CEH Marketing Research Report

LINEAR ALKYLATE SULFONATES

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SUMMARY

Linear alkylbenzene sulfonate (LAS) is the world's largest-volume synthetic surfactant and is widely used in household detergents as well as in numerous industrial applications. It was developed as a biodegradable replacement for nonlinear (i.e., branched) alkylbenzene sulfonate (BAS) and has largely replaced BAS in household detergents throughout the developed countries.

The products referred to as LAS or linear alkylate sulfonates include the various salts of sulfonated alkylbenzenes as well as the free acid. Volumes shown in this report are based on 100% active sodium alkylbenzene sulfonate. In fact, most LAS is sold as the sulfonic acid or as water solution in various concentration of the sodium salt. LAS is generally produced in equipment that is also used to produce other sulfonated/sulfated products; therefore, capacities far exceed demand for LAS alone.

The following table shows the 2002 supply/demand balance for LAS in the three major world areas:

Supply/Demand for LAS by Major Region—2002[a]
(millions of pounds)

	North America[b]	Western Europe	Japan	Total
Capacity[c]	2,614	3,968	628	7,110
Production	707	981	170	1,858
Imports	neg	neg	11	11
Exports	neg	223	2	225
Consumption	707	758	179	1,644

(thousands of metric tons)

	North America[b]	Western Europe	Japan	Total
Capacity[c]	1,140	1,800	285	3,225
Production	321	445	77	843
Imports	neg	neg	5	5
Exports	neg	101	1	102
Consumption	321	344	81	746

a. All data are based on 100% active sodium salt of alkylbenzene sulfonic acid (based on average chain length of C-12).

b. North America includes the United States and Canada, but excludes Mexico. Production and consumption in Mexico amounted to about 639 million pounds (290 thousand metric tons).

c. Capacity data refer to total sulfonation capacity as of July 1, 2003 and include capacity to produce other sulfonated or sulfated products.

SOURCE: CEH estimates.

About 80-85% of LAS is used in household detergents, including laundry powders, laundry liquids, dishwashing liquids and other household cleaners. Demand in the laundry segment fell sharly in 2001-2002, as a result of reformulations away from LAS to alternative surfactants. This reflected much higher prices for LAS's raw material, linear alkylbenzene (LAB), during this period. Industrial, institutional and

commercial cleaners account for most of the other applications of LAS, but it is also used as an emulsifier (e.g., for agricultural herbicides and in emulsion polymerization) and wetting agent. Very small volumes are also used in personal care applications. The following table shows a breakdown in the use of LAS in the various end-use categories, as well as projections for future market changes over the 2002-2007 period:

Consumption of LAS by Major Region—2002
(millions of pounds)

	North America[a]	Western Europe	Japan	Total
Laundry Powders	207.5	331	134.5	673
Laundry Liquids	238	132	6.5	376.5
Dishwashing Liquids	111.5	137	6.5	255
Other Household Cleaners	35.5	--[b]	4.5	40
Nonhousehold Uses	114.5[c]	159	26.5	300
Total	707	759	178.5	1,644.5

(thousands of metric tons)

	North America[a]	Western Europe	Japan	Total
Laundry Powders	94	150	61	305
Laundry Liquids	108	60	3	171
Dishwashing Liquids	50.5	62	3	115.5
Other Household Cleaners	16	--[b]	2	18
Nonhousehold Uses	52[c]	72	12	136
Total	320.5	344	81	745.5

Average Annual Growth Rate
(percent)

2002-2007	2.7%	–0.6%	0%	0.9%

a. North America includes the United States and Canada, but excludes Mexico.

b. Consumtion for other household cleaners is included in NONHOUSEHOLD USES.

c. Consumption in this category also includes inventory shifts; see the **Consumption** section for further details.

SOURCE: CEH estimates.

LAS competes with several other major surfactants for use in household detergents. Some of the competitive surfactants have greater hard-water tolerance and better compatibility with enzymes and are milder than LAS. Because of its low cost and other favorable properties, however, LAS will remain a major surfactant for many years. Although the overall consumption of LAS in the developed world will not increase significantly, its consumption in the developing world is likely to grow more rapidly. North American consumption of LAS will increase both because of the growth of laundry liquids and some

reformulation favorable to LAS. The latter development seems likely based largely on a more favorable price relationship to the competing alcohol-based surfactants during middle of the current decade than in early 2002.

Most of the LAS production is accounted for by detergent manufacturers that captively consume it. The largest of these detergent manufacturers are the Procter & Gamble, Unilever, Colgate-Palmolive, Henkel, Lion and Kao groups. The latter two operate principally in Japan and other East Asian countries. The balance of LAS production is accounted for by surfactant producers that supply it either to smaller detergent manufacturers that have no LAS production capability or to other end-use market segments, the largest of which is industrial and institutional cleaning companies. The merchant suppliers may also perform toll sulfonation for some of the large detergent manufacturers that do not have sufficient capacity to meet their own requirements and they may also sell smaller volumes of LAS in the form of formulated products. Examples of large merchant suppliers are Stepan Company in the United States, the Sasol Group in Western Europe and Tayca Corporation in Japan.

MANUFACTURING PROCESSES

Linear alkylbenzene sulfonic acid is prepared commercially by sulfonating linear alkylbenzene (LAB) with either oleum (10-25% sulfur trioxide [SO_3] in sulfuric acid) or an SO_3-air mixture. In both processes, sulfur trioxide is the sulfonating agent and the major product is p-alkylbenzene sulfonic acid. Both batch and continuous processes are used.

One advantage of the SO_3-air route is that it is easier to produce lighter-colored sulfonic acid using this process than with oleum. In addition, the oleum route leads to a product that contains a significant level of by-product sodium sulfate. Although the oleum-derived product is readily formulated into powders, it is less desirable for use in formulating liquid products, where the excess sodium sulfate can create solubility problems. Thus, the SO_3-air process is the preferred route for LAS used in liquid formulations. Since merchant producers of LAS prefer a product that can be sold for either use, all have converted to the SO_3-air process. Also, merchant producers are able to use the same process and equipment to produce other sulfonates (e.g., alpha-olefin sulfonates and methyl ester sulfonates) and sulfates (e.g., alcohol sulfates and alcohol ether sulfates). Some detergent manufacturers that captively consume most of their product in powders and liquids continue to use both routes, but they rely on the older oleum route for most of their powder formulations and use the newer SO_3-air route for most of the LAS used in liquid formulations. As of early 1999, only five oleum plants were operated by detergent manufacturers still producing LAS in North America.

In a typical batch oleum sulfonation process, oleum is added to the LAB reaction mixture at the suction side of a pump that is recycling the contents of the reactor. Under normal commercial conditions, 1.0-1.2 pounds of oleum are required per pound of linear alkylbenzene. The reaction temperature is carefully controlled while the acid is added and the reaction goes to completion during a 30- to 45-minute digestion period. Excessive time or high temperature produces undesirable dark-colored products. In a typical continuous oleum sulfonation process, oleum and LAB are proportioned to a reactor mixing head and the reaction temperature is closely controlled using recycling of the reaction mixture through a heat exchanger. The reaction is generally completed in eight to fifteen minutes. Whether batch or continuous, the reaction is carried out until sulfonation is 98-99% complete.

Sulfonation with oleum produces linear alkylbenzene sulfonic acid containing considerable excess sulfuric acid. If this material is neutralized with aqueous sodium hydroxide, the resulting low-active

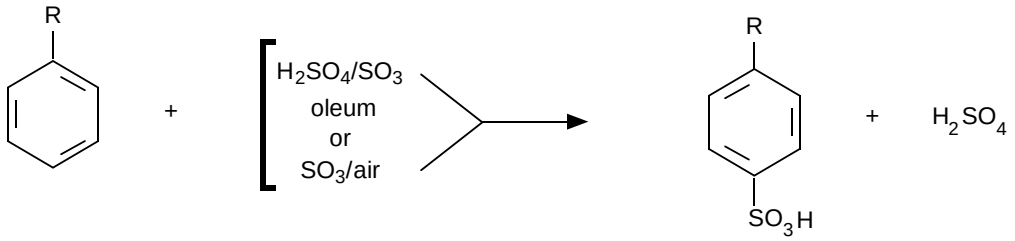
detergent slurry contains about four parts of sodium sulfate for every six parts of the active LAS. These low-active detergent slurries are somewhat restricted in their areas of application because of the high sodium sulfate content. This shortcoming of the oleum-derived products may be partially overcome by adding enough water to the final sulfonation reaction mixture to dilute the sulfuric acid present from about 98% to 71-72%. At this concentration, the sulfuric acid is insoluble in the linear alkylbenzene sulfonic acid and separates as a second layer. Decanting of this sulfuric acid layer leaves an upper phase containing 87-90% linear alkylate sulfonic acid and only 7-9% sulfuric acid. When this product is neutralized with caustic soda, a high-active detergent slurry results.

In a typical batch SO_3-air process, liquid sulfur trioxide is vaporized in a stream of dry air and the resulting 5-15% SO_3 stream is then reacted with the linear alkylbenzene.* As in oleum processes, good mixing and heat removal are necessary to avoid oxidation and charring, which result in dark-colored products. The reaction mixture is digested to complete the reaction. Air and the small remaining excess of sulfur trioxide (only a 3-5% molar excess is used) are removed. The reaction mixture is then hydrated with a small amount of water to hydrolyze any alkylbenzene sulfonic acid anhydrides present in the reaction mixture. In continuous SO_3-air processes, the color of the sulfonic acid products is improved by careful control and maintenance of reaction temperatures. Variations in the method of temperature control include recycling the reaction mixture through heat exchangers and the use of two or more reactors connected in series. When the mixture is neutralized with sodium hydroxide, a 96-97% sulfonate product is obtained.

The free acid in a liquid form (97% active) is the product most commonly sold in the merchant market, since it can be transported at the lowest cost. Shipping a 40% solution of the sodium salt is more expensive since it adds the cost of transporting large volumes of water. Most of the free acid is ultimately converted to the sodium salt by detergent manufacturers and other end users. The sodium salt is preferred, because it combines low cost with physical and performance properties suitable for a wide range of applications. For certain applications, however, other inorganic salts (e.g., ammonium, calcium, potassium) and organic amine salts (e.g., isopropylamine, triethanolamine) are also prepared.

