Production Cross Sections for ^{254}Fm and ^{256}Fm in ^{248}Cm + ^{22}Ne Reactions

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The cross sections for ^{254}Fm and ^{256}Fm produced in the interactions of ^{22}Ne ions with ^{248}Cm were measured. Excitation functions provide information about the reaction mechanism of transfer reactions involving actinides. By studying these reactions, we can design better experiments for production of exotic isotopes, particularly neutron-excess actinides. More immediately, if the production cross sections are known, ^{254}Fm and ^{256}Fm can be used to measure the efficiency of transporting reaction products to the detectors during compound nucleus experiments to produce Sg isotopes in the ^{248}Cm + ^{22}Ne reaction.

^{254}Fm and ^{256}Fm were chosen for this experiment for three reasons. The ^{22}Ne + ^{248}Cm reaction produces sufficient quantities of both isotopes. Detection of these nuclides is relatively easy as ^{256}Fm decays predominantly by spontaneous fission and ^{254}Fm emits a relatively high energy alpha particle that can be distinguished from the background activity. In addition, these Fm isotopes have half-lives that are suitable for this experiment.

Experiments were performed at two different cyclotron energies. With a lab energy of 139 MeV out of the cyclotron, the energy range of the Ne ions in the 1.26 mg/cm^2 target was 114.4-118 MeV. This energy range includes the Coulomb barrier, which is close to 116 MeV. The experiment was performed with a second target of 0.96 mg/cm^2. The projectile energy out of the cyclotron used with this target was 151 MeV in the lab frame. This is degraded to 119-121.5 MeV inside the target.

During each experiment, a gold foil was placed behind the Cm target to catch recoiling reaction products. The foil was then dissolved in aqua regia and the lanthanides and actinides were separated from the gold with an ion-exchange column. The eluate was dried on a platinum disk to produce a source for alpha and SF spectroscopy. These sources were monitored at various intervals with surface barrier detectors to discover isotopes that decay by alpha emission or by spontaneous fission.

Cross sections for production of the two isotopes were determined in each experiment. At the energy near the Coulomb barrier, the cross section for production of ^{256}Fm (σ_{256}) was found to be $0.27 \pm 0.11 \mu b$ and the cross section for production of ^{254}Fm (σ_{254}) was measured as $5.3 \pm 1.1 \mu b$. The ^{254}Fm value does not agree within 1σ error limits with that obtained by Lee et al. at the same energy.[1] In that study, σ_{256} was measured as $0.15 \pm 0.04 \mu b$ and σ_{254} was quoted as $3.1 \pm 0.4 \mu b$. In two experiments at the higher energy, the production cross sections increased. σ_{256} was measured as $0.57 \pm 0.11 \mu b$ and $0.48 \pm 0.08 \mu b$. σ_{254} was found to be $9.7 \pm 1.4 \mu b$ and $7.8 \pm 1.1 \mu b$. These results indicate that further studies of this system should be undertaken. In particular, excitation functions over a wider energy range for these Fm isotopes should be produced.

Footnotes and References

1. D. Lee et al., Phys. Rev. C, 25 286 (1982).