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.

M. G. Kramer

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)

c) Phosphates (trisodium orthophosphate, sodium hexametaphosphate, tetrasodium pyrophosphate, sodium tripolyphosphate, sodium tetraphosphate)
d) Borates (sodium tetraborate)

2. Alkali hydroxides (sodium hydroxide)
3. Neutral inorganic salts (sodium sulfate, sodium chloride)
4. Colloidal additives (bentonite and other clays, water glass of 1:2 to 1:4 $Na_2O:SiO_2$ ratio, sodium carboxymethyl cellulose, proteins, amino acids, methyl, ethyl and hydroxyethyl celluloses, water soluble cellulose ethers, sodium starch glycolate, lecithin, peptides)
5. Solvents (pine oil, aliphatic and aromatic solvents, hexalin, tetralin)
6. Sequestering agents (sodium salts of polyaminocarboxylic acids)
7. Proprietary mixtures

Among the alkali products noted above, the potassium derivatives are used in certain special cases but are generally too expensive. The proprietary builders are in most cases complex mixtures of products from the other classifications noted above and are designed for use in specialized applications.

Properties

One of the more important properties of the alkali salts is to furnish an alkaline solution, which by its buffering action controls the pH of the detergent bath. The alkali hydroxides impart high alkalinity but provide little buffering action. The pH values for solutions of these materials have been reviewed, e.g., by Niven and Gadberry (5). In general, at use concentrations, the alkaline builders provide the following approximate pH range:

Alkali	pH Range
Hydroxides	12.8
Carbonates	10.0–11.2
Silicates	12.0–12.6
Phosphates	7.6–11.7
Borates	9.2

Snell's investigations (6, 7) illustrate the importance of the control of the hydrolysis of soap by pH adjustment. In addition to the hydrolysis of soap in water, the acid nature of many soils causes formation of fatty acid, and it is necessary to maintain the pH of the bath at or above the pH of the soap to prevent the loss of the detergency power of the soap. An interesting exception is the laundering procedure advocated in Britain by Harwood (8) in which the degree of soap hydrolysis is deliberately increased by addition of acid (e.g., sodium acid phosphate or acetic acid) to form free fatty acid in the fabric capillaries and on fiber surfaces. Resaponification is then achieved by addition of alkali to provide a pH of about 11.2 with consequent high localized soap concentration and detergent action.

Another useful chemical property of the alkali products is their ability to saponify the fatty acid matter of soils due to their alkaline nature. This in effect adds detergent to the bath by the formation of soap, which is particularly beneficial because of its strategic presence in the soil that is to be deterged.

The water-softening effect of builders is indirectly related to detergency in that it prevents deposition of insoluble soaps and improves the stability of dispersions by tying up polyvalent cations. The water-softening effect is accomplished by precipitation of calcium and magnesium ions as insoluble salts with the sodium carbonates and silicates and with trisodium phosphate. These ions are also effectively removed by the "sequestering action" of the other phosphates and the polyamino-carboxylic acid derivatives by formation of soluble complex ions. Sodium carboxymethyl cellulose also has some water softening properties but to a lesser degree than the agents noted above (9). This property of these builders is of relatively minor importance in commercial laundries where water-softening equipment is usually employed but is a major factor in compounding household detergents containing soap, particularly for use in hard water areas.

The general effect of alkaline builders is to increase the surface tension of soap solutions, apparently primarily due to a hydroxyl ion concentration effect (10). This effect is opposed by a lowering of interfacial tension as the concentration of builder is increased.

With synthetic detergents, interfacial tension effects in detergent-soil-substrate systems are dependent to a certain extent on pH, but it is our experience that pH requirements for laundering are not particularly critical from a detergency viewpoint.

Builders may conceivably also affect the action of a detergent system by ion-exchange with soil components, effect on adsorption of the detergent on the fiber, swelling of fiber, and modification of the electrical charge on soil and substrate. Sanders and Lambert (11) have concluded that with synthetic detergents and cotton fabric these factors, particularly the latter, are involved in the building mechanism to a greater extent than changes in the surface activity of the detergent.

