

English Abstracts

2S01 The role of radiochemical neutron activation analysis in multidisciplinary research

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2S03 Nuclear fission

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History of Nuclear Fission Studies is briefly reviewed, especially, from the days of “charged liquid drop” understanding to the days of “incorporation of nuclear shell effects of both the fissioning nuclide and fission fragments”. We, the joint research group of Tokyo Metropolitan University and Japan Atomic Energy Research Institute, have attempted to experimentally verify the two-mode, or multi-mode character of nuclear fission and to further clarify the characteristics of each mode.

Some new aspects of nuclear fission are expected for the new isotopes of transactinium elements. For a better understanding of nuclear fission, development of a dynamical nuclear fission theory that incorporates nuclear shell effects into the charged liquid drop model with proper treatments of mass inertia and friction force needs to be waited.

3S01 Radiocarbon dating of the ancient Japanese document and kohitsugire calligraphy

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In this study, radiocarbon ages of the ancient Japanese documents of known age and unknown samples (kohitsugire) were measured. The result of known-age samples showed that the Japanese paper is a suitable sample for radiocarbon dating because little discrepancy was observed between the calibrated radiocarbon age and the written age. Kohitsugire are paper fragments with elegant calligraphy and were cut from old manuscripts written mainly in the Heian-Kamakura period. Complete manuscripts written during the period are quite rare. Kohitsugire with known age, therefore, contains significant information for historical, literary and paleographical studies. Radiocarbon dating on the kohitsugire attributed to Fujiwara no Yukinari is a notable example. The calligraphy was written on Tobikumogami paper, which has a billowing cloud pattern decorated with indigo-blue-dyed fiber. Radiocarbon age indicated the middle Heian period when Fujiwara Y. flourished as a calligraphist. Although it was commonly accepted that Tobikumogami is peculiar to the middle 11th to early 12th century, the result suggested that it is the oldest example among the extant Tobikumogami and that the origin would date back to the last 10th or the early 11th century.

3S02 Thermodynamic study of the actinide and lanthanide hydrous oxides

SASAKI, T.

The influence of the formation of polynuclear and colloidal species on

the apparent solubility of the actinide and lanthanide hydrous oxides was investigated. The solubility and the size distribution of soluble species were measured by using different pore size filters at the acidic and neutral pH in order to obtain the solubility products of the oxides and the hydrolysis constants of the metal ions. Systematic trends of mononuclear and polynuclear hydrolysis constants were analyzed by using an electrostatic hard sphere model. Also, the formation constants of a metal ion with a series of carboxylates were determined by solvent extraction method. In order to analyze the observed trend of the formation constants, a simple model was developed in which the ligand molecules were considered as composed of a certain number of fragment components of functional groups and chemical bridges each of which differently contributes to the formation constant. The model is useful for predicting the formation constants of humate complexes by combining the fragment components and parameter values.

1A01 Adsorption behavior of element 104 rutherfordium on cation-exchange resin in HF/HNO₃ solution

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We have investigated cation-exchange behavior of Rf together with the lighter homologues of the group-4 elements Zr and Hf, and the tetravalent pseudo-homologue Th, in HF/HNO₃ solution using Automated Ion exchange separation apparatus coupled with the Detection system for Alpha spectroscopy (AIDA). The K_d values of Zr, Hf, Th and Rf in HF/0.1 M HNO₃ were decreased with increasing the concentration of the fluoride ion [F⁻], indicating the formation of the fluoride complexes. The sequence of the fluoride complexation strength is Zr ~ Hf > Rf > Th. In the symposium, we will also present the cation-exchange behavior of Rf, Zr and Hf depending on the concentration of the hydrogen ion at the constant [F⁻].

1A02 Chemical behavior of element-105, Db, in mixed HF/HNO₃ solutions

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Anion-exchange behavior of ²⁶²Db (half-life $T_{1/2} = 34$ s) produced in the ²⁴⁸Cm(¹⁹F, 5n) reaction at the JAEA tandem accelerator was

investigated in the mixed 0.89 M HF/0.3 M HNO₃ solution ([F] = 3 × 10⁻³ M) with the automated ion-exchange separation apparatus coupled with the detection system for alpha-spectroscopy (AIDA). Anion-exchange behavior of its lighter homologues, Nb and Ta, was also studied under the same conditions using ⁸⁸Nb (*T*_{1/2} = 14.3 min) and ¹⁷⁰Ta (*T*_{1/2} = 6.76 min) produced in the ^{nat}Ge(¹⁹F, *xn*) and ^{nat}Gd(¹⁹F, *xn*) reactions, respectively. It was found that the adsorption probability on the anion-exchange resin is in the order of Ta > Nb ~ Db under the present condition.

1A03 Gas phase chemistry of the group-4 elements using carbon cluster transport system

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Our group has studied the volatile properties of the compounds of group-4 elements including Rf, especially tetrachloride compounds, using an isothermal gas chromatographic method. When He/KCl and HCl were used as the aerosol for the transportation and the chlorinating reagent respectively, serious problems arose, for example, the generation of the nonvolatile chloride oxides by the residual oxygen in the system. Then the carbon cluster was applied as the aerosol in order to eliminate the residual oxygen in the system. In the test experiments using the fission fragments from ²⁵²Cf, it was found that the transport efficiency was comparable to that of the KCl aerosol, and the volatile compound of Zr was observed. In this work, we carried out the on-line experiments of Zr and Hf in order to apply this system to the experiments for Rf. The production efficiency of the volatile compounds in this system was higher than that in He/KCl and HCl system. It is suggested that the residual oxygen was eliminated sufficiently by the carbon cluster.

1A04 Study on the synthesis of heavy elements using the Ba+¹⁶O and La+¹⁶O reaction systems (II)

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In order to study the nuclear fusion of deformed nuclei with heavy ions, we adopted near lanthanoid targets, which are known to be deformed as actinoides. We performed bombardment of Ba and La targets with ¹⁶O ions at the Research Center for Nuclear Physics, Osaka University. In order to check the incident energy, we used a Rh target for comparison with the reference data, and we irradiated an Al target with Au catcher foil, for the calibration of the beam current. We obtained the reaction cross sections of short-lived nuclides with a gas jet transport system. With these results, we are in constructing accurate excitation functions for the nuclear systems.

1A05 Some examples on the relation between isotope effects and nuclear charge radii in chemical reactions

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The origin of uranium isotope effects in U(IV)-U(VI) exchange equilibrium has been proved to be in the nuclear volume effect or field shift effect which is generated by the electron-nucleus interactions. In the present work, the correlation between nuclear charge radii and isotope effects is discussed based on the experimental results on electron exchange reactions and ligand exchange reaction of selected elements.

1A06 Characteristics of neutron multiplicity and nuclear charge polarization in proton-induced fission of ²³³U

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Characteristics of neutron multiplicity and nuclear charge polarization have been studied in the 11.5 MeV proton-induced fission of ²³³U. Fragment mass and the average neutron multiplicity were measured by a double time-of-flight method. The most probable charges of secondary fragments were evaluated from fractional cumulative and mass yields. The nuclear charge polarization of primary fragments at scission was obtained by correcting the most probable charge of secondary fragments for neutron evaporation. The results show that the nuclear charge polarization at scission is associated with the liquid drop properties of nuclei and the proton shell effect with *Z* = 50 of heavy fragments. We will discuss the partition of excitation energy and the nuclear charge polarization.

1A07 Precision measurement of the half-life of ^{99m}Tc

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In order to investigate the relationship between decay constant and chemical structure, we attempt to determine the half-life of ^{99m}Tc in various chemical states with good precision. Technetium-99m isotopes are able to obtain by disintegration of ⁹⁹Mo, which is produced in the ¹⁰⁰Mo(γ , n)⁹⁹Mo reaction. After the irradiation of the ¹⁰⁰Mo target, ^{99m}Tc isotopes were isolated from the target by several chemical separation methods. Two sources of ^{99m}Tc were prepared in different chemical forms; K₂TcO₄ and Tc₂S₇. The half-lives of the ^{99m}Tc in different chemical structures were determined by the reference source method using ¹³⁷Cs. The results show that the ^{99m}Tc half-life in K₂TcO₄ is shorter than that in Tc₂S₇, which is consistent with previous findings reported by Bainbridge *et al.* and Mazaki *et al.*

1A08 ^{238}U - ^{230}Th - ^{226}Ra radioactive disequilibria in the volcanic products from younger Fuji and Izu-Oshima volcanoes

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Magma genesis at subduction zone is generally inferred to be induced by the partial melting of the mantle wedge by the addition of fluid derived from the subducting slab. Uranium-series disequilibria in the volcanic products can be helpful to estimate the time-scales of magmatic processes. Observations were carried out on the radioactive disequilibrium among ^{238}U - ^{230}Th - ^{226}Ra with the volcanic products from younger Fuji and Izu-Oshima volcanoes. ^{238}U and ^{230}Th in volcanic products were determined by isotope dilution method coupled with alpha-ray spectrometry. ^{226}Ra was determined by gamma-ray spectrometry. Activity ratios of $^{238}\text{U}/^{230}\text{Th}$ and $^{226}\text{Ra}/^{230}\text{Th}$ in the volcanic products from younger Fuji and Izu-Oshima volcanoes were more than unity, being enriched in ^{238}U and ^{226}Ra relative to ^{230}Th , which is often observed for volcanic products from young island-arc volcanic products. ^{238}U - ^{230}Th - ^{226}Ra radioactive disequilibria observed in the volcanic products from younger Fuji and Izu-Oshima volcanoes imply a short period of time (< 8,000 years) between magma genesis and eruption.

1A09 Production rate of ^{36}Cl in chondritic meteorites

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As an initial study for estimation of an irradiation condition of meteorites, production rate of ^{36}Cl , which is a one of cosmogenic nuclides, in chondritic meteorites were tried to be determined. Mineral phases with different chemical compositions were separated from two chondrites, Barwell and Allegan, by both physical and chemical processings. Elemental compositions and ^{36}Cl concentrations in those phases were analyzed by activation analysis methods and AMS method, respectively. Though production rates of ^{36}Cl in each target element were fail to be obtained, those values for elemental pairs, (K+Ca) and (Fe+Ca), in Barwell were found to be 247 dpm/kg and 25 dpm/kg, respectively. The similar values were also obtained using Allegan meteorite. Further study for contribution of chlorine and depth dependent are required.

1A10 AMS analysis of Be-10 in ice core collected from Dome Fuji (Antarctica)

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Be-10 (half-life: 1.5 million years) is produced in the atmosphere by cosmic ray spallation of oxygen and nitrogen. Solar activities and

geomagnetic fields influence the intensities of cosmic rays entering into the atmosphere, subsequently production rate of Be-10 varies with time. In this study we have determined Be-10 concentrations in 60 samples collected from an ice core of the depth 95-122m (corresponding to the age of 1100-238 B.C.), Dome Fuji, Antarctica, to investigate the secular change of cosmic rays. Be was separated from the sample with cation exchange resin and precipitated as $\text{Be}(\text{OH})_2$, then it was heated to form BeO. Be-10/Be-9 ratios were determined by AMS (Accelerator Mass Spectrometry) at MALT, University of Tokyo. From the analytical results we could obtain information on the secular variation of the annual flux (deposition) of Be-10. The values were in the range 20×10^4 - 40×10^4 atoms/cm²/y. Around 700 B.C. a peak with the maximal Be-10 value was observed, suggesting that the levels of the cosmic rays decreased in this period.

1A11 Vertical distribution of particulate Th and Pu off Aomori

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We examined the vertical distributions of ^{230}Th , $^{239+240}\text{Pu}$ activity and $^{240}\text{Pu} / ^{239}\text{Pu}$ atom ratio in particles collected by large volume water in-situ pump in the western North Pacific Ocean (off Rokkasho, Japan). This is the first information of vertical distribution of plutonium activity and Plutonium atom ratio in small particle (1-70 μm) and large particle (> 70 μm). $^{240}\text{Pu}/^{239}\text{Pu}$ atom ratios in large particle and small particle are almost constant in all samples. The ratios are comparable with those reported in western north pacific in earlier studies (Norisuye et al., 2006, Yamada et al., 2006). Increase of $^{239+240}\text{Pu}$ specific activities in large particle could attribute to aging of particle. Low specific activity in small particle at deepest layer could be consequence of dilution by resuspended sediment particles. High specific activity in small particle at shallowest layer suggests old decomposed particles (which has higher specific activity) accumulate in this layer.

1A12 Co relationship on the behaviors between radionuclides and organic matter in sweater

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Mesocosm experiment using the mesopelagic water of Suruga Bay was carried out. Autotrophic biomass increased from 0.2 $\mu\text{g C l}^{-1}$ to 1.3 mg C l^{-1} during the first 7 days of incubation. Nitrate and phosphate were depleted rapidly during Days 7 to 12. Both nutrients-rich condition and low grazing pressure due to the low concentration of predator in the mesopelagic water at initial time caused bloom of autotrophic components. These results suggest that organic materials were transferred from autotrophic components to bacteria and subsequently to HNF and ciliates through the microbial loop. POM (particulate organic matter) was divided in to the different size (>500 μm , 500~105, 105~25, and 25~0.4), and Th-234, Pb-210, Po-210 were measured in each

fraction. Th-234 was not detected in dissolved form, while 80% of Th-234 in particulate form was found in size fraction from 0.6 to 500 μ m. The behaviors of Th-234, Pb-210 and Po-210 was due to POM with size of 0.4 to 25 μ m. The size distribution of P-32 is corresponding to the size of nano-phytoplankton, and its turnover time is one week.

1A14 Radiation education using fireworks

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A new method for radiation education using fireworks has been performed for beginners or children for the purpose of visual and merry learning of radiation. Torahiko Terada, a famous scientist for his deep literal literacy, wrote an essay under the title of "Sparkler". The essay gave us a hint that a stage of fire globe of the sparkler may be employed for a model of nucleus at an excited state. If the fire globe will function as a model of excited nucleus, we are able to look sparks from the fire globe upon as radiations from the nucleus. This dynamic model of radiation emission using sparkler has been exhibited at various kinds of science events for both children and citizens. After the demonstrations using sparklers as the model of radiation emission from nucleus, we have performed radiation measurement experiments of natural samples of natural level, and typical samples derived from special areas well known as high-level natural sites. Radiation measurements combined with demonstration of sparklers were greatly appreciated by audiences of science events. In addition to the sparkler, we have tried a rat type of firework.

