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OVERVIEW:

Research in the Department of Nuclear Physical Chemistry concentrates on three main topics:

1. Radiochemistry of transactinide elements;
2. Environmental radioactivity and related problems;
3. Preparation and applications of radioactive isotopes.

The investigations on radiochemistry of transactinide elements are carried out in the Laboratory of Chemistry and Radiochemistry. Practical difficulties due to short half-lives and very low cross sections of formation of the superheavy nuclei are being overcome by developing fast and efficient methods of chemical separation, basing mostly on ion-exchange processes which are thoroughly studied via model experiments on lighter homologues of the elements of interest.

During the year 2001, work with composite ferrocyanide sorbents was continued, and the efforts resulted in a patent application. The developed ion-exchangers (whose characteristics are constantly checked and improved in the laboratory) can find practical applications in environmental protection as well as in fundamental studies on the most exotic elements: $_{104}$Rf, $_{105}$Db, $_{106}$Sg, $_{107}$Bh, $_{108}$Hs, and more. As to the latter, the discovery in Dubna of the relatively long-lived element 114 ($t_{1/2} \approx 30$s) gives hope that studies on aqueous chemistry of the elements $Z \geq 107$ would be feasible. In this context, chemical methods of separation and identification of the heaviest elements are necessary to know the behaviour of the whole decay chains, for example: 114 —α→ 112 —α→ 110 —α→ 108 —α→ 106.

The group is contributing its expertise to the top specialist international co-operation, involving the Joint Institute of Nuclear Research, Dubna, Russia, the Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences, Moscow, Russia, and three German institutions: the Technical University of Dresden, the University of Mainz, and the GSI Darmstadt.

The Environmental Radioactivity Laboratory is following up traces of α-, β-, and γ-radioactive isotopes in the environment. The ultra-low-background detection methods developed in the laboratory are constantly upgraded, along with amelioration of radiochemical separation procedures. All this allows very low radioactivities to be seen in the live and still nature, from the depths of lakes to stratospheric altitudes. The interest of the team is concentrated upon the natural and artificial alpha emitters, predominantly Pu and Am isotopes, and on the main medium Z components of the radioactive fallout: ^{90}Sr, ^{131}I, and ^{137}Cs. The most important practical aspect of the group's activity is the ability of early warning about nuclear events (since its very beginning, the laboratory is an active part of the appropriate network). In the scientific aspect, the detected contaminations can (and do) serve as very low-cost tracers in a variety of studies on biological, geochemical, meteorological and related processess in the environment.

The scientific co-operation of the group is wide. The main institutions involved are the following: the Technical University of Budapest, Hungary, the University of Extremadura, Spain, the Bremen University, Germany, the IAEA, Vienna, Austria, the Academy of Medical Sciences of the Ukraine, the University of Northern Arizona, USA, and among the Polish institutions: the Central Laboratory of Radiation Protection, Warsaw, and the Health Physics Laboratory of our Institute, the Institute of Geography, Jagiellonian University, Kraków, and the Institute of Geology of the Polish Academy of Sciences, Kraków.

The Laboratory of Physical Chemistry works on preparation and calibration of sources for various applications. Last year, using a temporary target assembly on the AIC-144 cyclotron, several isotopes were produced, from which the most useful was ^{85}Sr. In the meantime a remote-control system for the new target assembly was completed by a contractor, in co-operation with the Mechanical Works and the Cyclotron Group of the Institute. Simultaneously, calibration of ^{32}P sources for intravascular brachytherapy was continued, in relation to the co-operation with the Medical University of Silesia (two clinical hospitals in Zabrze, Poland), the Institute of Oncology, Division in Gliwice, Poland, and from our Institute: the Health Physics and the Ion Implanter research groups.

Last but not least, studies on selenium and vanadium status in healthy or diseased animals and humans were continued, contributing to the co-operation with the Rowett Institute, Aberdeen, Scotland, the Medical College of the Jagiellonian University, Kraków, the Drug Institute, Warsaw, Poland, and the National Institute for Veterinary Research, Puławy, Poland.

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