An Approach to Formulating Cold-Water Laundry Products

TED P. MATSON and **MICHAEL F. COX**, Chemicals Research Division, Research and Development Department, Conoco Inc., P.O. Box 1267, Ponca City, OK

ABSTRACT

Trilinear plots showing the performance of linear alkylbenzene (LAS), alcohol ether sulfate (ES) and alcohol sulfate (AS) mixtures are used to optimize surfactant active composition for maximum cold-water detergency. Superimposition of cost lines allows for estimating cost/performance. Results show that the composition of the optimally performing LAS/ES/AS mixture depends strongly on temperature, water hardness and cloth type. Under most conditions at low water hardness levels, optimum cost/performance is obtained by an all-LAS active composition. When water hardness exceeds the hardness removal capability of the builder, an LAS/ES blend is best.

INTRODUCTION

Higher energy costs and the increased use of synthetic fabrics have made cold water detergency performance very important. This paper presents an approach for evaluating the cost/performance of mixed-active systems, which is shown to be useful in formulating cold water laundry powders.

Several advantages exist for making a laundry detergent with a mixed-surfactant system. Under certain wash conditions, a mixed-active system can show better performance than the same formulation with any one active ingredient. A mixed-active product can also give good detergency over a wider range of wash conditions. The poor performance of one surfactant may occur under conditions where another surfactant performs better, and vice versa.

Disadvantages also exist in mixed-active systems. These include the storage and handling of multiple surfactants, the increased complexity of processing and increased raw material costs. By definition, mixed-active systems contain more than one active ingredient, and only one can be the least expensive.

The 4 major surface-active ingredients commonly used in laundry powders in the United States are linear alkylbenzene sulfonate (LAS), alcohol ether sulfate (ES), alcohol sulfate (AS) and alcohol nonionics (NI). Of the 4 major active ingredients, LAS, ES and AS are the 3 largest in volume and are used commercially in mixed-active formulations. Although LAS/NI systems are used in liquids, they are no longer used in laundry powders.

EXPERIMENTAL

The detergency performances of 10 LAS/ES/AS mixtures were determined using a 15% active/30% builder formulation. As shown in Figure 1, these 10 formulations represent a complete cross section of all combinations of actives.

Detergency testing was performed using a Terg-O-Tometer with a 10 min wash cycle and a 5 min rinse. Tests were performed in duplicate for statistical evaluation of data. Test procedures were followed as outlined in Conoco CTS Lab Method No. 303-74, which is similar to ASTM Method No. D3050-75 (1). Performance was determined by measuring the reflectance (in Rd units) of the washed cloth. Both sebum-soiled cotton (Testfabrics S/419) and permanent-press (Testfabrics S/7406) cloth were used (1,2). The permanent-press cloth used was a 65% cotton/35% Dacron blend with a permanent-press finish. The effects of temperature and water hardness on the performance of the LAS/ES/AS formulations were determined. Formulations were tested at an 0.15% use level. The surfactants used are listed in Table I.

This paper was presented May 10, 1983, at the 74th Annual Meeting of the AOCS in Chicago, Illinois.

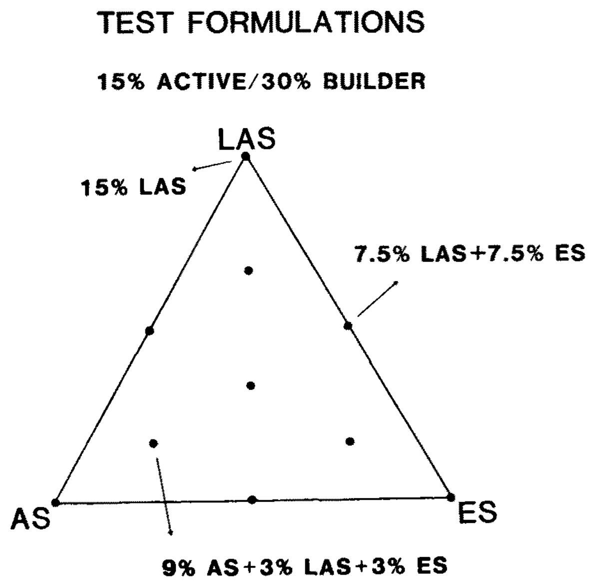

FIG. 1. Illustration showing how the 10 LAS/ES/AS mixtures tested form a cross section of all possible surfactant combinations.