The alkaline builders themselves have little or no emulsifying power, and emulsification effects in systems containing oily soil are probably due to the reaction product of the builder and saponifiable material. Interfacial tension is also reduced in such systems by the same mechanism.

The soil-suspending properties of builders are of great importance, and rating is somewhat difficult since the nature of the dispersed material and of the substrate are critical factors. In general, among the alkaline builders the order of decreasing effectiveness is silicates, phosphates, hydroxides, and carbonates.

The neutral inorganic salts are not particularly suitable for use with soap since, except at very low concentrations, they salt out the soap. They are used extensively with anionic synthetic detergents, particularly the alkylsulfates and alkylarylsulfonates. Harris (12, 13) has shown that with dodecyl benzene sodium sulfonate, with certain reservations, they improve foaming, wetting, and detergency properties and lower surface and interfacial tension. The surface activity is dependent upon the valency of the added ions; the greater the valency, the less the electrolyte required to produce maximum activity. The effect appears to involve micelle formation by coagulation of colloids by oppositely charged ions.

Colloid clays, such as bentonite, prevent redeposition effects by adsorption of soil and minimize bleeding of colored fabrics by adsorption of dyes. Bentonite also has emulsifying powers, and coarser grades might exert abrasive action.

The peptides and amino acids reduce the surface tension of surface-active agents. Lecithin has been claimed to improve the emulsifying and foaming power of soap. Tucker and Richardson (14) have proposed that certain higher fatty amides and nitriles will improve the detergency of anionic sulfate and sulfonate synthetic detergents. The proteins and starch and cellulose derivatives form protective colloids and thus assist greatly in the suspension of soil. Of this group sodium carboxymethyl cellulose has been the most widely used.

The solvents are generally used in applications involving heavy grease soils. Their function is to dissolve the soil so that it can be emulsified and easily removed.

Stericker (15) has shown that the sudsing of soap solutions in which oil is emulsified is substantially improved by addition of a silicate such as $Na_2O \cdot 3.3 SiO_2$. The work of Baker (16) indicates that, in general, alkaline builders increase the foam volume of sodium stearate to an optimum with increase in pH or alkali concentration. He attributes the increase to maxima to decreased hydrolysis of soap and greater conversion of soap to the colloidal form. The decline of foam volume after reaching the maxima is explained by the salting out effect of alkali.

The effect of several electrolyte builders on foaming of an alkylarylsulfonate has been studied by Morrisroe and Newhall (17), using the Ross-Miles procedure in hard water. They obtained maxima at about 25% concentration of either TSPP or TSP in the builder-detergent mixture. Decline in foam volume at higher builder ratios was attributed to reduction in detergent concentration. In alkylarylsulfonate-sodium stearate-TSPP systems the soap had an inhibiting effect on foam formation, and most foam was obtained with the lowest soap and builder content.

The effect of builders on foam volume has been studied (19), using a cylindrical washwheel and a procedure which permits evaluation under practical conditions (18). In hard water at 120°F. the alkaline builders increased the foam volume of a medium titer soap. The order of decreasing effectiveness was, in general, sodium tripolyphosphate, trisodium phosphate, ortho- and meta-silicate, sodium hydroxide, sodium carbonate, and modified soda. With a 40% active sodium kerylbenzenesulfonate the effect of the builders was without practical significance except at high builder concentrations.

Under similar conditions of test Vaughn, Suter, and Kramer (18) have shown that addition of CMC does not significantly affect foaming properties of this medium titer soap and alkylarylsulfonate.

Of primary interest to the user of builders is the effectiveness in a specific detergent process. Surface tension, interfacial tension, wetting, adsorption, etc., are all factors which contribute to the overall result. Because of the complex and highly specific nature of a particular detergent application it is impracticable to attempt to predict ultimate performance from one of the basic surface-active properties. Detergency measurements on a laboratory scale in such cases where they have been properly correlated with field results, and where they include the proper type of substrate and soil, may serve a useful purpose in evaluating detergent systems. Laboratory procedures have been more highly developed for detergency on fabric than for metal or other types of cleaning.

