Technical News Feature

U.S. Detergent/Surfactant Trends — 1980s[1]

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ABSTRACT

The U.S. surfactant market is large, mature, and likely to grow at a rate of 2-3% over the next 10 years. The household, personal care and industrial markets will maintain roughly the same market shares of the total that they have held historically. Within the household market, there should be a continued trend toward the use of alcohol-based surfactants at the expense of linear alkylbenzene sulfonates (LAS). Several factors point to greater usage of nonionics in the future: popularity of heavy-duty liquids and detergents containing enzymes and fabric softeners, a trend to lower laundry wash temperatures and decreasing dependence on phosphate builders. In personal care end uses, alpha olefin sulfonates are expected to show growth due to cost performance advantages in liquid soaps and shampoos. The industrial surfactant market will remain highly segmented and will grow at ca. 3% annually, mainly as a result of overall industrial expansion. Ample capacity and anticipated feedstock availability at acceptable prices will allow producers of synthetic surfactants to satisfy demand through the rest of the decade. Research will lead to formulations aimed at cooler laundry washing conditions and increased enzyme usage. Enhanced oil recovery may involve new surfactants, but large-scale consumption will not begin before the end of the decade.

INTRODUCTION

The U.S. detergent/surfactant market is large and mature, but it is growing and changing. Most of the change is occurring as a result of changes in trends—end-use patterns, raw material economics and innovation from research and development.

The technology and feedstock sources for production of surfactants are well established and would not be expected to change drastically over the rest of this decade. The bulk of today's surfactants and key intermediates are made from petroleum-based feeds: ethylene, propylene, *n*-paraffins and benzene. Soap and lignosulfonates are major exceptions, since they are still derived primarily from natural sources: oilseeds, animal fats and wood.

MARKET DESCRIPTION

The market has three major categories: household, personal care, and industrial. U.S. demand for surfactants in these markets is estimated at 2.5 million metric tons in 1982. The weight percentage breakdown for these markets last year is shown in Table I. Growth rate for total U.S. demand between 1972 and 1981 was ca. 3% per year. The business recession in 1982 had a significant effect, however, so that demand was down 50,000 metric tons relative to 1981. From the 1982 low point, we are projecting an average growth of ca. 2.5% through 1992. Using 1981 as a more reasonable year from which to measure long-term growth, the rate would be closer to 2% per year.

MAJOR SURFACTANTS

The major surfactant types employed in these markets are shown in Figure 1. The nine surfactants listed account for nearly 70% of the total U.S. surfactant demand in 1982. Linear alkylbenzene sulfonates (LAS), alcohol ether sulfates, alcohol ethoxylates and alcohol sulfates have been used for many years, mainly in the household product market. The total for alcohol-based surfactants last year was greater than that for LAS by ca. 48% on an active matter basis. Ten years ago, these relative positions were reversed. The crossover occurred around 1975-76.

Alpha olefin sulfonates (AOS), the smallest major volume surfactant, and soap, the largest, are employed primarily in the personal care area, although soap is used to some extent in the household and industrial end-use markets as well. Alkylphenol ethoxylates, lignosulfonates and petroleum sulfonates are used almost exclusively in industrial applications. Although AOS has been used mostly in personal care products (such as liquid soaps and shampoos), there is great interest in several potential new areas including household and industrial applications.

The 30% of demand not covered by these surfactant types is met by at least 25 smaller volume products including such materials as carboxylic acid esters, various amines and imidazolines.

TABLE I

Surfactant End-Use Markets

	1977	1982	1992
	(% of market)		
Household laundry	28	30	28
Personal care	16	15	15
Industrial	56	54	57
Total surfactant use (metric tons)	2,420,000	2,530,000	3,300,000

INFLUENCES

With that brief description of the market, I will discuss some of the important factors that have influenced the market in the past and that we see influencing surfactant usage today and in the future. These factors are end-use market trends, production economics, environmental concerns, research and development, and demographics.

