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C/Be neutron converter design for increasing production amount of medical radioisotopes in accelerator neutron method/重陽子加速器中性子源を用いた医療用 RI 製造量増加を目的とした C/Be 複合コンバータの設計

Accelerator neutrons generated by deuterons are new source for radioisotope (RI) production. In this system, neutrons are produced by the (d, n) reaction by deuteron irradiation on a thick neutron converter made of single element light nuclide such as C or Be. Generated neutrons irradiate the nuclides in a raw material turned into medical RI by direct reactions.

As a feature of the neutron converter, the single-material Be can generate higher neutron yield, but it starts expanding during deuteron irradiation and finally breaks. This effect is known as blistering, which must be suppressed as much as possible for long life of the converter. Thus, we focused on a new target converter design. The converter consists of two materials, Be and C. On the deuteron incident side beryllium is placed to generate intense neutrons but the length is 0.1 mm shorter than incident deuteron range to dispose the deuterons downstream. The penetrated deuterons are absorbed inside thick carbon part with generating feint neutrons. The thickness of the Be is determined to dispose 99.7% of deuterons. Using the range R_{Be} and its deviation σ_{Be} calculated by the SRIM [1] code, beryllium having $R_{Be} + 3\sigma_{Be}$ mm thick target can achieve the disposing condition. We select thick carbon absorber because the length must be simply determined to shield almost all of deuterons.

We conducted a neutron generation experiment to investigate the performance of the designed C/Be converter at the JAEA tandem accelerator. Deuterons were accelerated to 20 MeV and bombarded on C/Be target to produce neutrons via the C(d, n) reaction. The neutron yield was measured by multiple-foil activation method. The unfolding code GRAVL [2] was used to analyze the neutron yields using the obtained activities of products of the specific reactions. Response functions were analytically determined from cross sections stored in JENDL5 [3]. Initial guess spectrum derived by the Monte Carlo simulation code PHITS [4]. The results are compared with our previous experiment results using a beryllium-single material converter performed at CYRIC.

As a result, a composite converter was designed using the SRIM code, which has a durability 769 times longer than Be converter. The neutron yield when using the combined converter was derived from the experimental results of the JAEA tandem.

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