Controlled Foam Laundry Formulations[1]

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ABSTRACT

Heavy duty laundry systems are complex formulations containing a large number of ingredients. They can be formulated to produce a variety of foam profiles. This work has demonstrated that laundry detergent systems, which consist principally of biodegradable nonionic active components, may be formulated to exhibit low and moderate controlled foam profiles under typically American and European working conditions. In addition these formulations demonstrate excellent detergency properties when compared to currently distributed commercial brands.

INTRODUCTION

Although foaming characteristics have no effect upon the soil removal properties of a heavy duty laundry detergent, consideration of the detergent's foaming properties are important for more than merely aesthetic reasons. The widespread use of tumbler type washing machines in the home, as well as high speed processing equipment in the textile and commercial laundry industries, requires detergent systems with moderate and low foaming characteristics to insure proper, trouble free mechanical operation.

In North America most home laundering is carried out at a temperature of 50-60 C (ca. 120-140 F), although in recent years cold water washing at 25 C (77 F) has increased due to the widespread use of permanent press fabrics. In this range of temperature moderate and low foam levels may be achieved by using all-nonionic active systems or principally alkyl benzene sulfonate systems containing some nonionic active and/or tallow-based soap as a foam depressant (see Table I). The foam profile of the latter Sodium Linear Alkylbenzene Sulfonate-Soap-Nonionic mixed active system is dependent on the hardness of the water being employed; in the absence of hardness these systems tend to be rather high foaming.

Unlike American washing practices, much home laundering in Europe is carried out at temperatures just below the boiling point of water, i.e., ca. 95 C or 203 F. Because of the high vapor pressures occurring at this temperature and the differing solubilities of detergent components, many detergent active systems which exhibit low foaming characteristics at American conditions will exhibit very high foaming characteristics at 95 C. Moderation of foam is commonly achieved at these higher temperatures by utilizing mixtures of alkyl benzene sulfonate and sodium soaps derived from both tallow and higher molecular weight fatty acids, e.g., arachidic, behenic, etc. (1-4). Some formulations attain foam control by using low levels of active and "end-capped" nonionic defoamers. Table I shows some typical high temperature, controlled foam formulations.

The rapid growth of polyester and other synthetic fiber usage for permanent press, soil release finishes and economic considerations, has resulted in increasingly larger percentages of these fabrics; (both alone and in cotton-synthetic blends) in the household washing load (5). Simultaneously efforts are being made to reduce the level of inorganic phosphate sequestering agents (builders) in laundry detergents in order to help reduce the eutrophication rate of lakes and rivers (6-8). Both of these developments have given rise to a trend towards increased nonionic active levels in laundry detergents. Nonionics have been shown to be very effective in cleaning synthetic fabrics (9), and are more resistant than anionic actives to the deleterious effects of calcium and magnesium hardness ions in containing low levels of detergent builders.

For the reasons cited previously, this investigation deals with formulations in both the moderate and low foam category, which are based upon predominantly nonionic active systems. The nonionics chosen for our studies were based on ethoxylates of synthetic linear primary alcohols, since these have been shown to be the most highly biodegradable of the various nonionic types used in laundry detergents (10-15). Although low foam levels may be easier to attain with nonionics having an "end capping" of propylene oxide or butylene oxide at the end of an ethylene oxide chain, these materials have been avoided because of their generally slower rate of biodegratation.

EXPERIMENTAL PROCEDURES

Methods

All of our foaming tests were carried out using typical levels and types of detergent builders and additives; the compositions which were employed are shown in Table II.

[1]Presented at ISF-AOCS World Congress, Chicago, September 1970.

