Oral Presentations

Thursday, 26 September 2013

Hall & Meeting Room, Kanazawa Bunka Hall

	Thursday, 26 September				
Time		Hall		Meeting Room	
09:00-09:10	9:00	PL-07	**Plenary** S. B. Clark		
09:10-09:20					
09:20-09:30					
09:30-09:40	9:30	PL-08	**Plenary** H. Ueno		
09:40-09:50					
09:50-10:00					
10:00-10:10	10:00	**Coffee Break**			
10:10-10:20					
10:20-10:30	10:20	NPI-01	**Invited** W. Sato	EDI-01	**Invited** J. John
10:30-10:40					
10:40-10:50					
10:50-11:00	10:50	NPO-01	General K. Nomura	EDI-02	**Invited** W.S. Wu
11:00-11:10					
11:10-11:20	11:10	NPO-02	General J. Wang		
11:20-11:30				EDI-03	**Invited** A. Yokoyama
11:30-11:40	11:30	NPO-03	General M. Kaneko		
11:40-11:50					
11:50-12:00	11:50	NPO-04	General G. Yoshida	EDO-01	General S. B. Sarmani
12:00-12:10					
12:10-13:20	12:10	**Lunch Time**			
13:20-13:30	13:00	**Excursion** **(Shirakawa-go)**			
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19:00-19:20	19:00	**Banquet**			
19:20-19:40					
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APSORC'13 - 5th Asia-Pacific Symposium on Radiochemistry
Kanazawa, Japan, 22-27 September 2013

PL-07

Preparing the Next Generation of Radiochemists for Global Challenges

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Abstract – Nuclear and radiochemists are needed to support the expansion of nuclear energy, nuclear medicine, and environmental management. In this presentation, the changing needs for educating future generations of radiochemists are described. Consideration of the global nature of these market sectors is given, along with observations and recommendations for changes in academic curricula and training opportunities.

Keywords– nuclear chemistry, education, curriculum development

I. INTRODUCTION

Nuclear and radiochemistry is a sub-discipline within chemistry, and is referred to simply as radiochemistry in this presentation. These chemists study nuclear properties, nuclear reactions, and the chemical manipulation of radioactive substances for applications in physics, chemistry, biology, medicine, earth and space sciences [1]. The global radiochemistry workforce includes individuals employed in basic research and the allied fields of nuclear energy, nuclear medicine, defense, and the interface of these sectors with the environment. As nuclear energy and nuclear medicine grow world-wide, the need for a well-educated global workforce of critical thinkers is a challenge for many countries. In this presentation, the preparation of radiochemists for these future opportunities and challenges is discussed.

II. RADIOCHEMISTS IN ENERGY

Nuclear power plants provided more than 12% of the world's electricity production in 2011, generated by over 400 reactors in 30 countries worldwide, with a 70 new nuclear plants under construction in 14 countries [2]. The global nuclear power industry requires radiochemistry expertise to support (1) the operation of existing nuclear power plants and supporting facilities within a country's nuclear energy cycle, (2) the licensing and regulation of these facilities, and (3) research into future generations of nuclear energy facilities and approaches.

Chemists who work in these areas require expertise in areas such as nuclear reactions, radiation detection, radiation effects, separations, and chemical engineering, to name a few. As some countries move towards closing their fuel cycles and implementation of fusion energy technologies to transmute nuclear wastes while generating energy, developing unique expertise in the chemistry of materials and their corrosion in extreme, high radiation environments, and challenging chemical separations will be required. Anticipating these needs and altering university curricula to provide the necessary skills for those working in fusion energy will be important for advancing such new nuclear energy systems.

III. RADIOCHEMISTS IN MEDICINE

Nuclear medicine involves the use of radiopharmaceuticals for imaging to assess physiological processes, and to diagnose and treat diseases [3]. Future generations of radiochemists are needed for careers in academia, government laboratories, industry, and pharmacy. Academic radiopharmaceutical chemists typically provide the initial education and training, and the basic research that drives innovation in this technical area. Radiochemists working in government laboratories build upon the basic research foundation from academia to further develop radiopharmaceutical compounds. Industrial radiochemists synthesize radiopharmaceuticals, and conduct clinical trials of potential new pharmaceuticals. Nuclear pharmacists are the practitioners who prepare and sometimes administer the drugs, in collaboration with physicians. As the use of isotopes in the diagnosis and treatment of disease continues to expand, a global workforce of radiochemists who are also knowledgeable in biochemistry, molecular biology, synthetic chemistry and medicine are needed worldwide.

IV. RADIOCHEMISTS IN ENVIRONMENTAL MANAGEMENT

As with any industrial sector, nuclear energy and nuclear medicine both generate waste streams that require management for eventual disposal. Nuclear accidents and past radioactive waste management practices in countries that have used nuclear technologies for national defense and/or energy production have resulted in environmental legacies that require remediation. A new generation of radiochemists who are prepared to resolve such environmental legacies is needed. For example, as a result of the Fukushima accident in Japan, a new professional society of scientists was formed [4]. Developing strategies that meet international regulatory requirements relies on development of a pipeline of radiochemists who are also knowledgeable in disciplines such as environmental science and engineering, communications, sociology, and political science.

