Substantia
An International Journal of the History of Chemistry

Firenze University Press
www.fupress.com/substantia

Historical Articles

Udagawa Youan (1798-1846), Pioneer of Chemistry Studies in Japan from Western Sources and his Successors

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OPEN ACCESS

Citation: Siderer Y. (2021) Udagawa Youan (1798-1846), Pioneer of Chemistry Studies in Japan from Western Sources and his Successors. *Substantia* 5(1) : 99-117. doi: 10.36253/Substantia-963

Received: Jun 08, 2020

Revised: Sep 06, 2020

Just Accepted Online: Sep 14, 2020

Published: Mar 01, 2021

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Abstract. This work presents chemistry studies of the Japanese scholar Udagawa Youan (1798-1846), specifically, his pioneering book *Seimi Kaiso*, introduction to Chemistry, and includes a short biography of Youan. The first aim of this work is to present Youan's contribution to Western chemistry in Japan. Youan studied many Western books and listed their authors. The new terms he invented for chemistry in Japanese influenced the development of chemistry writing and application in Japan. The seven books of *Seimi Kaiso* that were published during 1837-1847 and republished with annotation in Japanese in 1975 are discussed in this article. The impact of Youan' terminology on the history of chemistry writing in the nineteenth and twentieth centuries is discussed. The conditions of knowledge transfer among Japanese and Western scholars were very different. Youan had severe difficulties facing the strict attitude of the Tokugawa authorities toward studying and distributing knowledge coming from foreign countries. The later development of Japanese chemistry language and studies is also described.

Keywords: Japan, Udagawa Youan, *Seimi Kaiso* – Introduction to Chemistry, Western sources of science, Dutch Studies in Japan, Japanese chemistry terminology.

1. UDAGAWA YOUAN (1798-1846) – SCHOLAR OF DUTCH STUDIES

Udagawa Youan– A multi-talented nineteenth century scholar

Udagawa Youan (1798-1846) was a scholar of many talents who touched very many topics during his lifetime.[1] Youan was a medical doctor of Tsuyama town in Okayama prefecture, translated and investigated plants in Edo Japan, studied modern chemistry and many other topics like musical instruments, geography, history of Holland and playing cards; he wrote an early article on coffee and more. Youan studied foreign languages, first Dutch, to some level German, even Latin and Greek Russian, and copied a list of Arabic letters. It is told that in 1822 he stayed on a British ship for three nights in order to learn English. He saw maps of the world from which he could study names of European and other countries.[2]

Figure 1. Scholar Udagawa Youan.

In his youth, Youan studied Chinese Classics in the house of his teacher and adoptive father Udagawa Genshin. An official translation office of the Tokugawa regime, *Bansho wage goyo* was established in 1811; Youan joined the translation office in 1826. Youan collaborated there in Dutch translation with his adoptive father, his teacher Baba Sajuro, Otsuki Gentaku who was one of the founders of Dutch Studies and other Japanese scholars. They translated parts of Chomel encyclopedia, from which Youan learnt about Western botany.[3] Youan's good knowledge of Chinese Classics and good knowledge of Dutch language that he acquired due to years of translating books on plants, botany, medical drugs, and other topics, helped him understanding and coining suitable terms in Japanese for the new discipline, chemistry: names of the chemical elements, compounds, and chemical processes. Youan's innovation of scientific language remains in use today.

2. *SEIMI KAISO* – INTRODUCTION TO CHEMISTRY – YOUAN'S BOOK AND ITS CURRENT RESEARCH

Youan's main book on chemistry *Seimi Kaiso* will be dealt with in the following chapters. Before this book he wrote several other, shorter books on various chemical topics translated from the scientific books imported to Japan. A thorough survey in archives was carried out by J. Mac Lean searching the years 1712 – 1854. He studied the records of the Dutch Factory in Japan, and from the Colonial records, both preserved in the *Rijksarchief* (State Archive) in The Hague, the Netherlands. Mac Lean listed the year that a ship arrived, its name, its captain's name, the scientific instruments and books that were imported; the names of those who ordered those items are also listed.[4] Udagawa Youan might have had access to some of those books and instruments, especially those delivered to the official translation office whose member he was since 1826.

A partial list of U. Youan's early chemistry books includes: Metal Chemistry, Introduction to Chemistry Characters Sound, Dyeing Chemistry, Earth Chemistry number 1, Chemistry of Light, Element Earth (non-metal) Chemistry, Consideration of Western Measures, Note on Western Mineral Springs, Introduction to Chemistry Sequel Potassium Nitrate Theory, Theory on Hot Springs Experiments in Several Provinces.[5]

Description of Seimi Kaiso

Udagawa Youan's *Seimi Kaiso* is considered the first extensive book on chemistry in Japan. It includes seven books; each divided into three volumes and numbered chapters. Six books are considered inner books that are the main text; the seventh book is called an external or appendix book. All together it has more than 1100 pages, published between 1837 to 1847. The print is in Kanji and katakana. The books are bound by ribbon with several stiches along the back of the book. The pages are folded and numbered on their margin. Fig. 2 presents a full set of seven books in an original book case at the Edelstein Collection of The National Library of Israel (NLI) in Jerusalem. Supposedly, it was bought by Dr. Sidney Edelstein from a books shop in New York.

The first page of the first book is presented in figure 3. The upper line, written from right to left, shows the year of printing, corresponding to 1837. On the upper right side is written "Udagawa Youan translator." *Seimi Kaiso* 舎密開宗 are the four large letters in the middle of the figure. *Seimi* 舎密 meaning "Chemistry" follows the sound of the Dutch word *Chemie*. The word for chemistry was changed to *kagaku* 化学 meaning "the study of change" after the Chinese term.[6] There is a written warning against forgery on the left lower first page of each book.[7]

In *Seimi Kaiso* Youan dealt with topics such as chemical affinity, solution, caloric, alkali, salts, phosphoric acid, ammonia, oxidation and reductions of metals, glass, constituents of plants and more. Youan studied the ingredients of water in hot springs in Japan and

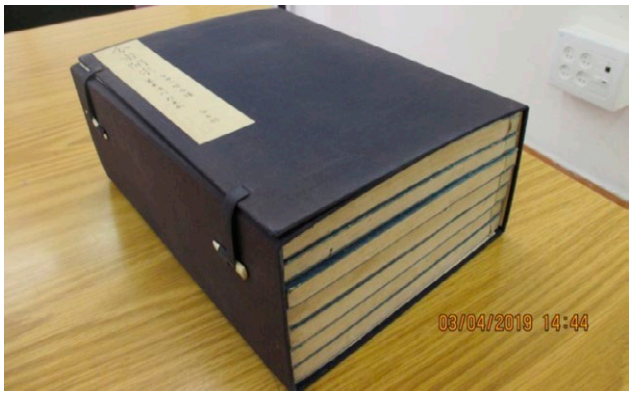

Figure 2. *Seimi Kaiso* set of 7 books at Sidney Edelstein Collection of the History of Science, The National Library of Israel (NLI) in Jerusalem. Photo: Y. Siderer.

Figure 3. *Seimi Kaiso* first page of the first book. Photo: Y. Schley.

described chemical ingredients of hot springs in foreign countries. Udagawa Youan cited fifty-eight elements, five of them were found to be mistakes, among those are caloric and light.[8] The chemistry studies that Youan started continued after him, some of the chemistry terms that he coined are still in use, see below, chapter 4.

In 1975 Youan's *Seimi Kaiso* was rewritten in modern Japanese, including translators' comments. *Seimi Kaiso* is based on about 24 chemistry books from Europe of late eighteenth and early nineteenth centuries. The revised text is written in Kanji, hiragana, and katakana, the last one is used for foreign names of places, people and chemicals. This volume, *Seimi Kaiso Research* holds 570 pages, in a hard black cloth cover, a paper cover and a book case. The book is opened from right to left, as are the original *Seimi Kaiso* books. Editor and preface writer is Tanaka Minoru. Each page shows the original book on its upper part and its currently rewritten text below it, (figures 4 and 5). It contains index of foreign names, index of Japanese materials, photos of several of Youan's apparatus drawings and copies of relevant books' covers. It also contains conversion tables of units of length and volume (p. 542) and weight (p. 543).[9] The main *Seimi Kaiso Research* book (hence SKR) is followed by a second book, written by Tanaka Minoru, Sakaguchi Masao, Dōke Tatsumasa and Kikuchi Toshihiko, with articles on Udagawa Youan, his life, work and his diary. This book of articles will be referred to as *Seimi Kaiso Articles* (hence SKA).[10]

Western Books that Youan Studied

Japanese and Dutch scholars tried to find out the original books from which Youan received his knowledge. In the introduction to *Seimi Kaiso* Youan wrote the names of the authors of the books he studied from and his translation of the title of the book, in Japanese. In Figure 4 a circle ◯ marks the beginning of a book or author's name.

