Oleochemical Surfactants and Lubricants in the Textile Industry

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This paper reviews the published literature on the uses of oleochemical surfactants and lubricants in the textile industry with a dual emphasis on textile technology and effects that oleochemicals can have on that technology. Oleochemical derivatives are used in the textile industry as surfactants, emulsifiers, wetting agents, antistatic agents, softeners, antimicrobial agents, water and oil repellents, antisoil agents, lubricants, cohesive agents and dyeing assistants. The relationship between the amount of fatty acid derivatives consumed in textile operations and global fiber production is discussed. Small amounts of oleochemicals acting at interfaces are invaluable in their effects on textiles. Oleochemical surfactant chemical and physical properties of importance in textile operations are described, and the relationships between certain properties of oleochemicals and their performance on textile fibers are reviewed. The basic principles and technology of spin finishes and textile processing aids are discussed. The effects of oleochemical surfactants in dyeing and as finishing agents for textile fibers are described briefly. The conclusion presents the prognosis for the future of oleochemicals in the textile industry.

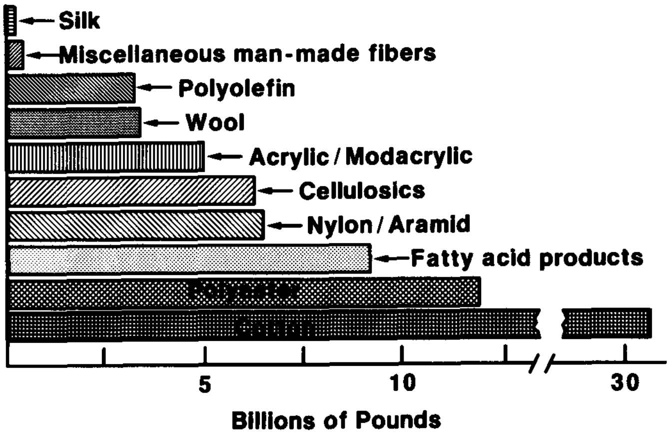

FIG. 1. Estimated production-use relationship of organic fibers to fatty acid products in 1983. Reprinted from Ref. 1, courtesy of Marcel Dekker, Inc.

The literature contains many articles about the uses of oleochemical surfactants and lubricants in the textile industry. That literature is reviewed in "Fatty Acids in Textiles," by Patterson and Proffitt, to be published by Marcel Dekker as one chapter in a two-volume book, *Fatty Acids*, edited by R.W. Johnson and E. Fritz (1). The purpose of this article is to provide for oil and surfactant chemists a brief overview of the literature on oleochemical-based surfactants and lubricants in the textile industry.

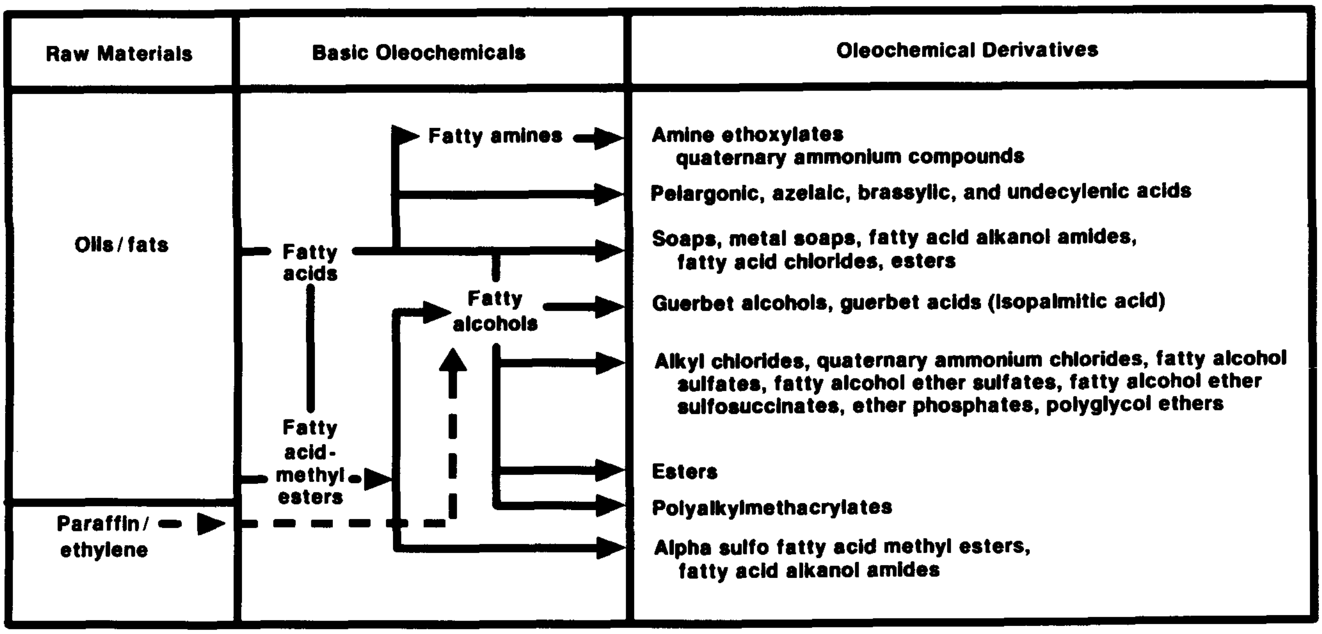

FIG. 2. Production flow chart for basic oleochemicals and derivatives. Adapted from Ref. 4. Reprinted courtesy of the American Oil Chemists' Society.

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The relationship between the 1983 consumption of fatty acid derivatives in textile operations and global fiber production—which totaled 70 billion lb—is shown in Figure 1 (1). Worldwide consumption of edible fats and oils was 132 billion lb in 1982 (2), and 6.7% of fatty acids and their derivatives were used by the textile industry in 1980 (3). Based on these facts, it is estimated (1) that about one lb of fatty acid products is used for every eight lb of textiles. An alphabetical listing of oleochemical derivatives used in the textile industry includes antimicrobial agents, antistatic agents, cohesive agents, detergents, dyeing assistants, emulsifiers, lubricants, softeners, soil release agents, surfactants, water and soil repellents and wetting agents.