V. REFERENCES

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PL-08

Researches with stopped radioisotopes at the RIKEN RIBF facility

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RIKEN has started the operation of the new facility for the Radioactive-Isotope Beam Factory (RIBF) project [1] since 2006. In this project, intense primary beams are delivered at the energy E/A = 350–440 MeV over the whole range of the atomic number utilizing newly constructed three cyclotrons, K = 700 fixed-frequency Ring Cyclotron (fRC), K = 980 Intermediate-Stage Ring Cyclotron (IRC), and K = 2500 Superconducting Ring Cyclotron (SRC) together with the existing K = 540 RIKEN Ring Cyclotron (RRC). Beams are delivered in the cyclotron cascade-acceleration scheme, in which AVF, RILAC, or RILAC2 is also included as an injector depending on the energy and the mass of a beam. The beam extracted from SRC is then transported to superconducting in-flight RI separator BigRIPS [2] in order produce radioactive-isotope beams (RIBs). BigRIPS is characterized by its large acceptance and two-stage scheme. The former is realized by the large aperture superconducting triplet Q-lens system, which enables BigRIPS efficiently to collect in-flight ^{238}U fission products. The latter is effective in the isotope separation and particle identification event-by-event basis. After the first beam was delivered on December 2006, the beam time for 1701 days, including 298 days for BigRIPS-based experiments, will be conducted until the end of September 2013. The beam current and the stability in beam delivery have been improved significantly by the improved performance of the 28-GHz ECR ion source and fRC, and the installation of a He-gas charge-stripping system [3], where the maximum beam currents 415, 100, 38, and 15 pnA, have been recorded for typical primary beams of BigRIPS-based experiments, ^{48}Ca, ^{70}Zn, ^{124}Xe, and ^{238}U, respectively [4].

In order to fully capitalize the RIBF facility, several experimental key devices have been installed downstream of the BigRIPS separator. Many nuclear-physics experiments are performed by means of the in-flight secondary nuclear reaction of radioactive-isotope beams (RIBs). For this purpose, a multi-function spectrometer for particle identifications (ZeroDegree [2]), a superconducting large acceptance and multi-particle detection spectrograph (SAMURAI [5]), and a high-resolution spectrograph under the scheme of the dispersion matching (SHARAQ [6]) were constructed following BigRIPS. In addition, the construction of the Rare-RI Ring [7], which is an isochronous storage ring to measure the mass of rare radioactive isotopes, is underway. Aiming at the first e-RI scattering experiments, the SCRIT [8] system is also under development.

Apart from the reaction-based approaches, nuclear-structure studies have also been conducted using stopped RIBs, where measurements are performed on the techniques of nuclear spectroscopy that take advantage of intrinsic nuclear properties. In particular, at the BigRIPS site, the EURICA (Euroball RIKEN Cluster Array) project [9] had been unfolded taking a high priority over the period of year and half since April 2012. In this program, structure of far unstable nuclei, which can be currently accessible only with the RIBF, have been investigated through the β-γ spectroscopy with the γ-ray detector array consisting of twelve high purity germanium cluster detectors from the Euroball IV array [10]. Combining the recently developed new method to produce spin-oriented RIBs [11], spin-related observables of RIs such as nuclear moments and spin parities will be measured in the stopped-RI type experiments. As for slowed-down and stopped RIBs, it should be noted that the construction of the SLOWRI system [12], which is a system to stop and extract the fast fragmentation RI by means of He and Ar gas catchers combined with the RF ion guide technique, has just started. The system is expected to provide a unique opportunity to investigate nuclear structure of RIs through atomic-physics techniques such as the laser spectroscopy.

Besides these BigRIPS-based experiments, which is categorized as the high-energy mode in RIBF, beams are also available in the low-energy mode whose acceleration scheme is AVF or RILAC (→RRC), where the accelerators in parentheses can be skipped in the cascade acceleration, depending on the beam used. RIBs are also available at E/A ~ 70 MeV in this mode with the former projectile-fragment separator RIPS [13]. Researches with stopped RIBs are actively conducted in the low-energy mode, in which an advanced usage of RIPS by changing the configuration of the beam-transport line has been proposed [14].

In the talk, after the overview of the RIBF facility, researches with stopped RIBs at BigRIPS and RIPS sites will be presented.

Reference

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Local Structure at the In Impurity Site in ZnO Probed by the TDPAC Technique

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Abstract – Local structures produced in 0.5 at.% In-doped ZnO were investigated by means of the time-differential perturbed angular correlation method using the ^{111}*Cd probes generated in the disintegration of different parents,* ^{111}*In and* ^{111m}*Cd. From distinct perturbation patterns, it was ascertained that the doped In atoms locally form a unique structure dispersed in ZnO matrix without forming macroscopic agglomerates of their own. The microscopically associated structure of In atoms is discussed based on the hyperfine parameters at the probes in comparison with those for other metal oxide compounds.*

Keywords – Zinc Oxide, Perturbed Angular Correlations, Indium, Impurity, Local Structure

I. INTRODUCTION

Zinc oxide (ZnO) is an intrinsic *n*-type semiconductor having optoelectronic properties, and its wider industrial application as functional devices has been highly expected. For the control of the *n*-type conductivity, it is of importance to understand the state of being of impurities on an atomic scale.

From this point of view, we have studied the local fields at the impurity sites in ZnO doped with group 13 elements (Al[1], Ga[2], In[3]) by means of the time-differential perturbed angular correlation (TDPAC) method using the ^{111}Cd(← ^{111}In) probe. Among these impurity doped samples, the TDPAC spectrum for 0.5 at.% In-doped ZnO exhibits a single high-frequency component reflecting a characteristic local structure surrounding the probe, which is distinct from the one appearing in the spectrum for undoped ZnO[3]. In addition to the structural uniqueness, we found that this component is thermally stable in ZnO matrix. In the present paper, the characteristic local structure formed in the In-doped ZnO is discussed.

