



- *In methane dry reforming* the study of novel composite catalysts prepared by sol/gel method,
- *In relation with environmental catalysis*, the optimization of N₂O decomposition and methane elimination on modified ZSM-5 zeolite catalysts, the investigation of hydrodesulfurisation using ³⁵S labelled thiophene on Ni, MoO_x and NiMo_x catalysts, and the catalytic wet oxidation of wastewaters of high organic content, disposal and utilisation of process wastewaters of pharmaceutical production.

Besides the previous aims a significant part of the institute's activity has been devoted to providing ***expertise and consultancy for authorities***, on the fields of nuclear security, on radiation safety, on transport and maintaining the the database of radioactive materials used nationwide, and in the identification nuclear materials of unknown origin.

Among the assignments of the institute an important one is the operation of a ***unique instrument*** in the framework of the Budapest Neutron Centre, where professional and technical background should be furnished in Transnational Access (TA) for EU researchers.

II. Outstanding research and other results in 2010

II/a Outstanding research and other results

Improvement of nuclear analytic techniques:

The unique cold neutron Prompt Gamma Activation Analysis (PGAA) and Neutron Induced Prompt-gamma Spectroscopy (NIPS) equipments were improved and operated. The instruments are available for TA from EU Framework Programs for appropriate proposals of EU researchers. In the course of the methodological developments the standardisation of 23 elements were improved and added to the PGAA library. Twelve k_0 values were determined for short-lived radionuclides using the beam chopper of the facility. Their values are compared by an international committee (ICAA) with the values used in the Instrumental Neutron Activation Analysis.

Applications of PGAA:

- Neutron capture cross sections were measured for (^{235,238}U, ⁵⁴Fe), angular and energy distributions were acquired for cold neutron induced fission neutrons for ²³⁵U and spectra and isotopic compositions were determined for (¹¹⁴Cd and ¹⁷⁷⁻¹⁸⁰Hf), and were compared to earlier experiments.
- The result of a 15 year long IAEA co-ordinated research project – called „Reference Input Parameter Library for Calculation of Nuclear Reactions and Nuclear Data Evaluations” –was published, which is a collection of basic data and calculation methods for nuclear reaction calculations.
- The elemental compositions of different chipped and polished stone tools, ceramics and their potential raw materials were measured to their provenance in collaboration with the Hungarian National Museum and foreign users.
- Successful differentiation could be achieved for Croatian and Bosnian obsidian findings (both from Carpathian and Mediterranean sources).
- A method was worked out to distinguish different medieval baroque glass workshops on the basis of the elemental composition of the art objects.
- The provenance studies were continued for polished stone tools found in Gorzsa near Szeged.

- Elemental composition, neutron and X-ray diffraction studies were applied for the characterization of Neolithic copper pearls found at Polgár-Csőszhalom archaeological site to establish their restoration procedure.
- Major and trace elemental compositions of geological samples (serpentinites, diamonds) acquired from three continents, rocks (basalt, andesite) and chondritic meteorites were measured to find out the geological processes that created them.
- In the framework of the comprehensive petrographic, geochemical and geochronological investigation of intrusive igneous rocks of the Carpathians rock samples from the Pieniny, Moravian and Torojaga area were examined. Our aim was to understand the role of these intrusive igneous bodies in the evolution of the Neogene-Quaternary calc-alkaline volcanism of the Carpathians. Based on the trace element distribution of the samples from all three territories, the intrusions took part in the subduction processes. Boron content of the Pieniny andesite indicates that the igneous body was hydrothermally altered (enriched in fluid mobile trace elements, especially B and Pb) by a subsequent intrusion of melted material. The elevated B content of the Moravian and Torojaga andesites correlates with their K₂O content, which can be interpreted as fluid enrichment, derived from the melting of the crustal material. The age of the Trojaga intrusion is older than the age of the southern volcanic formations.
- Structural and other materials have been analysed. Composition and trace element content of catalysts were determined. The *in situ* PGAA method was proven to be particularly advantageous for detection of hydrogen either in the surface of the catalysts, or in gas, or in the solid phase, thereby providing a means to determine the reaction mechanism.
- In cooperation with the EU JRC ISPRA ISPC an instrumentation was developed for determination of nuclear materials present in trace amounts in various hosts by neutron coincidence measurements at the chopped neutron beam of NIPS. They attained a detection limit of 1 µg ²³⁵U, thus improving by 6 – 7 orders of magnitude the limit accessible earlier with conventional measurements performed with Am-Li neutron sources. It has been proven that the intensity of the signal does not depend significantly either on the host, or on the size of the sample.
- The assembly of the low temperature in beam Mössbauer facility had been continued, measurements were performed on high dispersion gold samples at 77 K.

