SESSION VIII
Conference Resume

MATSON: The other day when I was introduced, Fred Gerecht said something about my growing up with the industry. The three gentlemen on the panel today also have grown up with the detergent industry.

The first member of the panel is Jan Törnquist. He is with Berol Kemi AB, in Sweden. He is the Deputy Laboratory Manager and has been active in numerous European and Scandinavian technical societies.

The second member of the panel is Arno Cahn. Arno is Director of Development of the Household Products Division of Lever Brothers at their research headquarters in Edgewater, New Jersey. He is very active in the American Oil Chemists' Society and in many other technical societies. He is a member of the AOCS Education Committee responsible for planning detergent short courses.

Carl Kerfoot is Director of the Customer Service Laboratory, Chemicals Research, for Continental Oil Company. He is an Arkansan by heritage but has been a transplanted Oklahoman for quite some while, and so, I'd like to introduce from Ponca City, Oklahoma, Carl Kerfoot.

We are charged with giving a resume of the conference. The manner in which we are going to attempt this is first to review each of the particular sessions in order. After that time, any questions that might remain in our minds, we'll discuss. The good job done by all the previous speakers makes our task easier than it might otherwise be.

We are going to start off with Sessions I and II on "World Trends in the Soap and Detergent Industry" and "Raw Materials." They fit closely together and so we're combining those. Carl Kerfoot will summarize those two sessions.

SESSION I

World Trends in the Soap and Detergent Industry

KERFOOT: The first session which was held on Monday was designed to give us an up-to-date status report on the detergent industry throughout the world. Raw materials, new technology, environmental considerations, changes in trends and consumer lifestyles, were reviewed for North America, Western Europe, Asia, Australia, and the Middle East. The first paper of this session was presented by Ted Brenner on North American trends. North America produces and consumes 31% of world production of soaps and detergents. The U.S. accounts for about 95% of this. Synthetic detergents account for about 85% of the total U.S. as well as North American production.

The major development in detergent formulation types in recent years in the U.S. has been the growth of heavy duty laundry liquid formulations. These now account for about 20% of total laundry detergent volume. Changing lifestyles toward more 1- and 2-person households also offer markets for more convenience-type products. Environmental concerns and regulations are causing substantial changes in formulations compositions. The latest example is the issue of eutrophication and the role played by detergent phosphates. Legislation has been passed in numerous areas limiting or banning use of phosphates in detergents. This has led to the use of a variety of substitute builders in commercial laundry detergents, none of which is quite equivalent to phosphate, however, on a one-to-one substitution basis. To help compensate for the reduced builder efficiency, formulators are using higher levels of active ingredients and more of those active ingredients which are less sensitive to water hardness. Federal regulatory agencies continue to exert and acquire more control over U.S. industry with no end in sight. Despite the problems this poses, however, the outlook for continued growth in the detergent industry is considered to be good.

The second paper on trends in Western Europe was presented by Pierre Costa. He presented statistical data showing production of soaps and detergents for the period 1972 to 1976. Although population growth in the AIS countries averaged only slightly over 2% during this period, there was over a 25% increase in sales of soaps and detergents. This reflected a 15% increase in average production and about an 11% increase in average consumption. Countries showing the greatest consumption gains during the period were Portugal, Spain, Germany, and France. Those showing decreases were Finland and Denmark.

Synthetic products account for about 85% of the total market on the average. Anionic detergents, such as LAS, continue to be the major surfactant type in use, followed by nonionics. Liquid detergents for dishwashing continue to increase rapidly. There has been a shift in light duty liquid formulations from the very low active levels to the higher active premium quality products. Automatic dishwashing machines are growing in use in many countries, requiring a different type of detergent containing only fairly low levels of nonionic. All anionic detergents used in the AIS countries are of the biodegradable type, and discussions are now proceeding toward possible regulations concerning nonionic biodegradability.

The next paper on trends in Asia and Japan was presented by Mr. Tokiwa. Although Asia accounts for over half of the world population, many of the countries are in relatively early stages of industrial development, and the per capita consumption of soaps and detergents is low. Total consumption of soaps and detergents in Asia is about 13% of world consumption today. The use ratio of synthetic detergents to soap is increasing; however, soap is still in greater use than detergents except in Japan. In most countries

except Japan, hard alkylbenzene sulfonate is still the major synthetic active ingredient, and formulations are relatively simple.

In Japan the soap and detergent market is fully developed with synthetics having about 85% of the total market. Future growth is estimated at 2 to 3% per year. Washing machines are used in almost all households, and water is relatively soft. Washing is usually done in cold water. A new development in heavy duty laundry formulations of considerable significance in Japan is the so-called condensed powder product. This is a powder formulation of higher bulk density and higher active level and provides substantial savings in manufacturing costs, shipping, and storage costs. About 26% of the heavy duty market in Japan consists of this type.

Heavy duty laundry liquid products, introduced just two years ago, account for 8 to 10% of the market in Japan. Phosphates have been voluntarily reduced to a level of 5.3% as phosphorus as of 1976. This has caused formulation changes.

The use of alcohol-based nonionics has increased appreciably, although LAS continues to be the workhorse active ingredient in Japan.

Peter Strasser discussed trends in Australia in the next paper. Australia, being a nation of large land mass and relatively low population density, presents a set of problems of manufacturing, marketing, and distribution somewhat different from those elsewhere in the world. Synthetic detergents have increased steadily since 1960 at the expense of soap and now account for about 78% of the total market. The growth rate has slowed in recent years reflecting a slowdown in population growth.

The major synthetic active ingredient used in Australia is LAS. Alcohol ethoxylates have not increased in use as much as in other parts of the world. Tripolyphosphate builder is used. Eutrophication is not considered a problem at this time.