1B01 Local fields of ZnO observed by means of the TDPAC method

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Zinc oxide is a typical n-type semiconductor, and it is known that its conductivity varies with the introduction of dilute dopants. In order to compare and/or contrast physical properties emerging into the bulk sample with microscopic information, we applied the time-differential perturbed angular correlation method with the ¹¹¹Cd(\leftarrow ¹¹¹In) probe to a study of local fields of Indium-doped and undoped ZnO. For a 5,000-ppm In-doped ZnO sample, temperature dependence was observed for the amplitude of the oscillating directional anisotropies; whereas this phenomenon was not observed for the undoped ZnO sample. As has already reported, in addition, the electric field gradients (EFG) were also different from each sample. In the present talk, we discuss the difference of the EFGs and the reversible temperature-dependent amplitude of the TDPAC spectra.

1B02 Investigation of atomic processes after the formation of pionic and muonic atoms.

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We have been studying on the electron state after the formation of pionic and muonic atoms. For this purpose, we have measured the electronic X-ray energies emitted after the formation of pionic and muonic atoms. The measurements for pionic atoms were performed at KEK-PS and those for muonic atoms at KEK-MSL.

The electronic X-ray energies are influenced by the atomic state of pion or muon. Electron state, that is, electron vacancies also affect these energies. In this paper, we estimated the electronic energies for various pionic or muonic state and electron structure conditions, and compared them with the measured energies to investigate atomic process after the formation of pionic and muonic atoms.

1B03 Spin conversion reaction of o-Ps with O₂

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Quenching processes of the thermalized orthopositronium (o-Ps) on an oxygen molecule have been studied by the positron annihilation lifetime measurement and age-momentum correlation technique. For the creation of o-Ps, mixture of CO₂ and O₂ gases was prepared for sample gas. A rate of the quenching, consisting of a pick-off annihilation and a spin conversion process, is estimated from a positron lifetime spectrum. A Doppler-broadening spectrum of the 511-keV gamma rays from o-Ps annihilations was measured. The Doppler-broadening spectrum consists of broad and narrow components. The broad component results from the pick-off annihilation of o-Ps with a bound electron of an O₂ molecule and the narrow component represents the self annihilation of p-Ps due to the spin conversion of an o-Ps. The ratio of the pick-off annihilation cross section to the spin-conversion cross section is deduced from the ratio of the area of the broad component to that of the narrow component. The cross section for the spin-conversion quenching is determined to be $(1.44 \pm 0.32) \times 10^{-19} \text{ cm}^2$.

1B04 Temperature dependence of the positronium formation in 1-hexanol

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Positron annihilation lifetime spectroscopy (PALS) has been applied to 1-hexanol as a function of the temperature and also the elapsed time in the dark as well as in the light. Positron formation mechanism below, around and above the glass transition temperature of 1-hexanol was investigated. Below the glass transition temperature the ortho-positronium intensity was decreased in the presence of visible light. It is known that this phenomenon is ascribed to a radiation effect. In the low temperature solid state, free electrons which are created by the

beta-plus irradiation are trapped by some trapping sites. An additional positronium is formed with the trapped electron. The trapped electron is released by visible light. Around the temperature, no additional positronium is seen. Above the temperature, this effect is considered to disappear because some degrees of freedom of the molecules would be released. In the case of 1-hexanol having a polar group, however, another additional positronium formation is seen. The ortho-positronium intensity was decreased in the presence of visible light. The new positronium formation mechanism will be discussed.

1B05 Studies on hot atom chemical behavior of energetic ions in solids (XII) - Implantation temperature dependence on chemical behavior of deuterium implanted into tungsten carbide -

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In D-T fusion reactors, carbon and tungsten would be employed as divertor materials. In divertor region, WC layer is thought to be formed by ion sputtering and high heat flux exposure during long-term plasma discharge. From the viewpoint of tritium safety for fusion reactors, it is important to elucidate the chemical behavior of energetic tritium implanted into WC.

In this study, implantation temperature dependence on chemical behavior of implanted-deuterium was studied by means of XPS and TDS. The four D₂ desorption stages was found from the TDS spectra. These peaks were located around 400, 490, 590 and 930 K (Peaks 1–4). It was found that Peak 1 was attributed to the desorption from the interstitial site in WC where arranges three W atoms on planate and other two C atoms on vertical, and Peak 2 that from the interstitial site which is opposite configuration of Peak 1. Peaks 3 and 4 were corresponded to the desorption of D trapped by C vacancy and bound to C, respectively.

1B06 Studies on hot atom chemical behavior of energetic in solids(XIII) - Effects of carbon impurity on chemical behavior of energetic deuterium implanted into carbon-contained boron film -

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In D-T fusion reactors, boronization which is one of candidates for the first wall conditioning techniques is expected to reduce the impurities such as oxygen and carbon in D-T plasma. It is also thought that the energetic tritium is also implanted into the impurities-contained boron films during fusion operations. Therefore, it is important to evaluate chemical behavior of tritium implanted in these boron films. In this study, energetic D₂⁺ were implanted into the films, and carbon impurity effects on chemical behavior of deuterium implanted the boron films were studied by means of TDS and XPS. And from the result of B-1s and C-1s XPS spectrum of peak energy and FWHM, that carbon exist in

some different chemical state in the boron film. In addition, it was also observed that the total D retention decreased and the amount of B-C bond was increased as the carbon concentration increased. Taking them into consideration, it was suggested that B-C-D bond was formed as a new trapping sight by containing carbon in boron films.

1B07 Studies on hot atom chemical behavior of energetic ions in solids(XIV) -Trapping processes of deuterium implanted into solid tritium breeding material, Li₂TiO₃-

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In blanket system for D-T fusion reactors, energetic tritium is produced by the tritium breeding materials (TBMs). Lithium compounds are thought to be used for TBMs to take advantage of Li(n,α)T reaction. From the viewpoint of tritium safety for fusion reactors and establishment of tritium recovery system, it is important to estimate the trapping processes of tritium in TBMs. In this study, to evaluate the tritium behavior, the trapping processes of deuterium in Li₂TiO₃ and its chemical behavior were studied by means of TDS and XPS. From the TDS spectrum, it is found that there were four D₂ desorption stages located, respectively, at around 380, 420, 500 and 600 K (Peaks 1-4). Peaks 1 and 2 were attributed to the desorption from the sample surface, Peaks 3 and 4 were attributed to the desorption from bulk and originated E'-center which is oxygen vacancy trapping one electron and D bound to O as O-D bond, respectively.

1B08 Composition change of iron oxide thin films produced by laser deposition depending on oxygen pressure and generation temperature

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Iron oxide films were produced by laser-evaporation of iron oxide solid (Fe₂O₃) in the oxygen atmosphere. The compositions and structures of the iron films were studied by Mössbauer spectroscopy, and the surface images were observed by SEM. The compositions of the iron oxide films varied depending on the pressure of oxygen atmosphere. When the Fe₂O₃ was laser-deposited in a vacuum, the film consists of Fe₃O₄ (two sets of sextet) and divalent iron oxide particles (doublet). The film obtained in 7 Pa of oxygen atmosphere was the almost neat Fe₂O₃ solid. When the oxygen pressure was high (45, 120, and 200 Pa), the trivalent iron particles became dominant. The laser-evaporated particles were cooled down by the collision of oxygen molecules, and the energy of the particles arriving on the substrate is too low to form large crystal structure. It was shown that the neat Fe₂O₃ thin film can be produced only in optimum oxygen pressure.

1B09 Control for spin orientation according to substrate surface

shape of iron thin films produced by arc-plasma-gun

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Fe atoms evaporated by an arc-plasma-gun were deposited onto Al substrates to produce Fe films, and their Mössbauer spectra were obtained in various geometries. The spin orientation of the iron film was found to be linear (one-dimensional) reflecting the shape of linear crystal produced along the grooves on the surface of Al substrates; a large number of parallel grooves (10-nm depth, 100-nm width) were produced on the surface of Al substrate (40-nm thick) by rolling Al plate. When the iron was deposited by the arc-plasma-gun onto a chemically-polished smooth surface, there observed no linear shape and the spin orientation was found to be parallel to the surface (two-dimensional). It was demonstrated that the spin orientation of the Fe films can be controlled by the deposition methods or the shape of substrates.

1B10 Magnetic and nano-structure analysis of SnO₂ doped with Sb and Fe

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We have studied the effect of the simultaneous Fe and Sb doping on the magnetic and crystallographic properties in SnO₂ nanocrystals. The samples, prepared by a sol-gel method, consisted of rutile type SnO₂ and were free of any impurity phase. ¹¹⁹Sn-, ⁵⁷Fe-, and ¹²¹Sb-Mössbauer spectroscopies demonstrate that Sn⁴⁺, Fe³⁺ and Sb⁵⁺ are the only oxidation states for these ions in the SnO₂ structure. For most samples, the presence of antimony did not improve *M_s*, but for Sn_{0.85}Sb_{0.05}Fe_{0.1}O₂, this value was increased up to 14 times. This sample exhibited a magnetic sextet in its ⁵⁷Fe Mössbauer spectrum in addition to two doublets. For the restricted Sb/Fe ratio, the magnetic ordering of the iron ions can be activated. The origin of the magnetic interactions is due to the existence of exchange interactions between the iron ions mediated by free-carriers in an impurity band. The free carriers increase by doping Sb⁵⁺ into SnO₂.

1B11 Electric Conductivity and Mössbauer Spectra of Vanadate Glass

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Electrically conductive vanadate glass (NTA glassTM) developed by Nishida *et al.* has several applications in the field of electronics, sensor, MEMS, *et al.* Mössbauer Spectra of NTA glassTM indicate that local distortion of FeO₄ and VO₄ tetrahedra, which play a role of network

former, becomes small as a result of “structural relaxation” caused by additional heat treatment at the temperature between glass transition temperature (*T_g*) and melting point (*T_m*). This heat treatment accompanies a marked systematic increase in the electrical conductivity (*σ*). In this study, activation energy (*E_a*) for the electrical conduction was estimated in order to clarify the relationship between the “structural relaxation” of the glass network and the *E_a*.

1B12 Multiferroic property for organic-inorganic hybrid compounds

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The design of compounds which show multifunctional properties is of current focus in materials research, due to the fundamental and technological importance. The term, multiferroic, is coined to envision ferroelectric, ferromagnetic, ferroelastic etc., in a single compound.

Compounds were prepared by simply mixing ethanolic solutions of alkyl ammonium salt, and anhydrous FeCl₂ in 2:1 molar ratios.

The single-crystal X-ray analysis reveals that the asymmetric unit of [C3A]₂FeCl₄ (C3A = *n*-propyl ammonium chloride) consist of a FeCl₆ octahedra and two amine ligands

We have succeeded in synthesizing a new family of layered organic-inorganic hybrid weak ferromagnets with a ferro or antiferro-electric behavior. All of these compounds form plate like transparent, yellow-orange colored single crystalline products, and have thus imparting added advantage for magneto-optical behavior.

1B13 Mössbauer spectroscopic study of the assembled iron complexes bridged by 1,3-bis(4-pyridyl)propane

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Assembled complex, Fe(NCBH₃)₂(bpp)₂ (bpp = 1,3-bis(4-pyridyl)propane) has novel 2D interpenetrated structure and shows spin-crossover phenomenon. We synthesized assembled inclusion complex, Fe(NCBH₃)₂(bpp)₂·2(benzene) by changing solvent and examined the spin state by using Mössbauer spectroscopy. Fe(NCBH₃)₂(bpp)₂·2(benzene) showed temperature-independent Fe(II) high-spin state. The guest molecule was partially released by standing it at room temperature. The spin state changed depending on the ratio of the release. The guest-free Fe(NCBH₃)₂(bpp)₂ was obtained by heating the sample at 120 °C. This had the similar structure with 2D interpenetrated one and showed spin-crossover phenomenon. The guest-free Fe(NCBH₃)₂(bpp)₂ included benzene molecule again by dipping it into benzene. The change of spin state was also supported by the magnetic susceptibility measurements.

1P01 Observation of Etch Pit Shape in CR-39 with Atomic Force Microscope for the Samples Irradiated with 250 MeV C-12 ions

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In this study, we aim to acquire the acquisition of standard data of the relation between an incident particle and its etch pit shape for particle identification with a solid-state track detector. The irradiation experiment of ^{12}C ion was done within the energy range from 66 to 250 MeV at the Wakasawan energy research center. The irradiated sample was etched for 15 minutes with 6M NaOH solution, and the generated etch pit was observed with an atomic force microscope. The depth of etch pit and the dimension of the opening were examined in relation to the incident beam energy. The depth of a etch pit became deep as the beam energy increases. And, its opening become small as energy increases.

1P02 Study on the reversed phase chromatography in trace concentration for solution chemistry of transactinide elements

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In order to research on the solution chemistry of transactinide elements such as rutherfordium, we measured distribution coefficients (K_d) of its homologues, Zr and Hf by a batch method and a microcolumn experiment in reversed phase chromatography. In the experiments, we utilize the resin containing tributyl phosphate for extraction solvent. The batch method was applied to the measurement by using tracers ^{88}Zr and ^{175}Hf . The microcolumn experiment was on-line measurement by using ^{85}Zr and ^{169}Hf . The results show that the measured K_d values are larger than the macroscale literature data, but they have similar tendency as functions of the acid concentration of HCl. Measured K_d values by batch method agree with those by microcolumn experiment. It was concluded that we could apply this method to Rf experiments and compare K_d values of Rf with those of Zr and Hf.

1P03 Development of timing and kinetic energy detector for measuring atomic number of fission fragments

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In order to investigate the mechanism of asymmetric mass division in low energy fission of actinides, we intend to measure an atomic number (Z) of a fission fragment (FF) together with its mass number (A) and total kinetic energy (TKE). For this purpose, a detector system consisted of a time of flight (TOF) spectrometer and a grided multi-anode ionization chamber has been developed. Z separation is based on the difference in a stopping power (dE/dx) of FF. The TOF spectrometer consists of a micro channel plate detector with an electrostatic mirror for a start timing

detector and double wire planes a the stop detector whose principle of operation is similar to a parallel plate avalanche counter. We will test this for determining the best condition at the various conditions.

1P04 Development of a gas-jet transport system for precision measurement of the half-life of $^{90\text{m}}\text{Nb}$

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The goal of our study is to clarify the relationship between decay constants of $^{90\text{m}}\text{Nb}$ and its chemical structure. In order to precisely determine the short half-lives of $^{90\text{m}}\text{Nb}$ in various chemical states, we have developed a gas-jet transport system on the beam line of the RIKEN K70 AVF cyclotron. Niobium-90m was produced in the nuclear reaction $^{nat}\text{Zr}(p, xn)^{90\text{m}}\text{Nb}$. The reaction products recoiling out from the target were stopped in the helium gas, attached to KCl aerosol particles, and were continuously transported to a dissolution apparatus. They were dissolved in 20 M HF and were subjected to γ -ray spectrometry with a HP-Ge semiconductor detector. The half-lives of $^{90\text{m}}\text{Nb}$ were determined by the reference source method using ^{137}Cs as a reference source. It was found that no serious background was observed in the gamma-ray spectrum for determination of the half-life of $^{90\text{m}}\text{Nb}$. The obtained half-lives will be reported at the presentation.