Japanese scholars searched the books left by Youan and tried to match his Japanese writing with the Dutch books found in his house, or in the house of other scholars of Dutch studies. Tsukahara Togo observed that "Youan must have been able to use those manuscripts because he occupied one of the most privileged position in the *Rangaku* society as the member of the Udagawa family and also through his official function in the translation bureau, he was supposed to have wide access to the Dutch sources. In Holland, the identification of the original works of *Seimi Kaiso* was attempted in 1858 by J. J. Hoffmann (1805-1878), the first professor of Japanese studies in Leiden that started in 1855, and later by Serrurier (1846-1901), curator of museum of ethnology in Leiden." Their work relied on deciphering the phonetical transcription of the author's name and the modified Western book title.[12]

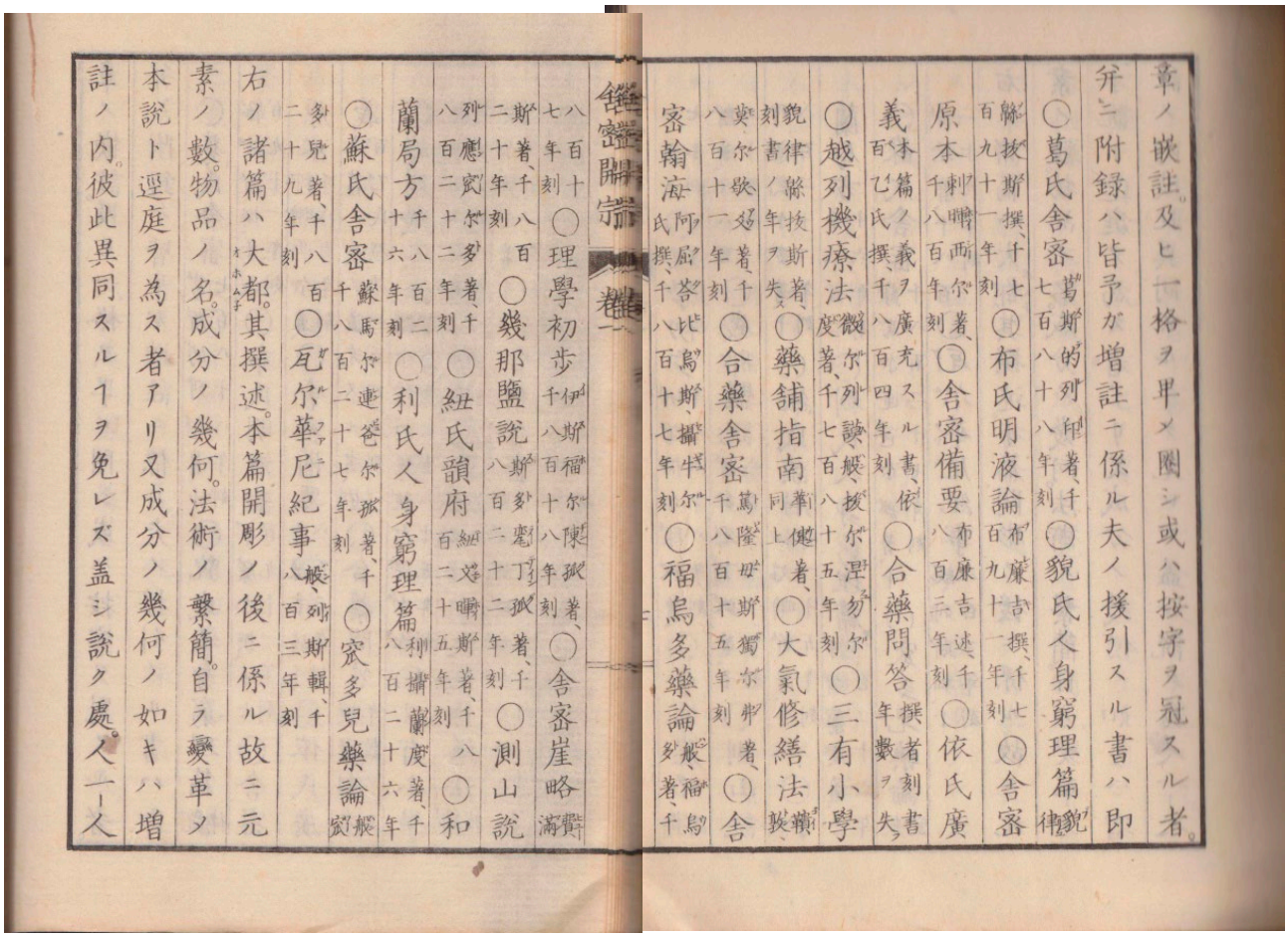

Figure 4. Names of Western authors and books in Udagawa Youan's *Seimi Kaiso* book 1 vol. 1 p. 7.[11] Photo: Y. Schley.

The List of Western Books and their Authors

Following is the list of authors as they appear in the original first book of *Seimi Kaiso* (Fig. 4), hence shortened SK.[13] The list presents the following authors names. Kasteleyn, P. J. (1746-1794), Blumenbach, J. F. (1752-1840), Plenck, J. J. (1735–1807), Lavoisier, A. L. (1743-1794), Ypey, Adolph (1749-1822), Niewenhuis, G., Bernvald, William van (1747-1826), Hagen, K. G. (1749–1829), Guiton de Morveau L. B. (1737-1816), Trommsdorff, J.B. (1770-1837), Ségur O. (1779-1818) , Houte, H. J. (1789-1821), Isfording, J. J. (1776-1841), Hijmans, H. S., Stratingh, E. (1804-1876), Reinwardt, C. G. C. (1773-1854), Dutch Pharmacopeaia 1826, Richerand, A. (1779-1840), Catz Smallenburg, F. van, Water, J. A. van de (1800-1832(?)), Rees, W. Van (1752-?).

Detailed descriptions of authors' names, their book or books and Western book source are presented in appendix 1, including: Author's name in English. Book's title in English, Japanese book's name in kanji, Japanese name in English letters, Japanese book title in English. Dutch book title. Book title in its original language in case there is one; further details and explanations. Youan wrote a shortened name for the authors he cited, in which the first syllable of the author's name is written before the book's title.

In some of the citations Youan mentions studying the book he had, in order to study another chemist whose book he did not have. These include citation of his European contemporary scientists e.g., Berzelius (1779-1848), Davy (1778-1829), Dulong (1785-1838), Gay-Lussac (1778-1850) and others. So actually he studied more than the books listed above and from those he chose which text and authors to cite.

Scholars cited by Youan from books not present in *Seimi Kaiso* list, include (not inclusive, there are more than 160 names of authors): Wedgewood Josiah, Empedocles, Cavendish Henry, Gaubius Hieronymus D., Gadolin Johann, Kirwan Richard, Gmelin Leopold, Glauber Johann R., Klaproth Martin H., Gay-Lussac Joseph L.,

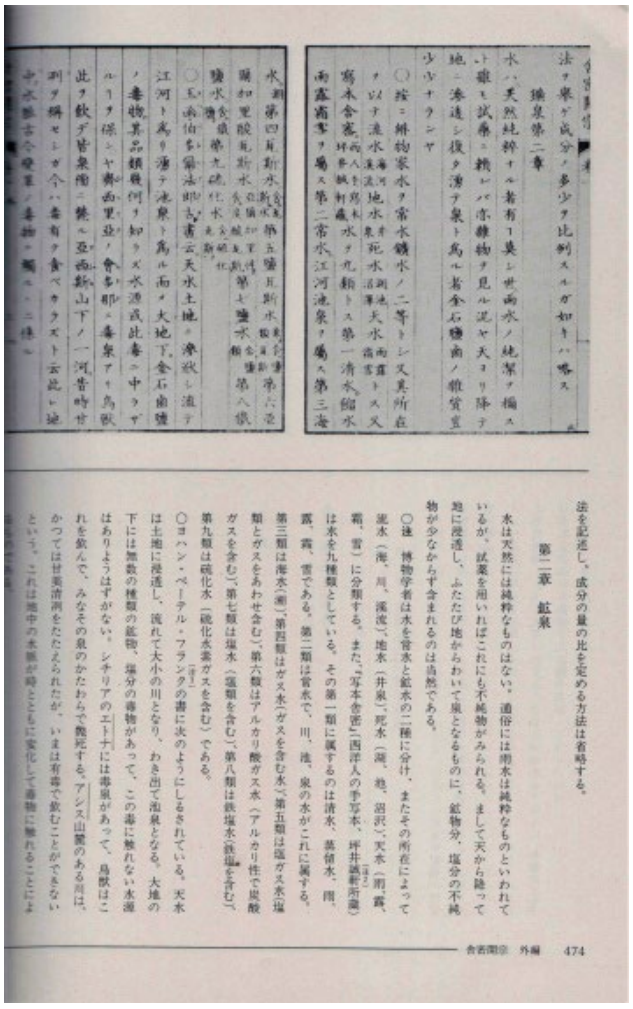

Figure 5. Upper part: *Seimi Kaiso* external book vol. 1, ch. 2 on mineral spring. Lower part: *Seimi Kaiso Research* p. 474. The first lines of the text on water impurities are dealt with in chapter 3 below. Photo: Y. Schley.

Scheele Carl W., Chaptal Jean A.C., Stahl George E., Seignette Pierre, Saussure Horace B. de, Thales, Davy Humphry, Döbereiner Johann W., Dulong Pierre L., Thomson Thomas, Hatchett Charles, Buffon Georges L.L., Faraday Michael, Black Joseph, Priestley Joseph, Fourcroy Antoine F. de, Proust Joseph L., Bergman Torbern O., Berzelius Jöns J., Berthollet Claude L., Boyle Robert, Hoffmann Friedrich, Beaumé Antoine, Homberg Wilhelm, Ure Alexander, Richter Jeremias B., Linné Carl, Rinman Sven, Lemery Nicolas, Rosello Hieronymus.[14]

We see the wide investment of Youan's chemistry study from books from the West, from original books in Dutch, and from books translated into Dutch from French, German, Latin, and Swedish. Most of the books were written in the late eighteenth or early nineteenth century, so Youan studied books that were about forty to ten years old in time of many new discoveries in chemistry. This could have led to his difficulty in understanding texts that were not clear or erroneous, or better understood in the West later.