The chart in Figure 2 (1,4) shows the broad range of chemicals derived from natural fats and oils. These oleochemicals and their derivatives are a major portion of the compounds used as textile processing aids. All have long alkyl chains, and similar materials might also be derived from petrochemical sources (5,6).

INTERFACIAL PERSPECTIVE

Surfactants and lubricants are the workhorse chemicals of textile processing. Small amounts of these materials acting at interfaces between fibers, between fibers and machine parts, or between fibers and processing liquids are invaluable in their effects on the processing performance and quality of textile products. This paper reviews some of the roles played by oleochemical derivatives at important interfaces during textile production. This interfacial approach is supported by the work of Jacobash (7), Schwuger (8), Kleber (9), and Billica (10).

SURFACTANTS AND THEIR PROPERTIES

Effects of surfactant properties which are important in textile production are shown in Table 1 (1). These effects include enhancement of wetting, dispersion, emulsification, foaming, lubrication, water repulsion and conduction of electrical charges. Reducing surface tension to enhance wetting of textile fibers is a key requirement. Many textile fibers have low surface energies, and wetting agents are needed to reduce the surface tension of water from 72 milliNewtons per meter (mN/m) down to a level equal to the surface energy of the fiber or to the "critical surface tension for wetting" of the fiber (35) for effective application of processing aids to fibers from aqueous solutions or for wet-processing of fibers. Typical values of "critical surface tension for wetting" (γ_C) for various fibers in Table 2 (1) show the large differences in wettability among fiber types. Water contact angles range from 38 to 112°.

The variety of available surfactant polar groups is shown in Figure 3 (1,41). The fact that a large proportion is anionic reflects inclusion of products used in commercial and home laundering.

Effects of oleochemical molecular structure on properties important in textile operations are demonstrated by the following figures and tables. For nonionic surfactants, surface tension reduction is made more efficient by increasing the length of the hydrophobic alkyl chain or by decreasing the size of the hydrophilic polyoxyethylene chain (Fig. 4). Figure 5 shows the effect of the N-alkyl group chain length on wetting strength for an N-dodecanoyl surfactant series. The optimum chain length is five carbons.

Most textile processing aids are applied to fibers from aqueous solutions or emulsions. A key property

TABLE 1

Effects of Surfactant Properties in Textile Operations

Property	Effect	Reference[a]
Surface tension reduction	Enhance wetting	(11,12)
	Facilitate oily soil removal	(13,14)
	Aid emulsification	(15,16)
Micelle formation	Solubilize oily soils	(17,18)
	Control diffusion rate in dyeing	(19,20)
	Stabilize emulsions	(11,21)
Elastic film formation	Produce stable foams	(22,23)
Adsorbtion on solid surfaces	Suspend dye particles	(24,25)
	Suspend solid soil particles	(11,26)
	Reduce boundary friction	(27,28)
	Increase water repellency	(29,30)
Lubrication	Control fiber friction	(31,32)
Electrical conduction	Control static electrification	(33,34)

[a] To representative discussions of indicated topics.

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TABLE 2

Fiber Wetting Properties

	Water contact angle		Critical surface tension for wetting	
Fiber type	Degrees	(Ref.)	mN/m[a]	(Ref.)
Cotton	47	(36)	44	(37)
Wool	61	(38)	45	(37)
Cellulose (Viscose)	38	(36)	57	(39)
Cellulose acetate	52	(36)	39	(39)
Polyacrylic	74	(40)	45	(40)
Polyamide	66	(40)	46	(37)
Polyester	71	(40)	43	(37)
Polyolefin	95	(40)	31	(37)
Polyfluorocarbon	112	(40)	19	(40)

[a] MilliNewtons per meter.

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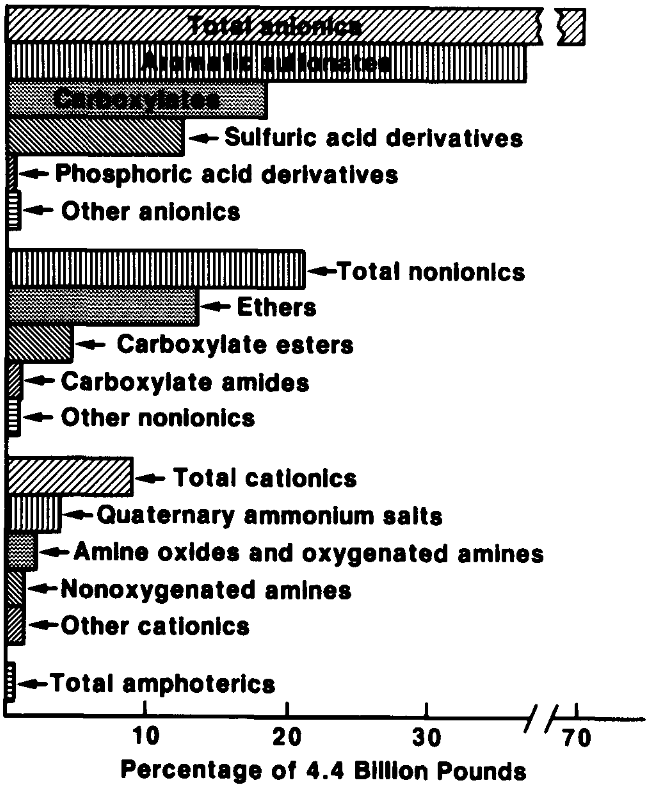

FIG. 3. 1982 surfactant production in the U.S.A. Reprinted from Ref. 1, courtesy of Marcel Dekker, Inc.