TABLE I

Active Systems Employed in Typical Moderate and Low Foaming Laundry Formulations[a]

North America					Europe			
	Active, wt%					Active wt%		
Components	Type A	Type B	Type C	Type D	Components	Type E	Type F	Type G
Sodium Alkyl[b] Benzene Sulfonate	10.0	10.0	7.0	---	Sodium Alkyl(2) Benzene Sulfonate	10.0	11.0	4.0
Sodium Soap (Derived from Tallow)	4.0	2.0	2.0	---	Sodium Soap (Derived from Tallow plus Higher Molecular Weight Fatty Acids)	3.0	3.5	---
Ethoxylated Fatty Alcohol Nonionic	---	2.0	2.0	10.0	Ethoxylated Fatty Alcohol or Alkyl Phenol Nonionic	3.0	3.0	3.0[c]

[a]In addition these products generally contain varying amounts of sodium tripolyphosphate, sodium silicate, sodium carboxy methyl cellulose, fluorescent whitening agents, sodium sulfate, and in some cases, sodium perborate.

[b]Alkyl = dodecyl or tridecyl.

[c]End-capped.

TABLE II

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Author: Provide column Heading	American	European
Test formulations, ingredient		
Active	As indicated	As indicated
Sodium tripolyphosphate	38.0	35.0
Sodium silicate	6.0	6.0
Sodium perborate 5 H_2O	---	---
CMC	1.0	1.0
Water	8.0	8.0
Sodium sulfate	Q.S.	Q.S.
Test conditions		
Machine	Westinghouse No. LTH550W1	Miele No. 421
Fabric load	6 lb Terrycloth	5 lb Terrycloth
Soil load	As indicated	None
Water hardness	100 ppm	100 ppm
Detergent concentration	45 gm/8 gal, 0.15%	59 gm Prewash, 0.33% 59 gm Mainwash, 0.34%
Machine setting	"Hot" or 130 F (unless marked otherwise Regular wash cycle-large load	"White" or "Kochwasche"
Water volume per load		
Prewash input	---	18.0 liters
Prewash drain	---	9.2 liters
Prewash remainder	---	8.8 liters
Mainwash input	30.4	12.2 liters
Mainwash total	30.4 liters	21.0 liters

TABLE III

Identification of Products Used

Designation	Description
NaLAS	Sodium salt of sulfonated NALKYLENE[a] 600, a linear tridecyl benzene alkylate
1618-60 NI	ALFONIC[a] 1618-60 nonionic, a 60% ethoxylate of ALFOL[a] 1618 alcohol, a linear primary C_{16}-C_{18} alcohols
1618-65 NI	ALFONIC[a] 1618-65 nonionic, a 65% ethoxylate of ALFOL[a] 1618 alcohol, primary C_{16}-C_{18} alcohol
1620 Alcohol Sulfate	The sodium salt of sulfated ALFOL[a] 1620 alcohol, a linear primary C_{16}-C_{20} alcohol
1012-60 NI	ALFONIC[a] 1012-60 nonionic, a 60% ethoxylate of ALFOL[a] 1012 alcohol, a linear primary C_{10}-C_{12} alcohol
C_{18} Alcohol	ALFOL[a] 18 alcohol, a synthetic linear primary C_{18} alcohol
C_{20}-C_{22} Alcohol	ALFOL[a] 2022 alcohol, a synthetic linear primary C_{20}-C_{22} alcohol

[a]Registered trade marks of Continental Oil Co.

This table also indicates the test conditions used. Table III describes the detergent active materials used in our tests. The equipment employed for determining the foam profiles of the various active systems consisted of front loading, tumbler type washing machines which are typical of those commonly used in North America and Europe. The American machine drew upon water which was preheated to 130 F (55 C), while the European machine drew the water at unheated ambient conditions and utilized an internal electrical heater to bring the water temperature to 95 C, (ca. 200 F). The European machine also included a prewash phase in its cycle. The front windows of each of these machines were divided into eight equal sections which were used to measure the foam height during the course of each run.

It is known that most types of soil encountered in home laundries tend to lower washing machine foam levels. We therefore decided to eliminate soil from our tests in order to focus our attention upon conditions where high foam levels and overfoaming problems were most likely to occur.