II. EXPERIMENTS

For the production of 0.5 at.% In-doped ZnO, a conventional solid state reaction was applied to a mixture of stoichiometric amounts of ZnO and $In(NO_3)_3 \cdot 3H_2O$[3]. Two different parents of the ^{111}Cd probe were then introduced to the synthesized samples as impurities: droplets of ^{111}In HCl solution were added onto a disk of the In-doped ZnO, and it was heated in air at 1373 K for 2 h for diffusion of the probe[3]; ^{111m}Cd prepared by thermal neutron irradiation of enriched ^{110}CdO was doped into the In-doped ZnO by heat treatment[4]. TDPAC measurements were performed for both of the heat-treated samples using the same probe descended from different parents: ^{111}Cd(←^{111}In) and ^{111}Cd(←^{111m}Cd).

III. RESULTS

The TDPAC spectrum of ^{111}Cd(←^{111}In) in 0.5 at.% In-doped ZnO is shown in Fig. 1(a). One can see a characteristic pattern in the spectrum. This signifies that the doped In ion(s) produces a greater electric field gradient at the ^{111}Cd(←^{111}In) probe compared with the case for undoped ZnO[3]; that is, nonradioactive In ion(s) is adjacent to the probe, forming a certain association in the host.

Figures 1(b) and 1(c) show the TDPAC spectra of ^{111}Cd(←^{111m}Cd) in undoped and 0.5 at.% In-doped ZnO, respectively. (Note that 5 at.% Cd is inevitably introduced in the system when the probe as in ^{110}CdO is doped.) As is evident from the quadrupole frequency in Fig. 1(b), the ^{111}Cd(←^{111m}Cd) probe resides at the substitutional Zn site. For 0.5 at.% In-doped ZnO in Fig. 1(c), a spectral damping is observed; this trend becomes more pronounced with increasing concentration of In dopants[4]. These observations reveal the fact that a large number of microscopic local associations of a specific In compound are widely dispersed in ZnO matrix. In order to identify the compound formed in ZnO, we are now working on comparative studies about metal oxides comprised of Cd and In in expectation of their synthesis in ZnO matrix.

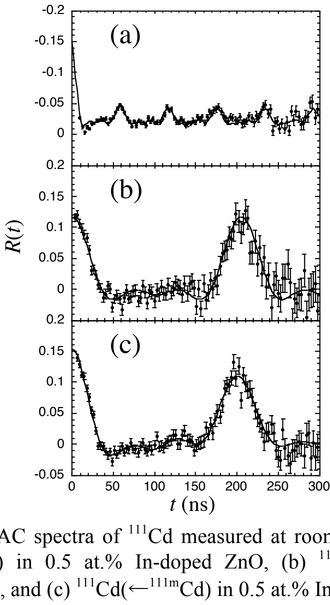

Fig. 1. TDPAC spectra of ^{111}Cd measured at room temperature: (a) ^{111}Cd(←^{111}In) in 0.5 at.% In-doped ZnO, (b) ^{111}Cd(←^{111m}Cd) in undoped ZnO, and (c) ^{111}Cd(←^{111m}Cd) in 0.5 at.% In-doped ZnO.

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Mössbauer Analysis of Iron Ore and Rapidly Reduced Iron Ore by Micro-Discharge

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Abstract

Several samples of iron ore were analyzed by Mössbauer spectrometry. Almost all iron ores are composed of hematite, goethite, and fine grains of oxides, of which the ratios are different among production area. The amount of hematite, magnetite and geothite are consistent with those obtained by conventional chemical analysis. MD method is proven to be efficient in rapidly reducing iron ores.

I. INTRODUCTION

Iron ore contains several kinds of iron oxides such as Hematite (α-Fe_2O_3), and Magnetite (Fe_3O_4), and iron oxy-hydroxides such as Goethite (α-FeOOH), and Lepidocrocite (γ-FeOOH). A chemical analysis is generally used for determining chemical composition of iron ore [1]. On a number of different ores, we compared qualitative and quantitative results obtained by Mossbauer spectrometry with those by chemical analysis. Further, we tried to perform the rapid reduction of iron ore by using micro discharge (MD) using carbon felt (CF) for shirt time [2].

II. EXPERIMENT

Using five ore samples (A and B from Brazil, C, E and M from Australia) and a reference Japanese standard sample (JSS805), the content ratios of Fe_2O_3, FeOOH, and Fe_3O_4 were determined by Japanese Industrial Standard (JIS) method. The content ratios of Fe_2O_3, FeOOH, and Fe_3O_4 obtained are as follows: sample A (91.7%, 2.8% 0.4%), sample B (85.4%, 10.2%, 0.2%), sample C (78.6%, 23.7%, 63.3%), sample E (23.7%, 63.7%, 0.2%), sample M (63.3%, 29.3%, 1.1%)１）.

Mössbauer spectra of the same samples were measured at room temperature by using ^{57}Co(Cr) source.

III. RESULT AND DISCUSSION

Results by Mössbauer spectra

Mössbauer spectra of Australian iron ores (C, E, and M) are shown in Fig. 1. A outer sextet with a large magnetic field (B_{hf} =51.5T, IS= 0.37mm/s, QS(2ε)= -0.20 mm/s) is assigned to α–Fe_2O_3, and the inner sextet with a small magnetic field (B_{hf} = 37T, IS = 0.37mm/s, QS(2ε) = 0.30mm/s) is to α–FeOOH. The Mössbauer spectrum of sample E show the broaden sextet due to α–Fe_2O_3 and paramagnetic peaks in addition to the more broaden sextet peaks of α–FeOOH due to fine grains of iron ore or isomorphic substitution of Fe^{3+} by Al^{3+}. The amounts of α–Fe_2O_3 and α–FeOOH were consistent with the results by chemical analysis.