Study of nuclear materials

- For *neutron coincidence measurements* 16 and 32 channel data acquisition units were assembled with data storage capability. They offer new diagnostic and research possibilities such as unfolding saved data into channel files, monitoring channel rates, calculating channel ratios, etc. The simultaneous data handling causes only a minor decrease in the impulse rate. The 32 channel version was tested with good results at Los Alamos National Laboratory. The instrument was compared both to the LANL's own prototype, and to the Canberra's single channel equipment.
- The rapid and simple analytical method developed earlier for the determination of uranium and plutonium in *safeguards swipe samples* was upgraded for the determination of other actinides, e.g. neptunium and americium. Using this method the ICP-MS laboratory is under a qualification procedure for joining the Network of Analytical Laboratories of IAEA.
- Methods were developed for the determination of the localisation of alpha emitting single particles on a sample holder. After the relocation of the sample holder to an other equipment the same particle can be retrieved for the other analysis. Furthermore, analytical method was developed for the determination of the isotopic composition and the enrichment level of

micrometer size uranium particles using laser ablation ICP-MS. This method can be used for characterisation of confiscated nuclear materials by using only a few particles taken from them.

- Analytical method has been developed for the *determination of the origin of confiscated nuclear materials* via trace element analysis using uranium containing model solutions, uranium ores and other uranium samples. The method is suitable for origin determination of real samples (e.g. seized uranium-oxide pellets) based on the investigation of the distribution of rare earth and other trace elements. It has been tested by analysis of real samples (uranium ores and uranium concentrates).

- The redox processes which influence the migration of radionuclides in geological media and take place in the minerals of stones were investigated in relation with *perspective deposition of high level nuclear wastes*. In a prospective Hungarian media, in the Boda Claystone Formation dominantly the sorption/desorption processes effect the migration, however $\text{Fe}^{2+} \leftrightarrow \text{Fe}^{3+}$ redox processes can also be detected under certain circumstances.

Radiation chemistry - dosimetry

- Selective adsorbents were synthesised by *radiation induced grafting* of glycidyl methacrylate to cellulose for the removal of organic impurities from aqueous solutions. Higher grafting efficiencies were obtained during simultaneous grafting (SG) than during pre-irradiation grafting (PIG). The adsorption capacity of samples prepared by SG was higher than those prepared by PIG. Further improvement in the adsorption ability of the adsorbents was observed when the grafted samples were functionalized by cyclodextrin.

- A method was elaborated for the *determination of ethylene permeability* through polymer films of different structures. The results of the measurements will be used by the cooperating partners when selecting the proper polymer for the production of a device applying controlled ethylene release for fruit ripening.

- The *radiation induced decomposition of diclofenac* (DCF, an anti-inflammatory, analgesic drug molecule) was studied in dilute aqueous solution. Both hydrated electron and hydroxyl radical were found to effectively decompose DCF. COD (chemical oxygen demand) value decreased by one order of magnitude and TOC (total organic carbon content) value decreased by 50% after irradiating the dilute solutions by 20 kGy absorbed dose. Cyclohexadienyl type radicals were found by pulse radiolysis experiments to be the intermediates formed during the decomposition of DCF.

- It was proven that *the effectiveness of degradation of highly toxic pharmaceutical wastewaters* by high energy radiation increases significantly in the case of phenol as model compound by applying dissolved oxygen with higher concentration.

- A *demonstration plant was designed, manufactured and installed* for the EB treatment of wastewater with 20 - 50 dm³ / h capacity. The water analysis laboratory was completed with a HPLC-MS/MS equipment, the procurement was partially supported by the International Atomic Energy Agency. The equipment was installed and it is now constantly used for product identification.

- A literature survey was performed with respect to elaborate *retrospective dose estimation procedures* based on the posterior examination of components of electronic devices (ED). The conclusion was drawn that surface-mounted resistors being applied in all EDs are suitable for this purpose. By carrying out a series thermoluminescence (TL) measurements it was found that some properties (sensitivity, emission wavelength, reproducibility) of the substrate

material (aluminum-oxide ceramic) are favourable for this purpose. However its fading is anomalous, so further examinations and development of a correction procedure is necessary in order to increase the accuracy.

