Production of ^{179m}W in the form of a carbonyl complex

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We are developing a CO gas-jet technique and plan to apply it to the separation of neutron-rich isotopes of Sg produced in the transfer reaction ^{248}Cm + ^{48}Ca. In this preliminary investigation, we successfully separated ^{179m}W, the lighter homologue element of Sg, from other heavy ions (^{89m}Zr, ^{28}Al et al.) in the form of a volatile carbonyl complex.

A 24-MeV d beam was extracted from the AVF cyclotron of the RIKEN RI Beam Factory. Five ^{nat}Ta targets were stacked with one ^{nat}Nb target in the sequence Ta/Nb/Ta/Ta/Ta/Ta. All targets were fixed in an Al holder with 5-mm distance between each other. The thicknesses of ^{nat}Ta and ^{nat}Nb target were 7.62 and 0.917 mg/cm^2, respectively. Reaction products emitted from the targets were thermalized and stopped in the He/CO mixed gas. Elements that could form volatile complexes with the CO reagent, e.g. $W(CO)_6$, were flushed out from the target chamber and extracted along capillaries of inner diameter (i.d.) 1.59 or 2.0 mm. After the volatiles were passed through a PTFE filter (SMC SFB 300-02) mounted at the outlet of the target chamber and a 2.1-m quartz column (2.0-mm i.d.) immersed in a chiller, they were collected using a charcoal filter (ADVANTEC CP20) and subjected to γ-ray spectrometry with a Ge detector. Because of the beam irradiation, CO molecules would be decomposed into carbon and oxygen. Most products adhered to the carbon particles and were removed by the PTFE filter. The length from the PTFE filter to the collection site was about 17 m. Flow rates of He and CO were controlled independently to adjust their concentrations in the target chamber. The lowest flow rate controlled by the mass-flow meter was 0.2 L/min.

As explained above, reaction products could be transported out in the form of volatile molecules or by using aerosols. First, to check all the products, a high-intensity beam with 2.9 particle μA (pμA) as well as 1.2(He)+0.2(CO) L/min mixed gas was used to generate many carbon aerosols. All nuclear products were efficiently carried to the charcoal filter by carbon particles without selectivity when the PTFE filter was removed. The 6.4-min ^{179m}W and 4.16-min ^{89m}Zr were identified by their γ-energies and decay curves. The production yields after 1-min collection were deduced to be 9.86±0.84 and 0.40±0.04 kBq/pμA for ^{179m}W and ^{89m}Zr, respectively. By changing the i.d. of the capillary and increasing the He/CO flow rate, the yield could not be improved further.

After the PTFE filter was installed, the 221.5-keV γ-line of ^{179m}W was observed subsequent to 7-min beam irradiation under 0.03 pμA (See Fig.1). Other nuclides, which could not form volatiles in a CO atmosphere, were removed, such as ^{89m}Zr. The transport efficiency for ^{179m}W in the carbonyl form was decreased with the beam intensity and CO flow rate, but it could be improved by increasing the He gas flow rate. By changing the i.d. of capillary from 1.59 to 2.0 mm, the maximum flow rate of He gas was increased from 1.2 to 4.0 L/min, corresponding to about 1 atm in the target chamber. Under 4.0 L/min He flow rate, the count of 221.5-keV γ-line was improved by a factor of 4 (see Fig. 1). The optimal relative transport efficiency for ^{179m}W was 13.1±2.2%, which was obtained by normalizing to the production yield of using carbon aerosols as the transmission medium under 2.9-pμA beam intensity. The yield of ^{179m}W that passed through an isothermal column at different temperatures was measured, and the results are displayed in Fig. 2. By fitting the breakthrough curve with a Monte-Carlo simulation[1], the adsorption enthalpy of the carbonyl complex was determined to be -47±1 kJ/mol, which agrees well with the 46.5±2.5 kJ/mol reported for $W(CO)_6$ in Reference[2].

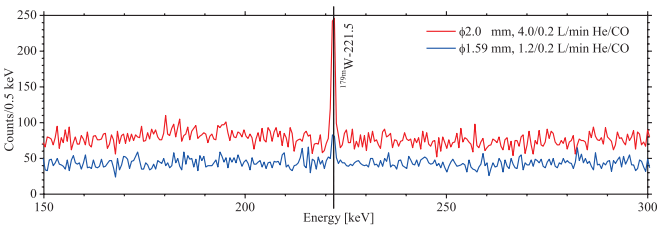

Fig. 1. γ-ray spectra obtained for ^{179}W in the form of a volatile carbonyl complex.

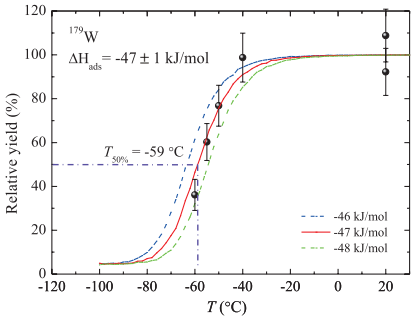

Fig. 2. Yields of ^{179m}W passing through the quartz column.

References

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2) J. Even et al.: Inorg. Chem. **51**, 6431-5433 (2012).

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