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**Session on Nuclear Chemistry Education and Training,
and CINCH-II project at RadChem 2014 conference**

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EXECUTIVE SUMMARY

A session dedicated to nuclear chemical education was organized during the Radchem 2014 conference (the 17th International conference on Nuclear- and Radiochemistry) in May 2014 in Mariánské Lázně, Czech Republic. Profs. Jan John and Jukka Lehto were the session organisers, Profs. Jukka Lehto and Kenneth Czerwinski were the conveners of the verbal part of the session. The session comprised one 1.5 hours verbal session and a poster session. The verbal part included 5 lectures, four of them were invited and delivered by the CINCH partners. These talks described the results achieved within the CINCH project and the plans of the CINCH-II project. One contributed lecture focused on the applied radiochemical education in the USA with regards to the technetium and actinides. The poster presentations presented more narrow topics from both the European and overseas institutions.

Both the verbal and poster parts of the Education session were very well attended – the number of participants at the verbal session can be estimated as about 100. Thus, the global nuclear and radiochemical community received a very good picture of the European activities in this field. Leading role of Europe in the coordination of education and training in nuclear and radiochemistry was clearly confirmed.

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1 INTRODUCTION

RadChem 2014 – The 17th international Radiochemical Conference – was held in Mariánské Lázně, Czech Republic, from Sunday 11 May 2014 to Friday 16 May 2014. The RadChem series is one of the major conference series in this field, together with the NRC series (International conference on Nuclear and Radiochemistry) it forms a series of biannual conferences guaranteed by the EuChemS – European Association of Chemical and Molecular Sciences. The conference gathered almost 300 hundred participants from all over the world; all continents were represented.

In the frame of the conference, Session on Education and training in nuclear and radiochemistry was organized. Profs. Jan John and Jukka Lehto were the session organisers, Profs. Jukka Lehto and Kenneth Czerwinski were the conveners of the verbal part of the session. The session comprised one 1.5 hours verbal session and a poster session. The verbal part was held on the 15th May and it included 5 lectures, four of them were invited and delivered by the CINCH partners. These talks described the results achieved within the CINCH project and the plans of the CINCH-II project. One contributed lecture focused on the applied radiochemical education in the USA with regards to the technetium and actinides. The poster part of the session was held on the same day as a part of a bigger poster session combining contributions from several fields of nuclear and radiochemistry. Four posters were presented on the education topics.

Detailed programme of both the verbal and poster sessions is shown below. The following chapters of this deliverable present abstracts of the presentations delivered.

Education 1 - Red Hall (13:30-15:00)

(session organised by CINCH collaboration)

- Conveners: Prof. Lehto, Jukka; Prof. Czerwinski, Kenneth

time	[id] title	presenter
13:30	[428] Cooperation in Education and Training in Nuclear- and Radiochemistry in Europe	JOHN, Jan
13:45	[400] EuroMaster Degree in Nuclear and Radiochemistry	LEHTO, Jukka
14:05	[434] Current Status of Nuclear and Radiochemistry Education in Europe	KOIVULA, Teija
14:25	[430] NucWik - Nuclear and Radiochemistry Teaching Material Wiki	OMTVEDT, Jon Petter
14:45	[363] Radiochemistry Education: Combining Fundamental and Applied Studies	CZERWINSKI, Kenneth

Poster Session - Education - (17:30-18:45)

[id] title	presenter	board
[80] A laboratory exercise on systematic effects in gamma spectrometry	RAMEBÄCK, Henrik	
[424] Nuclear Chemistry in the Central European Energy Institute	CUBOVA, Katerina	
[14] Practical Experience in the Scientific and Educational Activities of Radioactive Waste Management at FSUE "RADON"	GORBUNOVA, Olga KARLINA, Olga	
[239] Radiochemistry Courses in the Nuclear Science Program at Universiti Kebangsaan Malaysia	SARMANI, Sukiman	

2 VERBAL PRESENTATIONS

2.1 Cooperation in Education and Training in Nuclear- and Radiochemistry in Europe

OPENING INVITED LECTURE - Prof. JOHN, Jan (Czech Technical University in Prague, Czech Republic)

