

Summary and Conclusions

Positron emission Tomography (PET) is one of the most modern and progressive non-invasive diagnostic techniques used in nuclear medicine. It is superior to other techniques in two respects: (a) it is dynamic in nature, i.e. it allows to study physiological functions from outside of the body, and (b) it provides quantitative results. The ongoing development in the field of diagnostic imaging requires versatile radiopharmaceuticals, labeled with the commonly used positron emitters like ^{11}C and ^{18}F , to be able to study different organ functions. On the other hand, there is also need of development of novel positron emitting radionuclides for several other applications. In particular, for studying slow metabolic processes, longer lived positron emitters are of special interest. The possible applications and production of those radionuclides highly depend on a precise knowledge of nuclear data. The reaction cross section data are significant for production of radionuclides with high purity and high specific activity.

In this work the cross section data of the three important non-standard positron emitters, namely ^{64}Cu , ^{76}Br and ^{124}I , were evaluated. This evaluation entailed a comprehensive analysis of the data. The experimental data were adjusted in accordance with the latest standards of monitor reaction cross sections and decay data of the concerned radionuclide. An interesting feature of the present evaluation is the nuclear model calculations which were performed by three nuclear model codes, namely STAPRE, EMPIRE and TALYS. The model calculations did not validate the absolute values of experimental data, but were able to validate the consistency of different experiments in different energy ranges. Good agreement could be achieved between calculated and measured excitation functions by a careful choice of the nuclear model parameters. Reliable experiments indirectly help to refine nuclear models, particularly in depicting the significance of various model parameters. On the other hand, nuclear model calculations can be applied to predict with some confidence the results of a nuclear reaction without experimental data. Thus experiment and nuclear modeling have a synergistic relationship. A statistical procedure (supported by nuclear model calculations) was then used to obtain the recommended excitation

functions. In this method a polynomial function was used to fit the deviations among measurements and calculations. The recommended data are reported with uncertainties. Therefrom integral yields were calculated. A comparison of different production routes for the production of a specific radionuclide was also carried out. The recommended data should be helpful in estimation of the production yield of a certain radionuclide over a given energy range via a particular reaction.

The radionuclide ^{64}Cu ($T_{1/2} = 12.7$ h) is an important non-standard positron emitter, suitable for combining PET imaging and targeted therapy. In this work the cross section data for seven nuclear reactions, viz. $^{64}\text{Ni}(p,n)^{64}\text{Cu}$, $^{64}\text{Ni}(d,2n)^{64}\text{Cu}$, $^{68}\text{Zn}(p,\alpha n)^{64}\text{Cu}$, $^{66}\text{Zn}(p,2pn)^{64}\text{Cu}$, $^{64}\text{Zn}(d,2p)^{64}\text{Cu}$, $^{66}\text{Zn}(d,\alpha)^{64}\text{Cu}$ and $^{\text{nat}}\text{Zn}(d,x)^{64}\text{Cu}$, leading to the formation of no-carrier-added ^{64}Cu were evaluated. A critical comparison of the various production routes of ^{64}Cu is presented. The $^{64}\text{Ni}(p,n)^{64}\text{Cu}$ reaction, utilizing a highly enriched target, is the method of choice.

Cross section data for the production of medically important radionuclide ^{124}I ($T_{1/2} = 4.18$ d) via five proton and deuteron induced reactions on enriched tellurium isotopes (i.e. $^{124}\text{Te}(p,n)^{124}\text{I}$, $^{125}\text{Te}(p,2n)^{124}\text{I}$, $^{126}\text{Te}(p,3n)^{124}\text{I}$, $^{124}\text{Te}(d,2n)^{124}\text{I}$ and $^{123}\text{Te}(d,n)^{124}\text{I}$) were evaluated. Along with the above mentioned reactions, the ^3He and α -particle induced reactions on antimony isotopes, viz. $^{121}\text{Sb}(\alpha,n)^{124}\text{I}$, $^{123}\text{Sb}(\alpha,3n)^{124}\text{I}$ and $^{123}\text{Sb}(^3\text{He},2n)^{124}\text{I}$, were also evaluated. The evaluated excitation functions for the production of ^{125}I ($T_{1/2} = 59.4$ d) are also given to assess the level of this impurity in the production of ^{124}I . Presently the $^{124}\text{Te}(p,n)^{124}\text{I}$ reaction seems to be the method of choice for production of high purity ^{124}I in sufficient amounts at a small-sized cyclotron; however, the $^{125}\text{Te}(p,2n)^{124}\text{I}$ reaction also appears to have great potential. The recommended excitation functions for a few proton induced reactions were also validated by comparing the data with the measurements on natural tellurium target. The recommended data also show that the investigated $^{123}\text{Sb}(\alpha,3n)^{124}\text{I}$ process can produce significant amounts of ^{124}I ; however, this process would require an intermediate energy cyclotron with α -particle beam.

The radiobromine ^{76}Br ($T_{1/2} = 16.2$ h) is another medically significant non-standard positron emitter. The evaluated reactions for the production of this

radionuclide include: $^{76}\text{Se}(p,n)^{76}\text{Br}$, $^{77}\text{Se}(p,2n)^{76}\text{Br}$, $^{78}\text{Se}(p,3n)^{76}\text{Br}$, $^{75}\text{As}(^3\text{He},2n)^{76}\text{Br}$ and $^{75}\text{As}(\alpha,3n)^{76}\text{Br}$ processes. The formation of ^{76}Br via the indirect $^{79}\text{Br}(p,4n)^{76}\text{Kr} \rightarrow ^{76}\text{Br}$ route was also discussed. A comparison of different production routes was performed along with the corresponding amounts of ^{77}Br ($T_{1/2} = 57.04$ h) and ^{75}Br ($T_{1/2} = 1.6$ h) impurities. The $^{76}\text{Se}(p,n)^{76}\text{Br}$ reaction appears to be the method of choice due to high yield and high radionuclidic purity. However, the $^{75}\text{As}(^3\text{He},2n)^{76}\text{Br}$ reaction is also interesting since it also gives a high-purity product. Besides ^{76}Br , the suitable reactions for the production of ^{75}Br were also evaluated. Attempts to validate some of the evaluated data were also undertaken.