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Nuclear Physics A 753 (2005) 29–52
NUCLEAR PHYSICS A

Excitation functions of residues in the interaction of ^{12}C with ^{103}Rh up to an incident energy of 400 MeV

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Received 8 November 2004; received in revised form 7 February 2005; accepted 24 February 2005

Abstract

The excitation functions for production of 45 residues in the interaction of ^{12}C with ^{103}Rh at incident energies ranging from about 40 to 400 MeV are analysed in terms of many competing reaction mechanisms including complete and incomplete fusion reactions and the quite relevant contribution of the decay of the target nucleus excited in the inelastic scattering of the incident ^{12}C ions. The cross-sections of most of these mechanisms have been obtained by extrapolation from the values measured in the interaction of ^{12}C with the neighbouring nucleus ^{93}Nb. The agreement between experimental data and model predictions is very good in most cases.

PACS: 25.70.Gh; 25.70.Mn

Keywords: NUCLEAR REACTIONS ^{103}Rh(^{12}C, X), $E = 40$–400 MeV; measured evaporation residues isotopic production σ, excitation functions. Activation technique, Monte Carlo calculations, Boltzmann master equation theory.

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0375-9474/$ – see front matter
doi:10.1016/j.nuclphysa.2005.02.126

1. Introduction

There is an ever-increasing demand for the use of nuclear physics concepts, theories and experimental information in other sciences and for applications of interest to mankind. The importance of this trend should not be underestimated and we should ask ourselves if our present knowledge is adequate for these purposes. In fact, their fulfillment needs quantitative, systematic and comprehensive information. This information is often lacking, especially in the field of nuclear dynamics. Considerable efforts are actually being made to create databases of experimental data and theoretical predictions which could be used for interdisciplinary purposes. Examples of such work and of calculations performed for nucleon induced reactions are available in the literature [1–4]. However, for heavy ion reactions comparable information is still lacking, in spite of its equally increasing importance for applications in transdisciplinary fields.

The work described in this paper is part of research aimed at acquiring data which could produce the required comprehensive information and thereby aid in developing phenomenological theories which are able to provide a quantitative account of all measured observables in reactions induced by lighter heavy ions, such as ^{12}C and ^{16}O. These data include the spectra of all emitted particles and the yields of recoiling residues which are produced; in other words of all the measurable consequences of the interaction of these light heavy ions with matter.

The first of these investigations [5,6] consisted of the measurement of the excitation functions for residue production in the interaction of ^{12}C with a medium heavy nucleus (^{103}Rh) at energies ranging from the Coulomb barrier up to 400 MeV. Subsequent experiments also investigated reactions induced by ^{16}O and the data were extended to include the forward range and angular distributions of residues [7], emission spectra of α particles [8] and intermediate mass fragments (IMFs) [9–13], produced in these interactions with nuclei having mass varying from 60 to 200. The Doppler broadening and shift of the γ lines of the observed residues from the interaction of ^{12}C with ^{63}Cu were also studied [14]. A number of cross-sections for production of residues not previously observed were measured at 400 MeV by performing radiochemical separations [15,16]. These investigations [5–16] led us to propose a *scenario* which may provide a comprehensive and consistent description of all these observables.

Although the main conclusions drawn from the original analysis of the excitation functions for production of a large number of residues in the interaction of ^{12}C with ^{103}Rh [5–7] are still considered to be essentially correct, the additional accumulation of new data certainly enables us to refine the initial tentative assumptions. These improvements were necessary in order to reproduce together with the experimental excitation functions also the spectra of α particles and IMFs measured at a later stage. Thus, it is appropriate to present in this paper a consistent re-analysis of all our data (some of which were not published before) combined with the analysis of the results obtained in the most recent experiment [15, 16] in which the cross-sections for production of certain near-target residues were measured at an incident energy of 400 MeV. Our new experiment was performed to test the correctness of a very significant prediction done on the basis of the results of our original analysis, i.e., that the near-target nuclei are produced with the highest cross-sections. Since