Performance Characteristics

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IT is not possible to discuss synthetic detergents without considering their performance characteristics. That statement is axiomatic; the commercial detergents are made because of some particular feature in the performance of each one which makes it useful. This discussion has been limited to the detergents, therefore it is limited to those surface-active agents which wash, and that of course includes soap.

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The Ideal Detergent

The obvious ideal in a washing agent would be a product which washes instantly, at a concentration approaching zero, with no input of work. If it were necessary to spend an hour to wash the hands, or if it were necessary to use ten cents worth of soap, there would be very few clean hands. In contrast to this, if soiled things could be made clean by a quick rinse with an inexpensive detergent and then instantly drained dry, the world would indeed be full of the little girls and boys dressed in crisp, clean things just as they are shown in magazine advertisements.

Anomalous Properties of Detergents

While these ideals are interesting to speculate on, they have real and practical limitations, particularly when all of the properties of a detergent are taken into consideration. In the first place, detergents are a particular group in the general class of surface-active agents. As such, they very often show diametrically opposite properties, depending on their method of use. It is well known that surface-active agents are used to penetrate solids, such as insoluble dyestuffs, into goods, and to wash solids away from goods, as in the laundering of cotton. They are used for emulsification, as for example in cosmetics; and they are employed for de-emulsification in the breaking of crude oil emulsions which plague the petroleum industry. One of the most important characteristics of a detergent to the household user is the sudsing. Nevertheless detergents are available for defoaming and for certain operations — particularly industrial uses — they are of particular value if they do not foam. Other anomalous functions of the detergents include their use as antibiotics and as growth promoters as well as wetting and waterproofing agents.

Practical Limitations Due to Detergent Structure

Other practical limitations with respect to performance are encountered when the choice of the detergent is made. To begin with, detergents are mixtures. A modern detergent may have as many as ten or more essential ingredients; there are very few detergents that do not have at least three or four. When the selected ingredients are mixed, the individual members may show a synergistic action; they may show an additive action; or, if improperly chosen, one product may destroy the other. For example, if a cationic and an anionic washing agent were mixed together, the resulting product would be insoluble and worthless. It is obvious that there must be practical limitations to the behavior of such a mixture, depending on the factors which govern the selection of the ingredients and the amount used.

The most important choice in selecting the ingredients for a detergent centers on the material known as the "active" detergent; that is, the surface-active sulfonate, sulfate, quaternary ammonium compound, or polyglycol derivative. It is well known that surface-active agents go through a well-characterized variation of properties, depending on their structure. While there is a popular viewpoint that all detergents are the same, this is far from being the case. There is a very great variation of the behavior with changes in the structure and the molecular weight. Each detergent manufacturer emphasizes one low-cost type of product made in sufficient quantity to make possible efficient low-cost operation, but no one product gives a universal action. There is no product which possesses all of the properties desired for every use. The result of this has been the development of a very great number of these active detergents. There are several thousand commercial trade names to be found in the lists which have been prepared, and each one of these differs in some way, large or small, from all the others. Most of them are small specialties, but there are many which are produced in quite substantial quantities. Our own organization lists over 50 detergents designed to fill special requirements.

Low Cost Important

Most of the active detergents have a long fatty chain. It is not necessary that a surface-active agent nor even a detergent should have a long fatty chain. Such products have come into popular use because they have two very essential characteristics. In the first place, simple organic chemicals with saturated fatty chains are generally colorless; and in the second place, they may be made at a relatively low cost. The fatty chains are derived from vegetable oils, animal oils, or petroleum, which are among the cheapest sources of raw material.

Cleanliness can be expensive as well as time-consuming. A survey of the active detergents, and indeed of all of the other products going into the detergent mixture, would show that in almost all cases they have been derived from the very cheapest of raw materials. Because of this, low cost soap is well within the means of practically everybody in this country. It has made this country the cleanest nation in the world, and with that cleanliness have come those advantages which you would expect to derive from cleanliness.

For example, it is well known that death from infectious diseases in the United States is but a small fraction of that in those countries where there is a low consumption of soaps and detergents.

