Isomeric ratios for several residues in the interaction of ^{16}O with ^{181}Ta and ^{103}Rh

Devendra P. Singh[1],* Abhishek Yadav[1], Unnati[1], Pushpendra P. Singh[2], Manoj Kumar Sharma[1], Sunita Gupta[3], K. S. Golda[4], R. Kumar[4], A. K. Sinha[5], B. P. Singh[1], and R. Prasad[1]

[1]*Department of Physics, Aligarh Muslim University, Aligarh (UP)-202 002, INDIA*
[2]*INFN-Laboratori Nazionali di Legnaro, I-35020 Legnaro, ITALY*
[3]*Department of Physics, Agra College, Agra (U.P.) INDIA*
[4]*Inter-University Accelerator Center, Aruna Asaf Ali Marg, New Delhi - 110 067, INDIA and*
[5]*UGC-DAE-CSR, Bidhan Nagar, Kolkata - 700 098, INDIA*

Introduction

During the last several years a great deal of interest has been observed in the study of heavy ion (HI) reaction dynamics and decay characteristics of the nuclei at incident energies near and above the Coulomb barrier (CB)[1, 2]. When the HIs, of energy more than CB, are incident on the target nuclei, compound nuclei may be populated in high angular momentum states. As the compound nuclei de-excite by emitting nuclear particles and/or γ-rays, the residual nuclei are formed in the state close to yarst line. Final nuclei may be populated in both the ground as well as meta-stable state, depending on the states coupled to isomer and the probability of their production. The isomeric cross-section ratios of the residues populated in different projectile-target combinations may provide information of considerable importance about the structure of a nucleus and on the mechanism of its production. The main factors which govern the isomeric ratios are; i) the distribution of excitation energy and angular momentum in the compound nuclei, ii) the probability of population of the ground and meta-stable states after each step of the de-excitation cascades, iii) the angular momentum removed by the emitted particle or γ-quantum at each step of the de-excitation, iv) the number of de-excitation cascades and decay paths of each states and v) the spins of the isomeric-pair states. Isomeric production ratios R $(= \sigma_m/(\sigma_m+\sigma_g)$ may be determined from the ratio of experimentally measured activities of the final reaction products of interest. In the present work an attempt has been made to study the dependence of isomeric production cross-section ratio of several residues on the energy of the incident heavy-ion in ^{16}O+^{181}Ta and ^{16}O+^{103}Rh system.

*Electronic address: dpsingh19@gmail.com

Experimental details

The experiments have been performed at the Inter-University Accelerator Center (IUAC), New Delhi, India, using energetic $^{16}O^{7+}$ ion beam[3], obtained from the 15UD-Pelletron accelerator. The targets of ^{181}Ta ($\approx$99.99%) of thicknesses $\approx$1.5-2.0 mg/cm^2 were prepared by the rolling method. The stacked foil activation technique has been used to cover a broad energy range. The irradiations have been performed in the General Purpose Scattering Chamber (GPSC) having invacuum transfer facility (ITF). Stacks of targets alongwith the catcher foils were irradiated at different beam energies. The irradiations have been carried out for the duration of $\approx$6-8 h, with a beam current $\approx$5-7 pnA. After irradiation, the activities produced in each sample-catcher assembly of the stacks were counted separately using a pre-calibrated high purity germanium spectrometer. Cross-sections for the meta-stable and ground state populations of residues ^{194}Tl, ^{193}Tl, ^{192}Tl, ^{193}Hg, ^{191}Hg, ^{115}Te, ^{110}In and ^{108}In have been determined from the

TABLE I: Experimentally measured cross-sections for the residue ^{193}Hg^{g,m}populated in the interaction of ^{16}O with ^{181}Ta system alongwith the isomeric ratio for this residue.

E_{lab} (MeV)	$\sigma(^{193}$Hg$^{g})$ (mb)	$\sigma(^{193}$Hg$^{m})$ (mb)	R
76 ± 1.1	23±3.5	8±0.8	0.26±0.06
80 ± 1.5	47±7.0	21±2.1	0.31±0.07
85 ± 1.2	60±8.9	30±3.0	0.33±0.08
87 ± 1.0	49±7.4	22±2.2	0.31±0.07
88 ± 1.6	42±6.2	24±2.3	0.36±0.08
93 ± 1.1	29±4.4	13±1.3	0.31±0.07
97 ± 1.0	12±1.7	8 ±0.7	0.4±0.08
99 ± 0.9	10±1.5	6±0.5	0.38±0.08

intensities of the γ-lines of corresponding residues. As a representative case, the experimentally measured values of the cross-sections for the isomeric and ground state population of residue ^{193}Hg are given in Table I.

Results and discussion

Isomeric production cross-section ratios for ^{194}Tl, ^{193}Tl, ^{192}Tl, ^{193}Hg, ^{191}Hg, ^{115}Te, ^{110}In and ^{108}In produced via CF and/or ICF channels have been determined. As an example the residue ^{193}Hg may be populated by CF process via the reaction ^{181}Ta(O,4n)^{193}Hg. The same residue ^{193}Hg may also be populated via the decay of higher charge isobar precursor ^{193}Tl formed via ^{181}Ta(O,4n) channel. The precursor contribution could not be seperated[3]. The isomeric state ^{193m}Hg ($J^{\pi} = 13/2^{+}$) has a half-life of 11.8 hrs, while the ground state ^{193g}Hg ($J^{\pi} = 3/2^{-}$) has a half-life of 3.8 hrs. As a typical example, the cross-section values for ^{193}Hg, given in Table I, have been plotted in the upper panel of Fig. I. In order to study the energy dependence of isomeric production cross-section ratio R on beam energy, the isomeric ratios R for the residues $^{193}Hg(p3n)$ have been plotted in the lower panel in Fig. I. It may be noted from the Fig. I(b), that the isomeric production ratio increases with energy. It may be because, as the entrance channel energy increases, it gives rise to increased angular momentum brought into the system

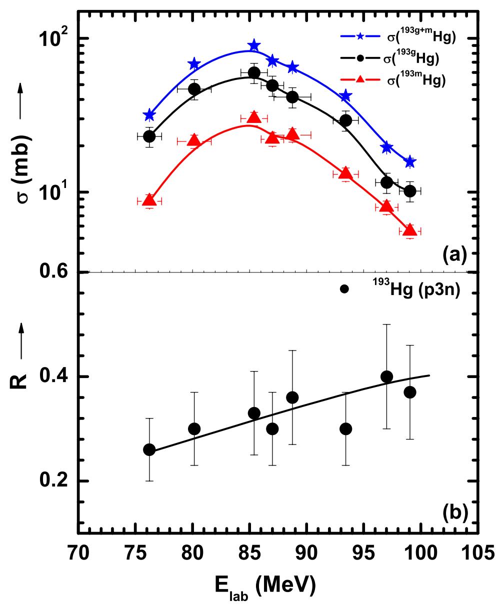

FIG. 1: (a) The cross-section values for both the states of ^{193}Hg, (b) Isomeric ratios for the residue $^{193}Hg(p3n)$ populated in ^{16}O+^{181}Ta system.

and hence increased population of isomeric states in the nuclei ^{193}Hg as compared to ground state population. Similar trends have been observed in some other nuclei as well. The details will be presented.

References

[1] Pushpendra P. Singh, et al., Phys. Lett. B 671, 20(2009).

[2] P. Vergani, et al., Phys. Rev. C 48, 1815 (1993).

[3] Devendra P. Singh, et al., Phys. Rev. C 80, 014601(2009).