It is estimated that an average of 0.707 pound of LAB is required per pound of sodium alkylbenzene sulfonate produced. Production of linear alkylbenzene sulfonic acid and neutralization to the corresponding sodium salt may be illustrated as follows:

* One variation of the batch process uses a liquid sulfur trioxide–sulfur dioxide mixture in which the sulfur dioxide acts as a diluent for the sulfur trioxide, as a solvent for the reaction and as a refrigerant so that the reaction can be run at very low temperatures (–7 to –9°C).

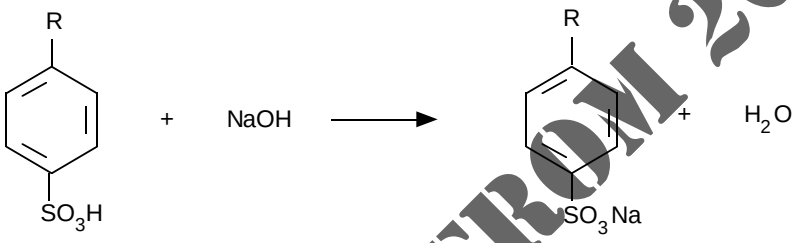


linear alkylbenzene

linear alkylbenzene-sulfonic acid

mol wt: 246 (average C_{12} chain)

326 (average C_{12} chain)



linear alkylbenzene-sulfonic acid

sodium alkylbenzene-sulfonate

mol wt: 326 (average C_{12} chain)

348 (average C_{12} chain)

ENVIRONMENTAL ISSUES

LAS has been safely consumed in large volumes throughout the developed world for over thirty years.* Although its use has been questioned in Western Europe because of its lack of biodegradability under anaerobic conditions, LAS is disposed of under aerobic conditions (i.e., sewage treatment plants), where it does fully biodegrade. Various studies have confirmed this view. For example, a comprehensive risk assessment study carried out by the Netherlands government concluded that the usage of LAS in laundry detergent powders does not involve any significant environmental risk. LAS, as well as other large-volume surfactants, are efficiently (over 99%) removed in the sewage treatment systems. Similar conclusions were included a report of Britain's Department of the Environment. This report stated that LAS is "readily biodegradable," and its use in consumer products "poses no hazard to human health or the environment."

The Regulatory Committee on Ecolabeling of the European Union agreed to permit detergents based on LAS to qualify for the EU ecolabel. However, the Danish Environmental Protection Agency (DEPA) has warned consumers to avoid using LAS-containing detergents and withheld the Nordic Swan ecolabel from these detergent products sold in Denmark. The action is based on concerns that LAS deposits in sewerage sludge that is subsequently used as a fertilizer do not biodegrade rapidly and may endanger beneficial bacteria in the soil. Various studies, including those of other Danish agencies, dispute this

* Further information documenting biodegradation of LAS may be found in A. M. Nielsen et al., *LAS Biodegradation: Ultimate Fate of Alkyl and Ring Carbon*, paper presented at the 1980 Annual Meeting of the Soap and Detergent Association, January 31-February 3, 1980, Boca Raton, Florida.

claim; however, most surfactant manufacturers withdrew LAS from detergents sold in Denmark. A similar position was taken earlier by governmental agencies in Sweden and LAS has largely been withdrawn from detergent products in both countries.

SUPPLY AND DEMAND BY REGION

NORTH AMERICA

PRODUCING COMPANIES

The companies listed in the following table produce linear alkylbenzene sulfonic acid by sulfonation of alkylbenzene. Most of these sulfonators also neutralize at least a portion of their output to produce salts. None of the current domestic sulfonators has captive supplies of linear alkylbenzene. In addition to the companies listed in the table, other companies produce salts from purchased acids. According to industry sources, there are many such companies and most use these salts captively.

A definitive identification of U.S. capacity dedicated to the sulfonation of linear alkylbenzene cannot be made since chemicals other than linear alkylbenzene (e.g., alpha-olefins) can also be sulfonated in some of the same equipment. Also, facilities using SO_3-air processes are often used for the sulfation of alcohols and alcohol ethoxylates. Therefore, the annual capacity figures given below represent only potential production capacity for LAS, provided that capacity was devoted solely to this task.

North American Producers of LAS

Company and Plant Location	Annual Capacity as of January 2003[a] (millions of pounds)	Sulfonation Process	Products
Akzo Nobel			
Akzo Nobel Surface Chemistry LLC			
Houston, TX	75	SO_3-air	Acid; calcium, triethanolamine, diethanolamine, sodium and ammonium salts
Colgate-Palmolive Company			
Cambridge, OH	96	SO_3-air	Sodium salt
Jeffersonville, OH	78		
The Dial Corp.			
St. Louis, MO	90	SO_3-air	Acid and sodium salt
Huish Detergents Inc.			
Houston, TX	175		
Intertrade Holdings, Inc.			
Copperhill, TN	na	na	Sodium salt
JemPak Canada Inc.			
Oakville, ON, Canada	30	SO_3-air	Acid and sodium salt

North American Producers of LAS (continued)

Company and Plant Location	Annual Capacity as of January 2003[a] (millions of pounds)	Sulfonation Process	Products
Pilot Chemical Company			
Lockland, OH	30	SO_3-SO_2	Acid; dimethylamine, isopropylamine,
Middletown, OH	30	SO_3-SO_2	triethanolamine and sodium salts
Middletown, OH	50	SO_3-air	
The Procter & Gamble Company[b]			
Procter & Gamble Chemicals			
Alexandria, LA Augusta, GA Brockville, ON, Canada	400	Oleum	Sodium salt
Rhodia Inc.			
Blue Island, IL	30	SO_3-air	
Stepan Company			
Anaheim, CA Fieldsboro, NJ Longford Mills, ON, Canada Millsdale, IL Winder, GA	1,400	SO_3-air	Acid; isopropylamine, triethanolamine, sodium, calcium and potassium salts
Uniliver Home & Personal Care USA			
Lever Brothers Business Unit			
Baltimore, MD	75	SO_3-air	Acid and sodium salt
Hammond, IN	30	SO_3-air	Acid and sodium salt
Toronto, ON, Canada[c]	25	SO_3-air	Acid and sodium salt
Total	2,614		

a. Theoretical capacity, if production were solely devoted to 100% active linear alkylbenzene sulfonic acid.

b. The sulfonation plants and capacities listed for The Procter & Gamble Company do not include the companies' chlorosulfonic acid sulfonation units, since these units are not used to make LAS. Also excluded are Procter & Gamble's SO_3-air plants at Baltimore, Maryland and Kansas City, Kansas, which do not produce LAS.

c. Plant will close in 2003.

SOURCE: CEH estimates.

Since 1996, one producer has terminated production of LAS and other significant changes have occurred. These are listed below.

- Crompton Corp. sold its remaining surfactant business, including its sulfonation plant in Houston to Akzo Nobel in 2001.
- Huish brought on-line a new 175 million pound capacity SO_3-air sulfonation unit in Houston, Texas in 2002. The plant was designed to make methyl ester sulfonates, as well as other sulonated products. Huish is believed to have shut down operation of its 18 million pound capacity oleum unit in Riverton, Wyoming.
- Pilot Chemical Company closed is Avenel, New Jersey plant.

Of the eleven producers listed in the table, six are household detergent manufacturers that internally consume most or all of their LAS production for detergents. Internal consumption by these six producers (including toll sulfonation for them by merchant suppliers) accounted for about 75% of North American LAS production in 2002. Merchant sales (excluding tolling arrangements) by the other five producers accounted for the balance of LAS production in 2002. Four of these producers (Pilot Chemical Company, Stepan Company, Rhodia and Crompton Corporation) accounted for at least 98% of the merchant market (including LAS-containing blends of surfactants sold to smaller detergent manufacturers). Of these four, Stepan is by far the largest and Pilot is a distant second. The other two are very small.

SALIENT STATISTICS

All volumes of LAS presented in this report are based on the sodium salt of the linear alkylbenzene sulfonic acid with an average alky chain of 12 carbons (100% active basis). The following graph and table provide estimates of the U.S. supply/demand balance for LAS between 1975 and 1996. The subsequent table shows the North American (i.e., U.S. and Canadian) supply/demand balance for LAS for 1995-2002.

U.S. Supply/Demand for LAS—1975-1996
(millions of pounds)

	Production	Imports	Exports[a]	Apparent Consumption
1975	631	1	3	629
1976	663	1	4	660
1977	679	1	4	676
1978	736	1	5	732
1979	725	1	6	720
1980	699	1	6	694
1981	626	1	4	623
1982	599	1	5	595
1983	623	1	3	621
1984	652	1	6	647
1985	698	10[b]	4	704
1986	746	10	4	752
1987	798	10	4	804
1988	855	10	5	860
1989	848	8	4	852
1990	906	10	7	909
1991	855	10	5	860
1992	857	5	5	857
1993	795	neg	neg	795
1994	641	5	5	641
1995	622	2	6	618
1996	661	neg	neg	661

a. Exports are only for LAS as such; any LAS exported in detergent formulations is not included.

b. About 90% of the LAS imports in 1985 were probably accounted for by LAS-containing laundry detergent products imported from Canada. Imports in subsequent years were of LAS itself.

SOURCE: CEH estimates.

North American Supply/Demand for LAS[a]
(millions of pounds)

	Production	Imports	Exports[b]	Apparent Consumption
1995	695	--[c]	--[c]	695
1996	726	--[c]	--[c]	726
1997	802	2	6	798
1998	752	--[c]	--[c]	752
1999	802	--[c]	--[c]	802
2000	847	--[c]	--[c]	847
2001	811	--[c]	--[c]	811
2002	707	--[c]	--[c]	707

a. Includes the United States and Canada, but excludes Mexico and Central America.

b. Exports are only for LAS as such; any LAS exported in detergent formulations is not included.

c. Unknown, but assumed to be negligible.

SOURCE: CEH estimates.

The sodium salt accounts for over 98% of production, as most of the sulfonic acid is ultimately converted to the sodium salt by either the producer or the customer. The value of the 2002 North American production of LAS is estimated at $330-340 million.