1P05 Development of microchannel-microelectrode chip for redox reaction of heavy elements

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(Osaka univ.)

For the redox reaction of heavy elements, we developed a microchannel-microelectrode chip which is a microchip integrated with electrodes. The microchannel-microelectrode chip was fabricated by photolithography and a wet-etching method. The microchannel-microelectrode chip was composed of channel and electrode substrates. Polydimethylsiloxane (PDMS) was used for the channel substrate, and a glass for the electrode substrate. The length, width and depth of a microchannel in the channel substrate were 56 mm, 1 mm and about 20 μm , respectively. The vacuum deposited Au electrodes were used for working (47 mm in length) and counter electrodes. The Ag wire inserted into the microchannel was used for reference electrode. The efficiency of redox reaction of ^{139}Ce was measured for simulation of the redox reaction of No (element 102).

1P06 Magnetic properties and nano-structure of amorphous IZO thin film doped with Fe

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The mixed powder of indium oxide and zinc oxide doped with ^{57}Fe was prepared by a sol-gel method. The thin films were prepared by laser-ablation of the pellet of this powder under various conditions of air pressure and substrate temperature. Kerr effect were strongly observed for the sample prepared under 10^{-6} torr at RT and annealed at 400°C for 1 hour. The film were characterized by ^{57}Fe DCEMS using a back scattered type of a gas proportional counter. It is found that $\alpha\text{-Fe}$ and Fe(III) species were produced from Fe(II) by post-annealing.

1P07 Nano structure analysis of Fe doped Indium Tin Oxide (ITO)

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Powder of Indium oxides doped with various ratios of Sn and Fe ion was prepared by a sol-gel method, and annealed at 500°C for 2 hours. The magnetic properties and nano structure of these oxides were characterized by VSM, XRD and Mössbauer spectrometry. XRD pattern showed that the powder is like In_2O_3 cubic structure. The samples of $\text{In}_{91}\text{Sn}_8\text{Fe}_3$ and $\text{In}_{85}\text{Sn}_9\text{Fe}_6$ showed weak ferromagnetic and paramagnetic susceptibility, and the others showed only paramagnetic one. In Mössbauer spectra, two peaks of doublets and magnetic relaxation peaks were observed. The relation between content ratio of Sn and Fe ions and magnetic properties are discussed.

1P08 Investigation of initial process in negative pion capture by measuring pionic X-ray intensities

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(^aOsaka Univ., ^bKEK.)

Our group has been investigating the electronic structure of pionic atom by measuring the electronic X-ray energies. The energies of electronic X-rays are also influenced by the atomic state of the pion. To quantitatively discuss these effects we have examined the initial process in negative pion capture. We measured the intensity patterns of pionic X-rays from the target of various chemical forms ranging from $Z=29$ to 92. We also calculated X-ray fine structures from cascade code by providing various conditions for initial states. In this paper we compare the experimental values with the calculated ones and discuss the chemical effects on the initial state of the captured pion.

1P09 Measurement of hyperfine field in metal complexes and mavycyanin by PAC method using ^{111}Ag probe

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A parent PAC probe of ^{111}Ag , which has a half life of 7.45d was introduced to TDPAC measurements in order to seek a better condition for biomolecular study. The parent nuclei ^{111}Ag were obtained by irradiating a metal foil of Pd of natural abundance with thermal neutrons. The nuclei were produced via the $^{110}\text{Pd}(n, \gamma)^{111}\text{Pd}$ reaction and the following β decay of ^{111}Pd ($T_{1/2} = 23.4$ min). Therefore the irradiated metal was let stand for 5 days for growth of the products of interest and disintegration of the by-products. Then, it was dissolved for preparation of the tracer solutions of ^{111}Ag through chemical separation. Complex samples were prepared with the solution and subject to PAC measurements. The electric field gradient values obtained from the TDPAC spectra demonstrate that the data shows characteristics of the field, from which we could obtain useful information on the metal site.

1P10 Muonium in calcium phosphate

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An ESR study showed that calcium phosphate (TCP) kept a stable neutral hydrogen atom between two phosphate units for several months at room temperature after irradiating TCP by X-ray. This hydrogen was supposed to be generated by the combination of an electron produced by the X-ray irradiation and the remnant hydrogen ion incorporated during the preparation procedure of TCP from aqueous solutions. MuSR is capable of obtaining the information about neutral hydrogen and hydrogen ion sensitively because the muon is considered as a lighter proton. By using the muon one can investigate the behavior of hydrogen in TCP without X-ray irradiation. We performed a MuSR measurement of TCP with a DC beam at PSI and obtained a clear muonium precession signal which confirmed the formation of neutral muonium in TCP. The spin relaxation rate of the muonium in TCP was fast and the signal almost disappeared after 0.2 microseconds from the muon stop in TCP. The muonium yield did not show any significant temperature dependence from 293K to 5K.

1P11 Temperature dependence of neutron in-beam Mössbauer spectrum of iron disulfide

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A neutron in-beam Mössbauer spectroscopy measurement system at liquid nitrogen temperature has been developed in order to investigate the chemical and physical change caused by the gamma-cascade immediately after the thermal neutron capture reaction $^{56}\text{Fe}(n, \gamma)^{57}\text{Fe}$ at the PGA beam port of the JRR-3 reactor at the Tokai

Research Center of JAEA. A cryostat with thin Mylar beam windows, an aluminum foil sample mount on an 4N aluminum cold finger attached to cryohead, an improved S/N Mössbauer spectrum was obtained for an iron disulfide (marcasite type crystal structure) sample for the first time at 78K. There were two main doublet components observed as was seen at room temperature.

IP12 Mossbauer analysis of corrosion products of iron in aqueous solutions

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Chemical characterization of corrosion products of iron has been so far studied extensively from the industrial and environmental viewpoints, which has not been clarified completely, especially the corrosion processes in aqueous solutions. In the present work, Mossbauer analysis was performed for corrosion products of iron in aqueous solutions. We reported previously and preliminarily the Mossbauer characterization of corrosion of iron in a fiber state (called "steel wool") immersed in aqueous solutions, revealing that the utilization of steel wool was very effective to investigate the in-situ corrosion process in the solutions. However, it was also shown that such a method was not so adequate for the initial corrosion stage in aqueous solution system. Here, in order to obtain much clearer understanding, we tried to do Mossbauer measurements for the products in aqueous solution drops on metallic iron plate, which allowed us to obtain the products at a relatively initial stage. The Mossbauer data were analyzed as well as those for our previous Mossbauer results on steel wool.

IP13 Mössbauer spectroscopy of nanowires produced in carbon nanotubes

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When composing multiwalled carbon nanotubes (MWCNTs), Fe nanowires, which may be considered as magnetic nanowires encapsulated in carbon nanotubes, have been found in thin carbon shells under a certain production condition. In order to detect and characterize nanowires, the transmission Mössbauer measurements were carried out on four different Fe-filled MWCNT samples: A; tt25rrt (weight percent of ferrocene as precursor: 5wt%, preparation temperature: 800°C), B; tt28rrt (3wt%, 800°C), C; tt30rrt (10wt%, 800°C), D; tt31rrt (3wt%, 750°C). These samples of MWCNTs are purified by applying high temperature treatment, but the Fe nanowires remain inside MWCNTs. The results obtained from spectral analyses indicate that Fe phases encapsulated within the MWCNTs comprise α -Fe, iron oxides, and iron carbides, showing magnetically splitting peaks.

IP14 Mössbauer resonance absorption on FePSe₃ single crystal

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We have already reported the first steps towards a proof-of-principle experiment, demonstrating electromagnetically induced transparency (EIT) with gamma radiation for the Mössbauer effect in the mineral siderite FeCO₃ using the level-crossing technique. We have tried to seek other candidates for absorbers possible to use in the same type of experiment. The first candidate we had already tried was the single crystal of FePS₃, whose internal-magnetic-field strength was not enough to make the absorption lines of (-3/2 \leftrightarrow -1/2) and (1/2 \leftrightarrow -1/2) merge into one single line, in order to observe EIT. Recently, we have succeeded to synthesize the single crystal of FePSe₃ using a solid phase reaction method. A series of Mössbauer measurements at the temperatures ranging from R.T. to 30K using the FePSe₃ single-crystal absorber thus obtained indicates some possibility to demonstrate EIT as a proof-of-principle experiment.

IP15 Electric Conductivity and Mössbauer Spectra of New Cathode Material for Lithium Ion Battery

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New cathode material for lithium ion battery, LiFeVPO_x glass, developed by Nishida *et al.* has attracted much interest. A part of iron in LiFeVPO_x glass was replaced by cobalt in order to increase the battery voltage since cobalt has higher cell potential than iron. Composition of the new cathode material studied here is expressed by: LiFe_{0.5}Co_{0.5}VPO_x and LiFe_{0.25}Co_{0.75}VPO_x, in which a marked increase was observed in the discharge capacity especially in the region of less than 2V. Mössbauer spectra of these samples consist of quadrupole doublet due to high spin Fe^{III} irrespective of the heat treatment at 500 °C, which results in a systematic decrease of the quadrupole splitting (Δ), reflecting a structural relaxation of the glass network. Heat treatment of these glasses causes a marked increase in the electric conductivity and that of the discharge capacity of Li-ion battery.

IP16 Mössbauer Spectra of Li₂O-2FeO-V₂O₅-P₂O₅ Glass as a New Cathode Material for Lithium-ion Battery

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Among well-known 4.0 V cathode material for lithium-ion battery, LiCoO₂, LiNiO₂ and LiMn₂O₄ are now used commercially. Olivine-type LiFePO₄ crystal has attracted much interest as a new cathode material for lithium-ion battery because of its high theoretical capacity (170 mAh/g; operating potential 3.4 V) and because iron is less toxic and less expensive than Co and Ni. In this study, Mössbauer spectra of xLi₂O-2FeO-V₂O₅-P₂O₅ (x=0, 0.5, 1 and 1.5) glasses are measured for determining the local structure and the occupancy of the Fe^{III} sites. For comparison, Mössbauer spectra were measured on xNa₂O-2FeO-V₂O₅-P₂O₅ (x=0, 0.5, 1, and 1.5) glasses.

1P17 Mössbauer study of Fe-substituted layered oxide Li₂MnO₃

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Fe-substituted layered oxide Li₂MnO₃ has a layered rock-salt structure (α -NaFeO₂ type structure). Because of the "layered" structure Fe-doped Li₂MnO₃ has been paid much attention for cathode materials of lithium-ion batteries. This series of Fe-substituted Li₂MnO₃ contains an excess of Li thus the valence of transition metal cation is potentially higher than three. In this study, Fe-substituted Li₂MnO₃ with Fe/(Fe+Mn) = 0.3 of good crystalline quality are used to investigate the valence state of Fe by means of Mössbauer spectroscopy. Mössbauer spectrum at low temperature (5 K) consisted of two sextet with distribution of hyperfine fields and one doublet. The sextet with average hyperfine field of 46 T was assigned to Fe³⁺ state and that with 14 T was assigned to Fe⁴⁺ one. Note that hyperfine field of 14 T is similar to that reported for Sr_{0.5}La_{1.5}Li_{0.5}Fe_{0.5}O₄. The doublet had a relatively small isomer shift of -0.6 mm/s thus it corresponded to the valence state of Fe⁵⁺ or higher. The effect of anneal condition on iron valence state will be discussed.

1P18 Production of ⁶⁴Cu as a biotracer and applications to *in vivo* imaging of ⁶⁴Cu in a plant

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Positron emitter, ⁶⁴Cu has been used in medical applications with positron emission tomography (PET). We have developed a novel method in ⁶⁴Cu production to obtain ⁶⁴Cu-labelled antibodies as a PET reagent. On the other hand, ⁶⁴Cu can be used for *in vivo* imaging of copper in a "living" plant by positron emitting tracer imaging system (PETIS). Production of ⁶⁴Cu was carried out via the ⁶⁴Ni(p,n)⁶⁴Cu nuclear reaction. The produced ⁶⁴Cu (330 MBq) was purified by an

ion-exchange method from the irradiated ⁶⁴NiO target. The ⁶⁴Cu was obtained with high yield (89%) and high radionuclidic-purity ⁶⁴Cu (> 99%). The target material ⁶⁴NiO was recovered in good yield (> 99%). The ⁶⁴Cu was added to a plant (soybean) for an imaging experiment and the movement of ⁶⁴Cu was visualized by the PETIS. This result shows that ⁶⁴Cu can be applied as a useful tracer for not only medical applications and also plant physiological studies.

1P19 Production of ⁷⁶Br PET-radionuclide and ⁷⁶Br-labeled antibody for PET imaging of cancer diagnosis

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⁷⁶Br is of potential interest in nuclear medicine: ⁷⁶Br has been suggested as a halogen label with a convenient half-life (T_{1/2} = 16.1 h) and a sufficient β -branching ratio (57.2%) in PET. In this study we present the development of ⁷⁶Br production and the synthesis of monoclonal antibody (mAb) labeled with ⁷⁶Br and evaluated the potential for tumor diagnosis with PET. ⁷⁶Br was produced from the ⁷⁶Se(p,n)⁷⁶Br and the ⁷⁹Br(p,4n)⁷⁶Kr (T_{1/2}: 4.6 h)→⁷⁶Br reactions. The targets were used SeO₂ and KBr of the natural isotope composition, respectively. After radiochemical separation, direct bromination has been applied for ⁷⁶Br labeling of NuB2. The production yields were found to be 21-24 kBq/ μ A·min with SeO₂ target and 126 MBq/ μ A·min with NaBr target (EOB). The results of tumor localization studies show that ⁷⁶Br labeled mAb was highly accumulated to tumor. From these data, the use of ⁷⁶Br has great advantage for PET utility.

1P20 Oxidative stress by Se-deficiency and trace elements in cell fractions of rat liver

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Contents of Mn, Co, Fe, Cu, Zn, and Se in the liver cell fractions of 8-week old Se-deficient Wister female and male rats were determined by INAA. Selenium (Se) levels in every four cell fraction of SeD group were found to lower than those in Se-control (SeC) group in both female and male rats. However, Se level of each cell fraction in SeD group was higher in female rats than in male rats. Fe levels were found to be the highest in the MC fraction both for female and male groups, were secondly highest in mitochondria (MT) fraction for both sex groups, and thirdly in nucleus (Nu) fraction. In every four cell fractions, the Fe levels were higher in SeD group than in SeC group for both sexes. The results are presented in connection with the antioxidant enzyme activities, antioxidant contents in liver homogenates.

