Importance of Alkalis, Dispersants and Sequestrants in Building Action

FUMIKATSU TOKIWA and **TETSUYA IMAMURA,**
Research Laboratories, Kao Soap Company, Wakayama-shi, Japan

Abstract

The builder effects of a variety of alkalis, dispersants and sequestrants on detergency have been examined by changing builder compositions of detergents. The detergent formulated with an alkali, a dispersant and a sequestrant exhibits a high detergency, comparable to the standard detergent built with sodium tripolyphosphate. When any one of these three components is omitted, the detergency does not reach a satisfactory value. Further, when any two of them are eliminated, the detersive power is further reduced. Using these results the importance in building action of the combination of the three builder components has been discussed.

Introduction

Although a variety of inorganic and organic builders are used in detergent formulations, the mechanism of their building action in improving performance properties is not necessarily well established in all of its aspects. The building action is probably not attributable to any one single physical or chemical effect.

In the previous work (1), the detergency builder effects of a series of condensed phosphates and other types of electrolytes have been studied in relation to the pH of detergent solutions and the abilities of dispersion and sequestration. The results have shown that the following factors are at least of importance in building action: (a) the alkalinity including alkali buffering action to keep a detergent solution alkaline, (b) the dispersion of soil particles in the solution, and (c) the sequestration of deleterious ions. It has also been shown that condensed phosphates, especially sodium tripolyphosphate, have an ability to satisfy these factors although their alkalinity is not strong.

The purpose of the present investigation is to verify this conception. The builder effects of alkalis, dispersants and sequestrants on detergency have been examined by combining these builder components without using sodium tripolyphosphate, widely used as an excellent builder.

Experimental Procedures

Materials. Inorganic compounds (sodium carbonate, silicate, borate and sulfate), sodium nitrilotriacetate (NTA), sodium ethylenediaminetetraacetate (EDTA) and sodium diethylenetriaminepentaacetate (DTPA) were of reagent grade. The sodium salt of β-naphthalene sulfonic acid-formalin condensate (β-NSF), which is a commonly used dispersant, and sodium alkylbenzene sulfonate (LAS), the average alkyl chain of which was C_{12}, were the same samples as those used in the previous work (2).

Polyethylene glycols (PEG) were commercial samples, obtained from Sanyo Yushi Co. Polyvinyl alcohols (PVA) and polyvinyl pyrrolidones (PVP) were supplied from Nippon Gosei Co. and General Aniline & Film Co., respectively. The PVA with a lower molecular weight was fractionated from water-acetone and the PVP with a lower molecular weight from chloroform-ethyl ether by the ordinary method (3). The molecular weights of these polymers were determined with an osmometer, Hitachi-Perkin Elmer Model 115.

Laundering Experiments. Two different types of soiled cloths were used, one of which (soiled cloth A) was the same as that described previously (1) and the other one (soiled cloth B) was prepared as follows. An artificial soil was formulated, having a composition of 60% cotton seed oil, 10% cholesterol, 10% oleic acid, 10% palmitic acid and 10% liquid and solid paraffins. In 10 liters of tetrachloroethylene containing 17 g of this soil mixture, 0.43 g of carbon black was added and suspended well with an ultrasonic mixer. The cotton cloth, which had been desized, scoured and bleached, was impregnated with this carbon black suspension. The soiled cloth thus prepared was cut into 5 × 10 cm swatches after removal of the solvent, and was kept for a week in a desiccator at 25 C before use.

Laundering experiments were carried out the same way as that described previously (1). The hard water used was one containing calcium and magnesium ions in a mole ratio of 2 to 1, having a total hardness of 72 ppm as calcium carbonate. Soil removal efficiency was determined by reflectance measurement, and the result was expressed as per cent detergency (4).