Washing machines are used in 85% of Australian homes and are of the top-loading type. There is a trend toward washing with cooler water. Liquid laundry formulations have recently been introduced, but it's a little early to judge their success. Hand dishwashing is widely practiced, and as a result, the per capita consumption of dishwashing liquids is the world's highest. These are mostly LAS based with some ether sulfates. A product that is unique to Australia is the home-dilutable concentrate, which the housewife dilutes to fit her own needs. These have gained significant acceptance in recent years.

The last paper of Session I was presented by Mr. Katz on the trends in Israel. Although extremes of washing methods are found in Israel, the urban population predominates; therefore, over 65% of the homes do have washing machines. Most water is quite hard, about 400 parts per million as calcium carbonate.

The major laundry detergents are the highly alkaline low-foam powders. Dishwashing is mostly done by hand, although mechanical dishwashers are beginning to appear. The currently used dishwashing detergent is an anionic paste. No premium quality type liquid dishwashing products are marketed in Israel at this time. A synthetic soap bar of about 35% active has been marketed quite successfully for over 25 years. Its success is due partly to the high water hardness that is encountered.

Most detergent raw materials are imported, and LAS is the major synthetic active ingredient used, although nonionics are increasing in use in laundry powders. Alkylphenol ethoxylates are the nonionic types mostly used. These detergent ingredients are projected to continue to be the ones of choice for the foreseeable future in Israel.

Based on Session I, I think that if there is any overall statement that might be made, it is that there is a very wide variation in washing practices, conditions, and needs around the world, and much opportunity for growth and development still exists. The workhorse synthetic surfactants and household washing products are the alkylbenzene sulfonates followed by the nonionics, and environmental and energy consumption concerns are leading to formulation changes in many countries regarding types and levels of active ingredients and builders used.

SESSION II
Raw Materials

KERFOOT: Session II was devoted to a look at the status and prospects for raw materials for the soap and detergent industry. Those specifically reviewed were the natural oils and fats, petrochemical raw materials, inorganics, silicates and alumina silicates, and fragrances.

The first paper of this session was on natural oils and fats prospects for the 1980s presented by Mr. Lysons. His paper examined the prospects for supply and demand and pricing for the soapmaking oils: coconut oil and tallow. He makes the point that the total oil and fat market must be considered since the soap and detergent industry uses only a very small part, about 9%, of the total. There is considerable interchangeability between the various natural oils and their end uses, and, thus, the changes in the total oil market will dictate what happens to the prices for coconut oil and tallow. Although fats and oils prices have fluctuated sharply over the past five years due to unusual supply swings, Mr. Lysons concludes that the situation will stabilize in the 1980s. He predicts a surplus of edible oils, soy and palm oil, between now and 1990, which will result in declining real prices. He feels this will also affect coconut oil and tallow. He projected prices for coconut oil for 1990 of possibly $750 per ton.

The next paper was on petrochemical raw materials presented by Mr. Haupt. He addressed the important question of future availability of raw materials derived from petroleum that are used in a detergent industry. With the continuing reduction in reserves of oil and natural gas in the future and the increasing energy demands, he asked the question, "Will the petrochemical raw materials continue to be available for detergent manufacture? The three basic raw materials involved are ethylene, normal paraffins, and benzene. All of the major surfactant intermediates that are in use today are derived from these basic raw materials. Mr. Haupt projects that even though the demand for these raw materials for surfactant manufacture will continue to grow through the period up to 1990, the amounts of those raw materials needed as a percentage of their total production or availability will still be quite low. Only about 3.5% of the total ethylene will be needed for detergent use, and only 1.5% of the benzene, for example. Therefore, the availability should be no problem providing the petrochemical industry can compete for it successfully with other users. In order to assess how well the petrochemical industry can compete with other users for oil and gas as a raw material or for energy value, he examines first the alternates available and second the value added to crude oil and natural gas in each area of consumption. He shows that the ultimate value for crude oil or natural gas when it is used to make chemicals including detergents is vastly greater than when it is used as an energy source for transportation or for electrical generation. This being the case, he concludes that the petrochemical industry should be able to compete readily for raw materials in the future – and they will be available. He also projects that the cost of surfactants through 1990 should increase at only about the economic inflation rate.

Mr. Lowe presented the next paper on inorganic chemicals used in detergents. He gave an informative review and status report on the major inorganic components that are used in the soap and detergent formulations. These have

historically been composed of five materials: sodium perborate, sodium silicate, sodium tripolyphosphate, sodium carbonate, and sodium sulfate. One additional newcomer to the scene is the sodium aluminosilicates or the zeolites. Due to differences in formulation and washing conditions, consumption of these inorganics varies widely in different world locations. Sodium perborate, for example, is extensively used as a bleaching agent in many European products but sparsely in the U.S. Total worldwide consumption of perborates in detergents in 1975 was about 650,000 tons or about 15% of the world borate production.

Sodium silicate has long been used as a corrosion inhibitor in powder detergents at levels typically of 5 to 10%. In the U.S. in recent times, some of the nonphosphate formulations have included levels of 10 to 20% silicate. Total silicate consumption in detergents is about 20% of total worldwide production. The recent development of sodium aluminosilicates as substitute builders for phosphates could have a substantial impact on silicate manufacture since about one third of zeolite is represented by sodium silicate.

Sodium tripolyphosphate consumption held its own during the period of 1970 to 1976 in spite of the substantial reduction in its use in the U.S. due to legislation. Total worldwide production was about 2.8 million tons in 1976.

Sodium carbonate usage in detergent formulations has increased in recent times, especially in the U.S. in the nonphosphate formulations. Very large quantities of soda ash are also used in the manufacture of tripolyphosphate, accounting for about 10% of total world soda ash production.