Low-cost detergents make it possible regularly to clean many things which in the past were rarely cleaned, if they were cleaned at all. The practice of washing rugs, halls, lobbies, buildings, and even the streets has undergone a remarkable increase as the relative cost of washing has steadily decreased.

Limitations Due to Adsorption

A further limitation on the performance of any detergent is brought about by the fact that active detergents of all types are adsorbed by surfaces.

There is one easy way to observe this adsorption. Take a little synthetic detergent, paste it up with a little water, rub it thoroughly over the hands, and then rinse them thoroughly. If the hands are rubbed together, they will lather just as though soap or fresh detergent had been used. They may be rinsed and lathered up again and again until the detergent adsorbed on the surface is finally exhausted.

An extreme case of this adsorption may sometimes be noted in the washing of wool. The synthetic detergent takes the dirt off the wool with extreme rapidity—five to ten squeezes are generally enough to wash out the dirtiest wool socks; but if washing should be continued for say half an hour, the detergent is taken up by the surface of the wool and the dirt in the solution is redeposited on the wool.

This ability of the surface to take up the detergent is greatly influenced by the chemical nature of both the detergent and the surface. It increases with time; it increases with temperatures up to about 180°C.; and it increases rapidly with a lowering of the hydrogen ion concentration below pH 7. Fortunately this loss of detergent due to adsorption is favored by those factors which for most purposes we seek to avoid. For practically every use it is desirable to have the detergent wash as rapidly as possible in luke-warm to cold water, at as low a strength as possible, and in neutral solution. Each of these features reduces adsorption.

Washing

There is no way which better exemplifies the value of the new detergents than in street washing. The street washing truck travels down the highway at 15-20 miles an hour; a detergent solution is sprayed out under high pressure so that each spot on the road is struck by the detergent stream for just one brief instant. That instant is enough to pry the grease and dirt loose from the seemingly clean street and to float it down into the gutter. Since there is no time element, the adsorption is almost zero; so very low concentrations can be used effectively. Ten pounds is enough for 4,000 gallons of water. That solution will wash two miles of city streets, and with water which is cold because the washing truck is filled directly from the water main. In spite of the cold water and the low detergent concentration there are plenty of rich suds to float away the oil. No strong acids or alkalies are necessary. In fact the solution should be neutral to avoid injury to vegetation and to the pedestrians.

Street washing and the washing of hard surfaces in general are a special type of washing which shows the detergent at its best. Unfortunately the average type of washing is not as simple. It does not offer such a perfect set of circumstances for the most efficient use of the detergent. In washing a white cotton shirt, it is not possible to get out the individual fibre and submit it to the high pressure sluicing. The dirt must be taken out from between the tightly wound fibres, which have a decided tendency to trap such particles as carbon black. Washing solid dirt away becomes a matter of compromises, where the detergent which is ideally suited for instantaneous washing must give way to the detergent which can remain effective over the relatively long periods of time required to work the soil out from between the fibres.

Other Desired Properties

Surface Tension Lowering. So far, we have discussed the problem of removing the solid dirt from surfaces and from textiles. There are many other desired properties of a detergent necessary to its efficient use, which it possesses by virtue of being a surface-active agent but which may or may not be related to its ability to remove soil. For example, it is important that the products have low surface tension to speed up the draining of any washing solution. Washing of dishes is one of those operations which consumes a large part of the household detergent. In this day and age when most dishes are drain-dried, it is necessary to have a washing agent which will cause the dish water or the rinse water to drain quickly and completely from the washed plates and glasses. It is also desirable to speed up the draining of the water from textiles or from any other object which may be washed. It is a fortunate characteristic of most detergents that remarkably small quantities bring about a very great lowering of the surface tension. The surface tension of water drops from 73 to about 35 dynes per cm., or less, with solutions which contain a washing concentration of almost any commercial detergent.