Any of the potential options for the nuclear power – both the renaissance, if any, or the phase out – will require significant numbers of the respective specialists, amongst others the nuclear and/or radiochemists. In parallel, a significant demand exists for these specialists in non-energy fields, such as environmental protection, radiopharmacy, nuclear medicine, biology, authorities, etc. Since the numbers of staff in teaching and the number of universities with facilities licensed for the work with open sources of ionizing radiation has decreased on or sometimes even below the critical level, coordination and collaboration are required to maintain the necessary teaching and training capabilities. In this paper, the motivation, history and status of coordination of education and training in nuclear- and radiochemistry in Europe will be reviewed and correlated to similar activities in other nuclear fields such as the nuclear engineering of radiological protection. The achievements of the Euratom FP7 project “Cooperation In education in Nuclear CHEMistry (CINCH)” will be described in detail. This description will cover both the status review and the development activities of this Collaboration. The proposed long term sustainable strategy for nuclear- and radiochemistry education in Europe will be presented. Its main aim is to create conditions for coordination of the current fragmented and diverse activities in both the education and training field at both the Ph.D. and undergraduate levels. In the education field, the aim is to introduce the EuroMaster in Nuclear and- Radiochemistry quality label recognized and guaranteed by EuCheMS - European Association for Chemical and Molecular Sciences. In the training field formation of a long-term Euratom Fission Training Scheme (EFTS) is the ultimate goal that should ensure availability and quality of the training in this field. These measures are currently under development in a follow-on Euratom FP7 project “Cooperation In education and training in Nuclear CHEMistry (CINCH-II)”. They are hoped to contribute to moving the education and training in nuclear chemistry to a steady and qualitatively new level.

2.2 EuroMaster Degree in Nuclear and Radiochemistry

INVITED LECTURE - Prof. LEHTO, Jukka (Laboratory of Radiochemistry, University of Helsinki, Finland)

The first EU project CINCH (Cooperation in education in nuclear chemistry) 2010-2013 was planning the Euromaster degree in nuclear and radiochemistry. The second CINCH project 2013-2016 will implement the degree. According to present plans a consortium of European universities will apply for the NRC Euromaster label from the European Chemistry Thematic Network (ECTN) which is the body granting Euromaster status labels. The consortium is open for all European universities and those universities not participating in the application can join the consortium at a later phase. The educational content of the common NRC Euromaster degree will be based on the minimum requirements planned out in the first CINCH project (see <http://cinch-project.eu/>). According to this plan a master's program eligible to NRC Euromaster label should have at least 50% (60 cu) of its master's studies on nuclear and radiochemistry. Of this 60 credit units at least 10 credit units should be practical exercises and at least 30 credit units should comprise of master's thesis and project work. The educational program should cover most relevant aspects from the following five topic areas - Radioactivity, radionuclides and radiation - Radiation safety - Detection and measurement of radiation - Chemistry and analysis of radionuclides - Nuclear reactions and production of radionuclides According to ECTN requirements the content of the educational programs in the NRC Euromaster consortium should be similar. Exchange of students between

partner universities and organization of common courses, such as summer schools, would be required as well.

2.3 Current Status of Nuclear and Radiochemistry Education in Europe

INVITED LECTURE - Dr. KOIVULA, Teia (Laboratory of Radiochemistry, University of Helsinki, Finland)

Cooperation in education and training In Nuclear Chemistry - CINCH-II project - aims at coordination of education and training schemes in nuclear and radiochemistry (NRC). One of the specific objectives of the project is therefore to identify the current level of NRC education in Europe. Surveying universities and various educational programmes was started under CINCH-I during the years 2010-2011. Results were published in a report “Nuclear and radiochemistry curricula in the European universities” and a list of contact information to the universities/departments that were included in the study (<http://www.cinch-project.eu/>); altogether 69 universities in 22 countries participated in this survey. The results showed diversity of the NRC education in Europe. At BSc level NRC is mainly taught in basic courses under various educational programmes such as chemistry or environmental sciences. There are only few complete programmes, i.e. BSc/MSc degrees in NRC; however, education in the same extent can be attained in various specializations under e.g. the degrees MSc in Chemistry or Chemical/Environmental engineering. Majority of these specializations are general NRC, one large specified topic is environmental radiochemistry/radioecology. Research training and diploma work have a strong role in specialization; however, the extent of specialization varies significantly in different educational systems. Furthermore, some countries/universities are only on their way to accreditation of the Bologna system. Curriculum in NRC typically reflects research interests of the department. Many universities have high level of research and offer possibility to do PhD-work in NRC related fields but have only limited education at lower level(s). Collaboration between universities and industry/research units brings education and training closer to each other and also effects development of the academic programmes. To have an up-to-date view on the current status of the education in NRC the survey is now continued under the CINCH-II project. Universities/departments already included in the first report are therefore asked (via their contact persons) to update relevant information on their unit, especially concerning changes in the curricula and focus of education in NRC. Other interested units can join the survey by sending free-form e-mail or by answering short questions in a questionnaire on the project web page. CINCH project partners will also contribute on the current situation in their respective countries. Perspectives on the current status of NRC education in Europe will be presented in this talk. Report from the overall survey will be published on the project web page by the end of 2015.