Such measurements may be used to show that the effect of alkaline builders on the soil removal properties of soap may be entirely different from the effect on the redeposition of the soil. Vaughn and Vittone (20) have shown that these builders improve the soil removal properties of the system and have a deleterious effect on the redeposition properties. These opposing influences on overall washing effectiveness may be counteracted by judicious selection of builder combinations and are one of the primary reasons for the existence of proprietary builders.

The alkaline builders generally behave with synthetic detergents of the alkylarylsulfonate type as they do with soap in this respect. The neutral builders also improve the soil-removal properties and reduce the whiteness retention values of anionic synthetic detergents. Harris has published data illustrating the extent of improvement in soil removal (12). Kramer (19) has shown that sodium sulfate reduces whiteness retention values of sodium kerylbenzenesulfonate as measured by the method described by Vaughn and Suter (21) from a relative value of 280 for an essentially salt-free mixture to a value of 118 for a 40% active agent-60% sodium sulfate mixture, the active agent being held constant at 0.1% in the test solution.

Among the colloidal additives the sodium salt of carboxymethyl cellulose (CMC) is the most effective from a cotton detergency viewpoint. Hoyt (22) has described its development and application in Germany, where it was first used and known as Tylose HBR.

The effectiveness of CMC in improving overall detergency is due to a great extent to its ability to prevent redeposition of soil. German sources have reported that it can replace two to three times its weight of soap. Bayley, Weatherburn, and Rose (23) have concluded from redeposition tests that in soap-builder solutions CMC compensates to a large extent for reduction in suspending power caused by the builder and permits a reduction in the quantity of soap used.

Among others, Vaughn, Smith, Suter, Lundsted, and Kramer have extensively studied the effectiveness of CMC on various types of detergents, using carbon soil removal and whiteness retention test procedures (9, 18, 25, 26, 27).

More recent data have been obtained, using these procedures, which have been described previously (21). The data are shown in Figure 1 and serve to illustrate the effect of both CMC and alkaline builders on sodium kerylbenzenesulfonate (40% active deter-

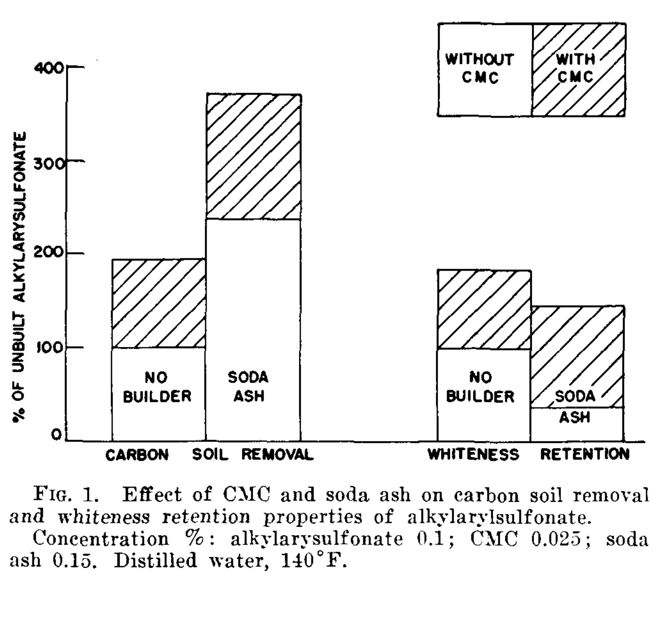

FIG. 1. Effect of CMC and soda ash on carbon soil removal and whiteness retention properties of alkylarylsulfonate.
Concentration %: alkylarysulfonate 0.1; CMC 0.025; soda ash 0.15. Distilled water, 140°F.

gent). Although, as stated previously, the effectiveness of CMC is due to a large extent to its minimization of soil redeposition, it also improves soil-removal properties. It is interesting to note that the carbon soil removal obtained with the alkaline builder is improved further by the addition of CMC. It is also evident that the depreciative effect of the alkaline builders on whiteness retention is entirely overcome by the addition of CMC.

