# Extraction of multi-nucleon transfer reaction products in $^{136}$Xe and $^{198}$Pt systems

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We have developed the KEK Isotope Separation System (KISS) to study the $\beta$-decay properties of the neutron-rich isotopes with neutron numbers around $N = 126$ for astrophysics research[1–3]. In the KISS, a gas cell filled with argon gas at a pressure of 50 kPa, in which nuclei produced by multi-nucleon transfer reactions are to be stopped and collected, is essential equipment for selectively extracting the isotope of interest by using a resonant ionization technique. Using the elastic events of $^{198}$Pt in the $^{136}$Xe beam and $^{198}$Pt target system, we evaluated the absolute extraction efficiency and beam purity of the KISS gas cell system. We successfully measured the lifetime of the unstable nucleus of $^{199}$Pt extracted from the KISS.

We performed on-line tests using the $^{136}$Xe beam with an energy of 10.75 MeV/nucleon and a maximum intensity of 20 pnA. The $^{136}$Xe beam was directed onto the $^{198}$Pt target placed in the gas cell, and was stopped at a tungsten beam dumper after passing through the gas cell. The thermalized and neutralized $^{198,199}$Pt atoms of the reaction products were re-ionized in the gas cell, and the ions were extracted and detected after mass separation by using a Channeltron detector for ion counting. The lifetime of $^{199}$Pt was measured by using $\beta$-ray telescopes newly installed at the E3 experimental hall[4].

We successfully extracted laser-ionized $^{198}$Pt atoms emitted from the target by elastic scattering. However, the $^{198}$Pt ions formed molecular ions such as $^{198}$PtH$_2$, $^{198}$PtH$_2$O, and $^{198}$PtAr$_2$ with the intensity ratio of 1, 1, and 6, respectively, relative to the intensity of $^{198}$Pt ions. Figure 1 shows the measured extraction efficiency of the $^{198}$PtAr$_2$ molecular ions ($A = 278$) as a function of the primary beam intensity. The extraction efficiency was defined as a ratio of the number of $^{198}$PtAr$_2$ ions detected to the number of $^{198}$Pt atoms emitted from the target by elastic scattering (17 barn). The measured efficiency of about 0.20% was observed to be independent of the primary beam intensity, as shown in Fig. 1, owing to the bend structure of the gas cell. The obtained beam purity was $> 99.7\%$ at the maximum primary beam intensity of 20 pnA.

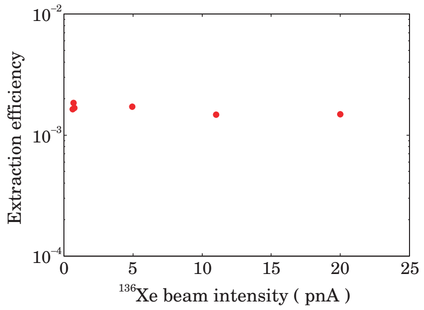


Fig. 1. Extraction efficiency of $^{198}$PtAr$_2$ molecular ions measured as a function of the $^{136}$Xe beam intensity.

After the extraction of $^{198}$Pt, we extracted laser-ionized $^{199}$Pt ($t_{1/2} = 30.8(2)$ min) atoms that mainly formed $^{199}$PtAr$_2$ molecular ions like $^{198}$Pt did. Figure 2 shows the measured lifetime when $^{199}$PtAr$_2$ molecular ions are used. The measured lifetime $t_{1/2} = 33(4)$ min was in good agreement with the reported value. Thus, the molecular formation does not affect the lifetime measurement of unstable nuclei.

Considering the production rates of nuclei around $N = 126$ calculated by the GRAZING code[1], we can measure 12 new lifetimes with an efficiency of 0.1%, beam purity of $> 99.7\%$, and a primary beam intensity of 20 pnA. To extend this study to more neutron-rich nuclei, we have been developing a new sextupole ion guide with a large angular acceptance for increasing the extraction efficiency.

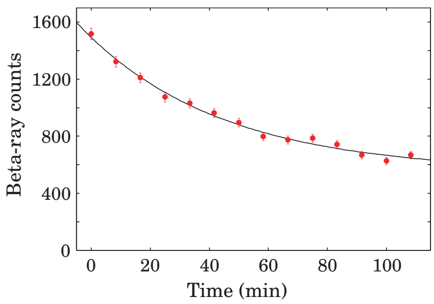


Fig. 2. Lifetime measurement of $^{199}$Pt.

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