Sodium sulfate as an inorganic filler or processing aid has increased some in the U.S. and Canada in recent times, again mostly as a result of reduction in phosphate builder. Total sulfate consumption in detergents is estimated at about 750,000 tons or about 20% of world production. Mr. Lowe concludes that the substantial inorganic raw material requirements of the detergent industry can be adequately supplied for the foreseeable future without undue disturbance on the world inorganic chemical industry.

Mr. Schweiker presented an informative review of the chemistry, manufacture, economics, and consumption of sodium silicates and sodium aluminosilicates used by the detergent industry. The industry consumes about 30% of the total sodium silicate in the U.S. and other industrially developed countries of the world. It serves many useful functions in detergents such as corrosion control, hard water control, alkalinity, and soil suspension. Sufficient manufacturing capacity is in place to handle the expected growth over the next several years in the U.S. However, additional capacity will be needed to handle the greater growth in Europe, Latin America, Near East, and Africa.

Sodium aluminosilicates, or zeolites, have recently been introduced as builders in laundry detergents. This could prove to become the major use for zeolites in the future, and if so, will require considerable additional manufacturing capacity to satisfy the requirements.

The final paper of Session II was presented by Mr. Morris on fragrances – natural versus synthetic. He gave a very interesting account of the different fragrances employed by the soap and detergent industry, comparing their sources and relative prospects for the four major perfumes that are used today. These are hydroxycitronellal, geraniol, methyl ionone, and linalol. Generally, each of these fragrances can be obtained by any of three routes: one being from the natural oil, one being synthetically from a natural raw material: pinene, which comes from turpentine, and a second synthetic route from petroleum-derived raw materials. The quality of the fragrances derived synthetically has been proven perfectly suitable compared to those from natural oils in each case. Mr. Morris points out that the synthetic fragrances were originally developed to overcome problems of uncertain price, quality, and availability historically presented by the natural oils. Once they were developed, the synthetics have largely taken over and replaced the natural sources as suppliers to the detergent industry.

Mr. Morris projects that synthetic fragrances will continue to be the dominant source in the future, and of the two synthetic sources, pinene versus petroleum-derived, he projects that the pinene source may have the long-term advantage, since it is based on by-products of the huge paper industry with its self-restoring forest programs. At any rate, the perfume needs of the soap and detergent industry should be well cared for in the forseeable future.

MATSON: I have a question for you, Carl, but I will hold it until we review all the sessions. So summarizing now Session III with a voluminous number of papers involved on ingredients, technology, and function, Arno Cahn.

SESSION III

Ingredients – Technology and Function

CAHN: There are fifteen papers to be covered in Session III, and this session in many ways is the core of the conference for those of us who are involved in the formulation of detergents. I will try in a few brief minutes to extract the major significance of the papers and attempt to put all of them together in a unifying context. I will try also to point out some holes in our knowledge so that once these are filled, we might have material for a future world conference.

The format of Session III reflected the perfectly traditional view of a fully formulated detergent– that is, a combination of builder, surface-active agent, and certain adjuncts or adjuvants. Traditional, too, is the view that the builder targets at the hardness ions, that the surfactant performs those physicochemical or interfacial functions in which soil is being removed, and that the remaining adjuncts are there to help solve specific laundry problems where the combination of builder and surfactant is not quite up to the task.

We have recognized for some time that there is an interdependence between builder and surface-active agent. In recent years, however, events which were not directly linked with optimizing detergent performance have brought home a view which goes somewhat beyond interdependence; in fact, it would suggest a certain measure of interchangeability, not total but certainly much greater than we would have considered before the need for reducing phosphate levels had become paramount. Thus, mention was made, and I believe it was by Dr. "X. Pert," of major commercial products in the U.S. which contain no builders at all but contain instead rather high levels of surface-active agents.

In view of the findings which Dr. Yamaji presented in his first paper of the session on the amount of hardness which is introduced into the washload through both the soil and the residual hardness from prior washing and rinsing operations, the fate of this hardness remains somewhat uncertain in totally unbuilt detergent formulations. We also learned from Dr. Yamaji's paper that, in Japan at least, housewives appear to use more detergent than manufacturers recommend even though in this attempt they do not quite manage to titrate the hardness ions to the point of equivalence with sodium triphosphates. It is at this point of equivalence, according to Dr. Yamaji, that we obtain good detergency.

The conditions for good detergency were also the subject of the next speaker, Mr. Hollingsworth. His focus was not so much on the equivalence point but rather on the concentration of free calcium ions which are left in the washing solution. At a calcium ion concentration of 10^{-5}, a very good washing effect is obtained. When the residual calcium ion concentration is 10^{-3}, the washing effect is

poor, and at intermediate concentrations, detergency is moderate.

STP, in this analysis, remains the builder of choice, not only because of its ability to reduce the concentration of free calcium ion but also because of its important secondary effects – soil suspension and some specific adsorption effects. On the whole, it was Mr. Hollingsworth's view that removal of hardness ions in a soluble complex was the "most elegant way," I believe he called it, to soften water compared to, say, the precipitation route.

Our next speaker was Dr. Berth, who made it quite clear that we must now add to the well-established binary choice of *either* sequestration *or* precipitation a third option: that of ion exchange. Dr. Berth reported, with considerable elegance in his own right, on the many conditions which had to be met before one could put on the map, as it were, ion exchange with sodium aluminosilicate as a detergency process capable of compensating for performance loss resulting from reduced phosphate levels. Structural requirements of sodium aluminosilicate itself, the need to achieve a reasonable exchange rate within the time frame of the normal washing operation (about 10 minutes in the U.S.), the human and environmental requirements, consumer acceptance, and many other aspects were covered in his report.

