2006-1226: EDUCATIONAL ACHIEVEMENTS IN NUCLEAR AND RADIOCHEMISTRY AT THE UNIVERSITY OF TEXAS AT AUSTIN

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Educational Achievements in Nuclear and Radiochemistry at the University of Texas

Abstract

Over the last three years we have developed a very robust nuclear and radiochemistry program at The University of Texas at Austin. The cornerstone of support was the DOE Radiochemistry Educational Award Program (REAP) which was awarded from 2002-2005. A second award for the period of 2005-2008 was just received. This award has enabled us to support many educational activates from vanguard classroom instruction, to laboratory enhancements, to research activities at the graduate and undergraduate levels. Both traditional radiochemistry and advanced topics in nuclear instrumentation have been supported.

Introduction

In the last two decades there has been an increased realization that training of scientists and engineers in radiochemistry and nuclear chemistry is of vital significance to the goals of national laboratories, industry, and hospitals and medical institutions. More recently, the aims of the Department of Homeland Security have also included radiological (dirty bomb) scenarios as part of their mission to prevent and track such events. In the 1990's the Department of Energy set up the Radiochemistry Research Award Program (REAP) to help universities develop more active educational and research opportunities in a wide variety of areas. In August 2005, the Nuclear and Radiation Engineering Program at the University of Texas received its second three-year REAP grant largely due to the success of both traditional radiochemistry and more advanced nuclear chemistry teaching and research. Increased interactions with national laboratories, placement of students in radiochemistry careers, and significant pedagogical improvements all contributed to the second REAP award.

Educational Activities

The cornerstone of the educational activities revolves around a series of complimentary courses and training in radiochemistry. These courses include the following:

Nuclear and Radiochemistry

The subjects are taught in a web-based format for the graduate course in nuclear and radiochemistry. The subjects taught include pioneers and the historic events in nuclear and radiochemistry, a nuclear and radiochemistry overview, naturally-occurring radiation and radioactivity, counting statistics, radioelements, isotopes and nuclides, physical properties of atomic nuclei, radioactive decay, decay modes, neutron activation analysis, and the nuclear fuel cycle. Further topics that have recently developed include radionuclides in geo-cosmochemistry, dating techniques, actinide chemistry, production of radionuclides and labeled compounds. Experimental laboratories include health physics and safety, determination of fission activity, counting statistics, solvent extraction, alpha particle analysis, neutron activation analysis, metal ion adsorption at solid/water interfaces and liquid scintillation counting. Further experiments being considered include ^{99m}Tc production and its separation through the ^{98}Mo(n,γ)^{99}Mo → ^{99m}Tc reaction, low-level gamma ray counting and fission product separation. A detailed and complete description of the web-base course is given elsewhere[1].

Nuclear Health Physics

The subjects covered in health physics include an overview of health physics, atomic structure, sources of radiation, radioactivity, interaction of radiation with matter, interaction of gamma-rays, neutron interactions, radiation dosimetry, chemical and biological effects of radiation, radiation protection guidelines and nuclear medicine/pharmacy.

Radiation and Radiation Protection Laboratory

The lecture subjects covered in the radiation and radiation protection laboratory include: nuclear instrumentation, Geiger-Mueller counters, neutron shielding, neutron activation analysis, radiation counting statistics, gamma-ray shielding, gamma-ray spectrometry and low-level gamma ray counting. Experimental laboratories include; personnel monitoring, radiation statistics, natural background and low level fission product identification, neutron shielding, gamma-ray shielding, sodium iodide, alpha counting for uranium and reactor health physics.

Radioactive Waste Management

The subjects covered in radioactive waste management include: an overview of the nuclear fuel cycle and power generation, first order decay and nuclear reactions, radiation sources, exposures, health effects of radiation, low-level waste management, spent fuel management high-level waste management, TRU waste management, uranium mill tailings management, mixed waste management, disposal of radioactive waste forms, environmental restoration, isotopes in everyday life, transportation, and decommissioning and decontamination.

Nuclear Fuel Cycle

A survey of the nuclear fuel cycle, including resource acquisition, fuel enrichment and fabrication, spent fuel reprocessing and repository disposal. Nuclear fuel management and reactor physics are addressed in the context of fuel burnup calculations. In addition to treatment of engineering aspects of fuel cycles, the course utilizes cross-disciplinary tools such as cost-benefit and environmental impact analyses. In addition to fuel cycles currently in use, advanced fuel cycle concepts currently being presented in the technical literature are studied. The course also includes a group project to research, analyze and document the technical, economic and/or environmental ramifications of one of these advanced fuel cycles.