Reduction treatment of iron ore by micro-discharge (MD) using carbon felt (CF)[2)]

A sample can be heated up to 1000°C by MD/CF for about 100 seconds. Mössbauer spectrum of sample M, treated in alumina crucible by MD/CF with 500 W for 2 min, is shown in Fig. 2. Two sextets and two doublets were additionally observed in the Mössbauer spectrum. The Mössbauer parameters indicate that the two sextets come from the Fe^{2+} and Fe^{3+} species occupied in octahedral (site B) and Fe^{3+} in tetrahedral (site A) sites of inverse-spinel, magnetite. Two doublets with small and large QS values were observed. The former is due to Fe^{2+} species as wüstite (FeO). The latter doublet with large QS is considered due to formation of siderite ($FeCO_3$) although the QS value is larger than expected for this mineral. The large QS may be a result of the dispersion in oxide matrix. Unquestionably the micro-discharge method produces a noticeable fast reduction of all treated ores.

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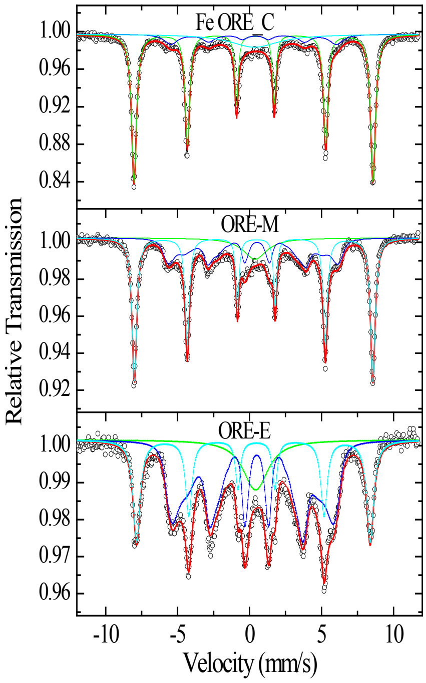

Fig.1 MS spectra of Austrian iron ore.

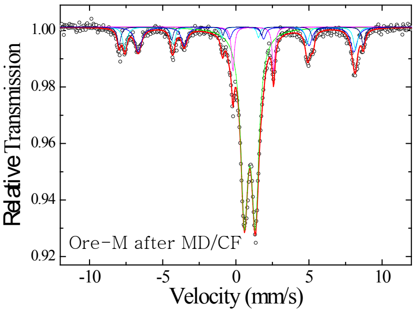

Fig.2 MS spectrum of iron ore M treated by MD/CF.

Three Ways to Fix Cs in Prussian Blues

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Prussian Blue (PB) and its analogues have a very high capacity for incorporation, or sorption, of various alkali ions. Among all the alkali elements in PB Cs is absorbed most firmly. The mobility of alkali ions in channels of the hexacyanometalate structure drops dramatically with increasing the alkali ionic radius. We have explored three routes towards fixation of Cs in the solid phases of the PB analogues. Our sorption experiments showed that the insoluble hexacyanocobaltates are rather slow sorbents, however, our newly synthesized soluble PB analogues are having much larger sorption capacity accessible at short times.

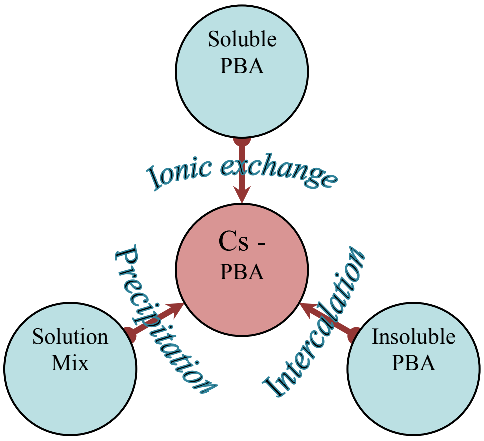

Fig 1. Explored routes of Cs fixation in PB.

The sorption rate is the crucial functionality parameter of a sorbent for sorption of the radioactive isotopes. This is because in a realistic radioactive contaminated environment the PB sorbent attains too much activity well before the saturation in Cs. Therefore, it is vital to compare the rates for known ways of the synthesis of a target cyanometallate $CsFe[Co(CN)_6]$ in Fig.1.

Measuring the Mössbauer spectra of the sorbents allows to understand the changes in local surrounding of the Fe^{2+} ions [1]. In Fig. 2, we show that the ionic charge of Fe^{2+} becomes distributed more isotropically with increasing Cs content. The latter is controlled by the Rietveld analysis of x-ray diffraction patterns.