If I include in this resume a part of the lively discussion at the end of the day, I should note that Dr. Berth's view was that STP-based detergent formulations, with sufficient STP, remain unchallenged as the most effective washing product, followed by those based on combinations of STP and sodium aluminosilicates and these, in turn, are followed by products based on the combination of sodium aluminosilicate with weak sequestrants.

The selection of STP as the builder par excellence was, in fact, the common thread that ran through the reports of the first three speakers in our session. They seemed quite unanimous in their yearning for paradise lost.

Dr. Crutchfield, our next speaker, and in fact also Dr. Berth, while giving no hint of disagreeing with the first three speakers, commented to us briefly and quite succinctly about the stupendous amount of organic synthetic effort to make new sequestrants on the perfectly reasonable assumption that paradise lost is unlikely to be regained in our lifetime. As Dr. Crutchfield reported, a few organic sequestrants have emerged out of this mass of structures that was synthesized which carry a reasonable promise of commercialization. These are notably CMT and CMOS. They can be considered, at least, as semi-elegant in their functionality. With their rapid and complete biodegradation, they offer a certain compensating elegance in that they self-destruct, so to speak, which is the ultimate in ecological desirability. Given the recognition that it is the total formulation which provides washing effectiveness, the utility of these weak sequestrants looks promising, indeed.

Another point that emerged from Dr. Crutchfield's report is of interest mainly from a scientific point of view. I would venture to suggest that few of us would have predicted that compounds which contain only carbon, oxygen, and hydrogen could ever attain calcium lowering effectiveness comparable to STP. At the very least, we would have anticipated the need for a stronger electron donor such as nitrogen in the chelating structure, and yet Dr. Crutchfield reported pCa values that actually exceed that of STP.

Unfortunately, the American "law" which says that "there is no such thing as a free lunch" holds here too. We seem to have encountered what might be termed the rule of inverse biodegradability: the stronger sequestering power of the experimental builder, the lower is its biodegradability. That rule applies with particular vengeance in the case of high molecular weight polymers which turn out to be fine sequestrants but, alas, are quite refractory to biodegradation.

So much then for the builder part of the session which deserved all of the attention and the discussion that it received.

In the surfactant area, the next part of Session III, we heard four papers that truly belonged under the heading of Surfactants. It turned out that surfactants come in two types: "workhorses" and "those that want to be." Our chairman, Ted Matson, paraded the whole stable before us. What should be remembered, apart from Ted's engaging presentation, is that there are in practice some steep entrance requirements for admission to workhorsedom. They include effectiveness and performance, proven safety, availability, and not unexpectedly in a commercial context, reasonably low cost. LAS, alcohol sulfates, alcohol ethoxylates, and their sulfates all have satisfied these requirements.

At the risk of beating a dead horse, or at least a dead horse analogy, it should be noted too that even workhorses jockey for position within the team. As Dr. McKenzie stated in his paper, we have seen an increase in recent years in the use of alcohol- and ethylene oxide-based surfactants, and this trend is expected to continue. It is the sum total of the individual factors of effectiveness, proven safety, availability and cost, that I just mentioned, which in the context of the user's requirements, that is, in the context of the formulator's specific needs, that ultimately determines the usage of the given surfactant.

In the next paper, Mr. Tuvell reported to us some very attractive, basic properties of alpha olefin sulfonate, AOS, a material which prima facie has much to recommend itself to the potential user, if only because of the relative simplicity of its structure: a hydrocarbon chain and a polar sulfonate group. As Ted Matson had noted, the use of AOS in the U.S. is limited today. In Japan, AOS is in fact being used on a significant scale, and Mr. Yamane in his paper reported to us on at least some of the reasons which led to products whose performance proved good enough from market introduction: improvement in color as a result of process changes and the right formulation approach at low phosphate levels.

Dr. Linfield's paper on soap and lime soap scum dispersants and Mr. Fernley's report on zwitterionic surfactants really did not deal with surfactants per se in the stricter sense of the word, but might be considered as contributions to the phosphate replacement problem. Dr. Linfield concerned himself with attempts to rehabilitate the original self-built surfactant – soap – by overcoming one of its major shortcomings, precipitation in hard water, and that through the incorporation of significant levels of materials which act as lime soap scum dispersants.

Mr. Fernley next reported on the class of surfactants whose permanently built-in compensating polarities make the molecules sufficiently "introverted" as to be more immune than the workhorse surfactants to the absence of builders. That immunity is not complete since the varying degrees of zwitterionic surfactants do perform somewhat more effectively in the presence of builders. Mr. Fernley used the term "specialty surfactants" in referring to sulfobetaines, hydroxysulfobetaines, and plain betaines. In the days when I first met Ted, "40 or 50 years ago," and when I was concerned with synthesizing new surfactant structures, the term specialty detergent in those halcyon days of no inflation always referred to new surfactant structures for which we estimated a cost of more than 10 cents per pound – and that was generally the kiss of death.

The third part of our session was devoted to actives and adjuncts. I defined them earlier as being needed to solve certain specific laundry problems for which the surfactant/builder couple is inadequate. Fluorescent whitening agents to maintain the whiteness and brightness of fabrics, bleaches for removing specific laundry stains, antiredeposition agents to prevent the washed goods from becoming

dingy upon repeated washing, and enzymes for the removal of protein stains – these are the materials which traditionally have been used.

If we consider softening as an effect not ordinarily attainable with the surfactant/builder combination, then the discussion on quaternaries also properly fits into this section.