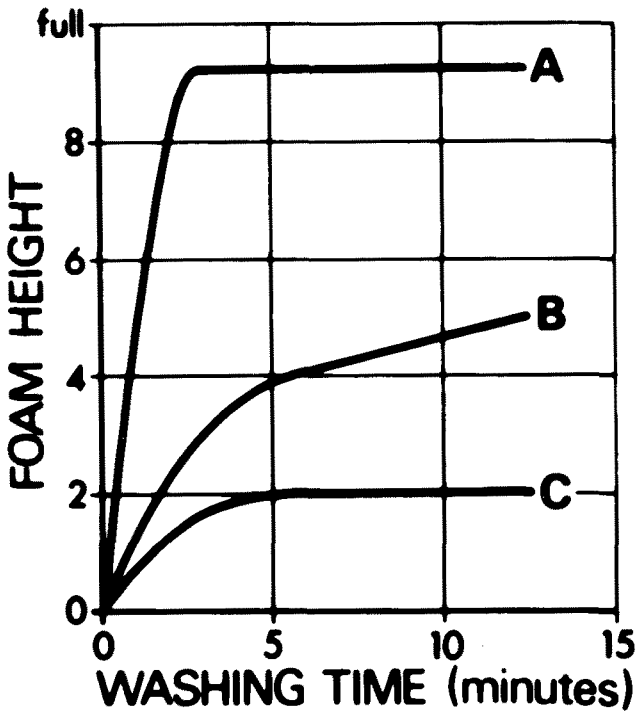

FIG. 1. Commercial American detergent at 130 F–foam profile. (A) Based on NaLAS; (B) based on NaLAS plus soap; (C) based on nonionic.

DISCUSSION AND RESULTS

As points of reference, foam profiles were determined for several commercial formulations which are typical of the various foaming types presently being marketed in North America. These are shown in Figure 1. It shows a low, moderate and high foaming type of detergent in an American front loading washing machine.

Figure 2 shows how a small difference in the degree of ethoxylation can affect the foam profile of formulations

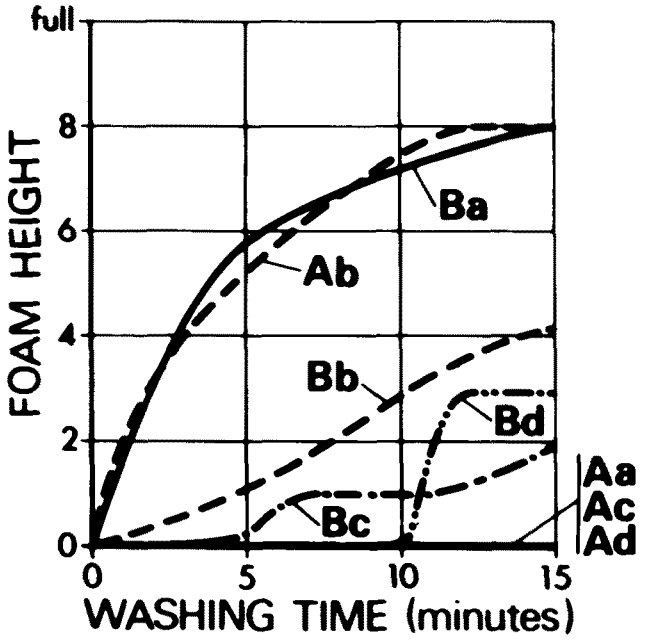

FIG. 2. Commercial American detergent–effect of temperature. (A) 10% "ALFONIC" 1618-60; (B) 10% "ALFONIC" 1618-65 (——a=150 F, —b=125 F, -·-·-c=74 F,·····d=45 F).

