adoption of petrochemical-based active ingredients. At one time it was necessary to tie up vast sums in inventories of oils and fats if one were to avoid shortages and price squeezes. An active and alert staff was required to follow the ever-changing markets. Many an ulcer was born in this strained atmosphere!

One last thought: the United States now exports about 1.5 billion pounds a year of tallow and grease. If the soap industry were still tallow-based, this amount of fats would not replace the 3.5 billion pounds of syndets sold in 1957. This can mean one thing only, prime tallow would be even higher than the currently (5/58) quoted price of 8¢ a pound. It might well be 12¢ a pound.

Textile Uses of Syndets and Soap

G. M. GANTZ,[1] General Aniline and Film Corporation, New York, New York

THE TEXTILE INDUSTRY is an important market for soaps and synthetic detergents. One estimate of this market is 50 to 100 million lbs. per year (1) whereas another is 64 million dollars (2). For many years this industry has served as a proving ground for synthetic detergents. The initial commercial use of most important syndets can be traced to one or more textile applications.

G. M. Gantz

The textile industry uses a great variety of chemicals which can be considered as surface-active agents. By considering only those products which have no effect on performance of yarn or fabric, one can eliminate softeners, lubricants, water repellents, and antistatic agents. The remaining surface-active agents can be classified into four functional categories: detergents, wetting agents, emulsifiers, and dyeing assistants. By way of reference, Table I lists several types of surfactants and their functional uses in textile processing.

This discussion will cover only soaps and synthetic products that exhibit detergent properties. Important processing operations involving detergency will be considered successively for cotton, wool, and man-made fibers. Several recent references may be cited (1–4). Special mention must be made of the second edition of Speel's "Textile Chemicals and Auxiliaries" (5) and Vol. II, "Surface-Active Agents" by Schwartz, Perry, and Berch (6).

[1] Present address: Central Research Laboratory, General Aniline and Film Corporation, Easton, Pa.

TABLE I

Important Surfactant Types and Their Functional Uses in Textile Processing

	Detergency	Wetting	Emulsification	Dyeing
Soap	x		x	
Ethoxylated alkylphenols	x	x	x	x
Alkyl benzensulfonates	x	x		x
Alkyl sulfates	x	x		x
Sulfonated amides	x	x		x
Sulfonated esters		x		
Ethoxylated alcohols and acids		x	x	x
Alkyl napthalene sulfonates		x		x
Sulfated oils and fats			x	x
Petroleum sulfonates			x	
Alkylol amides	x		x	
Ethoxylated amines				x
Quaternary ammonium salts				x

Cotton

Mature cotton fibers contain a variety of materials other than cellulose as shown below (7):

Constituent	*%, Dry Weight*
Cellulose	94.0
Protein (N × 6.25)	1.3
Pectic substances	1.2
Ash	1.2
Wax	0.6
Total sugars	0.3
Pigments	Trace
Other	1.4

Yarns and fabrics may contain also "trash" comprising bits of leaves, stems, seed-coat fragments, and aborted seeds. In the course of spinning, weaving, or knitting, yarns and fabrics may pick up dirt, rust, and grease. Warp yarns of fabrics usually contain a size, applied to add abrasion resistance and strength. The detergent problem, in the case of cotton, is to remove natural impurities in the fiber, incidental contaminants from harvesting, spinning, or weaving, and deliberately applied sizing material.

Cotton fabrics are normally subjected to an enzyme desizing treatment, a hot alkali treatment, bleaching with hypochlorite or peroxide, and mercerization. After these treatments the fabric may be dyed, printed, or finished as white goods.

Enzymes convert starch into sugars, and the desizing treatment removes sizing material as well as water-soluble contaminants from the cotton. The hot alkali treatment removes most of the naturally occurring pectins and waxes as well as pigments, protein residues, seed coat fragments, and ash. Bleaching removes very little from the cotton except color. Detergency is involved in the alkaline steeping or boiling operation.

In kier boiling, which is becoming obsolete, thousands of yards of cloth in rope form are piled into an iron vessel which is then purged of air, sealed, and heated with steam. Liquor is circulated continuously from the bottom through a heated side arm and sprayed onto the goods from the top. A typical solution would contain 1–2% sodium hydroxide, ½% sodium silicate, and ¼ to ½% soap or syndet.

A great variety of soaps, syndets, and solvents have been used in kier boil formulas. Potash soaps, sulfated oils, alkanol sulfates, sulfonated amides, and

alkylphenol nonionics have been most widely used. Although caustic soda is the key ingredient, soaps and syndets assist by emulsifying the waxes and dispersing the residues during the rinsing operation.

