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A Study on the Terminological Heterogeneity in Chemistry between South and North Korea

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Abstract Since the division of South and North Korea in 1945, there has been little exchange in science and technology, despite some interchange in a few fields including the chemistry area. Accordingly, the difference in scientific and technological terminology between the two Koreas has become intensified. This is because North Korea carried out a campaign to purify the Korean language and blocked the inflow of foreign words. They also tried to convert into their own North Korean terms in many fields. This circumstance in North Korea aggravated the heterogeneity of inter-Korean scientific and technological terms. In particular, the heterogeneity of chemical terminology has worsened due to the different characteristics of the technology donor countries such as the United States and Japan in South Korea, and China and the Soviet Union in North Korea between the two Koreas and the different way of technological development. The purpose of this study is to collect chemical terminology data used in two Koreas and analyze similarities and differences. Through comparative analysis of inter-Korean terminology in the chemical field, it can be possible to recognize how the chemical terms between the two Koreas have changed since the division and the degree of heterogeneity based on different technical systems and language policies. The outcome of this study would present basic data on the unification of chemical terminology in preparation for before and after unification, and contribute to communication and academic exchange between researchers in the inter-Korean scientific and technological fields, including chemistry.

Keywords North Korea, Chemistry, Chemical Terminology

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I. Introduction

Academic events such as seminars are very important opportunities to share research results and information among scientists. In 2017 and 2019, the Korea Research Institute of Chemical Technology (KRICT) held academic seminars with research institutes in Hamhung, North Korea, and researchers from North and South Korea presented their research results. It started with an awkward and stiff atmosphere as it had been a long time since scientists from two Koreas met, but it was a meaningful seminar where researchers working at public research institutes in the chemical field could share their research achievements. However, they could not fully understand each other because the terms used in research phenomena and methods were quite different. For example, in North Korea, there were terms not used in South Korea, such as Jeonmulbunhae (전물분해), Geodumryul (거둠률), and Neulimryul (늘임률)[1]. It was possible to understand the meaning of the terms depending on the context of the contents in the research results, but it was rather difficult to know immediately with the terms themselves.

North and South Korea have differently maintained languages and cultures for a long time after division, and their heterogeneity in many fields is deepening because they have spent the intervening years without much interaction in the context of different systems. As a result, North and South Koreans now differ considerably in their ways of thinking and living. This difference has also led to heterogeneity in terminology between North and South Korea. This is because the language also reflects the social context of its speakers. In fact, in the 70 years since the division of the Korean peninsula, many technical terms in the fields of science and technology as well as the humanities and social sciences are now expressed differently in the two Koreas. There are many cases in which terms are used differently or have different meanings, and that can make communication between the two Koreas difficult. For inter-Korean exchanges and practical cooperation in the future, it is necessary to compare and analyze terms in each specialized field to identify differences. Furthermore, the two Koreas should prepare alternatives for communication and common terminology.

Terminology heterogeneity between two Koreas can become an important negative factor in efforts to restore ethnic homogeneity and establish a Korean national identity as a single nation. Therefore, as part of efforts to expand and revitalize inter-Korean exchanges, the government and institutions are making

[1] Korean in the article was written by converting the sound of letters into English. In case of Jeonmulbunhae (전물분해) and neulimryul (늘임률), there is no properly-matched English word. Geodumryul (거둠률) is ‘percent yield’ in English.

efforts to compile, analyze, and compare the linguistic heritage of our people. Many representative inter-Korean terminology system construction and comparative studies have been conducted at the National Institute of Korean Language. Starting with the 'Inter-Korean Basic Terminology Analysis' in 2015, 'Inter-Korean Terminology Construction' in 2016, 'Construction of Inter-Korean Terminology in the Korean Language Field' in 2017, 'Construction of terminology in inter-Korean history' in 2018, and 'Construction of terminology in inter-Korean music and art fields' in 2019 have been conducted.

Inter-Korean scientific and technological exchanges are needed for reconciliation, cooperation, and peace in the Korean Peninsula. Various inter-Korean S&T cooperation policy roadmaps such as the 'New Economic Guidance Initiative on the Korean Peninsula' and 'Development of Inter-Korean relations through activation of Inter-Korean exchanges' have been produced by the Ministry of Science and ICT and the Ministry of Unification. Among them, inter-Korean chemical technology cooperation is one of the most efficient methods because it will boost Korea's chemical industry by allowing utilization of abundant resources such as minerals in North Korea. Effective communication between inter-Korean scientists is particularly important for chemical technology cooperation. Hence resolving the present heterogeneity in terms by collecting and analyzing data on inter-Korean chemical terminology would be very helpful, as well as a guide to better understanding the technical systems of North Korea. Basic data preparation for the unification of terms in the chemistry field by comparative analysis of inter-Korean chemical terminology will also contribute to facilitating communication and academic exchange between researchers in other S&T fields of South and North Korea, as well as chemistry.

In this study, the chemical glossaries published by the Korean Chemical Society (KCS) in 2008 and 2014 were compared with Mirror 2.0 and Civilization published in North Korea, which contain specialized terminology in the field of chemistry. The key values for matching North and South Korean were English terms, which were used to compare their characteristics, and then corresponding pairs were created. The corresponding pairs were classified into chemical subfields and compared with each other based on three characteristic comparison tools.

