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Investigation of production routes and production cross sections of non-standard PET radionuclides

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It is conventional to use standard Positron Emission Tomography (PET) radionuclides (^{11}C, ^{13}N, ^{15}O, ^{18}F) for imaging; however, the decay energy <3 MeV and β+ intensity (>10%) of some other radionuclides (called non-standard) also makes them correspondingly suitable for PET imaging. The importance of non-standard PET radionuclides (e.g. ^{45}Ti, ^{60}Cu, ^{61}Cu, ^{64}Cu, ^{86}Y, ^{124}I) in clinical nuclear medicine has been realized by imaging the biological systems. Cyclotrons are the best solution to produce desired beta emitters. Smart choice of target and projectile makes it possible to produce the PET radionuclides in most economical way. Keeping in view the importance of medical radioisotopes, we investigated the production route and production cross-section of few non-standard radionuclides (^{55}Co, $^{61,64}Cu$, $^{66,68}Ga$, ^{86}Y, ^{89}Zr, ^{90}Nb, ^{94}mTc) using medium energy proton and alpha beams. Stacked-foil activation technique was applied to irradiate the samples (natNi, natFe, natCu, ^{89}Y, ^{93}Nb and natMo) with external beam of MC-50 cyclotron installed at Korea Institute of Radiological and Medical Sciences (KIRAMS), Korea. Off-line γ-ray spectrometric technique was used for spectrum analysis and measurement of production cross-sections of radionuclides of interest. Based on the cross-section, thick target yield information was also obtained. We studied natNi(p,x)55Co, natFe(p,x)55Co, natCu(α,x)^{61,64}Cu, natCu(α,x)^{66,68}Ga, natCu(p,x)^{61,64}Cu, ^{89}Y(p,x)^{86}Y, ^{89}Y(p,x)^{89}Zr, ^{93}Nb(p,x)^{90}Nb, ^{89}Y(α,x)^{90}Nb, ^{93}Nb(α,x)^{94}mTc and natMo(p,x)^{94}mTc reactions in the energy range from their threshold to 45 MeV. Proton and alpha beams were bombarded on different targets to investigate the production routes and production cross-sections of different radionuclides. However, chemical separation of these non-standard PET radionuclides or their application to image biological systems was not studied. Stacked-foil activation technique was applied to irradiate the sample with external beam of MC-50 cyclotron installed at Korea Institute of Radiological and Medical Sciences, Korea. Thin metallic foils (10-50 nm) of 1×1 cm^2 area were placed in front of beam of 10 mm diameter (100-200 nA current) to irradiate for 0.5-1 hours depending on the experimental setup. Off-line γ-ray spectrometric technique was used for spectrum analysis and measurement of production cross-sections of produced radionuclides. Besides aforementioned reaction products, some other short lived non-standard PET radionuclides were also produced but their production could not be identified due to their very short half-lives. As the produced radioisotopes are medically important, therefore, the integral yields for thick target of the investigated radio-nuclides were also calculated from the measured excitation functions. The measured results were compared with the literature data as well as with the theoretical values obtained from the TENDL-2015 library based on the TALYS 1.8 code. The study of the production of non-standard PET radionuclides from different reactions describes the cross-sections and yield information in the energy range of 2-45 MeV. Most of the reaction products are directly produced so chances of contamination and unwanted impurities are minimum. One of the advantages of this technique is carrier free production of desired radioisotopes and easy separation through chemical process. We did not investigate the methods to separate chemically the desired radionuclides and their applications to image biological systems. However, based on our study the best production route and suitable energy for maximum production can be identified to produce the desired radionuclide in the economical way. Though the study has been provided by other investigators, yet discrepancies were observed in their measurements, so the current study is enough to enrich the literature data except a few where further investigations are required to make the production economically viable. The information provided about integral yield is pertinent for those involved in radioisotope production.

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