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64Cu and 67Cu radionuclide to diagnose and treat of cancer: Experimental and theoretical Production yields

As the number of patients suffering from different cancers has been increased, researchers have evaluated several ways to diagnose and treat these abnormalities. In this regard, application of radionuclides is an interesting option through which some cancers can be simultaneously diagnosed and treated. Radionuclides used in medicine can be produced through nuclear reactors, linear accelerators, generators, fission and fusion.

^{64}Cu is one of the most useful radionuclide as a theranostic agent with γ, β^+ and β^- decay (E.C. (43.53%), β^- (38.48%) and β^+ (17.52%); End-point $E_{\beta}{}^+$ = 653 keV, End-point $E_{\beta}{}^-$ = 579 keV, Eg=1345.84 keV, I_γ = 0.47%) and also 12.7 h half-life making it an interesting option in Positron Emission Tomography (PET) imaging and targeted endoradiotherapy. ^{64}Cu can be produced with ^{63}Cu(n,g)^{64}Cu and ^{64}Zn(n,p)^{64}Cu reactions in nuclear reactor. Another copper radionuclide is ^{67}Cu with γ and β^- decay ($E_{\text{mean }\beta}{}^-$ = 141 keV) , E_γ = 184 keV (46.7%), 93 keV (16.60%), 91 keV (7.26%)) and 2.576 days half-life which is useful in radioimmunotherapy, Single Photon Emission Computed Tomography (SPECT) imaging and tracer kinetic studies. It can be produced with ^{67}Zn(n,p)^{67}Cu reaction. The decay schematic of ^{64}Cu and ^{67}Cu is shown in Figure 1.

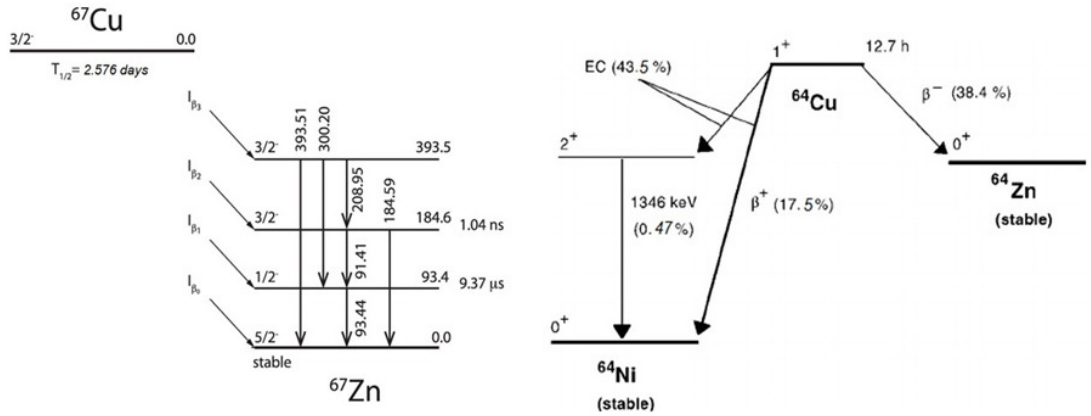

Fig. 1. The decay scheme of ^{64}Cu and ^{67}Cu radionuclides.

The present study examined these reactions with ^{nat}ZnO, ^{nat}ZnO nanoparticles (NPs), ^{nat}Cu and ^{nat}Cu-NPs targets in Tehran Research Reactor (TRR) for ^{64}Cu and ^{67}Cu radionuclides productions. Radioactive nanoparticles enjoy the ability of having several radioactive atoms. The prepared samples were inserted in one of the irradiation box of nuclear reactor core with the significant thermal and fast neutron flux about 30 minutes. After cooling times, the irradiated samples were pulled out from the reactor core and prepared for gamma spectrometry with a high purity p-type detector (HPGe). The production yields were also assessed with HPGe detector.

Theoretical calculation of radionuclide production yields required consideration of several different physical parameters such as reaction cross section, radiation time, half-time and neutron flux. Cross section parameters

were calculated with benefit nuclear codes such as TALYS-1.8 (the last update). The production yields of ^{64}Cu and ^{67}Cu were calculated using MCNP code which needs to simulate the reactor core of TRR with a maximum power of 5 MW, pool type with 9×6 grid plate containing cool fuel elements, radiation box and etc. This reactor is designed for research, train and production of radionuclides. The theoretical and experimental production yields were compared to each other which showed a good agreement between them. Therefore, MCNPX can be used to optimize radionuclide production condition in the nuclear reactor. On the other hand, comparing the experimental production yields with nano target showed insignificant changes.

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