2.4 NucWik - Nuclear and Radiochemistry Teaching Material Wiki

INVITED LECTURE - Prof. OMTVEDT, Jon Peter (University of Oslo, Norway)

An open access database, implemented as a "Wiki" (same technology as e.g. used by Wikipedia [1]) was set up to enable university teachers and others to share teaching material and experiences. The basic idea is that teachers and institutions will share and co-develop teaching material for Nuclear and Radiochemistry use, in particular calculation and laboratory exercises. Furthermore, the Wiki – named NucWik [2] – is an ideal place for sharing experiences and discussing how to improve the material further. In this way a lot of work can be saved when setting up a new exercise or course: If someone already developed something similar it can either be directly used or at least provide a very good starting point for a local implementation. It should be made clear that NucWik is not a site intended to be directly used by students. Instead, teachers use it to put together material for their teaching. As a long-term goal we also intend to put together a complete Radiochemistry course book, which will be freely available from NucWik. NucWik was created as part of the CINCH [3]

EU-project, headed by Prof. Jan John, with a goal to strengthen training and education in nuclear and radiochemistry in Europe. However, the NucWik service is freely available for everybody, regardless if they are outside or inside Europe. For any Wiki to be successful, including NucWik, it heavily depends on user participation. Thus, we strongly urge teachers to actively contribute with material and input to discussions. Currently (April 2014) only a limited amount of material has been uploaded, primarily to demonstrate NucWik's potential and encourage teachers to contribute. An important issue with any database or wiki where material can be freely uploaded is quality control. For NucWik this is addressed by implementing a quality control system where we differentiate between documents that has been simply uploaded and those that have been "peer reviewed". Peer reviewed documents have been review by two independent scientists from a group appointed by the CINCH consortium. Such documents will be stamped with "CINCH approved" and cannot be edited (without undergoing another peer review). In this way NucWik will provide an easy and quick way to share and co-develop documents, but also include mechanisms to ensure that trustworthy and scientifically sound material can be downloaded with confidence. At RadChem'2014 possible uses of NucWik will be demonstrated and its potential as a site for active teaching collaboration highlighted. Discussion of and ideas for possible use and future development will be welcomed both after the presentation and later. [1] Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a non-profit organization. Access is through <http://wikipedia.org>. [2] <http://nucwik.wikispaces.com> [3] CINCH – "Cooperation in Education and Training in Nuclear Chemistry" is a FP7 EU-funded coordinated action supported by the European Atomic Energy Community's 7th Framework Program (EURATOM FP7 2007-2011) under grant agreement No. 605173, see <http://cinch-project.eu> for details.

2.5 Radiochemistry Education: Combining Fundamental and Applied Studies

CONTRIBUTED VERBAL PRESENTATION - Prof. CZERWINSKI, Kenneth (University of Nevada, Las Vegas, USA)

Technetium and the actinides are radioelements of importance to the nuclear fuel cycle. Compounds composed of these elements are used in nuclear fuel, separations, safeguard applications, and isotope utilization. These radioelements also represent an underexplored section of the periodic table. Studies on compounds with technetium and the actinides provide opportunities to expand basic chemical knowledge, particularly when coupled with computational studies. Performing experiments with these elements requires specialized facilities and radiochemical expertise. The training of students and scientific rewards for examining this relatively unexplored area of the periodic table are worth the intrinsic difficulties associated with experiments using these elements. The radiochemistry program at the University of Nevada, Las Vegas is described, with emphasis given to the facilities, education mission, and collaborations. The linkage of the UNLV radiochemistry program with DOE and international research efforts is presented. Examples are provided on separations, fuel synthesis, and waste form studies. The incorporation of internet lectures with a laboratory intensive program for undergraduates is also described. The undergraduate program has been demonstrated as an effective pipeline for student recruitment to graduate programs.

