Industrial Uses of Soap and Synthetic Detergents

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SOAP and synthetic detergents are used by practically every industry as an essential raw material or operating supply. The importance of these materials to industry and service organizations was brought into sharp focus during World War II when a general shortage of fats and oils threatened to curtail the supply for industry to such an extent that production would be hampered and the war effort impeded.

During 1942 federal regulations were created that seriously reduced the quantities of fat and oil that could be used for household packaged soap, but the government at that time recognized the importance of soap for industrial applications and, with the exception of inventory controls to prevent hoarding, provided sufficient fat for all industrial soap requirements.

The exact origin of soap probably cannot be stated with accuracy, but more than 2,000 years ago soap plants were in operation, as revealed in excavations among the ruins of Pompeii. The first industrial use of soap on a relatively large scale might be considered to have been in the textile industry during the 15th century for silk degumming. The same industry initiated the use of synthetic detergents in dyeing operations during the first quarter of the 20th century.

Since its early use in industry more than 400 years ago, soap now finds application in many important industrial applications. Among the service trades the commercial laundry is the prime user of soap products. Many manufacturing industries, including the previously mentioned textile industry as well as paper, rubber, metal finishing, leather, wire and metal drawing, paint, cement and ceramics, all require soap as an important raw material in operations. All of these applications will be discussed more or less in detail as to the manner in which soap is used and the specific requirements of the soap. It might be well to consider the chemical characteristics of soap employed by industry so that the selection of the proper type in the different industries may be correlated to the composition.

The bulk of industrial soap is made from animal tallow and grease. The characteristic of this soap is a high melting point or titer of the fatty acids obtainable from the soap. Tallow produces a soap of 42 degrees centigrade titer, and grease produces lower titer soaps varying down to 35 degrees centigrade. It is interesting to note that the fatty acids obtainable from natural fats may be separated into varying fractions of different melting points. Many industrial soaps of very low titer really have their origin from tallow after stearic and palmitic fatty acids have been separated from the liquid oleic acid.

The second type of soap made from natural fats and oils, and in this case primarily oils, shows a titer of from 20 to 25°C. This type of soap may be made from olive oil and its derivatives as well as from corn, peanut, soya bean, cottonseed and a few other less prominent oils.

With the exception of liquid soap, for which many manufacturers employ 100% coconut oil, we find that the use of coconut oil is restricted to modifying the properties of animal fat soaps. For example, a standard blend of 75% tallow and 25% coconut oil is used to produce a type of soap having a titer of approximately 35 degrees, which is readily soluble and has quick foaming characteristics.

All of the foregoing soap products are available as so-called neutral soaps or with added alkalies of the carbonate, silicate, and phosphate type to modify the properties and efficiency of the soap product. The soap products are produced in liquid, bar, chip, and granulated forms.

Synthetic Detergents

The chemical nature of soap was quite definitely established in the year 1816 by the French chemist, Michel Chevreul, and with this knowledge certain of the shortcomings of soap were understood for the first time. The inability of soap to function properly in the presence of hard water, soluble metal salts, or acid, is of course to be expected since soap forms insoluble compounds with these metallic salts, and fatty acid is liberated by acid. It required slightly over 100 years for scientists to develop a suitable synthetic detergent that would be unaffected by acids or metallic salts. These compounds are soluble salts of organic sulphates and sulfonates. There is still another group of synthetic detergents called condensates. Chemically, these products are obtained from the reaction of long chain alcohols and ethers, and the reaction products are further treated with ethylene oxide to produce the desired water solubility.

Synthetic detergents of the sulfate and sulfonate variety now constitute the type in greatest demand. The basic synthetic also may be blended with complex phosphates to increase its detergent power.

With all due respect for the good qualities of synthetic detergents, there is still considerable research work that shows they do not compare in detergent power to soap used under conditions ideally suited for the maximum efficiency for soap. This condition would include the use of soft water, high temperature of solution, and proper alkalies to promote maximum detergency.

Commercial Laundries

The commercial laundry industry with more than 7,000 power laundries in the United States probably consumes more soap than any other industry. This industry uses about 200,000,000 pounds of tallow soap annually, and in addition substantial quantities of synthetic detergents are used for specialized purposes.

While repeated efforts are being made to introduce specially compounded synthetic detergents in commercial laundries for the washing of cotton work, only partial replacement of soap has taken place. As stated previously, many operators still feel that the use of soap for washing white cotton in soft water with the addition of appropriate alkalies to enhance detergent power represents the detergent for the purpose.

The conventional washing equipment used in power laundries basically consists of an outside cylinder and an inner perforated cylinder. Clothes are placed in the inner cylinder, which is rotated in the washing solution contained in the lower portion of the outside shell. The inner cylinder rotates in alternating direc-

tions on a definite cycle and provides the mechanical action and so-called drop for the clothes to produce efficient cleaning action. After two or more sudsing operations softened hot water is introduced to the wash wheel and rinses of short duration applied.