End-Use Market Trends

Household. Last year the household market consumed ca. 750,000 metric tons of surfactants. Between 1982 and 1992, we expect it to grow at a rate of 1.5-2% annually. It is made up of several end-uses, the largest being laundry and light-duty liquids (LDL) for dishwashing. Together these two accounted for ca. 77% of the total surfactant usage in this category last year.

Laundry. The household laundry market, which had a demand of 390,000 metric tons of surfactant in 1982, is

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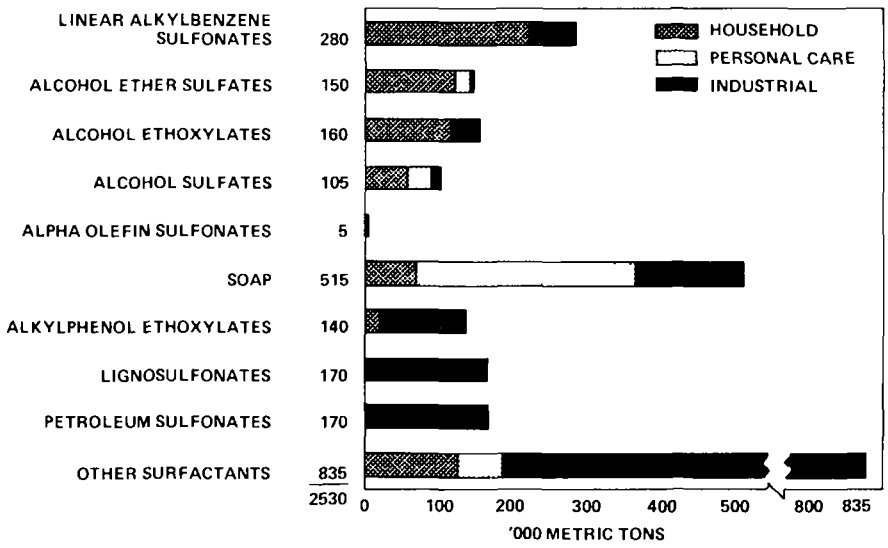

FIG. 1. U.S. major surfactants by end-use market in 1982.

expected to grow at a rate of ca. 1.7% during the next 10 years. One of the most dramatic recent developments has been the rapid increase in the popularity of concentrated laundry products. By concentrated products, we mean liquids and/or powders with recommended use of ¼-½ cup (59-118 cc) per washload. Heavy-duty liquids (HDL), for example, increased their market share from 2 to 22% in the period 1972-82. Although growth recently has slowed, we expect HDL to achieve a 25-30% market share by the early 1990s.

Concentrated powders were introduced in the late 1970s and achieved a 3-4% share in 1982. Agglomeration technology using high nonionic surfactant content facilitated this development. To date, success has been confined mainly to one brand, but at least one other is in test market. Based on past trends, we expect concentrated powders to achieve a 6% share of washloads by 1992.

Detergents containing fabric softeners also have become popular in the past five years. We term such brands multifunctional products. Last year, two HDL products and one powder brand containing softeners held almost an 8% washloads share after their introduction in the late 1970s. Additionally, two existing brands, a liquid and a powder, were reformulated to contain softeners and are undergoing market introduction.

As the cost of energy increases, development of detergents effective in cooler water becomes important. Consumers have become aware of energy savings possible by going to lower washing temperatures since energy needed for heating water represents the major energy input into washing machines and the major cost of laundering clothes. In 1970, ca. 50% of washloads in the U.S.A. were done in hot water (50 C), another 25% in warm water (35 C) and less than 20% in cold water (17 C). By 1990, we expect less than 5% of the washes to be done in hot water, ca. 60% in warm water, and ca. 35% in cold. Of course, 50 C would not be considered "hot" by usual European standards. This trend favors the use of nonionics for two reasons: HDL detergents, increasingly based on nonionics, are preferred because of solubility considerations and nonionics also have a performance advantage at lower temperatures.