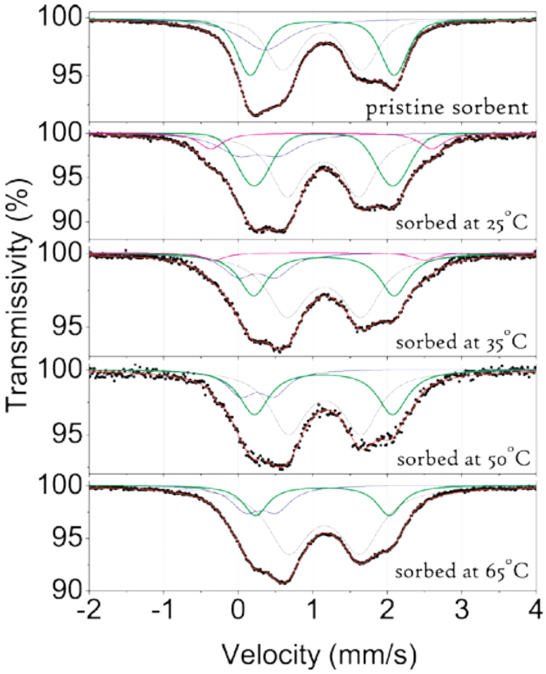

Fig.2. Mössbauer spectra of the insoluble pristine sorbent $Fe_3[Co(CN)_6]_2 \cdot xH_2O$ and the products of its reaction after soaking in solutions containing the Cs ion. The aliquotes of 35 mg of the sorbent were stirred in a beaker with 25 mL of 0.1 M solution of CsCl for 40 h at the temperatures of 20 °C, 35 ^{o}C, 50 ^{o}C and 65 ^{o}C. Inner doblet (lower EFG owing to smaller charge anisotropy) is increasing with Cs content from top to bottom.

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Theoretical study on Mössbauer parameters of iron assembled complexes

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Abstract – The calculation of ^{57}*Fe Mössbauer parameters* (δ_{Fe}, ΔE_Q) *using density functional theory to 20 benchmark complexes was performed and showed a good correlation with experiment values. And the calculation to the mononuclear model of iron assembled complexes was also performed. The result of isomer shift was in good agreement with experiment, while that of quadrupole splitting did not show a good correlation with experiment.*

Keywords – ^{57}*Fe Mössbauer spectroscopy, density functional theory, iron assembled complex*

I. INTRODUCTION

Assembled complexes with transition metal ion as a center metal can show various structures and properties. And assembled iron(II) complexes bridged by bipyridine-type ligands (L) $[Fe(NCX)_2(L)_2]_n$ (X = S, Se, BH_3; L = 1,2-bis(4-pyridyl)ethane (bpa), 1,3-bis(4-pyridyl)propane (bpp)) showed a stereospecific structure depending on the conformer of L[1][2]. Furthermore, in these system, the quadrupole splitting values obtained by ^{57}Fe Mössbauer spectroscopy experiment showed a drastic change depending on anions, which were NCX^-, in spite of isomorphous structures[1][2].

Then we can easily perform the molecular orbital calculation including transition metals using density functional theory (DFT) thanks to the progress of arithmetic capacity. And benchmark studies of Mössbauer parameters (δ_{Fe}, ΔE_Q) on mononuclear complexes which possess noncubic electric field gradient show a good correlation between experiment and calculation value[3].

In the present study, we report the electronic states of assembled systems using DFT to reveal the quadrupole interaction by changing anions.

II. COMPUTATION DETAILS

All DFT calculations were performed using the ORCA software package. The spin-unrestricted Kohn-Sham method has been used for iron(II) high-spin octahedral system. In the present study, we have used the simple cluster model $[Fe(NCX)_2(pyridine)_4]$ referenced by single crystal X-ray analyses to 1D chain structures of bpa and bpp complexes. Single-point energies were calculated by using a B3LYP functional. CP(PPP) for Fe and TZVP for other atoms were assigned to basis functions. Isomer shift was calculated by fitting experiment δ_{Fe} with calculated ρ_0, which is the electron density at Fe nucleus, using benchmark study. ^{57}Fe quadrupole splittings were calculated using electric field gradient tensor (V_{ii}) and asymmetry parameter (η) obtained by DFT calculation.

III. RESULTS AND DISCUSSION

As shown in Figs.1 and 2, calculated δ_{Fe} and ΔE_Q were strongly correlated with experiment values. The correlation coefficients of δ_{Fe} and ΔE_Q were 0.99 and 0.98 respectively.

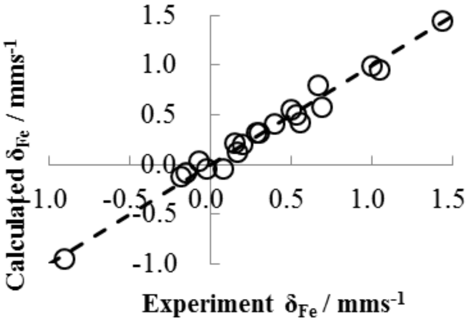

Fig.1 The correlation of δ_{Fe} between calculation and experiment.

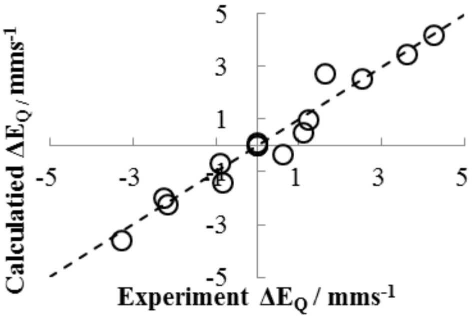

Fig.2 The correlation of ΔE_Q between calculation and experiment.

And the result of mononuclear models referenced by iron assembled complexes was shown in Tbl.1. Calculated δ_{Fe} values were in good agreement with experiment while calculated ΔE_Q values did not correlate with experiment. These results suggest the effect of assembly and these reasons are under study.

Tbl.1 Mössbauer parameters of pyridine model referenced by $[Fe(NCX)_2(L)_2]$ (unit in mm s^{-1}).