1P21 Treatment for bone metastasis by using alpha-emitting

radiopharmaceutical, ²²⁷Th-EDTMP.

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An alpha particle emitting radionuclide is promising for treatment of bone metastasis. Thorium-227 ($t_{1/2} = 18.72$ d) is one of the promising α -emitting nuclide due to the high LET and short path length of alpha particles. In order to evaluate the efficacy of ²²⁷Th, we started the preclinical therapeutic study of bone metastasis using a bone seeking radiopharmaceutical, ²²⁷Th-EDTMP. Seven-week-old female Sprague-Dawley rats were inoculated syngeneic MRMT-1 mammary tumor cells into the left tibia. Three weeks after cell inoculation, rats were injected 250 kBq/kg b.w. of ²²⁷Th-EDTMP intravenously. To evaluate therapeutic and pain palliation effects, tumor size measurement and von Fly filament test were applied. Toxic effect was also monitored by blood cells counting. ²²⁷Th-EDTMP injected rats showed bone pain palliation compared to control groups. There also showed therapeutic effects for inhibition of tumor proliferation. On the other hand, toxic effect was not shown. These results show that ²²⁷Th-EDTMP is able to use for treatment of bone metastasis.

IP22 Study of the PZC ¹⁸⁸W/¹⁸⁸Re generator and of the synthesis condition of ^{186/188}Re-DMSA

NOGAWA, N., IKEDA, K., MORIKAWA, N., MOTOISHI, S., MATSUOKA, H., HASHIMOTO, K.

Rhenium-186 ($T_{1/2}$, 90h; E_{β} , 1.1 MeV; E_{γ} , 137 keV) and rhenium-188 ($T_{1/2}$, 17h; E_{β} , 2.1 MeV; E_{γ} , 153 keV) are β^- particle emitting radionuclides with excellent properties for targeted radiotherapy. Re-188 has the advantages associated with carrier-free, generator-produced radionuclides. PZC generator with many tungsten molecules is expected for as practical generator. This generator was experimented for clarifying a characteristic. Meso-2,3-dimercaptosuccinic acid (DMSA) is applied for palliative treatment of pain associated with disease. Effect of pH is studied on preparation of ^{186/188}Re-DMSA.

IP23 Measurements of multi-radionuclides in seawater samples from the Sea of Japan by applying low-background γ -spectrometry and their implications

NAKANO, Y.,^a INOUE, M.,^a MINAKAWA, M.,^b KOMURA, K.^a
(^aK-INET, Kanazawa Univ., ^bNatl. Res. Inst. Fish. Sci.)

In the current study, a coprecipitation method was employed by adding Ba, Fe, Pb, Be carriers and ammonium phosphomolybdate (AMP) to seawater samples, and ⁷Be, ²¹⁰Pb, ²²⁶Ra, ²²⁸Ra, ²²⁸Th, ²³⁴Th and ¹³⁷Cs were isolated together with BaSO₄, Fe(OH)₃ or AMP. By applying low-background γ -spectrometry, all of these nuclides were detected using a small volume of seawater samples (20 L). As a practical

application, fourteen seawater samples (50 L) were collected from a water column within the Sea of Japan (3700 m depth; N41°01'; E138°01') during the 5th Soyo Maru expedition (1 Leg: 16-26 July, 2007). To determine short-lived ²³⁴Th ($t_{1/2} = 24.1$ d) and ⁷Be ($t_{1/2} = 53$ d), many of coprecipitation treatments were carried out on a research vessel. From vertical profiles of ⁷Be, ¹³⁷Cs, ²¹⁰Pb, ²²⁶Ra, ²²⁸Ra, ²²⁸Th and ²³⁴Th activities, we assess geochemical cycles in marine environments within the Sea of Japan.

IP24 Measurements of multi-radionuclides in seawater samples from the Sea of Japan by applying low-background γ -spectrometry and their implications

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IP25 ^{239,240}Pu in the water columns of the Eastern Pacific

SUMI, T.¹, KINOSHITA, N.², YOKOYAMA, A.¹, NAKANISHI, T.¹
(¹Grad. School Nat. Sci. Tech., Kanazawa Univ., ²KEK)

The ocean, by virtue of its large surface area, has received a major share of the fallout Pu. With the aim of understanding the sinking behavior of Pu in water column, depth distributions of ^{239,240}Pu, ²³⁸Pu were measured in water columns of the Eastern Pacific. It was found that ^{239,240}Pu concentration increased from surface to 600 m and showed low concentration from 1000 m to the bottom. ²³⁸Pu was clearly detected in the southern hemisphere of the Eastern Pacific. ²³⁸Pu in the southern hemisphere is attributable to the SNAP-9A accident in 1964.

IP26 The concentrations of radionuclides in groundwater samples after the Noto Peninsula Earthquake 2007

YAMADA, N.¹, UESUGI, M.¹, SHIMIZU, T.², YOKOYAMA, A.¹, NAKANISHI, T.¹

(¹Grad. School Nat. Sci. Tech., Kanazawa Univ., ²Fac. Sci., Kanazawa Univ.)

A ruinous earthquake (M 6.9) struck Noto Peninsula on 25 March

2007. It has been known these about 40 years that there is some correlation between earthquake and the change of radionuclides concentration in groundwater and surface-air. In the present study, groundwater samples were obtained every month after the earthquake near the earthquake center to analyze U and Th isotopes, ^{226}Ra and ^{210}Po . The results are as follows: (1) ^{238}U and ^{234}U concentrations ($0.13\sim 0.23\text{ mBq L}^{-1}$) and $^{234}\text{U}/^{238}\text{U}$ activity ratio (≈ 1) showed only slight change during 3 months after the earthquake, but (2) ^{210}Po concentration decreased from 3.24 mBq L^{-1} to 0.60 mBq L^{-1} during 1 month after the earthquake. These results suggest that the flow pass of groundwater was not changed largely on the earthquake, but considerable amount of ^{222}Rn dissolved in ground water system.

IP27 $^{230}\text{Th}/^{238}\text{U}$ and $^{226}\text{Ra}/^{230}\text{Th}$ activity ratios in rhyolite from Izu arc volcanoes

TAKAHASHI, M., KURIBARA Y., SATO, J.,
(Meiji Univ.)

Observation was made with rhyolitic volcanic rocks erupted from Kozu-shima and Nijijima on Izu arc for activity ratios of $^{230}\text{Th}/^{238}\text{U}$ and $^{226}\text{Ra}/^{230}\text{Th}$. The activity ratios ranged from 0.97 to 1.18 and from 0.71 to 1.04, respectively.

IP28 Radiocarbon analysis in tree rings of Yaku-cedar by AMS for investigating secular variation of atmospheric $^{14}\text{C}/^{12}\text{C}$ ratios

UENO, H.,¹ MURAMATSU, Y.,¹ MATSUZAKI, H.,² TSUCHIYA(SUNOHARA), Y.²
(¹Gakushuin University, ²University of Tokyo)

Atmospheric radiocarbon is produced in the stratosphere by cosmic ray reaction with nitrogen ($^{14}\text{N}(n,p)^{14}\text{C}$). The produced ^{14}C is oxidized immediately to form $^{14}\text{CO}_2$ and enters into the carbon cycle in the atmosphere. Then it is absorbed into plants through photosynthesis. Therefore, by measuring $^{14}\text{C}/^{12}\text{C}$ ratio in tree rings, it is possible to obtain information on the secular change of cosmic ray intensity. In this study, we have determined $\Delta^{14}\text{C}$ values in a long-lived Japanese cedar tree (Yaku cedar) by Accelerator Mass Spectrometry (AMS).

We could measure $^{14}\text{C}/^{12}\text{C}$ ratio using small sample size (about 20mg of wood sample) with a sufficient accuracy (3~5%) by AMS. Our data shows a similar pattern to IntCal04 which is an age calibration curve database constructed by the European and American samples. But some differences of $\Delta^{14}\text{C}$ value relative to IntCal04 were observed around 600-700 A.D. These differences might be a characteristic variation in Japan. Maximal value observed around 700 A.D. might be related to the Manyo cold period (around 620-740 A.D.).

IP29 Mass-dependent isotopic fractionation during preparation for ^{14}C dating of elemental carbon for studying the origin of atmospheric aerosol

HIDEKI WADA¹, KUNIYOSHI NAKAJIMA¹, HIROYUKI

MATSUZAKI², YOSHIMI SUZUKI¹, HIROSHI IWATA¹, SHOUGO AKUTSU¹

(¹Shizuoka Univ. ²Univ. of Tokyo)

We examined an analytical procedure for accurate determination of ^{14}C concentrations in elemental carbon (EC) of an aerosol in the atmosphere. When carbon dioxide released by a combustion of EC is converted to graphite for ^{14}C measurement with accelerator mass spectrometry (AMS), sulfur, nitrogen and halogens co-released impede the conversion to graphite. We examined an appropriate condition for effective formation of graphite on metallic Fe powder. We used Ag wire and Sulfix[®] for removing halogens and sulfur oxides and also used a reduced copper metal for reduction of nitrogen oxides to nitrogen gas. During the preparation of graphite conversion using Sulfix in order to purification of released gas from EC, we observed large fractionation effect on $\Delta^{14}\text{C}$ and $\delta\text{-C}$ values, rather than the normal mass-dependent isotopic fractionation effect.

IP30 Measurement of exposure age by determination of secondary cosmic-ray-induced ^{26}Al and ^{10}Be .

HOJO, K.,^a SEKIMOTO, S.,^b TAKAMIYA, K.,^b OKI, Y.,^b SHIBATA, S.,^b SASAKI, T.,^a MATSUZAKI, H.,^c KIM, S. H.,^d MOON, J. H.,^d CHUNG, Y. S.,^d MAHARA, Y.^b

(^aSchool of Eng., Kyoto Univ., ^bRes. Reactor Inst., Kyoto Univ., ^cSchool of Eng., Univ. of Tokyo, ^dKorea Atomic Energy Res. Inst.)

Secondary cosmic-ray-induced ^{26}Al and ^{10}Be in terrestrial quartz were measured by accelerator mass spectrometry (AMS) after chemical separation and neutron activation analysis. Preliminary results of these nuclide concentrations were obtained. From the depth profiles of ^{26}Al and ^{10}Be , long-term erosion rates of inland peneplain which consists of weathering granitic soil in northern Abukuma Plateau, Japan are discussed.

IP31 Development of key technologies for safety treatment of tritium in NIFS

ASAKURA, Y., TANAKA, M., KAWANO, T., UDA, T.
(NIFS)

Deuterium plasma experiments are currently being planned for the Large Helical Device (LHD) of the National Institute for Fusion Science (NIFS), following the present hydrogen plasma experiments. Under the deuterium experiment conditions, tritium will be generated in the LHD plasma vacuum vessel. In order to realize the safety management of the tritium, we are planning to realize the following specific methods, one is the gaseous tritium recovery system applying a polymer membrane dehumidifier and the other is the high sensitivity tritium monitor applying proton conducting ceramics as the hydrogen pump. The applicability evaluation results and the prospect of practical use of the each key technology will be summarized.

IP32 Fundamental knowledge about radiation and radioactivity which should be taught as compulsory course at junior or senior high schools

MATSUURA, T.,^a EDA, M.,^{ab} IIRI, Y.,^{ac} KUROKUI, S.,^a HIROI, T.,^a MIKADO, S.,^{ad} FUNADA, M.,^{ae} YATAGAI, H.,^{af} WATANABE, T.^{ag}
(^aRadiation Education Forum, ^bAomori Univ., ^cKoryoiki Kyoiku Kenkyukai, ^dChiba Univ., ^eFunabashi S. High School, ^fBunkyo Gakuin High School, ^gRikkyo Niiza High School)

We (Radiation Education Forum) are proposing an improved plan of educational curriculum at schools for teaching about radiation and radioactivity to Japanese Government (Ministry of Education, Science, Technology, Culture, and Sports). The proposal includes teaching the following items at as an early stage at school as possible:

- (1) The fundamental nature of radiation and radioactivity, action of radiation on human body, and the present status of utilization of radiation in various areas,
- (2) The existence of natural radiation and radioactivity around our environment by students' own experience or teacher's demonstration, and
- (3) The procedure of avoiding radiation exposure, (a) by taking distance from the radiation source to worker, (b) by placing shielding material between the source and worker, and (3) by minimizing the duration of exposure.

IP33 Workshop activities at Radiation Education Forum

MATSUURA, T.,^a EDA, M.,^{ab} HORIUCHI, K.,^{ac} KAWAMURA, S.,^a KANEKO, M.,^{ad} TANAKA, R.^a
(^aRadiation Education Forum, ^bAomori Univ., ^cOtsuma Women's Univ., ^dRadiation Effects Association)

"Radiation Education Forum" was established in 1994 in order to promote the proper education both at school and in society, based on correct scientific facts. The Forum has six workshops. They are:

- (1) Workshop on educational curriculum at school—discussing how should be the education of energy and environmental problems, including radiation and nuclear-related matters at school (elementary, and junior and senior high schools). The group have presented the documents of proposal for improving the present system to Japanese Government.
- (2) Workshop on experimental tools for radiation education—discussing experimental methodology for teaching radiation at school
- (3) Workshop on how to adopt the concept of RISKS—discussing how to teach the risk-benefit analysis and various risks existing in the daily life at school education
- (4) Workshop on how to understand the health effects of low level radiation. We believe this approach of making the right information about radiation widespread to the public is the most effective method for proliferating the nuclear technology.
- (5) Workshop on the description in textbooks in schools about radiation

and nuclear-related matters. We study the currently used textbooks of every kind of subjects, scientific and social, and are proposing the amended description when we find incorrect ones.

(6) Workshop on the reports of mass media about the nuclear-related matters—watching the incorrect reports in daily newspaper and TV.

IP34 Present Status of Enforcement in "Energy, Environment, and Radiation Seminar"

HASEGAWA, K., MATSUURA, T.,
(Radiation Education Forum)

To serve "Recommendation to Integrated Science and Education" for the school teachers in primary, junior, and senior high schools, the Seminar has been keeping up with us in 2001. The presentation will include the significance of energy, environment, and radiation in the present status of enforcement on this Seminar. It will, moreover, be proposed to the subjects of Seminar for further discussion.