II. Literature review

As exchanges on science and technology between the two Koreas have decreased due to strained inter-Korean relations, the differences in terminology for each field have grown, and a comparative study is needed to solve the difficulties in communication in preparation for unification in the future.

Although common terminology is the fundamental basis for inter-Korean scientific and technological cooperation, it has not been possible to update or modify the terms used in North and South Korea. The linguistic and literary system, norms, and guidelines for term comparison were not consistently prepared, and the use of terms and systematic basis were not established. Like a general dictionary, linguistic and literary guidelines are needed, but have not been prepared.

There are no guidelines or regulations for the integrated management of scientific and technological terminology since they are published by field, and since most glossaries are published only in booklets or PDF files, there is no environment for users to easily access them online. In addition, it is necessary to investigate the cause of the differences between terms, so that they can be more easily accepted and understood, but such efforts have been insufficient. Since terminology research began in the South in the late 1990s, and comparative research on terminology between North and South Korea was developed in the early 2000s, there has been no effort to integrate and compare inter-Korean terms in each field. More than 15 years have passed since the Korea Federation of Science and Technology Societies (KOFST) conducted a comparison of science and technology terms between South and North Korea in 13 fields, and it was published as a glossary. At that time, some organizations conducted a comparison of inter-Korean terminology, but it was not systematic.

In addition, the comparative study of inter-Korean science technology terminology was mainly carried out by government projects or through research in the relevant field by public or related organizations, such as government-funded research institutes (GRIs). For example, Korea Astronomy and Space Science Institute (KASI) developed research with the topic of 'Comparative Analysis of Astronomical Terminology between South and North Korea' in 2019 in order to clarify the difference in astronomical terms between the two Koreas. Korea Research Institute of Science and Technology Information (KISTI) proceeded with a similar project in the field of ICT in 2020. In the same year, the Korea Institute of Construction Technology (KICT) compiled the 'Construction Standards Glossary in North and South Korea' to collect construction terms from North and South Korean. Korea Institute of Oriental Medicine (KIOM) also published a 'Comparative Glossary of Traditional Medicine' to classify medical terms currently used in two Koreas. Korea Railroad Research Institute (KRRI) also published the 'Comparative Dictionary of Inter-Korean Railroad Terms' and is currently providing its contents through the Naver Knowledge Encyclopedia[2]. Each GRI conducted comparative studies

[2] Naver, which is the largest portal site in South Korea, provides comprehensive knowledge information from various dictionaries. That is 'Naver Knowledge Encyclopedia' and one of dictionaries is the 'Comparative Dictionary of Inter-Korean Railroad Terms' by KRRI.

between North and South Korea relating to its research field like astronomy, ICT, construction, oriental medicine, and railroad technology with collecting, classifying and corresponding terms. It is significant to publicly garner special field terms to investigate and analyze so that scientists in North and South Korea will reduce the difference of term usage.

At the individual researcher level, studies for inter-Korean terminology have been conducted in various ways. Shin (2019) studied the comparative systematization of scientific and technical terminology between two Koreas and a term management plan, which suggested a research methodology for systemizing and managing scientific and technical terminology. In particular, the linguistic analysis examined the features and aspects of scientific and technical terminology and presented comprehensive management guidelines. It contained information on the linguistic analysis method procedures, guidelines, and management necessary for this comparative study.

In prior research on chemical field terminology between the two Koreas, some chemistry-related societies [3] like the Korean Chemical Society (KCS), and other research institutes have conducted some terminology studies in the chemical field, but systematic data collection and analysis have not been carried out due to insufficient management and updates. It was published separately as a chemical terminology dictionary and sold in the market. Unlike the glossary of academic terminology, it was edited to be used for educational purposes. In the case of academic research, it was mainly investigated and analyzed based on the North-South chemistry textbooks (Shim, 1997; Lee, 2005; Kim, 2007; Lee, 2008). Shim (1997) collected chemistry terms based on North Korean chemistry textbooks and dictionaries and then compared them with South Korean terms. It was found that there was a difference between the element name and the compound name, and some inappropriate use due to the language refinement in general chemical terms. Lee (2005) extracted 711 terms related to compounds, chemical terms, and experimental tools from chemistry textbooks for high school and middle schools in North Korea. By comparing these with South Korean secondary chemistry textbooks, a corresponding pair was created, and 404 terms (56.7%) with the same form and meaning were found. 307 terms (43.3%) had different forms but same meanings. Also, the ratio of Chinese characters was high in both North and South Korea, and Korean characters such as Hangul were low. Kim (2007) also compared academic terms based on South and North Korean textbooks. In the case of chemistry, 1,346 terms from South

[3] In South Korea, there are various chemistry-related specialized organizations such as Korean Chemical Society (KCS), Korean Institutes of Chemical Engineers (KIChE), Korean Society of Industrial and Engineering Chemistry (KSIEC), Polymer Society of Korea(PSK), Korean Ceramic Society(KCerS), and Korean Union of Chemical Science and Technology Society(KUCST).