Similar effects are obtained in soap systems but to a lesser extent. Also, the effect of the other alkaline builders is similar to that of soda ash.

The indications derived from such laboratory tests have proven out in practice. For example, it has been shown (27) that the whiteness retention of cotton test panels after 20 washes in commercial laundries is improved by the use of CMC in the detergent system.

Sequestering agents, such as ethylenediamine tetraacetic acid and its sodium salts, are said to improve the detergency of stearate soaps both in hard water and at low temperatures (28). The effect is attributed to a soap-solubilizing or micelle-modifying effect since much smaller amounts of the sequestering agent are required than expected on the basis of calcium binding action.

Commercial Laundering

In commercial laundries most washing is done on the alkaline side for the following reasons:

1. to maintain a buffered solution at a pH above that of soap,
2. to saponify fatty acid soil to form soap in situ,
3. to take advantage of improvement in surface activity, and
4. to provide the proper alkalinity for the hypochlorite bleaching process.

The required alkalinity is supplied by the addition of alkaline builders to the washwheel in one of the following ways: as a dry powder, a stock-builder solution, a stock-built detergent solution, or a dry-built detergent. The built detergent may be based on either soap or a synthetic detergent and in many cases requires use of additional builder, particularly with heavily soiled loads. Table I shows a typical wash formula for heavily soiled linen supply work. With such heavily soiled loads the builder is usually added to the first operation or after a flush. The operation is termed a "break." In it the acid soil is neutralized, and soil removal is started by the detergent action of soap which is formed. The amount of builder in this and subsequent "suds" operations is adjusted to provide the required alkalinity. The alkalinity is determined in practice by titration with acid to the phenolphthalein and methyl orange end-points; pH measurements may also be made. With soap the phenolphthalein titration is frequently used by experienced laundrymen as the sole criterion of proper adjustment. Typical phenolphthalein values for the break or first suds for various classifications, expressed as the number of drops of Normal H_2SO_4 required to titrate 25 cc. of wash liquor, are as follows:

	Drops Normal H_2SO_4
Linen Supply	
Heavy soil	15-20
Medium soil	8-10
Light soil	3- 5
Family Whites	8-10
Colored Work	
Heavy soil	8-10
Light soil	6- 7

Detergent to builder ratios will vary from 1:4 on heavy soil loads to 3 or 4:1 on light soil classifications.

The choice of a builder for commercial laundering is complicated by the many variables to be considered, e.g., water hardness and temperature, type of fabric and soil, degree of soiling, and type of detergent. A generalization of work classifications in which alkaline builders are applicable is given in Table II.

Sodium Hydroxide. This has the highest neutralizing power of the alkalies and is often used alone on very heavily soiled linen supply classifications. More generally it is employed in conjuction with buffering alkalies to increase alkalinity in a buffered system.

Silicates. The silicates are used on all classifications requiring relatively high alkalinity. The buffering range with soap solutions is approximately 10.8 to 11.5 or greater. They possess good whiteness retention properties. The commercial orthosilicates usually consist of equi-molecular ratios of Na_2O and Na_2SiO_3. They are slightly lower than caustic soda in alkalinity but have much greater buffering properties and are generally used on heavily soiled work. The sesqui- and meta-silicates provide a gradual lowering in pH range and selection is usually based on the desired pH.

Carbonates. Sodium carbonate is the least expensive of the alkalies and is widely used, particularly on medium and light soiled work. Modified soda and sodium sesquicarbonate are used on lightly soiled classifications, particularly in institutional laundries.