Following the large-scale introduction of LAS in the mid-1960s, its production increased as it replaced the slower-to-biodegrade BAS and the use of light-duty liquid detergents using LAS grew rapidly. Production was relatively stable through the early 1970s, except for recessionary 1971 and 1975. During 1976, production of LAS recovered and it steadily increased through 1978 in response to the growing market for laundry liquids and nonphosphate laundry powders containing high LAS levels. Production declined sharply in 1979-1982 as a result of several major laundry detergent reformulations in which LAS levels were greatly reduced. Production generally increased during 1983-1990 following the introduction of several household detergents with high LAS levels and strong growth in the household laundry liquid market. However, the production of LAS declined again in 1991-1994 as a result of detergent reformulations that reduced or eliminated the LAS content of these products. Indeed, the 1995 LAS production level was the lowest since 1982. Production increased 1997 and was in the range of 800-850 million pounds through 2001, before falling shaply to only 707 million in 2002. See the following section for a more detailed analysis of the issues that account for these reformulations and the fluctuating demand for LAS by the detergent industry over the last two decades.

CONSUMPTION

About 80-85% of the U.S. consumption of LAS is in household detergents, including laundry detergents (both powders and liquids), dishwashing detergents and various general-purpose household cleaners. The balance of the LAS consumption is in industrial, institutional and commercial cleaners, as well as in a number of diverse industrial applications, where its use is not related to its cleaning properties.

The following table provides a breakdown of U.S. consumption of LAS by end use from 1975 to 1996. The subsequent table provides similar data on a North American (U.S. and Canadian) basis for 1997-2002.

U.S. Consumption of LAS by End Use—1975-1996
(millions of pounds)

	Household Products					
	Heavy-Duty Laundry Powders	Heavy-Duty Laundry Liquids	Light-Duty (dishwashing) Liquids	Miscellaneous Household Cleaners	Other[a]	Total
1975	356	75	101	27	70	629
1976	361	87	106	29	77	660
1977	365	99	107	29	76	676
1978	385	132	102	30	83	732
1979	386	133	100	30	71	720
1980	356	141	99	31	67	693
1981	315	91	91	31	95	623
1982	276	98	114	31	76	595
1983	264	101	122	32	102	621
1984	288	106	124	32	97	647
1985	305	150	121	32	96	704
1986	310	169	125	34	114	752
1987	317	208	132	36	111	804
1988	340	238	140	35	107	860
1989	371	244	123	30	84	852
1990	410	251	129	30	89	909
1991	370	233	127	30	100	860
1992	366	240	124	29	98	857
1993	288	279	102	26	100	795
1994	290	149	85	22	95	641
1995	290	132	81	24	91	618
1996	308	155	93	27	78	661

a. Includes all nonhousehold uses (i.e., industrial, institutional and commercial uses) and may include producer inventory adjustments.

SOURCE: CEH estimates.

North American Consumption of LAS by End Use[a]
(millions of pounds)

	Household Products					
	Heavy-Duty Laundry Powders	Heavy-Duty Laundry Liquids	Light-Duty (dishwashing) Liquids	Miscellaneous Household Cleaners	Other[b]	Total
1997	356	200	110	27	105[c]	798
1998	342	200	102	26	82[c]	752
1999	na	na	na	na	na	802
2000	303	306.5	103.5	30	104.5	847.5
2001	na	na	na	na	na	811
2002	207.5	238	111.5	35.5	114.5	707

a. Includes United States and Canada, but excludes Mexico and Central America.

b. Includes all nonhousehold uses (i.e., industrial, institutional and commercial uses) and may include producer inventory adjustments.

c. Actual consumption in this category is believed to amount to about 95 million pounds in 1997 and 1998. The consumption shown also includes inventory shifts, which could be as much as 15-20 million pounds in some years.

SOURCE: CEH estimates.

The following table presents estimates of the 2002 North American consumption of LAS by end use, the projected consumption in 2007 and the average annual rates of change for the major categories of end use:

North American Consumption of LAS
(millions of pounds)

	2002	2007	Average Annual Growth Rate, 2002-2007 (percent)
Household Products			
Heavy-Duty Laundry Powders	207.5	171	–3.8
Heavy-Duty Laundry Liquids	238	357.5	8.5
Light-Duty Liquids	111.5	117	1.0
Miscellaneous Household Cleaners	35.5	37	0.8
Industrial, Institutional and Commercial Applications[a]	114.5[a]	121.5	1.2
Total	707	804	2.6%

a. Category may include some inventory adjustments by LAS producers.

SOURCE: CEH estimates.

Household Products

About 592 million pounds of LAS were consumed in North American household detergents in 2002, compared with 820 million pounds in the peak year of 1990 and 743 million pounds as recently as 2000. From the late 1960s, when it replaced BAS, until 1993, LAS was the largest-volume surfactant consumed in household detergents. In 1994, however, alcohol ether sulfates (AES) replaced LAS as the largest-volume anionic surfactant used in household detergents in North America (i.e., United States and Canada, but excluding Mexico). The issues that led to this decline in LAS usage are described in considerable detail in the subsequent sections on the various household detergent types. Nevertheless, LAS remains a major surfactant in household detergents.

Most synthetic detergent formulations are fairly complex mixtures and manufacturers have developed considerable sophistication in varying the contents to achieve the desired performance at the lowest possible cost. The choice of which surfactant to employ is based on the advertising claims the manufacturer wishes to make for a product and on cost/performance considerations that depend upon its performance in the formulated product and the ease of processing of the surfactant in combination with other ingredients in the formulation. The characteristics that have contributed to the widespread use of LAS include the following: excellent surfactant properties, low cost relative to alternative surfactants, ease of processing into nonhydrous powders when spray-dried, favorable solubility characteristics for use in liquid formulations, compatibility with other surface-active agents used in mixed-actives systems, medium to high sudsing characteristics in formulations and long-accepted biodegradability and favorable performance under toxicological scrutiny.

The sales of detergents and other household products by mass merchandisers or “warehouse” consumer outlets (e.g., Wal-Mart) represent an increasing share of total sales. Since these outlets generally offer only a few brands at greatly reduced prices, detergent manufacturers must offer the lowest possible prices to secure shelf space at these outlets. This development has caused major restructuring in the detergent industry and intensified manufacturers’ efforts to reduce formulation costs.

The dominant North American producers of household detergents (and consequently the largest consumers of LAS) are The Procter & Gamble Company (P&G); Unilever; Colgate-Palmolive Company; The Dial Corp.; Armus (a joint-venture of USA Detergents, Incorporated and Church & Dwight); Huish Detergents Inc.; and JemPak Canada Inc.

Six manufacturers of household products produce and captively consume LAS, although some of these manufacturers also purchase additional quantities of LAS from merchant suppliers. The latter transactions usually reflect the capacity limitations of some manufacturers for producing LAS using the SO_3-air process, which is preferred for making LAS that is subsequently used in liquid products (see the **MANUFACTURING PROCESSES** section of this report). Most smaller detergent producers purchase all of their LAS from merchant suppliers.

The major household product categories consuming large volumes of LAS are heavy-duty laundry powders, heavy-duty laundry liquids and light-duty dishwashing liquids. (See the CEH *Surfactants, Household Detergents and Their Raw Materials* marketing research report for a discussion of the formulation of these products.) Smaller volumes of LAS are also consumed in a variety of general-purpose household cleaners.

The individual household detergent categories and their consumption of LAS are discussed in the following sections.

Heavy-duty laundry detergents (powders and liquids)

North American consumption of LAS in household laundry detergents amounted to about 446 million pounds in 2002. This represents a decline of over 160 million pounds from the 2000 level. This decline was largely related to an unfavorable price relationship of LAS to the competing alcohol-based surfactants. To a lesser degree, it also reflected the continuing consumer shift from laundry powder to laundry liquids, as LAS can be more easily replaced in liquids. LAS had enjoyed a price advantaged relative to the alcohol-based surfactants in the late 1990s, as prices of the latter rose as a result of several developments. One was high natural gas prices that drove up the prices of ethylene, upon which synthetic detergent alcohols are based. Another was high prices for coconut oil, upon which natural alcohols are based. Stong demand had also led to a very high capacity utilization of many synthetic detergent alcohol plants. However, these developments were quickly reversed in the early 2000s. Prices of both natural gas and coconut oil declined and two large new alcohol plants (Shell Chemical's new alcohol plant in Geismar, Louisiana and the new Sasol plant in South Africa) came on-line in 2001. At the same time, crude oil prices rose sharply in 2002, pushing up the price of benzene and n-paraffins, from which LAB and LAS are derived. As a result of these developments, LAB/LAS prices rose, while those of the alcohol-based surfactants moderated and customers switched formulations to use more of the latter. The economic recession during this period also motivated detergent manufacturers to resist price increases for LAB/LAS and to lower surfactant levels to maintain their margins at the expense of chemical suppliers. As a result of the falling demand, prices for LAB dropped significantly in late 2002.

The adverse situation for LAS will likely improve somewhat by the middle of the decade, as lower prices for LAB will likely lead to at least some reformulation back to LAS. An improving economy should also increase demand somewhat for detergent products. However, the excess alcohol capacity may hold down alcohol pricing. Consequently, the shift back to LAS may be less dramatic.

The North American laundry market is expected to grow at an average annual rate of a little over one percent (washload basis) over the 2002-2007 period. During the 1980s, the overall growth in the North American market for laundry detergents was larger, reflecting various demographic and lifestyle considerations (e.g., more leisure activity and more frequent changes of clothes). Laundry liquids have accounted for all of the growth, whereas the volume of powders has fallen in recent years. This contrasts sharply with other world areas where liquid detergents are only a small share of the laundry market. Since LAS has a processing advantage over the alcohol ethoxylates in its use in spray-dry powders, the decline of these products is an unfavorable trend. Although powders are likely to continue to decline at a rate of a little over 5% per year, the decline of LAS consumption will be less (only about 3.8%) on the assumption of some reformulation back to LAS based on its cuurrent lower prices.

Laundry liquids have been growing rapidly, because consumers prefer the rapid and complete solubility and their ability to pretreat stains. The addition of high levels of enzymes to these products has also improved their performance. Growth in this product category is expected to continue at a rate of at least 5% per year over 2002-2007, largely at the expense of laundry powders. In addition to the growth in the liquid products, some reformulation to higher LAS levels seems likely. Thus, growth in the consumption of LAS in liquids over 2002-2007 should average about 8.5% per year.