As phosphate levels have come down, the surfactant/builder couple seems less able to perform even its normal tasks with the result that the employment of additives has assumed increased importance. In the specific case of bleach, consumers appear to have recognized the need themselves because the usage of bleach, as reported by Mr. Coons, particularly in those areas in the U.S. where phosphates have been banned, appears to have increased considerably. Currently used oxidative bleaches, as Mr. Coons reported to us, while functional are not ideal in the totality of their properties. Generally speaking, they are either too strong or too weak. Reductive bleaches have not as yet attained a position of commercial importance. The ideal bleach as described by Mr. Coons is yet to be developed, and that again is a development a report on which we might look forward to at a future world conference.

Enzymes, the subject of Mr. Christensen's report, surely have a place in detergent formulations. As heavy duty liquids have gained consumer acceptance, improvements in the stabilization of enzymes have made possible their incorporation into these products – with the proviso that neither the pH nor the water level can exceed certain limits, or stability will be adversely affected. The utility of enzymes, particularly the ability to effect stain removal almost instantly in a presoak situation, was a new and important finding.

New developments in the field of fluorescent whitening agents were reported by Dr. Siegrist. They were concerned mainly with improvements in bleach stability and in the manufacturing process, which has brought about an overall improvement in product quality.

Our next speaker, Mr. Greminger, presented us with data on hydroxyalkyl-substituted cellulose ethers – another set of materials that has assumed increased importance and increased usage in recent years. The important point about these products is that they seem to be quite effective both in redeposition as well as in providing some soil shielding for carbonate-based detergents which are used in the phosphate ban areas in the U.S.

In the final paper of the session, Mr. Egan gave us an overview of the different types of quaternaries. At one end of the scale, with its greatest softening effectiveness but relative poor rewetting characteristics, were the normal ditallow dimethyl quaternaries. Imidazoline derivatives, on the other hand, have the best rewetting properties – although, as was noted at least in the discussion period, housewives have not really given any indication that they are very much concerned about the differences in rewet values that can easily be measured in the laboratory.

Laboratory measurements on softening, we heard, are difficult. Quantitative instrumental methods are not readily available so that we are back to the old panel evaluations in the laboratory, and they are always the last resort.

For rinse conditioners, Mr. Egan pointed out that the presence of certain builders has an effect on the kind of softening one obtains. Phosphate-built detergents do not affect softening in the rinse, whereas carbonate- and silicate-based detergents do.

He very briefly discussed the dryer products which turn out to provide effective antistatic performance but appear to provide an uneven distribution of softener on the cloth.

Finally, Mr. Egan gave us an indication of some mechanistic work being done in the Ashland laboratories. By means of radiotracers, it was determined that not quite as much residual softener was being removed by detergents in the subsequent wash as we had originally thought.

SESSION IV

Processing and Packaging

KERFOOT: Session IV was designed to give us an update on the technology involved and the major steps in manufacturing and packaging of soap and detergent products used today. In the first paper, Mr. Lanteri of Mazzoni in Italy gave an excellent review of commercial sulfonation and sulfation technology in the detergent industry with emphasis on the sulfur trioxide processes. The various reaction processes and commercial reactor designs were discussed. These utilize SO_3 or silver trioxide vapor in an inert diluent gas as the reagent. Differences among the various commercial systems mainly involve how the reactants are contacted, how heat is removed, and how the reaction product is protected from decomposition. Among the processes that were discussed in considerable detail were the following: (a) the Ballestra process, which is one of the first commercial continuous air-SO_3 processes used in combination with the sulfur burner for generating SO_3. The reaction system consists of a series of stirred tank reactors in a cascade sequence. (b) The Berol process, which uses a cylindrical shell reactor with an inner revolving cooled drum. Reactants in this system are introduced at the bottom and flow upwards, and mixing and turbulence in the reactor are enhanced by a series of pins that extend into the annular space between the drum and the cylinder. (c) The commercial thin film reactors and film processes were also described in detail. These consisted of the Stepan, the Allied, the Chemithon, and the Mazzoni reactor designs. In all of these, the process is similar in that a cocurrent tubular reactor is involved, and the organic feed moves downward as a thin film and is contacted by gaseous SO_3 and air reactant. (d) The newly introduced spray process, the Chemithon impact jet reactor, was also discussed. This involves the reaction of an organic liquid as a fine mist with the gaseous SO_3 air reagent.

Also described were the processing conditions and requirements for most of the conventional detergent feedstocks including alkylbenzenes, fatty alcohols, fatty alcohol ethoxylates, alpha olefins, and the fatty acids and esters. This paper is an excellent reference on the general subject of sulfonation and sulfation of the major detergent active ingredients.

Next, Mr. Davidsohn presented a very detailed review of the spray-drying process for detergent formulations including slurry preparation, crutching, and aging steps. Both batch and continuous slurry preparation systems and their operation were discussed. Conditions of the spray tower operation were described in considerable detail and related to the physical properties of the spray-dried bead or powder.

Also included in this paper was an account of the manufacture of powder detergent products by dry neutralization or dry blending. This technique has taken on additional interest and importance in recent years with the trend toward increased nonionic levels in laundry detergents and toward increased bulk density of laundry powders. Higher nonionic levels can cause some problems in spray-drying processes such as stickiness, plugging in the tower, and so forth. The dry neutralization approach overcomes some of these problems. Mr. Davidsohn described equipment and procedures for producing powdered products directly by loading or otherwise reacting the active ingredients directly on the builder. The active can be a nonionic or an alkylbenzene sulfonic acid, for example.

By this technique, powdered product having over twice the bulk density of a spray-dried product can be obtained. This powder can be used as is, or it can be combined with conventional spray-dried powders, and this gives considerable flexibility to this approach as well as some savings in cost and energy requirements.