TABLE I

Surfactants Used in Study

LAS	Dodecylbenzene sulfonate—commercial C12 (average) LAS Tridecylbenzene sulfonate—commercial C13 (average) LAS
AS	C12-18 linear alcohol blend (23% C12/24% C14/30% C16/23% C18)—sodium salt
ES	C12-18 linear alcohol blend (same as above) with 40% ethylene oxide—sodium salt

Triangular performance-contour plots were constructed using a Simplex optimization computer program (4). An example is given in Figure 2. The reflectance value is listed for each mixture. The higher the reflectance value, the better the detergency performance. In most tests, a difference of 0.5 reflectance unit is considered significant at a 95% confidence limit. Simplex optimization is used to determine the region of optimum performance. This "optimum detergency zone" includes the best-performing mixture plus all other mixtures having a reflectance within 0.5 Rd unit of its performance. This includes mixtures the Simplex program estimates will fall into the detergency zone. In this example, the best-performing mixture is the all-LAS formulation. The optimum detergency zone is centered around LAS and LAS/ES mixtures. Regions of poorer performance are also calculated. Under these conditions, performance decreases as the level of alcohol sulfate in the LAS/ES/AS mixture is increased.

In the following text, performance plots will show only the optimum detergency zone as calculated by the Simplex program.

RESULTS AND DISCUSSION

The detergency data obtained can be used in 3 ways:

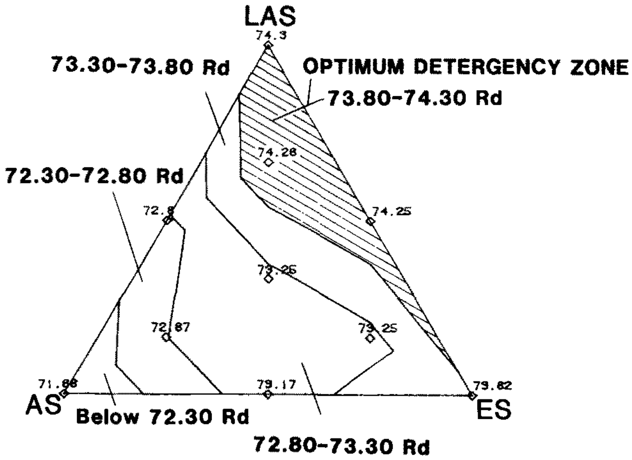

FIG. 2. Computer-generated triangular performance plot (for dodecyl LAS/C12-18 ES/C12-18 AS/carbonate-built formulations at 50 ppm, 100 F, on sebum-soiled cotton cloth).

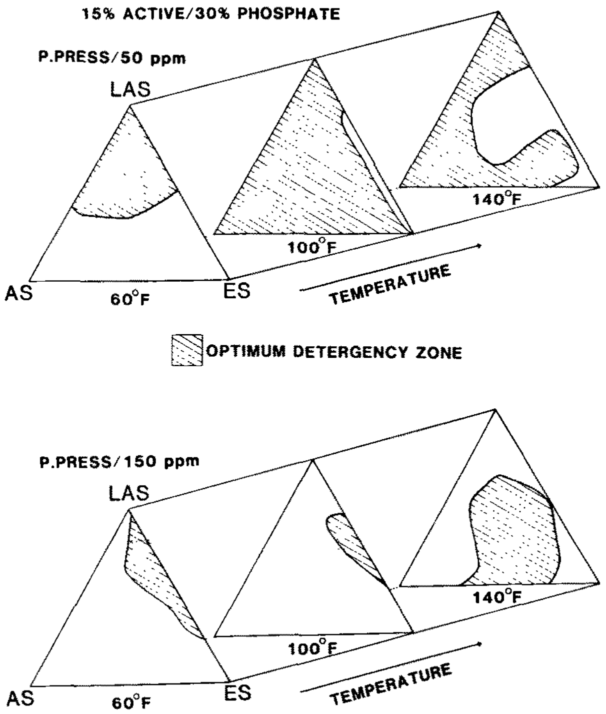

FIG. 3. Detergency performance as a function of temperature (on permanent-press cloth).