- The assembly of the home-built equipment for measuring optically stimulated luminescence (OSL) was completed. The instrument is suitable for every-day usage after fine-tuning based on test measurements.

- Series of comparative measurements of basic TL properties was done on differently doped lithium tetra-borate dosimeter materials synthesized in different countries (Serbia, Ukraine). The main luminescence features were determined for a newly developed magnesium borate material with potential application for dosimetry.

Catalysis – environmental catalysis

- In the study of Au containing catalysts

= Investigation of the relationship between the catalysts structure and CO oxidation activity was continued on FeO_x/Au inverse model systems formed on $\text{SiO}_2/\text{Si}(100)$ surface. Gold and different composition bimetallic AuFe layer and subsequently Fe overlayers of various thicknesses were deposited by molecular beam epitaxy (MBE) in collaboration with Research Institute for Solid State Physics and Optics, HAS. The presence of (111) orientation gold, metallic iron and the amorphous structure of iron oxide was evidenced by XRD. The observed order of the catalytic activities, $\text{FeO}_x/\text{Au}/\text{SiO}_2/\text{Si}(100) > \text{FeO}_x/\text{SiO}_2/\text{Si}(100) > \text{Au}/\text{SiO}_2/\text{Si}(100)$, was the same as experienced earlier on model catalysts prepared by other methods. Also the activity of $\text{FeO}_x/\text{Fe}_{50}\text{Au}_{50}/\text{SiO}_2/\text{Si}(100)$ was larger than that of $\text{Fe}_{50}\text{Au}_{50}/\text{SiO}_2/\text{Si}(100)$. Calcination strongly decreases the activity, that can be recovered by another reduction treatment.

= Study of Au/MnO_x catalysts produced by Au colloid deposition on MnO_x prepared by oxalate precipitation method have been commenced in CO oxidation, PROX and NO+CO reactions. The MnO_x formed by the calcination of Mn-oxalate stored for a long time did not show the high specific surface area, needle like structure, that was obtained earlier by decomposition of fresh Mn-oxalate, and consequently it was less active in CO oxidation. By modification with gold (by deposition-precipitation (DP) by urea and sol adsorption method) the CO oxidation activity increased, higher, but still only 60% CO conversion could be reached in PROX. The reductive pretreatment resulted in worse catalytic properties than the oxidative one.

= SiO_2 , TiO_2 and CeO_2 supported Au catalysts prepared by adsorption of two types of Au colloids of different sizes were studied in selective glucose oxidation. Opposite support and size effect was observed as compared to CO oxidation activity. TiO_2 and CeO_2 supports active in the latter process decreased the glucose oxidation activity.

= Investigation of AuAg bimetallic catalysts in CO, NO removal and selective oxidation reactions have been started. Hydrosols were prepared containing bimetallic particles as evidenced by UV-visible spectroscopy, with 4-6 nm size, in various compositions. These were adsorbed on different supports. In glucose oxidation the bimetallic $\text{Au}_{80}\text{Ag}_{20}/\text{SiO}_2$ catalyst showed synergic activity increase.

= The effect of TiO_2 polymorphs on the CO oxidation activity of Au/TiO_2 catalysts was studied. Au was deposited on pure brookite, anatase-brookite (55:45) and anatase-rutile (85:15) mixture supports by two different methods; 5-6 and 3-5 nm mean diameter Au nanoparticles were adsorbed from hydrosol and formed by DP with urea, respectively.

Based on the structural characterisation (TEM, XRD, XPS) and catalytic studies, taking into account the Au and TiO₂ particle sizes, the higher activity of Au-anatase related to that of Au-brookite perimeter was suggested.

- *In the research of methane dry reforming*

= On the Ce-Zr oxide supported Ni catalysts as compared to the MgAl₂O₄ supported ones only low amount carbon deposition was observed, that was attributed to the mobile oxygen in CeZr oxide. The wide Ni size distribution and the presence of larger, sintered metal particles increased the longterm stability of the catalysts. In the catalysts of large Ce/Zr ratio the sintering of Ni built in the fluorit lattice is negligible, however its reducibility is lower resulting in lower activity. The possibility of the reverse Boudouard reaction as an assumed side reaction of the reforming reaction was studied on selected samples in the elimination of methane decomposition originated carbon by CO₂.

