Fifth report on offline tests for RF carpet transportation in RF ion guide gas cell at the SLOWRI facility

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We are developing an RF ion guide gas cell at the SLOWRI facility. The present gas cell has a gutter structure[1)] where the ions travel over a long distance on the 2nd RFC after they are first collected to the 1st RFC, travel over a short distance on the 1st RFC, and are pulled to the 2nd RFC (see Fig. 1 in Ref. 2)). We adopted the "ion surfing" method on the 2nd RFC by superimposing weak audio-frequency (AF) signals to form an ion traveling potential wave.[3)] We have so far reported offline tests with ions from surface-ionization ion sources in an "ion current" mode where the electrodes of the RF carpets and an ion beam guide were used as a Faraday cup.[1,2,4,5)] However the performance could be different from an online experiment because 1) ion currents contain many molecules and 2) ion currents of more than an order of pA could cause a space charge or a charging-up effects.

We conducted offline tests for $^{36}Ar^+$ and $^{86}Kr^+$ ions produced in the helium gas cell. We cannot evaluate the absolute transport efficiency in these measurements because the Ar and Kr contaminant rates in a helium gas are unknown. However, we can solely measure the count rates of $^{36}Ar^+$ or $^{86}Kr^+$ with the elimination of isobar impurities owing to the high resolving power of the MRTOF-MS, and we can investigate the transport performance in a similar condition as an online experiment.

We placed an ^{241}Am α-source behind the 6-μm-thick Mylar gas cell window at the downstream side. The emitted alpha particles enter the gas cell through the window and lose their energies in the helium gas to ionize the Ar and Kr atoms that are contained. Figure 1 shows the 2nd RFC AF voltage dependence of the transport performance in 200 mbar, in a room-temperature equivalent value, of 70 K helium gas. The RF voltage applied to the 2nd RFC was 103 Vpp at 11.8 MHz, and the push DC field onto the 2nd RFCs was 18 V/cm.

The present results for $^{36}Ar^+$ and $^{86}Kr^+$ clearly show different AF voltage dependence. This investigation has been coducted in clear conditions for the first time, *i.e.*, only focused on a separated mass instead of an ion current of mixed molecules as shown in the previous report.[2)] Contrary to the case when using a Cs ion source, a clearly different trend for light masses and heavier masses is now visible, showing a limited region of effective AF amplitudes for light masses of $A \approx 40$. For the $A \approx 80$ region, a stable transport is achieved for all tested amplitudes above 3 V. In both cases, the choice of the AF frequency seems to play a minor role for the transport efficiency, but has an impact on the transport time,[3)] which becomes important for short-lived isotopes. We plan to measure the transport time systematically in the gas cell for different AF conditions, producing a pulsed ion by placing a mechanical shutter in front of the α-source. We also plan to modify the 1st RFC configuration to achieve a faster ion collection. The transport time measurement results will be compared.

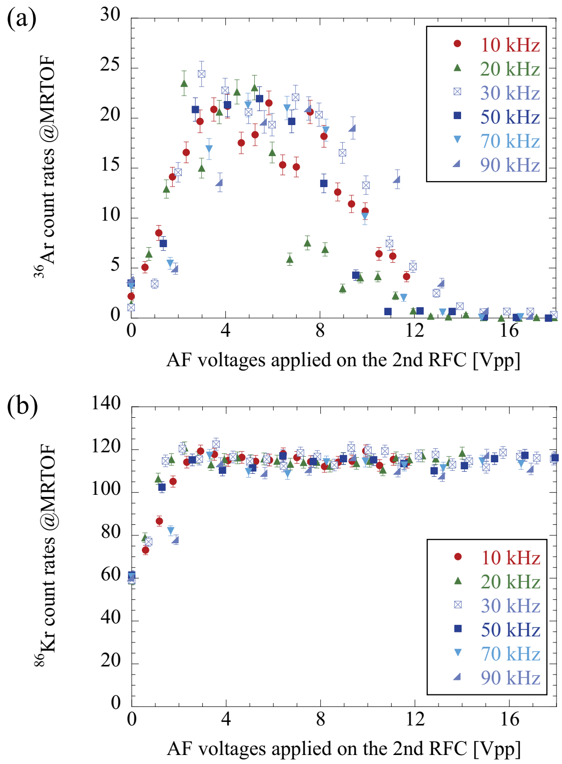

Fig. 1. Ion transportation count rates as a function of AF voltages at different AF frequencies for (a) $^{36}Ar^+$ and (b) $^{86}Kr^+$ in offline tests.

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