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ABSTRACT :

By chemical evaporation technics, neutron deficient Hafnium nuclei have been on-line separated at the ISOCELE facility, from the isobar rare-earth elements, in the metal-fluoride HfF_3^+ ion form. Half-lives of $^{162-165}\text{Hf}$ have been measured. Similarly, Tantalum has been selectively separated on the TaF_4^+ form.

It is well known that the presence of halogens and oxygen increases the separation efficiency of refractory elements forming volatile halides or oxides. This effect has been used for example to separate the short life fission products in the gaseous phase with controlled O_2/HCl mixing in the transport N_2 gas (1), or to separate the Zr, Mo elements by reaction with metal-chloride vapours (NbCl_5) as impurity in the carrier N_2 gas (2).

In the case of on-line mass separation, the chemical reaction in the ion-source was first observed by Ravn and al. (3) who reported the production of BaF^+ ion at ISOLDE. The fluorine originated from impurities in the target or the material of the ion-source. At the Orsay-ISOCELE on-line separator, in an attempt to separate the La, Ba, Cs isobars, we developed this method by controlled feeding of CF_4 gas in our target ion-source system. Very pure neutron deficient La sources were obtained in the LaF_2^+ form with a very weak mixing of Ba and Cs isobars (4).

According to the same principle, we searched to separate the refractory Hf (valence 4) which form a volatile and stable fluoride compound HfF_4 .

2. EXPERIMENTAL PROCEDURE AND RESULTS

The target, inside the ion-source, was constituted by 2 grammes of anhydrous Ytterbium fluoride powder put in a cylindrical container. A continuous gas support for fluorination to favour the formation of HfF_4 at the surface of the YbF_3 powder was supplied by introduction of CF_4 vapour through a small Mo tube connected at the bottom of the container. The target was bombarded by $1 \mu\text{A}$ 280 MeV ^3He beam from the I.P.N.-Orsay synchrotron and heated progressively by an auxiliary heating system.

The neutron deficient Hf isotopes were formed by Yb ($^3\text{He}, \text{xn}$) reactions. The maximum temperature of the ion source was about 1200°C . In these conditions, we obtained an important YbF_2^+ stable beam ($\sim 1,5 \text{ mA}$). The isotope identification was based upon single high-resolution spectra with coaxial Ge(Li) and X rays intrinsic Ge detectors. The multispectrum analysis was performed for half-life measurements. On the masses $162 \leq A \leq 168$, the γ spectra showed an important isobaric mixing of Hf, Lu, Yb and Tm. This mixing remained also on the $A + 19$ (MF^+) and $A + 38$ (MF_2^+) masses.

While on the masses $A + 57$, we obtained, as expected, very pure HfF_3^+ ion, the rare-earth families (valence 3) in this case were negligible. For illustration, figure 1 shows the first spectrum of the eight 1mn spectra of a multi spectrum analysis on the mass $A = 164 + 57$. Half-life measurements were performed on the decay curves of K_{α} Lu peaks (figure 2-5) and four isotopes ($^{162-165}\text{Hf}$) unknown up to now were identified.

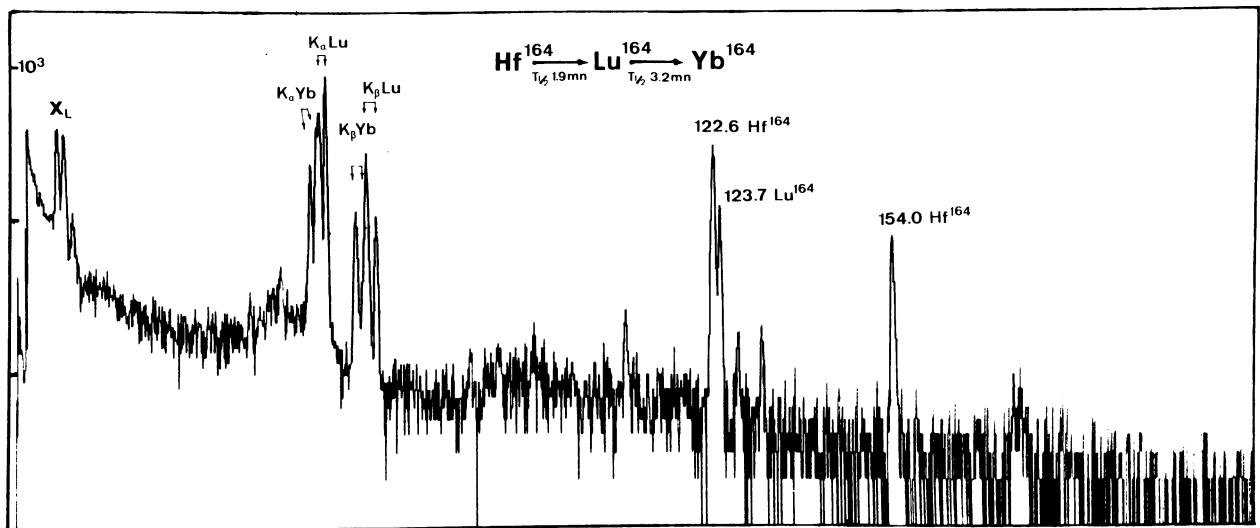


Figure 1 : Spectrum $\text{Hf}^{164} \rightarrow \text{Lu}^{164} \rightarrow \text{Yb}^{164}$
 First spectrum of the 8 multispectrum analysis (one minute measurement for each after a 4 minutes collection time).