Mathematical Methods for Nuclear and Radiation Engineers

Fundamental mathematics necessary for graduate studies in nuclear and radiation engineering are given. The topics include statistics, experimental data, propagation of error, detection limits, differential and partial differential equations encountered in graduate level nuclear and radiation engineering courses. Both time dependent and space dependent solutions are covered.

Software Development

To better train graduate students in nuclear and radiochemistry in data handling and systems analysis two software programs have developed. One program is the use of EXCEL files and GENIE-2000 (Canberra) for neutron activation analysis. This allows the student to automatically use the sophisticated peak fitting algorithm in gamma-ray spectra and use EXCEL to calculate the final trace elemental concentrations and detection limits. The second software program developed is the Nonproliferation Assessment Tool (NAT) for teaching proliferation concepts regarding the nuclear fuel cycle. The NAT software package is an advancement in the field of nuclear nonproliferation because of its ability to collect, manipulate, analyze, and store large amounts of Nuclear Fuel Cycle (NFC) facility data in order to produce a comparative Proliferation Resistance (PR) value as well as a Nuclear Security (NS) measure for NFC facilities and facility chains, respectively.

Many of the students are also encouraged to use the standard codes of ORIGEN (Oak Ridge Isotope Generation and Depletion Code) and ORIGEN ARP for a variety of nuclear fuel cycle studies, and MCNP (Monte Carlo Neutron Particle) transport code used for shielding and nuclear medicine. Los Alamos National Laboratory developed the code many years ago and continues to support it and hold training sessions on its use.

Research Activities

A major component of our funded research activities are radiochemistry, nuclear chemistry, nuclear medicine, dosimetry, nuclear materials and nuclear fuel cycle studies. Below is a comprehensive list of PhD and MS titles in the past several years.

PhD Dissertations

Feasibility Study of *In Vivo* Partial Body Potassium Determination in the Human Body Using Gamma-Ray Spectroscopy

Evaluation of the Impact of Non-Uniform Neutron Radiation Fields on the Dose Received by Glove Box Radiation Workers

Development of Neutron Beam Analytical Techniques for Characterization of Carbon Fiber Composite Materials

Characterization of Finnish Arctic Aerosols and Receptor Modeling

Development of Composite Materials for Non-Leaded Gloves for Use in Radiological Hand Protection

Radiological Dose Analysis of Target Materials for Accelerator Transmutation of Waste (ATW) Applications

Estimate of Radiation-Induced Steel Embrittlement in the BWR Core Shroud and Vessel Wall from Reactor-Grade MOX/UOX Fuel for the Nuclear Power Plant at Laguna Verde, Veracruz, Mexico

Active Interrogation of Highly Enriched Uranium

Alpha Radiation Effects on Weapons Grade Plutonium Encapsulating Materials

MS Theses

Creating a Robust, Reliable, Reproducible, Automated Electrodeposition System for Analyzing Trace Quantities of Actinides

Testing and Assessment of the Nuclear Fuel Cycle Simulator (NFCSim) Computer Code

Monte Carlo Simulations of Germanium Detector Efficiency Curves

Characterization of the University of Texas Nuclear Engineering Teaching Laboratory Beam Port 3 Texas Cold Neutron Source-Prompt Gamma-Ray Activation Analysis Facility

Monte Carlo Simulations of Germanium Detector Efficiency Curves

Minimizing Glovebox Breeches in Plutonium Handling Facilities at Los Alamos National Laboratory

Development of a Methodology for the Assessment of International Safeguards on the Commercial Nuclear Fuel Cycles of Argentina and Brazil

Mechanical Properties of Irradiated and Unirradiated High-Chromium Ferritic/Martensitic Steels for Use in Nuclear Applications.

