Alpha Activity of Natural Neodymium

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The alpha activity of natural neodymium and enriched Nd^{144} and Nd^{145} was studied with gridded ionization chambers. The alpha energy of Nd^{144} was found to be (1.83 ± 0.02) MeV and its half-life $(2.1 \pm 0.4) \cdot 10^{15}$ years. The alpha half-life of Nd^{145} was found to be longer than $6 \cdot 10^{16}$ years.

The natural alpha activity of neodymium was discovered independently by Waldron, Schultz and Kohman [1] and Porschen and Riezler [2]. The results obtained in these and subsequent studies are given in Table 1.

Investigator	Source material	E_α (MeV)	$T_{1/2}$ (y)
Waldron et al. [1]	Natural Nd	1.90 ± 0.1	$1.5 \cdot 10^{15}$
Porschen, Riezler [2]	Natural Nd	1.8 ± 0.1	$5 \cdot 10^{15}$
Porschen, Riezler [3]	Enriched Nd^{144}	1.8 ± 0.1	$2.2 \cdot 10^{15}$
Macfarlane, Kohman [4]	Enriched Nd^{144}	1.83 ± 0.03	$(2.4 \pm 0.3) \cdot 10^{15}$

Table 1. Results on natural alpha activity of neodymium.

The above results would indicate that the alpha activity of Nd^{144} is well established. However, Bradley, Bowman and Kurbatov [5] recently saw no alpha activity below a half-life of $1.8 \cdot 10^{16}$ y in the alpha energy range of 1.2 to 2.6 MeV in a sample of isotopically enriched Nd^{144}. We wish to report an investigation where both natural neodymium and enriched neodymium isotopes were studied.

The alpha spectroscopy was done with the parallel-plate gridded ionization chambers and photographic pulse recording systems described by Karras [6] and Nurmia [7]. Samples of enriched Nd^{144} oxide (93.7% Nd^{144}) and Nd^{145} oxide (70.46% Nd^{145}) both obtained from Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA, and natural neodymium (purity 99.9%), obtained from the Lindsay Chemical Division, American Potash and Chemical Corp., West Chicago, Ill., USA, were used as source materials. The natural Nd was purified by ion exchange to remove alpha active impurities, mainly from the natural thorium series.

The enriched neodymium oxide was converted into nitrate, dissolved in ethyl alcohol, and "painted" on the source plates, and the natural Nd oxide was vacuum evaporated onto source plates. The area of the sources was 28 or 177 cm² and their thickness 30 to 70 $\mu g/cm^2$. The alpha energy scale was calibrated with Sm^{147} (2.23 MeV [8]), Th^{232} (3.99 MeV), U^{238} (4.195 MeV) and U^{234} (4.770 MeV). In the half-life measurements the Nd was dissolved from the source plates and determined gravimetrically. The results are given in Table 2.

Source material	Amount (mg Nd_2O_3)	Length of run (h)	E_α (MeV)	$T_{1/2}$ (y)
Enriched Nd^{144}		170	1.82	
Natural Nd		137	1.83	
Enriched Nd^{144}	9.9	384.1		$2.1 \cdot 10^{15}$
Natural Nd	9.2	423.9		$1.9 \cdot 10^{15}$
Enriched Nd^{145}	10.0	288	—	$>6 \cdot 10^{16}$
Adopted values for Nd^{144}:			1.83 ± 0.02	$(2.1 \pm 0.4) \cdot 10^{15}$

Table 2. Results of the present investigation.

The spectrum obtained for the determination of the alpha energy of natural neodymium is shown in Fig. 1.

The close agreement of our values for natural and enriched Nd confirms the assignment of the natural activity to Nd^{144}.

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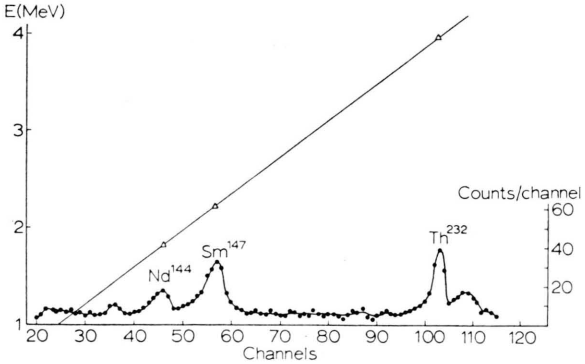

Fig. 1. Alpha spectrum of a natural neodymium source.

It has been noted previously that the alpha half-life of Nd^{144} seems to be shorter than expected from the theory [8]. The suggestion has been made [9] that the true alpha energy of Nd^{144} is somewhat larger than the experimental values. However, our results verify both the half-life and decay energy obtained earlier. The nomograph of NURMIA [10] predicts an alpha half-life of 10^{16} y for an alpha emitter with $Z=60$ and $E=1.83$ MeV. This is five times longer than the experimental values, so that the puzzle remains unsolved.

The mass tables of MATTAUCH, THIELE and WAPSTRA [11] give a Q-value of 1.598 MeV for alpha emission from Nd^{145}. This corresponds to an alpha energy of 1.55 MeV; in Fig. 1 there is a peak at this energy. However, the half-life of a neodymium isotope against emission of 1.55 MeV alpha particles would be about 10^{22} years [12], so that this phenomenon, as indeed the emission of 1.55 MeV alpha particles from any rare earth element, must be undetectable by the present means.

A measurement on enriched Nd^{145} failed to show any activity beyond that due to its Nd^{144} impurity (see Table 2). No 1.5 MeV activity was detectable in any other measurement except that shown in Fig. 1. Its origin thus remains unexplained and shows that caution must be exercised in drawing conclusions from measurements on very weak activities.

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