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A NEW DETERMINATION OF THE HALF-LIFE OF $^{165}_{66}Dy$

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RESUMEN

Algunas inconsistencias en las mediciones de contenidos de disprosio en rocas por análisis instrumental de activación con neutrones (AIAN) nos motivaron a determinar la constante de decaimiento (λ) de ^{165}Dy. Nuestras mediciones dan una vida-media de 152 ± 4 min. para este radioisótopo, en vez de valores del orden de 139 minutos reportados por otros autores.

ABSTRACT

Inconsistencies in the measurements of dysprosium contents of rocks by instrumental neutron activation analysis (INAA) motivated us to determine the decay constant (λ) for ^{165}Dy. Our measurements give a half-life of 152 ± 4 min. for this radioisotope, as compared to 139 min. from earlier determinations.

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INTRODUCTION

Dysprosium is one of the 14 naturally occurring rare earth elements (REE) or lanthanides (La-Lu). In most rocks these elements are present at trace levels (~μg/g); they form an important group of elements in the study of many geological processes (e. g., Haskin *et al.*, 1966; Hermann, 1970; Condie, 1976a, b).

Instrumental neutron activation analysis (INAA) has been successfully used for determining REE concentrations in geological materials (Brunfelt and Steinnes, 1966, 1969, Gordon *et al.*, 1968; Pal, 1972; Jerome *et al.*, 1972). In this method, Dy content is estimated from the radioisotope ^{165}Dy, a product of neutron-activation of the stable isotope ^{164}Dy (28.18% natural isotopic abundance) by (η,γ) reaction. ^{165}Dy emits a number of γ-rays of different energies. Among them, 94.5 kev γ-ray is generally used for the quantitative determination of dysprosium. Rather poor reproducibility of the measurements of Dy contents led us to investigate possible cause(s) of the discrepancies in the determination of the dysprosium abundances. We first looked for some interfering γ-rays of energies close to 94.5 kev, produced from some other elements which could cause discrepancies in Dy determinations. This was regarded as improbable because of the very high resolution detector (ORTEC model 8013-10250 low energy photon Ge detector) employed in the experiments. Further the activities of monitor solutions of dysprosium (routinely employed with INAA) did not seem to obey the 139 min. half-life decay of dysprosium. So the half-life assigned to ^{165}Dy was suspected. A redetermination of this parameter is reported in this work.

EARLIER DETERMINATIONS

Several earlier workers have measured the half-life of dysprosium-165. Sher *et al.* (1952) used an end-window geiger counter to measure β-activity of irradiated Dy_2O_3 on lucite foils. They obtained a value of

139.17 ± 0.14 min. for the half-life of ^{165}Dy. Mangal and Gill (1962) using and end-window β-counter obtained 144 min. as the half-life of ^{165}Dy. Persson *et al.* (1963) used a 1 3/4" dia. x 2" NaI (Tl) scintillation detector connected with a 100-channel pulse height analyzer to measure the intensity of 94.7 kev gamma-rays and obtained 139.0 ± 0.5 min. for the half-life of ^{165}Dy. It should be mentioned that the counting systems employed in these experiments are low resolution systems, not capable of distinguishing β or γ-rays of similar characteristics.

PRESENT EXPERIMENT

Experimental details of our method (INAA) have been given elsewhere (Terrell and Pal, 1977). The principal difference in the present experiment as compared to earlier attempts for measuring the half-life of dysprosium, lies in the high resolution detector employed in this study. A brief description of experimental conditions is given below.

About 1 ml of a solution containing an adequate amount of dysprosium (about 250 μg/ml so as to give good counting statistics with errors less than 1% for short countings) was sealed in a polythene vial and irradiated in a thermal column of Triga Marck III nuclear reactor at Salazar, Mexico (I.N.E.N.) at a neutron flux of about 10^{12} n cm^{-2} sec.$^{-1}$. The 94.5 kev γ-ray activity was measured with a ~0.4 cm^3 low energy photon Ge detector (ORTEC model 8013-10250) having a resolution of better than 575 ev FWHM (Full width half-maximum) at 122 kev γ-ray energy. This value of resolution was quoted by ORTEC. Subsequent measurements of resolution at 122 kev with ^{57}Co source in our laboratory have given still smaller FWHM values. Obviously the FWHM for 94.5 kev γ-rays should be smaller than or at least similar to the value given for 122 kev γ rays. Signals from this detector were fed through an ORTEC 117-8 preamplifier, an ORTEC 452 spectroscopy amplifier and an ORTEC 444 gated-biased amplifier, to a 1024-channel HEWLETT-PACKARD 5401B pulse-height analyzer. Data from the analyzer memory were read out by a modified ASR-33 teletype. The γ-ray spectra were recorded at successive intervals of 5 min. for more than 2 hours and at greater intervals (30 min. or more) for later period of 6 hours. Sufficient time (more than 3 hrs.) was allowed to elapse before beginning the counting so that shortlived activities could decay out. The stability and reproducibility of counting equipment were tested by counting longlived γ -sources. The peak position was stable to within less than 0.5 kev and the results of activity (peak areas) were reproducible within the statistical errors of counting.