Korean textbooks and 1,572 terms from North Korean textbooks were extracted and 946 corresponding pairs were made. 649 pairs (68.6%) of those were matched with the same grammatical form, but 297 pairs (31.4%) responded differently. Lee (2008) did not directly compare North and South Korean chemical terms but tried to investigate the understanding degree of pre-service science teachers on North Korean chemical terms in South Korea. The understanding level of each teacher was different in each North Korean chemical term. It means high heterogeneity of terms between North and South Korea in case that their understanding level was low. Previous studies comparatively analyzed textbook-level chemical terms and tried to find out the characteristics of each term. However, it was not sufficient to compare and analyze the chemical terminology between North and South Korea as a multidisciplinary technical term used across all scientific disciplines. Furthermore, no related research was conducted in the 2010s.

III. What is North Korea's Chemical Industry?

North Korea's industrial development strategy is to adhere to a socialist planned economy. It intends to realize the construction of a socialist-style industrial state centered on self-reliance. That is similar to the typical strategy in the early stages of building a socialist state. In a state where capital and technology are scarce, socialist countries generally focus on heavy and chemical industries based on the concentration of resources following national plans. Although the primary results were achieved, the system was transformed through reform and opened by introducing a market economy after a certain period of time due to imbalances in the industrial structure, reduced productivity, and lack of will to work.

Prior to this study, it is necessary to know the characteristics of the North Korean chemical industry. In particular, the chemical industry in the North Korean economy has been considered a core industry for building a socialist industrial state and is called the 'chemical industry' in North Korea. In North Korea, the chemical industry is referred to by the term "Hwahakgongup (화학공업)[4]." This Korean word sounds like 'chemical engineering' in English, but its meaning is academically different. It is more similar to the industrial concept in the chemical field.

Even as emphasized several times in the New Year's address of Chairman Kim Jong-un, it has been fostered and promoted as a fundamental industry to

[4] From here on, we will use chemical industry as 'chemical engineering' for clear understanding.

strengthen national economic independence. The definition in the Economic Geography Chapter, Chosun Geography Encyclopedia, refers to it as "One of the periodical industrial sectors that produce chemical products and raw materials by processing raw materials produced in the extraction industry and other sectors of the national economy." This ideological emphasis is found in many books in North Korea. For example, Kim Il Sung's Writings Collection, published in1980, noted in Book volume 12 'There is a great development prospect as we have abundant resources such as electricity, anthracite, and limestone, which are the basis for the development of chemical engineering, and have a strong foundation for the chemical industry' and in Book volume 25, 'The development of the chemical industry has very important significance in strengthening the economic independence of the country by expanding the raw material base of the industry.' Kim Jong-Un, who is a grandson of Kim Il Sung, has strongly emphasized at the annual New Year's address[5] the importance of the chemical industry, as follows[6];

(in 2017 year) "The chemical industry is the foundation of the manufacturing industry and plays an important role in strengthening economic independence and improving people's living standards … in the chemical industry, the production of the 2.8 Vinalon[7] Allied Enterprises should be revitalized, the capabilities of important chemical plants should be expanded, and the production of chemical product and technical processes should be increased by remodeling the technological process in our own way … It is necessary to put effort into the business for the establishment of the C1 Chemical Engineering and carry out step-by-step tasks smoothly in a timely manner…."

(in 2018 year) "In the chemical industry sector, the establishment of C1 Chemical Engineering should be accelerated, the construction of a catalyst production base and phosphorus fertilizer plant should be promoted as planned, and the carbon soda production process should be reorganized and completed…."

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[5] Kim Jong-Un's New Year's Address was unusually not published in 2020 and 2021 without any official reasons from the North Korean government.

[6] The Government of the Democratic People's Republic of Korea (DPRK). (2017; 2018; 2019). *Kim Jong-Un's New Year's Address.*

[7] Vinalon, also known as Vinylon, is a synthetic fiber produced from polyvinyl alcohol, using anthracite and limestone as raw materials. Vinalon was first developed in Japan in 1939 by Ri Sung Gi, who is the most representative national scientist in North Korea, Ichiro Sakurada, and H. Kawakami. Trial production began in 1954 and in 1961 the massive February 8 Vinalon Complex was built in Hamhung, North Korea. Vinalon's widespread usage in North Korea is often pointed to as an example of the implementation of the Juche (self-dependence) philosophy, and it is known as the Juche fiber. (source: https://en.wikipedia.org/wiki/Vinylon)

(in 2019 year) "From the point of view of realizing Juche-based metal industry and chemical engineering … In the chemical engineering, we accelerated the construction of phosphorus fertilizer factory and the establishment of C1 Chemical Engineering, and developed the glauberite industry and artificial fiber industr…. The national power must be put in to guarantee full operation of chemical fertilizer factories and to boost production of the 2.8 Vinalon Allied Enterprises…."

Currently, chemical engineering in North Korea is recognized as the central link to shifting the chemical industry (coal, electricity, etc.) into light industry and agriculture in the industrial structure. Furthermore, the axis of the North Korean-style national economy is focused on rapidly fostering chemical engineering in the coal chemical industry and producing and supplying raw resources for products such as living necessities and industrial materials on their own. Up Stream Chemical Engineering using coal resources emphasizes economic self-reliance, and down Stream Chemical Engineering is based on the principle of self-sufficiency and promotes the systematization of production facilities and integration through local factories. However, after the economic crisis of the 1990s, which firstly affected the electricity and coal sectors, the chemical industry in North Korea rapidly stagnated and collapsed, and the national economy was fragmented. It has been difficult to recover most of the disintegrated North Korean chemical industry to the 1990s level without groundbreaking measures such as reformation, external support, etc.

