VI. 2. Measurement of the Cross Section of the $^{40}Ar(\alpha,2p)^{42}Ar$ Reaction

Yuki H.[1]*, Satoh N.*[2]*, Ohtsuki T.*[1]*, Shinozuka T.*[2]*, Baba M.*[2]*, Ido T.*[2]*, and Morinaga H.*[3]

[1]*Laboratory of Nuclear Science, Tohoku University*
[2]*Cyclotron and Radioisotope Center, Tohoku University*
[3]*Technische Universitat Munchen*

Introduction

Radiation sources are great important not only for research in basic science, material science, medical and radiopharmaceutical use but also for education in those area, and even in that in high school.

A ^{42}Ar-^{42}K generator was firstly proposed by Morinaga, who produced ^{42}Ar by the $^{40}Ar(t, p)^{42}Ar$ reaction using tritium accelerator. The half-lives of each nuclide, ^{42}Ar (parent) and ^{42}K (daughter), are 33 years and 12 hours, respectively, and they are in correlation of a secular equilibrium as shown in Fig. 1. Therefore, one can use for long time as a ^{42}K generator if a sufficient amount of ^{42}Ar is produced.

However, no tritium accelerator is available nowadays. Therefore, $^{40}Ar(\alpha, 2p)^{42}Ar$ reaction should be used to produce the ^{42}Ar-^{42}K generator even though the reaction cross section might be smaller than that of the $^{40}Ar(t, p)^{42}Ar$ reaction. No evaluated data for the cross section of the $^{40}Ar(\alpha, 2p)^{42}Ar$ reaction measured experimentally have been reported so far. In order to investigate its availability and the effective production of ^{42}Ar, we have measured the excitation function of $^{40}Ar(\alpha, 2p)^{42}Ar$ reaction[1-3].

Experimental

Since the experimental details have been described in ref.[3], here we briefly show the experimental procedure. The stacked gas cell targets have been irradiated and the excitation functions has been measured by means of and a γ-ray spectroscopy without chemical separation. Irradiations were carried out five times by changing the beam energies of E_α=40, 50, 60, 70 and 80 MeV.

The target cells of quartz glass 30 mm long and 30 mm inside diameter with 0.05

mm windows of polyimide foils (Kapton, Goodfellow Metals, England) were used to the irradiation. The cells were filled with natural argon gas by 1 atm. Thereafter four cells were set in a cylindrical cell holder at the beam course of CYRIC for the irradiation with the α-particles. The irradiated time was set in 7-9 hours by 500 nA. After the irradiation, the γ-rays emanating from ^{42}K were measured with a Ge detector coupled with multi-channel analyzer. Since the ^{42}Ar is 100 % β^-decay nuclide, the amount of ^{42}Ar can be deduced by an amount of ^{42}K by 1524 keV γ-ray, which is under correlation with a secular equilibrium. However, the ^{42}K was also produced simultaneously by the ^{40}Ar(α, pn)^{42}K reaction, An amount of ^{42}K produced by the decay of ^{42}Ar was deduced after the decay out of ^{42}K produced by the ^{40}Ar(α, pn)^{42}K reaction.

Results and Discussion

The cross sections of ^{40}Ar(α, 2p)^{42}Ar and ^{40}Ar(α, pn)^{42}K reactions obtained in the present work are shown in Fig.2. The energies of α-particles at midpoints of each target cell were determined by the calculation of energy degradation in Ar gas, air, Harvar, polyimide and Cu foils using TRIM code[4)]. Horizontal error in each energy scale were calculated by the energy degradation and the straggling of α-particles in Ar gas in each target cell, and which were almost inside each symbols in Fig. 2. Vertical error of the cross sections dominates the statistical errors and the uncertainty of the efficiency of Ge detector.