2A01 Studies on hot atom chemical behavior of energetic ions in solids (XV)

-The oxygen contamination effects on hot atom chemical behavior of energetic deuterium in boron films-

YOSHIKAWA, A.,^a KIKUCHI, Y.,^a ISHIKAWA, H.,^a SUDA, T.,^a OYA, Y.,^a ASHIKAWA, N.,^b SAGARA, A.,^b NODA, N.,^b AND OKUNO, K.^a
(^aRad. Res. Lab., Fac. of Sci., Shizuoka Univ., ^bNIFS)

For boronization technique in D-T fusion devices, it is expected that the boron films form boron oxide, and energetic tritium is trapped by films with the thermal and hot atom chemical processes. In this study, boron films with various oxygen concentrations were prepared by the P-CVD, and energetic D_2^+ were implanted with various implantation temperatures and ion fluence. Thereafter, TDS and XPS measurements were performed to evaluate the D retention and chemical behavior in the films. From the TDS results, it was found that oxygen in the boron films formed B-O-D bond and D_2O . D_2O was observed in QMS spectra ($m/e=20$) observed during the D_2^+ implantation. From the dependence of implantation temperature, no implantation temperature dependence of D retention resulting from the B-O-D bond was observed in the range from RT to 823 K. This result indicated that the formation of B-O-D bond was based on the hot atom chemical reaction.

2A02 Study for behavior of tritium adsorption and desorption on the material surface

KOBAYASHI, K.,^a HAYASHI, T.,^a YAMANISHI, T.,^a OYA, Y.,^b OKUNO, K.^b
(^aJAEA/TPL, ^bShizuoka Univ.)

In a fusion reactor of high safety and acceptability, safe confinement of tritium is one of key issues for the fusion reactor. Tritium should be well-controlled and not excessively released to the environment and to prevent workers from excess exposure. Especially, the hot cell and

tritium facilities of ITER will use various construction materials. For tritium desorption processes, so-called 'soaking' effect is important. This effect is based on sorption of tritiated water vapor on the materials and subsequent desorption from them. Therefore, in order to develop for the optimal desorption technique, the desorption experiment was carried out as a function of water vapor concentration in the purging gas (N₂) for epoxy paint, acrylic resin and butyl rubber, and the mechanism of sorption between tritiated water vapor and materials was also investigated. As the result, about 70% of the adsorbed tritium on the epoxy paint was removed by adding water vapor in purging gas for 12 hrs. The effect of adding water vapor was found on the decontamination for epoxy paint.

2A03 Investigation of hydrogen isotope behavior on water-metal boundary by using pure tritium

HAYASHI, T.^a, NAKAMURA, H.^a, ISOBE, K.^a, KOBAYASHI, K.^a, YAMANISHI, T.^a, SUDA, T.^b, OYA, Y.^b, OKUNO, K.^b
(a: JAEA, b: Shizuoka Univ.)

In order to accumulate data on tritium transferred to cooling water of a fusion reactor, a series of experiments of tritium permeation into water jacket pressurized to 0.8MPa by He gas was performed through pure iron piping, which contained about 1 kPa of pure tritium gas at 423 K. Chemical forms of tritium permeated into water were monitored periodically under continuous purging water jacket by He. Observation of metal surface was also carried out periodically by SEM and XRD analysis.

The actual tritium permeation rate was about 1/5 level of the calculated value. Even if surface oxide layer (magnetite, porous & fine layers) grew in the water boundary, tritium permeation rate to water was not changed drastically. On the other hand, hydrogen gas (HT) fraction of tritium permeated in water jacket decreased drastically with oxide layer growth. Furthermore, permeated species and amounts were not affected clearly by the dissolved hydrogen in water by purging 1% H₂ in He.

2B01 Improvements on determination of Pb-210 in lead

UESUGI, M.¹, NOGUCHI, M.², NAKANISHI, T.¹
(¹Grad. School Nat. Sci. Tech., Kanazawa Univ., ²JCAC)

Since natural lead contains radioactive isotope ²¹⁰Pb, lead materials has to be selected before constructing shielding box for low level radioactivity measurement. In this work, an improved method for determination of ²¹⁰Pb is proposed, which is based on radioanalytical separation by DDTC-toluene (sodium diethyl dithio carbamate) extraction and electrodeposition on a stainless steel disk, followed by alpha-ray spectrometry of ²¹⁰Po and ²⁰⁹Po as a tracer. Contents of ²¹⁰Pb in four commercially available lead samples (10-30mg) and an old lead sample (110mg) were analyzed by alpha-ray spectrometry, and were compared with the results by gamma-ray spectrometry.

2B02 Development of the uranium-enrichment screening method for particles by chemical etching of fission track detector (2)

LEE, C. G., IGUCHI, K., SUZUKI, D., ESAKA, F., MAGARA, M., SAKURAI, S., SHINOHARA, N., USUDA, S.
(JAEA)

Safeguards environmental sample analysis has implications on the examination of the existence of uranium particles with a higher ²³⁵U enrichment in swipe samples. If such uranium particles can be preferentially detected in a sample, this will be significant in simplifying the particle analysis in the safeguards environmental samples. In this study, a screening method for uranium particles according to their enrichment has been developed by using the characteristics of fission tracks (FTs). A two-step filtration system that can collect particles with desired diameters was used for the collection of uranium particles from a swipe sample in order to avoid the influence of the differences in the diameter on the etching behavior of FTs. In order to verify the effectiveness of the developed screening method, a mixed sample containing uranium particles (1~3 μm) with 10% enrichment and those with natural composition was collected on a polycarbonate membrane filter, from which particle layer was made and irradiated with thermal neutrons. The FT detector made of polycarbonate was etched with 1M NaOH at 45°C. It was shown that the enrichment-based screening of the uranium particles is improved by controlling the etching time to detect fission tracks and by comparing particle diameters.

2B03 Sorption of Pu(VI) by the mixture of bacteria and clay

OHNUKI, T.^a, OZAKI, T.^a, KOZAI, N.^a, SAKAMOTO, F.^a, SUZUKI, Y.^a, YOSHIDA, T.^b
(^aJAEA, ^bCRIEPI)

We investigated the interactions of Pu(VI) with a mixture of *Bacillus subtilis* and kaolinite clay to determine the role of the microbes in regulating the environmental mobility of Pu. The bacteria, the kaolinite, and their mixture were exposed to a 4x10⁻⁴ M Pu(VI) solution at pH 5.0. The amount of Pu sorbed by *B. subtilis* increased with time, but had not reached equilibrium in 48 h, whereas equilibrium was attained in kaolinite within 8 h. After 48 h, the oxidation state of Pu in the solutions exposed to *B. subtilis* and the mixture had changed to Pu(V), whereas the oxidation state of Pu associated with *B. subtilis* and the mixture was Pu(IV). In contrast, there was no change in the oxidation state of Pu in the solution or on kaolinite after exposure to Pu(VI). SEM-EDS analysis indicated that most of the Pu in the mixture was associated with *B. subtilis*. These results suggest that Pu(IV) is preferably sorbed to bacterial cells in the mixture, and that Pu(VI) is reduced to Pu(V) and Pu(IV).

3A01 Application of optical techniques to phoswich detectors composed of ZnS(Ag) for simultaneous counting of radiations

emitted from actinides

USUDA, S., YASUDA, K., SAKURAI, S.

(Research Group for Analytical Science, JAEA)

The authors have developed phoswich detectors with ZnS(Ag) as an essential component. The phoswich detectors consist of plural scintillators, which have specific sensitivity for each radiation and different decay time from each scintillator, and enable us to count simultaneously α , $\beta(\gamma)$ rays, thermal and/or fast neutrons emitted, when pulse shape and/or pulse height discrimination techniques are skillfully applied. In addition, if optical filters are suitably applied to the phoswich detectors, discrimination properties are improved. In this presentation, the authors introduce 1) summary of the rise time properties of scintillators and effects of optical techniques such as optical filters obtained under the almost same conditions, and 2) examples of application of optical techniques to improve the discrimination characteristics of the phoswich detectors.

3A02 Reliability evaluation of neutron activation analysis of Cr and Co in silicon nitride (NMIJ CRM 8001-a)

MIURA, T.,^a KUROIWA, T.,^a NONOSE, N.,^a HIOKI, A.,^a CHIBA, K.,^a KAMIOKA, H.,^b MATSUE, H.^c

(^aNMIJ-AIST, ^bGREEN-AIST, ^cJAEA)

NMIJ has been developing the certified reference materials under the following policies; 1) the traceability to SI unit is declared, 2) CRMs are developed under the quality management system, 3) the quality system is accredited by the third body, 4) the CRM developing systems and procedures are peer-reviewed by the international reviewers from other NMIs. In inorganic analytical chemical fields, ID-ICPMS is now considered as a primary measurement procedure and other atomic spectrochemical methods are usually used as the reference measurement procedures. In recent years, Neutron activation analysis is tried to use as a primary measurement procedure, so Japan Atomic Energy Agency and NMIJ started collaborative research program to investigate the feasibility of NAA to chemical metrology.

In this study, the analytical results of Cr and Co in Si₃N₄ ceramic obtained by NAA were in good agreement with those by other analytical methods including ID-ICPMS. The measurement uncertainty related to NAA was evaluated.

3A03 Estimation of the source of surface sediments in the pelagic sea by instrumental neutron activation analysis

SHOZUGAWA, K.,¹ KUNO, A.,¹ SANO, Y.,² MATSUO, M.¹

(¹Grad. School of Arts and Sci., The Univ. of Tokyo, ²Ocean Res. Inst., The Univ. of Tokyo)

Sea sediments consist of the elements brought about from various sources. We collected core samples from the Antarctic Ocean to the South Pacific Ocean in 2004-2005. In order to estimate the source in pelagic sea sediments, principal components analysis (PCA) was applied

to the data matrix which is made by determination values of sediments measured by instrumental neutron activation analysis. The results of PCA represented 3 factor models in each sediment, explaining 58-98% of the total variations in the sediments. A comparison of eigenvector of terrigenous elements loading from PCA indicated the existence of 2 sources of supply in sediments. One is Group 1 [SX09 (factor1) and SX18 (factor1)], suggesting continental dust. The other is Group 2 [SX16 (factor1) and SX21 (factor2)], suggesting volcanic rock. Variation of K/Ti ratio and Eu anomaly (Eu/Eu*) of sediments supported the above results.

3A04 Separation of An(III) from Ln(III) using a capillary electrophoretic technique

MORI, T.,^a ISHII, Y.,^a HAYASHI, K.,^a YANAGA, M.,^a SATOH, I.,^b SUGANUMA, H.,^a

(^aRadiochem Res. Lab., Fac. Sci., Shizuoka Univ., ^bIMR, Tohoku Univ.)

It was proved that the moving velocity of the chemical species of Eu(III) electrophoresed from anode to cathode was larger than that of Am(III) in the solution containing thiocyanate ion because the positive mean charge of thiocyanate complexes of Eu(III) is larger than that of Am(III). On the basis of the difference between the moving velocities of Eu(III) and Am(III), both in trace concentrations were electrophoresed in the mixed solvent (CH₃OH/H₂O) solutions of 0.00 ~ 1.00 M NaSCN + 0.10 HClO₄ using a capillary electrophoretic technique. The results showed that the Am(III)/Eu(III) separability increased as the concentration of NaSCN increased. Additionally, it was also demonstrated that the Am(III)/Eu(III) separability in the mixed solvent solution was higher than that in the aqueous solution containing the same concentration of NaSCN. The theoretical plate number (*N*) in almost all experiments was the order of 10⁴, and it became apparent that Am(III) was completely separated from Eu(III) in 0.40 ~ 1.00 M NaSCN solution system.

3A05 Mutual separation of rare earths and the short-lived lanthanide using capillary electrophoresis

KURIBAYASHI, T.,¹ OOE, K.,¹ OMOTO, T.,¹ FUJISAWA, H.,¹ KOMORI, Y.,¹ TAKAHASHI, N.,¹ YOSHIMURA, T.,¹ HABA, H.,² ENOMOTO, S.,² MITSUGASHIRA, T.,³ SHINOHARA, A.¹

(¹Osaka Univ., ²RIKEN, ³Tohoku Univ.)

The chemical behaviors of heavy actinides are little known, because the most of them are short-lived isotopes with very low production rates. It is difficult to mutually separate the trivalent actinides, because of the similarity of their chemical properties. The extraction and separation of Am and Cm is an important subject in nuclear wastes treatment. We have studied the mutual separation of Am, Cm and Cf using a capillary electrophoresis (CE) to improve the separation capacity. We used α -hydroxyisobutyric acid (α -HIBA) as a ligand and examined the dependencies of the separation capacity on pH of the background

electrolyte, the capillary length and the flow rate of the outlet. As a result, we achieved the high efficiency and resolution in the separation of Am and Cm. We also attempted to apply this CE methods to short-lived nuclides produced with an accelerator.

3A06 Application of UTEVA resin cartridge to separate Th and U in solidified product of simulated waste

FUJIWARA, A., KAMEO, Y., NAKASHIMA, M.
(JAEA)

Separation of Th and U in dissolved solution of solidified products of simulated waste with UTEVA resin has been investigated. Thorium and U were separated from the other elements such as Na, Al, Ca, Fe by column chromatography with UTEVA resin and recovered with the solution containing 0.1 M HNO₃ and 0.05 M oxalic acid. The concentration of Am and Pu in the fraction to recover Th and U was under the detection limit. Although 1% of Np was contaminated to the recovery fraction of Th and U, Np would not interfere the measurement of U. UTEVA resin cartridge system with flow pump was applied to the separation of Th and U. The result from cartridge system showed good separation of Th and U from Na, Al, Ca, and Fe. The flow rate with cartridge system was 4–5 times faster than that with column system to shorten the operation time.

3A07 Development of mass analysis technique by TIMS for FT-TIMS method

IGUCHI, K., LEE, C. G., SUZUKI, D., INAGAWA, J., ESAKA, F., MAGARA, M., SAKURAI, S., USUDA, S., SHINOHARA, N., HOSOMI, H., ONODERA, T., HUKUYAMA, H., ESAKA, K.
(JAEA)

We have developed mass analysis technique by TIMS in FT-TIMS method for particle analysis of safeguards environmental samples which is required to analyze a small particle with a sub-micron size. In the present work, experiments using uranium particles of isotope standard reference materials are carried out to obtain information for representing the ability of FT-TIMS method and advancing the method. By this method, minor isotopes ²³⁴U and ²³⁶U which provide detail information about nuclear activities are measured in addition to major isotopes ²³⁵U and ²³⁸U. Furthermore, a particle with a sub-micron size is successfully analyzed to determine the isotope ratios. In addition, particle sizes are obtained based on the uranium signal intensity in the isotopic measurements to be compared with accuracy and precision. The ability of FT-TIMS method is improved by connecting the information from isotopic measurements with the screening technique[1].

[1] C. G. Lee et al., Jpn. J. Appl. Phys., 45 (2006) L1121-L1123.