IV. Why is there a difference in terminology?

There are representative Korean dictionaries in North and South Korea. These are the Standard Korean Language Dictionary (1999) for the South and the Chosun Language Dictionary (2007) for the North. When comparing the differences in terms between North and South Korea using the two dictionaries, about 51.9% of terms are found only in the Standard Korean Language Dictionary and not in the Chosun Language Dictionary, and about 39.2% of the terms are found only in the Chosun Language Dictionary and not in the Standard Korean Language Dictionary. Excluding North Korean in the Standard Korean Language Dictionary, there are 439,816 terms, of which 192,208 are technical terms. There are 352,943 terms in the dictionary of Chosun Language Dictionary, of which 25,726 are technical terms. The proportion of terms communicated only in each region between two Koreas exceeds 60%, which means that it is necessary to prepare in advance for mutual communication and to understand

mutual terms. The difference in terminology between North and South Korea is more serious than differences in general words. The terminology used only in South Korea accounts for 65.5% of the total terminology in the Standard Korean Language Dictionary, and terminology used only in North Korea accounts for 59.7% of the total terminology in the Chosun Language Dictionary[8]. In the field of scientific and technological expertise, it is very important to use accurate expressions that fit the situation and subject. Therefore, if there is a discrepancy in the terminology used to refer to a single object between North and South Korean experts and the general public, there will be great difficulties in mutual communication.

The difference in scientific and technological terminology between the two Koreas has become intensified since the division of South and North Korea in 1945 because there has been little exchange in many fields after North Korea carried out a campaign to purify the Korean language and blocked the inflow of foreign words. They also tried to convert terminology in many fields into their own North Korean terms. Numerous inter-Korean glossaries have been published, but there are problems with the continuity, usability, and consistency of terms. This circumstance in North Korea has further aggravated the heterogeneity of inter-Korean scientific and technological terms. North Korea is actively intervening in people's language usage, using policies based on the socialist view of language. Since 1948, the 'Chinese Arrangement Project' and the 'Chinese Character Abolition Project' have been carried out. The 'Vocabulary Purification Project' was simultaneously promoted to remove the remnants of the Japanese. However, from the mid-1960s, the 'Vocabulary Refinement Project' was launched in earnest to purify Japanese, difficult Chinese characters, and unnecessary foreign words into native Korean. Not all Chinese characters and foreign words are the subjects of arrangement, but difficult Chinese characters and unnecessary foreign words have been converted into native Korean. In North Korea, 'professional terms' are called 'academic terms.' The 'Chinese Arrangement Project' and the 'Vocabulary Refinement Project' had the functional purpose of refining difficult terms into native Korean. That kind of state intervention resulted in the coexistence of practical terms and normative terms. It has intensified the difference in terminology between the two Koreas[9].

Before the Korean peninsula was divided, most scientific and technological terms were introduced from Japan, and their concepts were comprehended based

[8] Han, Y. U. (2018). "Status and Tasks of Recording Terminology in the North-South Dictionary". *New Korean Life*, Vol. 28, No. 4, pp. 29-30.

[9] Choi, H. K., Noh, K. R., and Choi, H. J. (2021). Differences in scientific and technological terminology between North and South Korea - Focusing on basic science terminology. *NK TECH FOCUS 2021-04*. pp. 2-4.

on this introduction. After the division, it was affected by the fact that South Korea and North Korea have different technology donors. The South shared technology from the US and Japan, while the North shared with the USSR and China. Amid the rapid scientific and technological developments globally, South Korea actively promoted international technology exchanges and adopted new academic scopes and terms. In contrast, after the collapse of the socialist bloc in the late 1990s, North Korea could not continue international exchanges with other nations and this has also contributed to the occurrence of term differences between the two Koreas. Since North and South Korea apply different norms for foreign words, there is a difference in notation even for the same term, because North Korea borrowed foreign words from the former Soviet Union, and South Korea borrowed a lot of American-style foreign words. This is the cause of the difference in the notation of terminology between North and South Korea. In the case of the chemistry field, similar to other sub-fields of science and technology, there was a difference in the terminology used by scientists in North and South Korea. There are also not many studies related to chemical terminology, so a systematic analysis study will be needed.

V. Research Scope & Methodology

For the comparative analysis of terminology in the chemical technology field, North and South Korea terminology resources and previous research data were collected and investigated. Domestic and foreign terminology resources were also secured for the comparative research, and inter-Korean chemical terminology was identified. To compare the characteristics of terms, analysis data of representative terminology from North and South Korea were selected and processed. Matching work was performed based on English terms as a key value to derive a pair of inter-Korean terms, and the matching pairs were listed. Then, a matching data analysis and categorization for this study was implemented using a three-step process as shown in the flow chart below (Figure 1). These results were reviewed by experts in the chemical field, and the classification of sub-fields terms was also carried out. Through this comparative analysis of inter-Korean chemical terminology, differences and characteristics were analyzed, and key terms in detailed fields were compared with each other. To compare the characteristics of North and South Korean chemical terms, they were categorized into three types based on English terms. Implications were drawn, and the results were utilized to suggest future collaborations in the chemical field between the two Koreas.

