UNIVERSITY OF OSLO
FACULTY OF MATHEMATICS AND NATURAL SCIENCES

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Scientific report of ESF Workshop on the Chemistry of the Transactinide Elements 2nd to 5th October, 2005 in Oslo, Norway

Executive Summary

The newly established Centre for Accelerator-based Research and Energy Physics (SAFE), organised under the Physics and Chemistry departments of the Faculty of Mathematics and Natural Sciences at University of Oslo, hosted a three-day workshop on the Chemistry of the Transactinide Elements with arrival in Oslo on Sunday afternoon 2nd of October 2005. The main workshop sponsor was the European Science Foundation, under their program of "Exploratory Workshops". The workshop was held in the beautiful hills west of Oslo called Holmenkollen at the Soria Moria Convention Centre. The facilities and food at the Convention Centre was excellent, which was confirmed and emphasised by the feedback from the participants.

The workshop concentrated on experimental and theoretical methods to expand the knowledge of the chemical properties of the transactinide elements. The focus was on discussing the latest results and methods, as well as presenting future plans and developments to advance the research field. The workshop included sessions on gas-phase chemistry, liquid-phase chemistry, theoretical predictions, synthesis and decay properties of heavy elements, and novel methods and techniques.

A particular emphasis was on the effects preseparators like the Berkeley Gas-filled Separator (BGS) and the new separator at GSI, named TransActinide Separator and Chemistry Apparatus (TASCA), will have on current technology limits. Such preseparators offer new possibilities for chemistry experiments which otherwise would have been impossible to perform. Many talks emphasised the importance of these separators. In addition, the forth workshop on building and commissioning TASCA was arranged as a "piggy-back" workshop at the University of Oslo campus, immediately following the ESF workshop.

In addition to the generous sponsorship by the ESF, additional sponsorship was received from the Institute for Energy Technology (IFE) at Kjeller, Norway, the GammaData group in Uppsala, Sweden, and from the Faculty of Mathematics and Natural Sciences. In addition, the Department

of Chemistry provided manpower, administrative support and facilities for planning and organising the workshop.

31 persons attended the workshop, including the ESF observer Prof. Massimo Martinelli. Of these, 8 participants were from Oslo.

The workshop costed 255.400 NOK (about 33,170 euro) in total. 42.7% of this was covered by the ESF, 9.1% by other sponsors, and 16.0% by the Chemistry Department. The rest, 32.2%, was covered by the participants. Participants who slept at the hotel payed 3.600 NOK each. Local participants (mostly students) who did not have a room at the hotel each payed 1200 NOK. Transport to and from the workshop was covered individually. Expenses for Prof. Martinelli is covered by ESF separately and have not been included in the breakdown above.

On Tuesday, the second day of the workshop, the afternoon was used for a tour followed by the main workshop dinner. The tour was to three museums at the Bygdøy peninsula: The Viking ships museum, the polar-vessel Fram and the Kon-Tiki museum. In addition, there was time to visit the panoramic cinema at the Maritime museum, which showed the Norwegian coastline in all its variation and moods. The weather was fantastic and the organisers had a distinct impression that the participants enjoyed both the walks between the museums and the museums.

The dinner was arranged at the Royal Norwegian Yacht Club at Dronningen, Bygdøy. The dean of the Faculty, prof. Knut Fægri, attended the dinner together with a some other specially invited guests from SAFE. In total 37 people participated. The dinner was excellent and the rooms at the Yacht Club well suited for such an arrangement.

The workshop ended at 4 PM on Wednesday 5th of October. 27 of the participants also attended the TASCA workshop arranged in the Physics building on Campus on Thursday. The costs for planning and organising the TASCA workshop has not been included in the ESF workshop.

Attached to this report is

- A report on the *Scientific Content of the Workshop*
- *Assessment of Results* from the workshop
- *Final Workshop Programme*
- Final *List of Participants*
- A report with *Statistical Information*

A financial report has been mailed to ESF separately.

Sincerely yours,

Prof. Jon Petter Omtvedt

Scientific Content of the Workshop

The workshop concentrated on experimental and theoretical methods to expand the knowledge of the chemical properties of the transactinide elements. The focus was on discussing the latest results and methods, as well as presenting future plans and developments to advance the research field.

As can be seen from the programme, the workshop started with a session reviewing the research field and some of the methods used. Utyonkov reviewed the latest results on synthesis and decay properties of superheavy nuclei, with emphasis on the work which has been done at FLNR with ^{48}Ca beams. Gregorich review the situation at LBNL with emphasis on how heavier targets than currently used enables chemical investigation, after separation with the BGS, of heavier elements than Rf and Db. A report of the status of the chemistry experiments on element 112 was given by R. Eichler. Furthermore a review by Haba were given about how Japan, at the RIKEN facility, is pursuing an ambitious and impressive research program to explore the chemistry of the heavy elements.

Traditionally, gas-phase chemistry experiments has been heavily presented at conferences and workshops. For this workshop the number of gas-phase experiment presentations were comparatively low. However, presentations of important new experimental data on Hs were given by Türler. Plans and preparations for 112 and 114 gas-phase experiments were presented by Yakushev and Eichler.

