Cross section calculations of medical ^{103}Pd radioisotope using α and ^{3}He induced reactions

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Abstract. One of the most popular radioisotopes used in the prostate brachytherapy is Palladium-103 (^{103}Pd). The radioactive plaque is sewn onto the eye as to cover the intraocular tumor shadow with a 2-3 mm margin. These plaques are temporary and radiation is continuously delivered over 5 to 7 days. At the end of treatment, the plaque is removed from eye. In this study, production cross–section calculations of ^{103}Pd radionuclide used in brachytherapy produced by ^{101}Ru(α,2n), ^{100}Ru(α,n), ^{102}Ru(^{3}He,2n) and ^{101}Ru(^{3}He,n) reactions have been investigated in the different incident energy range up to 35 MeV**.** Two-component Exciton model and Generalized Superfluid model of the TALYS 1.6 code used to perform calculations and calculation results were compared with experimental results reported in the literature.

1 Introduction

One of the most popular radioisotopes used in the prostate brachytherapy is Palladium-103 (^{103}Pd). It is chosen for brachytherapy of because of the low energy photons of 20.5 KeV. Thus, it is possible to minimize doses to normal structures thanks to their low energy with rapid dose fall-off. On the other hand their half-life's (17 days) are very suitable for the brachytherapy. Uveal melanoma can be treated using radioactive ^{103}Pd. Radioactive ^{103}Pd is produced in the form of seed. ^{103}Pd seeds are placed into a non-radioactive metallic plaque to apply the uveal melanoma. The radioactive plaque is sewn onto the eye as to cover the intraocular tumor shadow with a 2-3 mm margin. These plaques are temporary and radiation is continuously delivered over 5-7 days. At the end of treatment, the plaque is removed from eye (1).

Production of medical isotope is an important and constantly evolving issue. Cyclotrons and reactors are used for radionuclide production purposes. The cross–section data for nuclear reactor production are generally well–known and can be satisfactorily reproduced by nuclear model calculations. Theoretical models of nuclear reactions are generally needed to get the prediction of the reaction cross–sections, in a specific manner if the experimental measurements are unobtainable or are improbably to be produced because of the experimental difficulties. In this study, production cross–section calculations of ^{103}Pd radionuclide used in brachytherapy produced by ^{101}Ru(α,2n), ^{100}Ru(α,n), ^{102}Ru(^{3}He,2n) and ^{101}Ru(^{3}He,n) reactions have been investigated in the different incident energy range up to 35 MeV**.** Two-component Exciton model and Generalized Superfluid model of the TALYS 1.6 code used to perform calculations and calculation results were compared with experimental results reported in the literature.

2 Calculation method used in nuclear reactions

The production cross–sections of ^{103}Pd radionuclide used in prostate and uveal melanoma treatments has been calculated using two–component exciton and generalised superfluid models of the TALYS 1.6 have been used to PEQ reaction calculations. The PEQ reactions were considered by the two–component exciton model. In the two–component model of the TALYS code, the neutron and proton type of the produced particles and holes is explicitly followed all through the reaction. The generalised superfluid model of TALYS 1.6 code takes superconductive pairing correlations into account according to the Barden–Cooper–Schrieffer Theory which is described by a phase transition from a superfluid behaviour at low energy, where pairing correlations strongly influence the level density, to a high energy region which is characterized by the Fermi model. In this model there is no unsolved problem for the parameterization (2).

3 Results and discussion

The production cross–sections of ^{103}Pd radionuclide were calculated as a function of different incident energies up to 35 MeV by using the TALYS 1.6. The calculated and experimental cross–sections of ^{101}Ru(α,2n), ^{100}Ru(α,n), ^{102}Ru(^{3}He,2n) and ^{102}Ru(^{3}He,2n) reactions have been plotted in Figs. 1–4.

All experimental results used in this present study were taken from the EXFOR library (3).

The calculated cross–sections of ^{101}Ru(α,2n) reaction was compared with the experimental results in Fig. 1. The energy range of α particle was selected between 15 and 23 MeV to make a comparison with the results reported in the literature. Both model calculations are in good agreement with the experimental values except for 15 MeV incident energy.

