Yield measurements for ^{86}Kr + ^{198}Pt at KISS

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We have been developing the KEK Isotope Separation System (KISS) for spectroscopic studies of neutron-rich nuclei around $N = 126$. These neutron-rich nuclei are considered to be efficiently produced by multinucleon transfer reactions with the target nucleus ^{198}Pt. We have successfully extracted and performed nuclear spectroscopy for neutron-rich nuclei, such as $^{199–201}$Pt, $^{196–200}$Ir, and $^{193–198}$Os using the ^{136}Xe beam.[1] The yield development is essential for KISS to expand the research region toward $N = 126$. We attempted to use the ^{238}U beam, with which the GRAZING calculations[2] predict more production yields. However, we observed that the growth of the extraction yields slows down at an intensity of approximately 30 particle nA in contrast to 50 particle nA for the ^{136}Xe beam. Furthermore, the yields for various extracted isotopes were approximately ten times smaller than those with the ^{136}Xe beam.[3]

The reaction products are first thermalized and neutralized in the argon gas filled in a gas cell at KISS. They are transported via a laminar gas flow and are irradiated using lasers to be element-selectively ionized using the laser resonance ionization technique immediately before they exit the gas-cell orifice. These ions are transported by several RF ion guides and are accelerated with a high voltage of 20 kV to be transmitted to measurement areas. The reduction of the extraction yields for the ^{238}U beam may be attributed to the reneutralization of the laser-ionized isotopes by free electrons generated via radiation from more dense plasma in the gas induced by the elastic scattering of heavier beams. We have performed yield measurements using the ^{86}Kr beam to study the systematics of the extraction yields among different types of beams for the origin of the yield reduction with the ^{238}U beam.

The ^{86}Kr beam with an energy of 10.75 MeV/nucleon from the RRC was decelerated using three 5-μm titanium foils and impinged on a ^{198}Pt target with a thickness of 12.5 mg/cm^2 at an energy of 8.8 MeV/nucleon. Radioactive nuclei ^{199,200,202}Pt, $^{196–198}$Ir, and ^{195,196}Os were extracted. They were identified by measuring their lifetimes at the β-decay station or their masses using the MRTOF-MS. The top panel of Fig. 1 shows the beam intensity dependence of the extraction rates of ^{199}Pt for the ^{86}Kr, ^{136}Xe, and ^{238}U beams. The energies of the ^{136}Xe and ^{238}U beams are 9.4 and 8.9 MeV/nucleon, respectively. The rates for the ^{136}Xe beam are scaled by 0.3. The growth of the rates for the ^{86}Kr beam slows down at an intensity of approximately 80 particle nA, which is 30 particle nA larger than that of the ^{136}Xe beam. However, the extraction rates for the ^{86}Kr beam are smaller than those for the ^{136}Xe beam. The bottom panel shows a comparison of extraction rates for various radioactive isotopes for the ^{86}Kr (80 particle nA), ^{136}Xe (50 particle nA), and ^{238}U (26 and 36 particle nA) beams. The extraction yields of ^{196,197}Ir and ^{195,196}Os are comparable for the ^{86}Kr and ^{136}Xe beams. The extraction yields of ^{199,200}Pt and ^{198}Ir for the ^{86}Kr beam are smaller than those for the ^{136}Xe beam; however, the reduction is smaller than that for the ^{238}U beam for ^{199}Pt. The comparison of the extraction rates for various isotopes does not indicate any significant increase in the extraction efficiency using the lighter beam than ^{136}Xe. Further investigation including the gas-cell design, in-gas-jet ionization, and helium gas cell will be conducted to increase the extraction yields at KISS.

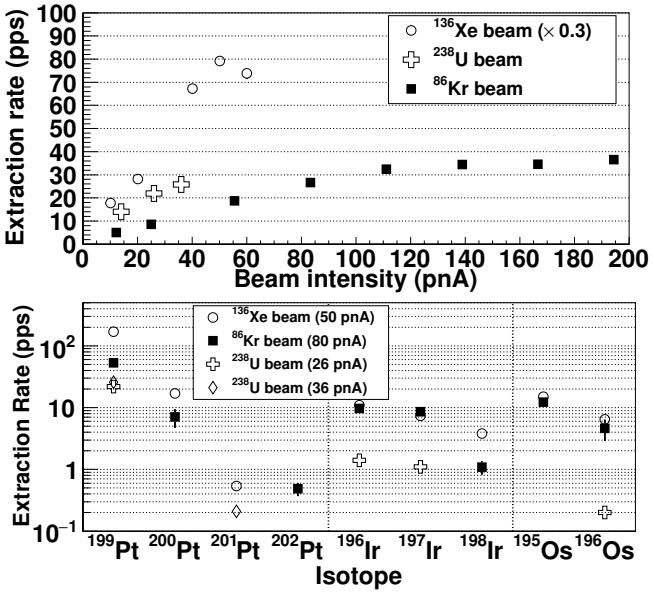

Fig. 1. (Top) Beam intensity dependence of the extraction rates of ^{199}Pt for the ^{86}Kr (squares), ^{136}Xe (circles), and ^{238}U (crosses) beams. The rates for ^{136}Xe (circles) are scaled by 0.3. (Bottom) Extraction rates of various isotopes for the ^{86}Kr (squares), ^{136}Xe (circles), and ^{238}U (crosses and diamonds) beams.

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