LIQUID SCINTILLATION COCKTAILS COMPARISON FOR TRITIUM CONTAMINATION MEASUREMENTS

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INTRODUCTION

Liquid scintillation counting is one of the most used techniques for the measurements of tritium contamination [1]. Until few years ago a problem related to this kind of measurement was the potential toxicity of the liquid cocktails used to produce the required scintillation. Some new products that guarantee an almost negligible impact on the environment and that are no longer toxic for the operators are now available.

Some of this new scintillation cocktail are suitable to be used for tritium measurement. Due to the great benefit from the health point of view of these new materials a test of their scintillation performance has been done at the ENEA centers to select the product having the best characteristics for tritium measurement.

THE COCKTAILS

Three new generation cocktails (biodegradable) were used in our test together with an old toxic (xylene based) scintillation liquid widely utilised in the past. Some characteristics of the examined cocktails are given in table 1, where the new products are indicated with the generic names SAFE 1, SAFE 2 and SAFE 3.

Table 1 - Cocktails characteristics

Cocktail	Applications	General composition	Flash point (°C)
SAFE 1 *low toxicity*	Low level counting, high sample acceptance	___	> 130
SAFE 2 *low toxicity*	High counting efficiency	Di-isopropyl-naphthalene (DIN)	148
SAFE 3 *low toxicity*	Low level counting	DIPN	150
OLD *toxic*	Large variety of application	Xylene	___

The four cocktails are appropriate for low level counting when large amount aqueous samples are needed.

INSTRUMENTS, METHODS AND SAMPLES

A Wallac 1220 Quantulus counter was used for all the measurements. The counter includes lead shielding, cooling system, liquid scintillation guard counter and pulse analyzer, to reduce the background level.

The Zinsser 900 vials (teflon coated) that were used for the counting process.

The preparation of the samples in the case of the cocktails SAFE 1, SAFE 3 and OLD was carried out adding 10 ml of scintillation liquid to 10 ml of tritiated or bidistillated water, for the SAFE 2 cocktail 9 ml of water and 11 ml of cocktail were used.

The percentage of the scintillation liquid used in the sample solutions was always that suggested by the cocktail manufacturer.

The counting time for all the measurements was 120 minutes. Two independent energy windows were fixed for each sample; the larger one (the same for all the cocktails) was choosen to contain all the tritium energy spectrum and the other was selected to maximize the figure of merit for the specifically used cocktail.

THE TEST PARAMETERS

The parameters considered to compare the cocktail performances were the efficiency and the Minimum Detectable Activity (MDA). The former was determined measuring a standard tritium source. The uncertainty on the efficiency determination can be calculated taking into account the following components. A first source of error is the uncentainty in the tritium quantity used in the sample. The tritium source used in our test is an organic substance soluble into water prepared by the Amersham International and distributed by Wallac. The uncertainty in the activity of this standard source is about 7.9 %. Other statistical errors have to be taken into account for the samples preparation depending on the specific cocktail and counter. In table 2 the total error (combined standard uncertainty) for each cocktail is reported [2].

Table 2 - Statistical error in efficiency evaluation

Cocktail	**Type B uncertainty (%)**	**Type A uncertainty (%)**	**Combined standard uncertainty (%)**
SAFE 1	7.9	5.9	9.8
SAFE 2	7.9	5.5	9.6
SAFE 3	7.9	5.7	9.7
OLD	7.9	7.6	10.9

The MDA has been evaluated with the following formula [2,3]:

$$MDA = \frac{4.66 \bullet Sb}{\varepsilon \bullet V \bullet 60} \quad [Bq/l]$$

where:
S_b is the estimation of the standard deviation (cpm)
ε is the efficiency
V is the volume of the sample (l)

Table 3 - Cocktail performances

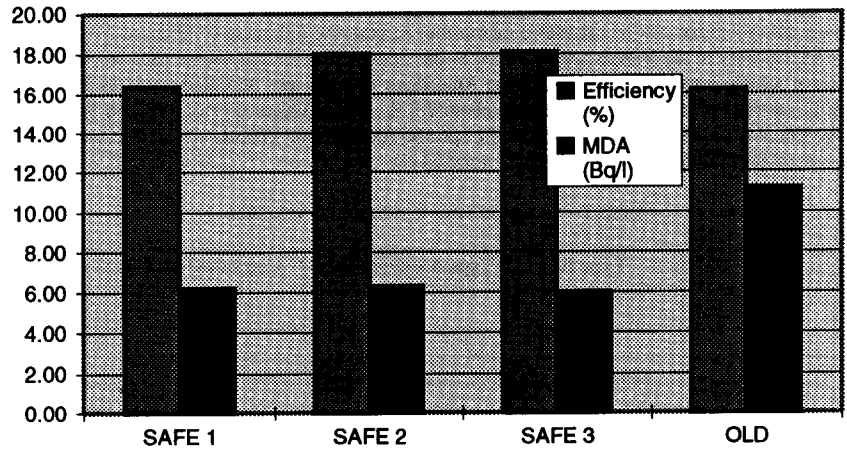
Cocktail	Window (channels)	Background ± σ (cpm)	MDA (Bq/l)	Efficiency (%)	FM	FMV^2
SAFE 1	20-270	2.23±0.13	6.2	16.4	120	12000
	20-120	0.63±0.08	4.5	12.8	255	25500
SAFE 2	20-270	2.48±0.13	6.3	18.0	130	10530
	20-130	0.70±0.08	4.4	15.1	325	26325
SAFE 3	20-270	2.51±0.14	6.0	18.1	130	13000
	20-130	0.76±0.10	4.9	15.1	296	29600
OLD	20-270	3.06±0.23	11.2	16.2	85	8500
	20-119	0.85±0.10	5.7	13.3	207	20700

RESULTS AND CONCLUSIONS

The results of the measurements were elaborated and the relevant parameters are presented in table 3.

Fig. 1 shows a graphic presentation of the efficiency and MDA for the various scintillation liquid tested. The conclusion that can be drawn from our results is that the three SAFE cocktails used show a similar behaviour and have better characteristics than the OLD cocktail

Figure 1 - Performance comparison



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