DECONTAMINATION AND MODIFICATION OF LIQUID SCINTILLATORS

Sachan S.R. and Soman S.D.
Health Physics Division, Bhabha Atomic Research Centre,
Trombay, Bombay - 400 085, INDIA.

INTRODUCTION

Liquid scintillators (LS) are effectively employed for evaluation of soft beta (H-3, C-14, P-32, I-125) and alpha emitting nuclides. (1) The monitoring of environmental samples at the source of release of tritium (Atomic Power Reactors and nuclear installations) is done very frequently. This involves consumption of large amount of LS and hence generation of active waste. The disposal of liquid waste poses a problem. It would be doubly advantageous to decontaminate the used LS and recycle it.

This paper discusses the new techniques of decontaminating and recycling the used active LS. A modification of hydrophobic scintillator for use with aqueous samples is also described. Both aliphatic and aromatic LS are effectively decontaminated. 1, 4 Dioxane based LS is decontaminated by extraction with NaOH. Single extraction gives a decontamination factor (DF) of about 90% and thus 3-4 extractions decontaminate the LS to background level (2). Aromatic LS Tritol which is a cocktail of 1:2 Triton x-100 and toluene scintillator (3) has also been similarly decontaminated.

EXPERIMENTAL

Aromatic LS (Tritol)

It is spiked with tritiated water and counting efficiency is determined by liquid scintillation spectrometer (LSS 3255). The counted LS is transferred to separating funnel and shaken with solid NaOH for about 20-30 minutes and kept for settling for about two hours. The two phases separate out. The concentration of NaOH should be about 15% in the aqueous phase. The bottom aqueous layer contaminating tritium is collected. The top organic phase which is intact LS is transferred to vails. The orginal amount of distilled water is added (to maintain constant water activity. This process is repeated 3-4 times depending upon initial level of activity.

Hydrophobic LS

The modification of toluene scintillator which does not hold water is attempted for solubilizing aqueous samples. Toluene alcohol solution of varying concentrations from 75% to 30% are prepared prior to addition of Naphthalene 100 gm/1, PPO 7.0 gm/1 and POPOP 0.3 gm/1. The counting efficiency and water holding capacity (WHC-maximum percent of water added to LS without phase separation) are evaluated for each ratio of toluene alcohol using LSS 3255. The counted LS is transferred to separating funnel and water to LS ratio is increased to 1:2 by addition of water. The mixture is shaken vigorously and kept

over-night for settling. The bottom aqueous layer containing tritium is collected. The top organic layer is taken out and made up to orginal valume with ethyl alcohol as major portion of the alcohol goes along with water. The decontaminated LS is again examined for remaining activity after adding initial amount of water. The counting efficiencies and flourescence characteristics of recovered and fresh LS are compared.

RESULTS

Atomatic LS

It is observed that about 90% of the spiked activity is transferred with orginic phase after first extraction. Figure 1 shows the degree of decontamination of Tritol with number of extractions. Three to four such extractions make the LS compeltely decontaminated.

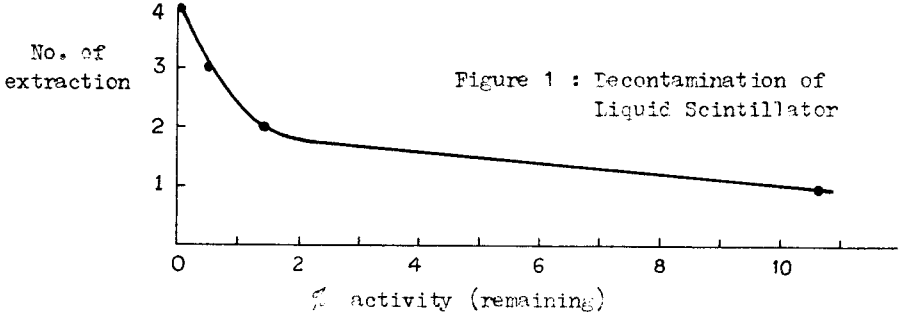


Figure 1 : Decontamination of Liquid Scintillator

The recovered LS is subjected to investigations for reuse. The counting efficiencies of fresh and recovered LS are compared by spiking these with equal amounts of tritiated water. Table 1 shows efficiencies of fresh and recovered LS.

TABLE I Comparison of Scintillators

Fresh Scintillator			Recovered Scintillator		
Bkg. cpm	Activity cpm	Efficiency percent	Bkg. cpm	Activity cpm	Efficiency percent
13.6	2811.0	25.2	21.0	2626.0	23.4
13.9	2847.0	25.5	20.3	2513.0	22.4
16.2	2623.0	23.5	22.2	2201.0	19.6

The wholesomeness of recovered LS and its suitability is examined by fluorescence characteristics also. It is observed that fluorescence characteristics of both fresh and recovered LS are identical except some loss of fluorescence yield in the case of recovered one. This explains the loss in counting efficiency.