The chemistry studies that Youan started continued after him, some of the chemistry terms that he coined are still in use, see below, chapter 4.

In *Seimi Kaiso* Youan dealt with topics such as Chemical affinity, solution, saturation, heat element, caloric. Gas, oxygen, nitrogen, atmosphere, hydrogen, water. Alkali, ammonia, acid, carbon. Youan addressed salts, sulfur and nitric acid. In the third book he addressed acids like phosphoric acid, boric acid, fluoric acid, and some metal compounds like barite, strontia and zirconia. Metals like gold, silver, iron, mercury, copper, lead, tin, zinc, bismuth, antimony, mangan, cobalt, nickel, and others were discussed. Organic acids like oxalic acid, citric acid, gallic acid, apple acid, tartaric acid, benzoic acid were studied. Youan wrote about soap, oils, resin, camphor, fiber, pigments and wax. In the last, external book, he wrote about analysis of mineral water, vegetable pigments, classification of springs and artificial preparation of mineral water.[15]

Tanaka Minoru devoted articles to Youan's perception of chemistry in *Seimi Kaiso* and discussed Youan's misunderstanding and mistranslation.[16] The question why Youan did not include the discussion about "atom" deserves further study.

3. EXAMPLES OF YOUAN'S TRANSLATIONS FROM WESTERN SOURCES

Four examples of Youan's studies are presented: 1. Henry-Youan: Water chemical ingredients analysis. 2. Galvani column. 3. Nitrogen oxides compounds. 4. Hot springs abroad and in Japan.

William Henry (1774-1836) text on Water Analysis and Udagawa Youan's translation

Examination of Mineral Water by Re-agents

Henry: Water is never presented by nature in a state of complete purity. Even when collected as it descends in a form of rain, chemical tests detect in it a minute proportion of foreign ingredients. And when it had been absorbed by the earth, had traversed its different strata, and is returned to us by springs, it is found to have acquired various impregnations. The readiest method of judging the contents of natural waters is by applying what are termed tests or re-agents, i.e. substances which on being added to a water, exhibit, by the phenomena they

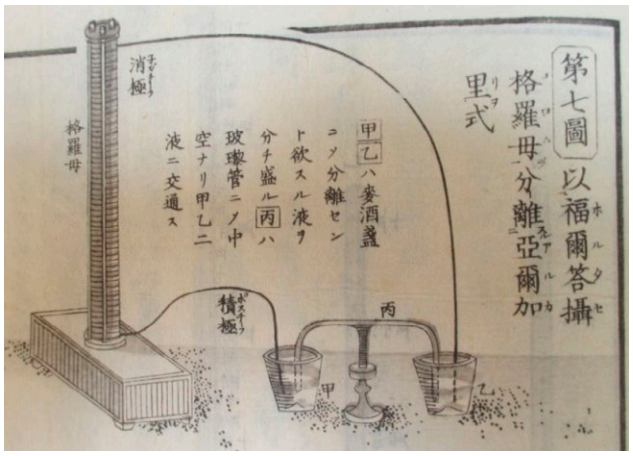

Figure 6. Youan's Volta pile sketch and explanation. SK book 1, vol. 3 Figure 7. Photo: Y. Schley.

produce, the nature of saline or other ingredients.[17]

Youan's translation, in the external, seventh book first volume, chapter 1-2 on mineral spring:

> Water is not a pure thing. In a popular way, it can be said that water is pure, but, by using a reagent it can be seen that it is not pure. From under the sky water goes down to the earth and penetrates. Then [coming out] from the earth a spring is formed, in it a part of mineral matter, naturally consisting of not a small amount of impurities.[18]

It is clear that Youan follows Henry in this section, even though it is a translation from Ypey's Dutch translation of Trommsdorff's German translation of William Henry's English text.

Mr. Volta Column (See Figure 6)

Youan describes the finding in 1791 by Galvani "by chance how electric power is generated and explained this fact to encourage junior. Volta (Alessandro) in the city made a column like a tower to generate electricity by piling up many metal plates whose form (is) oval." Youan gave a detailed description and drawing of its construction:[19]

> Volta's column is an unusual device of modern invention. The following is the construction: zinc (or tin) is casted into the oval form whose size is that of Dardel (the diameter is about one sun) and a little thicker than the Dardel.[20] Next, silver (or copper) is used to make the same size of oval and moreover felt (or thick paper) is used to make the size of oval. Then three kinds of 30 to 50 plates are piled up in order to make a column. The first is silver plate, the second is zinc and the last is felt dipped in condensed salty water and squeezed after it. Piling 20 to 30 sets, the last top plate is zinc plate [in the original paper's misprint stated that the last is silver plate]. On the bottom silver plate a strip of tin or lead is pierced which works as a contact to outside. If a tester touches the strip with his finger soaked in condensed salty water and another finger touches the top plate of zinc, he will get a shock in both arms. This shock strength is dependent upon the number of piled plates. (According to one theory, when the silver plate is used, salt water is effective, while for the copper plate, ammonium chloride solution is effective).

Youan added comment to his text:

> The pole of the power generated from the silver plate is named cathode (*negatief, ontkennende poo*l), and the power pole from zinc is named anode (*positief, stellige pool*). These two poles are different from each other as follows. ○ Anode is signed as +. The taste on tongue is alkali; it changes the color of *akana* solution to red.[21]

Nitrogen oxides compounds

In the following text Youan tells about Cavendish's discovery by citing Smallenburg's book. Youan invented terms for the degrees of oxidation in Japanese.

> Chemical combination of nitrogen and oxygen forms nitric acid. Nitric acid is formed from the combination of nitrogen and oxygen. Into nitrogen gas oxygen gas is mixed, electric spark is passed through, and nitric acid is formed. …According to "Smallenburg's Chemistry," in 1784, an Englishman, Cavendish, mentioned nitric acid composition for the first time. …According to several French and Dutch scholars, in nitrogen and oxygen compounds there are four grades.[22]

Foreign spas in Youan's Seimi Kaiso

Youan mentioned five springs in Bohemia, these include:

> Bernard Spring – there is a big building – it is called hospital; Mill Spring, since 1711. Temp. 138 degrees Fahrenheit [ca. 59° Celsius]." Youan mentioned the spring's therapeutic effect. "New Spring since 1748. Temp. 145 deg. Fahrenheit. It is attributed medical curative effects; Hot Spring - since 1725. Temp. 165 deg. Fahrenheit. Attributed medical benefits; Telesia Spring nearby. Temp. 135 deg. Fahrenheit: 'Many women patients are bathing.'
>
> The above 5 Springs compositions is about the same, including: 硫酸ソーダ: Na_2SO_4 sodium sulfate 24-46

grain; 塩酸ソーダ: NaCl sodium chloride 5-6 grain; 炭酸ソーダ: Na_2CO_3 sodium carbonate 10-15 grain; 炭酸カルキ: $CaCO_3$ containing CaO calcium carbonate – lime 1-4 grain; 酸化鉄: Mainly Fe_2O_3 iron oxide 0.02 grain; 炭酸ガス: CO_2 carbon dioxide gas ~ 5-30 cm^3; 硫酸苦土泉: $MgSO_4$.[23] 1 grain ~ 0.02 gram. Hot springs contain magnesium sulfate and iron oxide. The taste is bitter. Bitter taste comes from calcium and magnesium sulfate and the color from iron oxide.

Analysis of chemical ingredients of hot springs in Japan

Japan is famous for its abundance of hot springs and the tradition of hot springs bathing. Udagawa Youan studied the chemistry of the water in hot springs. A thorough study of Udagawa Youan research on chemical ingredients in hot spring was published by Osawa Masumi (1932-). Osawa studied Von Siebold's books and Bürger research on mineral contents of hot springs in Japan.[24] Some of von Siebold chemical collections are stored in the Museum of Ethnology in Leiden (*Museum Volkenkunde*). The reagents used by Youan are stored at Waseda University Archive. According to Osawa, "Chemical analysis of mineral spring water was first carried out by P.F. von Siebold (1796-1866) and H. Bürger (1806 -1858), medical officers of the Dutch East India Company (VOC) in Nagasaki, for several samples from Kyushu, southwest Japan in 1820s." When they went to Edo (now Tokyo) in 1826, they met Udagawa Youan (1798-1846), at Nagasakiya inn located in Hongokucho, Edo city several times during the 3rd day of March to the 12th day of April (lunar calendar).[25] They probably discussed mineral springs among other topics like Japanese plants. A lot of chemical reagents and equipment were carried to Japan when Siebold came to Nagasaki in 1823. Siebold and Bürger probably brought them to Edo. Then, from 1828, Udagawa started his chemical study of mineral springs from a wide area of Japan."[26] Osawa cites a summary of minerals found by Youan in Suwa, Shinshu (today Nagano prefecture) in 1829 (*Bunsei* 11) as written in a draft kept at Osaka Takeda Science Foundation Library. For example: ｽﾜｰﾌﾙｼﾞｭｰﾙ *Zwavelzuur,* 硫酸 *ryuusan*, sulphuric acid.[27]

4. COINING CHEMISTRY VOCABULARY AND THE DEVELOPMENT OF CHEMISTRY LANGUAGE IN JAPAN

Youan's terms, their original Dutch and their survival

Table 1 is composed of three contributions: Sakaguchi Masao listed 58 Japanese terms, as they were used in 1975, and he put in parentheses Youan's terms. Sakaguchi's Japanese list was followed by a list of the same terms in Dutch (1). The list in Japanese was previously published by Tanaka M. in 1964 (2).[28] English translation is added by the current author (3). It shows Udagawa Youan inventions of various terms for chemistry tools and processes. For most of the words Youan combined two characters that should transfer the meaning of the Dutch term into Japanese. Some words like no. 48 *cork* and no. 51 *retort* were written by Youan in kanji as *ateji*, phonetic pronunciation.