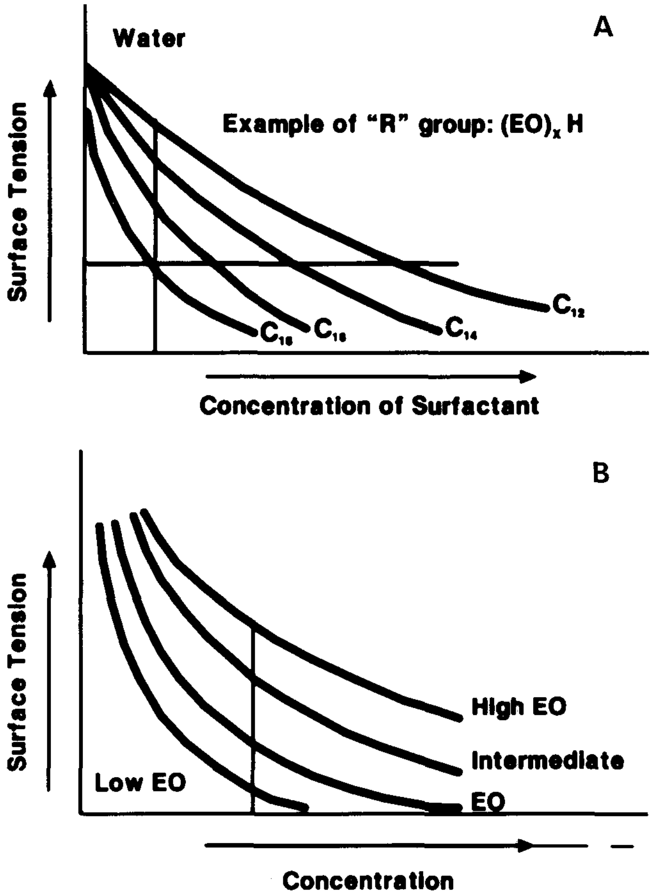

FIG. 4. Effects of (a) nonpolar and (b) polar variations in surfactant structure on performance. Reprinted from Ref. 12, courtesy of the American Association of Textile Chemists and Colorists.

related to the emulsifying capabilities of surfactants is the well-known HLB or "hydrophile-lipophile balance" introduced by Griffin (42). For nonionic surfactants the expression for calculated HLB is HLB = 20 (1-Mo/M), where Mo is the formula weight of the hydrophobic group in the molecule, and M is the total molecular weight. HLB values range from <1 to 40. Lower values indicate higher oil solubility and higher values indicate greater water solubility. Effects of surfactant structure on HLB are shown in Table 3 (1).

Another surfactant property important for textile processing is foam formation. In many operations low-foam surfactants are needed to eliminate the nuisance of foaming, but in other operations, like foam application of textile processing aids, dyes, or sizes, high-foaming surfactants are needed (1). Table 4 (1) shows the effect of surfactant structure on foaming. A 12-14 carbon alkyl hydrophobe with a sodium sulfate hydrophilic group gives the high foam needed for foam application (22).

Adsorption of surfactants on fiber surfaces in aqueous solutions is important, especially in fabric softening. Common fibers assume a negative charge in water and adsorb positively charged cationic surfactants more readily than anionic surfactants (46). Table 5 (1) shows the relationship between the amount of dodecylpyridinium bromide adsorbed and the zeta potential of the fiber. The more negatively charged the fiber, the greater is the amount adsorbed, except for the intermediate amount adsorbed on polyester.

SPIN FINISHES AND PROCESSING FINISHES

In processing of fibers, frictional drag can cause fiber damage, and static charge accumulation can disrupt fiber handling operations unless processing aids are applied. These nondurable chemical mixtures are called "spin finishes" when applied to fiber surfaces in the production of man-made fibers, and "processing finishes" when applied to natural or man-made fibers

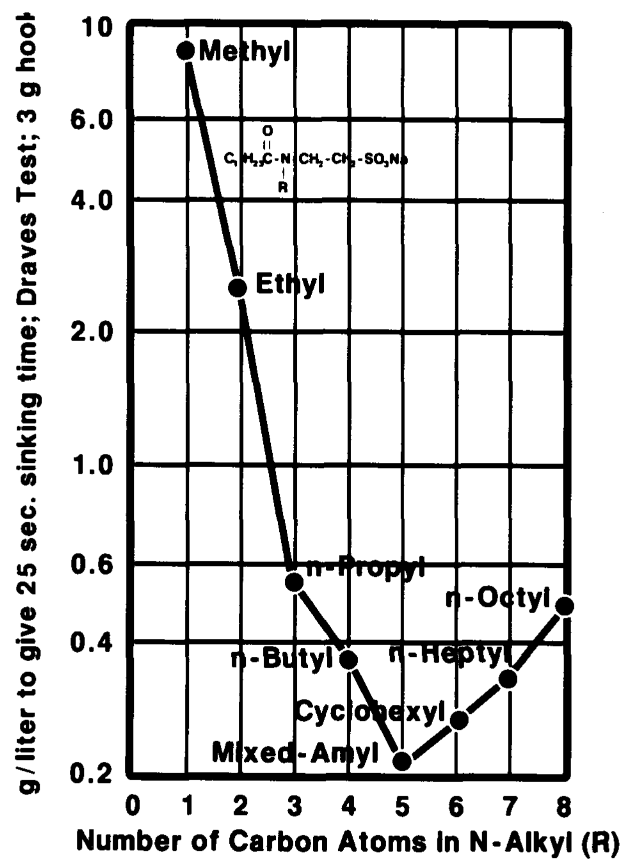

FIG. 5. Wetting strength of N-dodecanoyl series vs number of carbon atoms in N-alkyl group. Reprinted from Ref. 25, page 465, courtesy of Marcel Dekker, Inc.

TABLE 3

Effect of Surfactant Structure on HLB

Surfactant structure[a]	HLB
Sodium lauryl sulfate	40.0
PEG 6000 monostearate	19.1
PEG 1500 monostearate	16.8
PEG 1000 monooleate	15.9
PEG 1000 monostearate	15.6
PEG 600 monooleate	14.6
PEG 400 monolaurate	13.1
PEG 400 monostearate	11.7
Triglycerol monolaurate	10-11[b]
PEG 400 dilaurate	9.9
PEG 200 monostearate	7.9
Hexaglycerol distearate	7-9[b]
N,N-Diethylstearamide	7.0
Glycerol monostearate	3.8

[a] PEG, Polyethylene glycol; the number following is the molecular weight of the attached polyoxyethylene chain.