(a) to determine the effect of some parameter on detergency performance; (b) to determine the optimum formulation for a specific set of conditions; (c) to estimate the optimum cost/performance formulation. Before discussing an example of how the data can be used in the latter 2 cases, the effect of temperature on the detergency of LAS/ES/AS mixtures will be examined.

Effect of Temperature

The effect of temperature on the detergency performance of phosphate-built formulations using sebum-soiled permanent-press cloth is shown in Figure 3. At 60 F and low (50 ppm) hardness, the optimum detergency zone includes formulations high in LAS content. As temperature is increased, the optimum detergency zone shifts to include mixtures containing more alcohol sulfate. The performance of alcohol sulfate is poor at lower temperatures because of its relatively poor solubility. Only at high temperatures does its performance become significant.

At 60 F and higher (150 ppm) hardness, the optimum detergency zone centers around LAS/ES mixtures. As temperature is increased, the optimum detergency zone again shifts to include mixtures containing more alcohol sulfate. The extent of this shift is less than was observed at low hardness, because alcohol sulfates are also sensitive to water hardness. Identical trends are observed with cotton cloth, as shown in Figure 4.

DATA USE

The data obtained from this study are of practical value. If specific wash conditions are of interest, the detergency plots can be used to determine the best formulation for those conditions. For example, assume the following criteria are important in the development of a laundry product containing an LAS/ES/AS active: (a) cold (60 F) water performance; (b) detergency on sebum soil; (c) phosphate-built; (d) can contain C12 LAS and C12-18 alcohol or alcohol ether sulfate.

Figure 5 shows the performance curves for the formulations fitting the above criteria. As shown in the center plot, overlap of the 4 optimum detergency zones occurs at a region between an 11% LAS/4% ES active and a 7.5% LAS/7.5% ES active. Under these conditions, a formulation within this range would give optimum performance.

The detergency data can also be used to determine the optimum cost/performance formulation. Figure 6A illustrates the relative cost of each LAS/ES/AS mixture. The plot is divided into regions varying in cost by ½ cent per pound. Because LAS is the least expensive surfactant, mixtures containing more LAS cost less.

Cost/performance is illustrated in Figure 6B, where the overlap region from Figure 5 is superimposed on the cost curve of Figure 6A. The 11/4 LAS/ES mixture is clearly more cost-efficient than the 7.5/7.5 LAS/ES mixture, but a significant cost difference also exists between

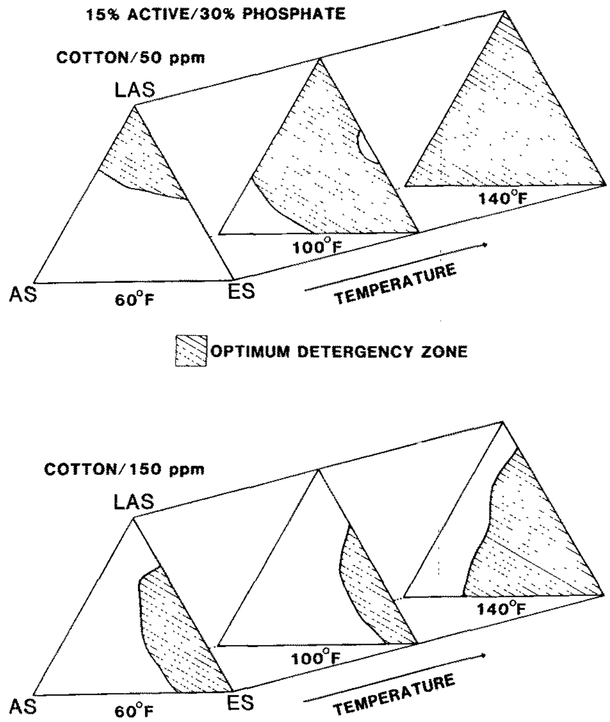

FIG. 4. Detergency performance as a function of temperature (on cotton cloth).

