Decay properties of ^{269}Hs and evidence for the new nuclide ^{270}Hs

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Three decays of the nuclide ^{269}Hs were observed by Hofmann et al. [1,2] as grand daughter of ^{277}112. The deduced relatively long half-life of about 10 s makes ^{269}Hs an ideal candidate for first chemical experiments with hassium (element 108). ^{269}Hs can be produced directly in the reaction ^{248}Cm(^{26}Mg, 5n). In the 4n de-excitation channel, the new nuclide ^{270}Hs is produced, which was predicted to be the next heavier "doubly-magic" nucleus after ^{208}Pb [3]. Its decay properties are of great interest to nuclear physics.

In order to investigate the chemical properties of Hs, the gas chromatographic separation system IVO (In situ Volatilization and On-line detection) [4] and the cryo on-line detector (COLD) [5] were set up at the rotating target- and window irradiation facility of the UNILAC at GSI Darmstadt. Hs is expected to belong to group 8 of the periodic table of the elements and should thus form very volatile HsO_4 molecules. Test experiments with short-lived Os isotopes, the lighter homologue element of Hs, showed that OsO_4 molecules were formed when the recoiling Os nuclei were stopped in a mixture of He and O_2.

In the course of the experiment, data was collected during 64.2 h and a beam integral of 1.0×10^{18} ^{26}Mg ions was accumulated. The count rate in all detectors was very low. Only the nuclides ^{219}Rn, ^{220}Rn, ^{211}At and their decay products were identified after chemical separation. While ^{211}At (and its decay product ^{211}Po) was deposited mainly in the first two detectors, ^{219}Rn and ^{220}Rn and their decay products accumulated in the last three detectors, where the temperature was low enough to condense Rn. Due to a defect, one side of detector sandwich 1 was not operating and was therefore excluded from the data analysis. The average count rate per detector pair was 0.6 h^{-1} in the relevant α-decay energy window E_α=8.0-9.5 MeV in detectors 2 through 9.

The data analysis revealed one four-member- and 4 three-member decay chains (Fig. 1) which all occurred within a time period of less than 70 s and which all have random probabilities of less than 7×10^{-5}. Since only about 77% of the inner surface of the COLD channel consisted of active detector surface, detection of a few incomplete decay sequences is expected. Two α–SF correlations were observed in detectors 3 and 4 that still have a rather low random probability, but could not be assigned with certainty to ^{269}Hs or ^{270}Hs. Also, 4 uncorrelated SF decays with fragment energies >50 MeV were registered in detectors 2, 3, and 4. Only for one SF both fragments were observed. All other detectors 5 through 12 registered zero SF events. The 4-member and the 3-member α-decay chains were attributed to the decay of the nuclide ^{269}Hs, since these almost perfectly match the decay properties observed previously by Hoffman et al. [1] (except for the low α-decay energy of ^{269}Hs in the three member decay chain). Three decay chains were terminated by spontaneous fission. From the previously known decay data such a signature would be expected only for the decay of the new nuclide ^{270}Hs. But, one of the terminating SF events had a rather long life-time of 7.9 s, which is not very likely for ^{262}Rf with a half-life of 2.1 s. A similar decay sequence has also been observed in one of the decay chains assigned to ^{277}112 [2]. Therefore, this chain was attributed to ^{269}Hs. Noteworthy are the very unusual decay properties of ^{261}Rf [6]. We tentatively assigned the remaining two decay chains to the new nuclide ^{270}Hs. From the measured E_α=9.16±0.03 MeV an α-decay half-life of 2-7 s was estimated.

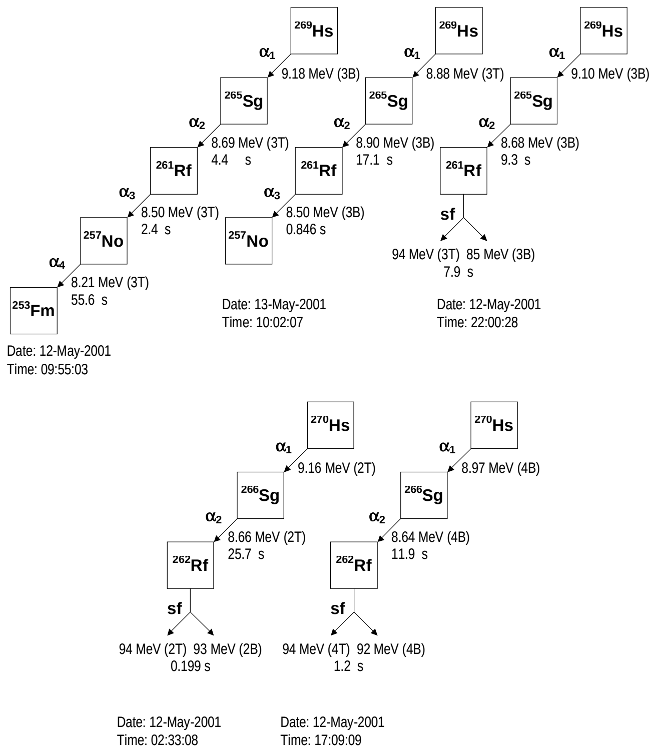

Fig. 1: Decay chains attributed to the decay of Hs-nuclides.

References

[1] S. Hofmann et al., Z. Phys. **A354,** 229 (1996).

[2] S. Hofmann et al., Rev. Mod. Phys. **72,** 733 (2000).

[3] Z. Patyk et al., Nucl. Phys. **A533,** 132 (1991).

[4] Ch.E. Düllmann et al., Nucl. Instrum. Meth. **A479**, 631 (2002)

[5] Ch.E. Düllmann et al., this Annual Report

[6] R. Dressler et al., PSI Scientific Report 2001, Vol. I (2002).