[b] Private communication from J.P. Redston and R.T. McIntyre.

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during subsequent processing steps. For many years, textile spin finish technology was a closely guarded secret, but much has been published in the last 10-15 yr. The chemistry, function and properties of these mixtures and their components have been described by Redston, Bernholz and Schlatter (47); Rieckert (48); Daefler (49); Guersen (50); Riehl (51,52); Postman (53); Vaidya (54); Garg (55); Nettles (56); Billica (10,57); Crossfield (58); Gray (59); Kleber (9,60-62); Jones (63); Patterson and Proffitt (1), and Kao Corp. (24).

Major processing effects controlled by finishes are friction, static and cohesion. In addition, spin finishes must satisfy a large number of requirements as demonstrated by the list in Table 6 (1) of spin finish attributes other than friction, static and cohesion control. The list includes general requirements like "chemical and physical stability" and highly specific requirements like "nonswelling to polyurethane."

Friction control. Olsen (31) described the frictional behavior of lubricated textile yarns at speeds up to 300 yd/min, but recent increases in textile processing speeds require expanded understanding of high-speed behavior. The friction diagram from Olsen's work was modi-

TABLE 4

Effect of Surfactant Structure on Foaming[a]

	Foam height (mm) Hydrophilic group				
Chain length of fatty hydrophobe	Sodium sulfate		15 Mol EO	20 Mol EO	30-33 Mol EO
C-12	240	220[b]	197	195	180
C-14	246	231	—	—	—
C-16	178	244	153	167	149
C-18 saturated	151	227	165	152	115
C-18 unsaturated	226	246	140	160	140
% Surfactant	0.11	0.25	0.25	0.25	0.25
ppm $CaCO_3$	100	0	300	300	300
Reference	(11,22,43)			(11,22,44)	

[a] Ross-Miles method, ASTM method D1173-53.

[b] Sodium dodecylbenzene sulfonate by comparison equals 208 mm (Ref. 45).

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TABLE 5

Adsorption and Fiber Surface Properties

Fiber type	Critical surface tension mN/m	ζ Potential[a] mV	Adsorption[b] g/cm^2 Fiber $\times 10^{10}$
Polypropylene	27	-112	33
Polyamide	42	-112	39
Polyester	43	-116	24
Polyacrylonitrile	—	-108	17
Polyvinyl alcohol	37	-73	7

[a] In water at pH 9.8.

[b] 0.0004 M dodecylpyridinium bromide at 9.8 pH. Data source: Ref. 46.

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TABLE 6

Supplemental Spin Finish Attributes[a]

- Biodegradable
- Consistent supply
- Ingredients easily handled
- Spontaneous fiber wetting
- Easily wettable
- Nonallergenic
- Nonirritating
- Nontoxic
- Odor resistant
- Resistant to bacterial growth
- Chemically and physically stable to storage
- Low foaming
- Nonswelling to polyurethane
- No dyeing interference
- Cost-effective
- Emulsifiable
- Thermally stable
- Limited volatility
- Nonsmoking
- Nondepositing
- Resistant to oxidation
- Nondegrading to fibers
- Nonyellowing
- Resistant to photodegradation
- Processable in blends with other fibers
- Scourable where needed
- Compatible with other customer processing needs
- Durable where needed

[a] Attributes other than friction, static and cohesion control.

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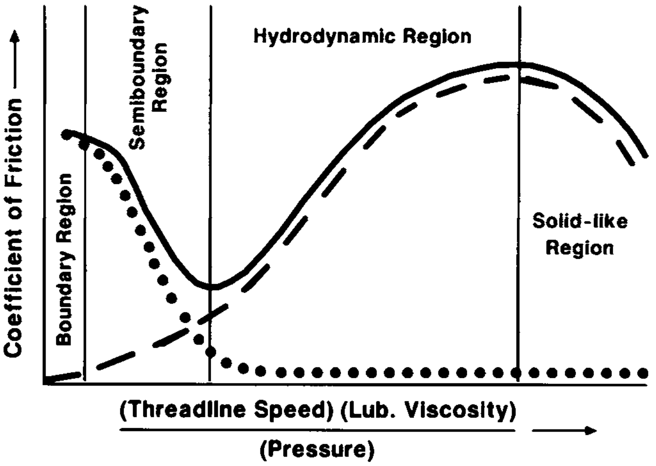

FIG. 6. General frictional behavior of lubricated textile yarn. Reprinted from Ref. 1, courtesy of Marcel Dekker, Inc.

fied by Kao Corp. (24) to add the "solid-like" region (Fig. 6) (1). The composite curve (solid line) is the sum of a boundary friction component (dotted line) and a hydrodynamic component (dashed line). There are four regions of frictional behavior. These regions, boundary, semiboundary, hydrodynamic and "solid-like," differ in lubricant viscosity and in speed and load conditions, as described in Table 7. Three literature explanations for the decrease in friction with speed in the solid-like region are: (i) slip is between the lubricant and a surface rather than within the lubricant layer (24); (ii) lubricant viscosity is reduced by the heat from friction (32); (iii) dynamic mechanical properties rather than steady-state viscosity are more important at higher speeds (64).

A textile finish must provide the right balance between fiber/fiber static friction and fiber/metal dynamic friction for the particular system on which the fiber is processed. Figure 7 (1) is a composite based on the work of several researchers (52,65–68), and shows the relative friction balance required for various processing systems.

BOUNDARY LUBRICANTS

At times high boundary friction is needed to hold masses of cut staple fibers together (10) or prevent "sloughing" of yarn from packages (24). Prevention of broken or damaged filaments, on the other hand, usually requires low boundary friction. Fiber/fiber static friction (Fig. 7) can be modified with materials known as boundary lubricants which are solids or viscous liquids which separate rubbing surfaces and may adsorb on them. With simple fatty-based molecules, such as alkanes, acids, alcohols, amines and amides, boundary friction is reduced by increasing alkyl chain length (Fig. 8), polarity of the terminal group (Fig. 8), or adsorption on either rubbing surface (27,28,69). Transition from the liquid to solid state, as lubricant chain length increases, causes a large reduction in boundary friction. This effect is reversed by increasing temperature to melt the solid lubricant (Fig. 9). Other materials useful as boundary lubricants include polyethylene wax, polyalkylene glycols and silicones (70).