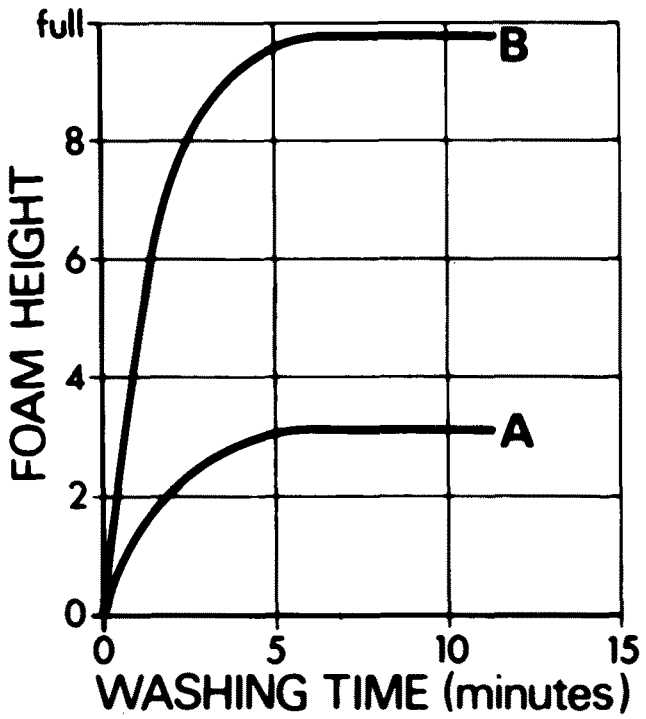

FIG. 3. Commercial American detergent at 120 F. (A) 10% "ALFONIC" 1618-60; (B) 8% "ALFONIC" 1618-60, 2% NaLAS.

based entirely on nonionic active. No direct correlation could be made between the initial defoaming of these nonionics at higher temperatures and their 1% cloud points, i.e., 144 F (62 C) for ALFONIC 1618-60 and 176 F (80 C) for ALFONIC 1618-65.

Almost completely defoamed systems may be obtained over a wide temperature range with the same nonionics by adding 1% (finished product basis) levels of a quaternary compound (di-stearyl dimethyl ammonium chloride) or a phosphate triester (trioctyl phosphate).

Higher foam levels may be attained by adding small amounts of sodium tridecyl benzene sulfonate (NaLAS) to

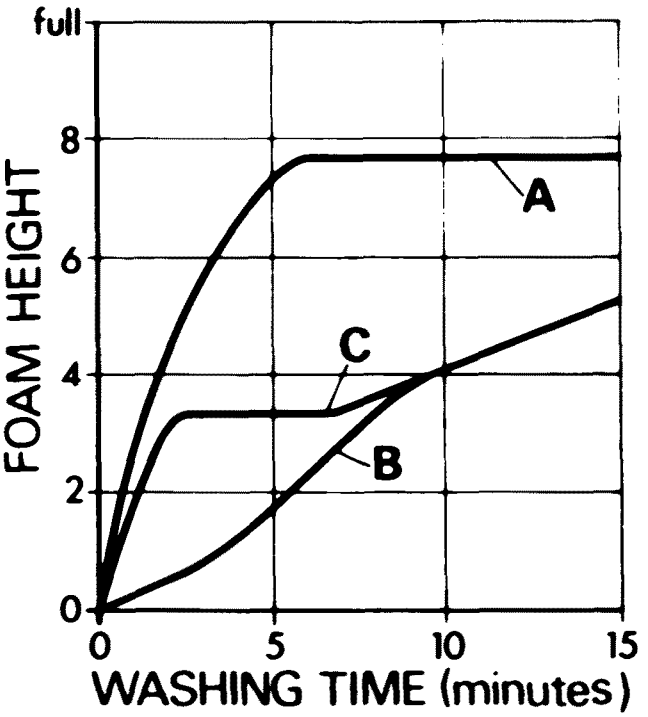

FIG. 4. Commercial American Detergent–effects of foam modifiers. (A) 7.5% "ALFONIC" 1618-65, 6.0% NaLAS: (B) 7.5% "ALFONIC" 1618-65, 6.0% NaLAS, 1.0% distearyl dimethyl ammonium chloride; (C) 7.5% "ALFONIC" 1618-60, 6.0% NaLAS, 1.0% tallow soap.