Stephen Kuti presented an informative paper on a subject somewhat related to dry blending or dry neutralization. His topic was agglomeration as an alternative to spray drying for the manufacture of detergent powders. Again, the incentive is a reduction in cost by reducing the energy requirements for producing the dried powder. Agglomeration is the blending of solids with liquids to give a granulated product of uniform composition. The key to the success of the agglomeration process is in the use of proper blending equipment to give homogeneous lump-free particles having uniform size. Various commercial blending equipment suitable for the agglomeration process was described, both batch and continuous systems, and operating conditions for the various mixer designs were also discussed. Detergent products obtained by the agglomeration processes can be comparable to spray-dried products in terms of being uniform, nonsegregating, free flowing, and readily dissolved in water. Bulk densities of 0.45 kg/l are obtainable. Costs are somewhat lower than for spray drying.

Dr. Schraut gave an interesting review of the current packaging practices for powder and liquid detergents and the trends and new developments in packaging these materials. In particular, he discussed the packaging functions of (a) protection of the contents and (b) the display or presentation aspect of the package to the consumer. The extent of the need for protection properties in the package depends upon the ingredients in the detergent formulation. For example, for powder products containing uncoated enzymes and perborate, moisture protection is necessary. Nonenzyme products usually require little or no moisture barrier protection. The trend in recent years has been toward less use of moisture barrier packaging due to the substantial costs savings involved and to the development of more stable formulations, for example, coated enzymes. Formulations containing higher nonionic levels generally do require a barrier to prevent bleeding of the printing inks on the package.

With regard to the package presentation aspect, there is a trend in the developed countries toward larger volume packages with more consumer convenience features, such as ease of opening, measuring, and so forth. In the developing countries, much of the powder products are packaged in plastic or plastic-coated paper packets of various sizes, and there is less emphasis upon the convenience features.

For liquid products most bottles are either blown polyethylene or polyvinyl chloride. Polypropylene bottles offer some advantages over polyethylene in regard to being less prone to stress cracking and weakening of the container with certain types of formulations. The trend is toward bigger bottles with handles. Much work is being done on reducing bottle weight and wall thickness by using special design for polymer types. Work is also being done on improved closure design features and dosing or measuring features. Adequate machinery and equipment is available for current as well as foreseeable packaging needs.

Mr. Herrick reviewed the various types of equipment available to the industry today for manufacture of soap. The major development in the industry in recent years has been the appearance of the new high speed machines capable of handling 300 to 400 bars per minute production rate, thus breaking the traditional 150 to 200 bpm historical rates. Stamping machines are now available that can produce 400 bpm, and other line equipment is available that will handle up to 300 bpm or more. Mr. Herrick discussed some of the alternate production systems that are available or required for the manufacture of conventional soap bars as well as the specialty bars such as synthetic detergent bars, mixed soap-synthetic detergent bars, and translucent bars. The factors entering into the selection of a soap plant configuration were reviewed: these factors being the types of bars desired, the product mix, the production rate required, and the bar quality required.

Mr. Spitz concluded Session IV with an interesting discussion on bar soap packaging, giving the classification of bar soap shape variations and bar soap packaging. There are two basic bar shapes, the banded and bandless, with four variations of each, for a total of eight possibilities. Bar soap packaging is divided into two main categories, the mass market packages and the specialty packages. Each of these has single and multi-pack variations and different styles, with the multi-pack specialty soap showing good growth in recent times. He then summarized the different types of bar soap wrapper, transfer, and carton equipment that is available. Mr. Spitz projects that the high speed lines will gain more acceptance as the new packaging machines gain in popularity. New and faster models of the specialty soap packaging machines are needed to replace the manual or semi-automatic machines that are in use today.

New soap wrapping materials such as foam, polypropylene, pearlescent-coated papers, and foil laminates will gain in use, and new cartons with protective inner coatings will be more widely offered.

Finally, Mr. Spitz stressed the need for more close cooperation and development work between the soap finishing line suppliers and the packaging material suppliers and the consumer to insure an active and progressive bar soap industry in the future.

SESSION V

Performance Testing

CAHN: It is late in the day and late in the week. You have shown fantastic stamina by still being here, so I think you have enough stamina to go along with me when I say that I can really do no better in summarizing what was said in the session on performance evaluation than to share with you a version of one of my favorite stories. It is a very old one, you have probably heard it before, but it is nonetheless very pertinent.

In the terms of a local context, it seems that one of our conference members after a somewhat bibulous evening at the Nightclub Hungaria, was observed by a local gendarme to be weaving rather unsteadily under one of the lamp posts by the main thoroughfare, seemingly looking for something. Indeed, upon asking our conferee, the gendarme learned that our friend *was* looking for something. He had lost his wallet with his credit card, his conference badge, and the ticket to the banquet. "Are you sure," asked the gendarme, "that you lost it here?" "No," replied our friend, "over there, by the hedges." "Why then," inquired the gendarme, "are you searching over here?" "Because," the answer shot back, "this is where the light is good."

It seems to me that much of our search for answers in the evaluation of the performance of detergent products is characterized precisely by the dilemma of our inebriated friend.

The five papers in Session V illustrate the point.

Surely the lamp post is the locale of Dr. Puderbach's work. His universe is nicely lit and well defined – the kind we are used to when we are doing scientific work. All variables except the one under study were kept constant, and he was in a position to gather some very useful knowledge. The distribution of fluorescers, the fate of cloth after repeated washing with detergents, under one condition, these and others were the areas which lent themselves to meaningful investigations, the results of which are finite and acceptable.