Since liquid laundry detergents are the fastest-growing segment, the level of their LAS content is critical to the future growth of LAS. A key issue in this regard has been the stability of enzymes in the presence of LAS in liquid detergents. Enzymes are used in laundry detergents to assist the action of surfactants by promoting the hydrolysis of protein and starch stains. Others contribute to preserving the appearance of cotton fabrics after repeated washing. Anionic surfactants in solution are known to inactivate enzymes over time, but the adverse impact of LAS is greater than with AES. As the level and complexity of the

enzyme systems used increased, the stability problem became more apparent. This resulted in the removal of LAS from some liquid products in 1994; however, newer developments in enzyme technology have permitted the use of limited levels of LAS in liquid laundry products with minimal enzyme stability problems. Consequently, LAS reappeared in 2000 in some of the products from which it had been removed. Enzyme stability in the presence of LAS has not been an issue in powders, where direct interaction between LAS and enzymes does not occur until the dissolution of the powder in the wash cycle. Since the inactivation of the enzyme occurs very slowly, no significant problem results before both are removed in the rinse cycle.

One of the most important considerations in the future consumption of LAS in home laundry products is the relative price for LAS compared with prices for the alcohol-based surfactants. LAS is derived from benzene and n-paraffins, both of which are in turn derived from petroleum. In contrast, the alcohol-based surfactants are produced largely from ethylene, which is derived mainly from natural gas liquids in the United States. Petroleum prices declined significantly in 1986 and remained relatively low compared with natural gas prices throughout most of the late 1980 and into the late 1990s, leading to comparatively low and reasonably stable prices for benzene and n-paraffins. Prices for paraffins rose near the end of the 1990s as a result of shortages. Then, prices rose again for both paraffins and benzene in 2002-2003 with increasing crude oil prices brought on by political instability in Venezuela and the war in Iraq. Ethylene prices have also been more volatile in recent years. Ethylene and ethylene oxide prices increased sharply in 1987-1989, reflecting strong demand for ethylene in plastics and other markets, along with a shortage in ethylene capacity. Prices for these products subsequently declined in recessionary 1990-1992, but rose again in 1994-1995, 2000-2001 and early 2003. Ethylene prices will continue to cycle, but, over the long term, LAS and the alcohol-based surfactants are expected to remain highly competitive on a cost/performance basis.

On relative cleaning performance, AE has lower hard-water sensitivity than LAS, a consideration that is especially important in liquid laundry detergents, all of which lack an effective builder (i.e., a sequestrant for hard water ions). However, LAS is more readily processed into powders than AE. LAS is generally considered more effective than AE on heavy particulate soils (e.g., clays), whereas AE is more effective on body oil stains. Consequently, most manufacturers prefer to use a combination of both to obtain the optimum performance for average washing conditions. Overall, these performance considerations suggest that LAS will continue to be a cost-effective surfactant, especially in powders where its processing characteristics are an advantage and where it has no adverse impact on enzyme stability.

Historical LAS consumption patterns

Historically, the U.S. consumption of LAS in laundry detergents grew rapidly in the late 1960s, as it quickly replaced the less readily biodegradable BAS in these products. By 1969, this substitution was complete and consumption of LAS grew more slowly, until it increased dramatically in the late 1970s as a result of two major developments. The first was the rapid growth in the use of laundry liquids (which generally use higher surfactant levels than do powders). The second was the major reduction in the phosphate levels of detergents, which initially required higher surfactant levels to maintain acceptable performance. The phosphate reduction reflected both the higher cost of phosphates and government restrictions on their use in certain regions of the country. LAS was the surfactant of choice for most producers in the late 1970s and the volume of its consumption in laundry detergents reached a level of 519 million pounds in 1979.

When raw material costs began to rise as a result of the second world oil crisis in 1979, detergent manufacturers began to reduce the cost of their detergent formulations by lowering the level of LAS and

using more of the alcohol-based surfactants. The price of ethylene (from which the alcohol-based surfactants are largely derived) had not risen as rapidly as n-paraffins and benzene (from which LAS is derived and which are tied directly to crude oil prices). As a result, the consumption of LAS in laundry products fell to only 365 million pounds in 1983 or 154 million pounds below the prior peak level in 1979.

Consumption of LAS increased significantly in the mid-1980s as a result of lower crude oil prices and the successful introduction of several new laundry products containing high levels of LAS, including P&G's Liquid Tide® and Unilever's Surf® laundry powder. Consumption continued to increase in the late 1980s as a result of the growth in demand for laundry liquids and the subsequent introduction of compact laundry powders that detergent manufacturers initially found easier to make from LAS than from other surfactants. Thus, both production and consumption of LAS set new record levels in 1988 and again in 1990.

Between 1990 and 1994, the consumption of LAS in laundry products greatly declined. Most of this resulted from the removal of LAS from the laundry liquids of P&G. Consumption of LAS increased, however, during 1995-1997 and again in 1999-2000, as previously described.

Light-duty liquid detergents

Nearly 112 million pounds of LAS were consumed in light-duty liquid detergents in 2002. These products are designed primarily for hand-washing of dinnerware and, to a far lesser extent, for hand-laundering of fine fabrics and hosiery. Most light-duty detergents use LAS in combination with lower levels of alcohol ether sulfates (AES) and fatty alkanolamides (FAA). Alternatively, Procter & Gamble has consistently used higher levels of AES, in combination with other surfactants (e.g., alcohol sulfates and fatty amine oxides) and does not use any LAS in its dishwashing liquids. This approach may be too expensive for other producers, but Procter & Gamble has an economic advantage, since it has a basic position in detergent alcohols, AES and fatty amine oxides.

The sales of the light-duty liquids have shown growth of only about one percent per year over the last ten years. The main reason has been the increasing use of automatic dishwashers, which use a different type of detergent. Automatic dishwashing detergents are based largely on inorganic builders (e.g., phosphates and silicates) and use only very low levels of specialty organic surfactants. Consumers, however, may use the light-duty liquids for other cleaning jobs in the kitchen, such as counter and stove tops. Also, many consumers use their auto dishwashers for tableware, but use light-duty liquids to hand wash pots and pans. Thus, some growth for these products has been sustained, in spite of the growing use of automatic dishwashers.

From 1982 through 1992, the consumption of LAS in light-duty detergents had been fairly stable. However, consumption fell sharply in 1993 and 1994, as several large manufacturers increased the use of milder surfactants, such as AES, alkylpolyglucosides (APG) and amphoterics and lowered their LAS levels. As prices of some of these milder surfactants, especially AES, began to increase in 1994 and 1995, some detergent producers may have switched back to LAS. Alcohol ethoxylates and alkylphenol ethoxylates cannot be employed in these products at high levels because of the possible skin irritation that would result from their use. Thus, detergent producers had fewer formulation options in hand-dish-washing liquids than in laundry detergents. Until 1993, therefore, the consumption of LAS in this market tended to reflect the growth in the overall use of dishwashing liquids and the market share of the light-duty detergents that use the LAS/AES/FAA formulation. This distribution had been more affected by the

success of the advertising promotions of the major producers than by any raw material cost considerations.

The greater emphasis on mildness that began in the 1990s has abated somewhat, but is still an important attribute. Because LAS has regained a cost advantage over most alternative surfactants, however, its consumption in dishwashing liquids should continue to increase at rate of one per cent per year in this market segment.

Miscellaneous household cleaners

LAS is frequently present at low levels in numerous household cleaners. Inorganic salts and solvents are usually the major ingredients and other surfactants are often used instead of LAS. Examples of the product categories and brand names that may contain LAS include heavy-duty hard-surface cleansers (e.g., Pine Sol® and Mr. Clean®), laundry presoaks and prespotters, as well as specialty cleaners (e.g., Soft Scrub® and Chlorox® 2).

An estimated 35.5 million pounds of LAS were consumed in these products in 2002. There will probably be a 0.8% average annual growth rate for the use of LAS in these products for the 2002-2007 period.

Industrial, Institutional and Commercial Applications

The historical estimates for the consumption of LAS in this category shown in the consumption table reflect the difference between estimates of the total volume of LAS consumption and the volume consumed in household uses. As such, it can include some changes in customer inventories of LAS (both household and nonhousehold) and may be subject to a much larger error than the other categories described. Thus, the reader should exercise some caution in interpreting the significance of changes in the consumption estimates for this category over time.

In 2002, an estimated 114.5 million pounds of LAS were consumed in nonhousehold markets, mainly industrial, institutional and commercial products and processes. Since nonhousehold markets for LAS are numerous and widely dispersed through industrial, institutional and commercial establishments, they are difficult to quantify. The largest consumption within this category is accounted for by industrial, institutional and commercial cleaning applications. These include its use in products for commercial laundries, commercial and institutional restaurants (e.g., hand-dishwashing formulations), janitorial cleaning services (i.e., various hard-surface cleaners) and transportation vehicle washing establishments. This segment probably accounted for nearly 100 million pounds of LAS in 2002.

Other nonhousehold uses of LAS include applications where noncleaning properties of LAS are important, including emulsification of agricultural herbicides, emulsion polymerization of monomers in polymer processing, construction materials (e.g., wallboard) and various oil field applications. Together, these noncleaning uses of LAS amounted to at least 15 million pounds in 2002.

Very small amounts of LAS are also used in personal care applications.

Consumption of LAS in all nonhousehold applications is expected to increase at an average annual rate of 1.2% over the 2002-2007 period.

PRICE

List prices for LAS declined significantly during 1991-1995 but increased somewhat in 1997 and and again in 2000. Average prices for large-volume purchases are well below list prices and were about $0.47-0.48 per pound on average during 2002.

The following table presents typical list price histories for linear alkylbenzene sulfonic acids and salts:

U.S. List Prices for Linear Alkylbenzene Sulfonic Acid and Salts[a]
(cents per pound)

	Acid[b]	Sodium Salt[c]	Triethanolamine Salt[d]
1966	15.0	13.2	18.5
1970	12.0	12.0	18.5
1975	29.5	29.5	31.0
1976	31.0	31.0	32.5
1977	32.0	32.0	32.5
1978	34.0	34.0	33.5
1979	43.0	43.0	39.5
1980	51.0	51.0	44.5
1981	54.0	54.0	45.0
1982	52.0	52.0	44.5
1983	53.0	53.0	43.0
1984	57.0	57.0	45.0
1985	57.0	57.0	45.0
1986	57.0	57.0	45.0
1987	60.5	60.5	49.0
1988	60.5	60.5	49.0
1989	65.5	65.5	57.5
1990	69.5	69.5	61.5
1991	70.5	70.5	63.0
1992	70.5	70.5	63.0
1993	73.5	73.5	64.5
1994	73.5	73.5	64.5
1995	73.5	73.5	64.5
1996	79.5	78.0	68.5
1997	84.0	80.5	71.0
1998	86.5	83.0	72.5
1999	86.5	83.0	72.5
2000	88.5	85	73.5
2001	88.5	85	73.5
2002	88.5	85	73.5

a. Prices shown through 1970 and for 1977-2002 are list prices on or about July 1 of the year indicated; data for 1975 represent list prices as of December. The 1976 list prices became effective October 1, 1976.

b. 96-97% active basis.

c. 100% active basis.

d. 60% active basis.