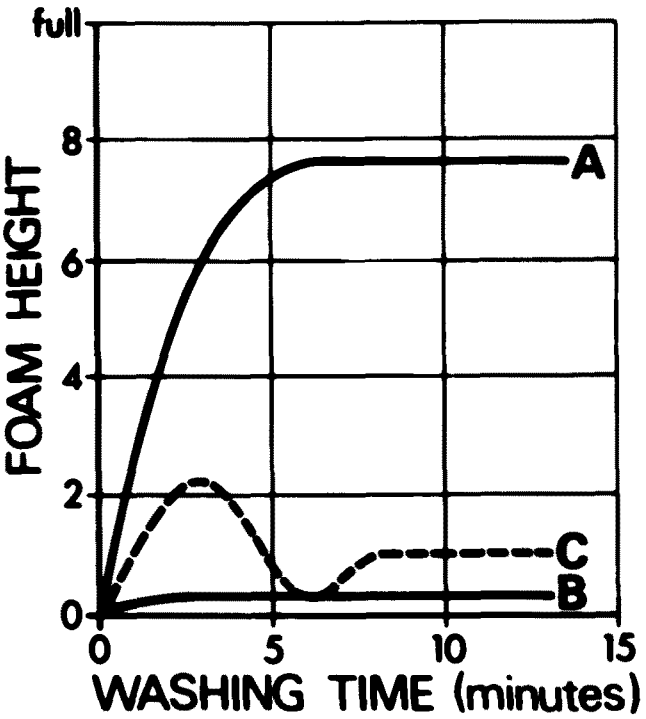

FIG. 5. Commercial American detergent–effects of foam modifiers. (A) 7.5% "ALFONIC" 1618-65, 7.0% 1620 alcohol sulfate; (B) 7.5% "ALFONIC" 1618-65, 7.0% 1620 alcohol sulfate, 1.0% tallow soap; (C) 7.5% "ALFONIC" 1618-65, 7.0% 1620 alcohol sulfate, 0.25% tallow soap.

principally nonionic systems as shown in Figure 3.

Figures 4 and 5 illustrate how high foaming mixed active, nonionic-anonic systems may be modified to produce moderate and low foaming formulations by the

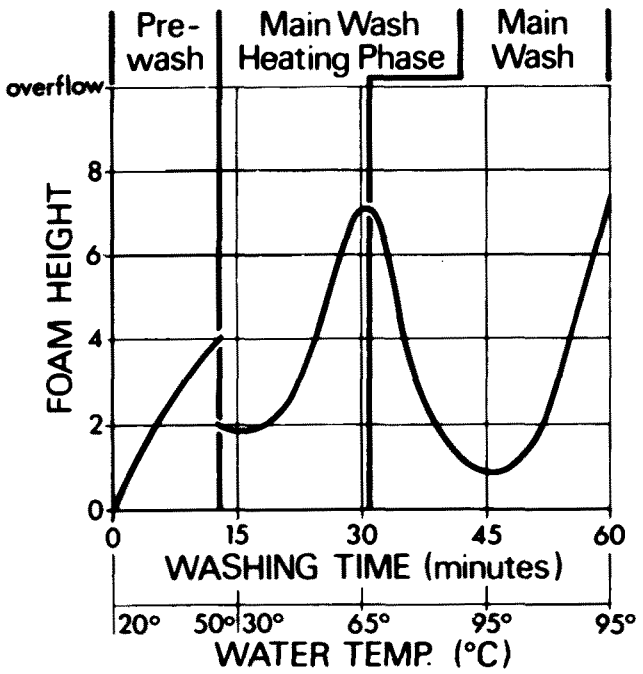

FIG. 6. Commercial European detergent.

