

Neutron Activation Analysis for Life Sciences

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In spite of competing non-nuclear analytical techniques (AAS, ICP-ES, ICP-MS, etc), reactor neutron activation analysis is continuing to be a most powerful multi-element analytical technique used in geosciences, life sciences and material sciences. Radioanalytical complex REGATA at the IBR-2 reactor for more than 20 years of operation has become a source of analytical data for a considerable number of international projects carried out with specialists from JINR member- and non-member states. Supported by grants of JINR Plenipotentiaries (Bulgaria, Czech Republic, Poland, Slovakia, Romania), they all together are joined in the JINR project REGATA (2000-2004) dedicated to air pollution studies in the above countries and Central Russia, South Urals, Bosnia and Herzegovina, Serbia and Montenegro, Macedonia (FYROM), and Western Ukraine. The results obtained in Dubna are reported to the European Atlas of «Atmospheric deposition of heavy metals in Europe - estimates on the basis of the analysis of mosses» edited each 5 years under the aegis of the UNO Commission of transboundary transport of atmospheric deposition in Europe (UNECE ICP Vegetation). The next all-European moss survey will be in 2005. Several more researchers from Greece and Turkey, as well as from some Asian countries (Vietnam, Mongolia, and China) expressed their desire to join our activity in this field. This led to a suggestion to prolong the JINR project REGATA for 2005-2007 with extension to Asian countries, besides Eastern Europe and Balkans. The other newly developing trend of applying NAA in life sciences is food quality and safety. IAEA Technical Cooperation (2003-2005) and IAEA Co-ordinated Research Programme (2002-2004) support these studies. The year of 2004 is the final one for our project in 5th Frame Programme of EU: «Workplace monitoring and health-related studies at fertilizer plants in Russia, Poland, Romania, and Uzbekistan». Our intense and productive cooperation since 1999 with the Georgian scientists in developing new pharmaceuticals (selenium- and chromium-containing) and sorbents of toxic elements (mercury, uranium, etc) based on blue-green micro-alga *Spirulina platensis* (biotechnology) resulted in two patents, the necessary prerequisites for production of *Spirulina* derivatives for food, perfume and medical needs. In the field of material science NAA is used to control the technological process of synthesis of fine crystalline diamond powders, as well as to determine the elemental content of different archaeological samples.

Department of NAA serves a basis for training young specialists in nuclear analytical techniques. A special course «NAA for studying the Environment» and practicals at the radioanalytical complex REGATA are offered for graduate and undergraduate students from the universities of Dubna and JINR member-states. Every year 5-6 Master and Bachelor diploma are prepared, one Ph.D. thesis is defended (2003), and another three are in progress.

Department of Neutron Activation Analysis is ready to accept 2 students for Summer-Practice at radioanalytical complex REGATA at the reactor IBR-2 FLNP JINR

Trend: Nuclear-related analytical methods used for Life Sciences and Material Science (development of new materials)

The main method: instrumental neutron activation analysis at the reactor IBR-2 FLNP JINR

For whom? Faculties of Natural Sciences (physical, chemical, biological faculties)

What student should know?

Obligatory: general physics, general chemistry, course on nuclear physics; fluent English and good knowledge in computing (EXCEL, STATISTICA, SURFER)

Desireably: practicum on experimental nuclear physics (practicum), gamma- spectrometry,

Course of general ecology (Earth Sciences), course of environmental chemistry, basic knowledge in soil sciences, statistical methods of data processing (chemometrics)

Those who are interested in writing Diploma (Bachelor and Master):

Besides a one-month practice while Summer School, 2-3 month practice for learning nuclear analytics is desirable. Time for Bachelor diploma is 4-5 months, Master thesis (Diploma) - 7-10 months.

We welcome English as a language for writing a diploma, though national languages are possible also.

The experimental results obtained while diploma period are published as JINR Preprints and papers in national and international scientific journals, they are reported at international conferences. Most of diploma topics are connected with realization of international projects, including projects supported by the grants from the JINR-member states. Good diploma written at the Department of NAA, FLNP JINR, is a 25-30% Ph.D. thesis in the chosen field of investigations. While post-graduate courses IAEA fellowships are possible for probation periods in the best European scientific centers where nuclear and related analytical methods are used.

During a one-month summer practice the acquaintance with the principles of instrumental neutron activation analysis (INAA), epithermal neutron activation analysis (ENAA) and cyclic activation NAA is planned.

CONTENTS

of Special Course during one-month practicals

Lecture 1 (2 hours)

What is Analytics?

