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Letter

A New Heavy Neutron-rich Isotope ^{238}Th*

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Abstract A new nuclide ^{238}Th has been produced via multinucleon transfer reaction induced by 60MeV/u ^{18}O ion irradiation of natural uranium. The thorium was radiochemically separated from the mixture of uranium and its reaction products. The activity of thorium was measured by using a HPGe detector and a planar HPGe detector. The ^{238}Th has been identified for the first time by measuring the growth and decay of the γ-rays from its daughter ^{238}Pa. The half-life of ^{238}Th was determined to be (9.4 ± 2.0) min. In addition, a new (89.0 ± 0.3) keV γ-ray with $T_{1/2} = (8.9 \pm 1.5)$ min was observed and assigned to ^{238}Th decay based on the measurement of transition energy and half life.

Key words multinucleon transfer reaction, chemical separation, new nuclide synthesis and identification

So far, the reported heaviest isotope of thorium is ^{237}Th produced through ^{238}U(n, 2p)^{237}Th reaction[1,2] using the 14MeV neutrons in 1993. This reaction mechanism mentioned above is not able to synthesize heavier isotopes of thorium. While the intermediate energy heavy ion induced multinucleon transfer reaction was proved to be one of the most effective ways for producing new neutron-rich isotopes as heavy as possible by the synthesis and identification of new heavy neutron-rich isotope ^{208}Hg, ^{239}Pa and ^{186}Hf[3—8] in our institute. In the present experiment, a new nuclide ^{238}Th was produced by 60MeV/u ^{18}O bombardment of uranium through the reaction(^{238}U − 2p + 2n).

The experiments were carried out at Heavy-Ion Research Facility, Lanzhou

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(HIRFL) in Institute of Modern Physics (IMP). The 60MeV / u ^{18}O beam with a current intensity of 30—60enA was used to irradiate the natural uranium ($1.5g/cm^2$). After irradiation of 25 minutes, each target was rapidly transferred to the chemical laboratory 30 meters far away by a pneumatic transport system. Thorium was radiochemically separated from the mixture of uranium and reaction products, and was then made a solid γ(X) counting source.

Following the chemical separation, the measurements started about 10 minutes after the end of irradiation by using two HPGe detectors. The first HPGe detector has efficiency 30% with energy resolution of 2.0keV(FWHM) for the 1.33MeV line of ^{60}Co. The other one was a planar HPGe detector with energy resolution about 580eV for the 122keV line of ^{57}Co. Each source was measured for 25 minutes. A total number of 67 such cycles were performed.

The measured γ spectra show that the chemical separation was successful. The 635.0keV and 1060.5keV γ-ray of ^{238}Pa were clearly observed. The growth and decay of these two γ-ray means that the activity of ^{238}Pa came from its parent nuclide ^{238}Th β^- decay. Because of the lower background and smaller amount of γ-rays of impurity in the relevant high energy region, the 1060.5keV γ-ray could be followed. A computer code for analyzing the decay of a radioactive series was used and the half-life of ^{238}Th and ^{238}Pa were extracted to be (9.4 ± 2.0) min and (2.1 ± 0.4) min, respectively (Fig. 1). The former is well consistent with the theoretical prediction given by A. Staudt et al[9], and the latter is in good agreement with the previous result[10]. Furthermore, an unknown γ-ray with energy of (89.0 ± 0.3)keV was found in the spectra gated with X-ray of Pa. Its half-life was determined to be (8.9 ± 0.3)min. The observed 89.0 keV γ-ray was tentatively assigned to follow ^{238}Th β^- decay based on the measurement of the transition energy and half-life. All the evidences mentioned above proved that the new neutron-rich isotope ^{238}Th was synthesized and identified in

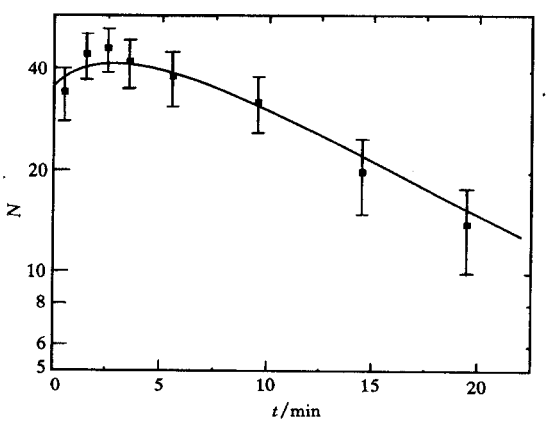

Fig.1 The growth and decay curve for the 1060.5keV γ-ray from ^{238}Pa

present experiment, and its half-life was measured to be (9.4 ± 2.0)min.

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新重丰中子同位素^{238}Th *

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摘要　利用兰州重离子加速器(HIRFL)所提供的60MeV/u的^{18}O离子束照射天然铀靶，通过多核子转移反应生成^{238}Th. 由快速放射化学分离技术从铀及其反应产物的混合物中分离出钍. 使用2台高纯锗(HPGe)探测器对样品的γ(X)活性进行测量，观测到了^{238}Th的β^-衰变子体^{238}Pa的635.0keV和1060.5keV 2条γ射线峰的增长、衰变行为. 利用分析递次衰变的计算机程序对其后一条进行了拟合，得到母、子体半衰期分别为(9.4 ± 2.0)min和(2.1 ± 0.4)min，二者分别与预言值和文献值相符. 另外，在由^{238}Pa的X射线开门的γ谱中，发现一条能量为89.0keV的新γ射线，经计算，其半衰期为(8.9 ± 1.5)min，由跃迁能量和半衰期的关系认定该射线来源于^{238}Th的β^-衰变. 从而证明本实验合成和鉴别了重丰中子新核素^{238}Th，并测定它的半衰期为(9.4 ± 2.0)min.

关键词　新核素　　多核子转移反应　　化学分离　　合成与鉴别

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