= The applicability of Au-Ni system in the methane dry reforming was studied on SBA-15, MgAl₂O₄ or MgAl₂O₄/SBA-15 supported samples. Low concentration (0.5 wt%) Au deposition on Ni/MgAl₂O₄ by impregnation method did not cause any significant effect, while in case of 3 wt% Au loading activity increase was observed, indicating the formation of Au-Ni interface. Au introduced on Ni/SBA-15 by DP technique decreased the activity, and total CO₂ conversion could not be reached even at higher temperature. The third, a novel type of Au introduction was the liquid phase reduction of Au(III) in Ni sol, just after its formation, then adsorption on the support. The optimization of this method is in progress. Ni sol was produced in tannic acid-citrate mixture used for Au sols, by borohydride reduction, resulted in 10 nm diameter monodisperse Ni particles. By this sol method the catalytic activity increased, the carbon formation drastically decreased related to that observed on the AuNi/MgAl₂O₄ produced by impregnation. This is likely due to the intimate contact between Au and Ni (decoration of Ni surface by Au).

– *In the studies on the processes for environmental chemistry*

= Within the framework of oxidation of wastewaters the parameter effect was investigated by DoE (design of experiments). The leading parameter is the temperature. The high energy radiation assisted wet oxidation was found effective for model solution of phenolate and for a real pharmaceutical process wastewater. The reaction took place at room temperature, which is a great decrease in comparison with the usual 150°C, 230°C temperatures respectively.

= The extent of irreversible sulfur uptake (^{irr}S_{upt}) and radiosulfur exchange (^{irr}S_{exc}) of non promoted and nickel promoted molybdena-alumina samples using ³⁵S labeled thiophene have been determined. These values were compared with those determined by sulfidation with ³⁵S labeled H₂S. Sulfur uptake and sulfur exchange/sulfur uptake ratios were significantly higher in the case of sulfidation by H₂S than by thiophene. The hydrodesulfurization activities did not depend, however, on the agent applied for the sulfidation. In the framework of cooperation with Pannon University, the effect of sulfur uptake on the catalytic behavior of 6 different samples applied by the industrial company MOL was studied. The sulfided samples were significantly more active in thiophene and in iso-butene conversion and less active in benzene and hexane conversion, than the non sulfided ones.

= In the study of CH₄+N₂O reaction a strongly acidic parent catalysts was prepared by liquid phase ion exchange of H-ZSM-5 zeolite with gallium. Mono- and bimetallic catalysts were synthesised by impregnation of H-ZSM-5 and Ga/H-ZSM-5 with transition

metal (Fe, Co, Ni, Mo, Ru, Pd, Ag, Ir, Pt, Au) salts. Based on TPR, CO adsorption and NH_3 thermodesorption (STD- NH_3) results, the presence of acid and redox double function in all the samples is suggested both in N_2O decomposition and in $\text{CH}_4 + \text{N}_2\text{O}$ reaction. In the TPR spectra of Ir and Ru containing samples only one band was detected on the contrary to other catalysts having several TPR bands. Consequently on these samples single type active sites are present with double, acid-redox function, likely both N_2O decomposition and N_2O reduction by methane takes place on these sites.

In conclusion, it shown that

- the *implementation* of the described results, the *cooperation with the economy* is manifested mostly in the application of the developed unique methods for various analytical purposes. This utilization covers a wide area, it may include the experimental determination of nuclear constants as well as the determination of the nuclear material content of the recapsulated fuel at the Paks power plant or the determination of isotope composition of small particles.
- the *relevance of studies* can be characterized by the extent of the successful project applications. The efficiency of the work was profoundly supported by the twenty projects awarded to the institute in 2010.
- The contribution to the *preservation of the cultural heritage* is provided mostly by the archeometric studies performed at the PGAA facility, occasionally even on objects shown in exhibitions. Principally novel information can be obtained by the provenience studies with respect to the historical trade conditions. The non-destructive survey of the status improves the effectiveness of the preservation and restoration of the objects, in general, in the maintenance of the cultural heritage.

II/b Relationship between science and society

The selection of the directions of the actual studies plays an important role in the evaluation of the relations between the science and the society. As for the institute, there is a sort of studies which may contribute to the elimination of difficulties which are important for the society. In this respect it can be mentioned first that the institute is the basic support organisation nationwide as for the matters of nuclear security and is one among the Technical Support Organisations of the Hungarian Atomic Energy Agency. The institute prepares frequently expert's studies on various topics as well as maintains and operates the database of radioisotopes used nationwide. The methods developed here contribute to the improvement of the efficiency of the forensic authorities and organisations in nuclear matters.