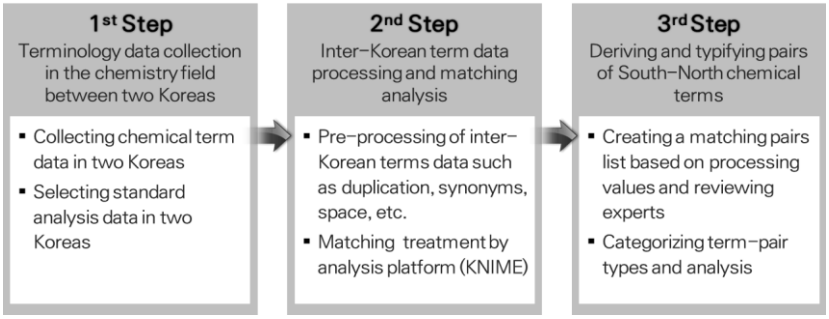

Figure 1 The research process for inter-Korean terms in the chemical fields.

1. Data Collection and Selection

After liberation from the Japanese colony, everyone knew that it was urgent to translate academic terms into Korean, but it was difficult to initiate the work due to the chaotic political situation in the early days of liberation and the Korean War. It was in Busan, the capital of refuge, in the spring of 1952 that KCS began work on formulating chemical terms. In fact, until the foundation of the KCS in 1946, there was no separate organization dedicated to managing chemical terminology data. Despite such difficulties, Chemical Terminology in South Korea was officially published in 1974 as the first edition. Most of the data were compiled by KCS, and other societies gathered data. However, no systematic updates such as corrections or supplements were made after the 5th edition of Chemical Terminology, which was published in 2003. Other chemistry-related societies in the South like the KCS gathered similar data, and educational chemical glossaries or dictionaries for junior and high school were also available on the market.

North Korean chemical terminology is compiled and distributed under the direct supervision of state institutions. The Chemical Dictionary was published in 1955 as a small volume in the field of physics to establish a system in the field of basic science after the end of the Korean War. Three Chemistry Dictionaries were published between 1969 and 1970, which can be considered the first mid volume chemistry dictionary in North Korea. The Agricultural Chemistry Dictionary was published around 1992 when North Korea was in economic crisis. This demonstrated the importance of agriculture and chemical fertilizer[10].

[10] Choi, H. K., Noh, K. R., and Choi, H. J. (2021). Differences in scientific and technological terminology between North and South Korea - Focusing on basic science terminology. *NK TECH FOCUS 2021-04*. pp. 11-12.

Table 1 Chemical Terminology Data Collection List in South Korea

No.	Title	Year	Publisher
1	Chemical Terminology (4th Edition)	1993	KCS
2	Organic Compound Nomenclature II	2000	KCS
3	S&T Terms Book between South and North Korea (Chemistry)	2000	KOFST
4	Inorganic Compound Nomenclature	2001	KCS
5	Terminologies of Chemical Science and Engineering	2002	KUCST
6	Comparison Book in Chemical Engineering Terms between Koreas	2003	KIChE
7	Comparative data of academic terminology in textbooks	2007	NIKL
8	Chemical Terminology (5th Edition)	2008	KCS
9	Chemical Terminology (general chemistry, physical chemistry, organic chemistry)	2014	KCS
10	Inorganic Compound Nomenclature (Revision)	2016	KCS
11	Organic Compound Nomenclature II (Revision)	2016	KCS
12	Chemical Terms Dictionary	2020	Iljin Publishing Co.

There were two types of glossaries. Mirror 2.0, published in 2017, contained the field classification and explanation (definition) of technical terms, and Civilization was published in 2019 without definitions. Mirror 2.0 is a comprehensive academic glossary containing 46 fields and 906,390 terms. Civilization is the newest edition, a comprehensive scientific and technological glossary for the mobile phone that contains dictionary terms in various fields including chemistry.

Chemical Terminology 2008 (4th edition) and 2014 (5th edition) were selected for terminology analysis in South Korea. Mirror 2.0 and Civilization were also selected for North Korea. The selection criteria are based on three perspectives, representativeness, professionalism, and quality as national chemical terminology data. The total words in the Chemical Terminology 2008 edition were 30,989 terms consisting of 15,955 Korean-English terms and 14,994 English-Korean terms. In addition, it had a glossary explanation but not definitions for each term. In the 2014 edition, there were a total of 1,996 Korean-English terms classified into three fields: general chemistry, physical chemistry, and organic chemistry. These included 637 terms in general chemistry, 693 terms in physical chemistry, and 666 terms in organic chemistry. The 2014

edition did not have a glossary explanation or definitions.

Table 2 Chemical Terminology Data Collection List in North Korea

No.	Title	Year	Publisher
1	. Chemical Dictionary	1955	Academy of Science Publishing Co.
2	Chemical Dictionary I, II, III	1969-1970	Academy of Science in Hamheung Institute
3	Agricultural Chemistry Dictionary	1992	Agricultural Publishing Co.
4	Grand Chosun Language Dictionary I, II	1992	Social Science Publishing Co.
5	Gwangmyeong Encyclopedia12 (Chemisty)	2012	Encyclopedia Publishing Co.
6	Chosun Language-related Dictionary	2013	Chosun Publications Import and Export Company
7	Mirror 2.0 (Chemistry)	2017	National Language Affairs Committee
8	Civilization	2019	Civilization Intellectual Product Distribution Center

The selected data in the South were mostly written as an electric file, so it was necessary to manually convert data sources for processing. Mirror 2.0 selected as the North Korean data, contained a total of 18,509 Korean-English terms only from the chemical field, including a summary and definition of each term. In Civilization, there were a total of 610,370 Korean-English terms that contained terms from many fields but no definitions.

