# Nuclear Analytical Chemistry I

## Introduction to Nuclear Analytical Chemistry

J. Tölgyessy

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## Introduction to Nuclear Analytical Chemistry

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# 1. Introduction

J. TÖLGYESSY

The discovery of natural radioactivity by Henri Becquerel in 1896 and subsequent discoveries by Pierre Curie and Marie Curie-Skłodowska, opened a new area in the natural sciences. These discoveries started an intensive development in atomic physics which led to unusually interesting and far-reaching concepts in the most diverse branches of science. Even a glance at the pages of current scientific journals reveals the steadily growing number of contributions that. in one form or other, deal with radioactive radiation and its practical applications. The same is also true to a large extent for chemical analysis.

Radionuclides find an extensive and multiple application in chemical analyses for detecting and determining elements and compounds. Viewed as an analytical aid, radioactivity possesses exceptional advantages over all other analytical properties used in other methods. These comprise, in particular:

- an extraordinary sensitivity,
- a wide-range selectivity in detection and determination,
- speed and simplicity,
- elimination of the chemical handling of the sample (nondestructive analysis).

The first references to nuclear chemical analysis are seen in the work by Hevesy and Paneth [1] who in 1913 made use of a natural lead isotope (RaD) as indicator to determine the solubility of lead sulfide in water.

Prior to the discovery of artificial radioactivity, the number of radionuclides suitable for analytical purposes was rather limited. In order to make it possible to employ the above advantages in the detection and determination of substances by measurement of their radioactivity with simultaneous determination of other elements, analytical methods have been worked out that utilize natural radio-

active elements as reagents. Radioactive substances began to be employed on a larger scale in analytical methods only after the production of the necessary artificial radionuclides in nuclear reactors had been worked out. Today radioisotopes of most of the elements are available, and as the original reason for the restriction in the development of these methods has ceased to exist, analytical methods using radionuclides have proved their worth in a wide range of applications. Recent years have witnessed the appearance of a number of new analytical procedures based on these principles. Therefore, today we may speak of a new scientific branch, viz., that of *nuclear analytical chemistry*.

*Nuclear analytical chemistry* forms part of applied nuclear chemistry, or of that section of analytical chemistry which in the qualitative or quantitative analysis of substances utilizes the nuclear characteristics of the corresponding nuclides. In the majority of cases, radioactive nuclides or nuclear radiation are involved, although stable nuclides may likewise be utilized (primarily as indicators) for analytical purposes. The difference lies solely in the methodology and the technique of the final measurement, i.e., the isotopic composition of the fractions is determined. In the case of light elements (hydrogen), this can be done by determining the density, and for the other elements by means of refractometric, interferometric or spectral methods, or, generally, by mass spectrography. The technique in the latter case is more exact and rather complex. This monograph series, *Nuclear Analytical Chemistry* is concerned before all else with the use of radioactive nuclides and nuclear radiation for analytical purposes.

An analytical utilization of radionuclides plays a considerable role in their overall application in chemistry. Nuclear analytical methods are gradually coming to be used as widely as any other physicochemical method. The importance of nuclear analytical procedures is proved also by the numerous scientific conferences and symposia devoted to this topic (organized by the International Atomic Energy Agency, e.g. the Symposium on the Use of Radionuclides in Science and Technology at The Hague in 1961; the Symposium on Radiochemical Analytical Methods, Salzburg, 1964, and others) or to selected methods of nuclear analytical chemistry, for instance, activation analysis (symposia on Modern Trends in Activation Analysis held in Vienna, at College Station, Texas, in Glasgow, etc.). Scientific meetings dealing with physicochemical analytical methods also include papers on nuclear analytical methods (for instance, at the IUPAC Conference, at national or international conferences).

At the Salzburg Symposium, Meinke [2] in his introductory speech aptly remarked that most of the nuclear analytical methods "have reached the stage of maturity during the last few years." Analytical methods that had formerly been judged unique, have now been refined on the technical and methodological side to such a degree that they are considered routine procedures in analytical chemistry and are applied even in industrial processes. Some of the nuclear analytical methods have already acquired their own tradition. Thus, for instance, activation analysis emerged from Prof. Hevesy's laboratory as a novelty 30 years ago. This particular analytical method