Several of the terms that were formed by two kanji combination were preserved and are still used today, e.g., 結晶 crystal. Others have been changed, either by one, e.g. 燃焼 combustion or both kanji letters, e.g., 融点 melting point. It may be said that Youan understood the meaning of the terms that he was translating and chose the appropriate kanji for them. Those new terms added to their practical use in chemical processing since the nineteenth century until today. For example: entry no. 40: 飽和 *houwa*, saturation, is formed by 飽 tired of, satiate, and 和 that has several meanings: harmony, Japanese style, peace, Japan. The same term 飽和 is used today for saturated fatty acid, as in 飽和 脂肪酸 *houwa shibousan*. Thus, contemporary scientists find it appropriate to use Youan's kanji combination for the Dutch term *verzadiging*, saturation. Another example, no. 41: Dutch: *opheffing* 昇華 *Shouka*, meaning sublimation: 昇- rise up 華 has several meanings: splendor, flower, gorgeous. This term is used today for transfer of matter directly from solid to gas. It is also used for sublimation in psychology.[29]

In his chapter on "Youan the Linguistic," Takahashi Terukazu (1944-) showed several kanji letters combinations that Youan chose in order to use phonetically. E.g., *an* 諳安, *ba* 抜婆、*ta* 太. [30] He used them for no. 51 in the table, 列篤爾多レトルト for retort; for writing the Western names shown in Fig. 4, e.g. 布廉吉 フレンキ佛如 Plenck; and for writing names of foreign countries, e.g. 波尓杜瓦尓 ポルトガル for Portugal. Other terms have a combination of katakana and kanji, like *litmus paper* ラッカムース紙. The pronunciation of no. 48 *Cork* コルク and no. 49 *beaker* ビーカー in today's reading is somewhat different than Youan's, possibly due to change in pronunciation during the years.[31]

The birth of the term 元素 *genso,* element. In 1834 Youan published his book *Shokugaku Keigen* 植学啓原 (Introduction to Physical Science. Principle of Botany). In its third, last volume, he addressed plant biochemistry; it became a textbook for natural sciences. In *Shokugaku Keigen* third volume there is the following exposition for the first time: Air, water, oil, salt. He used the

Table 1. Current and Youan's chemistry terms, Dutch terms he studied and their English translation.

	Dutch (1)	Recent Japanese (1,2)	Udagawa Youan (1)	English(3)
1	wet	法則	法則	law
2	eigenschap	性質	稟性	property
3	ontbinding	溶解､分解	分離	Dissolution, separation
4	Scheikundige probeermiddelen (reagentia)	化学者 試みの手段 (試薬)	試薬	chemist testing means (reagents)
5	droogeweg	乾式法	燥道の法	dry way method
6	onbewerktuigde ligchamen	無機物	無機性体	inorganic substance
7	bewerktuigde ligchamen	有機物	機性体	organic substance
8	verbranding	燃焼	熱焼	combusion
9	bestanddeel	成分	成分	component
10	volumen uitgebreidheid	容積 示量	容積	volume extensiveness
11	gewigt	重量	秤量	weight
12	eigendommelijke zwaarte	比重	異類重	specific gravity
13	gaz	ガス	瓦斯	gas
14	damp	蒸気	蒸気	vapor
15	vaste lichaamen	固体	凝体	solid
16	vloeibaare lichaamen	液体	流体	liquid
17	drukking	圧力	圧力	pressure
18	temperatuur	温度	温度	temperature
19	kooking opbruisching	沸騰 ドレッシング	沸騰	boiling dressing
20	het punt van kooking	沸点	沸度	boiling point
21	meltpunt	融点	熔度	melting point
22	uitzetting	膨張	廓張	expansion
23	vermeerdering van warmte	発熱	熱起	fever
24	luchtledige	真空	無気	vacuum
25	electriek, electriiteit	電気	越列気　エレキ	electric, electricity
26	stellige (positief) pool	陽極	積極	anode (positive) pole
27	ontkennende (negatief) pool	陰極	消極	cathode (negative) pole
28	kooken	煮沸	煮沸	boiling
29	vervliegen	揮発	揮散	volatilization
30	uitdamping	蒸発	蒸散	evaporation
31	droogheid, uitdroogen	乾 涸	乾固	dry up
32	overhauling	蒸溜	蒸餾	distillation
33	drooge overhauling	乾 溜	乾餾	dry distillation
34	schudding	振盪	振蕩	shock
35	beweging	攪拌	攪擾	stir
36	kristal	結晶	結晶	crystal
37	vervloeien in de lucht	潮解	潮解	deliquescence
38	oplossing	溶液	溶液	solution
39	filtreeren	濾過	濾過	filtration
40	verzadiging	飽和	飽和	saturation
41	opheffing	昇華	昇華	sublimation
42	nederplofsel benzinkzel	沈降 沈殿	澱	sedimentation precipitation
43	toestel	装置	装置	device
44	lakmoespapier	リトルマス紙	勒法母斯ラッカマース紙	litmus paper

Table 1. (Continued).

	Dutch (1)	Recent Japanese (1,2)	Udagawa Youan (1)	English(3)
45	curumapapier	クルクム紙	姜黄紙	turmeric paper
46	smelt-kroes	坩堝	坩堝	crucible
47	blaaspijp	吹管	吹管	Blowpipe
48	kurk	コルク	鳩爾古 キュルく	cork
49	bekerglas	ビーカー	玻黎ベーケル	beaker
50	flesschen	フラスコ	フラスコ	flask
51	retort kromhals	レトルト	列篤爾多レトルト	retort
52	glaspijp	ガラス管	玻黎筥	Glass tube
53	schaal	目盛	度目どめ	scale
54	kraan	蛇口	回銓 かいせん	tap
55	luchtledige klok	真空計	排気鍾はいきしょう	Vacuum clock
56	eudiometer	水「ガス」電量計	欧実阿墨多爾 ユーヂオメートル	eudiometer
57	thermometer	温度計	験温器	thermometer
58	calorimeter	熱量計	験熱器　カロリメートル	calorimeter

Table 2. Choices of kanji for element by Udagawa Youan and other scholars.

Udagawa Youan 宇田川榕庵	Hoashi Banri 帆足万里	Takano Choei 高野長英	Aochi Rinso 青地林宗
元素 *genso* element	原質	造質/原質	原質
酸素 *sanso* oxygen	酸質	酸質	酸質
窒素 Suffocating element- nitrogen 殺素 Lethal element	塞質	窒質 suffocating matter	窒気 suffocating gas
水素 *suiso* hydrogen	水質	水質	水質
炭素 *tanso* carbon	炭質	炭質	煤質

character so -素 for several elements: Oxygen, *zuurstof* is *sanso* 酸素; Nitrogen, *stikstof* is *chisso* 窒素; Hydrogen, *waterstof* is *suiso* 水素; Carbon, *koolstof* is *tanso* 炭素.

Genso 元素 is translated from *grondstof*. 元 *grond* meaning basis, 素 is equivalent to 物質 *busshitsu,* substance, matter*, stof in Dutch.*[32]

Youan used those terms for the first time in his botany book in 1834. However, other Japanese Dutch scholars have used the ending term [~質] *shitsu*, meaning substance, matter. Aochi Rinso 青地林宗 in his book *Kikai Kanran*, Overall View of the Atmosphere, of 1827; Takano Choei 高野長英 in his book 西説医原枢要*seisetsu igen suoyou,* Western Explanation of the Theory of Physiology, published in 1832; and Hoashi Banri 青地林宗 in 窮理通 *kyuuritsuu*, Generalities of Physics, (ca. 1836).[33] A comparison of the various kanji characters choices is shown in table 2.

Several other terms with different kanji were used by scholars. For example, *Caloric: Onshitsu* 温質 *Matter of warmth.* Youan*: Danso* 煖素. For nitrogen, Youan tried two different kanji combinations: 殺素 lethal element and *Chisso* 窒素 that is the term used to this day.[34]

Sugawara Kunika studied Misaki Shosuke (1847-1873) translation of Fresenius. Misaki, used terms coined by Youan, but no citation of Youan is shown.[35] Those words like 硫酸, 硝酸 for *Zwavelzuur* or *Salpeterzuur* should be from Youan. But, those words like 能溶薬, 硫化炭精, or 造塩質属 for *enkelvoudige oplossingsmiddelen*, *Zwavelkoolstof*, or *haloiden*, are probably not from Youan.[36]

Further evolution of chemistry language in Japan

Tsukahara Togo in the Introduction to his Ph.D. dissertation pointed out the influence of *Seimi Kaiso* on writing new chemistry books in Japan immediately after its publication and even fifty years later. That was in spite of the developments in chemistry in the world during those years, the second half of the nineteenth century. Tsukahara mentioned that in the curriculum of *Kaiseijo*, a governmental institute for Western learning founded in 1866, *Seimi Kaiso* was designated as a textbook for chemistry. Tsukahara observed that "…it is

righteous to assume that *Seimi Kaiso* paved the way for the introduction of Western chemistry in Japan, which was a prerequisite and indispensable condition for the development of chemical industry." He assured that "the creation of a new vocabulary was by all means the most essential part of the introduction of Western science in Japan."[37]

