APPLICABILITY STUDY OF PLASTIC SCINTILLATION DETECTORS FOR BETA RADIATION MEASUREMENTS

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ABSTRACT

This work consists of performance evaluation of the plastic scintillation detectors similar to NE 102, produced at IPEN, in order to obtain the experimental conditions for using in nuclear structure studies. To make it possible, a set of radioactive sources (^{60}Co, ^{72}Ga, $^{90}Sr + ^{90}Y$, ^{109}Cd, ^{137}Cs, ^{139}Ba and ^{207}Bi) were prepared by evaporation and electrodeposition. The energy dependence of scintillation detector response and its limit sensibility for beta radiation were investigated.

I. INTRODUCTION

Nuclear physics experimental studies which enable the nuclear parameters determination from beta decay are essential to the knowledge of the radioactive nucleous. To obtain the experimental parameters from beta spectroscopy, beta-gamma coincidence and beta-gamma angular correlation, a beta spectrometer was developed and assembled in the Nuclear Structure Laboratory at IPEN. It was described in details in reference [1].

The plastic scintillation detectors, produced at IPEN, are fabricated by the polymerizatoin of styrene with organic flours. They were used in present measurement. Its choice was based on its sensibility to the beta radiation and the conversion electrons [2].

II. METHODS AND RESULTS

Basically, to obtain the beta spectrum measurement it is necessary to define the scintillation dimensions (diameter and thickness), detection geometry, source preparation method and a computational program to the continuum spectrum interpretation.

In order to determine the plastic scintillation dimensions as well as the detection geometry, a systematic study in energy resolution terms was carried out in different measurements conditions. Studies [3] using these kind of detectors to beta radiation detection, in the 150 keV to 3.0 MeV energy range, pointed to 50 to 60 mm diameter and 3 to 6 mm thickness for the source-to-detector distance less than 5cm. Based in these data the geometry optimization was made using four scintillators (specified in table I) and ^{137}Cs and ^{207}Bi electrodeposited radioactive sources.

The geometry conditions were analysed as a function of the energy resolution from conversion electron spectrum with the 482 keV, 554 keV, 624 keV and 976 keV lines. The data were obtained in 30 minutes acquisition time to each of the selected condition measurement from Table 1, with a conventional electronic associated, as shown in figure 1.

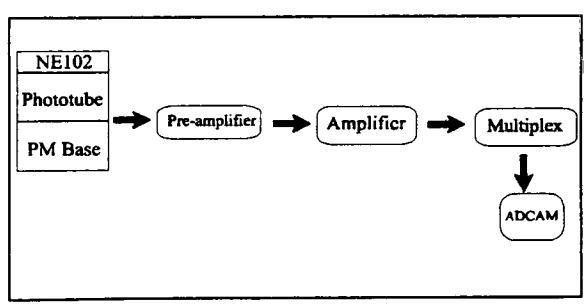

Figure 1. Associated Electronics

The IDF program [4] was used to calculate the conversion electrons areas. The energy resolution data (FWHM), presented in Table 1, indicate that the plastic scintillation detector produced at IPEN is comparable with the NE-102A commercially fabricated (13 % to 17%)[5].

The beta and conversion electrons spectrum obtained from ^{137}Cs and ^{207}Bi sources in the B1 geometry are shown in figure 2.

TABLE 1. Results of Systematic Study

geometry condition	source-to-detector distance mm	plastic scintillation detector		FWHM % energy from conversion electrons			
		diameter mm	thickness mm	482 keV	554 keV	624 keV	976 keV
A1	2	50	3	14.0	14.0	14.5	14.8
A2	5	50	3	14.0	14.5	13.5	13.5
B1	2	50	5	13.0	13.0	14.5	14.3
B2	5	50	5	14.0	13.8	15.0	14.0
C1	2	60	3	14.0	15.0	15.0	15.5
C2	5	60	3	15.0	15.6	15.8	15.0
D1	2	60	5	14.5	14.5	15.0	14.5
D2	5	60	5	15.0	15.6	15.6	15.6

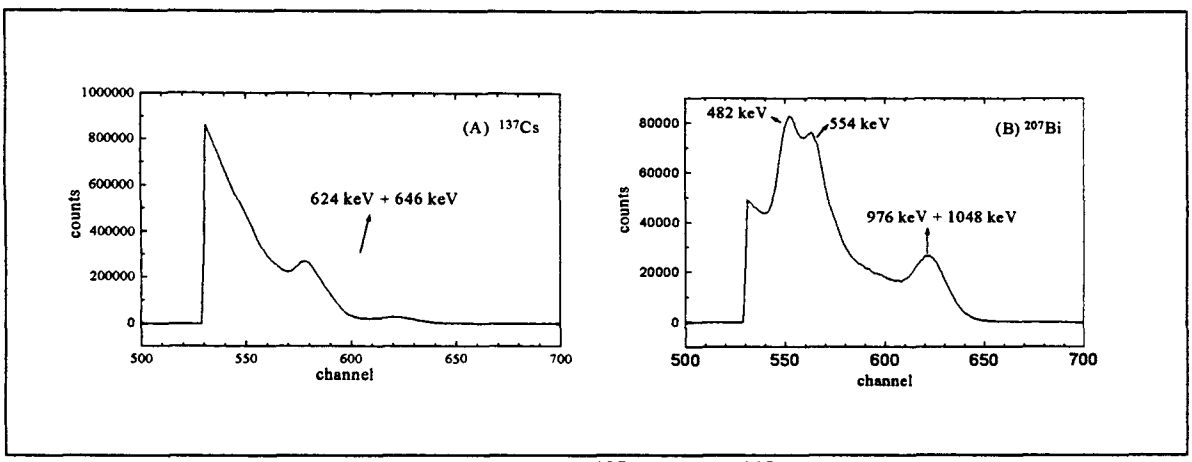

Figure 2. Spectrum of ^{137}Cs (A) and ^{207}Bi (B).

