Excitation functions of ^{195,198}Pt(p,n)^{195,198}Au for medical applications

S. Hinge,* P. Singh, K. Churi, and M. Hemalatha†
Department of Physics, University of Mumbai - 400098, INDIA

Introduction

In recent times, the trend to use charge-particle based production of radioisotopes for medicine has increased. The improvements in accelerator technologies has partly replaced production of medical isotopes via nuclear reactors by particle-accelerators, such as cyclotrons. The isotopes produced in nuclear reactions with particles (*eg.*, protons), once radiochemically separated have the ligands combined to prepare radiopharmaceuticals, which are then used in nuclear medicine. With the widespread usage of radiopharmaceuticals for diagnosis and therapy, the stable production and supply of isotopes is crucial.

Extensive studies are being carried out to obtain data, especially at incident projectile energies below 30 MeV. However, there are several deficiencies and new data are required for achieving complete database. Moreover, there are large uncertainties in data for lower incident energies, especially near reaction threshold energies for measurements done by conventional methods, like stacked-foil activation. Meanwhile, one has to rely on calculations carried out using robust theoretical formalisms. The peak energy of the excitation functions of reactions will be useful in deciding standardisation of production of isotopes in dedicated accelerator facilities [1, 2]. In the present investigation, we are interested not only in medical application of proton-induced reactions on ^{195,198}Au radioisotopes using Pt targets, but also in the reaction mechanisms involved using statistical model analysis.

*Electronic address: swarali.hinge@physics.mu.ac.in
†Electronic address: mhemalatha.tandel@physics.mu.ac.in

Properties of ^{195,198}Au isotopes

The physical characteristics of radioisotopes decide the medical uses in diagnosis, therapy or both. The isotope, ^{198}Au, with a $T_{1/2}$ of 2.7 d has potential use in radiotherapy for cancer treatments. The $T_{1/2}$ and β^- decay energy of ^{198}Au are favorable for use in medicine because its penetration range in tissue allows it to destroy tumors without nearby non-cancerous tissue being affected by radiation. ^{195}Au having a $T_{1/2}$ of 186 d is a β^+-emitter and has applications in therapy and imaging processes, like positron emission tomography (PET) and single-photon emission computed tomography (SPECT).

Theoretical Framework

The cross sections for ^{195,198}Pt(p,n) ^{195,198}Au have been calculated using statistical model code TALYS-2.0 [3]. There are several modules in the code for describing the nuclear structure and reactions. Here, we are interested in the nuclear optical model that provides the absorption cross section to describe the formation of the compound nucleus, and the nuclear level density models that account for its decay into stable or radioactive products. The Koning-Delaroche (KD) and the Jeukenne-Lejeune-Mahaux-Bruyeres (JLMB) optical model potentials (OMPs) in the folding model approach have been used to calculate the differential elastic and total reaction cross sections. For the calculation of the level densities (LDs), the back-shifted Fermi gas model (BFM) has been employed. The cross section calculations using the KD and JLMB OMPs as well as the BFM LD are denoted by KD-BFM and JLMB-BFM, respectively. Further information on similar calculations are given in Ref. [1, 2, 4, 5], and OMP calculations in Ref. [6].

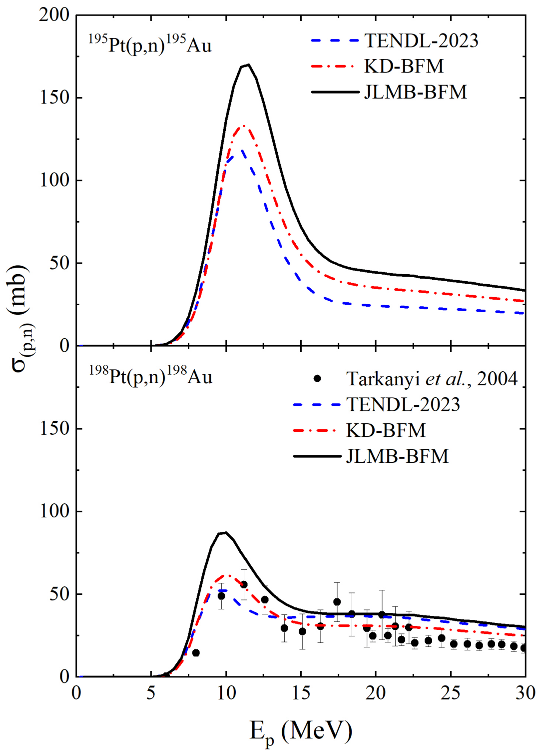

FIG. 1: The calculated excitation functions for ^{195,198}Pt(p,n)^{195,198}Au reactions.

Results and Discussion

The (p,n) reaction cross sections, $\sigma_{(p,n)}$, on stable isotopes of ^{195,198}Pt have been calculated for incident proton energy values upto 30 MeV. Fig. 1 shows the calculated excitation functions for ^{195,198}Pt(p,n)^{195,198}Au compared with corresponding data [7] and TENDL-2023. It is observed from the figure for ^{198}Au that in general, all the calculations agree with the data, except for JLMB-BFM, which overpredicts the data. None of the calculation is able to reproduce the shape of the excitation function in the tail region. The optimization of OMPs along with LD parameters would substantially improve the agreement with the data. The excitation functions exhibit a peak near 10 MeV, indicating maximum production, which will be valuable in planning the large-scale production of ^{195,198}Au isotopes. There are no data available for ^{195}Pt(p,n)^{195}Au reaction for comparison. It is proposed to perform a measurement of ^{195}Pt(p,n) reaction cross sections at an accelerator facility.

Acknowledgments

S.H. and M.H. are grateful to the DST-SERB, India, for financial assistance under Grant No. CRG/2021/008396. M.H. acknowledges the financial support from UGC-DAE-CSR through project CRS/2021-22/02/527. M.H. thanks the UGC-FRP for the support.

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