USE OF SOME SYNTHETIC DETERGENTS AS DECONTAMINATING AGENTS

by

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ABSTRACT

The trials carried on some of the detergents for their effectiveness in removing contamination from common surfaces are summarised in this paper.

Introduction

In Radiation Chemistry, decontamination may not appear to be a topic of much interest and excitement, but its importance cannot be underrated due to the difficulties involved in various techniques employed for removal of radioactivity. These are some of the main problems which face every worker who is responsible for the working place and the apparatus used by him. Some types of surfaces present special decontamination problems. Of the various physical and chemical methods employed, the most convenient method next to flushing with water is the use of a synthetic detergent, a number of which are now readily available in the market. The trials carried out by us on some of these detergents for their effectiveness in removing contamination from common surfaces are summarised in this paper.

Chemistry of detergents

For our purpose these synthetic detergents or surface-active reagents are those substances which on mixing with water, wet surfaces readily by decreasing the surface tension or the interfacial tension, remove dirt and disperse solid particles. The molecule of such a compound must possess two groups, a hydrophilic group which remains in water and a hydrophilic group which can penetrate oily matter. (1) They are divided into two broad classes according to the character of their colloidal solutions in water. (2) Those compounds which form ions in solution are called ionic and those which do not are known as non-ionic surface-active reagents. In case of the ionic type compounds, if upon ionisation the ion containing the large hydrophilic group assumes a negative charge and becomes the anion, the compound is known as an anionic reagent, whereas in case of a cationic reagent, the long hydrophilic group assumes a positive charge and becomes a cation.

Alkyl aryl sulphonates which are some of the most important synthetic detergents belong to the class of anionic reagents. Dodecylbenzene sulphonate is a typical compound of this class. The synthesis of such a compound may be outlined as (3):—

$$C_6H_6 \xrightarrow[\text{(Chlorinated kerosine fraction of petrolium).}]{\textit{Alkylation}} RC_6H_5 \xrightarrow{\text{Sulphonation}} RC_6H_4SO_2OH$$

The product is then neutralised with alkali.

The next important compounds of anionic reagents are the fatty alcohol sulphates. These compounds are sodium salts of monoesters of sulphuric acid with naliphatic alcohols containing 8 to 18 carbon atoms. Esters, glycerides or free fatty acids are detalytically hydrogenated over copper chromite at about 200°C under high pressure. The fatty alcohols are then converted into sulphates by concentrated sulphuric acid and afterwards the product is neutralised with alkali. Direct action of sulphuric acid on olefines is also employed for the manufacture of this type of compounds.

Cationic reagents such as cetyltriethylammonium chloride or benzalkonium chloride which find other uses are not so common as detergents, being relatively expensive. In the non-ionic surface-active reagents the strong highly ionisable hydrophilic group of the ionic reagents is replaced by a long chain containing a series of weak hydrophilic groups such as hydroxyl groups or ether linkages. The repetition of the weak hydrophilic groups has the same effect as one strong hydrophilic group, except that no ionisation takes place. These compounds may be obtained by the condensation of fatty alcohols or their derivatives or alkyl substituted phenols with excess of ethylene oxide. A compound of the general formula RO (CH_2. CH_2O) H is obtained, and by varying the hydroxy compound or the number of ethylene oxide molecules, different products may be formed.

Two brands of synthetic detergents Nansa 100 and Nansa 2L from M/s. Marchon Products Ltd., England and another brand of synthetic detergent Teepol L, a product af Shell Petroleum Co., Ltd., and already in use in this laboratory were tried by us. These products are proprietory items. According to the manufacturers, Nansa 100 is based on sodium dodecylbenzene sulphonate with a balanced addition of co-active non-ionic surface-active agent. Nansa 2L and Teepol L are also either the anionic type or a mixture of anionic and non-ionic type of surface-active reagents.

Experimental procedure/observations

(a) *The cleansing solutions*—1% solutions of these detergents in water were used as clean ing solutions and distilled water was used as a control.

(b) *The contaminating Materials*—The radioactive isotopes of iodine (I^{131}), a beta and gamma emitter and phosphorus (p^{32}), a beta emitter, were employed as the contaminating agents. The radio-iodine in the form of carrier-free sodium iodide and radiophosphorus in the form of carrier-free sodium dihydrogen phosphate were diluted with distilled water to a final concentration of 0·07 μC per ml in a volumetric flask.

(c) *The surfaces*—The surfaces employed for soiling were pyrex glass, brass, aluminium, linoleum and cemented concrete. In case of glass, 3 inch diameter watch glass and 100 ml beaker, both of pyrex quality, were used. For brass, aluminium, linoleum and cemented concrete, 3 inch square pieces were used.

(d) *Method of Testing*—The different surfaces were soiled with the active sulutions as indicated in the tables below. The solution from each surface was drained off as completely as possible so that no visible drops could be seen on the surface and the activity determined. The surfaces were then rinsed two times with 25 ml portions of distilled water and counts taken. Next these surfaces were washed with 25 ml of the detergent solution in small proportions for a total time of 2 minutes and then the surfaces finally rinsed with 5 ml of distilled water at room temperature and the level of activity again determined. No brushing or rubbing of any kind was done while removing contamination with these cleansing solutions or water.