SOURCE: CEH estimates.

For 1966-1994, the U.S. International Trade Commission reported unit sales value data (i.e., average sales value) for sodium, calcium and triethanolamine dodecylbenzene sulfonates. These values include both the branched (BAS) and linear (LAS) products. Since 1971, linear alkylbenzene sulfonic acid and salts are estimated to have accounted for over 90% of the total volume of sulfonates used to calculate these unit sales value data. The reported value of the sulfonic acid appears to be far below realistic averages for 1990-1993 and the reported value of the sodium salt appears to be much higher than likely for 1993. These data are listed in the following table for historical analysis:

U.S. Unit Sales Values for Alkylbenzene Sulfonates—1966-1994[a]
(cents per pound)

	Dodecylbenzenesulfonates				
	Acid	**Sodium**	**Calcium**	**Triethanolamine**	**Total[b]**
1966	--	14	38	25	16
1970	--	13	37	21	14
1975	--	32	77	28	34
1976	--	33	73	41	36
1977	30	31	74	40	36
1978	31	27	76	42	35
1979	37	32	86	45	42
1980	45	39	91	56	49
1981	46	50	91	60	53
1982	43	37	75	60	44
1983	44	47	99	57	48
1984	46	50	98	56	50
1985	46	54	102	58	52
1986	46	67	94	58	56
1987	47	66	109	59	57
1988	49	65	125	55	57
1989	53	60	145	59	59
1990	35[c]	69	111	82	46
1991	36[c]	74[c]	142	80	46
1992	32[c]	69[c]	164	81	42
1993	28.5[c]	81[c]	181	64	na
1994	38.6	60.8	173	85.7	na

a. Calculated from rounded figures on the basis of 100% organic surface-active ingredient. However, the reported values may be inaccurate in many years, as they often exceed the list prices for the same year as shown in the preceding table.

b. Includes alkylbenzene sulfonic acid, the three salts listed and all other salts.

c. Reported values are believed to be inaccurate.

SOURCE: *Synthetic Organic Chemicals, U.S. Production and Sales*, U.S. International Trade Commission.

During the 1970s, price increases for LAS generally reflected higher raw material (i.e., LAB) prices because of either the energy crises (1974 and 1979) or increasing demand for both LAB and LAS (1976-

1979). Actual market prices declined slightly in 1982-1983, reflecting stable or declining world oil prices and reduced demand for LAS. Market prices increased again in 1984 and throughout the late 1980s as demand for LAS increased, but dropped sharply over the 1990-1995 period. Prices rose again with increasing demand and shortages of n-paraffins in 2000, but fell sharply in late 2002 as demand fell.

Most large-volume sales of LAS are as the sulfonic acid, large volumes of which are toll-manufactured by sulfonators. In these arrangements, the detergent customer acquires the LAB raw material and has it delivered to the sulfonator's plant for conversion to LAS.

TRADE

LAS is not a significant item of international trade. Most LAS produced in the United States is consumed domestically, as are most of the finished detergent formulations. Imports of LAS are estimated to have been less than five million pounds annually in recent years.

Exports of all alkylbenzene sulfonic acids (linear and nonlinear) are believed to be less than 10 million pounds annually.

MEXICO

The following table lists Mexican producers of linear alkylbenzene sulfonic acid by sulfonation of alkylbenzene:

Mexican Producers of LAS

Company and Plant Location	Annual Capacity as of April 1999[a] (thousands of metric tons)	Sulfonation Process
La Carona		
México, Distrito Federal	68	SO_3-air
Clariant (México), S.A. de C.V.		
Santa Clara, Edo. de México	4	SO_3-air
Colgate-Palmolive, S.A. de C.V.		
Celaya, Guanajuato	68	SO_3-air
Nobleza		
México, Distrito Federal	3	SO_3-air
Procter & Gamble de México, S.A. de C.V.		
Guanajuato, Guanajato	170	SO_3-air
México, Distrito Federal	6	SO_3-air
Sánchez y Martín, S.A. de C.V.		
Guadalajara, Jalisco	17	SO_3-air
Sasil		
Monterrey, Nuevo León	16	SO_3-air

Mexican Producers of LAS (continued)

Company and Plant Location	Annual Capacity as of April 1999[a] (thousands of metric tons)	Sulfonation Process
Stepan México S.A. de C.V.		
Matamoros, Tamaulipas	6	SO_3-air
Union Química		
México, Distrito Federal	5	Oleum
San Juan del Rio, Guanajato	15	SO_3-air
Total	>378	

a. Theoretical capacity, if production were solely devoted to 100% active linear alkylbenzene sulfonic acid.

SOURCE: CEH estimates.

Mexican production and consumption of LAS is estimated at 290 thousand metric tons (as the sodium salt) or about 270 thousand metric tons as the sulfonic acid in 2002. Thus, the industry operated at about 71% of capacity in 2002.

WESTERN EUROPE

PRODUCING COMPANIES

In Western Europe, the large multinational detergent manufacturers are the major producers of linear alkylbenzene sulfonic acid and its salts. They captively consume nearly all of the production of LAS in formulated detergent products for household and industrial applications and use both oleum and the SO_3-air processes. In addition, many other producers of LAS sell to the merchant market; however, some of these also consume part of their LAS production captively or for the production of formulated products. Nearly all of the producers for the merchant market use the SO_3-air process.

The following table lists the major Western European producers of LAS, with estimates of their sulfonation capacity. It does not list the individual capacities of all of the major detergent manufacturers, some of whose capacities are unknown. However, an estimate of the total sulfonation capacity of the unlisted detergent manufacturers using SO_3-air, as well as of companies whose primary product in this area comprises textile treatment chemicals, is included in the total under "Other." The sulfonation capacities shown are not devoted solely to LAS, since the same facilities are often used for production of alcohol sulfates and alcohol ether sulfates. Thus total capacity is not a suitable basis upon which to calculate utilization rates, since other products are often produced in the same equipment and the exact proportion devoted to LAS production is unknown.

Western European Producers of LAS

Company and Plant Location	Annual Capacity as of March 2003[a] (thousands of metric tons)
Belgium	
Procter and Gamble	
Mechelen	10
TensaChem S.A. (formerly Manro S.A.)	
Ougrée	70
France	
Chimiotechnic SA	
Marseille	20
Cognis France S.A.	
Meaux	30
Pontivy	25
Huntsman Surface Sciences S.A. (formerly known as Albright & Wilson Saint-Mihiel)	
Saint-Mihiel	60
IfraChem S.A.	
Saint Pierre les Elbeuf	30
Procter & Gamble France S.A.	
Amiens	25
Germany	
Cognis Deutschland GmbH & Co. KG	
Düsseldorf	80
Deutsche Unilever GmbH	
Mannheim	15
Hansa Chemie AG (formerly known as Akzo Nobel Chemicals GmbH)	
Düren	25
Sasol Olefins & Surfactants GmbH (formerly known as CONDEA Chemie GmbH)	
Marl	115
Stepan Deutschland GmbH	
Wesseling	20
Greece	
Bianil	
Piraeus	15

Western European Producers of LAS (continued)

Company and Plant Location	Annual Capacity as of March 2003[a] (thousands of metric tons)
Greece (continued)	
Henkel Hellas AE	
Athens	8
Kappachim	
Athens	20
Lever Hellas A.E.B.E.	
Rentis	12
Trylat	
Athens	5
Italy	
Cognis S.P.A.	
Fino-Mornasco	25
Henkel S.p.A.	
Ferentino	25
Huntsman Surface Sciences S.r.l.	
(formerly known as Albright & Wilson Srl)	
Castiglione delle Stiviere	40
Patrica	35
Ital Silva	
Seregano	30
Procter & Gamble Italia S.p.A.	
Pomezia	10
Reckitt Benckiser Italia S.p.A.	
Mira	30
Rhodia Geronazzo SpA	
Ospiate di Bollate	5
Sasol Italy S.p.A.	
(formerly known as CONDEA Augusta S.p.A.)	
Terranova dei Passerini	60
Unil-It SpA	
Lever Division	
Casalpusterlengo	60
Netherlands	
Sasol Servo BV	
(formerly known as CONDEA Servo BV)	
Delden	10

Western European Producers of LAS (continued)

Company and Plant Location	Annual Capacity as of March 2003[a] (thousands of metric tons)
Norway	
Unger Fabrikker A.S	
Fredrikstad	40
Portugal	
IfraChem S.A. (formerly Shell Portuguesa S.A.)	
Lisboa	20
Spain	
Bilore, S.A.	
Zaldibia	20
Cognis Ibérica, S.L.	
Barcelona	30
Henkel Ibérica, S.A.	
Montornés del Vallés	15
Huntsman Surfactants Ibérica (formerly known as Albright & Wilson Ibérica S.A.)	
Barcelona	10
Massó y Carol, S.A.	
Santa Coloma de Cervello	5
PETRESA (Petroquímica Española, SA)	
San Roque	80
Procter & Gamble	
Mataro	15
United Kingdom	
Huntsman Surface Sciences (UK) Ltd.	
Whitehaven	45
Procter & Gamble UK Chemicals Division–Europe	
West Thurrock	120
Stepan UK Ltd. (formerly Manro Performance Chemicals Ltd.)	
Stalybridge	100
Unilever PLC	
Port Sunlight	35
Other[b]	300-400
Total	>1,750-1,850

a. The total capacity presented is not a suitable basis upon which to calculate utilization rates, since other products are often produced in the same equipment and the exact proportion devoted to LAS production is unknown.

b. Smaller producers, detergent manufacturers and companies whose production comprises textile treatment chemicals are located in most of the Western European countries listed above.

SOURCE: CEH estimates.

Significant developments within Western Europe since 1999 are mentioned below.

