Gamma ray emission probabilities in ^{153}Sm

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Introduction

Radiopharmaceutical ^{153}Sm has been used for many years in the form of an injectable solution for pain relief, in the treatment of disseminated skeletal metastases and in inflammatory joint disease therapy. Organic compounds of ^{153}Sm are used in nuclear medicine for tumor therapy and bone pain palliation because of their high local beta dose per disintegration, the relatively short half life and their selective metabolism in bones. Recently, consideration has also been given to the possibility of labeling monoclonal antibodies with ^{153}Sm. ^{153}Sm disintegrates by 16 beta transitions to the excited states (~82%) and directly to the ground state of ^{153}Eu . A resulting 103.2 keV gamma ray emission is convenient for scintigraphic imaging of its resulting biological distribution and for subsequent calculation of in vivo absorbed dose.

The use of ^{153}Sm as a therapeutic product requires precise activity standardization and good knowledge of atomic and nuclear decay data in order to calculate as accurately as possible, the internal dose delivered to the patient. In view of this need, several determinations of the absolute gamma ray emission probabilities were reported [1-4]. Although there is a good agreement in their reported half lives, there is a difference of more than 4% in the gamma ray emission probabilities per disintegration. In the present work, gamma ray emission probabilities per disintegration of the main line and several other gamma lines were determined using the precisely measured relative gamma intensities.

Experiment

The radioactive source of ^{153}Sm (half life = 46.50 h) produced by thermal neutron irradiation of ^{152}Sm at the CIRUS reactor of Bhabha Atomic Research Centre, Trombay, Mumbai was procured from BRIT as samarium chloride in HCl solution. For the intensity measurements in the low energy region, thin and uncovered sources were prepared by drying the source solution on a thin mylar foil. The count rates of the sources were kept less than 500 counts/sec. Measurements were performed using a large volume 60 cc HPGe detector optimized for the weak gamma rays and coupled to a PC based 8K MCA for the gamma spectra. The source to detector distance was 25 cm. A number of spectra were acquired for prolonged periods with sources of varied intensities. Typical counting periods were about 5 x 10^5 seconds. The spectra were normalized with respect to the intense 103.2 keV transition taken as I_γ = 29.25 from Helmer [5]. As this 103.2 keV transition in ^{153}Sm decay is very intense, the high energy (>400 keV) portion of the gamma ray spectrum was obtained separately with a stronger source and a 7.2 mm Pb absorber to attenuate this gamma, while having a negligible effect on the weaker, high energy gamma rays.. Spectral analysis was carried out with specialized software GammaVision and FIT.

Results and Discussion

The resulting photon emission intensities per 100 disintegrations are presented with their associated uncertainties in the Table I. The combined errors in these preliminary results include the uncertainty in counting statistics (0.1–5%), detector efficiencies (0.4 – 0.8%), source activity (0.2%) and other corrections such as half-life, source position, etc. The data obtained in this study are compared with most recent works and also with recommended values from an evaluation included in the evaluated database. The emission probabilities per 100

decays are compared to the measurement of Schotzig et al [3] and Helmer [5] within the experimental errors. Thus accurate intensities could be derived for these gammas with a lower uncertainty than previously evaluated. The new set of data will permit an update to the decay data and provide more accurate information for medical applications.

Table 1

E_γ keV	Emission probabilities per 100 decays		
	Schotzig et al [3]	NDS 2006 Helmer[5]	Present Work
68.3	-	0.0013 4	0.0014 3
69.7	4.65 5	4.73 3	4.89 4
75.4	0.233 19	0.193 26	0.238 24
83.4	0.211 11	0.192 7	0.200 1
89.5	0156 7	0.158 15	0.193 18
96.9	-	0.0073	0.0074 7
97.4	0755 7	0.772 18	0.749 5
103.2	29.23 18	29.26 32	29.25 17
118.1	-	0.00018 3	0.00033 5
124.9	-	-	0.00011 1
125.6	-	-	0.0021 2
137.5	-	-	0.000035 6
151.6	0.0115 6	0.0106 4	0.0100 1
166.5	-	0.00061 6	0.00080 7
172.3	-	0.00041	0.00042 6
172.8	0.0716 7	0.0741	0.0764 8
412.0	0.00189 13	0.00192 5	0.000192 4
424.3	0.00182 12	0.00189 5	0.00193 4
436.9	0.00167 9	0.0017 2	0.0020 1
443.2	-	0.00009 2	0.00008 1
462.0	-	0.0016 3	0.0014 2
463.6	0.01268 18	0.0136 6	0.0138 4
472.0	-	-	0.000025 2
485.0	-	-	0.00034 3
487.8	-	-	0.00047 3
509.2	0.00183 19	0.0020 2	0.00206 23
521.3	0.00676 11	0.0069 3	0.0066 3
530.0	0.0537 6	0.0547 9	0.0685 9
533.2	0.02930 27	0.0299 6	0.0336 6
539.1	0.02058 25	0.0211 6	0.0259 3
542.7	0.00218 17	0.0032 9	0.0022 6

E_γ keV	Emission probabilities per 100 decays		
	Schotzig et al [3]	NDS 2006 Helmer[5]	Present Work
554.9	0.00473 10	0.00474 9	0.00439 11
578.8	0.00341 10	0.00328 9	0.00340 10
584.6	0.00103 8	0.00106 3	0.00123 6
587.6	0.00047 8	0.00050 5	0.00052 4
591.0	0.00123 8	0.00118 5	0.00148 7
596.7	0.0104 3	0.0109 3	0.0107 2
598.3	0.00206 10	0.0018 3	0.00165 21
603.6	0.00436 9	0.0045 1	0.00408 11
609.5	0.0118 4	0.0128 7	0.0134 6
615.8	0.00068 7	0.0056 15	0.00074 14
617.9	0.00089 7	0.0007 2	0.00068 14
630.5	-	0.00010 2	0.00012 2
634.8	0.00045 10	0.00052 6	0.00067 5
636.5	0.00174 8	0.0019 1	0.00157 7
657.6	0.00041 7	0.00040 2	0.00072 5
662.4	-	0.00002 1	0.00002 1
677.0	-	0..00004 1	0.00004 1
682.0	-	0.0002 1	0.00021 7
686.0	0.00021 6	0.00023 2	0.00022 3
694.1	-	0.00002 1	0.000039 6
701.8	-	0.00003 1	0.000035 6
706.8	-	0.00002 1	0.000015 3
713.9	0.00027 11	0.00022 2	0.00027 3
719.0	-	0.00003 1	0.000022 4
760.5	-	0.00003 1	0.000031 5

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