Activation cross sections of alpha particle induced reactions on natural nickel up to 50 MeV

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^{67}Cu is a medium-energy β^- emitter radionuclide, which is similar to ^{177}Lu, but offers the advantage of radiation suitable for diagnostics along with a therapy effect. We investigated the ^{64}Ni$(\alpha, \mathrm{p})^{67}$Cu reaction by irradiating natural nickel targets. Cross sections of alpha particle-induced reactions, resulting in the production of ^{61,64,67}Cu, ^{55,56,57,58,60}Co, ^{56,57,66}Ni, and ^{62,63,65}Zn were determined, and the results were compared with data available in the literature.

The stacked target technique and activation method were used, followed by high-resolution gamma spectrometry of the activated target foils. Two independent irradiation experiments using different target foils and irradiation parameters were performed at the AVF cyclotron of the RIKEN RI Beam Factory. The stacked targets consisted of ^{nat}Ni target foils (4.11 mg/cm^2 and 4.45 mg/cm^2) and ^{nat}Ti monitor foils to monitor the beam parameters (2.40 and 4.95 mg/cm^2) of different thicknesses. The targets were irradiated for 1 and 2 h with alpha beams of 186 and 400 nA and energies of $E_\alpha = 41.6 \pm 0.35$ MeV and $E_\alpha = 50.73 \pm 0.30$ MeV, respectively. The primary beam energies were determined by the time-of-flight method.[1] The energy degradation in the targets was calculated by the semiempirical polynomial method of Ziegler *et al.*[2] The beam intensity was measured by a Faraday cup and was recorded every minute to check its stability in both cases.

The activity of the foils was measured by a HPGe spectrometer to identify the isotopes and to determine their intensity. The ^{nat}Ti$(\alpha, \mathrm{x})^{51}$Cr reaction was used to monitor the beam intensity and energy degradation through the whole stack. It was not necessary to correct the beam parameters obtained from primary measurements. The foils were placed in pairs in the stack and activity of the lower energy foil of each pair was measured supposing compensation of the activity loss due to the recoil effect.

The newly determined cross section data from the two irradiations correspond well in the overlapping energy region and can be used as one dataset. Because only the ^{64}Ni(α, p) reaction contributes to the production of ^{67}Cu, the measured data were normalized to the 100% ^{64}Ni target composition and were compared to the experimental data measured earlier as well as to the results of the theoretical nuclear reaction model code TALYS (Fig. 1) taken from the TENDL-2017 data library available online.[3]

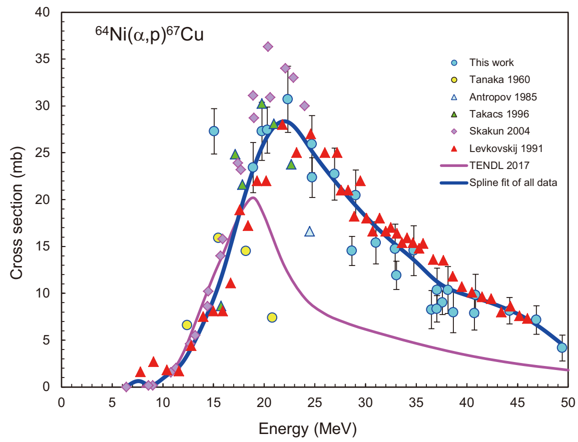

Fig. 1. Excitation function of the ^{64}Ni$(\alpha, \mathrm{p})^{67}$Cu compared with the previous results and with the results of theoretical model codes.

From the measured cross sections, yield curves were calculated and compared with the available experimental yield data. Our results agree well with most values in the literature except for the data of Tanaka (1960)[4] and Antropov (1985).[5]

Our preliminary data are, in general, in agreement with data in the literature, however, an additional experiment is required to cover the 20 MeV-to-threshold energy region of the excitation function. Owing to the high energy degradation of the alpha particles the usual stacked target technique cannot be used effectively below 20 MeV. Therefore, a new rotating irradiation setup is designed for measurements in this energy region.

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