- BASF Aktiengesellschaft closed its 15 thousand metric ton-per-year LAS plant in Ludwigshafen in 2003.
- Clariant Ibérica, S.A. closed its 15 thousand metric ton-per-year LAS plant in Vilaseca, Spain in June 2000.
- Henkel KgaA spun of its chemical business as a separate entity, Cognis Deutschland GmbH, in August 1999. Some of the LAS plants previously owned by Henkel are now operated by Cognis and Cognis is now toll manufacturing LAS for Henkel.
- Colgate-Palmolive shut down its 30 thousand metric ton LAS plant named Colgate SA in Compiègne, France.
- Hansa Chemie AG acquired the 15 thousand metric ton LAS plant in Düren, Germany from Akzo Nobel in January 2001. The plant was expanded to 25 thousand metric tons per year of capacity by April 2003.
- Henkel France S.A. closed its 25 thousand metric ton-per-year LAS plant in Reims, France in 2003.
- Huntsman acquired Albright & Wilson's European surfactants business from Rhodia in April 2001, including its LAS manufacturing sites in France, Italy, Spain and the United Kingdom.
- IBLA S.p.A. shut down its 10 thousand metric ton-per-year LAS plant in Ragusa, Italy in March 2002.
- Procter & Gamble (UK) expanded its LAS plant at West Thurrock from 25 thousand metric tons to 120 thousand metric tons in 2001.
- Sasol (South Africa) acquired CONDEA Chemie GmbH (Germany); including its subsidiaries in Germany, Italy and the Netherlands, from the German utility company RWE-DEA in March 2001.
- Stepan acquired the 75 thousand metric ton LAS plant at Stalybridge, United Kingdom from Manro Performance Chemicals in October 2001.

- TensaChem S.A. was formed in 2001 by management buyout from the former Manro S.A. in Belgium.

The following table summarizes the Western European LAS capacities of the major groups of chemical producers:

Western European Producers of LAS by Company Group

Company Group	Annual Capacity as of June 2003 (thousands of metric tons)
Henkel/Cognis Group[a]	238
Huntsman Group	190
Sasol Group	185
Procter & Gamble	180
Unilever	122
Stepan	120
PETRESA	80
TensaChem	70
IfraChem	50
Other	515-615
Total	1,750-1,850

a. Cognis is toll manufacturing LAS for Henkel exclusively in some plants previously owned by Henkel.

SOURCE: CEH estimates.

The Western European industry currently suffers from large overcapacity for sulfation/sulfonation, resulting in its current low profitability. Smaller and/or older sulfonation capacities will probably be closed or acquired. Most industry sources believe capacity must be brought in line with regional demand and realistic growth projections if the industry is to achieve economic viability.

SALIENT STATISTICS

The Western European supply/demand balance for LAS in recent years is shown in the following table:

Western European Supply/Demand for LAS
(thousands of metric tons)

	Production	Net Exports[a]	Apparent Consumption
1981	487	53	434
1982	460	27	433
1983	460	25	435
1984	465	20	445
1985	466	20	446
1986	463	33	430
1987	485	35	450
1988	495	35	460
1989	528	45	483
1990	510	35	475
1991	502	35	467
1992	488	30	458
1993	458	30	428
1994	439	30	409
1995	433	30	403
1996	389	10	379
1997	374	30	344
1998	411	85	326
1999	420	99	321
2000	434	96	338
2001	454	98	356
2002	445	101	344
2007	469	135	334

a. Imports of LAS are neglectible. Exports may include some LAS in formulated detergent products.

SOURCE: CEH estimates.

The data illustrate relatively stable Western European production of LAS during the 1982-1986 period, increased production during 1987-1989 and then declining production over the 1990-2002 period. The introduction of portion-sized home laundry detergent tablets into the Western European market during the latter five years has stimulated growth somewhat. See the **Consumption** section for a discussion of trends in recent years.

The sodium salt of sulfonic acid accounted for 95-96% of the total Western European consumption of LAS. The calcium salt, which is used as an emulsifier in pesticide formulations, accounted for most of the balance. All the other salts (e.g., triethanolamine, isopropanolamine) represent only a tiny percentage of total LAS consumption. The merchant market sales of the sodium salt of LAS as an intermediate are declining because of increased use of product containing free acid, which is cheaper to transport and is ultimately converted largely to the sodium salt by detergent producers.

CONSUMPTION

LAS is still the largest-volume anionic surfactant (excluding natural soaps) used in Western Europe. In the 1980s, its consumption increased at a rate of only about 1% per year, with a peak in 1989 of 483 thousand metric tons. Since then, consumption has declined continuously because of, among other things, stagnant population growth, environmental concerns, an organized effort to reduce per capita consumption of laundry detergents and a shift away from LAS to fatty alcohol–based surfactants, such as AS and AES. The following table presents Western European consumption of LAS by end use in recent years:

Western European Consumption of LAS by End Use
(thousands of metric tons)

	Heavy-Duty Laundry Powders	Heavy-Duty Laundry Liquids	Light-Duty Dishwashing Liquids	Industrial, Institutional and Commercial Applications[a]	Total
1982	252	1	107	73	433
1983	249	1	110	75	435
1984	250	1	114	80	445
1985	249	1	118	78	446
1986	215	20	115	80	430
1987	206	37	120	87	450
1988	200	45	130	85	460
1989	198	68	130	87	483
1990	205	55	128	87	475
1991	210	50	115	92	467
1992	207	47	113	91	458
1993	190	45	103	90	428
1994	190	44	85	90	409
1995	187	43	82	91	403
1996	174	44	75	86	379
1997	153	41	70	80	344
1998	147	38	66	75	326
1999	145	38	64	74	321
2000	148	53	62	75	338
2001	153	58	69	76	356
2002	150	60	62	72	344
2007	145	69	54	67	334[b]

Average Annual Growth Rate
(percent)

1997-2002	–0.4%	7.9%	–2.4%	–2.1%	0.0%
2002-2007	–0.7%	2.8%	–2.7%	–1.5%	–0.6%

a. Includes other household cleaners and industrial, institutional and commercial uses of LAS with other household cleaners representing about 22% of this amount.

b. Total does not equal the sum of the individual segments because of rounding.

SOURCE: CEH estimates.

Household Products

Detergents and cleaners still comprise the vast majority of applications for LAS and household products are most significant among them. The Association Internationale de la Savonnerie, de la Détergence et des Produits d'Entretien (AISE) estimated the value of household laundry products sold in the European Union, Norway and Switzerland in 2001 to be approximately 10.7 billion euros ($12.0 billion) or 41% of the combined value of all detergents and cleaning products retailed that year. Germany, France, the United Kingdom, Italy and Spain represent the largest national markets.

In recent years, the heavy-duty detergent market in Western Europe has been estimated at 3.5 million metric tons. The major manufacturers are Procter & Gamble, which maintained a market share of 30-35% throughout the decade; Henkel, whose estimated share is 20%; and Unilever, with a share approximated at 18%. Private label products take in roughly 10% of the heavy-duty market, with other notable participants such as Reckitt Benckiser and Colgate-Palmolive making up significant portions of the difference.

Heavy-duty laundry powders

An estimated 2.7 million metric tons of heavy-duty laundry powders were consumed in Western Europe between mid-2001 and mid-2002, including standard formulations, compact powders and tablets. The great majority of the regular powders are of the low-foam type that typically contain a combination of LAS, soap and alcohol ethoxylates. The total surfactant level is normally in the 11-15% range and the average LAS level is 4%. Some compact powders, however, may still contain an average LAS level of 6-8%. In recent years, increasing wordwide capacity for natural alcohols and higher LAB prices (often attributed to a shortage of high-quality kerosene for n-paraffin production) have encouraged detergent manufacturers to reformulate some products with less or even no LAS. This trend reduced LAS consumption in these products. Examples of this trend are major brands such as Henkel's Persil Mega Pearls® and Procter & Gamble's Futur, private label brands and tabletted products formulated with high proportions of alcohol sulfates. In recent years, however, cost/performance considerations have encouraged a return to LAS-containing formulations.

An estimated 150 thousand metric tons of LAS were consumed in laundry powders in Western Europe in 2002. Detergent manufacturing trends continue to favor nonspray dry tower routes, such as fluidized beds, agglomeration methods or extrusion. Reducing energy consumption is a major consideration. LAS consumption in heavy-duty laundry powders is expected to decline by –0.7% per year from 2002 through 2007.

Heavy-duty laundry liquids

Heavy-duty laundry liquids were first introduced on a commercial scale in Western Europe in the early 1980s. Consumption of standard and concentrated formulations totaled roughly 482 thousand metric tons by estimates made between mid-2001 and mid-2002. Liquid products account for roughly 12% of the total Western European laundry detergent market. The 2002 market shares of liquid products are estimated at nearly 25% in France, 23% in the United Kingdom, 22% in Belgium, 16% in Italy and 13% in Germany. Growth in Western Europe in the consumption of LAS for these products is projected at 2.8% annually through 2007.

Most of the nonconcentrated heavy-duty liquid detergents contain alcohol ethoxylates, LAS and soap at a total surfactant level of 35-45% and an average LAS content of about 10-13%. Newer types of heavy-duty liquid detergents often contain little or no LAS.

Light-duty dishwashing liquids

It is estimated that 1.1 million metric tons of light-duty dishwashing liquids were consumed in Western Europe in 2002, representing virtually no change from the 1993 estimates. The Western European consumption of LAS for light-duty dishwashing liquids in 2002 is estimated at 62 thousand metric tons, a decline of 3.9% annually from 1994. The market for these products grew rapidly during the 1970s and early 1980s. However, the market is now shrinking in most of the major countries.

The composition of light-duty dishwashing liquids differs widely, with the surfactant content ranging from 10% to 40%, although most of the products have a 20-30% surfactant level. The principal surfactants used in normal dishwashing liquids are LAS, AES and secondary alkane sulfonates (SAS or paraffin sulfonates). In recent years, usage of AES and betaines has been increasing at the expense of LAS in dishwashing liquids and this trend has reduced the consumption of LAS in this application. New, concentrated light-duty liquids (e.g., P&G's Fairy® Ultra) were introduced, but for formulatory reasons many of these products contain little or no LAS. Thus, the overall consumption of LAS in this application is expected to decline at 2.7% per year.