Synthetic fibers have become widely used over the years because of cost, easy care, durability and aesthetic considerations. Nonionic surfactants particularly are well suited for cleaning synthetic fibers which are susceptible to troublesome oily soils. Today synthetics comprise ca. 75% of the fabric in the average washload. We believe this mix has plateaued and thus do not expect any reformulation because of washload fiber mix changes.

There is renewed interest in incorporation of enzymes in laundry detergents as evidenced by the reformulation of two heavy-duty liquid brands. The leading concentrated powder includes enzymes. We believe enzymes will be used increasingly as a result of the wider range of cleaning performance provided.

During the recent period of higher inflation in the U.S.A., consumers grew more cost conscious, as evidenced by growth of generic (no brand name) laundry detergents. From 1979 to 1982, the generics' market share increased from 0.9 to 3.7%. At the same time, the market share of private label brands went from 12.8 to 11.4%.

To date, generics have achieved only a small share of the laundry market but there are signs that brand manufacturers are starting to take steps to limit penetration. For example, there are cases where savings from reduced advertising have been passed through to customers, and manufacturers are encouraging consumers to perceive superior quality associated with name brands.

Household-dishwashing. The light-duty liquid (LDL) market which utilized 190,000 metric tons of surfactant in 1982 is maturing. Automatic dishwashing machines, which are found in ca. 50% of U.S. homes, adversely affect the use of LDL. The growth rate of homes equipped with dishwashers seems to have slowed, however, and even where they already exist, the rising cost of energy encourages their use only when they are fully loaded. Thus there will be opportunity for more clean up with LDL between dishwasher loads, especially for smaller households. One manufacturer has test-marketed a new LDL containing fine abrasives to assist in the scouring of pots and pans. This could be termed a multifunctional LDL.

Nondishwashing uses for LDL have been somewhat limited by the proliferation of products for specialized tasks—fine fabric and car washing, to name two examples.

The net effect of these promoting and retarding effects will lead to an LDL growth of ca. 1.5% per year over the next 10 years.

As with laundry products, generics have increased from a 3.5% share of the LDL market in 1979 to 8.0% in 1982. This penetration, however, has been almost completely at the expense of private label brands which declined from

16.5 to 11.8% during that time span.

Personal care. Personal care is the smallest surfactant end-use market, accounting for 16%, or some 409,000 metric tons, of surfactant in 1982. Of this, soap constituted ca. 70%, mostly as toilet bars for hand washing, showering, etc. A smaller amount (7%) of other surfactants, including alcohol sulfates, was also used to formulate combination soap/detergent bars. Demand for bar soap is projected to grow at a rate of ca. 1.5% annually during the decade.

Liquid soaps were introduced about four years ago, initially for hand washing, but more recently they have been available in specially designed containers for shower use. Alpha olefin sulfonates, alcohol ether sulfates and alcohol sulfates, in that order, are the main surfactants used. Sales of liquid soap for the moment appear to have peaked at around a 5% share of the hand and bath soap market.

Shampoo required 63,000 metric tons of surfactants in 1982, most of which were alcohol sulfates and alcohol ether sulfates, with some alpha olefin sulfonates. Shampoo sales are projected to grow at a rate of ca. 3% in the future, which is slower than past rates of ca. 9%. This results from the market becoming saturated in terms of shampooing frequency and number of people who use shampoo products. We look for a continuation of the trend to alcohol ether sulfates at the expense of alcohol sulfates in this end use. Alpha olefin sulfonates are expected to find expanded use here also.

Industrial. Industrial end uses are the largest surfactant market segment and in 1982 accounted for 54% of U.S. surfactant demand, or 1,370,000 metric tons. It is convenient to consider the industrial market as two sectors: industrial and institutional (I&I) cleaning and processing aids.