Further on, research related to environmental protection processes have also important share in the studies exerted at the institute. For instance, one of them is connected to purification of water by degradation and elimination of the toxic pollutants with combining catalytic and radiation procedures. The results are expected to provide basics for future applications.

Information on the studies carried on at the institute is also provided for the public on the institute's web-page (www.iki.kfki.hu), primarily in sections of „news”, „seminars” and „about us”. An open day was organised for visitors on the occasion of the „Days of Hungarian Science”, on 12th November. General overview was given on different topics for the visitors and they paid visit in the various laboratories. Lectures were presented also on the session of „Material Science Studies at the Budapest Neutron Centre” in the central building of the Academy on 16th November.

A young scientist of the institute was invited for a talk at the m2 TV channel to account on her archeological studies performed in Peru.

III. A presentation of national and international relations

Agreements established in 2010

Bilateral co-operations:

- HAS-CNR, Istituto per lo Studio dei Materiali Nanostrutturati, CNR (Palermo) – Development of bimetallic catalysts for dry reforming of methane ,
- Austrian – Hungarian Action Fund OMAA 77öu14, „Feld- und Grenzflächeneffekte in der CO Oxidation auf Edelmetallen”.

International events

- The „Third Research Coordination Meeting of the IAEA Coordinate Research Project on *Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Selective Separation Purposes*” was held between 6 – 10 December,
- One day satellite course („*Neutron diffraction and neutron spectroscopies*”) was held connected to the conference of the International Mineralogical Associations, (IMA side meeting) in August 28
- Coordination meeting was held for the international ERA Chemistry project on 12 – 13 December.

Mobility of scientists

As for mobility matters, the main speciality for the institute is *hosting* visiting scientists. In the framework of three projects (FP6 EFNUDAT, FP7 CHARISMA, FP7 NMI3) applications can be forwarded for measurements at the PGA-NIPS facility in the Budapest Neutron Centre. After having their proposals accepted, 5 visiting scientists were hosted in CHARISMA, 5 scientists in four occasions in NMI3, and 9 scientists in four occasions in EFNUDAT in 2010.

4 scientists were hosted in the framework of IAEA training courses for a longer period. IAEA scholarship was provided for 2 researchers from Republic of Korea for 1 - 1 week. Two researchers were hosted from Palermo in the framework of bilateral HAS-CNR co-operation. One Slovenian researcher worked in the institute for a few weeks in the bilateral cooperation.

The *scientists of the institute* have also visited foreign institutions.

IKI researchers participated in transnational access in the framework of the EFNUDAT at the n-ELBE facility (Dresden), and in the framework of NMI3, IKI researchers were awarded with 3 access to the PGAA facility of FRM-II (Munich).

Four researchers of the institute were providing IAEA support work in the Korean Republic and in Brasil for several weeks. Another colleague was performing work on bilateral basis at the Université Libre de Bruxelles, by studying MnOx catalysts of high activity. In another bilateral project two researchers spent some weeks in Palermo (Istituto per lo Studio dei Materiali Nanostrutturati, CNR), and in Madrid (Instituto de Catálisis y Petroleoquímica).

National and international institutional relations on research and development

There are tight professional relations and cooperations with the International Atomic Energy Agency, in particular with the Department of Safeguards Division of Technical Support (SGTS). In this frame the institute organised several training courses for security controllers of IAEA. Further, the development of methods for neutron coincidence measurements plays also a role in the cooperation, namely, as a contribution to the Hungarian support programme with IAEA, as well as the implementation of Laser Induced

Breakdown Spectroscopy (LIBS) technique. The researchers of the institute presented a series of lectures in the headquarters of IAEA on nuclear security activities which are provided at the institute on nuclear security topics on February 19th (www.iki.kfki.hu/news/iaea_2010_hu.shtml).

The institute is represented also in international organisations devoted to nuclear security, e.g. ESARDA (European Safeguards Research and Development Association) and the ITWG.

A cooperation was established with the Industrial Technology Research Institute (ITRI, Taiwan), in the „Design of electrocatalysts for anode of membrane fuel cells” project in 2010.

The most important national relation with organisations is the one with the Hungarian Atomic Energy Authority (HAEA), which is manifested also in the form of an Agreement of Cooperation. This agreement provides a tool for the HAEA to access scientific and technical background in nuclear safety and forensic matters. The researchers of the institute presented lectures reporting on their work performed in these fields in the headquarters of the HAEA on 18th May.

