Analytical Chemistry as Methodology in Modern Pure and Applied Chemistry

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Analytical chemistry is an indispensable methodology in pure and applied chemistry, which is often compared to a foundation stone of architecture. In the home page of jsac, it is said that analytical chemistry is a learning of basic science, which treats the development of method in order to get usefull chemical information of materials by means of detection, separation, and characterization. Analytical chemistry has recently developed into analytical sciences, which treats not only analysis involving evaluation, diagnosis, and forecast but also intellectual region. It is not too much to say that all the branch of natural sciences is based on analytical chemistry. Natural science has constantly made remarkable progress day by day, and therefore modern analytical chemistry must be revised by taking the most newest information into the curriculum every year.

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What is Analytical Chemistry ?

History of Analytical Chemistry

Analytical chemistry aims at developing new methods(separation, purification, detection and identification etc.) in order to determine the chemical composition of all materials in nature and artificial substances, and at giving a logical concept of the methods(methodology).

The subject of its technique is composed of various analytical experiments by utilizing chemical reactions in solution(chemical equilibrium in solution).

Analytical chemistry has developed after the lapse of qualitative analysis(the 17th to 18th century), quantitative analysis(gravimetric and volumetric analysis, main current of the 19th century), and instrumental analysis(separation and coexistence analysis, state analysis, the 19th century up to the present day).[1-4]

Lavoisier (1743－1794)has broken down the phlogiston theory through his research works with balance, and established the law of constancy of mass－that is to say, chemical revolution－in 1789.[1] Balances of considerable accuracy have existed since ancient times, but the three key elements of the classical analytical balance(knives, plane and arrestment system) were introduced in the mid-eighteen century.

By the way, Ostwald(1853－1932)described the theoretical explanation of analytical phenomena(the introduction of ionic theory into qualitative analysis) in his book (Die wissenschaftlichen Grundlagen der analytischen Chemie), which was published in 1894. The object of the work is explained by the author in the preface, "How analytical chemistry holds an important position in natural sciences" as follows. "Analytical chemistry, which is the art of testing substances and their constituents, plays a very important role among the many application of scientific chemistry, because those questions which it answers arise whenever chemical processes are used for scientific or technical purposes. It is a measure of its importance that it has been used since the earliest times, and has thus collected almost all the scientific observations of quantitative chemistry.----".

Qualitative and gravimetric analyses on the basis of precipitation reaction of organic reagents with metal ions were the main current of analytical utility of organic reagents in the 19th century.[4]

The solvent extraction origin of inorganic compounds is the paper of E.Peligot(1811 － 1890), *Ann. Chim. Phys.*, **1842,** *(3)5*, 5, which describes the extraction of uranium nitrate with diethyl ether in the ion-association extraction system, and the paper of P.Cazeneuve, C.r. *Acad. Sci*., **1900**, *131*, 346, which describes the extraction of chromium with diphenylcarbazide in benzene in the chelate extraction system.[4]

From a practical point of view, the instrumental analysis of spectroscopy originates from Kirchhoff (1824－1887)and Bunsen(1811－1899).[1] They converted the examination of spectra into "spectrum analysis", which is now an important and self-contained branch of analytical chemistry.

Quantitative and colorimetric analyses of metal ions with organic reagents appeared from the 1930's. After 1940, the principles of coordination chemistry are extensively applied to the analysis of metal ions using chelating reagents and made possible the quantitative treatment of complicated equilibria involving metal chelate compounds in solution.[4]

It was found that a number of experimental apparatuses were invented by German chemists about the 19th century. The names attached to these apparatuss used today in chemical experiments can be attributed to their inventors.[4]Then fundamental chemical techniques have been established in the middle of the 19th century.

Position of Analytical Chemistry in Natural Sciences

Analytical chemistry is an indispensable methodology in pure and applied chemistry, which is often compared to a foundation stone of architecture.

In the home page of jsac(japan society for analytical chemistry), it is said that analytical chemistry is a learning of basic science, which treats the development of method in order to get usefull chemical information of materials by means of detection, separation, and characterization.

