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Increasing demands on analytical chemistry and chemical analysis

On occasion of International Year of Chemistry, I would like to express the important role of analytical chemistry in the establishment of a safe and peaceful society and the answer to the following three questions.

What are the aims/roles of analytical chemistry?

What is the difference between analytical chemistry and chemical analysis?

What technique is useful for Increasing Demands on Chemical Analysis?

In almost all areas of natural sciences, such as chemistry, physics, biology etc., some tools, by which we can access the mystery and the truth lurking in nature and can get the information on them, must be basically investigated and developed for solving doubts in nature and understanding nature more and deeply. In the chemistry area, such an academic discipline is "analytical chemistry", as is shown in Fig. 1. From the viewpoints of the academic and scientific discipline, the aims/roles of analytical chemistry are: (1) to develop the methodology for getting information on the truth and the mystery in nature in chemistry, and (2) to enhance intellectual assets through discovery of novel substances, search and identification of substances, and establishment of reliable methodologies for getting information on nature in chemistry.

In Fig. 1, the aims and the roles of each chemical discipline are illustrated. However, in reality, each role is not so severe; for example, "analytical chemistry" can sometimes propose theoretical ideas and opinions, and can advance the theoretical chemistry.

"Chemical analysis" is to clarify the essence of the mystery and the truth lurking in nature from the point of chemistry; that is, to clarify the characterization of substances existing in nature, the chemical species and their abundances in the substances, and the existing forms of the substances and their components, qualitatively and quantitatively. In order to carry out reliable chemical analyses, analytical chemists must develop novel tools, which can be used for chemical analyses of substances in nature and can produce reliable analytical results of the substances. Such analytical tools newly developed must be confirmed in the quality and the reliability of them, their accuracy, precision and applicability (a limit of detection, a limit of quantification and interferences from other materials) on the basis of the principle of analytical chemistry by the analytical chemist. The analytical tools, which include ideas, techniques and procedures, must be guaranteed by "analytical chemistry". Under the close relationship between chemical analysis and analytical chemistry, chemical analysis can often contribute to "extending the frontier of analytical chemistry", or vice versa.

The analytical tools developed for chemical analyses in nature will be applied to common chemical analyses, not only in academic wide areas, but also in life and pharmaceutical, forensic medicine, environmental, agricultural and food, industrial and business areas and so on. In this sense, analytical chemistry and chemical analysis can contribute to the establishment of safe and peace society worldwide.

Increasing demands on analytical chemistry and chemical analysis are put together in "SPARS" and "ZEC"; SPARS means the development of chemical analysis tools satisfying "sensitivity and selectivity", "precision", "accuracy", "rapidity" and "simplicity", and ZEC means the development of chemical analysis tools based on the concept of zero emission.

In almost all of chemical analysis methods, some pretreatment procedures are necessary prior to measuring target analytes; they are often very tedious, complicated, time-consuming, and necessitate special techniques and know-how.

What techniques do you think is more useful to overcome the inconvenience of the pretreatment procedures in chemical analysis methods and to improve SPARS and ZEC? I would like to recommend first a fluid (liquid) flow chemical analysis (FCA) method, the concept of which is based on a flow injection analysis (FIA) method and was proposed by J. Ruzicka and E.H. Hansen in 1975. In an FIA system, various kinds of pretreatment devices, such as reaction columns, separation/concentration devices, UV-irradiation unit, gas diffusion unit, etc., can be installed on line. Since FIA was introduced in analytical chemistry, there have been proposed numbers of FCA techniques, such as sequential injection analysis (SIA), lab-on-valve and bead injection/SIA, multi-commutation /FCA, multi-syringe/FCA, all-injection analysis, simultaneous injection/effective mixing analysis (SIEMA) and so on. These methods are all based on a computer-controllable FCA concept. However, their concept and principle is the same as FIA, where the dispersion of a sample, a reagent and a carrier zone flowing in a small-bore tubing is strictly controlled.

Chemical analysis methods using computer-controlled (CC) FCA systems seem to be one of the most promising methods for advancing SPARS and ZEC. Now, various kinds of computer-controllable pump modules, valve modules, and on-line pretreatment devices can be available, and in these years, the quality of a personal computer has been improved more and more; much complicated, tedious, time-consuming and technician-required chemical analysis methods can be easily automated, and analytical quality will be much improved compared with manually operated batch-wise methods. Furthermore, by coupling a CC-FCA system

