

Half-life of the ground state of Mn-52

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The ground state of ^{52}Mn ($^{52\text{g}}\text{Mn}$) is useful as a radioactive tracer in the field of biological science [1]. Manganese-52g is a β^+ decay nuclide with a total positron intensity of 29.4% [2]. This nuclide is expected to be applied to positron emission tomography (PET) imaging because of its low β^+ energy (Mean beta+ energy: 242 keV) and moderate half-life (5.6 d). We are planning to perform excitation function measurements on $^{52\text{g}}\text{Mn}$, to develop no-carrier added chemical separation methods for a $^{52\text{g}}\text{Mn}$ tracer, and imaging test using $^{52\text{g}}\text{Mn}$ complexes. In these, an accurate half-life is necessary for excitation function measurement. In this study, we report on the accurate measurement of the half-life of $^{52\text{g}}\text{Mn}$.

Manganese-52g was produced in the $^{51}\text{V}(\alpha,3n)$ reaction. The vanadium target was a 300 μm thick metal plate purchased from The Nilaco Corporation and cut into 5 mm squares. Irradiation with an alpha beam of 50 MeV was carried out using the AVF Cyclotron at Tohoku University. The beam current was approximately 1.5 particle μA . The target was irradiated for 1 h. After one week of the irradiation, the V target was dissolved in 13.5 M (mol/dm^3) HNO_3 , and $^{52\text{g}}\text{Mn}$ was purified from the solution by cation- and anion- exchange resin column methods. A 30 μL solution containing about 1.5% of the radioactivity of the purified sample was dried on a 15 mm square glass plate to prepare a counting source.

Half-life of $^{52\text{g}}\text{Mn}$ was determined by γ -spectrometry with a high-purity Ge (HP-Ge) detector. The counting source was placed at 110 mm from the HP-Ge detector. A ^{137}Cs source was positioned close to the counting source as a reference source to correct for influential factors for determination of the half-life such as pile-up effects. The accumulation of an γ -spectrum for 3600 s was successively repeated 310 times, which is longer than 2.3 times of half-life of $^{52\text{g}}\text{Mn}$. The internal clock time of the computer for data acquisition was calibrated by a NTP (Network Time Protocol) server every hour.

The γ -spectrum for the ^{52g}Mn counting source measured for the first 3600 s is shown in the Fig. 1. The dominant peaks at 744 keV, 936 keV, and 1434 keV are due to ^{52g}Mn . Other peaks in the spectrum are ascribed to ^{51}Cr at 320 keV, ^{54}Mn at 835 keV, ^{137}Cs at 662keV and annihilation radiation at 511 keV. It is shown that there are no nuclides that interfere with the half-life measurement of ^{52g}Mn .

The decay constant of ^{52g}Mn was determined based on a reference method using a ^{137}Cs source [3]. The ratio $R(t)$ is given by the following equation:

$$R(t) = \frac{C_{sample}(t)}{C_{ref}(t)},$$

where $C_{sample}(t)$ and $C_{ref}(t)$ are count rates of a sample and a reference source at the beginning of each data acquisition, respectively. The decay constant of the sample, λ_{sample} is described in the following equation:

$$\lambda_{sample} = \lambda_{ref} - a_{slope},$$

where λ_{sample} is the decay constant of the reference source, and a_{slope} is the slope of the graph of $\ln R(t)$ against time.

The decay curve obtained by least-squares fitting for the $R(t)$ of 744 keV peak and its residuals are shown in the upper and lower panels of Fig. 2, respectively. The residuals of the fits were within the range of approximately 1.0%. From this plot, the half-life of ^{52g}Mn is determined to be 5.593 ± 0.03 days. Table 1 shows the half-lives obtained from the 760keV, 567keV and 346keV peaks. The half-life of ^{52g}Mn is determined to be 5.593 ± 0.03 days days by the weighted average of three values, which is in good agreement with literature value 5.591 ± 0.003 days [4].

Table 1. Half-lives obtained from the 760keV, 567keV and 346keV peaks

Peak Energy	Half-life (d)	error
744 keV	5.593	0.003
936 keV	5.595	0.003
1434 keV	5.591	0.003

References

- [1] P. Gawne et al., Dalton Trans 47 (2018) 9283.
- [2] National Nuclear Data Center (NNDC) <https://www.nndc.bnl.gov/> [Accessed 01 Dec 2020].
- [3] M. A. L.da Silva et al., J. Radioanal. Nucl. Chem. 264 (2005) 571.
- [4] R. P. Yaffe et al., Phys. Rev. C 16 (1977) 1581.