Kier boiling has been superseded by continuous processing in large stainless steel J-boxes. Fabrics in rope or open-width form are saturated in a 3–4% caustic soda solution before plaiting into the J-box. Live steam may be injected into the J-box, or the cloth may be preheated in a tube. In this operation there is little or no mechanical action, and it is not as easy to demonstrate the value of a soap or syndet as in the case of the kier boil. Alkyl aryl sulfonates, alkylphenol nonionics and their sulfate esters have been used at 0.1 to 0.2% concentration. More often they are considered as wetting agents rather than as detergents. Bleaching with hydrogen peroxide is carried out in a second stage consisting of a saturator, J-box, and washers (8).

The one-stage bleaching system is a recent development which eliminates one J-box with its saturator and washers (9). The success of this system depends upon a prescour with caustic soda and a nonionic detergent as well as much higher concentrations of peroxide and silicate on the cloth. The nonionic should be low foaming as well as a good wetter, emulsifier, and detergent.

Fabrics that cannot be handled in kiers or J-boxes are scoured by other methods with caustic soda, soda ash, or polyphosphate plus a soap or syndet. Soap is quite often used if soft water is available. Alkylphenol nonionics are widely used because they are moderate foamers and economical on a price-performance basis. Inasmuch as fabric structures and scouring equipment vary widely, it is not surprising that many different types of detergents have been used for this application.

An important scouring operation for cotton fabrics follows dyeing or printing. Cottons dyed with vat or naphthol dyes are usually scoured to remove loose surface color, to develop their ultimate shade, and to insure maximum fastness properties. Printed fabrics are scoured for the same reasons and also to remove print gums which affect hand or softness.

Soap and soda ash have been used many years for scouring vat- and naphthol-dyed cottons. Syndets work just as well in most cases and are often preferred because they rinse out more quickly and do not form lime soaps. Soaps have better anti- redeposition properties than syndets, and an additive such as CMC can be used to advantage in scouring printed fabrics with syndets. This minimizes staining of the white ground in the pattern.

Wool

Wool fibers are usually scoured as the first operation in a textile plant. A typical analysis of raw wool fibers is 17.0% moisture, 17.0% wool fat, 0.5% other fat, 10.0% water-soluble suint, 4.0% sand and dirt, and 51.5% wool fiber.

Very fine apparel wools may yield as little as 25% fiber while coarse carpet wools yield as much as 80% fiber. It is apparent that wool is a much dirtier fiber than cotton, as delivered to a textile plant.

Scouring is carried out by passing wool fibers through four to six large tanks called bowls. The fibers are advanced gently through these bowls by mechanical rakes and are squeezed between rollers at the end of each tank. The first tank, called a suint bowl, contains only warm water to remove loose dirt, sand, and water-soluble salts. The second and third tanks are for scouring while the last two tanks are used for rinsing.

For a great many years soap and soda ash were used exclusively in this operation. Nonionic detergents gradually replaced soap in this alkaline-scouring system, primarily because they were cheaper to use. More recently a neutral scouring process based on a nonionic detergent has been adopted widely by the industry (10). Wools scoured by the neutral process are softer, whiter, and loftier.

The primary detergent function in raw wool scouring is emulsification of wool grease. Colored impurities must be removed as well as tar and paint used for sheep dips or brand markings. It may be mentioned in passing that wool grease has considerable commercial value, and all scouring processes are considered as to their effect on grease recovery.

Scouring of piece goods is another important detergent operation in processing wool. The major objective is to remove wool oils and sizing materials. Good wool oils, whether of vegetable or petroleum origin, are self-scouring and easy to remove. Cheap bunker oils are sometimes used on low-grade woolens and are often difficult to remove. Nonionic detergents are used frequently in alkaline, neutral, or acid media. As in raw wool scouring, use of a powerful synthetic detergent permits elimination of soda ash or other alkalies and reduces danger of fiber damage.

A controlled shrinkage or compacting of woolen fabrics or felts is called fulling. A fairly strong solution of soap or syndet is used in this operation. Detergency may or may not be involved since the soap or syndet is thought to function primarily as a lubricant. Most syndets, in fact, are unsuitable as fulling agents, and very few have been found which surpass soap.

Woolen fabric is usually tacked and sewed into an endless strand for fulling. Goods in rope form are drawn through a pair of rollers and forced into a constricted throat. Goods fall from the throat to the bottom of the mill until they are drawn up again by the rollers. The time and detergent concentration are varied, as required by fabric construction.

Fulling may be carried out under alkaline, acid, or neutral conditions. Fabrics are most commonly fulled in soap or soap and soda ash. Syndets may be used alone, with soda ash for alkaline fulling, or with acids for acid fulling. Alkanolamines, alkyl sarcosinates, and amphoteric compounds have been of greatest interest as synthetic fulling agents (11).