To varying degrees, the remaining speakers addressed themselves either to attempts of using lamp post experiments as predictive of the situation under the hedges – as did Dr. Krüssmann in his work on test cloths at Krefeld – or to pointing out the multitude of experiments which

must be done under the lamp post in order to have *any meaning at all* when it comes to moving to the hedges – as did Dr. de Jong – or to the near-impossibility of doing relevant experiments on the lamp post in the first place – as did Anne Lyng. Both Anne and Dr. de Jong – and indeed by implication Miss Cole – were quite unanimous in their definition of the situation at the hedges: *"it is the judgment of consumers,"* and this is the ultimate determinant of product quality and product choice. This is a very critical point, because going halfway from lamp post to hedge, which is what a performance standard under "average conditions" would represent, is *not* the same as letting consumers judge for themselves under the myriad of use conditions where such judgments are made daily.

Miss Cole discussed some approaches for working near the hedges. Study consumer habits and attitudes, was her advice, and this may lead to some clues. For greatest value, such studies should be carried out on a regular basis.

Unless there be some misunderstanding, let me make a final note. Everyone in the detergent industry uses a screening test of one form or another. Terg-O-Tometer, artificial soil clothes, bundle tests, consumer panels, everybody uses them, all of them, and then some. The *objective* of these tests is perfectly clear: to predict the eventual outcome, to maximize the chances, that when consumers will test these products under free market conditions, the results will not be a total surprise to the chap who puts out the product in the first place. In other words, the universal rule which says that no business management likes surprises holds here also.

But this approach is quite different from going halfway from lamp post to the hedges and *define* performance for consumers with results obtained in some semi-lamp post experiments. It is at this point where there is very serious disagreement with those who would propose such definitions.

SESSION VI

Health, Safety, Environment

TÖRNQUIST: Mine is the privilege of summarizing Session VI of this conference with its important and widely discussed theme: Health, Safety, and Environment. Let us first remind ourselves of the long and complex process behind the trivial act of buying a soap and detergent product.

Primary raw materials are collected from various vegetable, animal, or mineral sources. They are converted into building stones for the detergent raw material industry in a series of technically advanced industrial chemical processes. The soap and detergent industry transforms these materials into highly sophisticated consumer products which are mass distributed over big distances and promoted by various marketing aids. Imagine what a considerable amount of health and safety considerations this complex process represents, even before the products have encountered the consumer's interest. When making nonionic surfactants you are bound to produce and handle safely a highly toxic substance, ethylene oxide, which, by the way, has also been used as a warfare explosive! The safe handling of sulfur trioxide is involved in the manufacturing of anionics, and you can hardly produce a cationic surfactant without handling ammonia somewhere along the line. There are many other examples in the chemical industry of the safe handling of dangerous substances; unfortunately, accidents cannot always be avoided and do occur.

One such case within the soap and detergent industry was related here by Dr. Juniper in his paper on health problems of factory workers, when enzyme detergents were being introduced. As far as I understand, this problem has been virtually solved by the use of non-dusting encapsulated enzymes.

However, the safety aspects referred to so far are problems for the industry and should not be a matter of the consumer's concern. He and she direct their interest toward the safe use of their consumer products, and in recent years toward the environmental consequences of this use. Because of the large volume of products involved in the various detergent applications, their use has also been the object of governmental regulations in different countries. An update of such legislative or regulatory activities was presented by Ms. Idman.

The need for sufficient testing of any chronic and genetic effects of new big-volume chemicals was stressed by Dr. Golberg. Fortunately, the capacity for doing the necessary biochemical testing has been increased during the last few years. How thorough such a testing should be before new chemicals are introduced is obviously a very important question, and I welcome comments from the floor on this point. My personal feeling is that few household products are so well investigated with regards to their safe use as are soaps and detergents.

From the environmental point of view, we have had mainly three topics under consideration during the years: the biodegradability of surfactants used in soaps and detergents, the contents of phosphate and its effect on man-made eutrophication, and potential effects on aquatic life.

The last point was the theme of an interesting paper by John Alabaster. All surfactants are more or less toxic to fish due to the mere fact that they are surface active. Fish toxicity has been clearly correlated with the surface tension of the water: under a certain level the oxygen uptake is affected negatively. The use of biodegradable surfactants should diminish this problem, provided that the metabolites formed do not themselves show any harmful effects. Much research is being carried out in this area.

As to the eutrophication caused by phosphates, Dr. Bouveng has given you a review of the Swedish concept: a rather rapid increase of purification work capacity has drastically improved the water quality of the troubled lakes. Even in the midst of Stockholm, outdoor swimming facilities have been reopened to the public, although I personally wouldn't take the health safety risk of using them at this time of the year.

Finally, I would like you to recall the risk/benefit concept of Dr. Hall's and again stress that zero risk or complete safety does not exist. Those who know the soap and detergent industry know that much effort has been made to minimize the risks involved with the use of its products and that it has an extremely high record of safety.

SESSION VII

Development and Trends in Related Industries

TÖRNQUIST: In my review of Session VI, I tried to exemplify the various highly diversified industrial activities involved in the complex process of bringing the consumer product to its market.

A conference on soaps and detergents would certainly not be complete if we did not also give some thought to the developments within the interrelated industries; mainly in the textile fabrics industry and in the household equipment industry.

As Dr. de Jong pointed out, many things have changed since the times when the only washing equipment was a washboard and the only fabric to be washed was cotton. Knowing that the internal area of fabrics is something say between 20-30 m^2/g and a load of household textiles to be washed could be in the order of 3 kg, the energy spent in the process would be equivalent to the cleaning of a hard surface area of 50-100 thousand square meters. Hopefully the efficiency of the washing machine/detergent fabric triumvirate is adequately illustrated by this simple exercise in arithmetic.