L	X	δ_{Fe}^{exp}	δ_{Fe}^{calc}	$\lvert\Delta E_Q^{exp}\rvert$	ΔE_Q^{calc}
bpa	S	1.18	1.03	2.17	3.12
bpa	Se	1.18	1.03	0.74	3.32
bpa	BH_3	1.19	1.03	1.51	3.94
bpp	S	1.20	1.03	2.19	2.96
bpp	Se	1.19	1.02	1.24	3.07
bpp	BH_3	1.19	1.00	1.71	3.27

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NPO-04

Study on muon capture process for gaseous molecules containing C and O atoms

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Abstract –Muonic atom is an atomic system which has a negative muon substituted an electron. When a muon is stopped in a substance, a muonic atom is formed. It is known that muonic atom formation processes are influenced by the chemical environment of muon capturing atom such as molecular structure (chemical effect). However chemical effects still have not been well investigated. In this study, we performed muon irradiation for CO, CO_2 and COS molecules, and measured muonic X-rays precisely to investigate the chemical effect on muon capture processes.

Keywords – muon, muonic atom, exotic atom, muon capture

I. INTRODUCTION

A negative muon is one of the elementary particles (lepton) that has charge and approximately two hundred times heavier mass than that of an electron. When a muon is stopped in a substance, a muonic atom is formed. It is know that muon capture processes are strongly influenced by the structure of the muon capturing molecule; the muon capture probability of each atom (muon capture ratios) and the initial quantum state (*n*; principal quantum number and *l*; angular momentum quantum number) of the captured muon are changed drastically. For example muon capture probability ratio of boron atom to nitrogen atom for cubic structure boron nitride is 20% smaller than that of hexagonal structure [1]. This is called chemical effect.

To reveal the chemical effect on muonic atom formation processes, we previously performed muon irradiations for simple gaseous molecules containing nitrogen and oxygen atoms (NO, N_2O and NO_2). In high density condition, such as solid, liquid and high pressure gas samples, sample density affects muonic cascade processes after muon capture, hence we conducted all experiments at low pressure condition below 1 atm. In this study, we focused on gaseous simple molecules containing carbon and oxygen atoms (CO, CO_2 and COS).

II. EXPERIMENTAL

All muon irradiation experiments were performed at muon science facility (MUSE) in J-PARC. Low pressure sample gases (0.2 to 0.4 atm CO, CO_2 and COS) were put into a gas chamber and irradiated with low momentum muon beam (18.8MeV/c). Muonic X-rays were measured by germanium semi-conductor detectors.

III. RESULTS AND DISCUSSION

Muonic X-ray spectrum for CO_2 sample obtained by this experiment is shown in Fig.1. In this study, we discussed the experimental results about following two topics; muon capture probabilities of C and O atoms, and muonic X-ray structures (K_β/K_α and K_γ/K_α X-ray ratio etc.).

The muon capture probabilities of C and O atoms were determined from total intensity of muonic Lyman X-ray series of each atom. The muon capture ratios compared with the previous reports in high pressure sample conditions were in agreement [2,3].

The muonic X-ray structure reflects initial quantum state of the captured muon. The initial quantum state of muon was estimated using a simulation of muonic cascade processes [4]. The experimental structure of muonic C X-rays for CO_2 resembles that for COS, but that for CO resembles neither. This implies that the initial quantum state of muons captured by C atom differs between CO and other molecules. In fact, we found that muons captured by C atoms in CO molecule tend to have large angular momentum quantum number compared with that of CO_2 and COS from the cascade calculation. In the presentation, we will also discuss the initial quantum state of muons captured by O atoms for CO, CO_2 and COS samples.

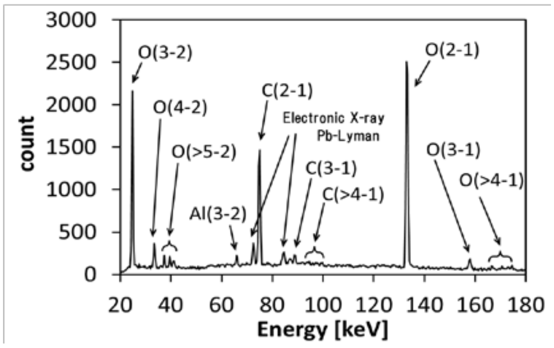

Fig.1 Muonic X-ray spectra of CO_2 sample. C(2-1) means the muonic X-ray series at muon transition from principal quantum number two to one on muonic carbon atom (K_αX-ray).

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CINCH–II Project – Next Step in the Coordination of Education in Nuclear- and Radiochemistry in Europe

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Abstract

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 univerzities 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.

The CINCH-II project, aiming at the Coordination of education and training In Nuclear CHemistry in Europe, will be a direct continuation of the CINCH-I project which, among others, identified the EuroMaster in Nuclear Chemistry quality label recognized and guaranteed by the European Chemistry Thematic Network Association as an optimum common mutual recognition system in the field of education in Nuclear Chemistry in Europe, surveyed the status of Nuclear Chemistry in industry / the needs of the end-users, developed an efficient system of education/training compact modular courses, or developed and tested two electronic tools as a basis of a future efficient distance learning system.

In the first part of this paper, the achievements of the CINCH-I project will be described. This description will cover both the status review and the development activities of this Collaboration. In the status review field, the results of a detailed survey of the universities and curricula in nuclear- and radiochemistry in Europe and Russia will be presented. Another survey mapped the nuclear- and radiochemistry in industry – specifically the training and education needs of the end users. In the development activities field, the main achievements of the CINCH project will be presented. They are particularly the NukWik – an open platform for collaboration and sharing teaching materials in nuclear- and radiochemistry based on a wiki engine. Further outputs are a set of compact joint modular courses in different branches of modern nuclear- and radiochemistry, or an e learning platform (CINCH Moodle) available for both education and training (applicable at the Ph.D., life-long learning, and MSc. levels).

