and deliver the cotton through a constricted orifice in the form of a sliver.

The sliver from the card is drawn out so that the fibres lie parallel to one another. The slivers must be reduced in size, given a twist and then combed to remove short fibres and spun to make ready for weaving.

Before finishing, cotton goods must be washed free of natural and acquired impurities. This boil-off is done in large kiers with boil-off compounds of variable composition.

If the goods is to be sanforized it must again be treated with an oil having hygroscopic properties and then sent through a steam jet to shrink the goods and draw the weave together.

WEAVING

Previous to the weaving of textiles it is usually necessary to apply warp sizing to the warp threads. Sulphated oils are mixed in with the gum and starch size to eliminate harshness, and impart flexibility after the size has dried on the threads. If the sizing is wiry, injury may result during weaving.

MISCELLANEOUS TEXTILE OPERATIONS

Because of the general nature of this article, the processing of all textile products cannot be thoroughly described. The purpose is to give a picture of the manner and extent to which fats and their derivatives find application in the textile industry.

The outlines given above carry the most common textile materials through processing preparatory to dyeing and finishing. Table (1) lists the many textile operations and the fat derivatives used in each case. When the properties of the various fat derivatives are kept in mind it is easy to reason the purpose of their use in each case. It is important to remember that wherever wetting, penetrating, emulsifying, scouring, softening or lubricating is demanded, one or several of the fat derivatives will serve; and wherever water is used in processing one of the fat derivatives will in some way facilitate the operation.

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Solidification Point Curves of Binary Acid Mixtures II. Palmitic, Stearic, Arachidic, Behenic, Lignoceric*

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THE saturated, straight-chain fatty acids offer one of the most complete series of compounds for the study of behavior as influenced by homology. In this instance, of theoretical interest is not only the effect of increasing length of the alkyl group upon the tendency towards compound formation between adjacent members of even-number carbon atom content, but also the changes in the pertinent solidification point curves which are deemed to reveal this property. Of practical interest is the fact that solidification point curves of binary systems of fatty acids are an analytical aid in the determination of the composition of two-component fatty acid mixtures (1).

Preparation of Fatty Acids

Palmitic and stearic acids were recovered from commercial products of *ca* 90 per cent purity by methods already described (2). Arachidic acid was isolated by fractional distillation of its methyl ester from a mixture of hydrogenated fish oil fatty acids. Behenic acid was prepared by hydrogenating its unsaturated homolog, erucic, which had been previously isolated from rape seed oil. Lignoceric (n-tetracosanic) acid was prepared from behenic acid by malonic ester synthesis. The quality of these acids is on a par with the high purity products prepared by Francis & Piper (3). Their properties are summarized in Table I.

TABLE 1.
Properties of Saturated Fatty Acids.

	Molecular Weight		Melting Point °C.		Solidifying Point °C.	
Acid	theory	found	reported	found	reported	found
Palmitic	256.4	256.7	60.95-62.90	62.90	62.30-62.60	62.22
Stearic	284.5	284.6	69.60-70.10	69.95	69.39	68.85
Arachidic	312.5	312.9	75.15-75.35	75.30	74.20	74.35
Behenic	340.6	341.0	79.60-80.00	79.80	79.20-79.70	79.35
Lignoceric	368.6	369.0	84.00-84.15	84.10	83.10-83.90	83.40

Determination of Solidification Points

Solidification temperatures were determined for palmitic-stearic, stearic-arachidic, arachidic-behenic, and behenic-lignoceric acid mixtures. Their percentage compositions ranged in approximately five per cent increments from zero to 100 mol per cent of each constituent. Because past experience (2) had shown that critical points in the solidification point curves of adjacent pairs of members in this homologous series may be expected at approximately fifty and seventy mol-per cent of the lower acid involved, the increment of change in composition was reduced in order the better to define the curve in these zones. Approximately forty points were established for each pair. All of them fell upon a smooth curve.

No essential change was made in the procedure previously described (2) for the determination of solidification points. Because of the higher melting points of the acids in question, the water jacket of the original apparatus was replaced by an oil bath electrically heated with an internal coil connected in series with a variable resistance.

As before, a sample weighing about 0.7 g. was melted in a three-inch test tube suspended in a loose-fitting glass collar. The bulb of a calibrated thermometer graduated in intervals of 0.2° was then completely immersed in the liquid, after which the heat input of the bath was so regulated that the rate of temperature fall of the system, using only the surrounding atmosphere as cooling medium, became approximately 0.8°C. per minute. This arrangement proved to be very satisfactory for the determination of the solidification point temperatures noted in the 44° to 80°-range characteristic of the fatty acid mixtures of this series (Table 2).

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*Assistance in the preparation of these materials was furnished by the personnel of Works Projects Administration Official Project No. 65-1-53-2349.