Many results, plans, and new techniques for liquid-phase experiments were presented at the workshop. Hummrich presented a novel electrochemical deposition method. Polakova presented results from liquid-liquid extraction of Rf. Eberhardt presented the latest news of the liquid-liquid extraction system micro-SISAK. Samadani presented preparations for liquid-liquid extraction experiments on Hs.

The workshop also included theory presentations. Brüchle presented calculation of elution peak shapes for liquid chromatography under transactinide chemistry conditions. Pershina presented a very useful introduction to how theoretical predictions and calculations can be compared to experimental data.

Finally there were presentations on new techniques and facilities. Of these, the most important is without doubt the new TASCA separator at GSI presented by Schädel. This facility will be an important common tool for both physics and chemistry experiments on the transactinide elements in the future. Several talks showed how new kind of chemistry experiments is possible when a preseparator is available: Eichler presented preparations for vacuum chromatography after a preseparator, Omtvedt reviewed how liquid-liquid extraction with the SISAK system suceded after using the BGS as a preseparator.

All in all, the presentations showed that there is many challenges in this field but that there is a large and dedicated group of researchers working on overcoming these challenges and there is rapid progress. A few years ago chemistry experiments on element 106, Sg was considered to be the limit. Today experiments on elements as heavy as 114 is being considered as not totally unrealistic!

Assessment of Results

Apart from presenting impressive and new results, the workshop was a boost to strengthen existing relationships between the research groups and establishing new co-operations. Everybody was impressed by the possibilities offered by the ESF by Martinelli and it was decided to establish a committee with representatives from the participating labs to explore possibilities offered by the ESF, and other funding agencies, to enhance the mobility of students and researchers between the labs.

The committee was set up with the following members:

Klaus Eberhardt	Institut für Kernchemie, University Mainz, Germany
Robert Eichler	Paul Scherrer Institut, Villigen, Switzerland
Ken Gregorich	Lawrence Berkeley National Laboratory, California, USA
Hiromitsu Haba	RIKEN, Japan
Jon Petter Omtvedt	Department of Chemistry, University of Oslo, Norway
Matthias Schädel	Gesellschaft für Schwerionenforschung, Darmstadt, Germany
Gunnar Skarnemark	Nuclear Chemistry, Chalmers University of Technology, Göteborg, Sweden
Andreas Türler	Institut für Radiochemie, TU München, Germany
Vladimir Utyonkov	Joint Institute for Nuclear Research, Dubna, Russia
Juha Uusitalo	University of Jyväskylä, Finland
Philip Wilk	Lawrence Livermore National Laboratory, California, USA

Representatives may be changed by the institutions and additional institutions added. Omtvedt is chairman of the committee.

One of the avenues which will be tried is to establish an ESF Scientific Programme on superheavy element research.

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Final Workshop Programme

	Sunday, September 2nd	
16:00-18:00	Registration	
18:00	Welcome reception	
19:00	Dinner	
	Monday, September 3rd Chairmen: G. Skarnemark, M. Schädel	
08:00-09:45	Registration	
10:00-10:05	Welcome	J.P. Omtvedt
10:05-10:20	ESF presentation	M. Martinelli
	Status and Reviews	
10:20-10:45	Synthesis and Decay Properties of Superheavy Nuclei	V. Utyonkov
10:55-11:20	Chemical Procedure for the Identification of Rf/Db Produced in the $^{48}Ca+^{243}Am$ Reaction	D. Schumann
11:30-13:00	Lunch	
12:45	Workshop photo	
13:00-13:25	SISAK beyound Rf - Plans for Studies of Heavier Transactinides	J.P. Omtvedt
13:35-14:00	Hot Fusion with ^{238}U Targets	K. Gregorich
14:10-14:35	Results, status and future plans for the 112 experiments	R. Eichler
14:45-15:05	Coffee break	
15:05-15:30	New results on synthesis of Hs isotopes	A. Türler
15:40-16:05	An Overview of the LLNL heavy element program - a new old chemistry program	P. Wilk
16:15-16:40	Startup of Superheavy Element Chemistry in RIKEN	H. Haba
16:55-17:20	Development of extraction systems for the study of rutherfordium and dubnium	R. Sudowe
19:00	Dinner	

	Tuesday, September 4th Chairmen: K. Eberhardt	
	Liquid-phase Chemistry	
09:00-09:25	Calculation of elution peak shapes in dependance of column length and Kd	W. Brüchle
09:35-10:00	Electrochemical Deposition Methods in Transactinide Chemistry	H. Hummrich
10:00-10:15	Coffee break	
10:15-10:40	Liquid-Liquid Extraction of Rf from H_2SO_4 with TOA	D. Polakova
10:50-11:05	Plans for Liquid-Liquid Extraction Studies of Dubnium	L. Zheng
11:10-11:25	Plans for Liquid-Liquid Extraction Studies of Hassium	F. Samadani
11:30-13:00	Lunch	
13:00-18:00	Social activity: Visit to the Viking Ship Museum, the Polar Ship Fram and the KonTiki museum	
19:00	Dinner at Dronningen (Royal Norwegian Yacht Club)	