2. Data Processing and Matching

Each data was processed to match the chemical terms from North and South Korea. In particular, a data pretreatment process was established to analyze the inter-Korean terminology data in the chemical field. English was set as a key value for the North-South term matching analysis, and then the processing data was purified. Matching was also conducted based on the English key value. For data matching analysis, KNIME[11] was used as an analysis platform.

[11] KNIME is a new open source platform as a collaboration and research tool for data analyzing, developing and reporting. It integrates various components for machine learning and data mining through its modular data pipelining "Building Blocks of Analytics" concept. (source: https://www.knime.com/)

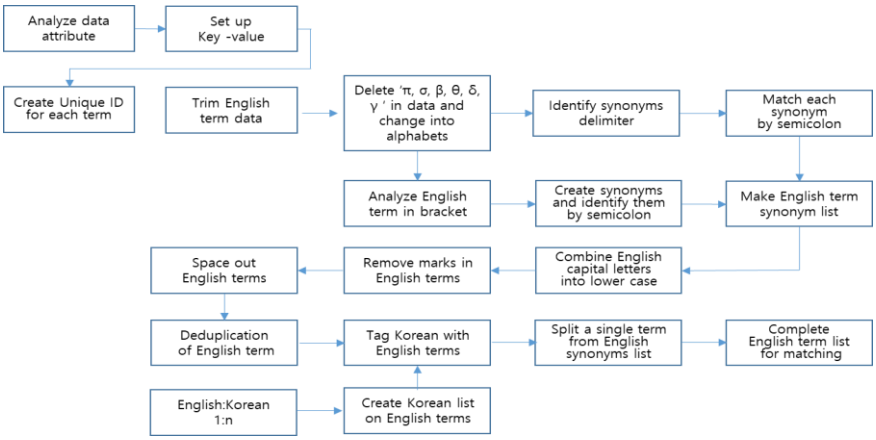

Figure 2 Data Treatment Processing Flow

In the first step, data collected from Chemical Terminology 2008 and 2014 was refined using the English key value, and 15,548 cases were obtained. Data from Mirror 2.0 were also treated using the same process, and 17,645 cases were revealed. The two types of results from Chemical Terminology and Mirror 2.0 were combined, and then 4,088 pairs were finally made as matching results. However, because the results represented a very small number of the raw data volume, additional matching analysis was performed by securing more data from Civilization and other fields in Mirror 2.0.

To discover additional data, 10,768 cases were generated by processing Mirror 2.0 and Civilization data. By matching this with Chemical Terminology 2008 and 2014, 5,705 new pairs were created. The final result for the inter-Korean term matching after removing duplicates was 9,760 pairs. The matching rate was 63%. Matching results with Mirror 2.0 included 4,019 pairs only in the Chemistry field, and 2,685 pairs in other S&T fields, Physics, Biology, and Medicine, etc. Matching with Civilization included a total of 3,056 pairs, of which 698 were in Chemistry, 18 in Chemical Engineering, 13 in Inorganic Chemistry, 94 in Organic Chemistry, and 2,233 in others. In conclusion, 4,842 pairs were obtained in Chemistry (49%) and 4,918 pairs in other fields (51%).

The matching results were reviewed in two directions. Initially, the Korea Research Institute of Chemical Technology (KRICT) experts group examined the matching pairs based on their English key value, definition, and Chinese characters, etc. Secondly, two North Korean experts[1 2] also reviewed them. North Korean expert A focused on English words considering differences in

[1 2] The two North Korean scientists are experts who fled North Korea and currently reside in South Korea.

terminology recognition and usage between North and South Korea. North Korean expert B reviewed matching values based on chemistry learning background in high school and University.

For sub-field classification in chemistry, the Korean Science and Technology Standard Classification System (11 classifications in chemistry) was utilized (Figure 3). In conclusion, 3,844 cases (39.4%) were matched for physical chemistry, 1,243 cases (12.7%) for other chemistry, 1,099 cases (11.3%) for biochemistry, and 1,006 cases (10.3%) for organic chemistry. Among the classifications, the field of physical chemistry created the most because physics and chemistry have a convergence character as adjacent disciplines of basic science. In addition, the field of other chemistry was second place for a similar reason.