The expected outcomes of the follow-on CINCH-II project will be described in detail. The CINCH-II project is built around three pillars - Education, Vocational Education and Training (VET), and Distance Learning - supported by two cross-cutting activities – Vision, Sustainability and Nuclear Awareness that includes also dissemination, and Management. Its main objectives, expected to have the broadest impact to the target groups, are further development and implementation of the EuroMaster in Nuclear Chemistry, completion of a pan-European offer of modular training courses for the customers from the end users, development of a Training Passport in Nuclear Chemistry and preparing the grounds for the European Credit system for Vocational Education and Training (ECVET) application in nuclear chemistry, implementation of modern e-learning tools developed in CINCH-I and further development of new tools for the distance learning, laying the foundations of a Nuclear Chemistry Education and Training Platform as a future sustainable Euratom Fission Training Scheme (EFTS) in Nuclear Chemistry, development of a Sustainable Systems for Mobility within the Nuclear Chemistry Network, or development of methods of raising awareness of the possible options for nuclear chemistry in potential students, academia and industry. The CINCH-II project will mobilize the identified existing fragmented capabilities to form the critical mass required to implement the courses and meet the nuclear chemistry postgraduate education and training needs, including the high-level training of research workers, of the European Union. Networking on the national level and with existing European as well as international platforms will be an important feature of the project.

Fostering of Personnel for Nuclear and Radiochemistry according to China's NPP Prospects after Fukushima Daiich Accident

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PartI China's NPPs Prospects after Fukushima Daiichi Accident

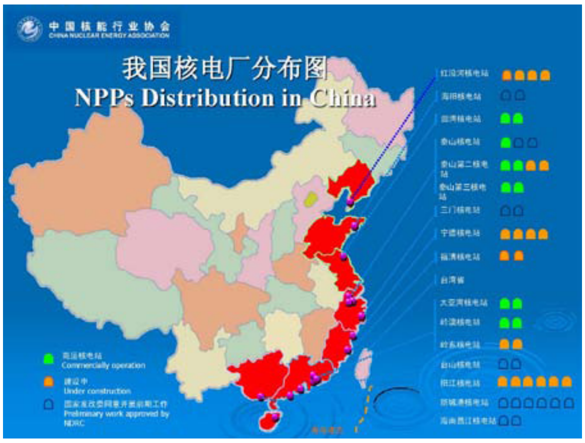
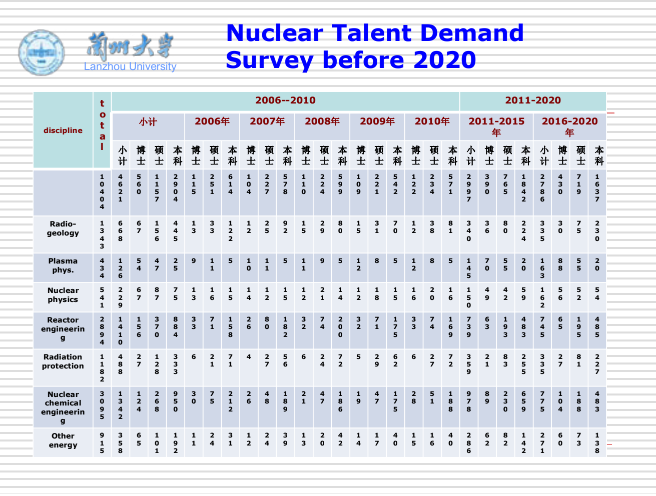


Fig.1 NPPs Distribution in China

PartII Fostering of Personnel for Nuclear and Radiochemistry



Lanzhou University

Nuclear Talent Demand Survey before 2020

discipline	total	2006--2010																			2011-2020							
		小计				2006年			2007年			2008年			2009年			2010年			2011-2015年				2016-2020年			
		小计	博士	硕士	本科	博士	硕士	本科	博士	硕士	本科	博士	硕士	本科	博士	硕士	本科	博士	硕士	本科	小计	博士	硕士	本科	小计	博士	硕士	本科
	10404	4621	560	1157	2904	115	251	614	104	227	578	110	224	599	109	221	542	122	234	571	2997	390	765	1842	2786	430	719	1637
Radio-geology	1343	668	67	156	445	13	33	122	12	25	92	15	29	80	15	31	70	12	38	81	340	36	80	224	335	30	75	230
Plasma phys.	434	126	54	47	25	9	11	5	10	11	5	11	9	5	12	8	5	12	8	5	145	70	55	20	163	88	55	20
Nuclear physics	541	229	67	87	75	13	16	15	14	12	15	12	21	14	12	18	15	16	20	16	150	49	42	59	162	56	52	54
Reactor engineering	2894	1410	156	370	884	33	71	158	26	80	182	32	74	200	32	71	175	33	74	169	739	63	193	483	745	65	195	485
Radiation protection	1182	488	27	128	333	6	21	71	4	27	56	6	24	72	5	29	62	6	27	72	359	21	83	255	335	27	81	227
Nuclear chemical engineering	3095	1342	124	268	950	30	75	212	26	48	189	21	47	186	19	47	175	28	51	188	978	89	230	659	775	104	188	483
Other energy	915	358	65	101	192	11	24	31	12	24	39	13	20	42	14	17	40	15	16	40	286	62	82	142	271	60	73	138

A strong impetus for radiochemistry is attributed to the rapid development of nuclear energy in China. In average, two nuclear power facilities per year will be installed even after Fukushima Daiich Accient. Nowadays there are 27 schools (or colleges) of nuclear science and technology (or engineering) in Chinese universities, of which 13 have nuclear and radiochemistry education and training with about 300 undergraduate students per year. The number of master and doctorate students in radiochemical field is about 50-60 annually. Several universities and institutes have research reactors, accelerators, neutron generators and other nuclear facilities used for radiochemical education and training. An exciting fact is that some big scientific platforms have been, are being or will be constructed, e.g. the Chinese Advanced Research Reactor, Shanghai Advanced Light Source, Chinese Spallation Neutron Source, Thorium Melted Salt Reactor (TMSR), Accelerator Driven Sub-critical System (ADS) and other big nuclear facilities, which are providing or will provide radio-chemists with advanced nuclear arsenal.