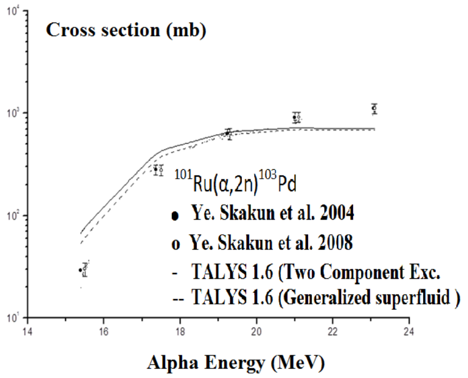

Fig. 1. The comparison of calculated cross–sections of ^{101}Ru(α,2n) reaction with the experimental values reported in the literature.

For the 100Ru(α,n) reaction, the comparison of experimental and theoretical results was given in Fig. 2. The energy range of α particle was selected between 11 and 25 MeV to make a comparison with the results reported in the literature. Both model calculations are in good agreement with the experimental data except for 18-25 MeV deuteron incident energy.

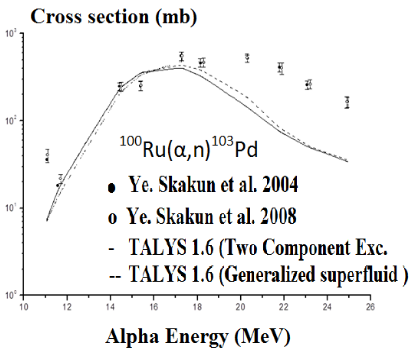

Fig. 2. The comparison of calculated cross–sections of ^{100}Ru(α,n) reaction with the experimental values reported in the literature.

The experimental and theoretical results on the production cross–sections of ^{103}Pd radionuclide via ^{102}Ru(^{3}He,2n) reaction was given in Fig. 3. The energy range of ^{3}He was selected between 14 and 34 MeV to make a comparison with the results reported in the literature. All model calculations are significantly disagree with the experimental data.

And finally, the experimental and theoretical results on the production cross sections of ^{103}Pd radionuclide via ^{102}Ru(^{3}He,n) reaction was given in Fig. 4. The energy range of ^{3}He was selected between 15 and 35 MeV to make a comparison with the results reported in the literature. Both model calculations are in good agreement with the experimental data except for 23-35 MeV ^{3}He incident energy.

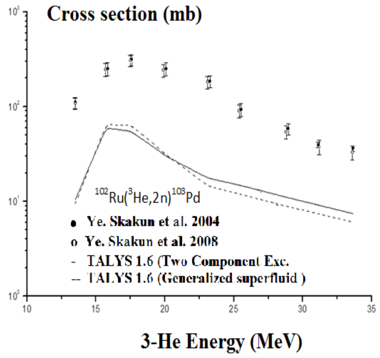

Fig. 3. The comparison of calculated cross sections of ^{102}Ru(^{3}He,2n) reaction with the experimental values reported in the literature.

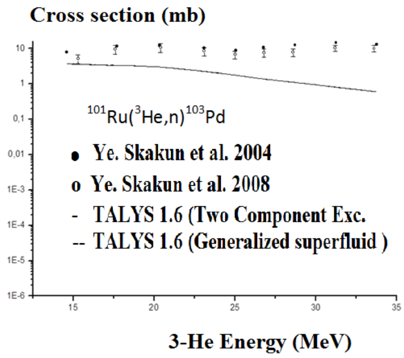

Fig. 4. The comparison of calculated cross–sections of ^{101}Ru(^{3}He,n) reaction with the experimental values reported in the literature.

Conclusion

The results can be summarized and concluded as follows:

1) The cross–section results calculated with TALYS 1.6 computer codes for all reactions are mostly in agreement with the experimental data except for ^{102}Ru(^{3}He,2n) reaction.

2) The TALYS 1.6 computer codes option for the production cross–section calculations of ^{103}Pd radionuclide can be chosen, if the experimental data are not available or are improbable to be produced due to the experimental difficulty.

References

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