I&I cleaning includes commercial and institutional cleaning (hotels, hospitals, schools, etc.), transportation cleaning and metal cleaning. This smaller segment of the industrial market accounts for ca. 15% of total industrial surfactant use, or 200,000 metric tons. Surfactants used include alkylphenol ethoxylates in addition to the major ones used in the household market: LAS, alcohol ether sulfates, alcohol ethoxylates and soap. Also consumed is a small amount of alpha olefin sulfonates. This market is forecast to have continued steady growth, reflecting increasing institutionalization and urbanization of our society. No particular change in surfactant types is foreseen, although there will be greater use of cooler washing temperatures in commercial laundries to save energy. Accompanying this trend is increased automation and computerization to allow matching surfactants and temperatures to the kinds of soils encountered. Major industrial detergent suppliers in some cases even sell or lease the equipment needed. In general, this is expected to favor the use of liquids and nonionics.

Processing aids. Processing aids represent ca. 85% of the surfactants consumed in industrial end uses, or 1,170,000 metric tons. They include such diverse areas as emulsion polymerization; textile, pulp and paper processing; paint, foods and agricultural applications; ore flotation; and petroleum production. The nine surfactants described earlier account for ca. 53% of the processing aids surfactant usage, or 620,000 metric tons. Soap, lignosulfonates and petroleum sulfonates represent ca. 450,000 metric tons of surfactant demand for this sector.

Surfactant demand for all industrial uses is forecast to grow at an average of ca. 3% per year between 1982 and 1992.

Production Economics

The next major influence on the surfactant industry which I want to review is economics. In looking at economic trends affecting the marketplace today, three areas are significant: feedstock costs, capacity utilization, and general state of the economy. The principal hydrophobes in the U.S. household and personal care markets are linear alkylbenzene and C_{12} and higher alcohols.

The basic cost of petrochemicals for the detergent surfactant markets, i.e., ethylene, benzene and normal paraffins, reached a peak in 1981. We believe the bottom of the recent decline is close, although falling crude oil prices may prove this incorrect. Making predictions for future costs, especially those related to crude oil, is very risky. Events of the last few months have dramatically shown how true this is. Single line forecasts are even more difficult to defend. We prefer to present our views about future prices of feedstocks and hydrophobe intermediates in terms of price bands.

We project petrochemical feedstock prices to rise no faster than general inflation over the next few years, centering around 50 cents/kg. With a stable oil market, these feedstock prices should stay flat in constant dollars.

Coconut oil, which historically has shown wide fluctuations in price, decreased from a price peak in 1979 to a level where it currently is in the same general range as petrochemical feeds. Coconut oil prices are now depressed relative to the long-term trend line. If prices correct back toward the trend line, as would be expected for an internationally traded commodity, the coconut oil price should move up toward 65 cents/kg. This natural source will remain an important feedstock in the future. Hydrophobe production based on it, however, is subject to several limitations such as commodity price fluctuations, limited technological flexibility, and coproducts balancing.

Prices of major surfactant hydrophobes (LAB and C_{12}-C_{16} alcohols) have followed the trends of feedstock prices in the past and this relationship should continue. Within the upper hydrophobe price (about $1.50/kg), lauryl alcohol has traditionally been near the upper boundary and LAB on the bottom (about $1/kg). Synthetic alcohol has moved in between, usually nearer the top. Despite this higher price, alcohol-based surfactants have been growing in market share at the expense of LAB. The cost performance advantages perceived for the alcohols and their derivatives have been sufficient to overcome the price differential.

Utilization of total capacity for LAB and detergent alcohols has been decreasing in the U.S.A. since 1979. This has occurred because of capacity increases, mainly from plant debottlenecking and because of reduced demand for LAB and tallow alcohol. This situation would have been further aggravated by the opening of Conoco's new LAB plant last year, except that Union Carbide closed down an older plant. If there are no changes in capacity for these hydrophobes, supply and demand should be in balance by about 1990.

Steady improvement in capacity utilization is anticipated as the U.S.A. and other national economies recover from the current business recession. Domestic demand should grow and export business should improve as currencies, particularly those in Europe and Japan, strengthen.