The cross section of ^{40}Ar(α, pn)^{42}K reaction has been presented by Tanaka *et al.*[5)] so far, and it was also shown in Fig.2. It should be noticed that our result is fair agreement with that obtained by Tanaka *et al.* The calculated cross sections by using ALICE code[6)] are also given in Fig.2. From the figure, it seems that the calculated values for the cross section of the ^{40}Ar(α, 2p)^{42}Ar with ALICE code can be overestimated in 30 MeV < E_α< 60 MeV and that for the ^{40}Ar(α, pn)^{42}K reaction can also be underestimated in E_α > 40 MeV.

References

1) Nozomi N., et al., CYRIC Annual Report (2003) 127.
2) Yuki H., et al., CYRIC Annual Report (2003) 130.
3) Yuki H., et al., CYRIC Annual Report (2004) 109.
4) Ziegler J.F., Biersack J.P., Littmark U., The stopping and range of ions in solids, Pergamon, New York (1984).
5) Tanaka S., Furukawa M., Mikumo T., Iwata S., Yagi M., Amano H., J. Phys. Soc. Jpn. **15** (1960)

952.
6) Blann M., Vonach K.H., Phys. Rev. C **28** (1983) 1475.

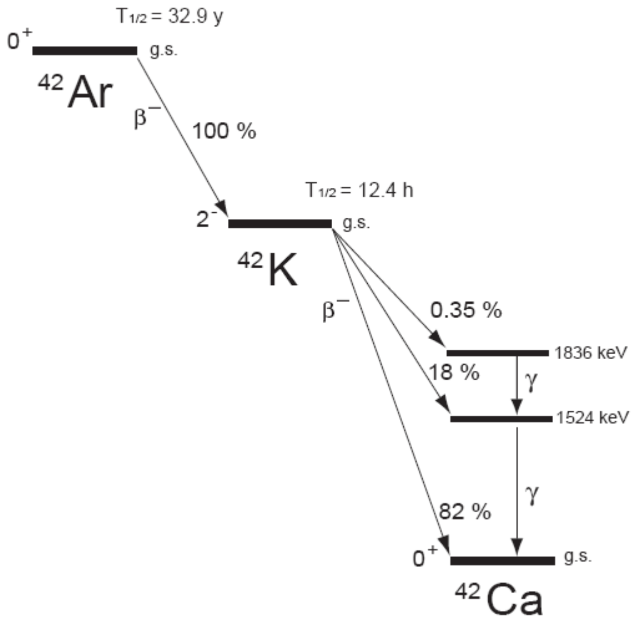

Figure 1. Decay scheme of Ar-42 and K-42.

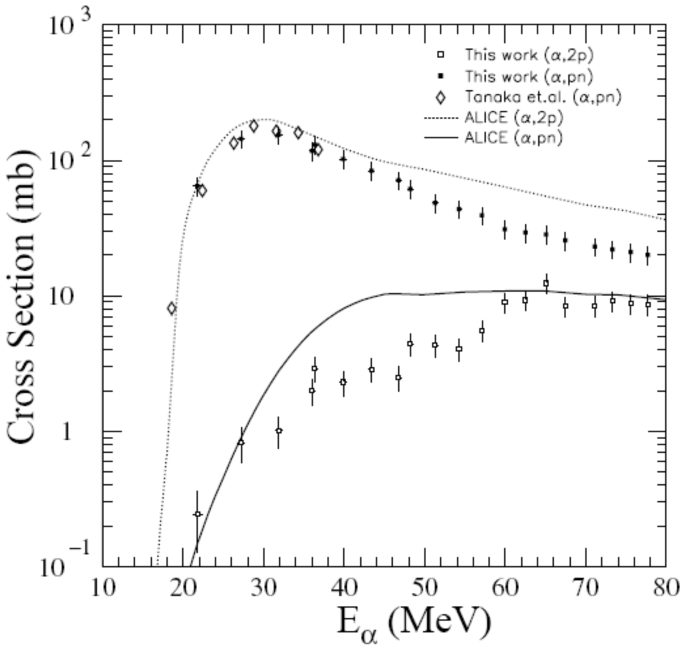

Figure 2. Comparison of the experimental and calculated excitation functions for the (α, 2p) and (α, pn) reaction on Ar-40 target.