Samples of beta emitting isotopes has to be prepared as a thin layer (< 1μg/cm^2) on a backing material which must also be thin (< 1mg/cm^2) in order to diminish the influence of absorption of the beta radiation in the sample and the influence of backscattering. Because of absorption the energy of the particle is decreased and because of backscattering the low energy β - components is increased, thus producing a distortion in the experimental spectrum.

Backing have to be made from material with low atomic number like Zn or Al, but organic compounds are therefore commonly used. The source preparation must be reproducible, has a high efficiency and low cost. Based on these requirements the evaporation of droplets and electrodeposition techniques were employed.

The principal requirement for the preparation of the sources by evaporation of the droplets is that the material must be soluble in water, or very slightly acidified water. In this method the radioactive solution is dropped onto the required backing and dried in a vacuum diseccator. This technique was used to the source preparation of ^{60}Co, ^{90}Sr + ^{90}Y, ^{109}Cd , ^{133}Ba and ^{137}Cs [6] for spectrometer calibration and for β-γ angular correlation of ^{60}Co [7]. All the active solutions were obtained by (n.γ) reaction, in the IEA - R1 reactor at IPEN, and dropped onto makrofol (backing) of known thickness (~ 250 μg/cm^2) suported by aluminium ring.

In the electrodeposition method is necessary to know the physiochemical parameters associated to the radioactive

material. This is carried out by potentiostatic and galvanostatic studies. The apparatus developed for the preparation of sample have been reported in details in reference [8]. This technique was used to source preparation of ^{72}Ga. ^{109}Cd. and ^{139}Ba [8, 9, 10] for spectroscopy and β-γ coincidence measurements [7].

Using the plastic scintillation detector, precise measurement have been performed of the end point energy of the beta ray spectrum from ^{60}Co. The radioactive source was prepared by evaporation on to backing of 200 $\mu g/cm^2$ makrofol foil [6]. The spectrum obtained in 2 hours acquisition time, in the B1 geometry condition, is shown in Figure 3. The fit was carried out with the BGAUSS program using eleven lorentzian lines and the result (~320keV with na uncertainty about 14%, associated to calibration lines) is compatible to na end-point energy of the ^{60}Co spectrum from [11] (~318keV).

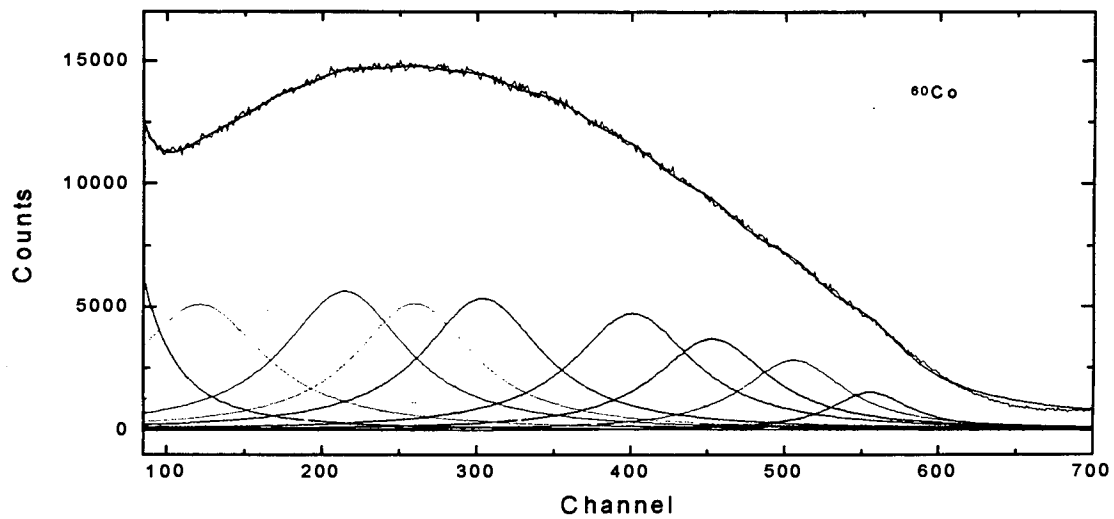

Figure 3. The beta - ray end - point energy of the ^{60}Co spectrum.

III. DISCUSSION

Plastic scintillation detectors does not present good energy resolution to electrons but it could be used since this property is not relevant like in beta-gamma coincidence and angular correlation studies where the measurements are carried out in the energy range above 100 keV.

IV. REFERENCES

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