Classification of different analytical techniques. Comparison of comprehensive and most advanced techniques (INAA, RNAA, XRF, TXRF, PIXE, ICP-ES, AAS, ICP-MS, SSMS).

Place and role of Nuclear Methods.

Lecture 2 (2 hours)

Radioactivity in the Environment. Primordial radionuclides. Cosmogenic radionuclides. Artificial radioactivity. Modes of decay. Nuclear fission. Nuclear stability and radioactive decay.

Lecture 3 (2 hours)

Nuclear reactions. Activation with neutrons. Cross section. Decay rate. Induced activity. Nuclear interferences. Irradiation facilities. Nuclear reactors. Neutron flux distribution. Other neutron sources.

Lecture 4 (2 hours)

Decay schemes. Branching ratios. Detection of gamma rays. Semiconductor detectors. Spectrometry equipment. Activation spectrometry.

Lecture 5 (2 hours)

Techniques: sample preparation; preparation of standards; reference materials; choice of irradiation conditions. Thermal neutron activation. Epithermal neutron activation. Fast neutron activation. Photon activation. Charged particle activation.

Lecture 6 (2 hours)

Counting techniques. Choice of gamma ray energy. Choice of detector. Counting time. Cyclic activation analysis. Delayed neutron counting.

Lecture 7 (2 hours)

Analytical investigations at the IBR-2 pulsed fast reactor in Dubna. Environmental applications (air, water pollution; atmospheric deposition studies using moss and lichens biomonitoring technique). Biomedical applications (man's biosubstrates – hair, blood, bones. In vivo analysis).

Lecture 8 (2 hours)

Geological applications (soil, sediments, silicate rocks, etc.) Industrial applications (petroleum, oil and pharmaceuticals. Semiconductor materials and glasses). General discussion.

Practicals are carried out in the radioanalytical complex REGARA at rooms 129 and 155 of the reactor IBR-2.

Practical No. 1 (2 hours)

Energy calibration of semiconductor high purity Ge detector.

To calibrate detector students use standard gamma-sources OSGI (^{24}Na , ^{60}Co , ^{137}Cs , ^{241}Am).

Practical No. 2 (2 hours)

Dependence of the efficiency of gamma-quanta registration on the distance of a sample from a detector surface.

To carry out this Practical students use hermetic reference source of ^{152}Eu .

Practicals No. 3. (25-30 hours with intervals)

Measurement of long-lived induced activity of real experimental samples irradiated in May 2006.

During this Practical student re-measures samples for determination of long-lived isotopes with half-life period of more than 30 days. They learn how to identify gamma-lines, how to use software developed in the Department for determination of elemental concentration in experimental samples (construction materials, biological samples, aerosol filters, etc.)

Before Practicals, students are instructed for radiation safety at radioanalytical complex REGATA (Instruction 43-8P) and get acquainted with Instruction on experimental work in the fields of ionizing radiation at JINR (Instruction РБ-П1Р).

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Marina Vladimirovna FRONTASYEVA, Candidate of Physics and Mathematical Sciences, Associate Professor. She is an internationally recognized specialist in INAA. M.V. Frontasyeva is one of the founders of the radioanalytical complex REGATA at the reactor IBR-2 designed for studies in the Life Sciences and Material Science. Since 1997 she is the head of the Department of NAA at FLNP JINR combining her activities with lecturing on nuclear methods for studying the environment at the Department of Chemistry of the International University of Nature, Society and Man of Dubna. She is leader of numerous international projects co-ordinated by the International Atomic Energy Agency (IAEA, Vienna) and by the European Union Frame Programmes. She is a holder of several grants for environmental studies from the JINR member-states mostly connected with studies on biomonitoring trace element deposition based on moss analysis. The results of these investigations in Central Russia, Bulgaria, Romania, Poland, Ukraine, Slovakia, as well as in Serbia and Montenegro, Bosnia, Macedonia (FYROM), Turkey (European Thrace Region) are presented in the Atlas on Heavy Metal Atmospheric Deposition in Europe edited under the auspices of the United Nations. She gave courses of lectures at international Schools for Young Scientists in Dubna, China, Egypt, Mongolia and Vietnam. Since 1994 Frontasyeva is a Scientific Secretary of the Scientific Council on Applied Nuclear Physics of the Russian Academy of Sciences. In 1997 she was elected to the International Committee on Activation Analysis (ICAA). Until 1997 she was a member of the editorial board of the international journal «The Science of the Total Environment», and since 2005 – of the international «Journal of Nuclear and Radiation Physics». Frontasyeva is the author and co-author of more that 300 scientific publications in refereed journals, two books and two patents of Russian Federation.