Detergent Research at SDA

Human safety, environmental acceptability are focus

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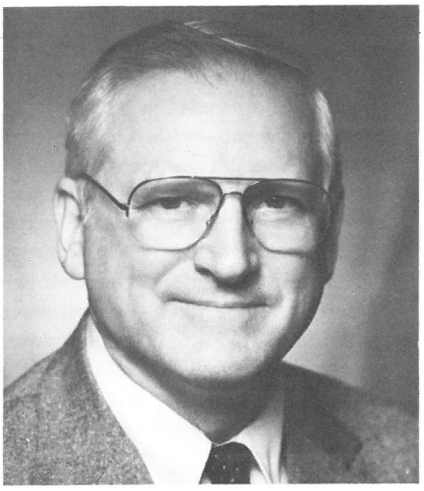

Keith A. Booman

The scope of SDA research over the past 10 years has been unusually broad. Research activity has been divided into two major areas: human safety and environmental acceptability of detergents and detergent raw materials. Briefly, SDA research in the human safety area has included efforts on fluorescent whitening agents, fragrances and surfactants. It has included research on how to carry out animal testing with great efficiency and less stress on animals, and that effort continues today. It has included the epidemiology of the acute effects of accidental eye exposure to, and ingestion of, cleaning products.

In the environmental area, the focus of SDA research activity has been on two detergent raw materials: surfactants and phosphates. The research on surfactants has included development of analytical methods for environmental samples, and study of the fate of surfactants in wastewater treatment plants and in estuaries. The SDA technical effort on phosphates has focused on the possible effects on water quality of governmental banning of phosphates. The effect of bans on the phosphorus loads to and from wastewater treatment plants and the effect of bans on the cost of phosphorus removal have been almost continually monitored during the last decade. Knowing how much phosphorus is involved, the effect of detergent phosphate bans on water quality can then be estimated.

We live in an age of proliferating regulation of all parts of individual and corporate life. While some regulation is good and necessary there has been a tendency to restrict consumer product content arbitrarily, on the basis of speculation colored by emotions. A principal objective of SDA research has been the development of information to replace speculation with fact, to limit to the extent possible the imposition of arbitrary limitations on our industry and its customers, the consuming public. Information is not of much value unless it is available to, or understood by, those in a position to propose and adopt regulation or legislation. The SDA research program has contributed to the dissemination of information, but that is an effort which transcends the technical effort and which others may need to continue for sometime after researchers have turned to other tasks. As I review the individual research efforts, you may wish to keep in mind the overall objectives which I have just mentioned.

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Human Safety—Completed SDA Programs

An ongoing project is the periodic updating of a bulletin called "Cleaning Products and Their Accidental Ingestion," now in its fifth edition.[1] This bulletin provides the medical profession with pertinent background on cleaning products. Topics covered include general formulation information and general guidance on caring for those, primarily young children, who have accidentally ingested some cleaning product. A section on accident prevention is also included. Every pediatrician, every new resident physician has a copy of this bulletin. If part of the practice of a physician involves the care of children, it is on his or her bookshelf. The fifth edition was edited by two medical experts, Dr. Anthony Temple, McNeil Laboratories, and Dr. Frederick Lovejoy, Harvard Medical School.

Information in the bulletin on the "who, what, when, where" of accidental ingestion comes from an SDA-sponsored epidemiological investigation Dr. Temple supervised while he was director of the Intermountain Regional Poison Control Center in Salt Lake City. After studying 768 accidental ingestion cases involving soaps and detergents, the conclusion was reached that the consequences were minimal and temporary, and that most cases occurred with a product that was in use (in measuring devices, etc.) rather than in the original container.[2] This research was helpful in reducing the tendency of some to consider every ingestion incident a "poisoning." It contributed to the realization that child-resistant packaging was simply not an appropraite general response to accidental cleaning product ingestion. The Salt Lake City study also covered eye exposure incidents. The perspective which evolved was similar to that developed for ingestion. A number of publications cover the results of the Salt Lake City study.[3]

Fluorescent Whitening Agents were the topic of another SDA technical investigation. At the time this effort was started, questions about the human safety of these laundry detergent ingredients were being raised. The assistance of Arthur D. Little, Inc. (ADL) was obtained to collect and evaluate all the available published and unpublished safety information. A review of what is known is always an appropriate preliminary response when safety questions are raised. After reviewing the information available for the fluorescent whitening agents, the ADL investigators concluded that there was no reason to be concerned. Their compilation of the data and evaluation of it, which was published in the CRC Critical Reviews of Environmental Control,[4] was a major factor in helping the EPA Interagency Testing Committee conclude that the development of further safety information was not necessary.

