Measurement of half-lives of $^{181, 182a, 182b, 183, 184m}$Re and ^{187}W

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Chemical characterization of superheavy elements is one of the most important and challenging subjects in nuclear chemistry. We plan to conduct model experiments for the chemical studies of element 107, Bh, using radiotracers of its homologs, Tc and Re. Long-lived ^{95m}Tc ($T_{1/2} = 61$ d), ^{183}Re ($T_{1/2} = 70$ d), and $^{184m, g}$Re (m: $T_{1/2} = 169$ d; g: $T_{1/2} = 35.4$ d) are useful for the model experiments. These isotopes are producible in the deuteron-induced reactions on ^{nat}Mo and ^{nat}W (nat: natural isotopic abundance) using the RIKEN AVF cyclotron. Previously, we measured the production cross-sections of the Re isotopes in the ^{nat}W(d, x) reactions for the quantitative production of $^{183, 184m, g}$Re.[1] In the course of measurements, we noticed that the half-lives of some Re isotopes such as $^{181, 183}$Re was slightly shorter than those adopted in literatures. Furthermore, recently, the half-life of ^{182a}Re has been revised from 12.7 ± 0.2 h[2] to 14.14 ± 0.45 h[3] because Bonardi et al. and Manenti et al. suggested that the half-life of ^{182a}Re is 13.74 ± 0.48 h[4] and 14.50 ± 0.45 h,[5] respectively. Therefore, it is worth reinvestigating the half-lives of these Re isotopes. In this work, we measured the half-lives of $^{181, 182a, 182b, 183, 184m}$Re and ^{187}W and compared them with the half-life values adopted in the Nudat 2.7 database.[6]

We determined the half-lives of $^{181, 182a, 182b}$Re and ^{187}W using a reference source method. Four ^{nat}W foils with a thickness of 20 μm were irradiated for 5 min with 24 MeV deuteron beam supplied from the RIKEN AVF cyclotron. The average beam current evaluated with the Faraday cup was 425 nA. After the irradiation, three of the ^{nat}W foils were repetitively measured with three Ge detectors every 4 h or 6 h with ^{88}Y ($T_{1/2} = 106.626 \pm 0.021$ d[7]). ^{88}Y was used as the reference source to correct the dead time during the radioactivity measurement.[8] The cooling time and dead time were ≥ 1.6 h after the end of bombardment (EOB) and $\leq 12.8\%$. The internal clock time of the computer for data acquisition was synchronized with the Internet time server in RIKEN every 1 h.

As for the long-lived isotopes, $^{183, 184m}$Re, we determined their half-lives by following their interference-free γ lines under low dead time condition of $\leq 3.0\%$. A ^{nat}W foil with a thickness of 100 μm irradiated with the 24 MeV deuteron beam for 125 min with a beam current of 5 pμA, was repetitively measured every 12 h with the Ge detector at the cooling time of 474 d after the EOB.

The half-lives of $^{181, 182a, 182b, 183, 184m}$Re and ^{187}W determined in this work are listed in Table 1 along with those adopted in the Nudat 2.7 database.[6] We found

Table 1. Half-lives adopted in Nudat 2.7[6] for $^{181, 182a, 182b, 183, 184m}$Re and ^{187}W and those determined in this work. Gamma energy (E_γ) used for analysis in this work is also listed.

Nuclide	Half-life (Nudat 2.7[6])	E_γ [keV]	Half-life (this work)
^{181}Re	19.9 ± 0.7 h[9]	953.6	18.94 ± 0.05 h
^{182a}Re	14.14 ± 0.45 h[3]	470.26	14.33 ± 0.03 h
^{182b}Re	64.2 ± 0.5 h[3]	1427.3	62.6 ± 0.5 h
^{187}W	24.000 ± 0.004 h[10]	685.81	23.92 ± 0.04 h
^{183}Re	70.0 ± 1.4 d[11]	291.723	66.5 ± 0.1 d
^{184m}Re	169 ± 8 d[12]	318.008	178.7 ± 0.4 d
		920.933	178.5 ± 0.4 d

that the half-life of ^{181}Re is 18.94 ± 0.05 h, which is 0.96-h shorter than the literature data of 19.9 ± 0.7 h.[9] The half-life of ^{182a}Re is 14.33 ± 0.03 h, which is consistent with the value of 14.50 ± 0.45 h reported by Manenti et al.[5] and the recently revised value of 14.14 ± 0.45 h by Singh.[3] The half-life of ^{182b}Re is 62.6 ± 0.5 h, which is 1.6-h shorter than the literature value of 64.2 ± 0.5 h.[3] The half-life of ^{187}W is 23.92 ± 0.04 h, which is slightly shorter than the literature value of 24.000 ± 0.004 h.[10] The half-life of ^{183}Re is 66.5 ± 0.1 d, which is 3.5-d shorter than the literature data of 70.0 ± 1.4 d.[11] The half-lives of ^{184m}Re determined by the decays of 318-keV and 921-keV γ lines are 178.5 ± 0.4 and 178.7 ± 0.4 d, respectively. The average half-life of ^{184m}Re is 178.6 ± 0.3 d, which is 9.6-d longer than the literature data of 169 ± 8 d.[12] For further discussion, we will compare our newly determined half-lives of these isotopes with the previously reported values.

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