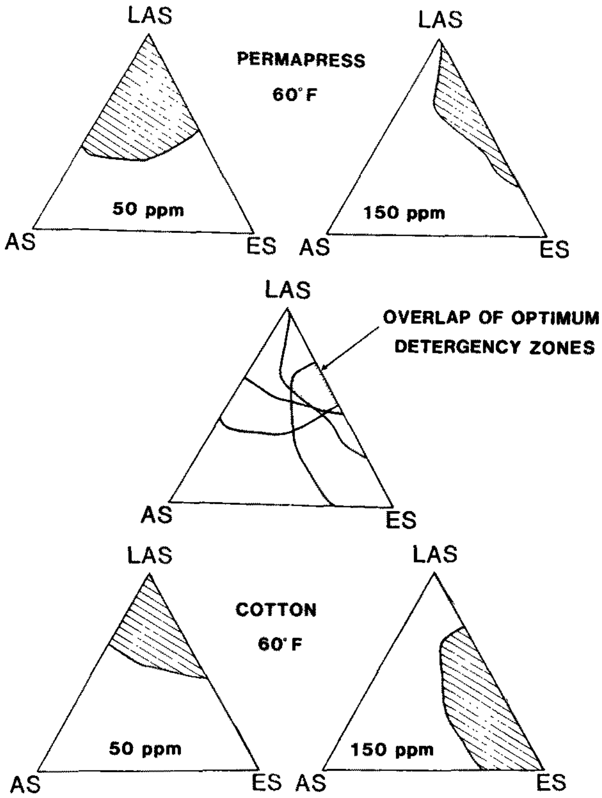

FIG. 5. Example of how performance data can be used to determine the optimum surfactant composition (dodecyl LAS/C12-18 ES/C12-18 AS/phosphate formulations at 60 F).

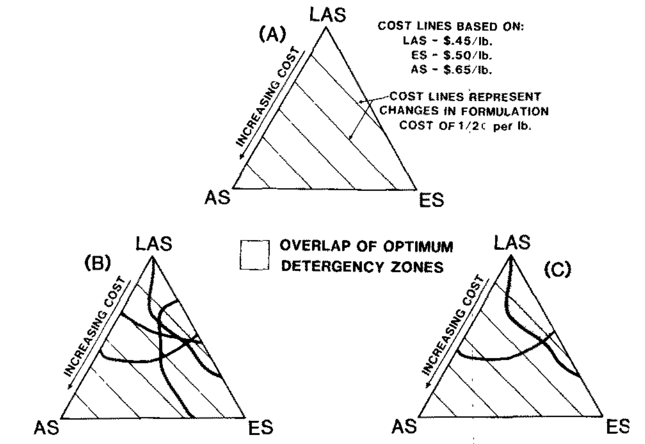

FIG. 6. A. Graph showing relative cost vs active composition. B. Cost/performance optimization plot using data from Figure 5. C. Same as B, except only performance on permanent-press cloth is considered.

the 11/4 LAS/ES mixture and the all-LAS formulation. Because the all-LAS formulation encompasses 3 out of 4 of the conditions, cost vs performance must be considered. The 11/4 LAS/ES mixture covers all cases, but it adds ca. 0.25 cents per pound to the cost of the product just to cover 1 condition—in this case, cotton at high hardness. If performance on cotton at high hardness is important, then the 11/4 LAS/ES formulation is best. However, because cotton is rapidly being replaced by synthetic fibers, performance on permanent-press cloth is often considered more important than on cotton. If only permanent-press cloth is considered, the optimum cost/performance formulation would contain an all-LAS active, as shown in Figure 6C.

FUTURE STUDIES

The experiments detailed here are part of a worldwide mixed active study involving laboratories in the United States, Japan and Spain. Other active systems, such as LAS/AOS (alpha olefin sulfonate) and LAS/NI (nonionic)/soap, will be explored. Mixed builders, different use levels and other soils will also be examined.

ACKNOWLEDGMENT

The authors thank June Scott for performing the detergency tests and the computer evaluation of the data.

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[Received August 22, 1983]