Other household cleaners

This category includes a large number of household products, such as hard-surface cleaners, toilet cleaners and certain bleaches that differ widely in their formulations; some do not contain LAS, while others may use up to 5% LAS. Consequently, this area is difficult to assess in terms of the volume of LAS consumed. This category also includes the older dishwashing powders that have largely been replaced by dishwashing liquids. In recent years, there has been good growth in sales of some of the small-volume specialty cleaner products, including several types employing LAS. Nevertheless, only a very small growth of LAS consumption in this category is likely.

Industrial, Institutional and Commercial Applications

LAS is used in industrial cleaners (e.g., for metals and textiles), in emulsifiers (e.g., for agricultural herbicides and in emulsion polymerization processes) and as a wetting agent. It is also used in many products sold to commercial laundries and hotels, as well as institutions (e.g., hospitals and schools) and these products often resemble the household formulations for laundry, dishwashing and general cleaning.

However, they may have been specifically formulated for large-scale use involving special equipment. Only slow growth is expected for LAS in these applications and demand for LAS in these areas is expected to shrink by annually 1.5% through 2007.

PRICE

Typical Western European prices for LAS (delivered) are listed below.

Western European Prices for LAS

	DM per Kilogram	Dollars per Kilogram	Exchange Rate (DM per dollar)
1983	1.98	0.78	2.55
1984	2.06	0.72	2.85
1985	2.08	0.71	2.94
1986[a]	1.96	0.90	2.17
1989	1.60	0.85	1.88
	Euros per Kilogram	**Dollars per Kilogram**	**Exchange Rate (euros per dollar)**
1991	0.73	0.90	0.81
1992	0.74	0.96	0.77
1993	0.73	0.85	0.86
1994	0.68	0.80	0.85
1995	0.72	0.93	0.77
1996	0.58	0.73	0.80
1997	0.64	0.72	0.89
1998	0.71	0.80	0.89
1999	0.77	0.82	0.94
2000	0.81	0.75	1.09
2001	0.88	0.79	1.12
2002	0.85	0.80	1.08
2003	0.88	0.97	0.91

a. Price is based on the average for the first quarter only.

SOURCES: (A) CEH estimates (data for DM PER KILOGRAM and EURO PER KILOGRAM).

(B) *International Financial Statistics*, International Monetary Fund (data for EXCHANGE RATES).

TRADE

Western European imports of LAS are negligible. Exports amounted to 95-110 thousand metric tons per year over the last few years to such regions as Eastern Europe, Latin America, the Caribbean and Africa.

CENTRAL AND EASTERN EUROPE

PRODUCING COMPANIES

The following table lists Central and Eastern European producers of linear/branched alkylbenzene sulfonates (LAS/BAS). The information presented may be incomplete. Capital for modernization and a secure raw material supply are lacking. In many cases, plants were operated under planned production systems rather than according to market demand and thus a realistic relationship between capacity and demand is not always apparent.

Central and Eastern European Producers of Linear/Branched Alkylbenzene Sulfonates

Company and Plant Location	Annual Capacity as of June 2003 (thousands of metric tons)	Remarks
Bulgaria		
Verila JSC Sofia	25	
Croatia		
Chromos Kutrilin Zagreb	6	
Saponia Kemijska Indusrija Osijek	18	
Czech Republic		
Lybar vel Vetg (former Spolek pro Chemickou a Hutni Vyrobu, a.s.) Usti nad Labem	6	
Rakona Rakovnik	10	The company is 100% owned by Procter & Gamble.
Hungary		
Caola Kozmetikai es Haztartasvegyi Rt. Budapest	7	
Macedonia		
Ohis Skopye	13	
Poland		
Cussons Polska S.A. Wroclaw	10	
Henkel Polska S.A. Raciborz	10	The company is 100% owned by Henkel.

Central and Eastern European Producers of Linear/Branched Alkylbenzene Sulfonates (continued)

Company and Plant Location	Annual Capacity as of June 2003 (thousands of metric tons)	Remarks
Poland (continued)		
Lever Polska		
Bydgoszcz	(10)	Plant was closed in 2002.
Zaklady Chemiczne "Rokita" S.A.		
Brzeg Dolny	10	
Romania		
Chimcomplex S.A.		
Borzesti	40	Mainly captive use.
Dero SA		
Ploiesti	4	
Procter & Gamble		
Timisoara	3	
Russia		
Chimprom Production Association		
Pervomaisk	6	
Kaprolactam State Enterprise		
Dzerzhinsk	15	SO_3-air process.
Kirishinefteorgsintez		
Kirishi	60	Captive LAB.
Sovhenk (Henkel Russia)		
Khimvolokno Plant		
Engels	9	Captive production.
State-Owned Complexes		
Angarsk	24	
Shebekino	7	
Volgodonsk	10	Joint venture with Huntsman.
Slovakia		
Petrochema Dubová, a.s.		
Dubová	15	LAB supplied by PETRESA, Spain.
Ukraine		
Chimprom Production Association		
Vinniza	24	Mainly captive use.
State-Owned Complexes		
Gorlovka	12	
Novomoskovsk	12	Major laundry detergent producer.

Central and Eastern European Producers of Linear/Branched Alkylbenzene Sulfonates (continued)

Company and Plant Location	Annual Capacity as of June 2003 (thousands of metric tons)	Remarks
Uzbekistan		
State-Owned Complex		
Tashkent	6	Operating status uncertain.
Total	362	

SOURCE: CEH estimates.

CONSUMPTION

The following table provides estimates of detergent production in the Eastern European countries. The ranges shown indicate the uncertainties in these estimates.

Eastern European Production of Detergents
(thousands of metric tons)

	1990	1994	1998	2002
Bulgaria	60-70	10-20	20-30	10-20
Czechoslovakia, Former	80-140	--	--	--
Czech Republic	--	90-100	100-120	90-110
Hungary	40-80	50-70	70-100	70-100
Poland	190-240	180-230	200-250	220-270
Romania	60-90	40-50	50-60	80-100
Slovakia	--	20-30	30-40	30-40
USSR, Former	1,300-1,500	400-700	500-700	350-450
Yugoslavia, Former	260-340	200-250	100-150	110-160
Total	1,990-2,460	990-1,450	1,070-1,450	960-1,250

SOURCE: CEH estimates.

The countries in the table above consumed about 2.3 million metric tons of detergents in 1990 and considerably less in the following years. The per capita consumption of detergents in Eastern Europe as a whole is in the range of 3-7 kilograms, whereas the corresponding number for Western Europe is 7-12 kilograms (compact and conventional). The production of detergents in Eastern Europe is estimated at between 960 thousand and 1,250 thousand metric tons in 2002. Assuming an average LAS/BAS level of about 7-10%, this would have required about 67-125 thousand metric tons of LAS/BAS in 2002.

JAPAN

PRODUCING COMPANIES

The major producers of linear alkylbenzene sulfonates (LAS) in Japan are listed in the following table. The producers all use the sulfur trioxide process for sulfonating linear alkylbenzene (LAB). The estimated

annual LAS production in 2002 is listed in the first column. Total capacity for the production of all sulonated/sulfated products, including LAS, is listed in the second column. Products produced by the sulfonation/sulfation facility are listed in the third column.

Major Japanese Producers of LAS

Company and Plant Location	Annual Production of LAS in 2002[a]	Total Annual Sulfonation/ Sulfation Capacity as of October 2003[b] (thousands of metric tons)	Products[c]
Kao Corporation			
Kawasaki, Kanagawa Prefecture	39	100	LAS, AS, AES
Wakayama, Wakayama Prefecture			
Lion Corporation			
Chemicals Division			
Ichihara, Chiba Prefecture	12	100	LAS, AS, AES, AOS, MES
Sakai, Osaka Prefecture			
Procter & Gamble Far East, Inc.			
Takasaki, Gunma Prefecture	9	20	LAS
Tayca Corporation			
Taisho-ku, Osaka Prefecture	17	65	LAS, BAS, AS, AES, xylene sulfonate
Total	77	285	

a. Estimated LAS production in 2002.

b. Capacity presented is total sulfonation/sulfation capacity including LAS production. Exact proportion devoted to LAS is determined by market demand.

c. Products produced at the sulfonation/sulfation facility are listed. LAS: linear alkylbenzene sulfonates, AS: alcohol sulfonates, AES: alcohol ether sulfates, AOS: alpha-olefin sulfonates, MES: methylester sulfonate (i.e., alpha-sulfonated methyl esters), BAS: branched alkylbenzene sulfonates.

SOURCE: CEH estimates.

Nissan Chemical discontinued LAS production in 2002. Kao discontinued LAS production in Sakat, but continues LAS production in Kawasaki and Wakayama. Kao had about 100 thousand metric tons of total sulfonation/sulfation capacity in 2003, a decline from the 140 thousand metric tons it had in 1999. Kao's LAS production was estimated at about 39 thousand metric tons in 2002, most of which was for captive consumption. Lion now has about 100 thousand metric tons of total capacity for sulfonation/sulfation in Ichihara and Sakai. Lion discontinued LAS production in Kawasaki in 2003. Lion's LAS production in 2002 was estimated at about 12 thousand metric tons. Procter & Gamble has LAS production in Takasaki and its LAS production in 2002 was estimated at about 9 thousand metric tons. Tayca, a merchant supplier of LAS, has about 65 thousand metric tons total capacity for sulfonation/sulfation and its LAS production in 2002 is estimated at about 17 thousand metric tons.

SALIENT STATISTICS

The table below provides estimates of Japanese production of LAS since 1974.

Japanese Production of LAS
(thousands of metric tons)

1974	138
1975	110
1976	111
1977	113
1978	122
1979	129
1980	92
1981	106
1982	117
1983	117
1984	115
1985	115
1986	115
1987	119
1988	128
1989	142
1990	144
1991	136
1992	142
1993	147
1994	151
1995	134
1996	117
1997	119
1998	108
1999	97
2000	97
2001	85
2002	77

SOURCE: CEH estimates.

Until 1986, Japanese imports of LAS were negligible and inventory changes are also assumed to have been small. Because exports of LAS were low, Japanese consumption of LAS was probably only slightly less than its production during most years prior to 1986. Since 1986, up to 5 thousand metric tons of LAS have been imported annually into Japan from the Republic of Korea. LAS has also recently been imported from Thailand. The following table shows the Japanese supply/demand balance for LAS in 1991, 1994, 1998 and 2002:

Japanese Supply/Demand for LAS
(thousands of metric tons)

	1991	1994	1998	2002
Production	136	151	108	77
Imports	3	4	4	5
Exports	1	1	1	neg
Apparent Consumption	138	154	111	81[a]

a. Does not equal PRODUCTION plus IMPORTS minus EXPORTS because of rounding.