However, a quite number of problems in Chinese nuclear and radiochemical educations still exist, among which the biggest one is shortage of bright young radio-chemists in China. In the meantime, experienced radiochemical teachers are urgently needed. Some radiochemical laboratories in Chinese universities are outdated and ill-equipped.

Some measures and strategies for pushing nuclear and radiochemistry research and education in China will be proposed in this text as well.

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Post-Fukushima Situation on Radiation Awareness Activities and Nuclear and Radiochemistry Education in Japan

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Abstract – The accident at Fukushima Daiichi Nuclear Power Plant in 2011 altered the working environment for radiochemists in Japan, who are supposed to be in charge of several problems such as radioactive contamination and nuclear wastes from reactors. Under the circumstances, we are compelled to reexamine the education relating to such matters. I discuss the effect of the accident on some aspects of education of the field.

Keywords – Fukushima accident/ radioactive contamination/ radiation awareness/ education

Research work in any field is affected by the educational prospects of the respective fields in both positive and negative ways. I would like to describe the present situation and future prospects for nuclear and radiochemistry education in Japan from my point of view, as a radiochemist, radiochemistry being one small part of the total discussion.

After the accident at Fukushima Daiichi Nuclear Power Plant in 2011, radiation-related topics such as radioactive contamination and nuclear wastes from reactors came to be the center of attention of people in this country. Furthermore, people's orientation concerning the nation's energy policy seems to be changing here. Under these circumstances I am compelled to reexamine the radiation awareness activities conducted for ordinary people (including children) as a university contribution to local communities. All these new situations cannot help affecting the educational content in many fields to some extent. I will discuss here the effect of the accident on the education for my field.

Nuclear science is still important in many industries and research fields in relation to nuclear medicine, material science, and the nuclear power industry to name a few.[1] Momentum towards the development of human resources is increasing in the nuclear power industry because of international pressure for carbon-oxide reduction and the need for development of nuclear waste treatment in Japan.[2] As a result, engineers, researchers and leaders of research groups have had to gain a broad perspective regarding energy crisis and environmental problems.

On the other hand, the number of students in the nuclear field, including radiochemistry, has decreased in recent years in Japan. Tight budgets at universities interfere with the maintenance of nuclear facilities, which in turn has largely discouraged students.[1,2]

Besides those aspects, the Fukushima accident has added several more complicated factors. We face several problems such as decontamination of everything in the area around the nuclear power plant, not to mention the decommissioning of the plant itself, all of which require radiochemical knowledge.

Primary education and secondary education had not paid attention to radiation awareness for many years. Nowadays, the situation is changing due to an education guideline change made by the government. It requires more opportunities to lecture to young people and their teachers and to discuss about radiation matters. The accidents have created more opportunities to talk to the general population on these issues, too. I am, however, not sure of the future contents to teach in relation to the Fukushima issues

On the university and graduate school level, a new methodology for human resources development for nuclear science and technology had been proposed by several universities in Japan and the Japan Atomic Energy Agency (JAEA). The network system has established a program by utilizing unique courses at universities and a real-time multi-directional network system as well as effective curriculums with practical exercises by utilizing JAEA's training and experimental facilities.[3] The network aims to implement the system with an eye to improving it with expanded experiences and increased the number of participant universities as well as to update the curriculums learning from the Fukushima issues.

Despite many difficulties, we have to overcome the current crisis to move towards a brighter dawn of the nuclear sciences and I think we still have a good chance of realizing the dream.

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Radiochemistry course in the undergraduate Nuclear Science Program at Universiti Kebangsaan Malaysia

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Universiti Kebangsaan Malaysia (UKM), is the only university in Asia offering an undergraduate degree program in Nuclear Science since 1978. The program has undergone several modifications due to changes in national policy and priority. The last adjustment was made in 2011 to ensure that the program is aligned with the aims and strategies of the National Nuclear Policy that guided the realization of Malaysia's first Nuclear Power Plant by 2021. The program covers nuclear sub-disciplines such as nuclear physic, radiobiology, radiochemistry and radiation safety. To graduate with a Bachelor of Science in Nuclear Science students are required to pass a total of 122 credits comprising of 20 credits of university courses and 102 credits of compulsory courses or core courses. Radiochemistry course involves both lectures and laboratory practicals. During the first year students are taught about basic physical and chemical properties of radioactive materials, radiation interaction and detection, radiation safety. In the second year lecture topics cover basic theory in radioanalytical chemistry, neutron activation, XRF, XPS and PIXE, tracer techniques, isotope dilution analysis, radioimmunoassay, nuclear dating and analysis of radionuclides in the environment. In the third year lectures are given on the chemistry of uranium, thorium and other actinides, isotope production and chemical aspects of nuclear fuel cycle. In the final year students may do a short project on applications of radioanalytical techniques, measurements of radioactivity in the environment or radiochemical separation. Recently, more students are enrolled into the program because of the National Nuclear Policy implementation and the program is in tandem with the thrusts and strategies of the policy. However, it is very difficult in getting new text books on radiochemistry particularly and nuclear science and technology generally. In the absence of good text book students are using on-line references published by reputable universities and organisations world wide.