Compound Nucleus formation and Survival probability of $^{50,51}V+^{242-248,250}Cm$ reactions

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Introduction

In recent decades, Nuclear physicists aimed to uncover the properties of atoms with atomic number>103, known as superheavy elements [SHE]. With persistent efforts, seventh row of the periodic table was completed by synthesising elements up to Z=118 through fusion processes. Elements from Z=113-118 are synthesized from hot fusion reactions initiated by Ca as a projectile to induce fusion with the suitable targets. But to produce an element Z>118 using a Ca projectile is very challenging due to poor availability of targets and extremely lower cross-sections. Therefore, in current work we have selected $^{50,51}V$ as a projectile [1,2] higher than Ca.

In present work we have investigated all possible isotopic combinations of V+Cm reactions.We have calculated formation (P_{CN}) and survival (P_{sur}) probability of compound nucleus [3,4] to predict the promising fusion reaction to successfully synthesis SHE Z=119. Hoping this result helps the experimentalists to extent the periodic table to 8th row.

Theory

The interacting potential barrier for a parent nucleus exhibiting fusion consists of Coulomb potential and nuclear proximity potential which can be found in the literature [5].

The formation probability of compound nucleus is expressed as;

$$P_{CN}=\frac{\exp[-C(\chi_{eff}-\chi_{thr})]+\psi_{sh}\sqrt{f_{sh}}}{\alpha f_{\beta}\zeta^{0.1}+\exp\left(\frac{E_B^*-E^*}{\Delta}\right)} \quad (1)$$

This P_{CN} is a function of effective fissility χ_{eff} [6], shell correction f_{sh} [7], bass barrier energy E_B^*, excitation energy E^*.The fitting parameters for this formula is suggested in the literature [8] by Manjunatha et al.,

The Survival probability of compound nucleus [9] is expressed as :

$$P_{sur}^{xn}(E_{CN}^*,l) = P_{xn}(E^*)\prod_{i=1}^{i_{max}=x}\left(\frac{\Gamma_n}{\Gamma_n+\Gamma_f}\right) \quad (2)$$

where Γ_n and Γ_f are the decay widths of neutr- -ons and of fission [10], respectively and function of compound nucleus excitation energy E_{CN}^* and angular momentum l.

Results and Discussions

In the present work we have made a detailed study of $^{50,51}V$ induced fusion reactions in order to synthesise superheavy element 119. The element Cm is taken as a suitable target with element V. Here we have investigated all possible isotopic combinations of $^{50,51}V$ projectile with $^{242-248,250}Cm$ targets. We have studied all fusion combinations of 16 reactions and tried to find the best suitable reaction to synthesise superheavy element 119.

The synthesis of superheavy element takes place in three different stages. First stage is capture, followed by the formation of compound nucleus and the last stage is formation of evaporation residue (SHE) [11]. The highly excited compound nucleus is formed by overcoming the hinderance known as quasifission. From **Fig. 1** we can observe the variation of P_{CN} as a function of center of mass energy (E_{CM}). P_{CN} increases with E_{CM} values and reaches saturation. Plot.1 shows the higher values of P_{CN} for the ^{51}V projectile with $^{242-248,250}Cm$ targets. This is due to higher values of mass asymmetry [12] and lower values of χ_{eff} parameter which reduce the tendency of quasifission [13]. This confirms that ^{51}V has

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the highest possibility to form a compound nucleus with $^{242\text{-}248,250}$Cm targets **Fig. 2** shows the variation of survival probability of compound nucleus (P_{sur}) as a function of atomic masses of target nuclei $^{242\text{-}248,250}$Cm with ^{50,51}V as projectile for fusion reactions.

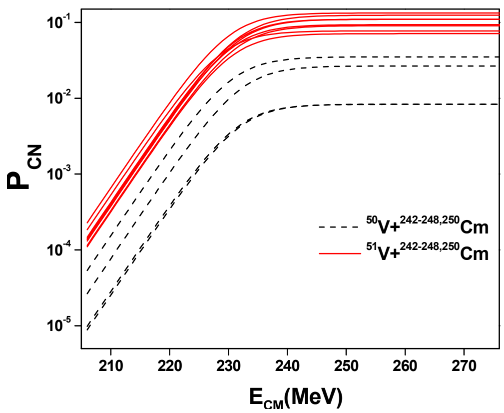

Fig. 1: Variation of formation probability of compound nucleus as a function center of mass energy (E_{CM}).

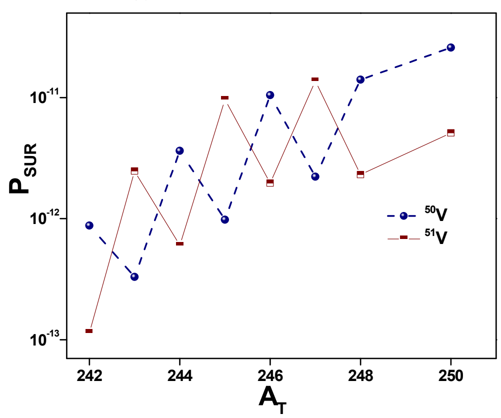

Fig. 2: Variation of survival probability of compound nucleus as a function atomic mass of target nuclei for ^{50,51}V projectiles.

By making keen observations from plot. 2, we can notice that ^{50}V+^{250}Cm and ^{51}V+^{247}Cm are the fusion reactions that show a higher value of P_{sur}. The compound nucleus formed with fusion of this P-T combinations has a higher tendency to survive against fusion-fission, leading to form evaporation residue by liberating 3 neutrons. By analyzing both parameters from 2 figures, we can conclude that fusion reactions with projectile ^{51}V have higher P_{CN} than ^{50}V, which in turn has the greater significance to survive against fusion-fission. Hence, we can conclude that ^{51}V+^{247}Cm as the best suitable fusion reaction to produce SHE Z=119.

Conclusions

In the present work we have systematically investigated all possible isotopic projectile and target combinations of ^{50,51}V+$^{242\text{-}248,250}$Cm fusion reactions. The valu--es of P_{CN} and P_{sur} for all the reactions are computed and examined for the outcomes. By analysing the values, we concluded that ^{51}V+^{247}Cm as the best promising projectile and target combination to synthesise superheavy element 119 to give fruitful results. Hoping that our predictions help the experimentalists to successfully synthesise superheavy element Z=119 in future days and extend the periodic table to 8throw.

References

[1] H. C. Manjunatha et al., Nucl. Phys. A. **981**, 17-37 (2019)

[2] Adamian G. G et al., Nucl. Phys. A. **970**, 22-28 (2018)

[3] Chopra et al., Phys. Rev. C. **91**, 034613 (2015)

[4] Manjunatha et al., Euro. Phys. Jour. A. **53**, 1-11 (2017)

[5] Santhosh et al., Nucl. Phys. A. **889**, 29-50 (2012)

[6] S Bjørnholm et al., Nucl. Phys. A. **391**, 471-504 (1982)

[7] Alberto Mengoni et al., Jour. Nucl. Sci. Tech **31**,151-62, (1994)

[8] H. C. Manjunatha et al., Phys. Rev. C. **110**, 014601 (2024)

[9] A. S. Zubov et al., Eur. Phys. J. A. **23**, 249-256 (2005)

[10] Sowmya N et al., Phys. Rev. C. **105**, 044605 (2022)

[11] K. P. Santhosh et al., Phys. Rev. C. **94**, 024623 (2016)

[12] E Vardaci et al., J. Phys. G. 46, 103002 (2019)

[13] H. C. Manjunatha et al., Phys. Rev. C. **102**, 064605 (2020)