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Photonuclear production of the medical isotopes ^{47}Sc, ^{67}Cu, ^{161}Tb, ^{166}Ho and ^{177}Lu

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In nuclear medicine, radioisotopes are used for diagnostic procedures, bone and tumor scans, radioisotope therapy and sterilization of medical devices [1]. Steady production of widely used and promising isotopes is essential for medical progress. Currently the majority of medical isotopes are produced in nuclear reactors or cyclotrons. However, disruptions and planned reactor shutdowns demonstrate that reactor-based production schemes are not always reliable (e.g., the problem with ^{99m}Tc production in 2009).

Therefore, in recent times there has been a growing interest in alternative methods for the production of medical isotopes, including photonuclear reactions on electron accelerators [1,2]. The advantages of using accelerators in comparison to reactors and cyclotrons include safety, cheaper operating and decommissioning costs, in certain instances, the simplicity of the chemical separation of micro quantities of the target nuclide from the macro quantities of the target. Furthermore, the compactness of electron accelerators may allow them to be used in close proximity to medical centers.

In order to assess the possibility of photonuclear production of medical quantities of radionuclides, it is first necessary to ascertain the yields and cross sections of all reactions leading to the formation of target and side nuclides. Isotopes ^{47}Sc, ^{67}Cu, ^{161}Tb, ^{166}Ho and ^{177}Lu are supposed to be obtained as a result of photoproton reactions ^{48}Ti(γ,1p)^{47}Sc, ^{49}Ti(γ,1p1n)^{47}Sc, ^{50}Ti(γ,1p2n)^{47}Sc, ^{68}Zn(γ,1p)^{67}Cu, ^{70}Zn(γ,1p2n)^{67}Cu, ^{162}Dy(γ,1p)^{161}Tb, ^{163}Dy(γ,1p1n)^{161}Tb,^{164}Dy(γ,1p2n)^{161}Tb, ^{167}Er(γ,1p)^{166}Ho, ^{168}Er(γ,1p1n)^{166}Ho, ^{170}Er(γ,1p3n)^{166}Ho, ^{178}Hf(γ,1p)^{177}Lu, ^{179}Hf(γ,1p1n)^{177}Lu, ^{180}Hf(γ,1p2n)^{177}Lu. A combined model of photonucleon reactions (CMPR) [3,4] was selected for the theoretical description of target and side reactions due to its superior ability to describe photoproton reactions in comparison to widely used numerical codes such as TALYS and EMPIRE. The advantage of CMPR is due to the consideration of isospin splitting of the giant dipole resonance (GDR), isovector quadrupole resonance (QR), the GDR overtone (GDR2) and the quasideuteron photoabsorption mechanism. Within the framework of the CMPR, the activities of target and side isotopes, optimal energies for photonuclear production of isotopes ^{47}Sc, ^{67}Cu, ^{161}Tb, ^{166}Ho and ^{177}Lu were determined on targets from a natural mixture of titanium, zinc, dysprosium, erbium and hafnium isotopes, as well as enriched targets ^{48}Ti, ^{49}Ti, ^{50}Ti, ^{68}Zn, ^{70}Zn, ^{162}Dy, ^{163}Dy, ^{164}Dy, ^{167}Er, ^{168}Er, ^{170}Er, ^{178}Hf, ^{179}Hf и ^{180}Hf. The radiochemical yields calculated within the framework of the CMPR were compared with the results of experiments on irradiation of targets from a natural mixture of titanium, zinc, dysprosium, erbium and hafnium isotopes on the pulsed racetrack microtron RTM-55 with a maximum electron energy of 55 MeV [5-7].

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Primary authors: KUZNETSOV, Alexander (Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University; Faculty of Physics, Lomonosov Moscow State University); PRISELKOVA, Anna (Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University); FURSOVA, Nadezhda (Faculty of Physics, Lomonosov Moscow State University; Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University); ALIEV, Ramiz (National Research Center "Kurchatov Institute"); BELYSHEV, Sergey (Faculty of Physics, Lomonosov Moscow State University; Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University); KHANKIN, Vadim (Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University)

Presenter: FURSOVA, Nadezhda (Faculty of Physics, Lomonosov Moscow State University; Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University)

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