Results and Discussion

The Builder Effect of an Alkali, a Dispersant and a Sequestrant on Detergency. Table I summarizes the builder effect of an alkali, a dispersant and a sequestrant on detergency towards the soiled cloths A and B at a detergent concentration of 0.20%. Sodium carbonate, β-NSF and NTA were chosen as an alkali, a dispersant and a sequestrant, respectively. Each of these components has one primary effect and shows only slight other effects: for example, sodium carbonate has the ability to make the detergent solution alkaline but has little dispersing ability for soil particles and no sequestering ability for deleterious ions. The detergents were formulated as given in Table I. For comparison, a typical formulation of commercial detergents—20% LAS, 30% sodium tripolyphosphate, 4% (sodium carbonate + sodium silicate), 1% carboxymethyl cellulose and 45% sodium sulfate—is also included in Table I.

TABLE I
The Builder Effect of Na_2CO_3, β-NSF and NTA on Detergency Towards Soiled Cloths A and B at a Detergent[a] Concentration of 0.2% at 25C

Sample. No.	Builder Components				Detergency (%)	
	Na_2CO_3 %	β-NSF %	NTA %	Na_2SO_4 %	Soiled cloth A	Soiled cloth B
1	10	10	10	50	79.3	60.0
2	5	5	5	65	75.4	56.5
3	....[b]	5	5	65	60.6	46.2
4	5	....	5	65	65.5	51.8
5	5	5	....	65	68.0	51.1
6	....	....	5	65	42.9	41.5
7	5	....	....	65	53.2	45.3
8	....	5	....	65	45.0	42.6
9	....	....	....	65	37.1	35.9
10	....	....	....	....	28.7	26.1
11	Standard formulation[c]				76.0	58.2

[a] Detergent composition, 20% LAS + builders given in the Table.
[b] Balanced with water to bring the total to 100%.
[c] See text.

TABLE II

The Builder Effects of Various Alkalis, Dispersants and Sequestrants on Detergency Towards Soiled Cloth A at a Detergent[a] Concentration of 0.2% at 25C

Alkali	Detergency, %	Dispersant	Mol wt	Detergency, %
Na_2CO_3	75.4	β-NSF	....	75.4
$Na_2O \cdot 2.5SiO_2$	77.0	PEG	3,500	75.7
$Na_2B_4O_7$	73.5		10,000	69.0
No added alkali	60.6	PVP	2,000	77.5
Sequestrant			10,000	71.6
NTA	75.4	PVA	4,000	75.4
EDTA	75.0		11,000	67.3
DTPA	73.9	No added dispersant		65.5
No added sequestrant	68.0			

[a] Detergent composition, 20% LAS + 5% alkali + 5% dispersant + 5% sequestrant + 65% Na_2SO_4 (see text).

It is to be noted that the detergents (sample No. 1 and 2) built with the alkali, dispersant and sequestrant exhibit detergencies comparable to the standard detergent (sample No. 11) built with sodium tripolyphosphate. When any one of these three components is omitted (sample No. 3, 4 and 5), the soil removal efficiency can not reach a satisfactory value. When any two of them are eliminated (sample No. 6, 7 and 8), the detergency is further reduced. These results support the concept described in the introduction of this paper. They may also explain the reason why sodium tripolyphosphate is widely used as a builder, that is, it has abilities to satisfy the three factors described above.

When we compare the building action of each component, it is seen from Table I that the action of sodium carbonate is higher than that of β-NSF or NTA. However, the action of sodium carbonate alone is not enough to obtain good detergency. Alkali builders, such as sodium carbonate and sodium silicate, exert a strong synergism with other builders. The sequestration capacity of NTA depends on the pH of the detergent solution and is greater in the alkaline region than in the neutral region (5,6). The suspension stability of soil particles which is closely related to the electrophoretic behavior of the particles, as reported in the previous papers (2,7), also highly depends on the pH of the solution. Thus, the building action is an over-all action obtained by the combination of the alkali with the dispersant and sequestrant.