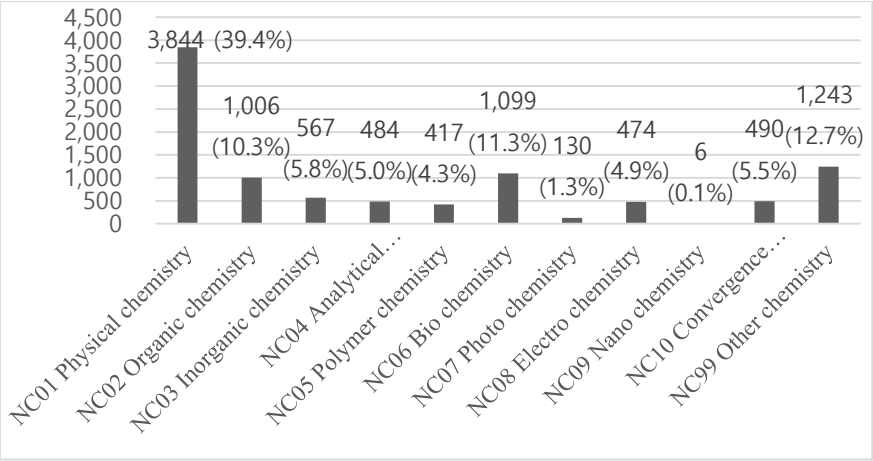

Figure 3 Sub-fields categorization in chemistry

3. Type categorization and remarks

Type categorization was done in matching pairs. The type categorization of inter-Korean terminology pairs refers to the work that Shin (2015; 2016; 2019) performed for terminology analysis. It is mainly divided into 3 types, AA, Aa, and AB by comparing the forms of the representative languages of South and North. The AA type indicates that the terminology of South and North Korea are perfectly the same. The Aa type indicates they are mostly the same but different due to grammar, such as a phonetic rule. Lastly, the AB type indicates the form of terminology in the South and North are distinct. This is when the South and North use different types of terminology for the same original English language. For the AB type, after the South and North components were divided

by definition, they were compared and classified. If there is at least one AB type word among the components, it is classified as AB.

As a result of type categorization processing, there were 3,558 cases (36%) of AA type, 961 cases (10%) of Aa type, and 5,241 cases (54%) of AB type. The largest category was AB type, which confirmed the level of heterogeneity in chemical terms between the two Koreas. The AB type has different forms in North and South Korea and usually consists of a combination of terms. This is because there are many multi-word units in terms that combine two or more words to form a single conceptual unit. This means the terminology analysis must consider the morphological structure, spacing, and the lexical system, such as the synthesis of native and foreign words. The proportion of abbreviations or omissions in term components or Chinese synonyms is relatively high because chemistry has a high correlation with other sectors due to the nature of the field. This makes it necessary to compare and analyze with other fields including physics, biology, and chemistry. In other words, AB types require discussion between the two Koreas because their heterogeneity is very high.

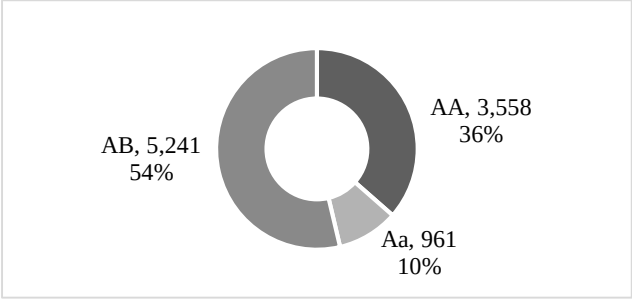

Figure 4 The final result of matching data type categorization

Compared with Mirror 2.0 and Civilization, the number of AB types was similarly the most. In the case of Mirror 2.0, there were 2,601 cases (39%) of AA type, 721 cases (11%) of Aa type, and 3,381 cases (50%) of AB type. Civilization included 956 cases (31%) of AA type, 240 cases (8%) of Aa type and 1,860 cases (61%) of AB type. The matching data cases with Mirror 2.0 showed that the heterogeneity of the matching term pairs was higher than that of Civilization, relative to the AB type, even though the AB type ratio was high in Civilization. This is because Civilization has adopted many English terms as the latest data in the chemical field, rather than Mirror 2.0.

Table 3 Type categorization results sample list [1 3]

Type	English	South Korean	North Korean
AA	absorbent	흡수제	흡수제
AA	acetylation	아세틸화	아세틸화
AA	adamantane	아다만탄	아다만탄
Aa	grain growth	입자 성장	립자성장
Aa	electrophilic	친전자성의	친전자성
Aa	spectrum	스펙트럼	스펙트르
AB	lattice constant	격자 상수	살창상수
AB	ramp generator	경사 전위발생기	톱날파발진기
AB	helicity	나선성	라선도
AB	aprotic solvent	비양성자성 용매	비프로톤용매
AB	anionotropy	음이온이동	아니오노트로피
AB	spectral band width	스펙트럼 띠너비	스펙트르대역너비

Several singularities were found in the type categorization review. First, South and North Korean terms were mismatched based on the English key value. In this case, similar terms were found and matched again. When 'back donation' was an English key value, the South Korean was 'yeogjegong (역제공),' but it mismatched 'geodaegyeoljeong (거대결정)' in North Korean. This was converted into a synonym, 'yeogjugi (역주기).' Even when 'disorder' was an English key value, it matched incorrectly with 'jagamyeon-yeogjilhwan (자가면역질환)' in South and was then changed into 'mujilseo (무질서)' in the North. 'Disorder' in English originally means 'mujilseo (무질서)' but the terminological definition differs. Therefore, it was revised again as a synonym, 'jagamyeon-yeogjilbyeong (자가면역질병)' in North Korea.

Second, it was difficult to process type categorization for compound words. In the case of 'spectrum' as an English key value, the North Korean matching term was treated as 'seupegteuleu (스펙트르)' an Aa type, but in the case of 'spectral band width,' the North Korean term was 'seupegteuleu daeeyeogneobi (스펙트르 대역너비)' and treated as an AB type. This was similarly matched to the meaning of the English key value, but as the type processing standard, the

[1 3] In this table, Korean is not separately converted to English pronunciation in order to show the type classification according to the results of matching North and South Korean chemical terms.