Kaji Masanori (1956-2016) mentioned those who followed Youan's chemistry book *Seimi Kaiso*. Among those was Kawamoto Kōmin 川本幸民 (1810-1871), a teacher of chemistry at the *Bansho Shirabesho,* School of Western Learning, who translated a number of chemistry textbooks, such as *Kagakushi Shinsho,* A New Book of Chemistry. In that book Kawamoto wrote for the first time concepts that were not in *Seimi Kaiso* like: *genshi* 原子 atom, *bunshi* 分子 molecule. In addition, topics like *tampaku* 蛋白 protein, *budoutou* ブドウ糖, grapes sugar, glucose, *nyouso* 尿素 urea, and the like are seen in *Kagakushi Shinsho* for the first time. Kawamoto wrote a text book on Dalton's atomic theory.[38]

The topic of the vocabulary and teaching language of chemistry remains relevant in Japan. First generation of Japanese chemistry teachers after 1868 Meiji Restoration studied in Europe and taught chemistry in English (or German?). As Kikuchi Yoshiyuki described "Sakurai [jōji] gave at least some of his lectures in English. His lectures on chemical philosophy in 1882-1883 at Tokyo University were in English… However…, teaching in Japanese became the norm by 1884 throughout Tokyo University and its preparatory schools as the number of foreign teachers decreased."[39]

5. EUROPEAN KNOWLEDGE EXCHANGE VS. JAPANESE ISOLATION

Many connections and extensive knowledge transfer existed between scholars in Europe: by personal correspondence, by scholars visiting scholars in other countries and by circulations of scientific journals. This is in comparison with the Japanese who were secluded from most of the world with almost no possibility to exchange knowledge with others out of Japan, except China, and restricted conditions for exchanging knowledge within Japan.

The political situation in Japan, the strict observance and surveillance of the citizens by the Bakufu authorities, including watching scholars of Dutch Studies, should be taken into consideration. E.g., watching the books that were allowed to enter the country and to be studied, and forbidding transfer of knowledge to lower rank people.[40] Moreover, as Goodman explained "…some orthodox Cunfucianists held to their belief that the Westerners would make use of Christianity to invade Japan. To the extent that all Western scholarship was considered as a tool of the religion of Christ, the work of the *Rangakusha* was subjected to the oppressive scrutiny."[41]

Fear of the persecution of scholars of Dutch Studies was also expressed by Fukuzawa Yukichi (1835-1901) in his autobiography. It is cited by Blacker from his memories that "had it been safe to do so he would certainly have taken western learning beyond the stage of scientific techniques and advocated it as a weapon against bullying feudal officials as well as against bullying foreigners."[42]

Interestingly, Fukuzawa told about running chemistry experiments with other students during his studies in the *Tekijuku* School in Osaka, directed by Ogata Kōan, a physician of Western medicine, in 1854-1855.[43] Fukuzawa decided to start learning English after he realized that his investment in studying Dutch was not useful when he wanted to speak and understand the American sailors of Commodore Perry's ships.

In Europe at the same time, a wide and intensive exchange of knowledge existed in the seventieth through the nineteenth centuries between scholars; by correspondence, reading and translating articles, as well as personal visits, e.g., Berzelius visit in France in summer 1818,[44] Berzelius visit with Davy in London in 1812 and their correspondence 1808-1813, as well as Berzelius correspondence with Wöhler, Berthollet, Mulder, Mitcherlich and many others.[45] William Henry in "The Elements of Experimental of Chemistry", in his examples and discussion in the chapter on analyzing water he mentioned Dr. Wollaston, Mr. Watt and Berzelius.[46] French, English, German, Swedish and Italian scientists were exchanging scientific knowledge, discussing information, arguing about their philosophical ideas and the interpretation of the results of experiments.

In contrast, Japanese scholars were isolated from the Western world and could hardly get any information from Europe. In 1826 and until 1830 Youan received some help from von Siebold and Bürger in botany, plant drawings, and hot spring water analysis. But von Siebold was not in Japan while Youan wrote *Seimi Kaiso* since 1836. In his letter to his friend and disciple Ito Keisuke (1803-1901) Youan complained that he could not meet foreigners in Edo and could not get chemistry books from them.[47]

Two events show Youan defending himself from the ruling authorities. After what is called the Siebold Incident in 1829, the work of the translation office was stopped by the Bakufu authority. On March 25, 1829, Udagawa Genshin, Youan and other members of the translation office wrote a letter to the authorities, saying

that they did not have any connection with that affair and asking to let the office continue its important translation work.[48]

We learn about a second event concerning Youan under such a prevailing socio-political, anti-Western spirit and anti-Christianity atmosphere. Takahashi Terukazu raised a question – "Was Youan Christian?" and presented a document that was written in order to remove suspicions against Youan who was involved in studies of Western books. The document dated 1834 is preserved in Waseda University Library, shows a declaration by the Head Priest of a Buddhist temple in Asakusa, Edo, concerning Udagawa Youan belonging to his Buddhist temple, and that Youan did not become a follower of Christ *Yasu* (Jesus).The priest declaration states that Youan's writing room was named 菩薩楼 *bosatsurou*, Bodhisattva Room, after a Buddhist Scripture, the Heart Sutra 般若心経 *hannyashingyou*. Youan attached the phrases from the Heart Sutra on the wall of his writing room.[49] Udagawa Youan did not know much about Christianity, he studied Western science without leaving his religious faith. Concerning Youan's religion, Goodman concluded that "… despite all his remarkable credentials as a *Rangakusha*, Youan was, like his father and Otsuki Gentaku before him, a committed Confucian scholar, devoted first and foremost to the Classical Chinese intellectual heritage of Japan."[50] In light of the continuing surveillance the achievements of Udagawa Youan, and indeed his colleagues, are even more impressive.

6. FURTHER CHEMISTRY STUDIES FROM THE WEST

Concerning the Japanese Dutch scholars, Tsukahara observed that "It is an over simplification to say that the Japanese have only copied Western sciences and exploited its practical parts. Philosophical discussions and practical demand were interrelated; they were interwoven into a new pattern of theory and practice, slightly different from that of the West. Likewise, it would also be a distortion to suppose that this interaction involved nothing more than the relationship between "pure" and "applied" sciences. Scientific theory and technical practice were merged in *Rangaku*. This tradition was a remarkable feature of science in Japan."[51]

By the middle of the 1850s the Japanese had both skillful capacity for craft production and basic scientific knowledge translated and adapted from the West. A change of attitude started after the arrival of Commodore Perry from America by the "Black Ships" in 1853 and again in 1854. One of its results was the opening of several Japanese ports to foreign ships. In 1868 the Meiji Restoration rejected the long feudal rule of Tokugawa and brought the Emperor back into power. Confronted with the American ships, cannons and other demonstration, the Japanese realized that they are not as advanced as they have believed, actually lagging behind the Western knowledge for large ships building, for the constructions of railroads and trains and manufacturing weapon like cannons. This realization was concluded in the decision to learn technology from the West, while keeping the Japanese spirit. Nevertheless, the educator Fukuzawa Yukichi explained that studying just the surface of technology is not enough if one wants to be able to further develop things by oneself.

In order to make progress in chemistry science and technology the Japanese invited foreign teachers to come and teach in Japan. Late 1860s to early 1870s, two foreign chemistry teachers were the American William Griffis (1843-1928) and the Dutch Konraad Wolter Gratama (1831-1888).

Early publication of chemistry textbooks in Japan since the 1870s included the translation of the chemistry lectures by American William Griffis (1843-1928) in Fukui. In a letter to Philadelphia to his sister Margaret Clark Griffis on June 25th 1871 he wrote: "In chemistry, I have carried out two classes through oxygen, nitrogen, hydrogen, sulfur, chlorine and carbon and their compounds." These lessons were translated by his students into Japanese and circulated among them. In a letter of July 15th 1871 he asked his sister to send him a copy of Roscoe's *Chemistry*, latest American edition. Teaching chemistry from Roscoe's book was later spread in Japan.[52] Roscoe's book was published in the same year, so Griffis could teach from an advanced chemistry book of his time [53]. Japanese students in the laboratory of Henry Enfield Roscoe (1833-1915) in Manchester translated his 1866 chemistry book into Japanese. Ichikawa Seizaburo's (*alas* Morisaburo) translation "chemistry entry book for elementary school" was published by the Ministry of Education 1873. Griffis moved to Tokyo after eight months in Fukui. His students in Tokyo became the first generation of Meiji chemists.