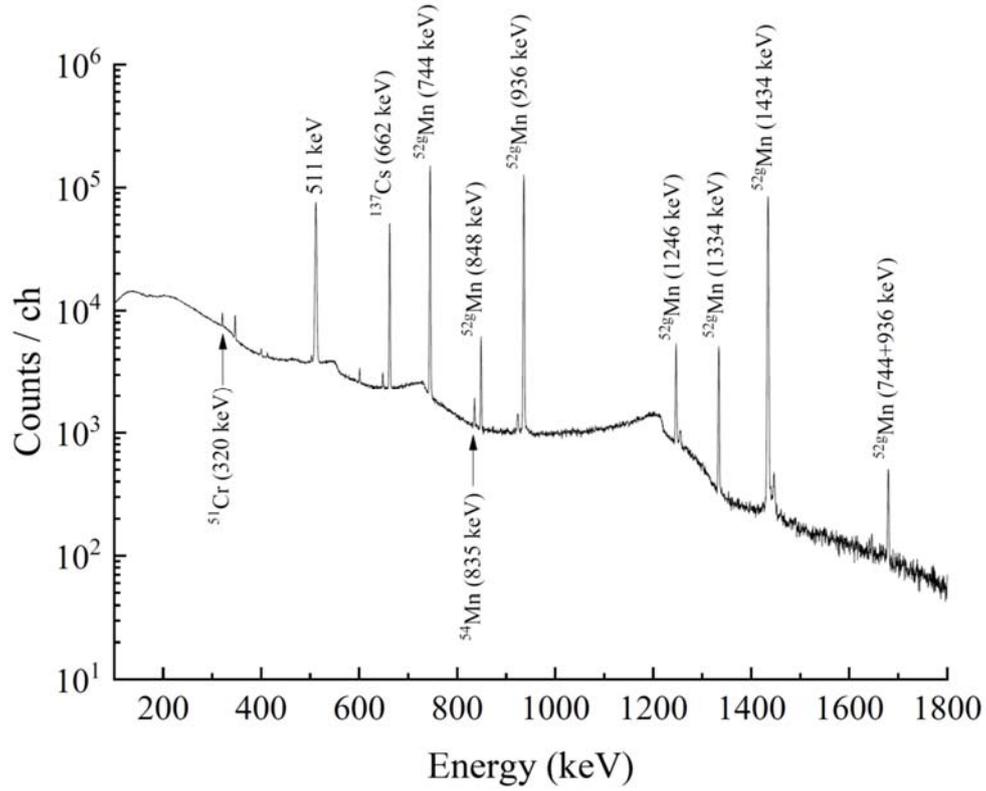


Fig. 1. γ -spectrum for the ^{52g}Mn counting source measured for the first 3600 s

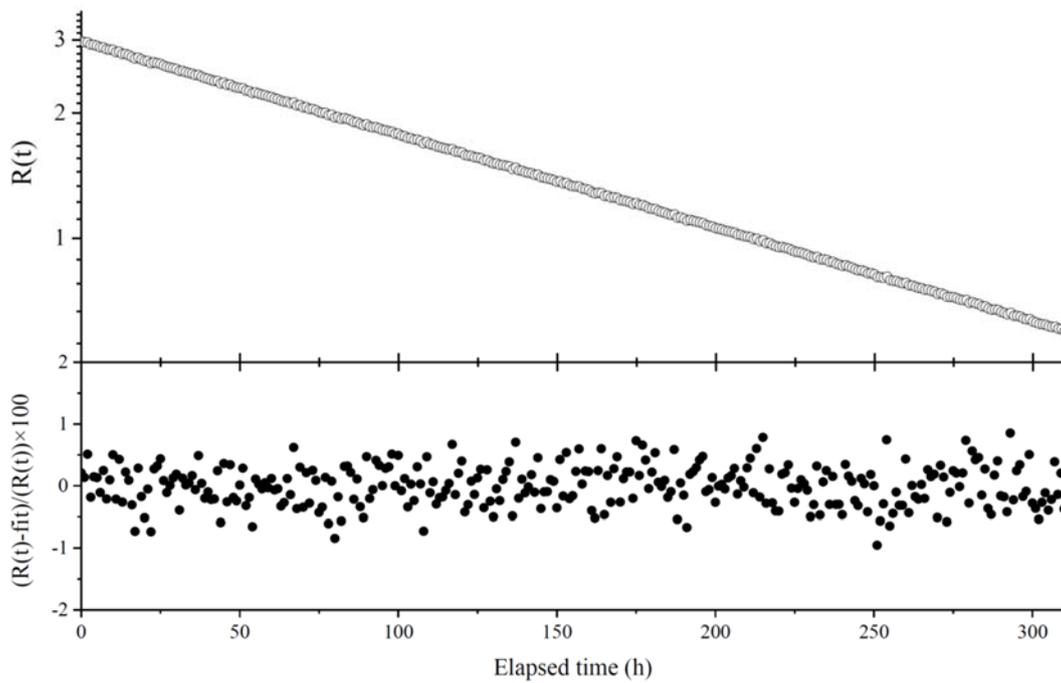


Fig. 2. The decay curve obtained by least-squares fitting for the $R(t)$ of 744 keV peak (Upper panel) and its residuals (Lower panel).