The washing operation on cotton material may be carried out in water of 160° to 180°F., using a high titer soap. Suitable alkalies are contained in the product as purchased or may be added separately by the operator. Because of the high temperatures used in washing cotton a high titer tallow soap should be selected in preference to softer oil soaps, which normally lather poorly at high temperature. This may be due to increased solubility and loss of some colloidal activity of the low titer soap. For washing at low temperature below 100°F. a low titer soap is normally used.

There are other auxiliary supplies used in the washing operation which include bleaching materials essentially of the chlorine type; however some hydrogen peroxide may be used. This operation is employed usually between the last sudsing operation and the first rinsing operation. Following the series of rinsing operations, the final operation involves the use of an acidic material to neutralize residual alkali. In this operation blue dye stuff is also introduced in order to overcome yellowing effects.

While vegetable type fabrics, such as cotton base material, represent the major classification in the industrial laundry, there are, of course, many minor classifications, including fabrics of fragile construction made from synthetic fibers. Natural animal fibers contained in silk and wool fabrics present special problems in washing. Fabrics made from synthetic fibers of rayon and nylon also represent an important classification. All these varieties require special treatment in order to avoid harmful effects that may be introduced by the mis-application of supplies or faulty procedures. For example, high temperatures have a felting effect on wool fibers, and high alkalinity has a solubilizing effect on all fibers of animal origin. The washing of fabrics containing fugitive dyestuffs also presents a serious problem to the laundry operator. In this particular case the use of synthetic detergents under neutral or even acid conditions is indicated since the alkalinity of soap promotes bleeding of the dye stuff.

The laundry industry has made considerable progress during the past 10 or 15 years in applying scientific methods. The industry sponsors a laundry association that maintains a school at Joliet, Ill., where training is provided for men in the industry. In addition, an experimental laundry is operated in connection with the school that has adequate facilities and trained personnel to determine the merit of new products being introduced to the field.

Textile Industry

In the manufacture and finishing of textiles there are many processes that require the use of soap and synthetic detergents and in certain cases combinations of both are employed.

The wet processing operations employing soap and synthetic detergents include the following: oiling, wetting, scouring, dyeing, fiber lubrication, and finishing. In these operations the determining factor as to the use of a soap or synthetic detergent is essentially the same as in the commercial laundry operation. In those operations where soft water and alkalies are permissible, the use of soap is indicated. On the other hand, many of the operations in the textile industry do not provide such ideal conditions either because of the location of the plant or the requirements of the particular textile being processed. In such cases the selection of a synthetic detergent is likely. Many textile operations do not require powerful detergent effects. For example, in many cases merely a wetting action is required and a synthetic should be used.

Wool

Raw wool contains many impurities which must be removed in a soap alkali detergent bath. Because of the harmful effects of high temperature on wool fibers, the scouring bath is maintained below 140°F. and frequently between 110 to 120°F. For this purpose a soap of low titer is preferable because it is more readily soluble at low temperature and better rinsing than a high titer tallow soap.

The scouring operation may also be carried out with the use of a synthetic detergent either alone or in combination with soap. In the latter case the synthetic serves to assist in the rinsing operation.

With the removal of the original impurities in the wool the product passes through a series of operations, which include spinning and weaving. In these operations impurities are again introduced into the fabrics in the way of special oils and processing agents. Prior to the removal of these added processing materials, the woven piece goods must be shrunk in a "fulling" operation. In this operation the woven piece is passed through a constricting opening, causing the fibers to shrink to some extent and pull together. Soap is added to the piece goods to provide lubrication, and the soap also serves to provide detergency in the following scouring operation to remove processing oils for the final time.

Wool may be dyed in several of the various processing stages. In dyeing good use is made of synthetic detergents to promote levelling and penetration of the dyestuffs.

Silk

The processing of silk in the United States has been reduced to a very minor role with the introduction of the newer synthetic fibers, such as rayon and nylon. In contrast to wool, the processing of silk in the initial stage is carried out in a boiling operation which leads to the term "boil off." In this operation the gum is removed from the silk by the solvent action of a neutral low titer soap. The alkalinity of the soap solution serves to dissolve acidic constituents in the silk gum, and the silk fiber remains as a softer, finer, lighter, and more lustrous material.

Silk may also be dyed prior to final weaving or knitting, and, if so, yarn dyeing equipment is employed, using synthetic detergents to aid penetration and wetting.