Another translation was of the chemistry course taught by the Dutch Konraad Wolter Gratama (1831-1888) in *seimikyoku*, the Chemistry School in Osaka specifically built according to his design. It was built for instructing technicians, methods to separate metals from the ores excavated in mines that included copper, silver and gold. Gratama used reagents, analytical tools and reference books that he brought with him by ship in nearly two hundred crates to Nagasaki in 1866. Gratama chemistry lectures were translated into Japanese by Misaki Shosuke 三崎肅輔 (1847-1873) into *seimikyoku kaiko*

no setsu, Chemistry Theory Course, 1869. The translated books were further circulated and studied in Japan.[54]

In the conclusion of his article Kaji observed: "The discovery of the periodic law between 1869 and 1871 and its dissemination in the 1880s coincided with the institutionalization of chemistry in Japan. This factor helped make the appreciation of the periodic system as a basis for chemistry in Japan easier. Most of the first generation of Japanese chemistry professors accepted the periodic law as one of the recent developments in chemistry in Europe without much doubt.[55]

The department of chemistry was founded in the governmental Institute for Western Learning, *kaiseijo*, in 1866. It became a Department of Chemistry of Tokyo University in 1877. For the role of foreign chemistry teachers at Tokyo University see for example Kikuchi Yoshiyuki's book.[56]

The Chemical Society of Japan (CSJ) was founded in 1878 "by approximately twenty motivated and enthusiastic young scholars wishing to advance research in chemistry."[57] They formed a committee to assemble chemistry dictionary, it worked for more than ten years.[58] The first English-Japanese chemistry dictionary that was the result of the work of the (Tokyo) Chemical Society of Japan was published in 1891. It presents in ABC order chemical names, experimental tools, processes etc., and contains Japanese terms in kanji, katakana, and their combinations. It reflects the development of chemical theory and the change of the dominant foreign language from Dutch to English.[59]

Detailed description of the current Japanese rules of naming chemistry compounds can be found in the *Japanese-English Chemical Dictionary* edited by Markus Gewehr, 2007.[60]

SUMMARY

This work presents Udagawa Youan pioneering studies of chemistry from Western books. He studied botany first and then chemistry and wrote several books before writing his larger book *Seimi Kaiso*, Introduction to Chemistry. He translated chemistry from Western scientific books in Dutch that are presented in this study. For the translation Youan coined new terms in Japanese. He could choose appropriate Chinese-Japanese characters to transfer the meaning of words from Dutch to Japanese, trying to shift the new terms from memories of the prevailing Confucian view of the world. The difficulty in moving from the Eastern philosophical thought to the Western is partly discussed. The Confucian traditional priesthood objection to introduction of foreign ideas contributed to obstacles faced by Youan and other *rangakusha*. Another difficulty pointed at was the objection of the ruling Bakufu to wide spread of Western knowledge. Still, Udagawa Youan's successful pioneering of chemistry translation and terminology can be considered as a milestone in Japanese modernization.

Chemistry studies and practice continued after Youan, using some of the vocabulary he invented. Teaching materials of foreign teachers in Japan, mentioned above are Griffis and Gratama, were translated into Japanese. Roscoe's book was also translated by his chemistry students in England. Following Meiji Restoration there was further progress in scientific studies, and the establishment of Tokyo University and other national Universities led to the creation of a successful Japanese academy and a prosperous chemical industry.

ACKNOWLEDGEMENTS

This research started as a grant recipient from Japan Foundation that let me spend six months at Tokyo Institute of Technology, at the unit of Prof. Kaji Masanori. He introduced me to the name of Udagawa Youan, and continued guiding me until the very day of his hospitalization on 12 July 2016, just before his untimely death. He is very much missed. My research continued during one year fellowship as a visiting scholar at Nichibunken, International Research Center for Japanese Studies in Kyoto, April 2009-March 2010. The devoted instruction of Prof. Frederik Cryns enabled me to continue the research after returning to my country and our discussions during annual short visits to Japan. I thank the scholars who helped me in various steps of this work for their advice and information: Prof. Sato Shin, my first chemistry teacher in Japan, Prof. Dōke Tatsumasa, Prof. Azuma Toru, Prof. Furukawa Yasu, Prof. Ochiai Hirofumi, Prof. Osawa Masumi, Mr. Uchida Masao, Prof. Ohmichi Naoto, Prof. Kato Nobushige, Dr. Yakup Bektas, Dr. Karl Grandin, Prof. Shimon Vega, Dr. Jochanan de Graaf, and Dr. Neomy Soffer. Colleagues of the Japanese Society for the History of Chemistry in Japan are deeply acknowledged. My gratitude is extended to the librarians at Nichibunken and to Ms. Chaya Meier Herr at the Edelstein Collection for the History of Science at the National Library of Israel in Jerusalem.

NOTES

1. T. Dōke, **1973** p. 99. Siderer, **2017**, p. 224.
2. Dōke, **1973** p. 105; Takahashi **2002** p. 172. Youan had access to maps of the world, at least one, a

map called "*shinsensokaizenzu* 新鐫総界全図"New engraved whole world map", 1809 (Ref. stored in the Waseda University Library, call mark is "bunko 08 c0995 (文庫08 c0995); Takahashi Terukazu p. 172. Takahashi mentioned the map drawn by the Italian Mateo Richi in China, *Great Map of Ten Thousand Countries*, in the beginning of 17th century and its revised map by Takahashi Kageyasu's *shinteibankokuzu* 新訂万国図 *shinteibankokuzu* New revision of Ten Thousand countries 1810, that Youan received.

3. Chomel Encyclopedia.
4. Mac Lean **1974**, p. 9.
5. T. Shiba **2010;** T. Azuma**, 2013;** T. Azuma **2017; Y.** Siderer **2017**.
6. K. Sugawara, **1987** p. 29. In Japanese (J), English abstract.
7. On *Seimi Kaiso* first page of each book there is a warning against forgery: "Our shop was opened outside the Asakusa castle gate, at the east of Kikayamachi-Asa(?), and it possesses all the books written by Master Udagawa, over a span of three generation, which our shop assembled entirely, made books and published. All our favorite wise customers! We recommend you surely to confirm the seal authenticity of each volume of the books. If there is a seal, the book is authenticated. If there is a fake seal, such book is a pirate edition. Sincerely yours, Owner of this bookstore, Seireikaku." Thanks to Prof. Ohmichi Naoto for this translation.
8. SK book 1, preface; SKR p. 11.
9. Tanaka Minoru 田中実 Ed., The authors of the modern revision and comments on Youan's *Seimi Kaiso* are: Books 1, 2,3 and 7: Hayashi Yoshishige 林良重; book 4: Kurokui Seiji 黒杭清治; book 5: Kusuyama Kazuo 楠山和雄; book 6: Kanazawa Shouji 金沢昭二.
10. M. Tanaka, M. Sakaguchi, T. Dōke, T. Kikuchi **1975**.
11. Copies of old prints of *Seimi Kaiso* books nos. 1-6 this author received with thanks from Prof. Osawa Masumi.
12. Tsukahara, **1993**, Hoffmann p. 319 and Serrurier p. 325.
13. The list follows researches on: *Seimi Kaiso* Rewritten **1975** shortened SKR; Sakaguchi Masao article in SKA **1975**; Tsukahara Togo **1993**; Azuma Toru **2006-2020**; Osawa Masumi since 2006; Miyashita Saburo **1997,** and references cited in those articles.
14. SKR index pp. 568-540.
15. Tsukahara, **1993**, p. 148.
16. M. Tanaka, **1975**, in SKA p. 104.
17. Henry, Epitome of Chemistry, **1808**, p. 413.
18. SK external book, vol. 1 ch. 2; SKR p. 474.
19. SK book drawing on last pages, Figure 7; SKR p. 78.
20. Currency name: A *daalder* is a silver coin which was first minted around 1500 in Joachimsthal (Tyrol), hence the name 'Joachimstaler' which later became 'taler' or 'daalder'.
21. SK book 1, vol. 2, ch. 50, Mr. Volta Column; SKR pp. 54. Thanks to Prof. S. Sato for the translation.
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23. *Seimi Kaiso* External book vol. 3; SKR pp. 519-520.
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37. Tsukahara, **1993**, p. 1.
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39. Y. Kikuchi, **2013**, p. 134; Appendix p. 175 and reference cited there.
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46. William Henry. **1808,** p. 415.
47. Dōke, **1973**, p. 109; Dōke, SKA **1975**, p. 84.
48. Goodman, **2014,** p. 187.
49. Takahashi, **2002**, p. 140.
50. Goodman, **2014**, p. 139; F. Cryns, personal discussion.
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64. SK book 3 vol. 7 ch. 144; SKR, **1975**, p. 187.
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76. SKA, **1975**, p. 24. Tsukahara, **1993**, p. 280. Mac Lean **1974**, p. 45, p. 50.
77. SK book 1, vol. 1 p. 7; SKR, **1975**, p. 14; Tsukahara, **1993**, p. 272.
78. Tsukahara, **1993**, p. 273; Sakaguchi, SKA, **1975**, p. 25; SK external book vol. 1 ch.10; SKR, **1975**, p. 486.
79. SK book 1, vol. 1, p.7; SKR, **1975**, p. 14; Tsukahara, **1993**, p. 274.
80. SK book 1 vol. 1 p. 7; SKR, **1975**, p. 14 and others; Tsukahara, **1993**, p. 274; Sakaguchi, SKA, **1975**, p. 25.
81. Sakaguchi, **1975,** in 科学史研究 *Kagakushi kenkyuu* **II**, 14, p. 67 (J), English abstract.
82. SK book 1 vol 1, p. 7; SKR **1975**, p. 14.
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97. SK book 1, vol. 3, ch. 58; SKR, **1975**, p. 64.
98. SK book 3, vol. 7, ch. 133; SKR, **1975**, p. 175.
99. SK book 3, vol. 8, ch. 155; SKR, **1975**, p. 200.
100. SK book 3, vol. 8, ch. 185; SKR, **1975**, p. 207.
101. SK book 3, vol. 9. ch. 166; SKR, **1975**, p. 219.
102. SK Book 5, vol. 15, ch. 259; SKR, **1975**, p. 386; Tsukahara, **1993**, p. 283.
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M.N. Chomel en J.A. Chalmot, *Algemeen Huishoudelijk, Natuur-, Zedekundig –en Konst Woordenboek, 2de druk,* Leyden, **1778**.

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J. Mac Lean, *Japanese Studies in the History of Science*, The Introduction of Books and Scientific Instruments into Japan, 1712-1854. **1974**, No. 3, p. 9

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Misaki, **1869**; Shihara and McAbee, **1988**, Sugawara, **1984**, 27. Uchida et al.

