

An EC-branch in the decay of 27-s ^{263}Db : Evidence for the new isotope ^{263}Rf

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The first hint for ^{263}Rf was reported by Czerwinski et al. who detected 7 spontaneous fission (SF) events with a half life of 500^{+300}_{-200} s in rutherfordium fractions separated by manual TTA extractions from the $^{248}\text{Cm}(^{18}\text{O}, 3n)$ reaction at 92.5 MeV [1]. No α events could be attributed to ^{263}Rf .

In 1990, we discovered the new isotope 27-s ^{263}Db in the $^{249}\text{Bk}(^{18}\text{O}, 4n)$ reaction at 93 MeV by eluting element 105 from cation exchange columns in unbuffered 0.05 M α -HiB [2].

In 1993, a rutherfordium fraction was milked from ^{263}Db , and 22 SF events were registered in that fraction. Of these, 8.8 events had to be assigned to a contamination by ^{256}Fm . A two-component decay curve with the ^{256}Fm fixed gave a half life of 10^{+5}_{-3} min for the isotope ^{263}Rf [3]. Based on the effective production cross section, an EC-branch in ^{263}Db on the order of 5% was deduced [3]. Two α particles at 7.9 MeV were discussed as possibly being associated with the decay of ^{263}Rf giving an upper limit for the α -decay branch of 30%.

A search for ^{263}Rf in the $^{248}\text{Cm}(^{22}\text{Ne}, \alpha 3n)$ reaction at 122 MeV by Dressler et al. [4] involving a chemical separation of Rf as the volatile tetrachloride yielded two α particles at 7.8 and 7.9 MeV and four SF events with very long life times. Another search using the same reaction and aqueous chemistry with fluoride complexes of Rf [5] yielded two α events near 7.9 MeV with unusually long life times. This was not considered to present conclusive evidence for ^{263}Rf [4],[5].

We have attempted to add further evidence for an EC-branch in the decay of ^{263}Db and for ^{263}Rf in an experiment at the Paul Scherrer Institute (PSI), Switzerland, producing again ^{263}Db in the $^{249}\text{Bk}(^{18}\text{O}, 4n)$ reaction at 93 MeV. The activity was transported by a He/KCl jet and collected for 15 min on a Ta disc. It was dissolved in 2 x 20 μl of unbuffered 0.5 M α -HiB and added on top of a 3 x 50 mm cation-exchange column (AG 50Wx8). The α -HiB solution contained ^{88}Zr tracer for the determination of the chemical yield for group-4 elements. These were eluted from the column with 1 ml 0.5 M α -HiB. The eluate was mixed with 3 ml 12 M HCl yielding a solution being 9 M in HCl. This was subject to liquid-liquid extraction with 200 μl of 20 vol% TBP/Cyclohexane which, after phase separation, was evaporated to dryness on a Ta disc. The Ta discs were assayed for α and SF activity starting about 8 min after the end of collection. The He/KCl jet efficiency was about 50%, the chemical yields were 70% on the average. The decontamination factor for Fm was on the order of 10^4 .

In some 200 experiments, a total of 9 SF events was registered of which 2 have to be considered a long-lived background. The life times are consistent with a half life of ^{263}Rf of about 22 min with an uncertainty of ± 5 min. Relative to the measured cross section for production of ^{263}Db in the $^{249}\text{Bk}(^{18}\text{O}, 4n)$ reaction at 93 MeV, 10 ± 6 nb [2], the new experiments give an EC-branch in the decay of ^{263}Db of

$$3^{+4}_{-1}\%$$

and provide additional evidence for the new isotope ^{263}Rf . The latter decays predominantly by spontaneous fission with a long half life of tens of minutes. In principle, the observation of α particles from the α -decay daughter of ^{263}Rf , ^{259}No (7.472 – 7.689 MeV), could help to fix the α -decay branch in the decay of ^{263}Rf . However, this part of the spectrum is masked by a contamination with the naturally occurring ^{214}Po (7.687 MeV). The picture that consistently emerges from [3] and the present work is shown in Fig.1.

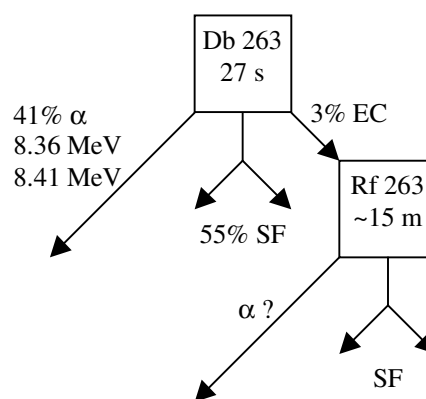


Fig.1 Decay scheme for ^{263}Db and ^{263}Rf

References

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