HYDRODYNAMIC LUBRICANTS

Oleochemical derivatives provide a broad range of lubricants for modification of hydrodynamic friction in textile operations. Lubricant shear resistance is the primary finish variable controlling hydrodynamic friction (31), but the level of shear resistance must be consistent with other needs. The literature (10,24,53,60) lists as lubricants (Table 8) natural oils and derivatives

TABLE 7

Characteristics of Friction Regions

	Characteristics			
Region	Sliding speed	Contact load	Friction vs speed	Comments
Boundary	Slow	Heavy	Decreases	Intimate contact
Semiboundry	Intermediate	Intermediate	Decreases to a minimum	Transition
Hydrodynamic	Fast	Light	Increases	Fiber rides on lubricant film
Solid-like	Fast	Light	Decreases	Slip between lubricant and surface (24) Thermal effect (32) Dynamic properties of lubricant; not steady-state viscosity (64)

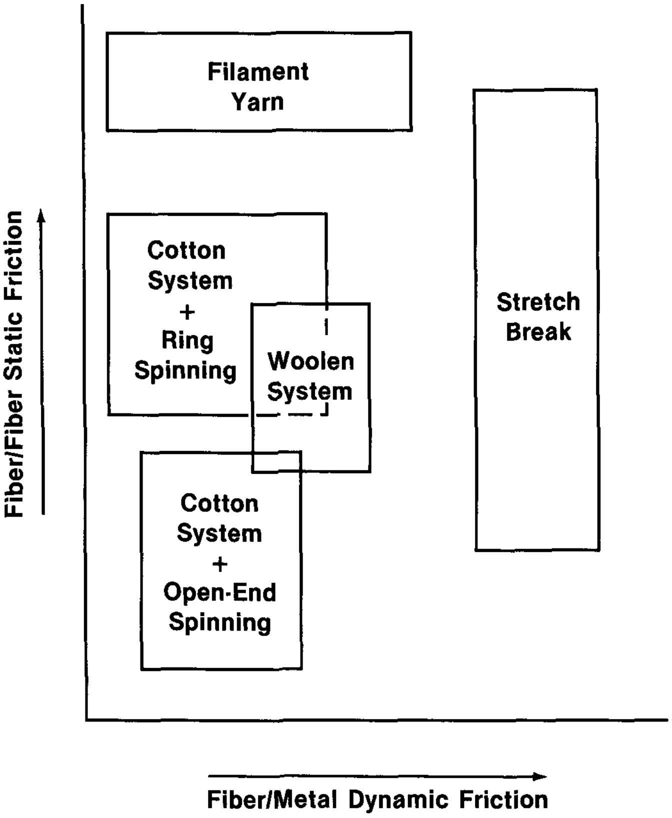

FIG. 7. Diagram of textile processing vs friction requirements. Based on work by Riehl (52), Sprenkmann and Marquardt (65,66); Kleber (67), and Marquardt (68). Reprinted from Ref. 1, courtesy of Marcel Dekker, Inc.

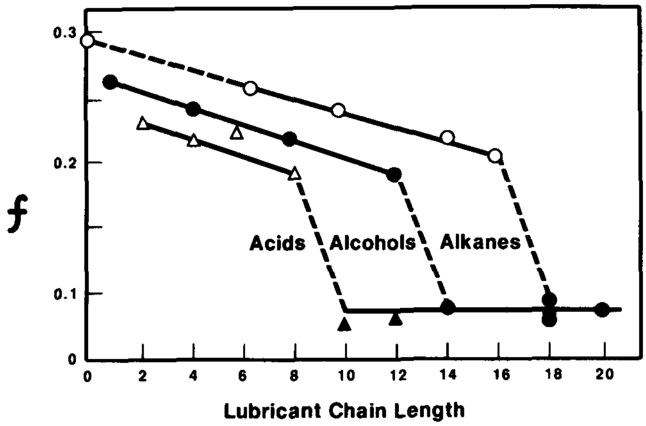

FIG. 8. Lubrication of polyethylene terephthalate by homologous series of fatty acids, alcohols and alkanes. Reprinted with permission from *Journal of Physical Chemistry 66*:1142 (1962). Copyright 1962, American Chemical Society.

including ethoxylated and propoxylated modifications, phosphate esters, and many related materials. Figure 10 demonstrates (24) the effects on friction of a broad range of fatty esters with different viscosities.

Increased use of high temperatures to modify the fiber configuration (71,72) has required lubricants which are resistant to long-term exposure to temperatures above 200°C. The main problems are smoking and deposit formation (73). Finishes for high-temperature processes must either decompose completely to gaseous products to leave no deposits or decompose very

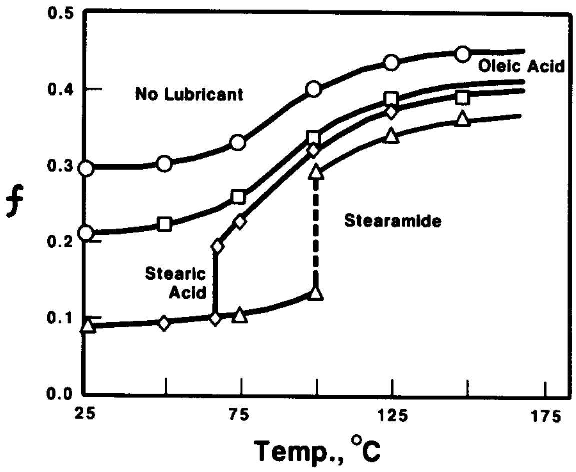

FIG. 9. Effect of temperature on the boundary lubrication of polyethylene terephthalate. Reprinted with permission from *Journal of Physical Chemistry 66*:1140 (1962). Copyright 1962, American Chemical Society.