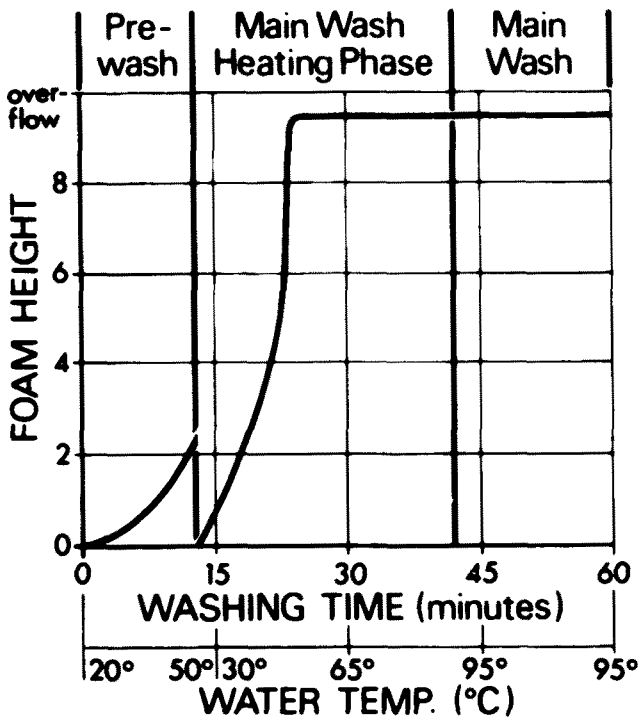

FIG. 7. Commercial European detergent. 10% "ALFONIC" 1618-65.

addition of small amounts of a quaternary or tallow-derived soap.

Figure 6 shows a foam profile of typical controlled foam European detergent formulations measured in a high temperature internal heater type washing machine. Figure 7 illustrates the observation that formulations, which may exhibit a low foam profile at American washing conditions can overfoam in a European machine at high temperatures. High molecular weight fatty alcohols were found to be excellent defoaming agents for all-nonionic active systems (see Fig. 8). Since laundry detergents used in Europe are

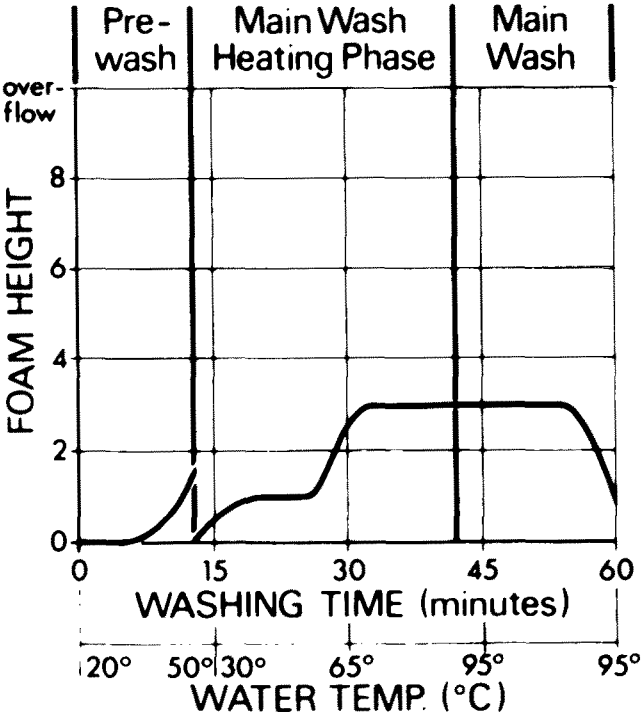

FIG. 8. Commercial European detergent. 9.0% "ALFONIC" 1618-65, 0.2% C_{18} alcohol.