Hydrophobic LS

The water holding capacity of modified toluene/alcohol LS decreases with increasing concentration of toluene in LS. Figure 2 shows linear relationship between water holding capacity and toluene concentration. WHC increases from 3% to 13% with decrease in toluene concentration from 75% to 30%.

Fig. 2 Water Holding Capacity

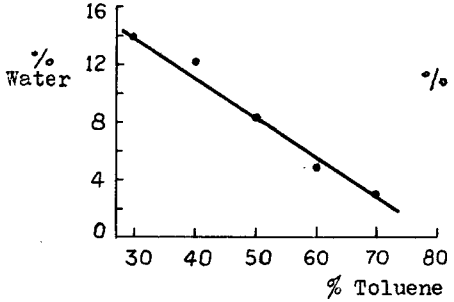
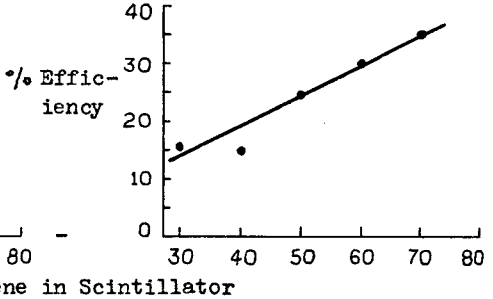


Fig. 3 Efficiency of Scintillator



% Toluene in Scintillator

The counting efficiencies for various toluene/alcohol ratios are determined and shown in figure 3. The efficiency increases with increasing concentration of toluene in scintillator at their maximum WHC. The efficiency increases from 16% to 35% with increase in toluene concentration from 30% to 75%.

The counting efficiency **increases with % toluene in LS while WHC decreases.**. The optimum working range is selected with highest figure of merit (4) which takes into account background, efficiency and volume of the sample. FM is found to be maximum around 50% toluene concentration.

The decontamination of used modified LS is acheived by single washing with excess amount of water. After proper dilution the background is checked prior to spiking. It is observed that the recovered LS has almost similar background as that of fresh one. Table II shows the relative counting efficiencies of 50% toluene/alcohol LS before and after decontamination. The counting efficiency of decontaminated LS is about 92% of the fresh LS. The quality of recovered modified LS is also compared on the basis of fluorescence characteristics. The spectral characteristics of both the LS are identical except slight loss in fluorescence yield in case of recovered one.

TABLE II Decontamination and Recycling

Fresh Scintillator			Recovered Scintillator		
Bkg. cpm	Activity cpm	Efficiency percent	Bkg. cpm	Activity cpm	Efficiency percent
51.6	1283.0	23.8	59.6	1191.0	21.9
54.7	1265.0	23.4	50.2	1191.0	21.8
50.8	1298.0	24.1	62.0	1209.0	22.2
56.0	1320.0	24.4	47.0	1242.0	23.1

DISCUSSION

It is, therefore, possible to recycle the same LS after decontamination. It will not only save expenditure on LS but solve the disposal problem also, as the activity is contained in aqueous phase with reduced volume. Gaylord (5) has suggested the disposal of used LS vials into sea after crushing them and filling LS in the varrels. This involves further expenditure on disposal besides loosing the liquid scintillation counting waste. Claycamp (6) et al have recently recommended the distillation of used LS to recover toluene for commercial use. They have shown that the energy input for distillation is much less than required to symthesise same amount of toluene from raw materials. However, this will involve the disposal of concentrate active waste and also impart some activity to the recovered toluene.

Our procedure on the other hand requires very little energy input to shake the mixture. The volume of active waste generated ranges from about 12% - 47% depending upon the initial level of activity present in LS. Thus all the three systems, aliphatic LS, Aromatic LS and Hydrophobic LS can be decontaminated effectively and used repeatedly.

REFERENCES

1. Mcklveen J.W. and T.R. Johnson (1975)
   Health Phys. 28 , 5
2. Sachan S.R. and Soman S.D. (1979)
   Health Phys. 36 , 67
3. Patterson M.S. and Green R.C. (1965)
   Analy. Chem. 37 , 854
4. Loevinger R. and Berman M. (1951)
   Nucleonics 9 , 26
5. Gaylord M.T. (1976)
   Health Phys. 30 , 499
6. Claycamp H.G., Cember H. and Prot E.A. (1978)
   Health Phys. 3 , 716