Study of Detergency. II. Effect of Sodium Tripolyphosphate

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Abstract

A study of the effect of added sodium tripolyphosphate (STPP) on oily soil removal efficiency in hard water showed that as the concentration of STPP increases, the water hardness at maximum oil removal efficiency increases and the sharpness of the oil removal peak is lessened. The value of maximum oil removal efficiency was not influenced greatly by the concentration of STPP. The action of STPP on oil removal efficiency in hard water was that of softening the water. The pH of various hard water/STPP/sodium dodecylbenzene sulfonate (0.1 wt. %) solutions had a maximum oil removal efficiency at 7.7.

Introduction

THE EFFECT OF SODIUM tripolyphosphate (STPP) on detergency was studied by many (1). Vitale et al. (2,3), pointed out that the amount of STPP required to obtain the highest possible detergency in carbon soil-cotton systems was dependent upon the amount of hardness present, and further addition of STPP beyond the amount necessary to soften the water does not increase detergency. They also found that the amount of STPP required for maximum detergency of sodium dodecylbenzene sulfonate (NaDBS) in hard water was decreased with increasing concentrations of NaDBS.

When we used ionic detergents such as NaDBS, and washed in hard water we found that maximum detergency was shown at the same water hardness for a given oil (4). Therefore we thought it would be helpful to understand the effect of STPP on detergency if we knew the effect of added STPP on the maximum oil removal efficiency.

Experimental

Material

The purification of sodium dodecylbenzene sulfonate (NaDBS, Neoplex 05; Kao Soap Co.) and the preparation of the hard water were as described in Part I (4).

Sodium tripolyphosphate (STPP) was obtained from the Wakojunyaku Co. in Japan.

Cotton cloth (Sarashi-kanakin; Kanebo Co., Japan) was soiled with a mixture of beef tallow (Kao Soap Co.) and liquid paraffin (cp) in 1:3 ratio, which was as described in Part I (4).

Method

Washing and oil removal efficiency were as described in Part I (4). Two test samples were washed (using Launder-o-Meter) in 60 ml of various hard water/STPP/NaDBS solutions with a washing time of 30 min and temperature of 30C. Following washing, each swatch was rinsed with 60 ml of distilled water and air-dried. Soil removal efficiency (% SRE) is calculated according to the formula; % SRE = (Rw−Rs)/Ro−Rs). Rw, Rs and Ro are the reflectance of the laundered swatches, of the soiled swatches, and of the original unsoiled fabric, respectively. In these experiments, Ro was in the neighborhood of 87 and Rs in the neighborhood of 28.

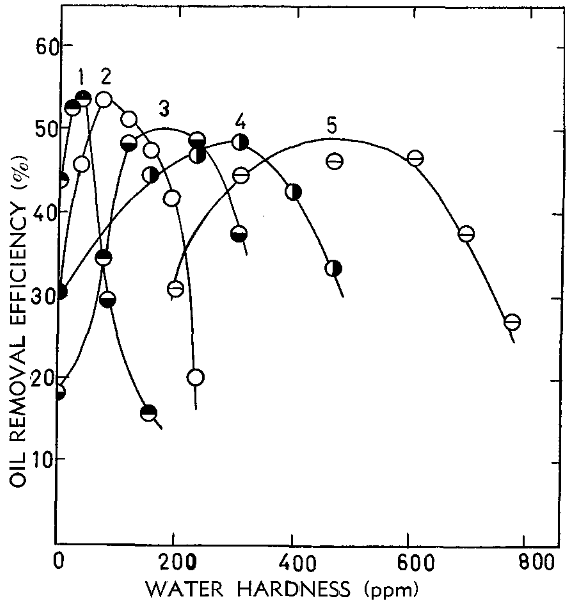

FIG. 1. The effect of concentration of STPP on the oil removal efficiency vs. water hardness.
The concentration of NaDBS is 0.1 wt %. Amount of oil soil (g)/a swatch is 0.014. The concentration of STPP (wt %) is 0 (1), 0.02 (2), 0.04 (3), 0.06 (4), and 0.1 (5).

Results and Discussion

We used the mixture of solutions with the added STPP in various hard water/NaDBS (0.1 wt %) solutions and washed. The relationship between water hardness and oil removal efficiency for each increment of STPP is shown in Figure 1. As the concentration of STPP increases, the hardness of water at maximum oil removal efficiency increases and the sharpness of the oil removal peak is lessened. The same result was also obtained for a different amount of oily soil [amount of oil (g)/swatch is 0.034].