Okayama Dutch Learning Group 岡山蘭学の群像 Udagawa Youan, De Vinci of Edo era, the man who coined the character(s) for [coffee]「珈琲」の文字を作った男 江戸のダ・ウィンチ 宇田川榕菴 The Sanyo Broadcasting Foundation, **2016**. p. 91 (J).

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I. Shihara and M. McAbee, *CE&EN*, Western Chemistry comes to Japan, A Historical Account, 31 October **1988**, p. 26.

Shiba Tetsuo, Chemistry and Industry 化学と工業 vol. 63-7 July **2010** (J).

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Sugawara Kunika, *A Historical Study of the use of the Term Kagaku for Chemistry in Japan*, in *Kagakushi* 化学史研究 **1987** p. 29. (J) English abstract.

Takata Seiji, 高田誠二. 維新の科学精神『米欧回覧実記』の見た産業技術 Scientific Spirit of Meiji Restoration written as seen in Industry and Technology World (in) [A True Account of the Ambassador Extraordinary & Plenipotentiary's Journey of Observation through the United States of America and Europe]. 朝日選書 547 朝日新聞社. (J). Asahi Shimbun Publisher **1995**.

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Tanaka Minoru, *Seimi Kaiso ni okeru Yoan no kagaku ninshiki* 舎密開宗における榕菴の化学認識 in *Udagawa youan seimi kaiso fukkoku togendai koyaku・chuu* 宇田川榕菴舎密開宗復刻と 現代語訳・注" Udagawa Youan *Seimi Kaiso* Republishing, (its) Recent Language and Explanatory Notes" Kodansha Publishing House, Tokyo, **1975** (J), pp. 99–114.

M. Tanaka, "Part 2 Chemistry" Chapter 6 *Seimi Kaiso* section 3, in Yuji Shibata ed. *Meiji-zen Butsuri Kagaku Shi, History of Physical and Chemical Science before Meiji Era*, p. 281, p. 321, **1964**.

T. Takahashi, *Siebold and Udagawa Youan, Edo Dutch Studies Friendship Account***,** Heibonsha, Tokyo, Japan (J). 高橋輝和: *Siebold to Udagawa Youan Edo rangaku kouyuuki* シーボルトと 宇田川榕菴 江戸蘭学交遊記 東京: 平凡社. **2002.**

T. Tsukahara, *Affinity and Shinwa Ryoku, Introduction of Western Chemical Concepts in Early Nineteenth-Century Japan*. Ph.D. Thesis. University of Leiden, Holland, J.C. Gieben Publishers, Amsterdam **1993.**

Tsujimura Natsuko, *An Introduction to Japanese Linguistics*, Blackwell Publishing **2007**. p. 422.

Uchida Takane, Oki Hisaya, Sakan Fujio, Isa Kimio, and Nakata Ryuji, *William Elliot Griffis' Lecture Notes on Chemistry*, In *Foreign Employees in Nineteenth Century Japan.* (E.R. Beauchamp and Akira Iriye Eds.), Boulder San Francisco and London. West View Press **1990.** p. 247

Udagawa Youan, *Seimi Kaiso.* In Edo: *Suharaya Ihachi* **1837-1847**, in Japanese.

APPENDIX 1.

◯ Kasteleyn, P. J., Descriptive and practical pharmaceutical, economic and physical chemistry 1788.

『葛氏舎密』 *ka shi seimi*, Mr. Ka chemistry. Youan used 葛氏 Mr. *Ka* as name abbreviation when he cited Kasteleyn.

Beschouwende en Werkende pharmaceutische, oeconomische, en natuurkundige Chemie, Tweede 2dln, Amsterdam, 1788.

This book was cited fourteen times in *Seimi Kaiso*, concerning the preparation of chemical reagents, but not theoretical issues. Kasteleyn (1746-1794) represented a group of chemists in the Netherlands at the end of the eighteenth century that was partly against the new doctrine of Lavoisier.[61] Youan favored Lavoisier, but used more of Henry's more practical descriptions.

Azuma Toru (1953-) thoroughly studies Udagawa Youan's chemistry translation by searching articles stored at Kyō-U Archive of Takeda Science Foundation in Osaka and at Waseda University Library in Tokyo. Azuma showed three journals that were edited by Kasteleyn, from which Youan translated chemistry in several of his books. Those books included *metal chemistry*, *Udagawa Chemistry Book*, *Dyeing chemistry*, *Plant chemistry* and *Seimi Kaiso* – introduction to chemistry.[62] In *seimi Kaiso* Youan mentioned Kasteleyn concerning sugar acid, oil extract and oxalic acid.[64] Oxalic acid is mentioned also in an earlier book of Youan, in a citation from Hijmans.[64]

2. ◯ Blumenbach, J. F., The Basic of Physics of the Human Being.

『貌氏人身窮理篇』 *Bushi jinshin Kyurihen* Mr. Bu Basics of the Human being

Groendbeginselen der Natuurkunde van den Mensch. Translated by G. J. Wolff, 1791.

Blumenbach (1752-1840) was one of the founders of comparative anatomy. However, no direct influence on *Seimi Kaiso* can be seen.[65] In the Dutch book the chapters include the human body, liquids in the human body, blood, muscles, respiration and more.

◯ "Three Little Studies". Questions and Answers on Pharmacy.

『三有小學』 *Sanyuu Kogaku*. This book is written under the 9th bullet on SK p. 7, Unknown publication

year. (Figure 5).

Handboek der natuurlijk historie of natuurgeschiedenis. 1802.

The topic of sulfur, its two forms of crystals, e.g. sulfur flowers crystals,[66] and the topic of barium sulfate were written by Youan.[67]

Interestingly, barium was written by Youan as 重土, whereas it is written today using katakana バリウム. It was explained that since barium element is heavier (than the second group in the periodic table), it was called *barys* from Greek language. So Youan used 重い, the kanji for "heavy" to name the barium element.[68]

3. ○ Plenck, J. J.,Physical and chemical description about the liquid in the human body.

『布氏明液論』 *Fu shi mei ekiron 1791*. Mr. Fu treatise on clear liquid.

Natuur-en Scheikundige Verhandeling over de vochten des menschlijken ligchaams1791.[69]

○ Second book by Plenck (SK 5th bullet in Fig. 5): Handbook of Chemistry 1803.

『舎密備要』 *Seimi biyou*

Grondbeginselen der Scheikunde, of oversicht over alle de vakken der Scheikunde, Uithet Lat. Vert. Door J.S. Swaan, Amsterdam, Elwe en Werlingshoff 1803.

Original book was published in Latin in Viena in 1800, titled *Elementa chymiae*.[70]

4. ○ Lavoisier, A. L., Elements of Chemistry, in a new systematic order, containing all the modern discoveries, English translation by R. Kerr, 1790.

『舎密原本』 *Seimi Genpon*. A Principle book for Chemistry.

Grondbeginselen der scheikunde. Utrecht, 1800.

Original French: *Traité Élémentaire de Chemie, présenté dans an ordre nouveau et d'aprés les découvertes modernes*, Paris 1789 Lavoisier, A. L. (1743-1794).[71]

Miyashita mentions three drafts by Youan of the 2nd parts of *Grondbeginselen* that are kept at Takeda Chemical Industries that is Kyō-U Library of Takeda Science Foundation since 1978.[72]

5. ○ See Plenck no. 3.

6. ○ Ypey, Adolph,

『依氏廣義』 *I shi kougi* Mr. I Broad Sense 1804.

Systematisch handboek der beschouwende en werkdadige scheikunde. Amsterdam, 1804-1812.

Ch*emie voor Beginnende Liefhebbers of Aanleiding* 1803.

William Henry's chemistry book – Epitome of Chemistry - was translated into Dutch by A. Ypey. Referred to as CBL for W. Henry Dutch translation: *Chemie, voor beginnende liefhebbers*, *uit het Engelsch*, van J.B. Trommsdorff verm. uitg door A. Ypey, Amsterdam, 1803.

Ypey's Dutch translation was used by Youan while writing *Seimi Kaiso*. In *Seimi Kaiso* preface p. 5 (SKR p. 13) Youan explained the use of books by Henry, Trommsdorff and its Ypey's translations. Youan stated that he mentioned names of only three men but he does not ignore achievements of others.[73] This was the most cited work in *Seimi Kaiso* for theoretical as well as practical topics.

Azuma studied three books in Dutch by Ypey that Youan used. Those are:[74]

- *Systematisch handboek der beschouwende en werkdadige scheikunde*, 5dln, Amsterdam, 1804-1812, in 9 vols. shortened name: SHS
- *Verbeteringen en bijvoegsels tot het systematisch handboek der werkdaadige scheikunde, 3dln*, Amsterdam, 1808-1810
- *Bladwijzer der voornaamste zaken, voorkomende in het systematisch handboek der werkdaadige scheikunde*, Amsterdam, 1812

Azuma showed ten unpublished manuscripts that Youan studied thru Ypey's books on chemistry; Compared Youan's citing SHS, and pointed at the places in Youan's texts corresponding to the places in Ypey's SHS.

7. ○ Niewenhuis, G., Questions and answers on Pharmacy.

『合薬問答』 *Gouyaku Mondou*. Printing date unknown. Questions and answers on Pharmacy.[75]

Bullet no. 19: ○ General Dictionary on art and science for the intellectuals in collaboration with Dutch scientists.

『紐氏韻府』 *Nishi Inpu* Mr. Ni's Dictionary. 1825.

Algemeen woordenboek van kunst en wetenschappen voor den beschaafden stand onder medewerking van een aantal vaderlandsche geleerden bijeenverzameld.