TABLE 8

Lubricants

- **Natural**
  - Mineral
    - Oils
    - Waxes
  - Vegetable Oils (triglycerides)
    - Coconut oil
    - Peanut oil
- **Synthetic**
  - Esters
  - Polyethers
    - Polyoxyethylene
    - Polyoxyethylene-polyoxypropylene
    - Polyphenylethers
  - Silicones
  - Ethoxylated fatty acid and alcohols
  - Ethoxylated synthetic alcohols
  - Polyethylene wax
  - Polybutenes
  - Ethoxylated castor oil

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little and remain fluid on hot surfaces (24). Polyether copolymers typify the decomposing type, and hindered synthetic fatty acid esters from alcohols with no β-hydrogens resist decomposition and remain fluid on hot surfaces.

Antistatic agents. Many textile fibers act as electrical insulators and, as such, they can accumulate electrostatic charges which may be troublesome in fiber processing and use. Accumulation of charges is related to two factors (74), charge generation (75) and charge dissipation.

TABLE 9

Triboelectric Series[a]

Positive

- Asbestos
- Glass
- Human hair
- Nylon-wool
- Lead[b]
- Cotton-viscose[b]
- Silk
- Aluminum
- Cotton-paper-viscose[b]
- Ramie[b]
- Steel[b]
- Sealing wax[b]
- Hard rubber
- Acetate
- Nickel-coper[b]
- Lucite® acrylic resin[b]
- Polyvinylalcohol[b]
- Synthetic rubber
- Dacron® polyester fiber
- Orlon® acrylic fiber
- Polyvinylchloride[b]
- Dynel[b]
- Velon[b]
- Saran
- Polyethylene[b]
- Polypropylene[b]
- Teflon® TFE-fluorocarbon
- Silicone rubber

Negative

[a] Derived by combining triboelectric series reported by Wilson (34), Lester Laboratories (76) and Lehmicke (77).

[b] Order varies from study to study, or all were not included in every study. ®Du Pont registered trademark.

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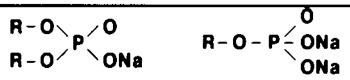
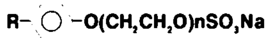
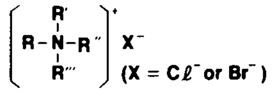
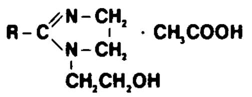
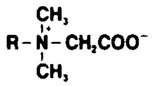
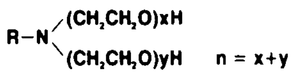
The ease of formation of a charge is determined by the position in the triboelectric series (Table 9) of a fiber and of the surface against which it rubs. The farther apart two materials are in the series, the more easily they can generate a charge when rubbed together and then separated.

Charge dissipation is controlled by the conductivity of the fiber and its finish as shown in the diagrammatic representation of the dissipation process (Fig. 11) from work by Medley (78). Log R or the logarithm of electrical resistivity is used as an indicator of the ease of charge dissipation. Figure 12 shows the relationship between static protection and Log R. When Log R is less than 10, static protection is good, and when Log R is greater than 13, static protection is very poor.

Antistatic agents either modify the position of the fiber in the triboelectric series (Kawanaka, H., and M. Katsumi, oral presentation, Japan Chemical Society Congress, Tokyo, 1963) or conduct charge away (78). Conductive oleochemical derivatives usually are the materials of choice to control static electrification in textile processing. Table 10 shows the types of surfactants used as antistatic agents (24). The list is domi-

TABLE 10

Main Surfactants Used as Temporary Antistatic Agents

Ionic	Chemical composition	Chemical structure (Ex)
Anionic	Alkyl phosphate type	
	POE alkyl ether sulfate type	$RO(CH_2CH_2O)nSO_3Na$
	POE alkylphenyl ether sulfate type	
Cationic	Quaternary ammonium halide type	
	Imidazolin type	
Amph-oteric	Alkyl betaine type	
Nonionic	POE fatty acid ester type	$RCOO(CH_2CH_2O)nH$
	POE alkyl ether type	$R\text{-}O(CH_2CH_2O)nH$
	POE alkyl phenyl ether type	
	POE alkyl amine type	

Note: R:C = 8∾22; n, additional mol of EO; reprinted from Ref. 24, p. 179, courtesy of Kao Corp.

TABLE 11

Chemicals Which Adjust Cohesion

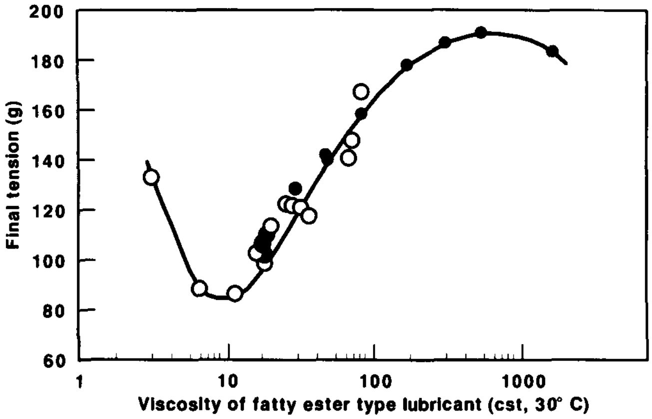
Agent	Cohesion level	Ref.
Fatty acid sarcosides	High	(48,52)
Vegetable oil	High	(79)
Mineral oil	Low	(79)
Anionic and nonionic materials	High	(80)
Cationic materials	Low	(80)
Triesters of phosphorus oxychloride	High	(62)
Mixtures which separate into tacky and lubricating phases	High	(24)
Solids with low water sensitivity	High	(24)

nated by oleochemical derivatives based on phosphorus, sulfur or nitrogen chemistry.

Cohesive agents. Cohesive agents are needed in textile processing for the temporary binding together of filaments (9,10,47,53) to give stability to packages and to prevent snagging on machinery parts or splitting apart of fiber assemblies such as tows. Cohesive agents either raise boundary friction or provide interfiber tackiness (63). Cohesive finishes can supplement the effects of fiber crimp to give integrity to fragile assemblies such as slivers and webs. Table 11 lists some of the types of chemicals which help control cohesion at a higher or lower level. No explanations are given for the low cohesion with mineral oils or cationic antistats, but in the case of cationic antistats, it is speculated that the low fiber-to-fiber friction associated with fabric softening reduces cohesion also.