Stability. Then there is the matter of stability. The person washing dishes in the household is not confronted with the problem of chemical stability, but these detergents find a rapidly increasing use in industry, as for example in the textile industry where they must stand up in hot caustic solutions, in hot strong acid solutions, in the presence of bleach, and under many other rigorous conditions. For these uses chemical stability is important.

Both the housewife and industry are concerned with the stability of detergents in solution. It is very desirable to have detergents which will function in any kind of solution. It is particularly important that they perform in soft or in hard water. From the standpoint of different uses the detergents should function in acid or alkaline solution. In the household and particularly in industry it is desirable to have detergents which are unaffected by metals and metal salts. In short, the detergent should not be adversely affected by the water supply whether it comes from a pure mountain stream, a swamp rich in organic matter, or from wells in a mineral-rich ground. Conversely the detergent should have no effect on metals.

Removal of Bacteria. One of the functions in the washing process is the disposal of bacteria. From a practical standpoint it does not matter whether the bacteria are washed away, whether they are destroyed,

or whether they are drained away. The important thing is that bacteria and other unwanted organisms should be removed as completely as possible, so that they do not remain to cause bad odors or illness. This is not directly related to the behavior of the detergent in the phenol coefficient test. A study was made of dishwashing by the use of Nacconol NR, which does not give negative values in the phenol coefficient test, in a restaurant where dishes were washed by hand. They showed that the detergent eliminated bacteria to the point where the cleanliness of the plate approached that of a heat-sterilized plate.

Sudsing. For as many years as the housewife has used soap, she has associated suds with washing. When the synthetic detergent was introduced, it was soon found possible to make detergents which would wash without suds. Nevertheless the housewife has found suds an indispensable indicator of the activity of the detergent without which she is at a loss to know whether her detergent is exhaused or whether it is still washing effectively. For this reason, sudsing is regarded as one of the most important characteristics of a detergent intended for household use while at the same time it is often one of the most objectionable characteristics from the standpoint of industrial use.

To the housewife suds are a measure of active detergent which is as effective as the physicist's instruments or the chemist's analyses. When the suds go, it is the danger signal for when the detergent has been exhausted, redeposition of soil soon follows. It is important that this characteristic be preserved. Any effort to take advantage of this situation by putting out household detergents which suds when they do not wash is certain to injure not only the manufacturer but the detergent industry and the public. The meaning of suds should be very carefully preserved until a better measure of active detergent can be provided.

Deodorizing Action. Detergents deodorize in several ways. For example, as described above, they eliminate bacteria which cause odors to form; they emulsify and wash away odoriferous substances; and they bring about conditions, such as low surface tension, which stop the rapid multiplication of bacteria. In addition to this, they have by themselves a remarkably true deodorant action. In the washing of textiles, if all of the detergent is to be thoroughly rinsed from the goods, the deodorant action will of course be lost. There has been an increased use of the no-rinse technique in the average home. This no-rinse technique leaves detergent in the goods which serves to cover up odors as they may be formed.

The deodorant action of detergents is particularly important in dentifrices, where it serves to reduce or eliminate bad breath.

Emulsification. It is questionable whether the problem of emulsification should be considered separately from detergency itself. In this world we wash many things, and one thing which must be washed away is grease. The ideal detergent should have a powerful emulsifying action. This is one of the most difficult features to measure because the product which emulsifies one oil very well may emulsify another very poorly, whereas the second detergent may completely reverse the order. Ideally, the detergent should emulsify any oil.

Benefits

It is not possible in any small space to describe all of the individual performance characteristics which serve to make detergents useful. Categorically it may be said that it is desirable to have as many useful properties as possible in any one product. On the other side of the picture, it is important to discover the unusual properties of the individual active detergents and to put those properties to work in the household or in industry. These special properties of detergents are serving in industry to make better manufactured products at a lower cost, which makes them available to a greater number of people. They serve in the household to lighten the burden of cleanliness. It is the study of performance characteristics which serves to expand the soap and detergent business over and above its present level. Those who bring about this expansion may derive great satisfaction from the improved cleanliness and the improved comfort that the detergents bring to the people of this country and, indeed,to the people of the world.