Cotton

The cotton fiber is very resistant to the effects of strong alkalies and high temperatures. Consequently in the initial operation the natural gums, pectins, and other impurities present in the cotton may be removed by the vigorous detergent action developed by soap or synthetic detergents in the presence of caustic soda. This operation is referrred to as kier boiling. Because of the high temperatures of the kier boiling and rinsing operations it is possible to use high titer tallow

soap. Synthetic detergents are also used in this operation.

As in the case of other fibers, the dyeing operations are carried out efficiently by the use of synthetic detergents and the necessary processing chemicals.

Synthetic Fibers

The processing of synthetic fibers requires very little soap, and the expansion of the rayon and nylon industry at the expense of other animal base fibers, particularly silk, has caused a considerable loss in tonnage for the soap industry.

During the actual manufacturing operations the synthetic fiber filaments are given a desired twist in the "throwing" operation. Yarns are passed through sizing solutions to strengthen the fibers and prevent undue wear during weaving. Ultimately, the fibers must be washed and desized to remove spinning oils, grease, and dirt. In this operation due respect must be given to the fragile nature of the fiber, and both soap and synthetic detergents may be employed in the boil-off operations. Soaps of low titer are to be used in preference to the harder soaps made from tallow.

Manufacture of Natural and Synthetic Rubbers

Soap finds application in the processing of natural rubber and in the manufacture of synthetic rubber.

In the processing of natural rubber the latex solution is coagulated with acid, washed, dried, smoked, and baled for shipment. Further processing of rubber takes place during the vulcanizing operation. Here many additions can be made to the product, providing certain qualities as required by the final application for the rubber. In the molding operation solutions of soap are applied to the mold to avoid adhesion of the rubber to the mold surface. This anti-adhesive property of soap solutions is also employed to apply a protective layer between slabs of rubber in the processing operation after milling prior to curing in molds.

A very interesting application of soap is in the manufacture of synthetic rubber, which in 1951 set a record of 2 billion pounds. In an effort to duplicate the natural latex solution produced in nature, certain chemicals from petroleum and grain alcohol, particularly butadiene and styrene, are mixed in water solution, using tallow and other soaps as a coupling agent. The artificial latex solution is allowed to age under certain conditions where chemical changes occur, producing the desired type of emulsion. After the polymerization operation the artificially produced latex is treated with acid, washed, and processed from this stage in a way similar to the operation with natural rubber. This type of synthetic rubber is referred to as Buna S or GR-S, and the 1.5 billion pound 1951 production in government plants has now relieved the shortage for auto tires. In the production of the artificial latex it is quite apparent that soap fulfills the requirements more than synthetic detergents, which would be stable under acidic conditions and not permit the necessary coagulation.

Immediately prior to World War II the government established the Rubber Reserve Corporation, which assumed the responsibility of coordinating research and production facilities of the soap industry in an effort to provide a soap product that would give the necessary properties to produce artificial latex. Many experiments were carried out, and it was ultimately found that a soap made from tallow served the purpose best. There continued to be difficulties arising from batch to batch of tallow soap that remained unexplained for a considerable period of time and caused difficulty in retarding production.

A very detailed study of the composition of fatty acids found in tallow led to the conclusion that even small quantities of highly unsaturated fatty acids which can be found in occasional batches of tallow delayed polymerization, thus increasing production costs and decreasing production capacity. The problem was solved effectively by using a partially hydrogenated tallow.

Miscellaneous Applications

The emulsifying properties of soaps and synthetic detergents also find application in the manufacture of paper, leather, ceramics, cement, and paint.

In the manufacture of paper the major raw material is wood, which is reduced to a pulp prior to being introduced into beaters where sizing fillers, binders, and colors may be added. In these operations soap is useful in providing emulsifying and lubricating effects on the fibers. Soap is also employed in the manufacture of special coatings or glazes which are applied to paper.

In the manufacture of leather soap finds application in the finishing operations, where the preserved and treated leather is again provided with oils which have been removed in earlier processing. In order to avoid hardening of hides, soap is used as an emulsifying agent for oil to restore the necessary fullness and softness to the leather. In other finishing operations involving the application of casein glue, egg and blood albumens for seasoning of the leather, soap is used as an emulsifying agent.

In the manufacture of ceramics soap is used as an emulsifying or wetting agent in the process involving the preparation of the "slip," which is a thorough mixture of raw clay and other substances to impart desirable properties to the finished product.

In the manufacture of cement both synthetic detergents and soaps are used to provide a more homogeneous mixture with water. Specialized uses for synthetic detergents have been found in the manufacture of concrete of very light gravity where air is entrapped in the mass by the emulsifying properties of the synthetic. The resulting concrete has a low thermal coefficient of expansion which increases resistance to freezing and thawing cycles.

