Proposed projectile target combinations for the synthesis of superheavy elements Z=119 and Z=120

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Introduction

Hot heavy ion fusion reactions have been successfully used to synthesise superheavy elements (SHE) with Z=112−118 using the ^{48}Ca beam incident on actinide targets. The production cross-sections for these SHE is of the order of pico barns which is the limiting measurement capability of the presently available experimental facilitities.

Here we propose specific target projectile combinations for the synthesis of elements with Z=119 and 120 in the conventional picture of complete fusion followed by de-excitation of the compound nucleus. In this approach the calculation of the production cross-section depends on the fusion probability to form the compound nucleus and the survival probability. The latter is the probability of the excited compound nucleus to decay to the ground state of the residual nucleus via evaporation of light particles (mainly neutrons) and thus avoiding fission.

Calculation and Results

We use HIVAP [1] code for the present calculations. The HIVAP code adopts the conventional picture of the complete fusion after passing the barrier along with the statistical de-excitation of the compound nucleus. It uses dynamically fluctuating barrier (gaussian distribution with cut-off at both sides after five standard deviations) for the calculation of fusion probabilities. Fussion is supposed to occur when the Bass barrier is passed which is

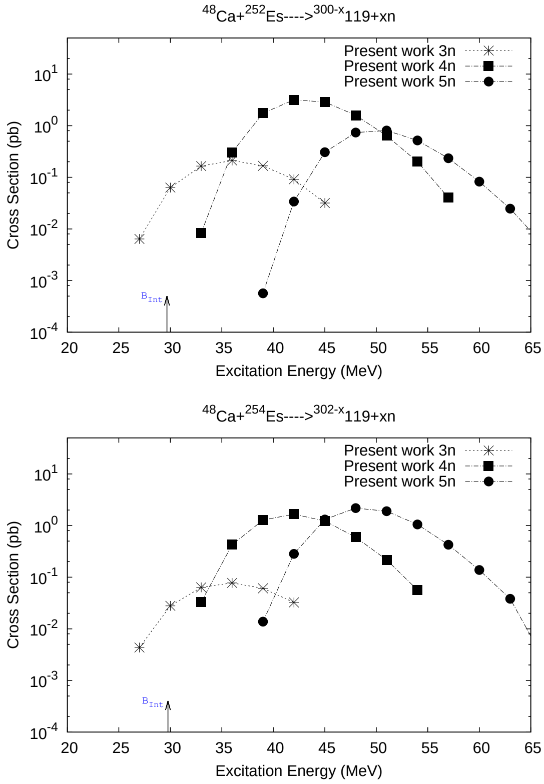

FIG. 1: Excitation energy (E*) dependence of the evaporation residue cross sections for the ^{252,254}Es(^{48}Ca,xn) reaction, leading to the synthesis of various isotopes of the element Z = 119.

the case in these reactions. Conventional statistical evaporation theory is employed for the de-excitation of the compound nucleus. The main parameters for this calculation for fission are level density, fission barrier and masses. We use available experimental mass values in the calculation. The details are described in

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reference 1.

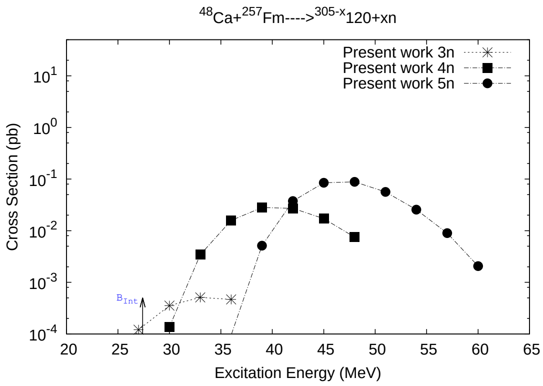

FIG. 2: Excitation energy (E^*) dependence of the evaporation residue cross sections for the ^{257}Fm(^{48}Ca,xn) reaction, leading to the synthesis of various isotopes of the element Z = 120.

The HIVAP code requires several input parameters. It is found that the calculations are sensitive only to a few parameters. The rest of the parameters can be frozen. Different parameter sets have been used for the calculation of the production/evaporation residue cross-sections (σ_{ER}) for specific reactions. Our aim is to find a single standard parameter set suitable for all available hot fusion reactions. For this purpose we first carried out a sensitivity test of the parameters for the production cross-sections and arrived at [2] a single standard parameter set to be used in all hot fusion reactions.

Here we propose the reaction ^{48}Ca+^{254}Es (^{252}Es) for the synthesis of superheavy element ^{302}119 (^{300}119). The half-life of target isotope ^{254}Es (^{252}Es) is 276 (472) days, sufficient to be used as target material. Fig.1 shows the calculated evaporation residue cross-section as a function of excitation energy E^* of the CN for the synthesis of Z=119 element. Here $E^*=E_{CM}+Q$ with $Q=(M_P+M_T-M_{CN})C^2$ where M_P (M_T) is the ground state mass of the projectile (target) and M_{CN} is the mass of the compound nucleus. Here B_{int} = Bass barrier + Q. It is clear from the figure that the maximum production cross-sections are of the order of pico barns for the 4n and 5n channels which can be measured experimentaly.

Similar results for the synthesis of the element Z=120 are shown in fig.2 for the reaction ^{48}Ca+^{257}Fm. The half-life of target isotope ^{257}Fm is 100 days. The calculated production cross-sections are indeed small, the maximum value is around 0.1 (0.03) pico barns for 5n (4n) channels at 48 (39) MeV excitation energy this probabily can be measured with the upgraded future facilities. For the synthesis of element Z=120 using the reaction ^{50}Ti+^{249}Cf in the reference [3] have suggested maximum cross-section values of 2×10^{-2} pb for 4n channel.

References

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