Participation in the education – graduate and PhD

The researchers of our institute participate in the teaching of students both at Hungarian and at foreign universities. Two PhD students were hosted from Austria in the part of a bilateral cooperation, as well as one from India for 7 months. Further possibilities are available for PhD students by utilizing the access to use the PGAA facility in the EFNUDAT project. The institute's researchers are also instructors at the ELTE and BMGE universities, and were advisors in MSc theses. A foreigner student prepared an MSc in the topic of „Grafting of cotton cellulose by radiation”. Six senior scientists are members of PhD schools at various universities. Five young researcher of the institute completed and defended successfully their PhD theses in 2010.

IV. Brief summary of national and international research proposals awarded in 2010

International projects awarded to the institute in 2010

- EU FP 7 (BOOSTER - Biodosimetric Tools for Triage to Responders)
- EU EUREKA - FRUITRIP, with the aim to develop household appliances for fruit ripening. (2010-2013, 15 million HUF)
- EU FP7 ERINDA (European Research Infrastructures for Nuclear Data Applications – EURATOM), with the aim of providing access to experimental and data acquisition facilities for EU researchers to determine nuclear data. (2010-2013, >9 million HUF),
- Swiss project (SH 7/2/14), „Sustainable fine- and pharmaceutical industry: selection and utilisation of liquid wastes containing organics” 2010-, in cooperation with EPFL (École Polytechnique Fédérale de Lausanne), BMGE, Sewage Works of Budapest, Geosan Ltd.
- Co-ordinated Research Projects at the IAEA were also applied for and were awarded, one entitled „Radiation treatment of wastewater containing pharmaceutical compounds” (2010-2013, 4000 Euro/year), and another one, „Nuclear forensic methods for combatting illicit trafficking of nuclear and other radioactive materials” received an extension for a year (12000 Euro).

National projects awarded in 2010:

- OTKA-NKTH consortial project: entitled „Novel efficient methods for oxidative treatment of water”, (2010-2013, 29,928 million HUF)

- NKTH project for „Neutronoptical and radiographic equipment for materials studies” (NORMA, 16 million HUF). The implementation of the project is postponed since none of the financial installments was transferred to the institute in 2010.
- OTKA: Low temperature in beam Mössbauer facility, (2010 – 2014, 14 million HUF)

The institute, as one of the Technical Support Organisations of the Hungarian Atomic Energy Authority, elaborated several technical procedures and described them in development reports. Topics of some typical ones:

- Detection of uranium using active periodic excitation,
- Trace element determination of seized uranium dioxide samples with ICP-MS technique,
- Determination of isotopic composition of single particles,
- Determination of trace elements in Hungarian uranium ores,
- Study of degradation of hermetic cable connectors used in high dose radiation fields,
- Verification of the extent of the enrichment in fresh power plant fuels,
- Elaboration of measuring methods for neutron coincidence studies

V. List of important publications

1. Guczi, L., Boskovic, G., Kiss, E., *Bimetallic cobalt based catalysts*, Catalysis Reviews: Science and Engineering, 52 (2010) 133 – 203.
2. Györfly, N., Tungler, A., Fodor, M., *Stereodifferentiation in heterogeneous catalytic hydrogenation. Kinetic resolution and asymmetric hydrogenation in the presence of (S)-proline: Catalyst-dependent processes*, Journal of Catalysis, 270 (2010) 2 – 8.
3. Széles, É., Varga, Zs., Stefánka, Zs., *Sample preparation method development for analysis of safeguards swipe samples by inductively coupled plasma mass spectrometry*, Journal of Analytical Atomic Spectrometry, 25 (2010) 1014 – 1018.
4. Wojnárovits, L., Földváry, Cs., Takács, E., *Radiation-induced grafting of cellulose for adsorption of hazardous water pollutants. A review*. Radiation Physics and Chemistry, 79, (2010) 848 – 862.
5. Capote, R., Herman, M., Obložinsky, P., Young, P.C., Goriely, S., Belgya, T., et al. (23), *RIPL - Reference Input Parameter Library for Calculation of Nuclear Reactions and Nuclear Data Evaluations*. Nuclear Data Sheets, 110 (12) (2009) 3107-3213.
6. Belgya, T. (szerk) *EFNUDAT – Slow and Resonance Neutrons. The 2nd EFNUDAT workshop on Neutron Measurements, Theory and Applications, 23-25 September 2009*. ISBN: 978 963 7351 19 8, Budapest, Hungary, Institute of Isotopes, (2010) 1-174.