Several copies arrived to Japan by the Dutch ships during 1832 – 1849. Sakaguchi attributed the dictionary to Egbert Buys, Tsukahara discussed other translations and attribution of the dictionary and suggested that Youan used Niewenhuis' dictionary and possibly acquired one.[76]

8. ○ Bernvald, William. van, Medical treatment by electricity 1785.

『越列機療法』 *Ereki Ryoho.1785*. Electricity Treatment.

Over de Geneeskundige Electriciteit, Amsterdam 1785-1789.[77]

9. ○ Bullet 9 is included in Blumenbach no. 2.

10. ○ Hagen, K. G., Pharmacy teaching.

『薬舗指南』 *Yakuho Shinan*. Pharmacy teaching.

Leerboek der apotheker-kunst. Amsterdam, 1807.[78]

It is cited three times in *Seimi Kaiso*, concerning procedures to make ink and tincture.

11. ○ Guiton de Morveau, L. B., The Method of Purifying Atmosphère 1811.

『大気修繕法』 *Taiki Shuuzenhou*.

Verhandelingen over de middelen om der lucht te zuiveren, en de besmetting te voorkomen Leyden, 1802. French Origin: *Traité des moyens de désinfectant l'air* 1801.[79]

12. ○ Trommsdorff, J.B., Experimental finding in Chemistry 1815.

『合薬舎密』 *Gouyaku Seimi*. Medicine chemistry.

Leerboek der artseneimengkundige, proefondervindelijke scheikunde, naar de derde veel verbeterde uitage uit het Hoogduitsche. Amsterdam, translated by N.C. Meppen 1815.

Original German title: *Systematische Handbuch der Pharmacie für angehende Aerzte und Apotheker,* Erfurt, 1792. 2nd. Ed. 1811.

Most frequently cited work in *Seimi Kaiso*. More than 34 times referred to, including theoretical and applied parts.[80] Trommsdorff, J. B. (1770-1837) was also the translator into German of *Epitome of Chemistry* (EOC) by William Henry. (See Ypey no. 6).

13. ○ Ségur, O.,The Sea of Letters on Chemistry.

『舎密翰海』 *Seimi kankai*. 1817. The Sea of Letters on Chemistry.

Brieven over de grondbeginselen der scheikunde: *gewezen leerling bij de polytechnische school*, Rotterdam, 1811.

Original French: *Lettres élémentaires* sur la *chimie* 1803.

Sakaguchi Masao noticed in Udagawa Youan's list of sources for *Seimi Kaiso*, the title *Seimi Kankai* by Octave Ségur. Sakaguchi identified that it is a translation of Octave Ségur's book, written after lessons taught by professors Berthollet, Fourcroy, Chaptal, Guiton de Morveau, etc. Udagawa Youan studied its Dutch translation translated by M.J. Reinhout, a medicine researcher from Leiden, Holland. In Ségur's book, following four chapters with an introduction and explanation about chemistry, the total of thirty two chapters describe topics of crystals of potassium carbonate, ammonium chloride, phosphorus, potassium phosphate, alum, silica, glass, black patina of silver, Iron, mucus, rubber and more.[81]

14. ○ Houte, H. J., Medicine Treaty 1817.

『福烏多薬論』 *Houto Yakuron*. Medicine Treaty by Houte

Handleiding tot de Materies Medica, 1817.

Except for Youan's first list, there is not another citation of this book in *Seimi Kaiso*.[82]

15 ○ Isfording, J. J., Physical handbook for students of medicine.

『理学初歩』 *Rigaku Shoho*.Basics of physical science

Natuurkundig handboek voor leerlingen in de heelen geneeskunde. Amsterdam, Translated by G.J. van Epen 1826.

German original: *Naturlehre für angehende Aertze und Wundärtze, als Einleitung in das Studium der Heilkunde*. Wien 1814.

Tsukahara mentions several translations for this book, but there is only one citation in *Seimi Kaiso*, in a chapter about heat element, Youan adds a note about light element 光素 *kouso*, that he also called *photogeniumu* and further describes the topics of calorique, photon and color.[83]

16. ○ Hijmans, H. S., Outline of General Chemistry

『舎密崖略』 *Seimi Gairyaku* Outline of General Chemistry 1820.

Ontwerp van eene Algemeene scheikunde. Dordrecht, 1820.

Chapter 187 is a discussion on chemical combination of chloride of lime and acids. Specifically, about the affinity between oxalic acid and lime, and boric acid and lime. Tsukahara discusses another book by Hijmans on chemical affinity for which Youan wrote a separate manuscript.[84]

17. ○ Stratingh, E., Chemical Study of Cinchonine and Quinine.

『幾那鹽說』 *Kina ensetsu*. Kina salt theory.

Scheikundige Verhandeling over de Cinchonine en Quinine bevattende eene opgaaf van derzelver verschillende bereidingen, eigenschappen, verbindingen en geneeskundige vermogens, Groningen 1822.[85] An autograph copy kept in Waseda University Library; it is a translation of chapters 1-9 on separation of quinine and 1-4 on its nature.[86]

18. ○ Reinwardt, C. G. C., Treatise on the measurement of the heights of mountains.

『測山説』 *Sokuzan setsu*. Mountain Measuring Theory.

Voorlezingen over de hoogte en vedere natuurlijke gesteldheid van eenige bergen in de Preanger regentschappen, wit Verhand. Batavia. T.W.IX deel, 1822.

Comment 10 p. 82 in SKR cites an article by Sakaguchi 1970 on Youan's special interest in the method of the boiling point of liquids at different heights. In *Seimi Kaiso* Youan presents exemples of five foreign mountains, boiling temperature on those mountains and their heights given in English and in Japanese units.[87]

19. ○ Niewenhuis, See no. 7.

20. ○ Dutch Pharmacopeaia 1826.

『和蘭局方』 *Waran (Oranda) Kyokuhou*. Dutch Pharamcopeia.

Nederlandsche apotheek 's-Gravenhage (The Hague) 1826.

This work is cited 15 times in *Seimi Kaiso*, about manufacturing and properties of substances that are mainly used in pharmacy. e. g., property of potassium carbonate,[88] and its manufacturing.[89]

21. ○ Richerand, A., New basics of the physics of human physiology 1826.

『利氏身窮理篇』 *Rishi Sinkyurihen*. Mr. Richerand's study of the physical laws of the human body.

Nieuwe grondbeginselen der Natuurkunde van den mensch. Amsterdam, 1826.

French origin: *Nouveaux elements de physiologie*, Paris 1801, Dutch translation by A. Van Erpecum, 1821 and 1826.[90]

In chapter 51 on "water containing vapor, vapor containing water", Youan comments saying that "according to Richerand, in water, there is a kind of gas, inner water is used in animal breathing, and the sense of hearing is affected. If you put fish in a bell exhausted of air, the fish dies. Also, insert into glass bottle, hermetically seal its mouth, the same thing happens".[91] Youan also cites Richerand's book on Human Physiology in a chapter on bismuth and other metals.[92]

22. ○ Catz Smallenburg, F. van, Chemistry Study Book.

『蘇氏舎密』 *Su shi seimi*, Mr. Su's chemistry.

Leerboek der scheikunde. Leiden, 1827-1829.

There are forty eight citations of Catz Smallenburg (1781-1848) in *Seimi Kaiso*. Youan could have acquired there the most advanced chemical ideas such as Berzelius' electro-dualism. Catz Smallenburg cited many authors, including Davy, Bergman, Gmelin, Döbereriner, Meinecke and others (1833 Leyden edition). Mac Lean mentions Catz Smallenburg Chemistry book presence in Deshima in 1837, it was brought on the ship *De Twee Cornelissen*.[93] The book was found in Udagawa House old possessions. Humphry Davy (1778-1829) is cited 15 times. Davy is cited concerning his use of the powerful Volta column and the isolation of Kalium. (See Rees no. 24 below).[94] Azuma found in Kyō-U library unpublished manuscripts by Youan. Azuma suggested that Youan was exploring the possibility of publishing a chemical book titled *Kaibutsu Engen-ko* 開物淵原稿, based on the content of Smallenburg's chemical book.[95] According to Tsukahara, Youan cites the work mainly from its practical and experimental parts; not advanced scientific theories but a more reflection of popular issues by a pragmatic chemist whose theoretical discussions were rather superficial.[96]

Interestingly, in the next section on Kalium, "that is also called potassium", Youan cites together the books by Ypey 『広義』, Smallenburg 『蘇氏舎密』 and Niewenhuis 『紐氏韻府』.[97] One may imagine Youan sits and those three books are opened in front of him, perhaps more than those three only. The text reflects Youan's professional approach to his study.

23. ○ Water, J. A. van de, Mr. Water's Pharmacy 1829

『窓多児氏薬論』 *Watarushi Yakuron*. Mr. Wataru's Pharmacy 1829.

Beknopt doch zoo veel mogelijk volledig handboek voor de leer der geneesmiddelen(materiamedica). Amsterdam, 1829.

Topics cited in *Seimi Kaiso* from Water's book include: Phosphoric acid,[98] magnesium carbonate,[99] potash and ammonia,[100] barium hydrochlorate,[101] and iodine.[102]

24. ○ Rees, W. van, A Report on Galvani. 1803.

『ガルヴァニ 紀事』 *Garubani Kiji* Galvani Account.

Verzameling van stukken, als bijdragen tot het Galvanismus, zoo in opzicht tot dezelfs genee- als natuurkundige werkingen, 2 dln (1st en 1803, 2nd en 1805), Arnhem, Moelman. [103]

End of Udagawa Youan's list.