In 1952, the jsac was established by people from various fields, i.e. from science, engineering, medicine, pharmaceutical science and agriculture as well as from various industries. [3]

The relationship between analytical chemistry and other learning groups of basic and applied sciences is as follows.[5] The learning groups of universal natural sciences such as analytical chemistry(methodology) and physical chemistry(theoretical) have a universal character as well as physics and mathematics, and investigate the new principles and methods utilized for all natural sciences.

Therefore, analytical chemistry is based on the development of all learning groups of objective natural sciences such as inorganic chemistry, organic chemistry, biological chemistry, radio chemistry, earth chemistry, biochemistry, mineralogy, and geochemistry, as well as objective applied natural sciences such as biomedical, pharmaceutical, clinical chemistry, farmerogical, chemical engineering, material science, and environmental, which have a specific name on the basis of their aim of object.

Analytical chemistry has also a duty to offer its method to various learnings, and simultaneously solve a problem and grant a request in each field of learnings. For the sake of the role, it is important once more again to take the initiative in tying a firm knot between analytical chemistry and other groups of various natural sciences.

Analytical chemistry has become an indispensable learnings in the wide fields of natural sciences such as earth environment(pollution and clean up of atmosphere, natural waters, and soil etc.), natural resources, energy, the health of human body(living body and medicine etc.), and functional materials.

Analytical Chemistry as an Indispensable Methodology in Pure and Applied Chemistry

Discovery and Improvement of Methodology Appeared in Nobel Prize

Chemistry is the study of matter, including its composition, structure, physical properties, and reactivity. By the will of Dr. A. B. Nobel(1833.10/21－1896.12/10), Nobel prize is given to the person who, during the preceding year, shall have conferred the greatest benefit on mankind through five equal parts such as physics, chemistry, physiology or medicine, literature, and peace congress without consideration of nationality, race, and religion.[6]

According to the Rules of the Nobel Foundation the discovery or improvement should be indicated for which the award is proposed . Here is the most important chemical discovery or improvement in the field of analytical chemistry.

Professor T.W.Richards(1868－1928), Cambridge, Mass., is a first American who gets Nobel Prize in Chemistry in 1914 , for his accurate determination of the atomic weight of a large number of chemical elements. Beginning in about 1895 and extending through the first quarter of the 20th century, T. W. Richards of Harvard University and his students determined with great care the atomic weight of 28 elements. During their work various special analytical techniques and procedures were developed, as well as many methods for the preparation of extremely pure compounds.

It is said that Professor M. Kobayashi determined an accurate atomic weight of silver under his guidance during stay in USA. Then Professor M. Kobayashi(Faculty of Science, Tohoku University) established first analytical chemistry courses in Japan in 1918.

The Nobel Prize for 1920 awarded in 1921 to Professor W. Nernst(1864－1941), Berlin, in recognition of his work in thermochemistry.

Dr. F.W.Aston(1877－1945), Cambridge, England, gets Nobel Prize in Chemistry in 1922 for his discovery, by means of his mass spectrograph, of isotopes in a large number of non-radioactive elements, and for his enunciation of the whole-number rule.

Dr. A.J.P. Martin(1910 －) , London, and Dr.R.L.M.Synge (1914－1994), Bucksburn, Scotland, get Nobel Prize in Chemistry in 1952, for their invention of the partition chromatography and application of this technique to amino acid analysis.

Professor Donald J.Cram(1919－), Los Angeles, CA, Professor Jean-Marie Lehn(1939 －), Strasburg, and Mr.Charles J. Pedersen (1904－1989), Wilmington, DE, get Nobel Prize in Chemistry in 1987 for their development and use of molecules with structure-specific interactions of high selectivity.

Analytical Chemistry as Analytical Sciences in Natural Sciences

The Aims and Scope of Journal in the Field of Analytical Chemistry

Analytical chemistry has recently developed into analytical sciences, which treats not only analysis involving evaluation, diagnosis, and forecast but also intellectual region. It is not too much to say that all the branch of natural sciences is based on analytical chemistry.

These results in natural sciences can be seen in about 60 journals published in the field of analytical chemistry(1800's to 1992).[7,8] The contents of the representative monthly journal are given next.

