Searching for fusion suppression in reactions having entrance-channel mass-asymmetry values around the Businaro-Gallone point

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It is widely recognized that a description of fusion of massive nuclei must go beyond conventional potential-barrier passing models applicable to medium-mass systems. For two massive nuclei experiments show that compound nucleus (CN) formation or fusion cross sections are strongly reduced at incident energies around the nominal fusion barrier due to the onset of competing reactions assigned mainly to the quasi-fission (QF) process. This limitation in fusion has been recently found to be significant even in rather asymmetric combinations, like those leading to Ra compound nuclei [1,2]. Thus, in the ^{12}C + Pb combinations no limitation seems to occur, while the effect becomes noticeable with ^{30}Si [1], ^{22}Ne [2] and even with ^{19}F [1]. Suppression factors are estimated to be within (35–45)% when one compares evaporation residue (ER) cross sections measured with ^{12}C and those for heavier projectiles, and reach about 70% in the case of ^{48}Ca [2]. An increase in this inhibition has to be accompanied by an increase in the QF component and vice versa. For asymmetric systems with ^{48}Ca, a prominent QF component is observed in the mass and energy distributions of fission fragments [3], it may affect the ER production in reactions leading to relatively weakly fissile compound nuclei [4]. The trend, in general, can be qualitatively discussed in terms of the liquid-drop model [5]. Depending on the location of the saddle-point energy with respect to the entrance-channel mass-asymmetry (the Businaro-Gallone point) [5], a di-nuclear system (formed after the contact of reactants) may evolve towards complete fusion (CN formation) or may re-separate, with a strong QF effect [1]. The details of how this dynamical evolution takes place are presently poorly understood.

Searching for the "starting point" at the entrance-channel mass-asymmetry coordinate, where the fusion suppression starts to show up, and its dependence on the asymmetry and fissility of CN, we analyzed available data on ER production and fission in a wide region of CN masses and asymmetry values. Comparing cross sections for the ER production and fission in reactions leading to the same CN, but having different values of entrance-channel mass-asymmetry, we extracted the fusion suppression factor in a more symmetric combination relatively to quite an asymmetric one, where no limitation seems to occur. We attempted to find correlations between the fusion suppression observed in the discussed combination of interacting nuclei and its position in relation to the Businaro-Gallone point at the mass-asymmetry coordinate. In application of the idea, we considered the effect of the entrance-channel mass-asymmetry (along with some other reaction parameters and properties of nuclei) on the production of the heaviest nuclei in complete fusion reactions.

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