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STANDARDIZATION OF S-35 RADIOACTIVE SOLUTION IN LIQUID SCINTILLATION COUNTING SYSTEM BY MEANS OF THE CIEMAT /NIST METHOD COMPARED WITH 4πβ−γ TRACING METHOD

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ABSTRACT

In the present paper the methodology adopted by the Nuclear Metrology Laboratory (LMN) at IPEN to standardize a ^{35}S radioactive solution in the LSC system is presented. ^{35}S decays with a half-life of 87.44 days only by a low energy beta particle emission (end-point energy 167.50 keV). For LSC measurements the CIEMAT/NIST method was applied and compared to conventional 4πβ−γ Tracing Method. The results from the two methods are in good agreement within the experimental uncertainties, and demonstrate the feasibility of using the LSC system for ^{35}S standardization on a routine basis.

1. INTRODUCTION

For many years the Nuclear Metrology Laboratory (LMN) at IPEN, have used the efficiency tracing technique for standardizing pure beta emitters. This method consists of measuring a pure beta emitter mixed with a β−γ emitter, which provides the beta detection efficiency.

However, this method is laborious and time consuming. To improve and speed up beta emitter standardization, the LMN is carrying out measurements in a LSC (Liquid Scintillation Counting system), which yields a high detection efficiency and simplifies the measurement. In the present paper the methodology adopted by the LMN to standardize a ^{35}S radioactive solution in the LSC system is presented.

The ^{35}S is a beta pure emitter widely used in different applications such as nuclear medicine, agriculture and food research and in industry as tracer. It decays with a half-life of 87.44 days only by a low energy beta emission with end-point energy 167.50 keV.

For LSC measurements the CIEMAT/NIST method, a standard technique used in most metrology laboratories, was applied. This method uses a ^{3}H standardized solution as tracer due to its very low beta energy. The results were compared with the activity determined by means the efficiency tracing technique with the $4\pi\beta-\gamma$ coincidence system in order to validate the adopted procedure.

2. EXPERIMENTAL METHOD

2.1. Ciemat/Nist Method

One of the methods used for standardizing beta emitting radioactive solutions by means of a liquid scintillation system is called CIEMAT/NIST [1]. By this method, the curves: experimental efficiency versus the quenching parameter (extinction factor) and Factor of Merit (FM) versus calculated efficiency of ^{3}H solution standard, yield the universal curve Factor of Merit (FM) versus quenching parameter. From the universal curve and from the calculated efficiency versus Factor of Merit (FM) of the radionuclide under investigation, it is possible to obtain the efficiency related to the quenching parameter. To obtain these curves the CN2001 code [2] was used.

There are many interpretations for the Factor of Merit [3], in this paper it is defined as the amount of energy required to produce one photoelectron at the photocathode of the Photo Multiplier Tube (PMT).

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2.2. Liquid Scintillator Counting System

The liquid scintillation system used was a TRICARB Mod 2100, consisting of two photomultipliers operated in coincidence. An external source of ^{133}Ba placed near the measurement system is used for determining the quenching parameter, tSIE (transformed Spectral Index of External Standard) which is calculated from the Compton spectrum induced in the scintillation cocktail by the external source [4].

2.3. Source Preparation

The samples for liquid scintillation counting were prepared in glass vials with low potassium concentration. Known aliquots of Ultima Gold liquid scintillator and radioactive material were mixed and stirred to obtain a homogeneous solution. For the present measurements, seven samples of ^{3}H and ^{35}S were prepared with different amounts of CCl_4 solution used as carrier, in order to obtain different quenching factors and therefore different efficiencies.

The masses of radioactive material used for LSC system were accurately determined by the pycnometer technique in a Sartorius MC 21S balance.

3. RESULTS AND DISCUSSION

To determine the ^{35}S efficiency the code CN2001 was applied to experimental liquid scintillation cocktail conditions either for the standards ^{3}H and ^{35}S.

In Table 1, the results from measurements taken at two different dates (October 2010 and January 2011) are presented. The amount of carrier, the quenching parameter (tSIE) and the efficiencies obtained by the application of CIEMAT/NIST method are also shown.

Table 1. ^{35}S activity results. The uncertainties correspond to statistical uncertainties.

Vial Nº	Carrier CCl_4 (μL)	Measurements					
		October 2010			January 2011		
		Efficiency %	tSIE	Activity kBq g^{-1}	Efficiency %	tSIE	Activity kBq g^{-1}
01	0	91.23(91)	544	182.90(28)	91.24(91)	545	182.94(38)
02	10	87.98(88)	383	183.99(31)	87.93(88)	381	183.90(43)
03	20	84.25(84)	278	185.45(30)	84.30(84)	279	185.32(42)
04	30	79.56(80)	206	187.66(30)	79.48(80)	205	187.55(43)
05	40	75.45(76)	163	186.06(29)	75.78(76)	166	186.57(39)
06	50	74.67(75)	156	187.78(30)	74.90(75)	158	189.52(41)
07	150	74.55(75)	155	185.74(31)	75.23(75)	161	189.10(46)
Average				185.6(6)			186.4(11)

The results from the two batches are in agreement with each other. These measurements were made within a time interval of 5 months showing that the cocktail have maintained its characteristics. Table 2 show the comparison between the activities obtained with the CIEMAT/NIST method and the $4\pi\beta-\gamma$ tracing technique showing good agreement between these two techniques.

Table 2. Comparison between experimental values of the activity obtained with the two methods. The uncertainties correspond to one standard deviation (u=1).

Method	*Activity* (kBq g^{-1})	Ratio
CIEMAT/NIST	(186.03±0.53) *	1.001
$4\pi\beta-\gamma$ TRACING TECHNIQUE	(186.20±1.06)	1
**Statistical uncertainty*		

4. CONCLUSION

The results from the two methods are in good agreement within the experimental uncertainties, demonstrating the feasibility of using the LSC system for ^{35}S standardization on a routine basis.

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