Confirmation of the Assignment of a 1.5-Second Fission Activity to ^{259}Fm

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In 1995, two separate experiments were performed at the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory to study the nuclear properties of ^{266}Sg using the reaction ^{248}Cm(^{22}Ne,4n)^{266}Sg at 118 MeV and 121 MeV. The results of these experiments will be discussed in a separate submission to this annual report. However, the use of this particular reaction provides an important opportunity to study the production of ^{258}Fm and ^{259}Fm in binary transfer reactions.

The assignment of a 1.5-second spontaneous fission(SF) decay to ^{259}Fm results from the tritium bombardment of a ^{257}Fm target[1]. Since ^{258}Fm was already known to decay by SF with a half life of 0.37 ms, the observed 1.5-second fission activity was assigned to ^{259}Fm, produced by the ^{257}Fm(t,p)^{259}Fm reaction.

However, the possible discovery[2] of a SF isomer in ^{262}Rf suggests that the 1.5 second fission activity could be from an isomer of ^{258}Fm. Because the target material is very scarce and finding a tritium accelerator is next to impossible, it would be difficult to repeat the original measurement. Even then it might still be difficult to differentiate between the (t,p) and (t,d) reactions.

Therefore, a different reaction was chosen to try to confirm the assignment of the 1.5-second fission activity. This reaction must selectivity produce either ^{258}Fm or ^{259}Fm. Bombarding ^{248}Cm with ^{22}Ne provides just such a reaction.

Several different isotopes of fermium are produced via transfer reactions in the bombardment of ^{248}Cm with ^{22}Ne. The excitation energy (E^*) of the target-like fragments help indicate the relative yields from the binary transfer reaction[3]. If the E^* is very negative that isotope will be formed with lower yield. A positive E^* below the threshold for neutron emission and fission is ideal for production of a particular nuclide. The following table shows the E^* values for the production of several fermium isotopes.

Table 1: E^* for ^{248}Cm(^{22}Ne,^{A}Be)$^{270-A}$Fm

Isotope	E^*(MeV)#
^{257}Fm	5.7
^{258}Fm	6.5
^{259}Fm	-7.8
^{260}Fm	-15.0

This table shows that conditions are optimal for the production of ^{258}Fm, but not for ^{259}Fm. This is, however, a blessing. While ^{258}Fm should be produced in measurable quantities, production of ^{259}Fm should be very limited. Therefore, the presence or absence of a 1.5-second fission activity should indicate its origin.

After analyzing all the available data, no evidence is seen for a 1.5-second SF activity. An upper limit on the cross section for production of a 1.5-second activity was found to be 150 pb. Comparison of this reaction with similar transfer reactions would indicate a cross section of approximately 10 nb for the production of ^{258}Fm. A longer-lived isomer would be expected to receive some significant portion of this cross section. Thus, it is likely that the 1.5-second SF activity arises from ^{259}Fm and not from ^{258}Fm.

Footnotes and References

E^* values calculated at the coulomb barrier

1. Hoffman, D. C. , et al, "Discovery of ^{259}Fm," Proc. 3rd Intl. Conf. on Nuclei Far from Stability, Cargese, Corsica, France, 19-26 May, 1976, Geneva, CERN 75-113, 15 July 1976, p. 558.

2. Lane, M. R. et al, Phys. Rev. C. **53,** 2893 (1996).

3 Hoffman, D. C. and Hoffman, M. M. " Calculated Excitation Energies for Transcurium Products of Binary Heavy Ion Reactions;" LA-UR-82-824 (1982).