Environmental Concerns

The next important factor affecting surfactant changes is the environmental issue. Biodegradability and builders are the most significant aspects of this issue.

Biodegradability. The impact of biodegradability was felt in the U.S.A. as early as the mid-1960s when users of

branched-chain alkylbenzene sulfonate (ABS) were encouraged to switch to more biodegradable surfactants, i.e., linear alkylbenzene sulfonate (LAS) and/or linear alcohol based derivatives. Legislation since that time such as the federal Water Pollution Control Act and Safe Drinking Water Act of 1974 implies that preferred surfactants are those which biodegrade as completely and rapidly as possible. Currently, the major issue is the extent to which alkylphenol ethoxylates (APE) should be used. The leading U.S. suppliers of household detergents voluntarily have formulated their products without APE because of biodegradability concerns. Suppliers of industrial detergents, however, generally have not felt an obligation to follow suit. Nevertheless, evidence showing more rapid biodegradability of alcohol ethoxylates compared to the alkylphenol-based material is convincing. Several industrial detergent producers are now considering moving away from APE because of these considerations.

Builders. Just about the time the detergent industry adjusted to the biodegradation issue, a second major environmental concern hit the industry in 1972. This involved the banning of phosphate builders in various parts of the U.S.A. The initial effect of the phosphate bans was to spur the use of HDL, since these products could be formulated without phosphates. There was also a tendency to increase surfactant levels in brands that used nonphosphate builders.

Currently, households located in ban areas represent ca. 20% of total, down slightly from 22% in 1981. The percentage of all households actually purchasing nonphosphate products is now ca. 24% due to overlap of warehousing and distribution. Assuming no new restrictions, the percentage of households covered by phosphate legislation probably will decrease slightly during the decade due to slower population growth in ban areas than in other parts of the country. The situation with respect to adoption of further bans is very fluid at this time. Discussions are taking place in several places about adding new ones as well as possibly eliminating some which currently exist.

Of greater concern today is the increasing cost of phosphates and the desire to reduce their use for economic reasons. Phosphate production is energy-intensive and the price of sodium tripolyphosphate advanced 142% between 1973 and 1983, an average of 9.3% per year on a constant dollar basis. This is comparable to cost increases in LAS and nonionic actives themselves. Availability of less costly builders is facilitating the trend toward lower phosphate-built products.

Among the leading alternative builders are synthetic zeolites. A major new production plant came on stream last fall, which improves supply and should stimulate expanded use. Although use of zeolites probably will not directly affect overall surfactant demand, it will favor use of surfactants that are more effective in hard water. This is because zeolites are not as efficient sequestrants of all hard water ions as are phosphates.

NTA (sodium nitrilotriacetic acid) now seems unlikely to become a major builder in the United States. Although the federal Environmental Protection Agency saw "no reason to take regulatory action against the resumed production and use of this substance for laundry detergents," New York State's Department of Environmental Conservation is expected to propose an NTA ban. This is significant because New York represents such a large portion of the nonphosphate market.

Research and Development

There are several research and development activities in progress which suggest new developments that will be important to the industry. Most companies are understandably quite secretive about their R&D programs. As a result, I can only discuss in general terms some areas currently under investigation.

One area receiving attention today is detergency fundamentals. Part of the reason to try to understand better how surfactants do their work is to use more effectively those surface-active agents that already are available. Introduction of new types of surfactants in end-use products is becoming an increasingly costly, time-consuming affair. For example, the Toxic Substances Control Act of 1976 requires extensive toxicity and safety testing before a new compound can be manufactured on a commercial scale.

Several groups in the detergent industry are trying to formulate detergents that will function more effectively at lower temperatures. Others are aiming for improved multifunctional laundry products, particularly ones which can incorporate bleach and/or higher enzyme activity.