TABLE I

Wash Formula for Heavily Soiled Linen Supply Classification
100-lb. load, 36" x 36" washwheel

	Softened Water		Temp., °F.	Time, Min.	Supplies added			
					Detergent		Builder, High Alkalinity	
	Inches in Wheel	Gallons (a)			Amount	Conc., %	Amount	Conc., %
1. Flush	12	74	135	3	......	......	......	......
2. Break	5	50	170	15	......	......	3 lbs.	0.72
3. Flush	12	74	180	2	......	......	......	......
4. Suds	5	50	170	10	8 oz.	0.12	1½ lbs.	0.36
5. Suds	5	50	160	10	6 oz.	0.09	2 oz.	0.03
6. Flush	12	74	160	3	......	......	......	......
7. Bleach	5	50	160	10	(b) 2 qts. of 1% hypochlorite bleach $\approx$ 84 ppm. available chlorine.			
8. Rinse	12	74	160	3	......	......	......	......
9. Rinse	12	74	160	3	......	......	......	......
10. Rinse	12	74	135	3	......	......	......	......
11. Rinse	12	74	100	3	......	......	......	......
12. Sour	5	50	120	5	......	......	......	......
Blue	12	74	100	5	......	......	......	......

(a) Includes water of saturation.
(b) Alkali concentration should be adjusted to insure a pH of 10.2 to 10.6 before addition of bleach.

TABLE II

Alkalinity and pH of Alkaline Builders and General Soil Classifications for Which They are Most Suitable in Commercial Laundering

		pH 0.1% Conc.	Soil Classification			
			Very Heavy	Heavy	Medium	Light
Sodium Hydroxide	$NaOH$	12.3	X	X		
Sodium Orthosilicate	Na_4SiO_4	12.0	X	X		
Sodium Sesquisilicate	$Na_3SiO_4 \cdot 5H_2O$	11.8		X	X	
Sodium Metasilicate	Na_2SiO_3	11.8		X	X	
	$Na_2SiO_3 \cdot 5H_2O$	11.6		X	X	
Trisodium Phosphate	Na_3PO_4	11.6			X	X
	$Na_3PO_4 \cdot 12H_2O$	11.3			X	X
Sodium Carbonate	Na_2CO_3	10.9			X	X
Sodium Sesquicarbonate	$Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$	10.1				X
Modified Soda	$Na_2CO_3 + NaHCO_3, xH_2O$	10.0				X
Tetrasodium Pyrophosphate	$Na_4P_2O_7$	10.0	Used principally for water softening properties; suitable only on light soil loadings when used alone.			
Sodium Tripolyphosphate	$Na_5P_3O_{10}$	9.6				
Sodium Tetraphosphate	$Na_6P_4O_{13}$	8.7				
Sodium Hexametaphosphate	$(NaPO_3)_6$	7.6				
Sodium Tetraborate	$Na_2B_4O_7 \cdot 10H_2O$	9.2				

They have strong buffering qualities and require less careful adjustment of concentration.

Phosphates. The relatively low alkalinity makes the phosphates rather expensive. Except for trisodium phosphate they are seldom, if ever, used alone as builders in commercial laundries and then only on light soil classifications. They are used in proprietary soaps and builders for their water-softening action and for their effect on surface-active properties.

Proprietary Builders. These products are carefully formulated to provide optimum washing efficiency for a given application. They range in composition from relatively simple mixtures to complex formulations which provide superior performance in certain applications. The latter class might include a combination of: caustic soda, to provide high neutralizing power; soda ash, for alkalinity and buffering action; a phosphate, for water softening properties; bentonite, for adsorptive characteristics; a solvent, such as kerosene, for emulsification and solubilization; CMC, for whiteness retention properties.

Proprietary built soaps for commercial laundering contain from about 25 to 60% soap. The builder component is varied for the particular application and often consists of a relatively small amount of silicate (3 to 15%) and caustic soda (5 to 30%) and a relatively large amount of soda ash (10 to 60%). CMC (2 to 8%) has been used to advantage in recent years.

Proprietary-built synthetic detergents contain about 13 to 20% active synthetic, sodium sulfate introduced by the synthetic (e.g., from a 40% active-60% Na_2SO_4 alkylarylsulfonate), 5-20% phosphates and other alkaline builders as dictated by the particular application for which the product is designed.

The foregoing applies to both soap and synthetic wash formulas. It has been our experience in commercial laundering that carefully compounded proprietary builders containing CMC are outstandingly effective performance-wise with either soap or synthetics and that synthetics are more versatile than soap.

