GAS CHEMICAL INVESTIGATION OF BOHRIUM (Bh, ELEMENT 107)

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Neutron-rich isotopes of Bh can be produced in the nuclear fusion reaction ^{249}Bk(^{22}Ne;4n)^{267}Bh. The half-life of ~17 s and the production cross section of about 50 pb, which have been determined during the discovery experiment in Berkeley [1], make ^{267}Bh an ideal candidate to be used for gas phase chemical studies.

Assuming Bh to be a member of group 7 in the periodic table, a suitable chemical isolation procedure was developed in several model experiments using various nuclides of Tc and Re [2,3,4]. The gas chemical separation of MO_3Cl (M = Tc, Re) was shown to be suitable for the study of short-lived isotopes of group 7 elements.

A 670 µg/cm^2 ^{249}Bk target, prepared by LBNL, was irradiated at the PSI Philips cyclotron with a total beam dose of 3.02*10^{18} ^{22}Ne^{6+} particles at a beam energy of 119±1 MeV in the target and an average intensity of about 250 pnA for about 4 weeks. The nuclear reaction products were transported to the reaction oven of a low temperature OLGA III set-up using a carbon aerosol gas-jet. Shortly before the reaction oven a reactive gas mixture of HCl and O_2 was added to the gas-jet. At 1000°C the aerosol particles were burned in the reaction oven and the nuclear reaction products were converted to a large variety of oxides, chlorides, and oxychlorides. Subsequently this mixture of chemical products was separated according their adsorption interaction with the stationary quartz phase in the isothermal part of the chromatography set-up. This part was held at three different isothermal temperatures (T_{iso}). Only the most volatile compounds, able to pass the chromatography, were attached to another gas-jet of CsCl aerosol particles suspended in Ar to transport them to the detection system ROMA. For more details regarding the experimental set-up see [4,6].

6 correlated decay chains, attributed to the decay of ^{267}Bh have been observed. At 180°C and 150°C isothermal temperature (T_{iso}) 4 respectively 2 chains were detected. No Bh was registered at the same experimental sensitivity at 75°C.

The unambiguous identification of Bh after chemical separation allows to conclude that Bh forms a volatile oxychloride compound, presumably BhO_3Cl, and behaves like a typical member of group 7 of the periodic table. In order to evaluate first thermochemical data of bohrium, the relative yields of Bh at the adjusted isothermal temperatures have been calculated applying a careful statistical analysis of the data. The results are shown in Fig. 1 (squares) together with the yield vs. isothermal temperature curves of the corresponding compounds of Tc and Re (circles). Assuming the Bh compound to be BhO_3Cl, and applying a microscopic model of the adsorption process [5], we evaluated the standard adsorption enthalpy of BhO_3Cl on the quartz surface, $\Delta H_{ads}(BhO_3Cl) = -75^{+9}_{-6}$ kJ/mol (68%c.i.) [6]. Applying a well established empirical correlation between the single atom property ΔH_{ads} and the property of the macroscopic solid state, sublimation enthalpy ΔH_{subl} [7], from the result of our experiment it was possible to evaluate the first thermochemical measure of volatility of a Bh compound $\Delta H_{subl}(BhO_3Cl) = 89^{+21}_{-18}$ kJ/mol. Thus, the series of the volatility of group 7 oxychlorides MO_3Cl (M=Tc, Re, Bh) on quartz yields the sequence Tc>Re>Bh. This sequence can also be expected from thermochemical stability trends in the periodic table [8] and from an empirical physisorption model [9]. Experimentally this sequence is supported by the fact, that BhO_3Cl was reclustered with CsCl. This is an additional indication that BhO_3Cl is more similar to ReO_3Cl than to TcO_3Cl, since TcO_3Cl could only be reclustered with $FeCl_2$-aerosol particles [4].

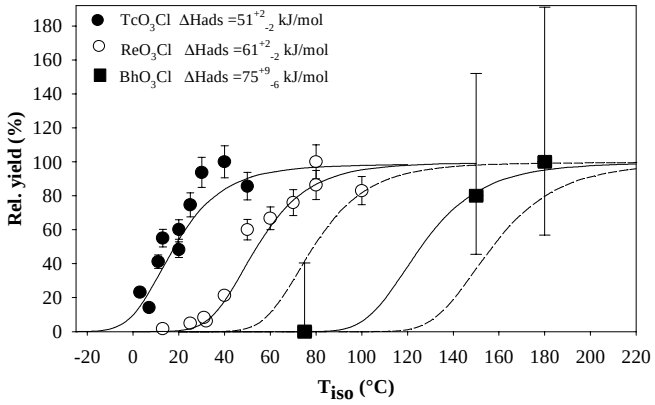

Fig. 1 Yield vs. isothermal temperature curves for the oxychlorides of ^{108}Tc ($t_{½}$=5.2 s), ^{169}Re ($t_{½}$=16 s), and ^{267}Bh ($t_{½}$=17 s). Symbols → Experimental data with 1σ–error bars; Lines → Monte Carlo model; thin lines → 1σ–error range for BhO_3Cl.

Acknowledgments

We are indebted to the US DOE for making the ^{249}Bk target material available through the transplutonium element program at Oak Ridge National Laboratory. We thank the staff of the PSI Philips cyclotron for providing intense beams of ^{22}Ne. This work was supported by the Swiss National Science Foundation.

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