

Development of a New Korean Textbook, Uranium Chemistry, for Human Resource Development

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1. Introduction

Human resource development is crucial for the advancement of the field of nuclear engineering. In particular, it is essential to enhance educational systems and resources—such as textbooks—regarding the chemistry of the nuclear fuel cycle. The authors have developed and implemented student programs that include practical training and facility tours[1]. In the former training course, the domestic experimental program related to fuel cycle chemistry is done at a Korean university. Then, the fundamental experiments in solid state and solution chemistry using uranium and radioisotopes are performed at Tohoku University in Japan. For these programs, basic knowledge of radiochemistry and inorganic chemistry are needed. However, information on those fields is insufficient because of the limited number of publications. On the other hand, Sato published two Japanese-language textbooks in this field, namely, "Uranium Chemistry (I): Fundamentals and Applications"[2] and "Uranium Chemistry (II): Methods and Practice"[3] addressing a long-standing lack of such publications in Japan. Consequently, the authors considered publishing a Korean textbook of uranium chemistry for human resources development.

2. Making procedure

First, N. Sato created a Japanese version tailored to the Korean context by adding new topics and data to the original two volumes. Next, K. O. Jang, working with students, translated the Japanese text into Korean. Sato checked the Korean version compared with Japanese one. After repeating these steps, K. H. Park supervised the content in its entirety. The final manuscript was completed following a detailed review by three professors.

3. Structure of the book

This book consists of 15 chapters and is divided into three parts. Chapters 1 through 8 constitute the Basics

section, covering the synthesis and properties of metals and various compounds. The Applications section addresses the nuclear fuel cycle in Chapter 9 and uranium-containing products in Chapter 10. The Experiments section covers the handling of radioactive materials, high-temperature reaction experiments, evaluation methods, and related topics. Details of each part are described below.

3.1. Basics part

The "Fundamentals" section consists of eight chapters. It begins with an overview of uranium and a description of the production and properties of uranium metal, followed by detailed accounts of various compounds, organized according to the periodic table. Chapter 3 covers hydrides, while Chapter 4 discusses types of oxides and their oxidation-reduction characteristics. Chapter 5 addresses halides—specifically fluorides, chlorides, bromides, and iodides—as well as oxyhalides, covering their synthesis and properties. Chapters 6 and 7 introduce compounds formed with Group 13 and 14 elements (borides, carbides, and silicides) and Group 15 elements (nitrides, phosphides, and arsenides), respectively. Finally, Chapter 8 covers chalcogenides, including sulfides, selenides, tellurides, and oxychalcogenides.

Table 1. Chapters of basics part.

Chapter	Title	Subject
1	Introduction	History, Radioactivity,
2	Metal	Production, Physical and chemical property,
3	Hydrides	Synthesis, Compounds
4	Oxides	Dioxide, Oxidation, Reduction,
5	Halides	Fluoride, Chloride, Bromide, Iodide
6	Group 13, 14	Boride, Carbide, Silicide
7	Group 15	Nitride, Phosphide, Arsenide
8	Chalcogenides	Sulfide, Selenide, Telluride

3.2. Application part

Chapters of application part are given in Table 2. Chapter 9 introduces the front-end and back-end processes of the nuclear fuel cycle. Specifically, it describes the processes of metallurgy (separating and refining uranium from ore), conversion and reconversion, enrichment, fuel fabrication, reprocessing, and radioactive waste management. Chapter 10 covers products containing uranium, such as uranium glass.

Table 2. Chapters of application part.

Chapter	Title	Subject
9	Fuel cycle	Front and back-end field, Uranium ore, Metallurgy, Conversion- reconversion, Enrichment, Fuel production, Spent fuel management, Reprocessing, Radioactive waste management
10	Products	Uranium glass, Catalyst, Bricks, etc.

For example, chloride electrolysis process flow appeared in Section 9.6 Reprocessing is shown in Figure 1. There are three main steps, (1)Uranium reduction, (2)Electrolysis and (3)Alloy production.

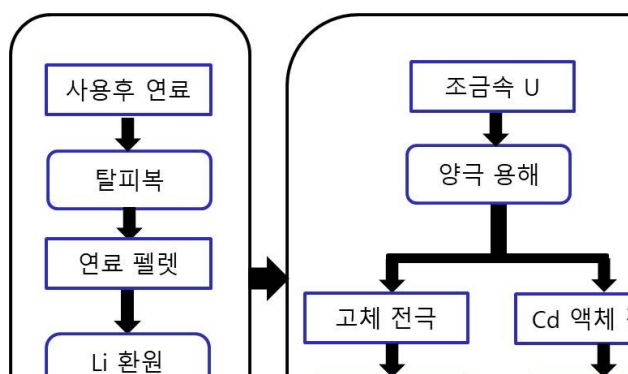


Figure 1. Chloride electrolysis process flow.

3.3. Experimental part

Chapters of experimental part are given in Table 3. Chapter 11 covers the handling of nuclear fuel materials and radioisotopes (RIs), sample preparation methods, and experimental equipment, while Chapter 12 introduces physical evaluation methods—such as X-ray diffraction—and chemical evaluation methods—such as ICP analysis—for samples. Chapter 13 describes high-temperature experimental techniques, including experiments using molten salts, high-temperature chemical reaction experiments, and active metal reduction experiments. Chapter 14 discusses experiments involving vacuum and controlled atmospheres, introducing the use of vacuum evacuation systems, gloveboxes, and glove bags.

Table 3. Chapters of experimental part.

Chapter	Title	Subject
11	Handling of radioactive materials	Nuclear fuel, RI, Sample preparation, Experimental apparatus
12	Evaluation of sample	Chemical method, Physical method
13	High temp. experiment	Molten salt, High temp. reaction, etc
14	Vacuum and atmosphere control	Vacuum system, Glove box handling and other items
15	Synthesis of Compound	Oxides, Fluorides, Chlorides, Sulfides

Finally, Chapter 15 explains the preparation and purification methods for uranium compounds (oxides, fluorides, chlorides, and sulfides), illustrating the processes with specific examples.

4. Features and Benefits

The features of this book and the benefits of its publication are as follows:

- It provides detailed descriptions of the synthesis and physicochemical properties of uranium compounds, organized according to their elemental groups in the periodic table.
- It introduces processes corresponding to each stage of the nuclear fuel cycle, with a primary focus on dry methods.
- Regarding compound synthesis, it provides detailed accounts of actual synthesis examples, including the experimental equipment and conditions used.

5. Summary

As part of a human resource development program in the field of nuclear chemistry, we undertook the creation of a Korean-language textbook titled *Uranium Chemistry*. The resulting book covers a wide range of topics, extending from chemical compounds and processes to sample preparation, and encompassing everything from fundamental knowledge to detailed experimental procedures. We hope this textbook will support the learning of students and faculty in the nuclear field and contribute to workforce development in this area.

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