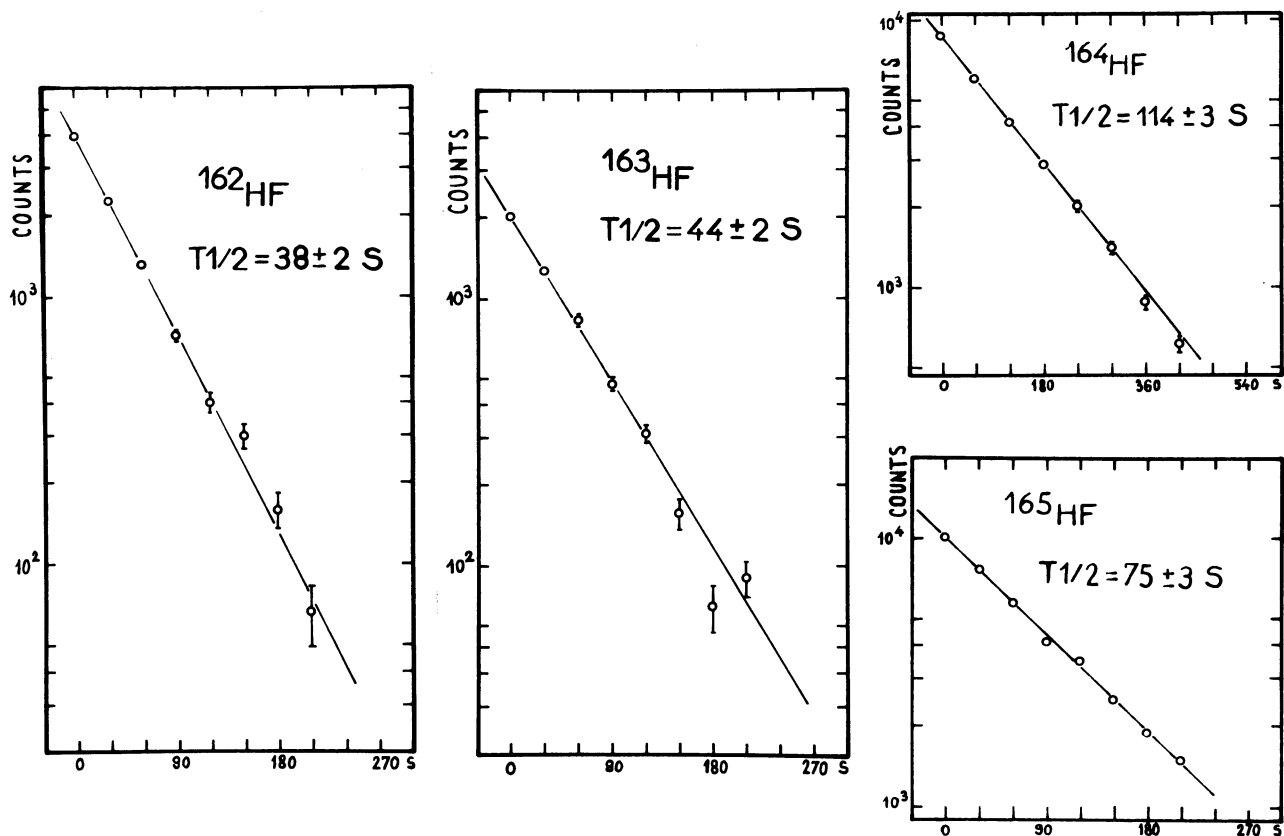


Figure 2 : Decay curves of $^{162-165}\text{Hf}$ measured at the K_{α} Lu peaks

Very recently, we attempted to exploit the same principle for selectively separating Tantalum (valence 5). Ta isotopes were produced by ($^3\text{He}, xn$) reactions on a Lutetium metal powder target continuously fluorinated by a CF_4 vapour flow. We obtained TaF_4^+ with a rather good yield at a lower target temperature than for the above reported Hf separations. Unknown $^{163-164-165}\text{Ta}$ isotopes were observed and analyses of the corresponding half-life measurements are in progress.

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