While formulation studies are receiving major emphasis by manufacturers of end-use products, work is also being done by suppliers to improve their process technology and product quality. At Shell, we are interested in producing alcohol ethoxylates with sharper peaks in the ethoxylate portion of the molecule. These compounds, referred to as narrow range ethoxylates (NRE), are still under active investigation but they have shown promise in several initial application tests. In the future, these or similar compounds may give additional flexibility to end-use marketers without the full burden of new product qualification.

Some of the most exciting research taking place in the world of surfactants is that in enhanced oil recovery (EOR). Although the current favorable oil supply situation probably has led to a delay in the time when EOR will be employed, the real questions are "when" and "what kind of effort will be needed"—not "whether."

Chemical flooding historically has attracted the most attention from surfactant suppliers because of the extremely large volumes envisioned. Low cost sulfonates generally have been used as the principal surfactants. They are sometimes produced as coproducts from lube and white oil manufacture. In other situations, they are made by sulfonating crude oil distillation cuts directly on the production site.

Regardless of what sulfonate is used as the primary surfactant, many reservoirs have special temperature or salinity conditions which require cosurfactants for optimum recovery performance. Compounds that have shown some degree of success in this application include alcohol ethoxylates and alcohol ether sulfates. Alkylphenol ethoxysulfonates and carboxylates have been evaluated in more demanding situations, but substantial improvement in cost effectiveness will be needed before commercial application can be seriously considered.

Perhaps the brightest area for surfactants in EOR today is their potential use as foaming agents to control the flow behavior of recovery fluids underground. The fluids can be steam in the case of thermal recovery or CO_2 in miscible flooding. Use of diverting foams is a novel and emerging technology, and, as such, is not as well understood as chemical flooding. Field pilot tests with various synthetic sulfonates as steam foam agents have been encouraging. Tests with alpha olefin sulfonates also have looked very promising. Technology based on these materials could be implemented relatively quickly since thermal (steam) flooding without foam is already a proven process. It is currently practiced on a large scale in California and Venezuela.

Other surfactants have shown promising results as foam generators under miscible gas flood conditions in the laboratory. This approach remains very clearly a research con-

cept, however, with considerable development work still needed to confirm its feasibility in actual reservoirs.

The situation today, even in the case of the most advanced chemical recovery process, is that current technology is not cost-effective, except in a few isolated cases. Since the amount of oil being left in the ground is so large, we expect research to continue in order to improve and demonstrate the technology. It is difficult to see significant commercial applications before the 1990s.

Demographics

End-use market trends, economics, environmental factors and research affect, or will affect, the surfactant market in a relatively straightforward manner. The next influence, demographics, or people and their living habits, is less direct in its effect. The way people live is changing and some changes have implications for the surfactant market. The influence is difficult to quantify, however. For example, the U.S. population is increasing more slowly and it is growing older. Growth for the 1980-90 decade is forecast at 0.9% per year and for the 1990-95 period it should be even lower at 0.8%. The number of people 65 years and older will increase from ca. 11 to 13% between 1980 and 1990. Slower population growth implies that growth in demand for certain consumer products will be correspondingly slower. Older people tend to have somewhat reduced laundry requirements and this may lead to the use of less detergents.

But several other trends taking place in the U.S. population will more than offset these effects. First, the number of households is growing—in the 10 years before 1980, the number of households grew three times as fast as the population as a whole. Obviously, the average size of the household shrunk, down to 2.8 persons in 1980 from 3.1 in 1970. More households translates to more bathrooms, kitchens, floors, etc., to be cleaned, and, hence, more surfactants to be consumed.

People are becoming more involved in outdoor leisure activities, particularly in the sunbelt regions. This implies additional clothes to be washed and more frequent baths.

Finally, the number of households having more than one wage earner is increasing. This points toward more interest in highly convenient and time-saving products such as concentrated and multifunctional detergents.

Overall, Americans are still striving for higher standards of living. The convenience and hygiene offered by surfactant-containing products are an integral part of that quality. These considerations will continue to lead to higher consumption rates than population growth alone would suggest.