

Preface

Throughout my life's work in science I have been greatly influenced by the standing problem of synthesis and studies of the heaviest chemical elements. In 1960 I joined the then-young Laboratory of Nuclear Reactions of the Joint Institute for Nuclear Research at Dubna. It was headed by G. N. Flerov who, with K. A. Petrzhak, discovered the spontaneous fission of uranium. The laboratory was equipped with a powerful cyclotron which could accelerate boron and heavier ions to energy of some 10 MeV per nucleon. A most ambitious goal was to discover new chemical elements. The first "planned" new nuclide, $^{260}104$, was expected to be produced by the bombardment of ^{242}Pu with ^{22}Ne . Estimates of its half-life were very uncertain, spanning many orders of magnitude. Necessarily, the initial emphasis was on physical methods of identification of the atomic and mass numbers because, in general, the physical techniques are effective down to very short lifetimes. On the other hand, element 104 was also of great interest for chemists. It was expected to be the first "transactinoid," resembling in its properties hafnium, the first "translanthanoid." As such it would strongly differ in chemical properties from all the lighter transuranium elements. This might facilitate and accelerate its chemical identification, which is an independent reliable method for the assignment of the atomic number and could eventually strengthen the primary physical evidence. The chemical identification of element 104 was the first task I got involved in. It was soon recognized that, with the availability of only one short-lived atom at a time, the processing of the accelerator bombardment products must be continuous and allow immediate chemical transformation of the new atom, once created. The goal was to achieve this, as well as the subsequent chemical isolation of the new molecules, in less than a second, which was the optimistic higher limit of $t_{1/2}$. Also required was highly efficient detection of the decay events of element 104 because the expected production rate was, by orders of magnitude, smaller than for any previous element. The more unusual was the combination of all these musts. The existing exclusively batchwise isolation techniques for hafnium and most other metallic elements took at least minutes to accomplish.

Our team did not see prospects of achieving the goal by simply upgrading the existing methods. In those times An. N. Nesmeyanov, head of the Chair of

Radiochemistry at the Moscow University, consulted the Flerov's laboratory in Dubna on radiochemical problems. He pointed to the expected considerable volatility of higher halides of the transactinoid, compared with that of similar compounds of actinoids, as a possible basis of fast separations. When seeking an experimental method which would make the most of the dissimilar volatility, I benefited from the experience and ideas I gained as a student of Professor Nesmeyanov. In his laboratory I separated various volatile brominated methanes to solve a problem in "hot atom chemistry." After a few years our small group of chemists did come with an efficient technique capable of isolating hafnium as tetrachloride in tenths of a second. The method combined the principles of hot atom chemistry and gas-solid chromatography. We successfully applied it to element 104 and subsequent transactinoids. A generation later, around 1990, other world laboratories involved in transactinoid studies also started experiments with gaseous compounds. Fortunately, all the transactinoid elements up to $Z = 118$ must either be volatile in elemental state or form some characteristic volatile compound(s), so that the gas phase techniques are a universal research tool in radiochemistry of the transactinoid elements.

The aim of this book is to outline and analyze some fundamental aspects of the work performed at Dubna and elsewhere, and to discuss prospects for the future.

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Methods for Studying Gaseous Compounds

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