Another SDA human safety investigation centered on the potential of *fragrances,* as used in cleaning and other consumer products, to cause allergic reactions in consumers. Considerable concern had been generated by articles in the medical literature about some cases of allergic reactions. The question posed was, "In the population as a

whole, how many people are affected and how seriously?'' Fortunately, a significant data base of pertinent information existed which SDA was able to tap. Both detergent manufacturers and fragrance suppliers carry out human patch tests on new ingredients and formulations to determine the potential for allergy problems. After reviewing and publishing an unprecedened 63,000 patch test results on major fragrance ingredients used by the detergent industry,[6-11] the issue has all but died. As in other areas of toxicology, dose-effect relationships appear to be very important for understanding the allergic potential of fragrances. The results from this investigation are expected to be a continuing guide to the safe use of fragrance ingredients by our industry.

Dose-effect relationships are important in risk assessment. What is the consequence of a given level of exposure? A prerequisite to answering this question is establishing the exposure level. Occasionally, questions are posed concerning the human safety consequences of volatile impurities in detergents which might be present in products at the part per million level or less. To become better able to deal with such questions, we had a predictive model developed for exposure to volatile impurities in two types of products: hand-dishwashing detergents and granular laundry detergents. The key components of this model were knowledge of deteregent use conditions and basic physical chemistry. A report covering the development and use of this model is available.[12]

Human Safety—SDA Programs In Progress

In recent years, approaches for evaluating the mutagenicity of chemicals have proliferated. Many of the short-term systems do not use mutations per se as an end point. Thus, a better description of the subject area is genotoxicity. While assessment of results showing that a given chemical is genotoxic is extremely difficult, positive results may indicate a carcinogenic potential.

By now, enough short-term testing of surfactants has been done to make a review of the results worthwhile. Information in the literature was collected and, as in the case of the fragrances study mentioned earlier, the available unpublished information was collected, too. The results, in a paper which has been accepted for publication, show that surfactants have negligible potential to cause genetic damage. Furthermore, none of the assays reviewed were incompatible with the tested surfactants. These included anionic, cationic, nonionic and amphoteric surfactants.

Eye Irritation

The potential for accidents in which cleaning products are splashed or otherwise get in human eyes has been a top concern of the detergent industry for years. Surely this has been an appropriate priority. Eye injury must be avoided. Consumers must know what the potential is. Neither they nor manufacturers can afford to be misled by poor information. Thus, the SDA has been interested in how to make eye irritation test results more predictive, more efficient and less stressful to the test animals.

An experimental study in which the comparative response of the rabbit and monkey eyes were investigated, showed that there were important differences.[13] The results suggested that the usefulness of the rabbit eye as a predictor of human experience could be enhanced by incorporating reference materials in testing protocols. The use of significantly smaller amounts of test material was also suggested. Unfortunately, regulatory agencies still have not accepted the use of smaller doses even though more predictive results could be obtained with less stress on test animals. SDA is actively pursuing this matter today.

Of course, one way to reduce stress on test animals is to use *in vitro* procedures when and wherever possible. SDA is currently supporting a several year project at the University of Illinois on the development of *in vitro* testing. This research is directed by Professor John Shadduck. The driving concept of this research is that information from a battery of *in vitro* tests may yield results which would satisfactorily predict the extremely complex course which human eye injury and healing takes.

A year into this project, one sees both promise and problems. The promise is that toxicity results with single cells roughly agree with known eye toxicity results from some surfactants. On the other side of the coin, evaluating interactions that involve pH and/or test material form (solid vs. liquid) must await further developments. Thus, it appears that it will be some time before meaningful, reliable label warnings can be based on *in vitro* tests.

Human Safety and Environmental Effects

A research activity which bridges human safety and environmental effects was the collection, evaluation and publication in one place of the available information on the seven major surfactants:

- Linear alkylbenzene sulfonates
- Alkylsulfates
- Alcohol ethoxylates
- Alcohol ethoxy sulfates
- Alpha olefin sulfonates
- Secondary alkane sulfonates

Arthur D. Little, Inc. had the responsibility for this task, which led to a report,[14] an update,[15] and a review article.[16] This effort was timely. The reports provided the basis in significant part for the TSCA Interagency Testing Committee concluding that enough was known about the two surfactant classes considered by that committee so far—linear alkylbenzene sulfonates and alcohol ethoxy sulfates. The ADL report and supplement are currently distributed by the National Technical Information Service (NTIS), an unusual procedure which reflects favorably on these non-government reports.

Environmental Studies

SDA research on environmental effects has followed standard patterns:

1. Determine environmental concentrations. Develop analytical procedures, if necessary. Use models to predict concentrations, if possible.

2. Determine the environmental impact of expected levels, or expected changes in levels. Do so by calculation, if the state-of-the-art allows it; otherwise, perform experiments.

As far as surfactants are concerned, their fate in the Potomac estuary was modeled for SDA by HydroQual, a preeminent engineering firm. in the environmental modeling field. This effort took into account both biodegradation and adsorption onto sediment particles.[17] The results showed that surfactants disappear very close to wastewater treatment plants in such an estuary, if they could be measured at all. The model was constructed in such a way that the fate of other chemicals in wastewater treatment plant discharges to the Potomac could be estimated, provided that the adsorption and biodegradation characteristics of the chemical could be approximated. The same approach could clearly be applied to other estuarine situations.