Man-Made Fibers

In general, man-made fibers present fewer detergency problems than natural fibers (12). They are quite clean as manufactured and contain only a finish designed to be removed readily. During conversion of fibers or yarns into fabrics, contamination may occur with floor dirt, rust, lubricating oil, grease, and mildew. Most warp yarns and some knitting yarns are sized. Fugitive tints are often applied to yarns for purposes of identification.

A normal "boil-off" for synthetic fiber fabrics consists of scouring with a soap or syndet and polyphosphate at 140–160°F. Fatty alcohol sulfates or fatty amide sulfonates are the typical syndets em-

TABLE II

Typisal Uses of Soaps and Syndets in Scouring and Dyeing Man-Made Fibers
(all percentages based on weight of fiber)

	Acetate	Nylon	Dacron	Orlon	Acrilan	Dynel
Scour	0.5% A 0.5% NH_3	1% A 1% S 1% TSPP	1% A or N 1% TSPP	1 %A or N 1 % TSPP	1 % N	1.5% N 0.5% SA
Dye						
Disperse						
Set bath	2 % A	2% S or A	1% N	0.5% A	0.5% A	—
Dyeing	—	1% A	1% A	1 % A	—	1 % A
Soaping	—	1% N	1% A	1 % N	1 % N	2 % S
Acid						
Set bath					0.5% N	2 % C
Dyeing			—		—	—
Soaping			2% N		1 % N	2 % S
Basic			—			
Set bath				0.5% N	0.5% A	—
Dyeing				3 % C	—	1 % A
Soaping				1 % N	1 % N	

A—Anionic Syndet; C—Cationic Syndet; N—Nonionic Syndet; TSPP—Tetrasodium Pyrophosphate; S—Soap; CA—Soda Ash.

ployed. Fabric construction and available equipment often determine the scouring process.

Viscose rayon fabrics often require desizing as the first wet operation. The second operation would be scouring with an anionic detergent plus a mild alkali, such as tetrasodium pyrophosphate. Some constructions must be handled in open-width at all times and would be scoured on a jig. Other fabrics must be set with boiling water in open-width before they can be scoured in rope form.

Acetate rayon must be scoured in a neutral or mildly alkaline bath to avoid saponification of the fiber. A typical formula would employ an anionic detergent and ammonia. Blends containing acetate must be handled as carefully as an all-acetate fabric.

Typical formulas for use of soap and syndets in scouring and dyeing a few man-made fibers are shown in Table II. It must be kept in mind that many new fibers are now on the market. They may appear in a great variety of fabric structures as well as in numerous blends. A variety of scouring conditions are encountered, and many different formulas can be used. Each fiber manufacturer and the larger dyestuff companies supply scouring and dyeing procedures.

Fabrics that are oily or contain grease would be scoured with a non-ionic detergent since they are most effective for removing oily soils. In the case of extremely dirty greige goods, the scour might call for 2% soap, 2% nonionic detergent, and 2% caustic soda. While this severe treatment could be used on viscose rayon, Nylon, or Dacron, it would not be used for acetate rayon and acrylic fibers. Occasionally petroleum solvents are added to the scouring bath to assist in stain removal.

Generally anionic and nonionic syndets are used most extensively. Most textile mills still use soaps however in one or more operations.

Summary and Conclusion

The textile industry employs many millions of pounds of soaps and syndets for a variety of detergency problems. Cotton fabrics require soaps or syndet with alkalies to remove waxes, pectins, and other impurities which accompany raw cotton fibers. Dyed and printed cotton fabrics must be scoured with soap or syndet to remove loose color.

Raw wool fibers are scoured with a nonionic detergent or soap and soda ash as the first wet processing operation. Wool fabrics are scoured before dyeing to remove vegetable or petroleum oils applied during processing. Wool fulling represents another large market for soaps and syndets.

Man-made fibers are almost always scoured with soap, an anionic syndet, or a nonionic syndet before dyeing. Syndets are often used in the dyeing process as well as for scouring after dyeing. Inasmuch as man-made fibers are used in many fabric constructions and blends, many different formulas have been devised for scouring and dyeing.

In this discussion only the most important detergent operations for natural and man-made fibers have been considered. It must not be forgotten that the textile industry is quite diverse and many different detergent problems may be encountered. Narrow fabrics, knit goods, thread, cordage, lace, hosiery, tufted products, and hats can be cited as important segments of the textile industry. Discussion of the detergent problems in the branches of the industry was considered beyond the scope of this paper.

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General Detergency

R. E. WOLFROM, Rohm and Haas Company, Bristol, Pennsylvania

SOAP, in one form or another, has been made and used since ancient times, and its virtues (it is one of the best detergents in soft water) and its drawbacks (chiefly its propensity to precipitate in hard or acidic water) are well known. Because of its virtues, soap was manufactured to the extent of 1.15 billion lbs. in this country in 1957 (1). Because of its drawbacks however, and for economic