3 POSTER PRESENTATIONS

3.1 Practical Experience in the Scientific and Educational Activities of Radioactive Waste Management at FSUE "RADON"

Olga Gorbunova, Olga Karlina, Elena Diordii, Irina Semenova, Aneliya Vitanova (FSUE "RADON", Russia)

Federal State Unitary Enterprise (FSUE) "RADON" is a multifunctional scientific-industrial complex, meeting the international standards of Quality Management System ISO 9001 and Environmental Management Systems 14001. More than 50 years, the enterprise successfully carries out the entire technological complex of services on radiation monitoring, decontamination of contaminated areas, collection, transportation, processing, conditioning, long-term storage (disposal) of radioactive waste of low and intermediate level of radioactivity, and the safety assurance of nearsurface storage of radioactive waste. FSUE "Radon" has a unique research-industrial, industrial, experimental and laboratory equipment to carry out education as training courses on the technological processes, covering all stages of radioactive waste treatment. The value of the technological support of the educational process in FSUE "RADON" is in the continuous improvement of the equipment and technology in the center of Research and Development, and in the scientific development and implementation of new methods and devices. It is not less important that the lectures and practical sessions involved staff members of the FSUE "RADON", and as a rule, they are developers representing the technologies and authors of the regulations, procedures, patents. In the late 90's under the IAEA guidance on the basis of the Scientific and Production complex of the enterprise «RADON» in Sergiev Posad Moscow region was established an inter-regional Educational Center for training specialists from Eastern Europe and former CIS countries in the field of radioactive waste treatment. With time the "geography" of students has been extended, and for 20 years of research and technical training, theoretical and practical training courses took place more than 500 specialists. The IAEA representatives put forward the requirements for the organization of courses, which includes defined themes, visa support, transport services, accommodation, food and cultural program. Our Educational and Training Center perfectly meet these requirements, what brought us the reputation of a reliable partner and a wealth of experience in organizing large-scale multidisciplinary educational activities. The FSUE "RADON" holds scientific and practical training for the employees working in the nuclear industry of Russia, as well as training for improving the skills of their own staff and for adaptation of the young professionals to the specifics of the production. Adaptive introductory courses not directly associated with the processing of radioactive waste are held for the personnel. They include a tour to the technological installations and storage of radioactive waste and lectures by leading experts on technology of radioactive waste treatment. Over the past decade, the company has managed to reach the leading positions in the country in the field of radioactive waste treatment. Today, the FSUE "RADON" is a competence center of the State Corporation "ROSATOM" in the field of radioactive waste management, with a high level team of specialists, including 11 doctors and 65 candidates of science. The specialists of the company are actively engaged as experts for solving various technical problems and expertise of international projects. Having a unique research and industrial complex and high-level specialists, the FSUE "Radon" successfully performs the task of advanced training and professional retraining of domestic industry specialists and foreign students.

3.2 A Laboratory Exercise on Systematic Effects in Gamma Spectrometry

Henrik Ramebäck, Sofia Jonsson, Stefan Allard, Christian Ekberg, Tim Vidmar (Swedish Defence Research Agency, Umeå, Sweden; Chalmers University of Technology, Göteborg, Sweden; SCK-CEN, Belgian Nuclear Research Centre, Mol, Belgium)

High resolution gamma spectrometry is a powerful method for the measurement of gamma emitting radionuclides. It requires most often only a minimum of sample pre-treatment. Moreover, gamma spectrometry is often considered as a transparent measurement method and is for that reason well understood by the users. However, often sample density and composition is different compared to standards used for the calibration of the measurement system. Another example of deviations between the calibration standard and the sample is when the sample container not can be filled to the same volume as the standard. Moreover, measurement of radionuclides emitting gamma photons in cascade, such as ^{134}Cs , will suffer from true coincidence summing (TCS) effects when the samples are measured close to the detector. These systematic effects will often be significant, and have therefore to be corrected. Everyday users of gamma spectrometry, at measurement laboratories such as within the nuclear industry, might be aware of these situations causing systematic effects and therefore deviations in the measurement results. However, methods for the correction of systematic effects are still rarely implemented in routine laboratories. One attempt to improve this situation was to develop a laboratory exercise for students in a master's course in nuclear chemistry. A spectrum containing peaks from ^{137}Cs and ^{134}Cs with an activity ratio of one was given to the students. The task comprised to evaluate the spectrum with respect to activity of the two radionuclides as well as their activity ratio. First this was done without correction. With the use of a program, EFFTRAN, for calculation of e.g. efficiency transfer factors and correction factors for true coincidence summing effects (TCS), the students could thereafter calculate the corrected activity of ^{134}Cs as well the corrected activity ratio. Moreover, the effect of sample-to-endcap distance on TCS was also evaluated. A third and last task in the exercise was to perform efficiency transfer for cases when volume differed between calibration standard and sample. The use of a calculation program, such as EFFTRAN, enables to illustrate the impact from the systematic effects on measurements with gamma spectrometry. The programs also allow the students to gain a deeper understanding regarding which parameters has the greatest influence on different effects and in which energy regions.

