Effect of closed shell on heavy-ion fusion reaction

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It is well known that in the heavy-ion fusion reaction, the fusion probability decreases from unity as the charge product of projectile and target exceeds about 1800 even if projectile has enough kinetic energy to surmount a fusion barrier. This fact, so called extra-push phenomena, is a large obstacle on the way to synthesis of the super-heavy elements. The fusion between massive nuclei depends on not only the charge product but also the nuclear structure of projectile and target [1,2]. Oganessian et al. [3] have reported the measurements of evaporation residues in the fusion reactions ^{130}Xe+^{86}Kr and ^{136}Xe+^{86}Kr, where the nucleus ^{136}Xe has a closed neutron shell N=82 and the neutron number of the nucleus ^{130}Xe is 76, six neutrons less than the closed shell. The nucleus ^{86}Kr has also the magic number N=50. They found that the measured evaporation residue cross-sections for the reaction ^{136}Xe+^{86}Kr are almost 2-3 orders of magnitude larger than those for the fusion reaction ^{130}Xe+^{86}Kr near the Coulomb barrier. Recently, we have measured the fusion evaporation residues in the reactions ^{82}Se+^{134}Ba and ^{82}Se+^{138}Ba [4] near the Coulomb barrier, where ^{138}Ba has the neutron closed shell N=82 and ^{134}Ba has a neutron number 78, four neutrons less than the closed shell. The projectile ^{82}Se has 48 neutrons, two neutrons less than the magic number N=50. The evaporation residues were measured by using a recoil-mass separator (JAERI-RMS). The measured evaporation residue cross-sections of *xn* and *pxn* channels for the reaction system ^{82}Se+^{138}Ba were considerably larger than those for the reaction system ^{82}Se+^{134}Ba, almost 100 times larger at the excitation energy of 20-30 MeV. The reduced cross section, which is the cross section divided by ð(ë/2ð)^2, was also the largest in the reaction system ^{82}Se+^{138}Ba compared with the other reaction systems which make the same compound nucleus ^{220}Th as the reaction system ^{82}Se+^{138}Ba, except the reaction system ^{16}O+^{204}Pb. We measured the evaporation residue cross sections of ^{16}O+^{204}Pb and found that the reduced cross section for the system ^{16}O+^{204}Pb was the one order of magnitude larger than those of the reaction system ^{82}Se+^{138}Ba. This is consistent with the recent result of Hinde et al. [5]. The present result shows that the fusion of the reaction system ^{82}Se+^{138}Ba is really hindered, while the neutron shell closure N=82 also plays an important role in the enhancement of the formation probability of the compound nucleus in the massive reaction system. We also measured the evaporation residues in the reactions ^{86}Kr+^{134,138}Ba and ^{82}Se+^{nat}Ce. Together with these data, we will discuss the effect of N=82 shell closure of target nucleus on heavy-ion fusion reaction.

References

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