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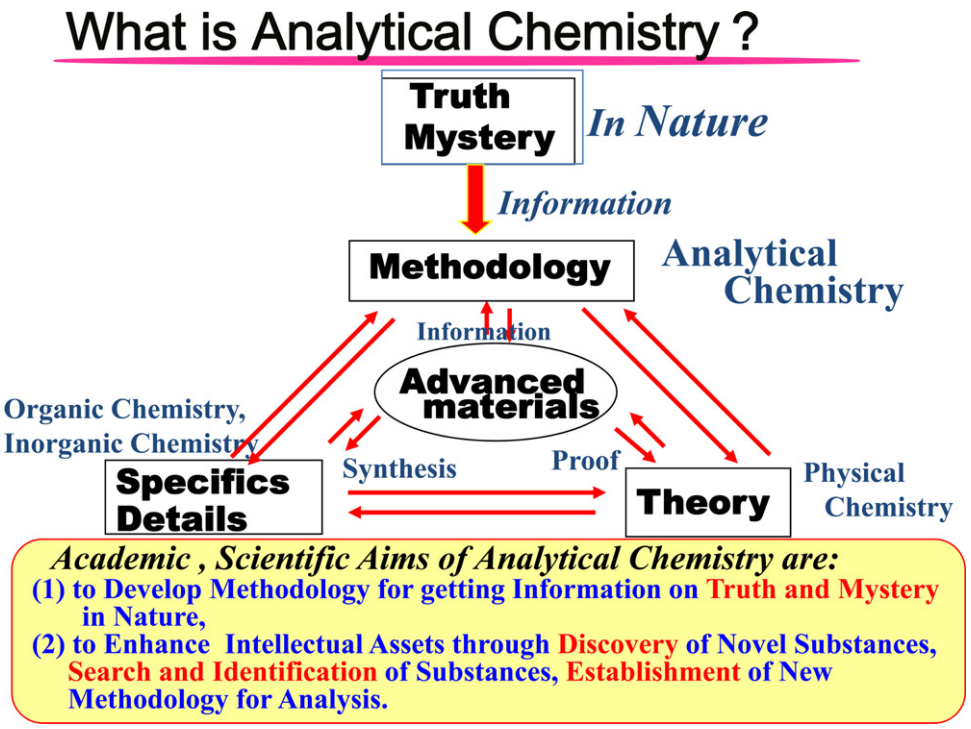

Fig. 1. Academic and scientific role of analytical chemistry.

with auto-sampling/auto-pretreatment systems, as well as with analytical data acquisition/processing systems, a total analysis system, from sampling to the final analysis, can be performed, as is shown in Fig. 2, which contributes to the safe and peaceful society.

Now we can use several sophisticated analytical instruments for the chemical analysis in scientific areas, social and industrial areas, and so on; they are often very useful for trace and ultra-trace chemical analysis. However, such instruments as hyphenated mass spectrometers are very expensive and special maintenance is often necessary; their cost performance prevents the instruments from spreading to analytical laboratories.

On the other hand, the cost of conventional CC-FCAs are less than one tenth of the hyphenated mass spectrometers, special maintenance is not necessary, and therefore cost performance is much better than the hyphenated mass spectrometers, though simulta-

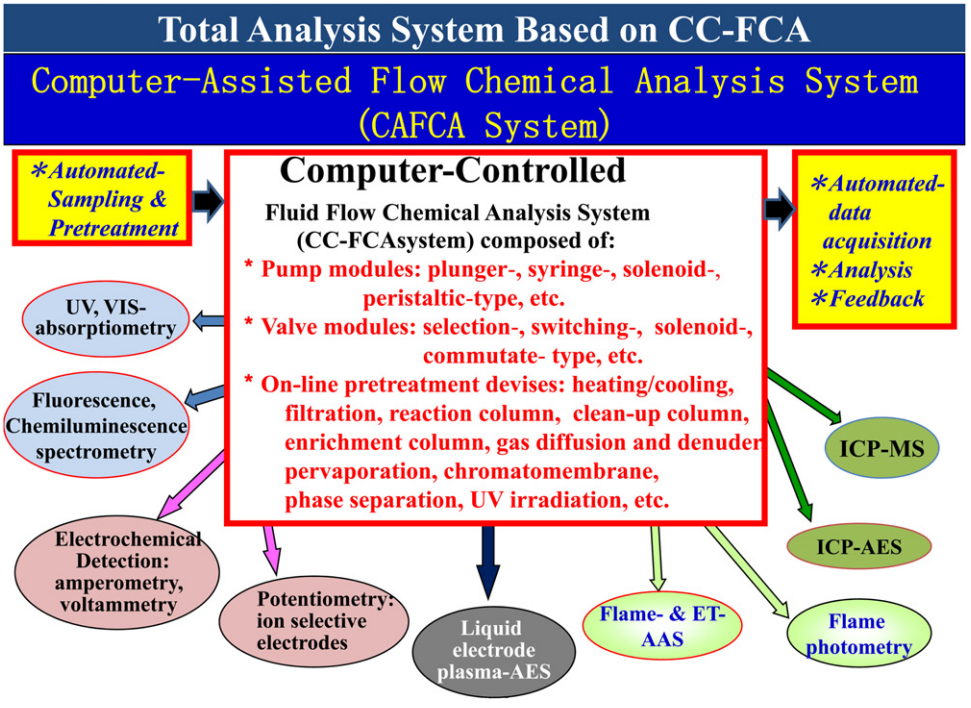

Fig. 2. Establishment of total analysis system satisfying SPARS and ZEC.

neous analysis is less promising in CC-FCA. By using conventional CC-FCAs, chemical species at nano or sub-nano mole/L levels can be measured, which will be able to satisfy more than 90% of increasing demand on chemical analyses.

Further, there is a long-term accumulation of analytical chemistry and chemical analysis methods, which include large numbers of analytical reagents, detection reactions and special procedures developed and improved so far. They will be able to be utilized favorably in CC-FCA, which will lead to the chemical analysis with SPARS and ZEC, and finally to the total analysis.

Analytical chemists must investigate chemistry for new frontier of analytical chemistry and chemical analysis.

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