Chinese word ‘daeeyeogneobi (대역너비)’ was included in the compound word, so it was classified as AB. Among North and South Korean terms, when they were compound words, they were classified as AB rather than AA and Aa, which had high similarity.

Third, there were native North Korean terms that were not used in the South. ‘Coupling’ as an English key value in South Korea was matched by ‘jjagjium (짝지움)’ and in the North by ‘baegyeol (배결)’. ‘Baegyeol’ is not used in the South and is uniquely used in the North. In a similar case, ‘‘coefficient’ in South Korea was matched by ‘gyesu (계수)’ and ‘gyeotsu (곁수)’ in the North. ‘Interaction’ in the South was ‘sangho (상호)’ and ‘hosang (호상)’ in the North were connected with each other. ‘Gyeotsu (곁수)’ and ‘hosang (호상)’ are native North Korean terms that were created as a result of the North Korean vocabulary purification project.

Fourth, it was difficult to match without an explanation of the definition of terms in North and South Korea. Chemical Terminology and Civilization do not have definitions to assist in matching and categorizing. Expert opinions were obtained or verified through Naver, Woorimalsem as an electric Korean dictionary, and NKTECH[14] terminology contents. Lastly, there were typos and errors in the selected data, so self-correction was required. For example, ‘Kaleubotan (카르보탄)’ was changed to ‘kaleubolan (카르보란)’, and ‘dubichlyangjagwajang (두빛량자과장)’ to ‘dubichlyangjagwajeong (두빛량자과정)’ as exact terms. There were a number of typos in the North-South glossaries, so revisions and corrections were needed.

VI. Conclusions

This research was conducted to collect chemical terminology resources and establish an integrated basis for comparing the chemical terminology of the two Koreas. Chemical Terminology (2008 and 2014) in South Korea was compared with Mirror 2.0 and Civilization published in North Korea, which specialized in terminology in the field of chemistry. The materials from North and South were treated for matching analysis using a three-step process. The key values for matching analysis were English terms to establish a characteristic comparison, and corresponding pairs were created. The final results from matching between the Chemical Terminology 2008 in South and Mirror 2.0 and Civilization in North were 9,760 pairs. They obtained 4,842 pairs in chemistry (49 %) and

[14] This is a platform to provide the information of science and technology in North Korea which Korea Institute of Science and Technology Information (KISTI) operates and manages.

4,918 pairs in other fields (51%), Physics, Biology, and Medicine, etc. For sub-field classification in chemistry among them, physical chemistry was the highest field.

The corresponding pairs were compared with each other based on three characteristic comparison types, AA, Aa and AB. The results after type categorization processing consisted of 3,558 cases (36%) of AA, 961 cases (10%) of Aa, and 5,241 cases (54%) of AB. The AB type had the most entries, confirming the heterogeneity of chemical terms between the two Koreas. With Mirror 2.0, more AB type cases were found than Civilization because Civilization has adopted many English terms as the latest data in the chemical field. There were many multi-word units with terms that combined two or more words to form a single conceptual unit. The proportion of abbreviations or omissions in term components or Chinese synonyms was relatively high because chemistry has a high correlation with other sectors due to the nature of the field. As a matter of fact, in the AA and Aa types, the chemical terminologies of South and North Korea are perfectly or mostly the same, so they are highly understandable. In contrast, the AB type is so distinct that North and South scientists might not be able to understand that terms. These results imply that the AB type is highly heterogeneous, so it should be discussed between the two Koreas.

This study focused on the comparison of chemical terms between the two Koreas, and the integration perspective method was not included. Therefore, follow-up research work is necessary. A review of initially matching data should be conducted by North and South Korean chemists together. The experts who examine the matching data with South Korean chemists are advised to check matching terms with North Korean chemists because the practical usage of terms in the North could be totally different from what we know, even though two North Korean scientists who currently reside and work in South Korea reviewed them. Second, only 9,760 North Korean corresponding terms were found out of 15,548 terms in Chemical Terminology and 17,648 terms in Mirror 2.0. It is necessary to analyze the reasons for non-matching on non-corresponding terms and re-match them. Considering the limitations of the result values using mechanical matching tools such as KNIME, a review of non-matching data should be conducted by experts in the chemical field and re-matching should be performed. Third, since the 5th edition Chemical Terminology by KCS, in 2008, there has been no full refinement or term definitions. Many errors or typos were revealed in that glossary, so it is possible that the North Korean chemical terms can be wrongly matched. To removal such a probability, it has been reviewed by many experts, and their opinions have been reflected. Nevertheless, for an accurate comparative study, Chemical Terminology in the South needs full refinement and revision.

In the coming new economic era of unification based on inter-Korean cooperation, the role and function of science and technology will become very important and require overcoming the existing heterogeneity in many fields between the two Koreas. Several terminology comparison studies in science and technical fields have been conducted for that purpose. However, they did not systematically focus on the chemical field, like this study, although there has been matching of simple chemical terms in scientific and technical comparisons. The results of this study can be used as basic data to promote mutual understanding of inter-Korean chemical terms and to allow inter-Korean experts in the field of chemistry to review terms together. The list of corresponding pairs will also serve as a stepping stone for inter-Korean communication and for the characterization of scientific and technological terms. It is also possible that it will contribute to mutual collaboration about which areas of chemistry the scientists in the two Koreas are interested in and which research topics they can cooperate on.

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