	Wednesday, September 5th Chairmen:R. Sudowe, A. Yakushev	
	Gas-phase Chemistry	
09:00-09:25	Thermochromatographic studies of ^{212}Pb and ^{205}Bi on different surfaces	F. Haenssler
09:35-10:00	Pb/Hg separation as modell for 114/112 chemistry	A. Yakushev
10:10-10:20	Coffee break	
	Theoretical Predictions	
10:20-10:45	Theoretical predictions of experimentally studied properties of the heaviest elements and relativistic effects	V. Pershina
	New Techniques and Facilities	
10:55-11:20	Recent experiments with the liquid-liquid extraction system MicroSISAK	K. Eberhardt
11:30-13:00	Lunch	
13:00-13:25	Vacuum Chromatography with Homologues of the Transactinide s- and p-Elements @ BGS	R. Eichler
13:35-14:00	The TASCA Project	M. Schädel
14:10-14:35	Using Cold Fusion Reactions to Understand Hot Fusion Reactions Used in Chemistry Experiments	C. Folden III
14:45-15:05	OCL@SAFE: Transactinide homologues available at the Oslo Cyclotron Laboratory for model studies	J. P. Omtvedt
15:15-15:20	Final words from the organisers	
19:00	Dinner	

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List of Participants

Prof. em.	Jorolf Alstad	Department of Chemistry, University of Oslo, Norway
Dr	Willy Brüchle	Gesellschaft für Schwerionenforschung, Darmstadt, Germany
Dr	Rugard Dressler	Paul Scherrer Institut, Villigen, Switzerland
Dr	Klaus Eberhardt	Institut für Kernchemie, University Mainz, Germany
Dr	Robert Eichler	Paul Scherrer Institut, Villigen, Switzerland
Dr	Charles III Folden	Lawrence Berkeley National Laboratory, California, USA
Dr.	Ken Gregorich	Lawrence Berkeley National Laboratory, California, USA
Dr	Hiromitsu Haba	RIKEN, Japan
Mr	Florian Haenssler	Departement of Chemistry and Biochemistry, , Bern University, Switzerland
Mr	Holger Hummrich	Institut für Kernchemie, University Mainz, Germany
Ms	Stefanie König	Paul Scherrer Institut, Villigen, Switzerland
Prof	Massimo Martinelli	Istituto per i processi chimico-fisici (IPCF), Pisa, Italy (ESF representative)
Ms	Mette Nilsen	Department of Chemistry, University of Oslo, Norway
Prof	Jon Petter Omtvedt	Department of Chemistry, University of Oslo, Norway
PhD	Karsten Opel	Forschungszentrum Rossendorf, Germany
Dr	Valeria Pershina	Gesellschaft für Schwerionenforschung, Darmstadt, Germany
Ms	Darina Polakova	Department of Chemistry, University of Oslo, Norway
Ms	Fereshteh Samadani	Department of Chemistry, University of Oslo, Norway
Dr	Matthias Schädel	Gesellschaft für Schwerionenforschung, Darmstadt, Germany
Ms	Frøydis Schulz	Department of Chemistry, University of Oslo, Norway
Dr	Dorothea Schumann	Paul Scherrer Institute,Villigen, Switzerland
Dr	Andreij Semchenkov	Gesellschaft für Schwerionenforschung, Darmstadt, Germany, TUM
Prof	Gunnar Skarnemark	Nuclear Chemistry, Chalmers University of Technology, Göteborg, Sweden
Ms	Liv Stavsetra	Department of Chemistry, University of Oslo, Norway
Dr	Ralf Sudowe	Lawrence Berkeley National Laboratory, California, USA
Prof	Andreas Türler	Institut für Radiochemie, TU München, Germany
Mr	Vladimir Utyonkov	Joint Institute for Nuclear Research, Dubna, Russia
Dr	Juha Uusitalo	University of Jyväskylä, Finland
Dr	Philip Wilk	Lawrence Livermore National Laboratory, California, USA
Dr	Alexander Yakushev	Institut für Radiochemie, TU München, Germany
Ms	Li Zheng	Department of Chemistry, University of Oslo, Norway

Statistical Information

Category:	Number	Percentage:	Comment:
Female	9	29,0	
Male	22	71,0	
Undergrad. students	3	9,7	
Graduate students	7	22,6	
Post.docs	7	22,6	
Staff scientists	14	45,2	
Finland	1	3,2	
Germany	9	29,0	
Italy	1	3,2	ESF observer
Japan	1	3,2	
Norway	8	25,8	
Russia	1	3,2	
Sweden	1	3,2	
Switzerland	5	16,1	
USA	4	12,9	
Age below 30	6	19,4	Age for some participants was estimated due to unavailable data.
Age 30 to 39	11	35,5	
Age 40 to 50	8	25,8	
Age above 50	6	19,4	