Washing of colored classifications presents the problem of bleeding and transfer of dye. Colored garments also usually carry more soil than a similar type of white garment and, since low temperatures and alkalinity are required to minimize bleeding and since bleach is used sparingly if at all, washing effectiveness becomes a problem. Bentonite or other colloidal clays are often used to absorb dyes. The low temperature tolerance of synthetics make them particularly applicable.

The effect of alkalinity on dye transfer could, of course, be overcome by washing in an acid medium, and synthetics have been used to a limited extent for this purpose. This laboratory has had moderate success on an experimental basis, using an alkylarylsulfonate built with CMC, sodium acid pyrophosphate, and sodium bifluoride. Bleeding was entirely eliminated, and colors were bright. Commercial products of this type have been marketed in limited areas.

Industrial laundering of wiper rags and work garments also utilize quantities of builders, principally colloidal clays, caustic soda, soda ash, silicates, and solvents.

Wool washing is often carried out without use of any builder; anionic synthetic detergents are particularly suitable. Modified soda, soda ash, and the phosphates are used but always under carefully controlled conditions. Similarly alklaine builders find limited use in silk and rayon washing.

Household Laundering

Builders for household laundering are marketed almost exclusively in built synthetic detergent or soap mixtures. Formulation design differs from that for commercial laundering in that foam requirements dictate the type of detergent. In cylindrical automatic washers foam volume must be kept low in order to avoid loss of mechanical action by cushioning the fall of the fabric and leakage of foam from the machine due to space limitations. With agitator type washers a higher foam volume is desired, if only for psychological reasons. Also, household laundering is usually conducted in unsoftened water at temperatures averaging about 120°F. Household laundering compounds may also be used for hand dishwashing and other household cleaning applications. Consequently mild alkalinity is required to avoid skin irritation due to contact of the detergent compositions with the user's hands. Corrosion of machine parts must also be considered.

Among the synthetics, the nonionic detergents are widely used for washing in the cylinder type of machines and the anionics for the agitator type of washers. Combinations of these synthetics and of soap and synthetics are winning increased acceptance. Such combinations in many cases provide synergistic detergency properties and also are selectively effective on various soil types.

As with any proprietary compound, consideration must be given in selection of ingredients to non-caking, flowability, solubility, and toxicity characteristics.

The complex sodium phosphates are widely used in household detergents, principally for their water-softening properties. In addition, they assist in minimizing iron stains. Their low alkalinity is desirable for non-irritating qualities and in washing woolens, silks, and other fabrics. The complex phosphates also improve detergency of both anionic and nonionic synthetic detergents. They cause darkening and corrosion of machine parts, but this disadvantage is readily overcome by the use of silicates.

The silicates are used frequently for their corrosion inhibiting effect as well as for other advantages noted previously. Sodium metasilicate is commonly used because of its low alkalinity.

The carbonates are widely used in combination with soap, frequently as the only builder. They are also used in conjunction with other builders and provide building action at a very low cost. Modified soda or sodium sesquicarbonate are often preferred over soda ash, particularly when used with synthetic detergents because of their lower alkalinity.

Borates are used to a more limited extent than the other alkaline builders and usually in relatively small amounts.

The alkali hydroxides have no place in household laundering operations because of their causticity and also because the degree of soil loading is relatively low.

The neutral inorganic salts are widely used with anionic synthetic detergents and less frequently as additions to other types.

CMC is in widespread use, usually in amounts ranging from 0.5 to 1.0%. Considerable advantage is to be gained with higher CMC concentrations.

The other colloidal and solvent builders are rarely used in this application.

Dishwashing

Hand dishwashing is usually done at temperatures below 115°F. Consequently non-irritating builders must be selected to provide optimum performance at low temperatures. The phosphates are particularly well suited. Compositions consisting essentially of synthetic anionic detergents built with sodium sulfate and a small amount of one of the polyphosphates predominate in this field.

Machine dishwashing is carried out at 140°F. or higher, and foam levels must be kept low so as not to reduce mechanical action. Consequently soap or synthetic detergents are used in minor amounts; the burden of detergency falls on the builders. These are usually mixtures of the complex phosphates and sodium metasilicate.

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