The Effect of the Concentrations of the Three Builder Components on Detergency. The effect of the concentrations of the alkali, dispersant and sequestrant in detergent formulations on detergency is shown in Figure 1 in which one of the three components is varied from 0% to 20% while the concentrations of the other two are kept constant at 5%. In all cases, when one of these components is formulated in an amount of approximately 10%, keeping the other two at 5%, the building action is saturated and the detergency does not show further increase. The detergency at 5% NTA is equal to that at 10% NTA in spite of incomplete chelation of Ca^{++} and Mg^{++} ions at 5% NTA. It has been reported (8,9) that if Na-LAS is used in hard water containing Ca^{++} ions a part of Na-LAS is converted to the calcium salt which promotes the soil removal in cooperation with Na-LAS. The formation of the calcium and magnesium salts does not necessarily lower the detergency as long as the amount of these salts present is moderate. The above result for the dependence of detergency on NTA content may be explained by this effect.

The Builder Effects of Various Alkalis, Dispersants and Sequestrants on Detergency. The results presented above indicate that the combination of at least the three builder components is necessary in detergent formulations to obtain a satisfactory detergency. Table II gives the builder effects of various alkalis, dispersants and sequestrants on detergency for the soiled cloth A at a detergent concentration of 0.2%. The builder composition of 5% sodium carbonate, 5% β-NSF and 5% NTA was chosen as a standard and, for example, when alkali materials were examined, sodium carbonate was replaced by other alkalis, the contents of β-NSF and NTA being kept at 5%.

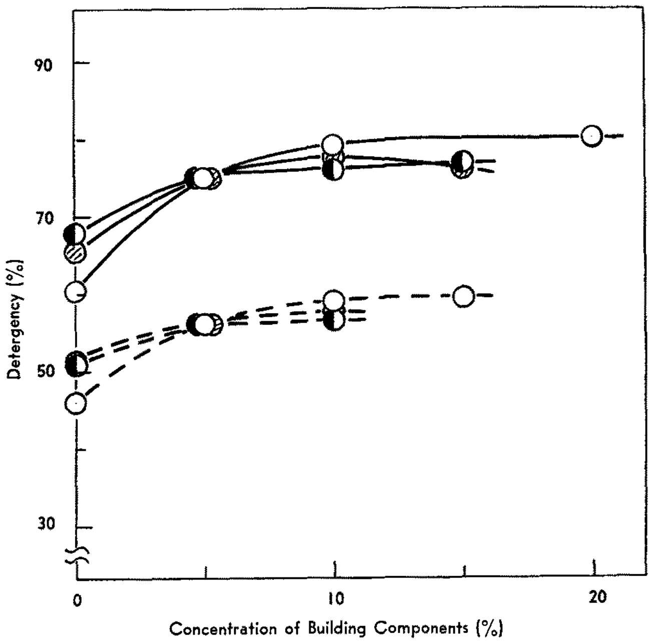

FIG. 1. The effect of Na_2CO_3 (○), β-NSF (⊘), or NTA (◐) concentration on detergency at a detergent concentration of 0.2% at 25C: ———, towards soiled cloth A; and – – –, towards soiled cloth B.

As seen in Table II, the effect of alkali builders on detergency is large in comparison with that of other type builders. If an alkali builder is absent, the detergency of the formulation using soiled cloth A is not very high even in the presence of a dispersant and sequestrant. However, no remarkable difference could be found among the alkali builders examined. Any one of the sequestrants also shows a builder effect.

Polymers are often used as dispersants or flocculants for colloidal suspensions, depending on their molecular weights, and low molecular weight polymers are generally effective as dispersants (10,11). As shown in Table II, in all cases the polymers with lower molecular weights are more effective as builder components than those with higher molecular weights and are as highly effective as β-NSF. This result indicates that the polymers are effective as dispersing agents in detergent formulations as long as their molecular weights are as low as 1,000–5,000.

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