RESULTS

A plot of the natural logarithm of the activity against time is shown in Fig. 1. The standard deviation of each measurement is represented by the size of the circles (errors $< 0.7\%$) unless a specific error-bar (errors $\sim 1\%$) is given. The slope of best fit was determined by the method of least squares using a computer program. A value of 152 ± 4 min. was obtained for the half-life of ^{165}Dy. The inclusion of 10 more measurements (not shown in the figure) having more than 1% error does not appreciably alter the result. The error in half-life ($\pm$ 4 min.) is only approximate and has been estimated from the graph following Persson *et al.* (1963). It is however difficult to explain the difference in the half-life of ^{165}Dy between this measurement and the earlier determinations. Errors due to background correction of finiteness of counting times would not seem to account for this difference. Measurements of the half-life of ^{165}Dy utilizing other γ -rays emitted by this radioisotope should be undertaken. Repeated measurements using different counting systems and more active ^{165}Dy so as to follow the counting for still longer periods (with acceptable statistical errors) should prove useful in explaining this discrepancy.

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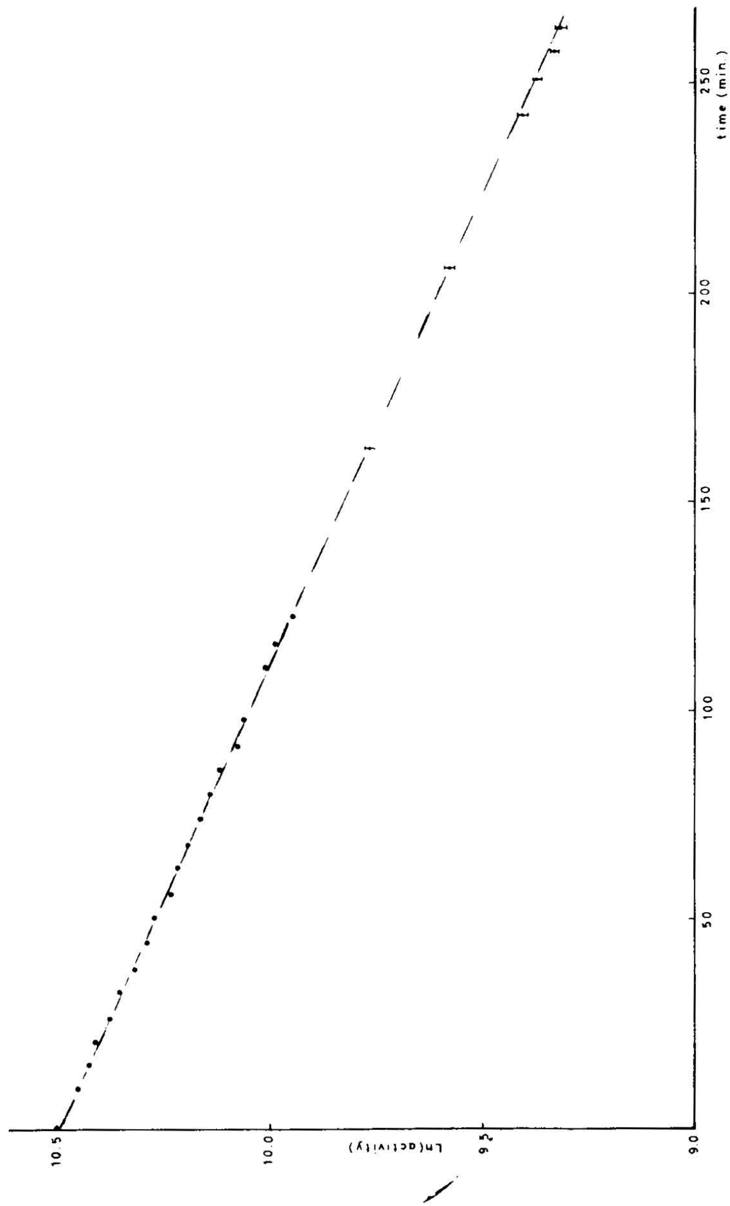

FIG. 1 Decay-curve for ^{165}Dy.

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