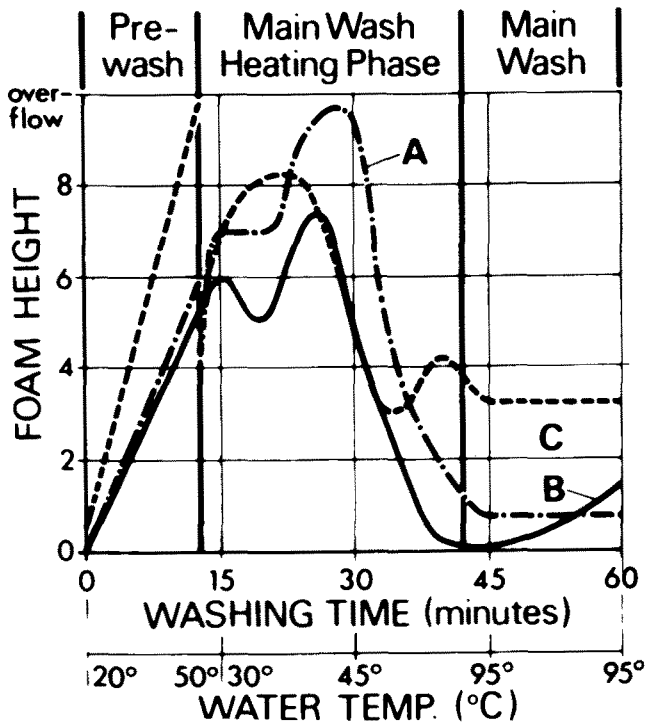

FIG. 9. Commercial European detergents. Formula A: 5.0% "ALFONIC" 1618-60, 4.0% 1012-60, 0.2% C_{18} alcohol; Formula B: 10.0% "ALFONIC" 1618-65, 2.0% 1012-60, 0.2% C_{18} alcohol; Formula C: 10.0% "ALFONIC" 1618-60, 1.0% NaLAS, 1.0% C_{18} alcohol.

recommended for both high temperature machine washing as well as low temperature laundering by hand, it is desirable that a product have high foaming characteristics at low temperature for consumer appeal in hand laundering applications, and controlled foam at high temperatures to prevent over foaming in a washing machine. When linear fatty alcohols in the molecular weight range of C_{16}-C_{22}

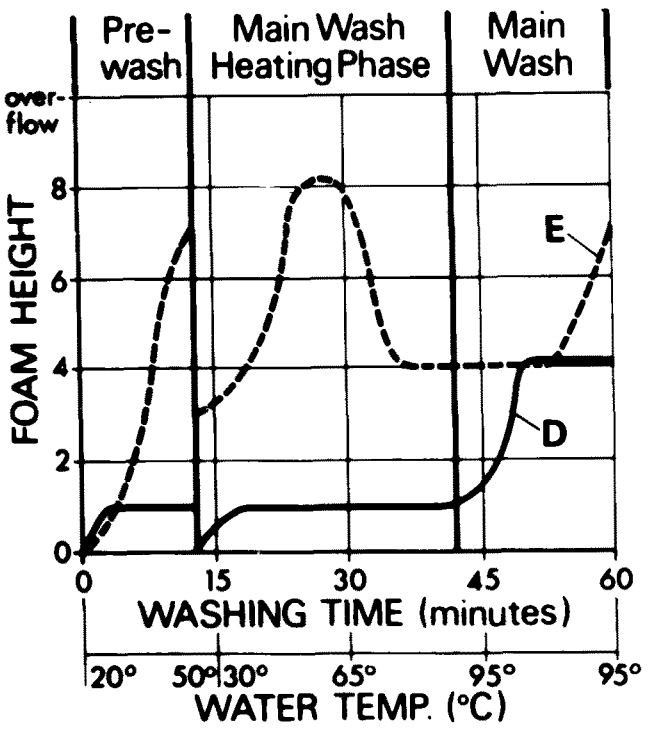

FIG. 10. Commercial European detergents. Formula D: 10.0% "ALFONIC" 1618-60, 5.0% NaLAS, 1.0% C_{18} alcohol, 2.0% distearyl dimethyl ammonium chloride; Formula E: 7.0% "ALFONIC" 1618-60, 7.0% 1620 alcohol content, 1.0% C_{18} alcohol, 2.0% tributoxyethyl phosphate.

