CHEMISTRY OF THE HEAVIEST ELEMENTS

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We report recent highlighted studies of the chemical separation and characterization experiments with the heaviest elements, in liquid-phase chemistry and in studies of atomic properties. Prospects for the future studies on chemical properties of the heaviest elements will be briefly considered.

Chemical characterization of the heaviest elements at the farthest reach of the Periodic Table is a challenging and fascinating subject not only in nuclear and radiochemistry but also in general chemistry [1, 2]. One of the most important and interesting aspects is to clarify basic chemical properties of these newly synthesized elements, such as ionic radii, redox potentials, or their ability to form chemical compounds as well as to elucidate the influence of relativistic effects on valence electronic structure of the heaviest elements and the impact on chemical properties of these elements. The heaviest elements with atomic numbers $Z \geq 101$, however, are all man-made elements synthesized at accelerators using nuclear reactions of heavy-ion beams with heavy element target materials. They can only be identified through measurement of their characteristic nuclear decay or that of their known daughter nuclei using sensitive detection techniques. As both half-lives and cross sections of these nuclides are rapidly decreasing, they are usually available in quantities of only a few atoms or often one atom at a time. Here, we demonstrate recent highlighted studies of the chemical separation and characterization experiments with the heaviest elements, in liquid-phase chemistry and in studies of atomic properties.

The liquid-phase experiments have been accomplished by partition methods with single atoms, e.g., liquid-liquid extraction, ion-exchange chromatography, and reversed-phase extraction chromatography. The recent studies of the early transactinides, rutherfordium (Rf) and dubnium (Db) are briefly reviewed [3]. Redox studies of the heaviest elements are expected to offer valuable information on valence electronic states influenced by strong relativistic effects, such as oxidation states and redox potentials. Well established electrochemical approaches like cyclic voltammetry are, however, not available for the one atom-at-a-time chemistry of the heaviest elements. Thus, one needs to investigate redox properties of the heaviest elements based on the partition behavior of single atoms between two phases instead of measurements of electric currents generated by redox reactions. A newly developed experimental approach to investigate single atoms of the heaviest elements with an electrochemical method has been developed based on a flow electrolytic cell combined with column chromatography. The successful redox experiments with nobelium (No) and mendelevium (Md) are reported [4].

Study of atomic properties of the heaviest elements is indispensable to understand electronic ground state configurations. The first ionization energy (IP_1) is an atomic property which most sensitively reflects the outermost electronic configuration. Precise and accurate determination of IP_1 provides significant information on the binding energy of the valence electrons, and thus on increasingly strong relativistic effects. Recently, the IP_1 value of the heaviest actinide element lawrencium (Lr) was successfully measured using a surface ionization technique coupled to a mass separator [5]. We will outline the experimental method and a result obtained from it. Prospects for future studies of chemical properties of the heaviest elements will be also discussed.

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