From the above results, we plotted in Figure 2 the relationship of concentration of STPP and hardness of water at maximum oil removal efficiency. It is clear from Figure 2 that the relationship between the concentration of STPP and the hardness of water at maximum oil removal efficiency is linear, and that the mole ratio of Calcium [1]/STPP is 1.7 The ratio of calcium/NaDBS at maximum oil removal efficiency is constant, independent of concentration of STPP when the Ca-STPP are at the 1.7 mole-ratio. On the other hand, the Ca/STPP ratio was approximately the same (1.2–1.4) as that obtained from hardness of water-concentration of STPP curves at maximum Orange-OT solubilization, using dodecyl-6-benzene sulfonate (5).

From Figure 2, the amount of STPP required to obtain the highest oil removal efficiency (T wt %) is shown by the following equation:

$$T = (0.22H - 4) \times 10^{-3}$$

where, H is the water hardness (ppm) and is >34 (the value shown is the hardness of water at maximum oil removal efficiency with no added STPP in

[1] Calcium (corr.) = Calcium (meas.) − 1.8×10^{-4} mole.

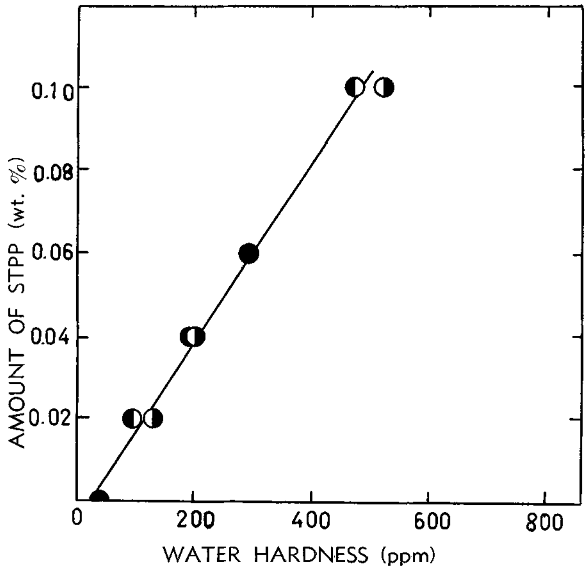

FIG. 2. The correlation between the amount of STPP and water hardness at maximum oil removal efficiency.
The concentration of NaDBS is 0.1 wt %. Amount of oil soil (g) per swatch is 0.014 (◐) and 0.034 (◑).

the system). The water hardness at a maximum oil removal efficiency was dependent upon the concentration and the kind of detergents, and the nature of the oily soil (4). Therefore, the amount of STPP required to obtain highest oil removal efficiency seems to be dependent upon these factors.

The value of maximum oil removal efficiency (see Figure 1) is seen not to be influenced greatly by the concentration of STPP.

The change of pH with added STPP in various hard water/NaDBS solutions was determined. The results are shown in Table I. As the concentration of STPP was increased, the pH in various hard water/NaDBS solutions increased. On the other hand, as the hardness of water increased, the pH decreased.

TABLE I

Change of pH with Added STPP in Various Hard Water/NaDBS (0.1 wt %) Solutions

Amount of NaDBS (wt %)	Hardness of Water (ppm)	pH				
		Amount of STPP (wt %)				
		0	0.02	0.04	0.06	0.1
0	0	...	9.6(T)	9.7(T)	9.7(T)	9.7(T)
0.1	0	5.65(T)	9.4(T)	9.5(T)	9.55(T)	9.6(T)
...	107	...	7.7(H)	...	...	...
...	175	...	...	...	8.45(T)	...
...	213	...	...	7.7(H)	...	...
...	304	...	...	...	7.8(H)	...
...	352	...	...	...	7.6(O)	...
...	500	6.1(O)	6.6(O)	6.6(O)	6.9(O)	7.7(H)
...	876	...	...	...	6.4(O)	...

T; Transparency, H; Haze, O; Opacity.

From these results, as from the results of Jones and Parke (6), it is clear that STPP forms a complex with Ca^{++} ion in NaDBS solution. It was interesting to note that the pH in various hard water/STPP/NaDBS (0.1 wt %) solutions which had a maximum oil removal efficiency (see Fig. 2) was approximately 7.7, and the appearance of this solution was hazy.

From the above results, it is clear that the effect of STPP on oil removal efficiency in hard water, as well as that of carbon black soil (2), is due to the water softening effect.

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