The evaluation of various washing machines of the German market was the topic of Ms. Milster. She stressed

the importance for the consumer of comparative testing, energy conservation, and product information.

Energy saving requirements were also pointed out by Mr. Weenen in his presentation of the trends in dishwashing appliances. He also pointed out significant differences between the U.S. and the European situations.

The growth of synthetic fiber usage in apparel, domestic and home furnishings will continue worldwide. Mr. Wilson elaborated in his paper the opportunities as well as problems for the laundry products industry that will be the result of the current trends of the changing makeup of textile fiber blend.

Some of those problems were further illustrated by the, at least for me, highly educational paper on trends in the coloration and finishing of textile fabrics given by Mr. Hildebrand. Also in this paper the energy saving aspects were stressed. I think that his final point was very well formulated, when he stressed the mutual dependence between the chemical industry, the textile industry, and the equipment manufacturers. This very conference is an illustration of the need for our various industries to deepen our contacts and strengthen our interrelations, realizing just that mutual dependence.

DISCUSSION

MATSON: Thank you, Jan. Several questions came to mind during these presentations. I'll only ask a few of them because of time limitations. One, for example, Jan, we have biodegradability restrictions in the U.S. and in Western Europe. Do you see these trends expanding to other parts of the world?

TÖRNQUIST: Yes, I certainly do. Obviously, we have to use biodegradable material in all parts of the world, but, of course, this process is a continuous one, and you shouldn't actually use this concept before you have the actual need for it.

MATSON: Well, that may bring up a question for you then, Carl. This means that there is some potential future substitution of LAS for branched-chain alkylbenzene sulfonate. Branched alkylbenzene sulfonate, though not mentioned often, is the third largest volume surfactant used. How does this affect some of the projections that were made in the talks which you have summarized, Carl, as far as the future volume trends for LAS?

KERFOOT: Well, it could have an effect, obviously. I think the projections that we have heard this week about the future requirements and consumption of the active ingredients were based primarily on those countries that are using LAS now. Those projections indicate that LAS consumption is going to remain fairly constant with no substantial rate of growth in those countries that are now using it and that would imply that the current production capacity might be adequate for some time to come. Now, I suppose if the other countries that are still using ABS go through the same cycle we have and switch from ABS to the biodegradable LAS, this could open up considerably larger demands or needs for LAS than the projections that we have heard this week would indicate. So I would say there is a chance that there will be needs for additional capacity for LAS providing we see the usual development sequence changing from ABS to LAS in those countries.

MATSON: Another question, Arno. We talked quite a bit about energy, and a couple of presentations stressed energy. How do you see the energy demands affecting detergent formulation?

CAHN: "There, obviously, will be some demand that energy will make on detergent formulations. It is very difficult to come to a total assessment of it. If one considers heavy duty liquids compared to powders, on the face of it, one saves the energy consumed in spray drying, but that is not the total equation. The universe has to be a little larger than that. Liquid detergents are packaged in plastic bottles, and somebody has to go back and calculate the total energy that is required starting right from scratch and taking the total system as a whole. I haven't really seen any *total* calculations of that kind of figure. By the same token, dry mixing is another way of making detergents, and we learned from Patterson-Kelley some ways of doing this. But then one has already spent the energy of evaporation to get to the dry components in the first place, and if these have to be a specific kind, again, I am not totally clear what the ultimate energy saving is going to be. It must be a *total* calculation rather than taking it in bits and pieces."

MATSON: This seems to fit in with your suggestion earlier that there are a lot of other things that could be added to our next conference and maybe we can have some of those calculations available. Jan, is the Swedish approach to eutrophication liable to be followed in other countries?

TÖRNQUIST: Yes, I think so, but, of course, again this is a matter of economics. We had the privilege in our country of being able to use the governmental funds especially made for the weak economy years 1970 and 1971. This approach may not be always applicable to other countries, but it was certainly a success in our country.

MATSON: Arno, one more question. How will these fiber trends that were mentioned this afternoon affect formulations?

CAHN: Actually, I think the fiber trends that were mentioned today are already in place as far as our products are concerned. The percentage of synthetics in the washload is unlikely to increase that much more, and current detergent formulations have really anticipated as best they can the need for cleaning synthetics under conditions where, for instance, wash temperatures have gone down as a result of use instructions and of the impact of energy considerations.

MATSON: I think I could ask many, many more questions, but the organization of this conference was such by the Steering Committee that it progressed logically from Session I through Session VI. First, there was the discussion of the trends and the raw materials. Next, we talked about the ingredients, both as to technology and as to function. Then those materials were put together in a process and packaging of the finished material was made. Next was performance testing where we evaluate that product and then see whether or not we satisfy the necessary health, safety, and environmental restrictions. Now you could start at any other point, and we could ask questions as we have here as to how one might affect the other. But, you can probably take the publication of the proceedings that you will receive in January and ask some of those questions. Hopefully by asking the questions at the right point, you will save a lot of time before getting to the last point and find that all the previous four or five were to no avail. I think that is the beauty of this conference. One of the aims, of course, was to look at all of these different factors with the whole idea being to come upon a better product at a more economical price in the long run so that the consumer would be satisfied.

The last statement might be that the announced purpose of this congress in the preliminary material that we received was to provide a forum for sharing and discussing the practical technology in production of soaps and detergents, and I think that surely has been provided. Karl Zilch and his group did a good job in making sure that this was a possibility. Karl in his opening address said something about hoping that everyone will be able to take away from this conference some concept or idea which can be utilized, and I am sure that everyone that was here will be able to take home concepts and ideas that will help in his or her daily work. I feel that is due to the excellent planning that went into making this conference what it was.