3A08 Adsorption behavior of technetium on tertiary pyridine resin in hydrochloric acid solution

SUZUKI, T.^a, SANGO, M.^a, FUJII, Y.^a, WU, Y.^b, MIMURA, H.^b

(^aTokyo Tech. ^bTohoku Univ.)

Adsorption behavior of technetium on tertiary pyridine resin in hydrochloric acid solution was investigated. Distribution coefficients of technetium were determined by batch experiments. Adsorption behaviors of technetium and rhenium were compared. Technetium has a little larger distribution coefficient in higher concentration hydrochloric acid region than rhenium. However, the tendency of adsorption behavior of technetium and rhenium is similar. We concluded that the rhenium can be used as the substitute for technetium. Adsorption behaviors of platinum group elements were also investigated. The separation of technetium from platinum group elements was discussed.

3A09 Redox reactions of technetium by radiolysis and sonolysis: formation and dissolution of Tc(IV) oxide nanoparticles

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(^aCAHE, Tohoku Univ., ^bGrad. School of Sci., Tohoku Univ.)

Redox reactions of Tc in aqueous solutions by sonolysis were investigated to compare redox processes of technetium by radiolysis. Nanoparticles of Tc(IV)O₂·*n*H₂O were formed by gamma-irradiation of aqueous pertechnetate (Tc(VII)O₄) solutions via reductions processes triggered by hydrated electrons and H radicals. In contrast to radiolysis, no reduction was observed by ultrasonic irradiation (200 kHz, 200 W) of aqueous TcO₄ solutions. However, we found that TcO₂·*n*H₂O nanoparticles dispersed in an aqueous solution were completely dissolved by ultrasonic irradiation within 30 min under Ar atmosphere, and TcO₄ was eventually produced. The production of TcO₄ was considerably suppressed in the presence of *t*-butyl alcohol, indicating that Tc(IV) was oxidized by OH radicals in hot cavitation bubbles created by ultrasound. The formation rate of TcO₄ under He atmosphere was slower than that under Ar atmosphere. Because thermal conductivity of He is much higher than Ar, thermal transport effectively occurs from the bubbles to the surrounding liquid. Thus, temperature of cavitation bubbles filled with He should be lower than those filled with Ar, resulting in the slower OH formation rate.

3B01 Depth distribution of ²⁴¹Am in water columns of the Eastern Indian Ocean and its adjacent seas

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Artificial radionuclide ²⁴¹Am (*T*_{1/2} = 432.2 y) in the environment is the daughter of ²⁴¹Pu (*T*_{1/2} = 14.35 y) from atmospheric weapons testing. In this work depth distribution of ²⁴¹Am was measured through the determination of the nuclide in large volume of water samples collected in the Eastern Indian Ocean and its adjacent seas during the period of 1996–1997. Depth distribution of ²⁴¹Am was compared with the depth distribution of ^{239,240}Pu. The depth distributions of ²⁴¹Am were also compared among sea-areas. The results suggest that subsidence behavior

of ^{241}Am is largely controlled by the flux and chemical composition of settling particles.

3B02 Colloid Transport of Plutonium in the Far-Field of the Mayak Production Association, Russia

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Sorption of actinides, particularly plutonium, onto submicrometer-sized colloids increases their mobility, but these plutonium colloids are difficult to detect in the far-field. We identified actinides on colloids in the groundwater from the Mayak Production Association, Urals, Russia; at the source, the plutonium activity is ~1000 becquerels per liter. Plutonium activities are still 0.16 becquerels per liter at a distance of 3 kilometers, where 70 to 90 mole percent of the plutonium is sorbed onto colloids, confirming that colloids are responsible for the long-distance transport of plutonium. Nano-secondary ion mass spectrometry elemental maps reveal that amorphous iron oxide colloids adsorb Pu(IV) hydroxides or carbonates along with uranium carbonates.

3B03 Behavior of plutonium in seawaters of the North and South Pacific Ocean

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The present levels of plutonium and its behavior in seawaters of the North and South Pacific Ocean are summarized. The $^{239,240}\text{Pu}$ concentrations in surface seawaters in the early 2000s were in the range of 1.5 to 9.2 mBq m⁻³ in the North Pacific subtropical gyre and 0.8 to 4.1 mBq m⁻³ in the South Pacific subtropical gyre, respectively. The vertical profile of $^{239,240}\text{Pu}$ in the South Pacific with surface minimum, mid-depth (600-800m) maximum and decrease in deeper layer was the similar pattern to that in the North Pacific, which is controlled by biogeochemical processes. The $^{239,240}\text{Pu}/^{137}\text{Cs}$ ratios, which reflect biogeochemical processes, increased exponentially with increasing depth within the depth range of 0 to around 1000 m in the North and South Pacific Ocean. In deep waters (> 1000 m), the plutonium concentrations in seawater of the North Pacific are generally higher than that in the South Pacific. The $^{239,240}\text{Pu}$ inventories (down to 2300 m) in the North Pacific are generally greater than that in the South Pacific.

3B05 Residual induced radioisotopes in the soil of the Semipalatinsk Nuclear Test Site in the former USSR

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Residual neutron induced radioisotopes in the surface soil from the Semipalatinsk Nuclear Test Site in the northern part of the Kazakh Republic have been studied. The radioactive concentrations of induced radionuclides, ^{60}Co and $^{152,154}\text{Eu}$ in the same soil sample collected at the bank of crater which was formed by an underground nuclear detonation on 15 January 1965 have been reported in the former research. The object of this study is to explore further investigation about the activation products, $^{59,63}\text{Ni}$, $^{108\text{m}}\text{Ag}$ and ^{207}Bi . Silver and bismuth were radiochemically separated respectively from large amount of ^{60}Co and ^{137}Cs to improve the precise determination of the radioactivity, and $^{108\text{m}}\text{Ag}$ and ^{207}Bi were measured with a high sensitive well-type Ge detector. Nickel was also purified radiochemically, $^{59,63}\text{Ni}$ was detected with a liquid scintillation counter. ICP-MS was used for the determination of the chemical composition of the soil. Neutron fluence has been estimated from the radioactivity of the induced radionuclides and the numbers of the target nuclides.

3B06 Behavior of environmental radioactivity in Mushrooms

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It has been more than 10 years from last nuclear experiment in the atmosphere or Chernobyl reactor accident, although radioactive Cesium (Cs-137), which came from above events, is still detected in some foods. Especially, it is well known that mushroom show the high concentration of Cs-137 compare with other foods.

In this study, we investigated the behavior of Cs-137 in some wild mushrooms, collected at the forest in Nanao city, Ishikawa, such as the difference of concentration by a kind and by a part, shift coefficient from ground substance (soil or parasite) and relations between stable alkali metals. Then we found that wild mushroom show the high concentration of Cs-137 in the upper part (pileus) and high shift coefficient of Cs-137 from ground substance (soil and parasite). We also found that the concentration of Cesium strongly correlate with that of Rubidium.

3B07 Estimation of origin of sample clinging on remains of Matsusaki site

NAKANO-OHTA, T.^a, ANDO, A.^b, NAKANO, T.^b, KUBOTA, T.^a AND MAHARA, Y.^a

(^aRes. Reactor Inst., Kyoto Univ., ^b Res. Inst. for Humanity and Nature) Matsusaki site, Aichi prefecture, is thought to be one of the famous salt-production site in Japan. Mori reported that the marine benthic diatom, *Cocconeis scutellum*, was detected from a sample clinging on remains of Matsusaki site. The discovery of this diatom supported the salt-production by using marine products in Matsusaki site. In this study, this adhesion thing was measured by following analytical procedures: 1) chemical composition by ICP-AES and AAS, 2)

chemical form by XRD, and 3) $^{87}\text{Sr}/^{86}\text{Sr}$ ratio by Mass spectrometry. The result showed that the sample originated from marine products.

3B08 Radium isotope geochemistry in Na-Cl type saline spring waters

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Radium (^{226}Ra , ^{228}Ra) and uranium (^{238}U , ^{234}U) isotopes dissolved in 57 saline spring waters from coastal areas of Niigata, where is famous for oil and gas production in Japan, Ishikawa and Toyama prefectures were measured along with dissolved major elements and δD and $\delta^{18}\text{O}$. The relationships of both $\delta\text{D}-\delta^{18}\text{O}$ and $\delta\text{D}-\text{Cl}$ indicated that spring waters sampled were probably mixtures of local meteoric water and sea water or fossil sea water. The concentration of ^{226}Ra and $^{228}\text{Ra}/^{226}\text{Ra}$ activity ratios ranged from 2.3 – 2400 mBq/kg and 0.28 – 9.7, respectively, and some hot spring waters with high ^{226}Ra concentration over 1000 mBq/kg were found. The ^{238}U concentrations were in the low range from 0.008–2.4 mBq/kg. By taking into account of such low ^{238}U concentration and insolubility of its daughter nuclide ^{230}Th , dissolved ^{226}Ra is unlikely to be supported by parent nuclide, and, therefore, other mechanisms should be considered. The factors of ion exchange depending on the salinity, α -recoil and bulk rock dissolution are probably important to consider the mechanisms of transport of Ra to solution phase.

3B09 Activity ratio of Ra isotopes leached from mineral and rock

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(Meiji Univ.)

Leaching behavior of Ra isotopes from radioactive minerals (monazite and euxenite) and rock (granite) was observed. The variation in the activity ratios of Ra isotopes in the leachates from monazite, euxenite and granite with HCl aqueous solution showed a common tendency. The leaching efficiency of Ra isotopes was estimated to be dependent on the difference in the history of decay processes which have formed Ra isotopes.

3P01 Determination of ^{26}Al produced by fast neutron-induced reaction (n, 2n) in an aluminum sheet at KUR

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To estimate a contribution of fast neutron-induced reaction ^{27}Al (n, 2n) ^{26}Al at Kyoto University Reactor (KUR), we determined ^{26}Al in the neutron-irradiated high-purity aluminum sheet using accelerator mass spectrometry (AMS) at Micro Analysis Laboratory, Tandem Accelerator, the University of Tokyo. The neutron irradiation was carried out for 50 min using Pn-2 at KUR. Based on the result, it was confirmed that

^{26}Al can be safely determined using AMS in the cosmochemical samples once used for instrumental neutron activation analysis at KUR. Additionally, we determine ^{26}Al produced in the aluminum sheet which was irradiated for 50-120 h in the reactor core in order to evaluate the contribution of fast neutron-induced reaction in the reactor core at KUR.

3P02 Measurements of isotope ratios in meteorite samples using neutron activation analysis with multiparameter coincidence method

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(Japan Atomic Energy Agency)

We developed a new technique of trace element analysis based on neutron activation analysis with coincident gamma-ray detection. In order to improve the low efficiency of coincident gamma-ray detection, an array of 16 Ge detectors with BGO Compton suppressors was used for this method. In the case of neutron activation analysis, measurements of gamma-rays from trace elements are strongly interfered by the gamma-rays from major elements, e.g., ^{24}Na , ^{56}Mn . So usually chemical separation processes are required to eliminate the major elements for determination of the trace elements. But using this method, we can detect very weak gamma rays from trace elements without chemical separations. In this study, we try to measure trace elements in presolar grains. Presolar grains are synthesis in the Super nova or Red giant, and found in the primitive meteorite. We obtained nanodiamonds as presolar grains from the Allende meteorite, and try to measure trace elements in the grains using this method. We also measured isotope ratios of some elements in meteorite samples, such as presolar grains, chondrules.

3P03 Long-term stability evaluation by neutron imaging and activation analysis of archeological samples for radioactive waste disposal study

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(JAEA)

For long-term stability evaluation of artificial barrier materials to use for disposal of disposal of high-level radioactive waste, we carried out the natural analog study using archeological samples that assumed a similar corrosion process in natural environment. In this study, we introduce some corrosion data for some iron and copper material sample to comparison for some radioanalytical techniques. We carried out non-destructive analysis with neutron imaging, neutron activation analysis, prompt gamma-ray analysis and X-ray computed tomography for the analysis of the sample corrosion thickness of the rust layer and multi-elemental analysis.

3P04 Distribution of secondary neutron produced at high-energy

accelerator facility in a shielding concrete

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(KEK)

The 12 GeV proton synchrotron of KEK has been utilized for high-energy physics. The shielding concrete of the facility has been exposed during machine operation. As a result, various radionuclides have been produced through both nuclear spallation reactions and thermal neutron capture reactions of concrete elements. We measured depth profiles of the radionuclides for the shielding concrete surrounding EP1 beam line. Some radionuclides such as Na-22, Mn-54, Co-60, and Cs-134 were measured using a conventional HPGe detector and a specialized HPGe which is covered by a NaI scintillation detector in order to reduce background component. We succeeded in a determination of ultra-low level of radioactivity by a gamma-ray spectrometry. We are going to discuss a distribution of neutron in a shielding concrete from the depth profile.

3P05 Analysis of boron-doped diamond using Doppler broadening method of prompt gamma-rays

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Prompt gamma-ray analysis of a thin boron-doped diamond film on silicon wafer was performed using the prompt gamma-ray analyzing system installed at the thermal-neutron beam guide of JRR-3M at the JAEA. The concentration of boron in the diamond film was 9×10^{20} atoms/cm³. The degradation constant D of energetic ⁷Li ion was determined by analyzing the Doppler-broadened line shapes of prompt gamma-ray at 478 keV emitted from ⁷Li. The D value experimentally obtained ($3.37 \pm 0.01 \times 10^{12} \text{ s}^{-1}$) for the boron-doped diamond was lower than the D value from the LSS theory ($3.67 \times 10^{12} \text{ s}^{-1}$). The difference might be due to some chemical effect on the degradation processes.

3P06 Radioisotopes in cosmetics.

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Cosmetics which declared hormesis effects are available through Internet. Although ingredients labels are obligations for cosmetics, the trace elements such as radiation sources are never shown. The existence of the daughter nuclides of Th and U series were observed by measuring the gamma rays with a high purity Ge detector. In this study, in order to clarify the contents of trace elements, the hormesis cosmetics were analyzed using prompt gamma activation analysis and observed by EPMA. Main elements of the hormesis cosmetics are some rare earth elements such as La, Ce, Sm and Gd. The ratio of Gd/Sm included in all the hormesis cosmetics is 0.70 ± 0.02 , and the ratio is different from

0.82-1.01 observed for general cosmetics. Furthermore, we evaluated a possibility of radiation exposure. The influence of gamma rays to skin surface from some hormesis cosmetics was estimated to be over 50 mSv per year. The addition of the radioisotope to cosmetics is prohibited in some countries by the laws. The examination of the object that should prohibit the addition of the radioisotope is necessary.

