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A New Heavy Neutron-Rich Isotope ^{239}Pa

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A new heavy neutron-rich isotope ^{239}Pa has been produced in the interaction of 50-MeV/u ^{18}O ions with ^{nat}U targets. Protactinium products were separated radiochemically from the complex mixture of the reaction products. The results observed from the decay of ^{239}Pa and its daughter, ^{239}U, show that the new heavy-rich isotope ^{239}Pa was synthesized and identified for the first time. The half-life of the ^{239}Pa was determined to be 106 $\pm$ 30 min.

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

Several nucleon exchanges between the target nuclides and the projectiles can result in the formation of new heavy neutron-rich isotopes in the interaction of heavy ions with heavy element targets. The reactions of several proton stripping and one neutron capture were used at GSI, Berkeley, and other sites [1,2] in the identification and study of several new neutron-rich isotopes. We used the multinucleon transfer reactions between the medium-energy neutron-rich projectiles (^{18}O) and heavy element targets to produce targetlike neutron-rich new isotopes by the exotic reaction channels of one-proton stripping and two-neutron capture.

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The experiments were performed at HIRFL, Lanzhou, China. Powder in the amount of 1.32 g/cm^2 from natural uranium targets $UO_2(NO_3)_2 \cdot 6H_2O$ was irradiated for 4 hrs with 50-MeV/u ^{18}O ions. The beam intensity, on average, was 30 enA. After the irradiation, the target samples were dissolved in 15 mL of 4 mol HCl solution. Protactinium products were separated radiochemically from the reaction products. Finally, Pa counting sources were prepared by precipitation with ferric hydroxide.

A planar HPGe detector, a 25% GMX HPGe detector, and a 30% HPGe detector were used for measuring the time sequence spectra of the low-energy γ-rays, γ(X) singles spectra, and γ(X)-γ coincidence events of the sources. The measurements lasted 4 hrs for every sample. The time sequence spectra or event spectra were recorded on magnetic disks with the PC-CAMAC Multiparameter Data Acquisition System. The obtained γ spectra were analyzed by the Leone program using the VAX-8350 computer.

^{239}Pa decays to known ^{239}U by β emission. In the low-energy γ-ray spectra, two stronger γ-rays of 74.66 keV and 43.53 keV, which can be assigned to the β decay of ^{239}U, were observed. The strongest, a 74.66-keV γ-ray, was carefully traced. The growth and decay behavior of the 74.66-keV γ-ray revealed the presence of ^{239}Pa. A radioactive series decay analyzing program was applied, resulting in the half-lives of 22 $\pm$ 5 min and 106 $\pm$ 30 min for ^{239}U and ^{239}Pa, respectively. The former is in agreement with the previous result [3]. In the γ singles spectra and γ-γ coincidence spectra, four γ-rays that can be attributed to the ^{239}Pa decay were observed. Their energies are 522.0 $\pm$ 0.5 keV, 562.0 $\pm$ 0.5 keV, 638.5 $\pm$ 0.5 keV, and 681.5 $\pm$ 0.5 keV, respectively. Their half-lives are in agreement with the measurement of 106 min. The transition energies are also consistent with the values reported by Schmorak *et al.* [4] in the ^{238}U(n,γ) ^{239}U reaction using an in-beam study.

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