1800's(2 journal): *Fresenius' J. of Analytical Chemistry*(Germany, UK, 1862, Springer)

The *Fresenius Journal of Analytical Chemistry* is an international journal dealing with all aspects of the analytical sciences including instrumentation, chemical, physical, and biological methods of analysis, computer based techniques, chemometrics, structure elucidation, process control, automation and robotics, industrial applications, quality assurance and laboratory accreditation. The journal is also devoted to the development of strategies for solving analytical problems.

The journal covers all fields of pure and applied analytical

chemistry, comprising environmental material, pharmaceutical and biomedical sciences, geochemistry, biotechnology, and food chemistry.

Analyst(London)(UK, 1877, RSC)

The *Analyst* is an international journal concerned with the development and application of analytical and bioanalytical techniques. The journal also includes critical, tutorial and mini-reviews on selected topics of interest to analytical scientists.

The *Analyst* publishes full papers and urgent communications on all aspects of the theory and practice of analytical science, both fundamental and applied, including bioanalysis(including biospecific assays), chromatography and electrophoresis, mass spectrometry, electrochemistry, sensors, imaging techniques, sampling and sample handling, chemometrics-statistics, atomic and molecular spectroscopy and all other areas related to measurement science.

1900－1940(4 journal):(World War I, 1914－1918)

J.－Association of Official Analytical Chemists(USA, 1915, AOAC)

Analytical Chemistry(USA, 1929, ACS)

Analytical Chemistry explores the latest concepts in analytical measurements and the best new ways to increase accuracy, selectivity, sensitivity, and reproducibility of results. Coverage includes the latest peer-reviewed research and applications from any of the phases of analytical operations, including sampling, chemical reactions, separations, instrumentation, mesurements, and data processing.

In addition, *Analytical Chemistry*'s A-page section contains feature articles about new analytical concepts, description of novel apparatus and techniques, summarises of noteworthy research published in other international journals, reports on the influence of computers and automation, and evolving approaches to analytical chemistry education.

Mikrochomica Acta(Austria, UK, 1937, Springer)

Spectrochimica Acta, Part A & B(UK, 1939, Pergamon)

1940's(3 journal):(World War II, 1941－1945)

Zhurnal Analiticheskoi Khimii(Russia, 1946)

Analytica Chimica Acta(Netherlands, Germany, UK, French, 1947, Elsevier)

Rassegna Chimica(Italy, 1949, Maria)

1950's(8 journal), 1960's(13 journal), 1970's(15 journal),

1980's(15 journal):*Analytical Sciences*(Japan, 1985, JSAC)

Analytical Sciences publishes papers on all aspects of the theory and practice of analytical science, including fundamental and applied, inorganic and organic, wet chemical and instrumental methods.

1990's(2 journal).

After World War II, many new journals were founded in the field of instrumental analysis such as Mass Spectrometry, NMR, Raman Spectrometry, X-Ray Spectroscopy, ESR, Liquid Chromatography, LC-GC, Atomic Spectrometry, and Electroanalysis.

Analytical Chemistry Curriculum for Future Generations of Chemists

The Division of Basic Science(Faculty of Science) investigates natural providence through new methodology of experiments, targeted materials, and theoretical study, and cultivates the "seed" of science technology, and try to understand the roots and origins of the natural world, which proves to be a truly exciting and fascinating task. Science has contributed greatly to mankind over the ages.

The course of Chemical Science (Department of Chemistry) aims to study an organic and complex compounds through experimental and theoretical methodology to develope highly functional materials useful for mankind in the 21st century.

Analytical Laboratory plays an important role in the educational curriculum of class and experiments through their courses. There are countless numbers of phenomena that still can not be elucidated in nature. The course aims to predict phenomenon appearance by grasping natural materials characteristics, distribution and change, by the method of analysis and observation, also the observations and surveys of various natural phenomenon, and clarifying the relations between them.

Training in each of these fields with textbook[9,10] (get information) and with experimentation (grow intelligent) through undergraduate chemistry courses (traditional analyses and modern separation analysis based on chemical equilibrium in solution, utilization of analytical techniques based on spectroscopic, electrochemical, and radiochemical methods, state analysis, and new methodology in the 21th century, etc.) provides a unique perspective to the study of chemistry.

Natural science has constantly made remarkable progress day by day, as seen in various journals described above, and therefore modern analytical chemistry must be revised by taking the most newest information into the curriculum every year.

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