3P07 Change of concentrations of trace elements in hepatocyte of mice at early stage of zinc deficiency

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Concentrations of trace elements in hepatocyte of Zn-deficient and control mice were determined. Eight-week old male mice of ICR strain were divided into two groups; one was fed with Zn-deficient diet, and the other with control diet. After one week, their livers were removed and separated into six fractions, such as nondestructive, nuclear, mitochondrial, lysosomal, microsomal, and cytosolic fractions, by centrifugal method. Each fraction was freeze-dried for instrumental neutron activation analysis, INAA. Concentrations of ten elements, Na, Mg, Cl, Mn, Fe, Co, Cu, Zn, Se, and Rb, in each fraction were determined by INAA. Furthermore, SDS-PAGE and two-dimensional electrophoresis were carried out for the cytosolic fraction. For zinc concentrations in all fractions, there were no significant differences between two groups. On the other hand, cobalt concentrations in several fractions of Zn-deficient mice were higher than those of control mice. No significant differences were found for the positions and numbers of protein bands or spots on the gel after SDS-PAGE and two-dimensional electrophoresis.

3P08 X-ray fluorescence analysis of trace elements in standard materials by SAGA-Light Source

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Kyushu Synchrotron Light Research Center (SAGA-LS) has been established by SAGA Prefecture at February 2006. This is the first applied research facility on synchrotron light in Kyushu. Electrons are accelerated up to 1.4 GeV and the light emitted is applied. Although this is a medium size facility as compared to the other facilities in the world, a high brightness of the synchrotron light is one of the characteristics. We present X-ray fluorescence analysis of trace elements in standard materials by SAGA-Light Source. We selected Rock (JG-1a), marine sediment (JMS-1) and coal ash (NIST-1633b) as standard materials and compared the results with the conventional method.

3P09 Tritium dynamics in the environment—Case study at Kagoshima Prefecture—

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Two PWRs are under operation in Kagoshima Prefecture. We present tritium level of atmospheric HTO, seawater, river water and organic samples and discuss the dynamics in the environment. Atmospheric HTO samples were monthly collected at three sampling sites during April 2000 through March 2006. The results show different tritium levels at each site. Tritium levels in seawater collected at three sampling sites were dependent on the distance from the PWRs. River water showed slightly higher than the seawater collected at control site. As for organic samples, we determined tissue free water tritium (TFWT) and tissue bound tritium (TBT) in 14 kinds of agricultural and marine products. The TFWT and TBT showed variable levels. The levels seem to reflect the tritium level of the environment during the growth of the products.

3P10 AMS Method for determination of I-129 in environmental samples

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We present AMS method for determination of ¹²⁹I in water, soil-sediment, organics and atmospheric I samples. After addition of woodward I carrier and pretreatments, I in the samples were finally collected as AgI powder. The following methods were performed as the pretreatments: solvent extraction for water, quartz tube combustion for soil-sediment, quartz tube combustion or Parr oxygen bomb for organics and TMAH extraction for atmospheric I collected by using quartz and charcoal filters. AgI target was prepared with a mixture of Nb powder and ¹²⁹I/¹²⁷I was determined by Purdue University AMS. ¹²⁹I/¹²⁷I of IAEA-375 (soil standard material) determined by our method was $1.58 \pm 0.08 \times 10^{-7}$ (N=3). This agreed with previously reported ¹²⁹I/¹²⁷I of 1.517×10^{-7} (Schmidt, 1998) and 1.7×10^{-7} (Muramatsu, 1995).

3P11 Determination of ¹²⁹I in soil samples collected from various places in Japan by AMS

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Iodine-129 (half life: 16 million years) is one of the most important radionuclides in environmental sciences. Because iodine is concentrated in thyroid gland of human body, it is necessary to measure the levels of this nuclide in the environment. In this study, we determined ¹²⁹I/¹²⁷I ratio by AMS (accelerator mass spectrometry) in environmental samples such as soils. For the analysis of stable iodine, we have used ICP-MS. Analytical results obtained for soil samples collected from various places in Japan, far from nuclear facilities, were as follows.

¹²⁹I concentrations: 1.4×10^{-5} - 2.0×10^{-3} Bq/kg
¹²⁹I/¹²⁷I ratio: 3.9×10^{-11} - 3.0×10^{-8}

We also measured ¹²⁹I concentration in soil samples around Rokkasyo-mura and Tokai-mura. Concentrations of ¹²⁹I in Aomori samples were almost in the same concentration range mentioned above. Concentrations of ¹²⁹I in Tokai-mura samples were higher than those from other places.

3P12 Determination of a long-lived radionuclide ³⁶Cl by AMS—study of sulfur reduction process in ³⁶Cl-AMS sample preparation—

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Chlorine-36 ($T_{1/2} = 3.01 \times 10^5$ yr) is mainly produced by the spallation reaction of cosmic-rays on ⁴⁰Ar in the atmosphere and is widely distributed in the environment. So that ³⁶Cl is effectively used as a monitoring tool for the environment study. Recently, the isotopic ratio ³⁶Cl/Cl is determined by accelerator mass spectrometry (AMS). It is necessary to chemically remove sulfur from samples, because isobaric ³⁶S interferes with ³⁶Cl in the AMS measurement. In general, sulfate is removed as BaSO₄ precipitate by adding saturated Ba(NO₃)₂ solution. However, the BaSO₄ method is time-consuming and causes a low chemical yield of AgCl. In this study, we propose new sulfur reduction methods, i.e. a coprecipitation of sulfate with BaCO₃ precipitate and an anion-exchange resin technique. The behavior of sulfur as sulfate in these methods was confirmed by the tracer experiments of ³⁵S. The results obtained suggest that a strong base anion-exchange resin technique is effective and could remove about 70% of the sulfate in the original solution.

3P13 Producing an apparatus to separate and to collect krypton in the atmosphere

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One of the important radionuclides being in environment is krypton-85. After emission to the atmosphere, this nuclide is spread over the earth according to advection and diffusion of the atmosphere, therefore the nuclide is noted as large-scale tracer of atmospheric circulation. And it is also noticed as the method to decide the age of environmental water. Thus, it is very useful to study about krypton in the atmosphere. So we are studying for the purpose of producing an apparatus to separate and to collect krypton in the atmosphere. At first, we examined vials to use at the measurement. As a result, Teflon vial was inappropriate for escaping krypton to outside. Next, we examined the gaschromatographic column for kind and temperature. After decision of the column, we actually injected the air and separated and collected

krypton. At this point, we also check separation condition of krypton.

3P14 Research of the environmental water dynamics using tritium as a tracer

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The tritium, which is formed with the cosmic ray in the atmosphere exists mainly in chemical form of the water. Environmental water, such as rain water and the river water, mutually has close relations. The tritium can be an important index in thinking about this water circulation. So the concentrations of the tritium were measured for environmental water samples. We estimated the underground water residence time by the compartment model in the Umi river, Fukuoka Prefecture. We used MOGRA(Migration Of Ground Additions) for analysis.

3P15 Effect of tritium injecting methods on the HT, CH₃T and CH₄ emission trends from stainless steel surface

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Unknown methane contamination occurs by the metal-metal collision or friction of stainless steel (SS). After T₂ gas was injected into the inner surface and many small SS balls placed in a canister made of SS, the contamination was simulated by shaking the canister. We reported previously that emission from SS canisters which tritium was injected by heating only (Thermal method). In this presentation, we injected tritium into a new SS canister by heating with shaking (Mechanical method). We simulated the contamination as well as previously reported, and compared these trends. The specific radioactivity of methane (CH₃T/CH₄) was almost constant with repeated extraction from the canister which injected by Thermal method. On the other hand, it was decreased by Mechanical method. The ratio between CH₃T and HT was almost constant from each canister. It was thought that the depth profile of T to H in SS injected tritium by Thermal method was almost constant, whereas it was high at near the surface by Mechanical method.

3P16 Examination on electroplating of Po on stainless steel disk

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²¹⁰Po is usually measured by isotope dilution alpha spectrometry. Hence it is important to prepare thin Po source with good recovery and convenience. In this work electroplating of Po on stainless steel disk was examined with making a change in conditions such as major anion species, presence of other metal-ion, temperature, current and plating time. On the hydrochloric acid, nitric acid and phosphoric acid solution

of Po gave good recovery, but sulfuric acid gave poor recovery. Two hours plating is sufficient on 0.2A at 90°C.

3P17 Investigation on extraction methods of environmental iodine with using I-126

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(^aRes. Reactor Inst., Kyoto Univ., ^bJAEA)

In analysis of environmental iodine, samples containing low I-129 are subject to contamination from reagents and apparatus. We measured the isotopic ratio of I-129/I-127 in brine which was collected at Mobara in Chiba prefecture and was characterized as having a high iodine concentration and a low isotopic ratio. The results, however, showed high isotopic ratios.

We suspected that the contamination was caused by using halogen containing reagents because the samples treated with Cl-form anion exchange resin in iodine extraction process were strongly contaminated. In this study, we have conducted halogen-free extraction processes such as ion exchange and solvent extraction whose recovery has been investigated with gamma spectrometry of I-126 produced through photonuclear reaction with the KURRI LINAC. The total iodine recovery through ion exchange with NO₃-form anion exchange resin and solvent extraction with dodecane was more than 80%.

3P18 Energy distributions of environmental neutron in liquids and solids

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Depth profiles of environmental neutron fluxes in freshwater, seawater, concrete, iron and lead have been measured by activation method of gold foils. Depth profiles of gold activity and neutron flux have been simulated by Monte Carlo neutron transport codes (MCNPX2.4.0) and the results were compared. The simulated depth profiles were well reproduced in all the experimental results, in case of using good MCNPX parameter sets. The energy distribution of environmental neutron source, especially fast neutron components, and its shape in air is significant for the depth profiles of flux. MCNPX is able to estimate environmental neutron flux, energy distribution, and induced activities in any materials at any depth. Our results are useful for the erosion and dating study in geo-science field, for the low-level radioactivity measurements, and for the design of detector and its shield.

3P19 Research of determination method of U and Th isotopes in river water by solid-phase extraction / alpha spectrometry

TAKAHASHI, K. HIRAI, S. OKADA, Y.

(Musasikougyo Univ)

Various alphaemitter that discharges the alpha ray exists in the natural world. Therefore, alphaemitter can be found in all places. The research

which these examine distribution is nature water. There is a solid-phase extraction method in the fixed quantity method and the collection method of trace alpha emitter.

The present study is Research of determination method of U and Th isotopes in river water by solid-phase extraction method.

3P20 Correlation between 212 , ^{214}Pb activities and lead concentration in the atmosphere by a gamma-ray measurement installing an *in-situ* weather monitoring station

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In this work, we have developed a gamma-ray measurement of ^{212}Pb and ^{214}Pb activities in the atmosphere in Tokushima using an high volume air sampler installing an *in-situ* weather monitoring station. The weather monitoring station was set up nearly close to the air sampler on the rooftop of the north building of School of Health Sciences at Kuramoto Campus. Using this weather monitoring station, it has been possible to observe the general weather conditions at the same time with collecting aerosol particles in the atmosphere. For the determination of lead concentration in the atmosphere, a soluble fraction was eluted by 1 M HNO_3 from a glass fibre sampling filter after the gamma-ray measurement of one sample, and the amount of lead atoms contained into the fraction was analyzed by a graphite furnace atomic absorption spectrometry. As a result, the present measurement system of $^{212,214}\text{Pb}$ activities in the atmosphere has enabled us to investigate correlation between their activities and lead concentration in the atmosphere under the different weather conditions.

3P21 Variation in the atmospheric concentrations of ^{214}Pb at Kawasaki, Japan

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Every four hours variations in atmosphere ^{214}Pb concentrations were observed at Kawasaki, Japan. The variation patterns within 24 hours of the atmospheric concentration of short-lived ^{214}Pb (half-life: 26.8 min.) is similar to that of ^{212}Pb (half-life: 10.6 h.). The variation in atmospheric concentrations of the short-lived ^{214}Pb was observed to depend strongly on the local meteorological conditions in a short period. High concentrations of ^{214}Pb tend to appear on the days with westerly wind from inland area, low wind velocity and without precipitation.

3P22 Development of a graded screen array for measuring size distribution of radioactive nano-particles

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In this work, we developed a prototype of the graded screen array (GSA) system optimized for measuring a size distribution of radioactive nano-particles formed in operating accelerators. The GSA is a useful technique for measurement of particle size distributions of small aerosols as well as the wire screen diffusion battery (DB). Although both of the GSA and DB separate the aerosol particles depending upon their diffusion coefficients using wire screens, the GSA has advantages of small size and rapid measurement over the DB. The small GSA can be placed in an accelerator room during machine operation and collect the nano-particles just after their formation by radiation. We found optimal parameters for the GSA system such as mesh size and diameter of wire screens, data processing method, air flow rate, and sampling duration. The prototype GSA system was examined using actually formed nano-particles in the 46-MeV electron linac at Kyoto University Research Reactor Institute.

3P23 Radioactivity content of papers (V)

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The radioactivities of naturally occurring radionuclides and ^{137}Cs in the ashes of papers were estimated from the data of the nuclide contents of the papers obtained in the previous works and ash content data obtained in this work. The average ^{226}Ra , ^{228}Th , and ^{40}K contents of all the 34 samples were respectively 27, 75, and 75 Bq kg^{-1} . The radium equivalent of the ashes was calculated to be 129 Bq kg^{-1} . The radionuclide contents of the ashes were compared with those of granite and the earth crust, and the level of the radioactivity contained in the ashes was discussed from the view point of radiation exposure.

3P24 Synthesis and crystal structures of the uranyl(VI) complexes coordinated by terpyridine

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Single crystals of $\{[\text{UO}_2(\text{OH})(\text{MeOH})(\text{terpy})]_2[\text{UO}_2(\text{NO}_3)_4]\}$ and $\{[\text{UO}_2(\text{NO}_3)(\text{terpy})]_2\text{O}_2\}$ have been synthesized, and the two crystal structures have been determined by using X-ray CCD. $\{[\text{UO}_2(\text{OH})(\text{MeOH})(\text{terpy})]_2[\text{UO}_2(\text{NO}_3)_4]\}$ has two distinct uranium atoms, a hexagonal-bipyramidal U(1) of $[\text{UO}_2(\text{NO}_3)_4]^{2-}$ and a distorted pentagonal-bipyramidal U(2) of $[\text{UO}_2(\text{OH})(\text{MeOH})(\text{terpy})]^+$. The equatorial positions of U(1) are occupied by the two monodentate nitrate ions and the two bidentate nitrate ions. The equatorial plane of U(2) is accommodated with one terpy molecule, one hydroxyl ion and one MeOH molecule. The $\{[\text{UO}_2(\text{NO}_3)(\text{terpy})]_2\text{O}_2\}$ contains the distorted hexagonal-bipyramidal geometry about the uranyl(VI) ion. The equatorial plane of the bipyramid includes three N atoms of the terpy molecule, one O atom of the monodentate nitrate ion and two O atoms of the peroxide ion. The peroxide ion bridges between two uranyl(VI) ions in $\{[\text{UO}_2(\text{NO}_3)(\text{terpy})]_2\text{O}_2\}$.