SOURCE: CEH estimates.

The production of LAS was estimated at about 108 thousand metric tons in 1998 and decreased to about 77 thousand metric tons in 2002, an average annual drop of 8.1%. The production of LAS for captive consumption by detergent manufacturers accounted for about 70% of Japanese production in 2002. The balance of production was sold in the merchant market to other detergent manufacturers that do not have their own (or adequate) LAS capacity or to other consumers of LAS.

CONSUMPTION

The following table provides estimates of the Japanese consumption of LAS by end use in 1991, 1994, 1998 and 2002:

Japanese Consumption of LAS
(thousands of metric tons)

	1991	1994	1998	2002
Household Products				
Heavy-Duty Laundry Powders	107	120	87	61
Heavy-Duty Laundry Liquids	2	4	3	3
Light-Duty Dishwashing Liquids	10	8	4	3
Other Household Cleaners	3	4	3	2
Industrial, Institutional and Commercial Applications	16	18	14	12
Total	138	154	111	81

SOURCE: CEH estimates.

In 2002, the consumption of LAS was estimated at 81 thousand metric tons, down from 111 thousand metric tons in 1998, at an annual decrease of 7.6%. The decrease of LAS consumption reflected mainly the decrease of the heavy-duty laundry powders, which was caused by the formulation changes by major detergent manufacturers (e.g., Kao and Lion). The formulation changes were partly designed to increase water solubility of these detergents, which is especially important during low winter temperatures. These formulation changes increased the level of AE at the expense of LAS. However, consumption of LAS is not expected to decline further and its overall consumption is likely to be stable in the next few years.

The consumption of LAS was somewhat variable in the early 1990s. In 1991, LAS consumption declined as a result of several reformulations that lowered the LAS content and the successful introduction of two

non-LAS-containing concentrated laundry powders, Lion's Spark® and Kao's Just®. The former uses alpha-sulfonated methyl esters (MES) and the latter uses alcohol ethoxylates as the major surfactant, rather than LAS. During 1992-1994, price competition between synthetic detergent manufacturers greatly intensified as low-cost "private label" products were introduced into Japanese detergent markets. To remain competitive, detergent manufacturers used more LAS, since it was the most cost-effective surfactant.

Consumption of LAS declined steadily in the late 1990s. In 1995, Japanese manufactures introduced new detergent formulations with higher sufactant levels, but required less detergent per washload. The net effect was to slightly reduce surfactant consumption per washload.

In 2001, Lion introduced improved Top® by minimizing detergent odor. In 2002, Procter & Gamble introduced Bold® containing softener and in 2003, Kao introduced Attack® containing "bleach" (i.e., components intended to improve whitening). Lion also introduced Blue Dia® containing "bleach". These "new value added mutlipurpose" laundry powders were successful and acquired a 30% market share in 2002. This share is expected to reach 35% in 2003. The major high-concentration detergents are Attack® from Kao, Top® from Lion and Ariel Pure Clean® from Procter & Gamble. These three major companies now have over 90% of the market for detergent powders in Japan.

PRICE

Alkylbenzene sulfonic acid is generally sold in bulk quantities in concentration of 94-96%. In October 2003, the price of LAS was about ¥110-130 per kilogram.

TRADE

There are no independent official trade statistics for LAS in Japan. However, it is estimated that Japanese imports of LAS amounted to 3 thousand metric tons in 1991, 4 thousand metric tons in 1994 and 1998 and 5 thousand metric tons in 2002. Most of these imports were from the Republic of Korea and Thailand. Imported products are used by middle-size detergent manufacturers and also by a major manufacturer that is importing LAS from its overseas group company. Japanese exports of LAS were about one thousand metric tons in 1994 and 1998 and negligible in 2002.

CHINA

Major producers of LAS in China are listed in the following table:

Major Chinese Producers of LAS

Company and Plant Location
Dalien Oil and Fat Chemical Plant Dalien, Liaoning
Huayang Company of Fushun Petrochemical Beitian Group Fushun, Liaoning
Jin Tung Petrochemical Co., Ltd. Nanjing, Jiangsu
Kao Chemical Corporation Shanghai Shanghai Municipality
Procter & Gamble Guangzhou Ltd. Guangzou, Guangdong
Shanghai Jingdi Chemical Co., Ltd. Shanghai Municipality
Shanghai Wujing Chemical Co., Ltd. Shanghai Municipality
Sichuan Pengshan Chemical Corporation Pengshan, Sichuan
Sinopec Jinling Company Nanjing, Jiangsu

SOURCES: (A) *2002-2003 Directory of Chemcial Producers—China.*

(B) CEH estiamtes.

In 2002, LAS production in China was estimated at about 475 thousand metric tons. Shanghai Jingdi Chemical has about 20 thousand metric tons of production capacity.

INDONESIA

Major producers of LAS in Indonesia are listed in the following table:

Major Indonesian Producers of LAS

Company and Plant Location
Aktif Indonesia Indah PT Surabaya, East Java
Albright & Wilson Manyar PT Gresik, East Java
Findeco Jaya PT Jakarta, Capital Territory

Major Indonesian Producers of LAS (continued)

Company and Plant Location
Kao Indonesia PT Jakarta, Capital Territory
Sayap Mas Utama PT Gresik, East Java
Timur Raya Indah PT Tangerang, West Java
Unilever Indonesia PT Bekasi, West Java
Wing's Surya PT na

SOURCE: CEH estimates.

In 2002, production reached 193.3 thousand metric tons in 2001, an increase from 158.5 thousand metric tons in 1997. Findeco Jaya has 35 thousand metric tons and Kao Indonesia has 4 thousand tons of production capacity.

Major detergent manufacturers in Indonesia are Unilever Indonesia, Wing's Surya, Kao Indonesia and Total Chemindo Loka. Total production capacity of detergents in Indonesia was 871 thousand metric tons in 2002. The detergents are also exported.

REPUBLIC OF KOREA

Major producers of LAS in the Republic of Korea are listed in the following table:

Major Republic of Korea Producers of LAS

Company and Plant Location	Annual Capacity as of October 2003[a] (thousands of metric tons)
Aekyung Industrial Co., Ltd. Taejon	15.0
Cheil Jedang Corporation Seoul	7.6
LG Chemical Ltd. Onsan, Kyongsangnam-do	26.0
Miwon Commercial Co., Ltd. Ulsan, Kyongsangnam-do	13.0
Pacific Corporation Yongin, Kyonggi-do	na
Total	>61.6

a. LAS production only.

SOURCE: CEH estimates.

Total production capacity of LAS is 61.6 thousand metric tons in 2003. Production of LAS was estimated at about 67 thousand metric tons in 2002. LAS is the most common surfactant for synthetic detergents in the Republic of Korea. BAS (branched alkylbenzene sulfonate) is only used in industrial applications, since BAS has been banned from use in detergents applications.

TAIWAN

Major producers of LAS in Taiwan are listed in the following table:

Major Taiwanese Producers of LAS

Company and Plant Location	Annual Capacity as of October 2003[a] (thousands of metric tons)
Chang Hwa Chemical Co., Ltd.	
Hukou Hsiang, Hsinchu Hsien	0.8
Chi Chia Chemical Industrial Co., Ltd.	
Luchu Hsiang, Taoyuan Hsien	1.2
Formosa Chemicals & Fibre Corp.	
Changhwa Hsiang, Changhua Hsien	13.0
Kao (Taiwan) Corporation	
Hukou Hsiang, Hsinchu Hsien	12.0
Lion Chemical Industry (Taiwan) Co., Ltd.	
Wu Ku Hsiang, Taipei Hsien	10.0
Synthepure Chemical Industrial Co., Ltd.	
Tayuan Hsiang, Taoyuan Hsien	10.0
Total	47.0

a. Annual capacity data are for sodium dodecylbenzenesulfonate only.

SOURCE: CEH estimates.

Total production capacity of sodium dodecylbenzene sulfonate is 47 thousand metric tons in 2003. Production of LAS was estimated at about 40 thousand metric tons in 2002. LAS is the most common surfactants, for synthetic detergents. BAS is only used in industrial applications.

THAILAND

Major producers of LAS in Thailand are listed in the following table:

Major Thai Producers of LAS

Company and Plant Location	Annual Capacity as of October 2003 (thousands of metric tons)
Cognis Thai Ltd.	
Amata, Chonburi	60[a]
Kao Industrial (Thailand) Co., Ltd.	
Amata, Chonburi	15[ab]
Lion Corporation (Thailand) Ltd.	
Bangkok	na
Tayca (Thailand) Co., Ltd.	
Amata, Chonburi	20
Total	95

a. Capacity of total sulfonation.

b. Capacity of LAS, AS and AES. Capacity is expected to increase up to 30 thousand metric tons in 2005.

SOURCE: CEH estimates.

OTHER ASIAN COUNTRIES

Southern Lion Sdn. Bhd has LAS production in Malaysia. PTN Chemicals Co., Ltd. has about 20 thousand metric tons of annual capacity for LAS in Vietnam.

BIBLIOGRAPHY

Chemical Economics Handbook—The following CEH marketing research reports and product review contain additional information that is pertinent to the subject of this marketing research report:

Detergent Alcohols
Industrial Phosphates
Linear and Branched Alkylbenzenes
Linear alpha-Olefins
Normal Paraffins (C_9-C_{17})
Surfactants, Household Detergents and Their Raw Materials

Process Economics Program—The following Process Economics Program report contains more detailed information on the manufacturing processes, process design and process economics of the chemicals

discussed in this report. Address inquiries concerning this information to the Process Economics Program, SRI Consulting, Menlo Park, California 94025.

Anionic Surfactants, Report No. 59B, September 1992.

Specialty Chemicals Update Program—The following SCUP reports contain additional information on the subject of this report. Address inquiries regarding this information to the Specialty Chemicals Update Program, SRI Consulting, Menlo Park, California 94025.

Industrial and Institutional Cleaners
Surfactants

Other References—The following list of additional references is suggested for supplemental reading:

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"P&G Cradle-to-Grave Study—Palm Oil vs. LAB," *European Chemical News*, May 6, 1991, p. 40.