Target study for magnetic moment measurement of ^{40}Sc

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We report a target study on the measurement of the μ moment of ^{40}Sc using the β-ray detected nuclear magnetic resonance (β-NMR) method[1)] at the Research Center for Nuclear Physics, Osaka University. In order to apply the β-NMR method, a spin-polarized nucleus is needed. A spin-polarized ^{40}Sc nucleus was produced in the ^{40}Ca($\overrightarrow{\rm p}$,n)^{40}Sc reaction. In the reaction, the polarization of the beam particles was transferred to each nucleus. The $\overrightarrow{\rm p}$ was produced using a polarized ion source[2)], and it was accelerated at $E/A = 72$ MeV using an AVF cyclotron. The polarized proton beam was implanted on a CaS, a CaO, and a CaF_2 target to produce polarized ^{40}Sc. The targets were placed at the center of the β-NMR apparatus at room temperature.

The higher the purity of ^{40}Sc, the more efficiently it can be measured; therefore, we performed purity measurement and comparison of the three targets. The β-ray emitted from ^{40}Sc were detected with plastic scintillator telescopes located above and below the targets. In order to deduce the purity of the ^{40}Sc, half-lives were measured using three targets. Figure 1(a), 1(b), and 1(c) are β-decay time spectra obtained using CaS, CaO, and CaF_2 targets, respectively. The time spectra obtained from the accumulated β rays in the ^{40}Sc experiment were fitted with two or three exponential functions in addition with a constant background arising from the long-lived impurities. The least squares method was applied to the analysis. The results of the fitting analysis are shown in Fig. 1(a), 1(b), and 1(c). The obtained half-lives were slightly longer than the reported half-life of 182.3(7) ms. The estimated impurities of ^{32}Cl($T_{1/2} = 298$ ms), ^{29}P($T_{1/2} = 4.142$ s), ^{13}N($T_{1/2} = 9.965$ m), and ^{37}K($T_{1/2} = 1.225$ s) have much longer half-lives than that of ^{40}Sc. Thus, the ^{40}Sc isotopes were correctly produced in the ^{40}Ca($\overrightarrow{\rm p}$,n)^{40}Sc reaction. The purities of the ^{40}Sc are obtained to be 23^{+36}_{-23}%, 23^{+33}_{-23}%, and 37±4% using CaS, CaO, and CaF_2 targets, respectively.

From the half-life measurements, the purity of the ^{40}Sc using CaF_2 was determined to be the highest. Thus, we applied a CaF_2 target for the measurement of the μ moment of ^{40}Sc by the β-NMR method. In order to maintain the spin polarization, a static magnetic field $B = 543$ mT was applied. The up/down ratio R of the β-ray counts is written as $R_0 \sim a(1 + A_\beta P)/(1 - A_\beta P)$, where a, A_β, and P denote a constant factor representing asymmetries in counter solid angle and efficiencies, the β-ray asymmetry parameter, and the degree of spin-polarization, respectively. An oscillating magnetic field perpendicular to the static field was applied to the CaF_2 target using an rf coil. If the frequency of the rf field corresponds to the resonance field for the spin-polarized ^{40}Sc, the direction of the spin polarization is changed by the NMR. Then, the ratio changes to $R \sim a(1 - A_\beta P)/(1 + A_\beta P)$. The β-ray asymmetry $A_\beta P$ is written as $A_\beta P = \sqrt{(R_0/R)} - 1/\sqrt{(R_0/R)} + 1$. The μ moment is derived from the frequency of the observed peak or dip in the $A_\beta P$ spectrum. The analysis is in progress.

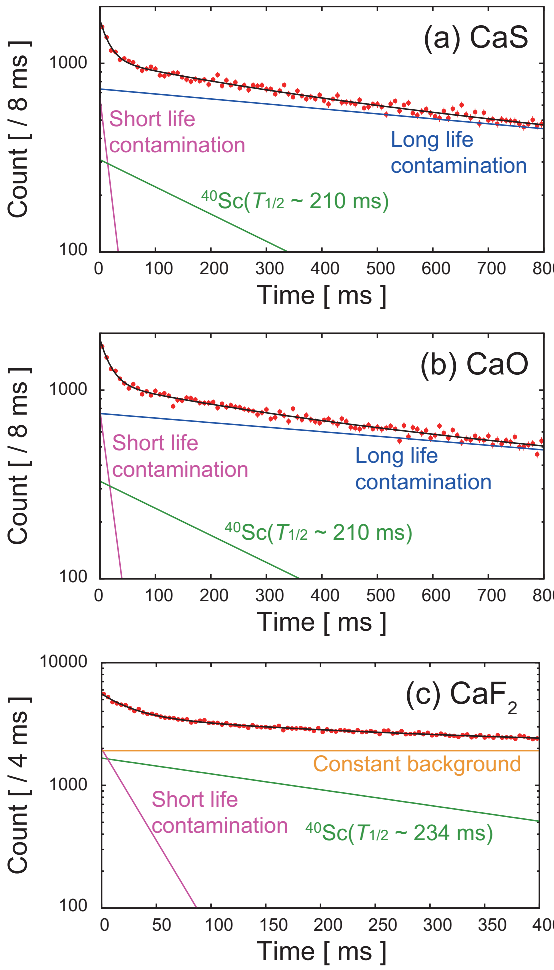

Fig. 1. β decay spectra for ^{40}Sc.

References
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