Emulsifiers. The functions of emulsifiers are to provide stable aqueous dispersions and to aid in the scouring of finish from fibers (63). The types of chemicals used as emulsifiers are shown in Table 12. They are common anionic, cationic, amphoteric or nonionic surfactants. Emulsifying properties of oleochemical derivatives were discussed earlier in dealing with surfactants and their properties, but Table 13 shows some specific comments from the literature on emulsifier requirements and the types of oleochemical emulsifiers which meet the requirements. Specifically mentioned are polyglycerol esters; sulfated and ethoxylated fatty acid derivatives; derivatives of fatty acids, amides, amines, alcohols, and of phosphate esters; and nonionic surfactants.

Additives. Certain additives are used in small amounts in textile finishes to achieve supplemental effects. Many of the additives are based on oleochemi-



Lubricant: fatty ester
Fiber: PET, 250 d-48 s, semi-dull
Friction pin: TiO_2 (12mm ϕ)
Contact angle: 180°
Oil concentration: 4–6%
Initial tension: 50 g
Yarn speed: 100 m/min

Ester	Viscosity (cst. 30°C)
Methyl laurate	2.91
Methyl oleate	6.73
Butyl stearate	9.00
Octyl oleate	12.10
2-Ethyl hexyl stearate	12.70
Tridecyl laurate	13.00
Octyl stearate	13.10
Neopentylglycol dicaprylate	14.00
Dioctyl adipate	14.60
PEG 200 dicaprylate	21.20
Tridecyl oleate	22.20
Oleyl oleate	23.80
Tridecyl stearate	24.50
Ditridecyl adipate	41.30
Trimethylolpropane trilaurate	49.70
Glycerol dioleate	68.80
Tridecyl ricinoleate	73.20
1,6-Hexanediol diisostearate	115.20
Pentaerithritol monooleate	562.00

FIG. 10. Effect of viscosity of fatty ester type lubricant on friction force. Reprinted with permission from Ref. 24, page 117, courtesy of Kao Corp.

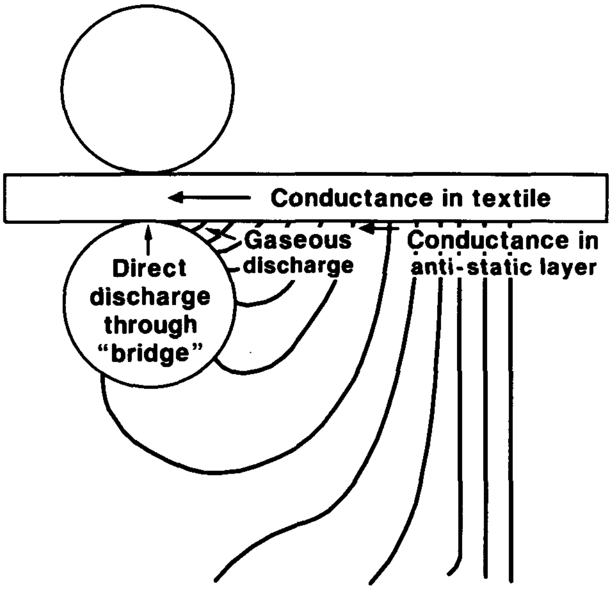


FIG. 11. Diagrammatic representation of dissipation process. Reprinted from Ref. 78, page 113, courtesy of the Textile Institute.

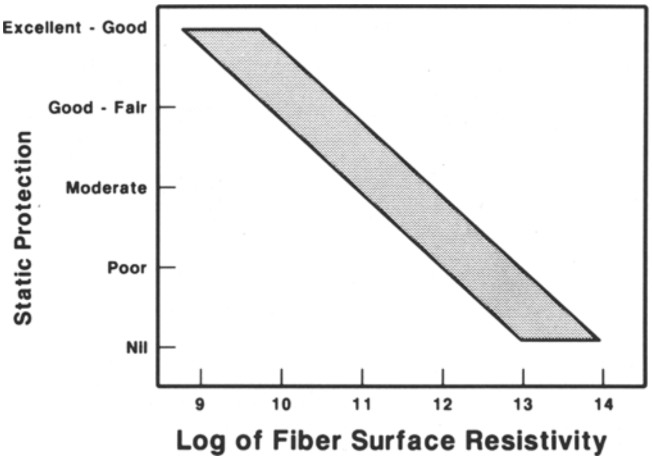


FIG. 12. Static protection vs fiber surface resistivity. Based on rankings by Valko and Tesoror (33) and by Wilson (34). Reprinted from Ref. 1, courtesy of Marcel Dekker, Inc.

TABLE 12

Emulsifiers

Anionic

- Fatty acid soaps (metals, alkanolamines)
- Sulfated vegetable oils
- Sodium dioctylsulfosuccinate
- Salts of ethoxylated alkyl phosphates

Cationic

- Fatty amines
- Ethoxylated fatty amines
- Quaternary nitrogen compounds
- Ethoxylated quaternary compounds

Nonionic

- Glyceryl monooleate
- Ethoxylated alcohols
- Ethoxylated fatty acids
- Ethoxylated alkyl phenols
- Glycols
- Ethoxylated fatty amides

Amphoteric

- Amino acids and their salts
- Betaines

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cals. Table 14 shows examples of antioxidants, antimicrobial agents, corrosion inhibitors, pH buffers, antifoam agents and viscosity controllers based on oleochemicals.