(e) *Determination of the level of activity*—The levels of the activity of the contaminated surfaces were determined by a collimated sodium iodide scintillation detector in conjunction with Nuclear Chicago made scale model 161A and a thin end mica (2 mg/cm^2) G.M. counter type 18504 along with PW 4035 type philips scaler. The scaler 161A model was employed to operate the photomultiplier at 1075 volts and G.M. counter was operated at 500 volts. The geometry of the detector was kept constant throughout the experiments. The back ground was counted before and immediately after examining each surface for radioactivity. Background readings were taken using a dummy surface. The determinations were carried out at room temperature.

Results and discussions

The percentage removals of the contamination of the surfaces soiled with I^{131} on treatment with water and the solution of Nansa 100 are given in Table I. In all the readings mean values have been calculated with concessions to the background counts and standard deviation. The ratio of the percentage removals in the case of water and the detergent is also indicated. All the surfaces were allowed to remain in contact with the isotope solution for twenty-four hours with the exception of a beaker surface which was given only two hours of soiling time.

TABLE 1

Percentage of contamination removed

Contaminant	Surface	Water	Nansa 100	Nansa100/ Water	Remarks
I^{131}	Watch Glass ..	99·0	100·0	1·0	
	Linoleum ..	31·2	40·2	1·29	
	Aluminium ..	64·5	95·0	1·47	
	Pyrex Beaker ..	55·5	62·2	1·12	
	Pyrex Beaker ..	88·5	88·5	1·0	Soiling time only two hours.

Table 2 indicates the removal of the contamination I^{131} from aluminium, brass and linoleum by water and by Teepol L solution. The linoleum surface was tested after remaining in contact with the contaminant for two hours as well as twentyfour hours.

TABLE 2

Percentage of contamination removed

Contaminant	Surface	Water	Teepol L	Teepol L/ Water	Remarks
I^{131}	Aluminium ..	91·1	94·0	1·03	
	Brass	64·0	65·3	1·03	
	Linoleum ..	13·5	13·5	1·0	
	Linoleum ..	90·0	95·0	1·05	Soiled only for two hours.

In Table 3 results of the decontamination of different surfaces by water and Nansa 2L solution are given. Here p^{32} was used as the contaminant and in each case the time allowed for soiling was not less than twentyfour hours.

TABLE 3

Percentage of contamination removed

Contaminant	Surface	Water	Nansa 2 L	Nansa 2L/ Water	Remarks
P^{32}	Pyrex beaker ..	83·3	96·1	1·16	
	Aluminium ..	27·0	37·5	1·38	
	Brass	0·0	0·0	..	Surface shows the formation of a dry stain.
	Linoleum ..	31·0	34·5	1·11	
	Ordinary cemented surface.	17·2	24·0	1·4	

The results obtained on the decontamination of the same surfaces and contaminated with p^{32} as above but treated with water and Teepol L solution are given in Table 4.

TABLE 4

Percentage of contamination removed

Contaminant	Surface	Water	Teepol L	Teepol L/ Water	Remarks
P^{32}	Pyrex beaker ..	77·7	87·7	1·12	
	Aluminium ..	31·0	40·3	1·3	
	Brass	0·5	5·0	10·0	A dry stain formed on the surface.
	Linoleum ..	29·0	29·0	1·0	
	Ordinary cemented surface.	1·0	8·0	8·0	

The different surfaces chosen for the experiments are some of the common ones which a worker comes across in his day-to-day work. The linoleum surfaces with which the radiation laboratories are floored can be easily decontaminated when soiled with I^{131} by Teepol L, provided the cleaning is carried within two hours after contamination as is evident from Table 2 (95 per cent. removed). But after twentyfour hours the same contamination is difficult to remove. Only 13·5 per cent. of the total contamination is removed by water or Nansa 100, with 1^{131} as the contaminant, while 37·5 per cent. and 29·0 per cent. of the contamination is removed by Nansa 2L and Teepol L respectively when p^{32} has been used as the contaminant. It appears necessary, therefore, that the linoleum surface should be cleaned quickly after it has been contaminated, otherwise if the contaminant remains in contact with the surface for a longer period, then decontamination would be possible only by removing the coating with a suitable solvent such as Xylene or trichloroethylene.

In the familiar surface of pyrex beaker it is found that the decontamination is fairly good when treated with any of the detergents (62·2 per cent. to 96·1 per cent). Glass surfaces appear to respond quite well to these detergents.

The results for the metal surfaces aluminium and brass, are varying. The brass surfaces contaminated with p^{32} had formed a stain and the removal of contamination by the detergents was negligible (0·0 per cent. to 5·0 per cent.). In the case of the aluminium surface soiled with 1^{131}, Nansa 100 removed the contamination to an extent of 95 per cent. whereas P^{32} contamination was removed to an extent of only 40·3 per cent. with Teepol L. It is felt that these surfaces should not be allowed to remain contaminated for a long period or dry before being decontaminated, otherwise special decontaminating agents such as c 10 per cent. nitric acid or dilute hydrochloric acid have to be employed.

No consistent results have been obtained with the cement surface, possibly because the different places chosen for the experiment seem to have absorbed the contamination to different extents because of a difference in the texture. However, it is clear from the results that these detergents are not effective in decontaminating the cement surface (maximum removed 24·0 per cent.).

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