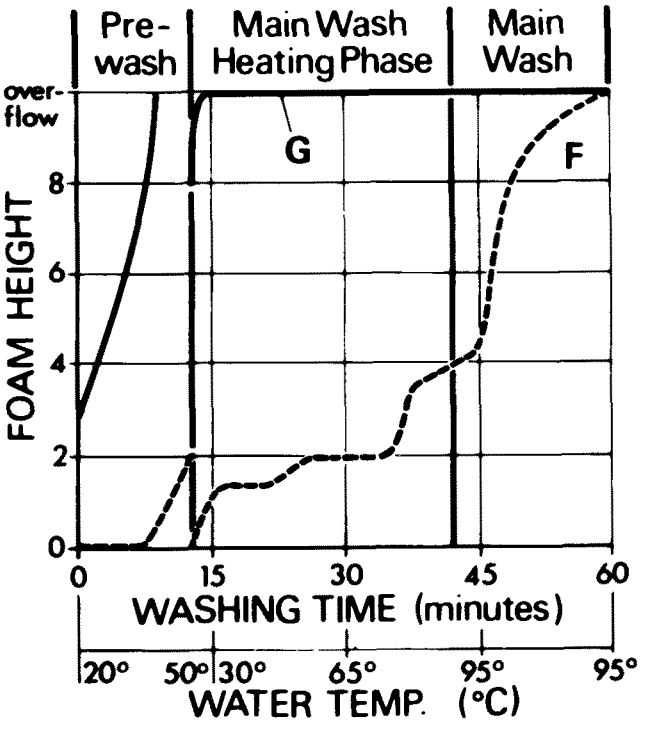

FIG. 11. Commercial European detergents. Formula F: 7.0% "ALFONIC" 1618-60, 7.0% C_{18} NaLAS, 1.0% C_{18} alcohol; Formula G: 7.0% "ALFONIC" 1618-60, 7.0% C_{13} NaLAS, 1.0% C_{18} alcohol.

TABLE IV

Terg-O-Tometer Detergency Study at American Conditions[a]

Material tested	Soil removal, %		
	Cotton	Permanent press cotton-polyester	Polyester
Commercial American detergent type B	32.0	32.1	26.7
Comercial American detergent type C	27.8	31.9	23.6
7.5% 1618-65 NI + 7.0% 1620 Alcohol sulfate sulfate[b]	31.8	33.7	26.9

[a]Terg-O-Tometer test conditions: (A) main wash only at 120 F (49 C) for all fabrics, 10 min at 0.20% detergent; (B) water hardness, 150 ppm; (C) soil composition: mixed synthetic sebum + air conditioner dust applied from an aqueous suspension (16); (D) soil removal; measured by increase in the L reflectance value on a Hunter Model D-25 color difference meter.

[b]Remainder of formula as shown in Table II.

TABLE V

Terg-O-Tometer Detergency Study at European Conditions

Material tested	Soil removal, %		
	Cotton	Permanent press cotton-polyester	Polyester
Commercial European detergent type	42.5	26.8	17.2
Commercial European detergent type	44.3	36.0 36.0	28.4
12% 1618-65 NI + 1% C_{1618} alcohol[b]	52.5	41.8	35.5

[a]Terg-O-Tometer test conditions: (A) prewash at 70 F (21 C) for all fabrics, 10 min at 0.25% detergent; (B) main wash at 190 F (88 C) for cotton, at 140 F (60 C) for other fabrics, 10 min at 0.35% detergent; (C) water hardness: in all cases, 250 ppm; (D) soil composition: mixed synthetic sebum + air conditioner dust from an aqueous suspension (16); (E) soil removal: measured by increase in the L reflectance value on a Hunter Model D-25 color difference meter.

[b]Remainder of formula as shown in Table III.

were included in principally nonionic formulations as foam control agents, it was found that overfoaming at higher temperatures could be avoided; simultaneously foam levels during the low temperature washing stages could be increased by adding nonionics derived from lower molecular weight alcohols, i.e., ALFONIC 1012-60 nonionic, or small amounts of sodium tridecyl benzene sulfonate (see Fig. 9). Higher levels of anionic activities proved difficult to defoam at high temperatures; various defoamers did yield some promising formulations in these cases (see Fig. 10). A formulation based on an experimental octadecyl benzene sulfonate was much easier to defoam than ones based on tridecyl benzene sulfonate (compare Fig. 11).

Detergency Studies

Terg-O-Tometer detergency studies were carried out on several representative test formulations to compare their detergency to widely distributed commercial products. The detergency results at American washing conditions are shown in Table IV. Table V illustrates relative detergency at European conditions. The results of these tests indicate that the experimental formulations compare favorably in detergency to commercial detergent products currently being distributed in Europe and North America.

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