Once environmental water concentrations of a chemical are known, one is

often interested in how much accumulation in fish tissue might be occurring. As an SDA research project, the bioaccumulation of linear alkylate sulfonate (LAS) was measured in the bluegill.[18] The safety factor associated with eating fish exposed to LAS in the squatic environment was estimated to be much greater than 5000, a very encouraging result.

Current environmental research on surfactants includes the development of a specific analytical method for alcohol ethoxylate nonionic surfactants, and the fate of LAS and alcohol ethoxylates in a conventional activated sludge wastewater treatment plant. Similar studies in the past were limited by analytical procedures which were non specific.

Eutrophication related research has been a continual part of the SDA technical effort during the last decade. Questions asked in one jurisdiction or another over the past decade have included:

1. How much phosphorus can be controlled by a detergent phosphate ban?
2. Is that amount environmentally significant?
3. Will a ban reduce wastewater treatment costs for phosphorus removal enough to make a ban economically worthwhile?

While our industry has a pretty good idea as to how much phosphorus is involved, it is always helpful to have estimates confirmed by field results. For instance, how much effect have bans actually had on the amount of phosphorus in sewage going to wastewater treatment plants? One serious problem in evaluating such an effect from field data is the drift and noise that is invariably present in such data. How much data from each side of a ban date should be taken into account? Should decreasing weight be given to observations more distant in time from the ban? A simple, satisfying and tractable model has been devised under SDA research and has been applied to the influent phosphorus load to the two Milwaukee plants, treating about half of the sewage flow of Wisconsin.[19] The answer shows that the industry estimate of 0.4 kg/cap/yr, or about 25% of the influent phosphorus, being due to laundry detergents is quite good. The procedure developed is applicable to any situation where one wishes to estimate the magnitude of a shift when data are noisey and show evidence of drift.

Phosphorus Runoff to Great Lakes

Early in the decade, SDA became concerned about a critical lack of information about the amount of phosphorus discharged to the Great Lakes in land runoff. The SDA response was to support a promising investigator who was just getting started on relevant research, Dr. David Baker, of Heidelberg College in Tiffin, OH. Early studies by Dr. Baker and his colleagues developed phosphorus runoff coefficients for watersheds in the Lake Erie Basin and sampling strategies that would yield more accurate phosphorus load estimates for rivers. The conversion of orthophosphate discharged from treatment plants to other forms of phosphorus was demonstrated to occur at an exponential rate, primarily by adsorption to suspended sediment which settles to the stream bottom.

Recent work at Heidelberg College has identified the fluctuations in the loading and transport of phosphorus, as well as other materials, from non-point sources. Understanding these fluctations has been instrumental in understanding the water-quality impact of non-point phosphorus loads. Non-point sources, by virtue of the simultaneous occurrence of both high runoff loads of soluble phosphorus and high rates of delivery during storms, contribute the most to the amount of phosphorus available for biological uptake in a lake downstream. On the basis of this work done by Dr. Baker and his colleagues, as well as the work of several others, the U.S. Army Corps of Engineers' *Lake Erie Wastewater Management Study* has recommended that the requirements for control of point source phosphorus discharged to tributaries to Lake Erie not be made any stricter. Providing Dr. Baker with funding to get his program started was eminently worthwhile.

The question of the effect of detergent phosphate bans on wastewater treatment economics has been a topic for continual review. An early keystone was an assessment for us by Professor Nicholas L. Clesceri, Rensselaer Polytechnic Institute, of the cost of phosphorus removal.[20] More recently, the assembled, pertinent information was evaluated by the economic consulting firm of Glassman & Oliver.[21] The conclusion reached in its 1980 report was that detergent phosphate bans were cost-ineffective phosphorus control measures when the consumer costs associated with a detergent phosphate ban were considered. That conclusion appears to be as valid in 1984 as it was in 1980.

In sum total, the information that has been developed allows SDA staff and member company scientists to make estimates as to the possible environmental impact of detergent phosphate regulation in a given jurisdiction with increasing accuracy, certainty and credibility. New questions are continually being asked. New phosphate control technologies, such as enhanced biological phosphorus removal, are continually being considered. Costs are continually changing. Accordingly, our research effort continues.

In conclusion, I would like to announce the publication of Professor V. W. Greene's monograph "Cleanliness and the Health Revolution," by SDA.[22] This monograph documents and celebrates the dramatic revolution over the past 150 years in human health, to which our industry has contributed so much. For our part, working to help everyone have a clearer understanding of the technical aspects of all the environmental and human safety issues associated with the soap and detergent industry is important and rewarding. We are pleased to be involved. ■

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