3P25 Crystal structures of $[\text{UO}_2(\text{acac})_2(4\text{-R-py})]$ (R = H, Me, Et, Bu, OMe, NMe₂)

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The crystal structures of the pentagonal bipyramidal uranyl(VI) complexes having 4-substituted pyridines, $[\text{UO}_2(\text{acac})_2(4\text{-R-py})]$ (R = H, Me, Et, Bu, OMe, NMe₂), are discussed. The U–N bond lengths (2.515–2.668 Å) are well correlated with the electronic properties of the substituents of the pyridine; 2.668 Å for R = CN and 2.603 Å for N(CH₃)₂. The U=O (1.755–1.789 Å) and U–O(acac) (2.342–2.366 Å) bond lengths are also affected with the substituents though some steric effects may be present; both the U=O and U–O lengths become longer as the U–N lengths are shorten, and the degree of the change is larger for the U=O length. The O(acac)–U–O(acac') (138.0–143.4°) and the dihedral angles between the equatorial plane and pyridine rings (37.8–56.1°) are also correlated with the U–N bond lengths.

3P26 Study on the separation of Am(III) from Eu(III) using self assembled monolayers

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It is expected that self assembled monolayers (SAMs) have the ability of selective absorption for metal ion based on HSAB principle. So, the absorption behavior of ^{152,154}Eu(III) and ²⁴¹Am(III) from (H, Na)NO₃ solution using 3-MPTS (3-mercaptopropyltrimethoxysilane) SAMs on SiO₂ particle (grain size; 1–5 μm) was investigated. In the region 4 < pH of the solution, 3-MPTS SAMs have an excellent affinity for both Am(III) and Eu(III). On the other hand, in the region pH < 4, 3-MPTS SAMs have stronger affinity for Am(III) than for Eu(III). It was found as the (H, Na)NO₃ concentration in the solution increases, the absorption for Am(III) and Eu(III) onto the 3-MPTS SAMs decreases.

3P27 Solvent extraction of Eu(III) and Am(III) using sulfur-coordination ligands.

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Solvent extraction of ^{152,154}Eu(III) and ²⁴¹Am(III) using sulfur-coordination ligands, such as toluen-3,4dithiol (TDT), 4,4'-diphenyltetrafulvalene (DPTTF), 1,4,7,10,13,16-hexathiacyclooctadecane (18-ane-S₆), 5,5'-dihexyl-2,2'-bithiophene (DHBT), 2,2':5',2"-terthiophene (TT), 2,5-bis(5-tert-butyl-2-benzoxazolyl)thiophene (BTBTT)), was carried out. When the organic phase was 1,2-dichloroethane or nitrobenzene containing a sulfur-coordination ligand alone and the aqueous phase 0.10 mol/dm³ sodium nitrate solution, it was found that Eu(III) and

Am(III) were extracted in the region of 4 < pH < 7. The distribution ratios, $D_{\text{Eu(III)}}$ and $D_{\text{Am(III)}}$, were nearly same values, or $D_{\text{Eu(III)}}$ was somewhat higher than $D_{\text{Am(III)}}$. It was also proved that the values of $D_{\text{Eu(III)}}$ and $D_{\text{Am(III)}}$ in the case of the organic phase of 1,2-dichloroethane containing a hydrophobic anion, TFPB, were higher than those without TFPB.

3P28 Determination of standard transfer energy of TcO₄⁻ ion between aqueous and organic solution phases

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The Gibbs energy for transfer ($\Delta G_{\text{tr}}^\circ$) of an ion between aqueous and organic solution phases is a fundamental parameter for distribution of the ion on solvent extraction. In the present study, the $\Delta G_{\text{tr}}^\circ$ of TcO₄⁻ was determined by partition method which is based on comparison of extractability of the ion and the reference ion, that is, NO₃⁻. The aqueous solution phase of 5 ml of HNO₃ containing TcO₄⁻ and the organic solution phase of 5 ml of tetrabutylammonium nitrate were mixed to be ion transfer equilibria. The $\Delta G_{\text{tr}}^\circ$ of TcO₄⁻ was calculated from standard ion transfer potential of NO₃⁻ and partition coefficients of these ions based on the Nernst equation. The $\Delta G_{\text{tr}}^\circ$ of TcO₄⁻ is found to be close to that of ClO₄⁻ whose ion size is similar to that of TcO₄⁻.

3P29 A study on adsorptivity of U(IV) onto monoamide resins

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Novel silica-supported monoamide resins have been investigated to develop resins with selectivity for U(VI) in HNO₃ media. It is known that monoamides extract also Pu(IV) in solvent extraction systems, and adsorptivity of Pu(IV) onto the resins may show different trends from the viewpoint of the three-dimensional conformation. In this study, batch experiments were carried out by using U(IV) as the simulated ion of Pu(IV). U(IV) was prepared by electrolytic reduction of U(VI). The adsorption studies have shown that Silica-VP(1), a pyrrolidone-based resin, has little difference in distribution ratio, K_d , between U(IV) and U(VI) from 0.2 to 9M HNO₃. While, U(IV) was not adsorbed onto Silica-DMAA(1), an acryl-based resin, in the concentration range of HNO₃ up to ca. 6M, which suggests that Silica-DMAA may have selectivity for U(VI).

3P30 Determination of ⁷⁹Se in radioactive waste samples

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On disposal of radioactive waste packages, evaluation of radioactivity inventories in the packages is required. Selenium-79 is one of the important nuclides from the viewpoint of safety assessment for disposal of radioactive waste, because of its very long half life. In the present

study, simple determination method for ^{79}Se was developed and applied to actual radioactive liquid waste samples arising from fuel reprocessing test facilities in Japan Atomic Energy Agency. Radioactivity concentrations of ^{99}Tc in the liquid waste samples were also determined by radiochemical analysis. The numbers of ^{79}Se and ^{99}Tc atoms in the liquid waste samples were estimated with a computer code (ORIGEN2). The half-life of ^{79}Se estimated from the results of radiochemical analysis and calculation was in good agreement with He, M., Jiang et al.'s reported value of 2.80×10^5 y.

3P31 Redox behavior of Ce(IV)/Ce(III) in the presence of organic acids

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We investigated the redox reaction of Ce(IV)/Ce(III) in the presence of NTA or desferrioxamine B (DFO) by CV and column electrolysis (CE). The cyclic voltammogram of Ce-NTA complex at pH 6.0 showed the reversible one-electron transfer at 0.51 V (vs. Ag/AgCl) (E_{NTA}). The E_{NTA} was independent of pH between 3.5 -7 and of the NTA concentration between 0.005-0.2 M, indicating that no association and dissociation of H^+ and NTA were occurred during the redox reaction of Ce-NTA complex. As the predominant species of Ce(III)-NTA complex is $\text{Ce}^{\text{III}}(\text{nta})_2^{3-}$ at the condition, the redox reaction was represented by: $\text{Ce}^{\text{IV}}(\text{nta})_2^{2-} + e^- \leftrightarrow \text{Ce}^{\text{III}}(\text{nta})_2^{3-}$. The coulopotentiogram of Ce-DFO complex at pH 7.3 showed the one -electron transfer at -0.055 V (E_{dfo}). The E_{DFO} lowered as pH increased from 7.3 to 10.6, showing that the H^+ was involved in the redox reaction, while it was constant at pH 10.6-12. The potentiometry of Ce(III)-DFO complex showed that the predominant species were $\text{Ce}^{\text{III}}(\text{Hdfo})^+$ and $\text{Ce}^{\text{III}}(\text{dfo})^0$ (H_2dfo : DFO) at pH 6.7-10.8 and 10.8-12, respectively. Hence, the redox reactions of Ce-DFO complexes were represented by: $\text{Ce}^{\text{IV}}(\text{dfo})^+ + \text{H}^+ + e^- \leftrightarrow \text{Ce}^{\text{III}}(\text{Hdfo})^+$ (pH<10.8), $\text{Ce}^{\text{IV}}(\text{dfo})^+ + e^- \leftrightarrow \text{Ce}^{\text{III}}(\text{dfo})^0$ (pH>10.8).

3P32 Radiocarbon dating of the silk fabrics laced with colored threads "Ezo Nishiki" by AMS

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Ezo Nishiki is silk fabrics laced with colored threads. They were imported into Japan from China by way of Amur valley and Sakhalin. The foreign commerce via this route is called Shandan trade. The beginning of Shandan trade can be traced back to 13th century by ancient documents and records, and it was disappeared in the latter half of 19th century. Most of Ezo Nishiki, however, have no definite woven ages. In this study, we measured radiocarbon ages of several Ezo Nishiki by AMS to estimate their woven ages. The radiocarbon dating indicated

that all the measured Ezo Nishiki were imported from the Qing dynasty during a period from the middle 17th to the middle 19th century.

3P33 Radiolysis of water on some oxides

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The Radiolysis of water is one of the ways to generate hydrogen gas. Hydrogen gas generation from water radiolysis on some oxides is studied. After ^{60}Co gamma-ray irradiation of vials contain catalyst and solution, hydrogen gas is detected by gas chromatography. The amount of generated Hydrogen gas is converted to G-values. The most G-values with catalyst are larger than the G-value without catalyst, and the G-value is max with SiO_2 as catalyst. We use several aqueous solutions instead of pure water. The increases of G-values are observed with KHSO_4 solution, NaHSO_4 solution and Na_2CO_3 solution.

3P34 Bacterial distribution and possible activity in deep subsurface environment

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When consider nuclear waste deposit into deep subsurface environment, knowledge of in situ bacterial abundance, diversity and activity must be substantial. However, studies in terrestrial deep subsurface are in particular limited. Bacterial distribution and community structure was examined in relation to geological setting for deep subsurface water with samples from boreholes in Horonobe, northern Hokkaido, Japan. Total direct count of bacteria (TDC) in groundwater amounted to 4.61×10^4 - 5.06×10^6 cells/mL. Bacterial vertical profile can't be explained simply by the knowledge obtained from marine systems'. Very high frequency of dividing cells of bacteria, an indicator of bacterial growth potential, was observed in a transition zone between two sedimentary rock formations of HDB-6-1. HDB-4, 1.5km northwest of HDB-6, was characterized with high abundance of domain *Archeae* contributing 10 to 20% to TDC, where *Methanosprillum* sp. was found by 16S rDNA. CH_4 vertical profile supported their possible activity in in situ. Bacterial distribution and possible functions are suggested to be clearly constrained by the geological property in deep terrestrial subsurface.

3P35 Involvement of the target of rapamycin (TOR) to uptake of amino acid and ammonia

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The target of rapamycin (TOR) is a highly conserved protein kinase that plays a central role in the control of cell growth. Fission yeast possesses Tor1 and Tor2. Tor1 is not essential for growth while Tor2 is essential. Temperature-sensitive *tor2* mutants mimicked nitrogen starvation response at the restrictive temperature, as the mutant displays a number of phenotypes that are normally induced only upon nitrogen deprivation. Here we characterized the uptake of amino acids and ammonia (nitrogen source) in the *tor2* mutants. The results showed that uptake of amino acids decreased rapidly upon temperature shift, while that of ammonia decreased only slowly. Rheb is a small GTPase that binds to and activates TOR. A constitutively active mutant for *rheb1*, *rheb1-10*, showed reduced a level of uptake of amino acids, while *rheb1-10tor2* double mutant recovered the uptake. The results suggest that Tsc1/Tsc2-Rheb pathway controls amino acid uptake via Tor2.

3P36 Rapamycin sensitivity of fission yeast TOR

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The target of rapamycin (TOR) is a highly conserved protein kinase that plays a central role in the control of cell growth. In the cell, TOR forms two distinct complexes, TOR complex 1 (TORC1) and TOR complex 2 (TORC2). Binding of the rapamycin-FKBP12 complex to TORC1 inhibits the TOR kinase activity and elicits a number of responses that appear to mimic nitrogen starvation response. These include a decrease in translation and ribosome biogenesis, changes in gene expression, altered sorting and turnover of nutrient permeases, induction of autophagy and cell cycle arrest at G1. Although growth is not inhibited with rapamycin, fission yeast possesses Tor1 and Tor2. Tor1 is not essential for growth while Tor2 is essential. Temperature-sensitive *tor2* mutants mimicked nitrogen starvation response at the restrictive temperature, as the mutant displays a number of phenotypes that are normally induced only upon nitrogen deprivation. Here we obtained novel Tor2 mutants whose growth was inhibited with rapamycin. The mutants mimicked nitrogen starvation response upon addition of rapamycin, which depended on FKBP12. The results suggest that Tor2 is a possible target of rapamycin in fission yeast.

3P37 Analysis of thyroid disrupting activities of environmental compounds using various assays

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Chlorinated phenol compounds, such as the chlorinated derivatives of bisphenol A, detected in effluents from paper manufacturing plants. We investigated the effects of endocrine disrupting chemicals (EDCs), such as bisphenol A, nonylphenol and their chlorinated derivatives,

o-*t*-butylphenol and 2-isopropylphenol on the binding of [¹²⁵I]3,3',5-L-triiodothyroine ([¹²⁵I]T₃) to the *Xenopus laevis* plasma thyroid hormone carrier protein, transthyretin (xTTR) and the ligand binding domain of *X. laevis* thyroid hormone receptor β (xTR LBD), and on T₃-induced metamorphosis in *X. laevis* tadpoles. Scatchard plots of T₃ binding to xTTR and xTR LBD revealed a single class of T₃ binding sites, with K_d values of 7.1 nM and 0.28 nM, respectively. Among the test chemicals, 3,3',5-trichlorobisphenol A and 2,4,6-triiodophenol were potent inhibitors of [¹²⁵I]T₃ binding to xTTR and xTR LBD, respectively. 3,3',5-Trichlorobisphenol A (2 μM) and 2,4,6-triiodophenol (1.2 μM) acted as T₃ antagonists in the *X. laevis* tadpole metamorphosis assay using endogenous T₃ responsive gene as a molecular marker. 2-Isopropylphenol and *o*-*t*-butylphenol, for which xTTR and xTR LBD had weak or no affinity, showed T₃ antagonists activity in the metamorphosis assay. Chemicals, detected in water downstream of effluents from paper manufacturing plants, interacted with xTTR using the TTR assay. Our results suggest that EDCs target the process of T₃ binding to xTTR and xTR LBD resulting in the interference with the intracellular T₃ signaling pathway.