A recent development in the paint industry is the emulsified water type of paint, which are water emulsions of alkyd resins and caseins. Soap is used as an emulsifying agent, and the resulting paint has many desirable properties such as quick drying, high covering power, the elimination of inflammable solvents, and good wearing qualities.

Soap and synthetic detergents are used in many phases of the metal industry, beginning with the early stages of ore concentration by flotation methods to the final finishing stages, where soap and synthetic detergents act as emulsifiers in cleaning and polishing operations.

The magnitude of the market varies, of course, depending upon industrial activity. However it is safe to assume that approximately 20,000,000 pounds of soap as such are used in various cleaning operations with another 5-6,000,000 pounds used as a lubricant for wire drawing operations.

A considerable volume of synthetic detergents is used as ore flotation concentrating agents. One partic-

ular operation involved the concentration of molybdenum ores, but, in general, both soap and synthetic detergents are used in conjunction with other frothing compounds to separate worthless portions of the ore from the more valuable fractions to make it worthwhile to extract the metals from the ore.

In the fabrication of metal items, drawing operations are employed in the manufacture of wire. To reduce the friction in the passage of wire through dies, sodium tallow soap in granulated form has found wide application. Some of the softer metals, copper in particular, use soaps in solution to provide lubrication, and these soaps are generally softer in body than tallow soaps to provide for the preparation of solutions that do not separate and later are more readily removed from the surface in the rinsing operations.

Soaps of low titer are also used in soluble cutting oils in machinery operations to provide better cooling, wetting, and penetration of the cutting oil.

Metal parts following the machining operation are subject to so-called deburring operations where the metal surface is freed from small adhering pieces of metal by the polishing action of cutting stones. This operation is carried out in a liquid medium, employing the use of soap and synthetic detergents as emulsifying and lubricating agents.

In finishing operations including those involving plating and painting operations, soap again finds application in providing emulsifying and cleaning powers for the operating solutions. Soap is also used as a protective covering in lacquer and paint spray booth operations.

There are also many other operations in the metal industry requiring the use of soap and synthetic detergents which will be merely mentioned. These include: a) wetting agent in lime bath to quench the pickle; b) ingredient of sodium silicate flux for welding rods; c) assistant for soldering flux; and d) leak-finding compounds for pipes and tanks.

Soap and synthetic detergents are used in many manufactured products, including insecticides and fungicides, printing inks, specialized industrial hand detergents, and many specialized water and dry cleaning preparations. Most of these manufactured products employ the emulsifying, wetting, and detergent properties of soap and synthetic detergents.

It has been said of glycerin, a co-product of the soap industry, that this important raw material is used from the cradle to the grave, having applications from surgical jellies to embalming fluids. Soap, indeed, predates the use of glycerin in this respect in pre-surgical washups, and finally synthetic detergents provide efficient wetting properties in the glycerin containing embalming fluids.

In conclusion, it must be noted that such a broad subject as the industrial uses of soap and synthetic detergents must of necessity be curtailed considerably in this presentation. There remain many uses that require soap or synthetic detergents in small quantities. Those uses which have been mentioned have been discussed touching only the highlights of the subject.

Builders for Detergents

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AT least as early as 1825 when von Fuchs (1) suggested and 1835 when Sheridan (2) patented the use of sodium silicate in soap, builders have been used in detergent processes. The volume of literature on builders is quite large, and it is possible, within the broad scope of this paper, to touch only lightly on the many aspects involved. Niven (3) and Schwartz and Perry (4), among others, have extensively reviewed and critically discussed the properties of builders. The fundamental principles of building action apply to all processes wherein it is necessary to separate a more or less tenacious "soil" from a base material with, in most cases, subsequent dispersion of the soil in a liquid which is usually water. Since the largest consumption of builders is undoubtedly in laundering applications, emphasis will be placed on the use of builders in the washing of fabrics.

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Classification

A builder may be generally defined as a material which, when added to a synthetic detergent or soap, will improve its performance. It is not a diluent but contributes to the over-all effectiveness of the cleaning operation. The more commonly used builders are inorganic compounds which have little or no inherent cleaning action but which greatly improve the cleaning effectiveness of a detergent. The practical effect is to provide satisfactory detergency at a reduced detergent concentration. Certain organic additives, not themselves surface-active, contribute special properties when admixed with detergents. Certain solvents fall within the above definition of a builder since removal of soil dissolved by the solvent is facilitated by emulsification with the surface-active detergent. Actually a detergent may be classed as a builder in cases where synergistic effects are obtained upon admixture with another detergent. Certain sequestering agents other than the complex phosphates also are currently arousing interest as builders.

Examples of the more prominent compounds used for building are given under the following major classifications:

1. Alkali salts of weak inorganic acids
   a) Carbonates (soda ash, modified soda, sodium sesquicarbonate)
   b) Silicates (meta-, sequi-, and orthosilicate)