DYEING AUXILIARIES

Leube (2) proposed the stages in dyeing (Table 15) to achieve rapid reproducible production of uniform fab-

TABLE 13

Emulsifier Requirements for Textile Finishes

Requirement	Chemicals which meet requirement	Ref.
Heat-stable emulsifiers	Polyglycerol esters	(47)
Heat and freeze-thaw stable emulsions	Sulfated and ethoxylated fatty acid derivatives	(81)
Good wetting for uniform application	Derivatives of fatty acids, amides, amines, alcohols, and of phosphate esters	(48)
Stable emulsions	Ehoxylated castor oil	(53)
Stable emulsions	Nonionic surfactants, phosphate esters, sulfated oils	(54)
Rapid wetting speed, resistance to bacteria, corrosion resistance, size compatibility, minimal polymer swelling, scourability	—	(58)

TABLE 14

Textile Finish Additives

Function	Example
Antioxidant	Alkyl phosphites (82)
Antimicrobial agent	Fatty alkyl quaternary ammonium chlorides (83-86)
Corrosion inhibitor	Fatty alkyl phosphates (87)
pH buffer	Fatty acid soaps (88)
Antifoam agent	Specific alkoxylates of fatty acids or of castor oil (89,90
Viscosity controller	Salts of dialkyl sulfosuccinic acid esters (47)

TABLE 15

Stages in Dyeing

1. Dispersion of dye particles
2. Solution of dye in bath
3. Association of dye with surfactant
4. Transport of dye solution to fiber surface
5. Diffusion of dye through adsorbed layer at fiber/dye bath interfaces
6. Dissociation of dye from surfactant
7. Adsorption of dye on fiber
8. Diffusion of dye into fiber

Based on information developed by Leube (20).

ric color. All stages, except 2 and 8, involve interaction of dye molecules with surfactants. Emulsified swelling agents are often used to increase dye level in Stage 8. Nonionic oleochemical surfactant-emulsifiers, such as oleic acid polyethoxylate, have also shown activity as dyeing assistants (91). Cationic surfactants like octadecyltrimethyl ammonium bromide have been used to level the basic dye coloration of wool and acrylic fibers by retardation of dye pickup (92).

TEXTILE FINISHING AGENTS

Finishing is the last stage of fabric production when fabric structure is stabilized and the tactile aesthetics, which customers expect, are imparted. Mosher's list (93) of the functions for chemical finishing agents is shown in Table 16. Chemical finishing agents can facilitate mechanical finishing, modify fabric "hand," increase textile utility, change chemical and physical characteristics, and increase textile marketability. Commonly used types of finishing agents are shown in Table 17 (1).

Softeners usually are either oleochemical derivatives or emulsions of polyethylene or silicones (94). Oleochemical quaternary ammonium compounds are the most prevalent softeners (95,96). Fabric softening is the single largest market for quaternary ammonium derivatives (97,98) like dioctadecyldimethyl quaternary ammonium chloride. Nonionics, such as stearic acid ethoxylates, have been used (99), but must be applied at higher amounts on fabric.

TABLE 16

Functions of Chemical Finishing Agents
Facilitate mechanical finishing and make more lasting
Modify "hand" and appearance of fabrics
Increase textile utility; e.g., increase abrasion resistance or dye light fastness
Change chemical and physical characteristics, e.g., water repellency or flame retardance
Increase textile marketability—adjuvants which promote sales

Based on information reported to Mosher (94).

TABLE 17

Finishing Agents
Fabric softeners
Antisoilants and soil-release agents
"Permanent" antistats
Water repellents
Permanent-press resins
Antimicrobial and antifungal agents

Soil-release agents are generally hydrophilic polymers rather than oleochemicals (1), and although antisoil finishes are usually fluorochemicals, alkyl pyridinium chlorides have been used alone or as additives to fluorochemical antisoilants (29).

In contrast to the fugitive antistats used in spin finishes, permanent antistats are usually either polymeric coatings or additives to polymer melts before fiber spinning. Both additives to polymer melts and permanent coatings may contain alkyl groups derived from oleochemicals (11,100,101).

Modern water repellents usually contain fluorochemicals but may also contain oleochemical-based quaternary ammonium chlorides as extenders (30).

Permanent press resins usually are not oleochemicals.

Antimicrobial finishes may contain oleochemical-based quaternary ammonium compounds or copper salts of fatty acids (102).

THE FUTURE

The decrease in the amount of human effort required to produce yarns and fabrics over the last 250 years is shown in Figure 13. As textile processing speeds and temperatures increase in the future to further reduce the amount of labor required, the requirements imposed on textile chemicals will be even more stringent. Thermal stability of finishes will be increasingly important, as will the quality of all materials used in textile processing aids. As manpower requirements are reduced even more by automation, the quality of textile chemicals must be consistent because automated equipment will require fibers to perform in a consistent manner.

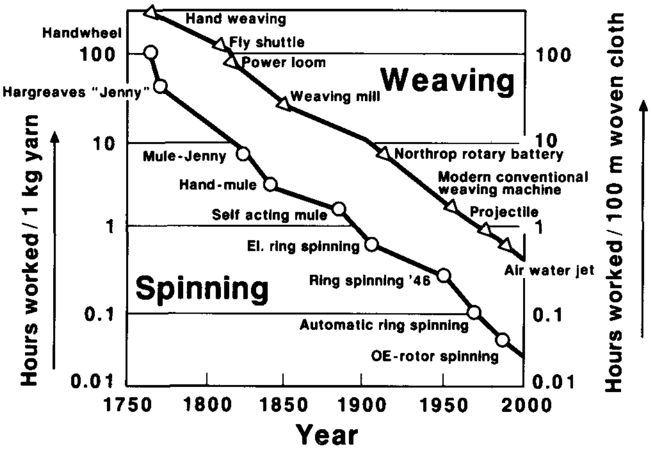

FIG. 13. Changes in the amount of human effort required in spinning and weaving during the last 250 years. Reprinted from Ref. 103, page 226, courtesy of Academic Press and K. Douglas.

World demand for natural and synthetic fibers including glass and olefin fibers increased from 70 billion lb in 1982 to almost 85 billion lb in 1986 (104). The annual increases were 5.30%, 4.74%, 6.02% and 3.38% for the years 1983, 1984, 1985 and 1986, respectively (104). If demand continues to grow at ~3.4% per year, it will exceed 100 billion lb/yr in the early 1990's. Based on the estimated consumption of one lb of fatty acid products for every eight lb of textiles produced, the volume of oleochemicals used for textile production should grow from the 8.8 billion lb/yr in the early 1980's to more than 12.1 billion lb/yr in the 1990's. Of course, the actual consumption of oleochemicals for this purpose will depend on the relative supplies and costs of oleochemical versus petrochemical feedstocks.

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