3.3 Radiochemistry Courses in the Nuclear Science Program at Universiti Kebangsaan Malaysia

Sukiman Sarmania, R. B Yahyab, M. S Yasira, I. A Rahmana, K. S Khooa (National University of Malaysia)

Universiti Kebangsaan Malaysia (UKM) also known as the National University of Malaysia offered an undergraduate and postgraduate degree programmes in Nuclear Science since 1983. The program has undergone several modifications due to changes in national policy and priority. The program covers nuclear sub-disciplines such as nuclear physic, radiobiology, radiochemistry, radiation chemistry and radiation safety. To graduate with a Bachelor of Science in Nuclear Science students are required to pass a total of at least 120 credits comprising of 20 credits of university courses and 100 credits of compulsory courses or core courses and electives. The radiochemistry component of the programme consists of radiochemistry, chemistry in nuclear industry, radiochemical analysis laboratory, radiopharmaceutical chemistry, and mini research project in radiochemistry. The radiochemistry components of the graduate programme cover specific topics on radiochemical separation, radioactive waste management, transuranium chemistry and environmental radioactivity. Radiochemistry research projects for PhD or MSc degrees include development of radiochemical neutron activation analysis, application of neutron activation,

radioisotope production and radiopharmaceutical synthesis.

3.4 Nuclear Chemistry in the Central European Energy Institute

Katerina Cubova (Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic)

The lack of the technically educated specialists is the problem concerning the whole Europe. The problem is strongly felt in the field of nuclear power engineering. There are for two main reasons responsible for the current situation. The first is lack of interest of the potential students in the study in technical fields. The second one is the long term problem related to the generation exchange of the specialists. Taking into account the problems mentioned, Czech technical universities decided to establish a Central European Energy Institute which is aiming at providing a sustainable, interdisciplinary and practical teaching programme for highly educated specialists in nuclear power engineering. Such concept is supported in the framework of Operation Programme Education for Competitiveness supported by the Czech Ministry of Education Youth and Sports. Key activity of the project is to ensure the innovation of the nuclear power engineering study programmes in all three levels (Bc, MSc and PhD study programme) including formation of new educational materials and introduction of E-learning system. An integral part of the educational programmes of the Institute will be curriculum in nuclear chemistry. It will aim to give the students – future engineers – indispensable radiochemical background with the emphasis on the chemistry of operation of nuclear power plants, technology of the fuel cycle of nuclear power stations and the waste management and treatment.

4 CONCLUSIONS

Out of the five verbal presentations of the “Education” section at RADCHEM 2014, four (invited) presentations came from within the CINCH II consortium. Presentations summarized some of the results obtained during both CINCH and CINCH II projects (see Attachment for the copies of presentations).

Based on the content of presentations, following conclusions could be done:

- 1) high demand for specialists in nuclear and radiochemistry exists in the industries, science and development
- 2) plans for minimum requirements in the education of radiochemists and for joint master education in nuclear chemistry has been laid out by CINCH consortium
- 3) there are only several universities in Europe offering full master courses in nuclear chemistry, let alone bachelor courses
- 4) to save time and resources necessary for the preparation of teaching materials, NucWik exists to share resources.

Both the verbal and poster parts of the Education session were very well attended – the number of participants at the verbal session can be estimated as about 100. Thus, the global nuclear and radiochemical community received a very good picture of the European activities in this field. Leading role of Europe in the coordination of education and training in nuclear and radiochemistry was clearly confirmed.