Radioactivity of Vectran (1/16") Rope and Nylon Balls by Direct γ-ray Counting

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Introduction

Samples of the production run of light Vectran rope for the SNO acrylic vessel attachments and of 3 cm diameter nylon balls have been counted in the ULBT germanium spectrometer located in the SNO research station on the 4600 ft level of the Inco Creighton Mine.

Experiment Details

A 10,000 ft spool of 1/16" diameter Vectran rope, received from Yale Cordage, was opened in the SNO laboratory ramp clean room. Handled only with latex gloves, a 1000 ft sample was wound on to an acrylic spool 18.4 cm in diameter and 2.9 cm thick. This sample was double bagged, weighed, and transferred to the SNO research station for counting.

The package of nylon balls was opened in the SNO research station on a clean table covered with plastic wrap. Groups of 8-10 balls were plastic-wrapped in long cylinders, and arranged around the cylindrical detector, to form a 1 ball thick blanket on the top and sides of the detector.

MnO standards were prepared to determine the detector efficiency for γ-rays in the U and Th decay chain as well as for potassium. A large (2.0 L) Marinelli geometry MnO standard was used for the nylon balls (approximately similar to the sample geometry), while a smaller standard disc (15 cm diameter by 3 cm thick) of volume 550 cm^3 was prepared and used for the rope disc sample.

The detector background with no sample in the chamber was also measured. All measurements were performed with the standard 5 cm copper inner shield and 25 cm lead outer shield in place around the detector.

Flushing of the sample chamber with "boil-off" nitrogen gas from a liquid nitrogen storage cylinder, was carried out at a rate of at least 10 L (gas) per minute, to eliminate airborne radon from the γ-ray spectra.

For the Vectran rope counting, gross counts over the full energy range 40 keV to 3.0 MeV averaged 0.031 cps (summing the 3 ULBT crystals which are each analyzed separately). Counting periods with gross counts more than 10% larger than this average were discarded,

since radon or microphonic noise contributions could be present. A total of 35 useable files (at 43,200 seconds each) were obtained over the 25 day count period (May 22 - June 15).

For the nylon ball sample, gross counts averaging 0.032 cps were observed, with count data more than 10% larger than this being discarded. 41 useable files (0.5 days each) were analyzed over a total count period of 25 days (April 1996).

Background spectra were recorded for a 12 day period in June. Gross counts averaging 0.021 cps were observed for 22 files of 0.5 day duration. The results are satisfactorily similar to previous background results for this detector obtained over the past two years.

Results are summarized in Tables 1 & 2 below.

Discussion

From Tables 1 & 2 it can be seen that the efficiency of the detector (in cps/g) is about 16 % higher for the 2L standard compared to the 0.5 L disc standard. Thus, variations of the samples from the geometry of the standard are unlikely to lead to efficiency variations greater than about 10-20%. The density difference between the two samples (specific gravity about 1.1) and the standard (specific gravity about 2.9) will lead to absorption differences at lower energies, and thus to an underestimate of the efficiency of low energy counting for the samples. This would tend to lower the concentration results for low energy peaks, and make the data more consistent.

For the Vectran sample, the counting results are consistent with the following concentrations:

U	< 2.5 ng/g (ppb)
Th	< 1.4 ng/g
K	$0.0131\ \% \pm 0.0009\ \%$

For the nylon balls, the counting results are consistent with the following concentrations:

U	3.9 ng/g $\pm$ 1.0 ng/g (1σ)
Th	2.4 ng/g $\pm$ 1.1 ng/g (1σ)
K	$0.00041\ \% \pm 0.00009\ \%$

If lower limits are required, larger samples would have to be counted. It would be possible to quadruple the size and mass of the Vectran rope sample (to 2 L including a ring down the side of the detectors), with rather similar detection efficiency. This could push sensitivity into the 0.7 ng/g region. However, nearly half the production rope would be needed, and this might not leave enough untouched rope for the AV uses required.

Table 1: Vectran Rope (1/16") Direct Counting Results

Elem	E_γ (keV)	Vectran (600 g) 1.450 Ms	Background 1.450 Ms	MnO Standard. (cps/g)	Concentrat (ng/g)	Uncertainty Limit (1σ) (ng/g)
U	186	ND	36.6	7.65		
	609	108	165	43.4		
	1001	ND	19.8	0.724		
	1764	58	39.7	8.60	2.45	2.6
Th	583	84	27.5	8.62	7.53	8.4
	911	45	21.3	6.06	4.49	7.7
	2614	31	25.9	4.26	< 1.38	2.9
K	1461	1639	93.1	0.0157	0.0131%	0.0009%

Table 2: Nylon Balls Direct Counting Results

Elem	E_γ (keV)	Nylon ball (1700 g) 1.600 Ms	Background 1.600 Ms	MnO Standard. (cps/g)	Concentrat (ng/g)	Uncertainty Limit (1σ) (ng/g)
U	186	177	40	8.89	5.66	8.2
	609	646	182	45.03	3.79	0.7
	1001	28	22	0.762	2.93	15
	1764	148	44	9.82	3.89	1.0
Th	583	87	30	5.27	3.97	4.0
	911	76	24	6.38	3.04	1.9
	2614	62	29	5.12	2.40	1.1
K	1461	286	104	0.0164	0.00041%	0.00009%