Development of a Probabilistic Network Model to Simulate the Smuggling of Nuclear Materials

Health Physics in a Neutron Activation Analysis Laboratory

Developing Computer Models for the UREX Solvent Extraction Process and Performing a Sensitivity Analysis of Variables used for Optimizing Flowsheets for Actinide Transmutation

Characterization of the Prompt Gamma Neutron Activation Analysis System at the University of Texas at Austin

Health Physics Regulations and Requirements for the State of Texas Linear Accelerators

Demonstration of the Feasibility of a Nuclear Archeology Methodology

Assessment of Radiological Dosimetry from the Diagnosis and Treatment of Venous Sinus Thrombosis with Intracranial Hemorrhage

Methodology for Assessing the Proliferation Resistance of Accelerator Transmutation of Waste Technology Options

Heavy Metal Determination and Lead Leaching Dynamics of Soil at the Pantex Firing Range, Amarillo, Texas

Evaluation of the Decoupled BC454/NaI Detector Coincidence System in Detecting Neutrons in a High Gamma Ray Field

A Corrosion Study of AL-R8 (Sealed Insert) Plutonium Storage Containers

Process Modeling of Plutonium Conversion and MOX Fabrication for Plutonium Disposition

A Computational Model for the ANL Centrifugal Contactor

Evaluation of the Performance of Inconel Alloy 600 in Molten Salt Oxidation Environment

Determination of Photon Self Absorption Fractions for Neutron Activated Rare Earth Elements

Conclusion

The Radiochemistry Education Award Program and national lab funding has allowed the Nuclear and Radiation Engineering Program at the University of Texas to be at the forefront of nuclear and radiochemistry educational and research activities and help secure the next generation of such needed expertise.

References

1. S. Landsberger, E. Strassberg, K. Schmidt, J. Radioanal. Nuc. Chem., 261 (2005) 121.

Biographic Information

Dr. Steven Biegalski is an Assistant Professor in the Nuclear and Radiation Engineering Program. He specializes in the fields of nuclear instrumentation, neutron radiography, analysis of environmental media with nuclear methods, and modeling of environmental pathways. Prior to working for the University of Texas, Dr. Biegalski has utilized his expertise to support the development of technology in support of the Comprehensive Nuclear Test-Ban Treaty (CTBT). This includes the development and installation of environmental aerosol and xenon monitoring stations, the development of software to analyze data from the radionuclide monitoring systems, and investigation of the trends, sources, and origin of anthropogenic radionuclides in the environment. In the past, Dr. Biegalski has used this expertise for investigations of air pollution sources in the Arctic, assessing the toxic metal input into the Great Lakes, and working on global change modeling.

Dr. Sheldon Landsberger is a Professor in the Nuclear and Radiation Engineering Program and Director of the Nuclear Engineering Teaching Lab. He is primarily involved in the determination of heavy metals in environmental samples using nuclear analytical methods. He has had experience many years of experience in analyzing air samples from the Arctic, Great Lakes, and other urban and rural areas. In particular he has developed improved nuclear techniques to better determine the elements of critical importance in identifying regional sources of airborne particles, and characterizing solid waste leaching dynamics. His current research interests include low-level counting of natural radioactivity, corrosion studies, Compton suppression gamma-ray spectrometry and risk assessment in radioactivity handling.

Dr. Kendra Foltz Biegalski is a Research Engineer in the Nuclear and Radiation Engineering Program. She has fifteen years experience in nuclear engineering, nuclear and chemical analytical techniques, and two years of nuclear reactor operations. She has thirteen years domestic and international experience in scientific research and collaboration as well as two years experience in the teaching, training, and licensing of nuclear scientists and nuclear reactor operators. Dr. Foltz Biegalski specializes in nuclear data analysis algorithm development for software applications. Prior to working for the University of Texas, Dr. Foltz Biegalski utilized her expertise to support the development of technology in support of the Comprehensive Nuclear Test-Ban Treaty (CTBT). This includes the development of software to analyze beta-gamma coincidence data from radioxenon monitoring systems.

Dr. Erich Schneider is an Assistant Professor in the Nuclear and Radiation Engineering Program. He has Schneider served as a technical staff member at Los Alamos National Laboratory. During his four years at LANL, Dr. Schneider has been involved in transmutation physics and systems analysis research activities for the US Department of Energy Advanced Nuclear Fuel Cycle Initiative (AFCI). His work in this area includes development of computational models for the simulation and optimization of nuclear fuel cycles, reactor physics calculations and cross section sensitivity analyses for advanced transmuting reactors and economic modeling including uranium resource base assessment. Dr. Schneider is also active in the areas of nuclear proliferation risk assessment, nuclear reactor and weapon safety, and reactor thermal hydraulic systems analysis.