Radionuclide Sensors for Water Monitoring

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Summary of Clemson University Accomplishments between June 1, 2003 and December 31, 2003
Number of Graduate Students Actively Involved in the Project: 4
Number of Undergraduate Students Involved (part-time) in the Project: 1 –

Completed off-line measurements of 99Tc with solid-state semiconductor detectors - Began evaluation of the above detection system for on-line measurements - Discontinued development of macroporous scintillating YSO - Conducted light collection efficiency of heterogeneous scintillators experiments and Monte Carlo simulations Batch sorption of 99TcO4- onto anion exchange resin and measurement with solid-state semiconductor detectors is completed. Solid-state semiconductor detection using a passived ion-implanted planar silicon (PIPS) detector of beta radiation from 99Tc is being investigated as an alternative to scintillation detection. There are advantages and disadvantages to each approach, which are being quantified. To utilize the CAM PIPS detector, 99TcO4- is being concentrated on DOWEX 1 resin. The batch procedure involves the aqueous solution and the resin coming in direct contact with the PIPS detector. The PIPS is spray coated with Teflon AF polymer to offer an additional thin (4-14 micrometers) barrier to the already rugged design. During equilibration time, the solution and resin are mechanically stirred. After sufficient contact time, the resin gravimetrically settles to the surface of the PIPS detector, at which point the detection commences. We are in the process of modifying this method for a continuous flow regime. With this new configuration the spent resin can be removed as a slurry from the detector and replaced with virgin resin. Using the batch arrangement we are able to obtain a detection efficiency of 14% with 0.01 g of resin. The background count rate 0.32 cps. The background count rate is significantly higher than one normally associates with a PIPS detector, this is the result of having to increase the amplifier gain to be able to observe the low energy deposition from the beta interaction. Reduction of the background may be accomplished by one of two methods: 1) digital signal processing or 2) cooling the detector to reduce the thermonic emissions. We are currently working on the former, if that is unsuccessful, we will work on the latter. Development of macroporous scintillating YSO as a replacement to the macroporous polystyrene based scintillator was concluded, unsuccessfully. A total of fifteen formulations of YSO fluor were attempted. BET measurement indicated that we were able to produce fairly high (691 m2/g) surface area materials, but with no measurable luminosity. Measurement of the luminosity was conducted by excitation of the YSO with 241Am and detection of the scintillation light with the Hidex Triathler. On the contrary, YSO that had good crystallinity, as measured by x-ray powder diffraction, and hence good luminosity (100% of P-47) had low surface area. It was concluded from these experiments that with the current formulation, in order to have high crystallinity and luminosity one needs to fire the sol-gel at high temperature (~1600 F), but to have high surface area one needed to fire at a lower temperature (~1100 F). A composite of ZnS: Ag-SiO2 porous phosphor was also produced. The purpose of this study is to prepare porous blue emission phosphor by combining ZnS:Ag and SiO2 to form a kind of composite material in such a way that ZnS:Ag provides the luminescence and SiO2 provides porous structure. The end result was a high porosity material that did not fluoresce. For our application, we desire both high luminosity (>10% NaI:Tl) and high surface area (>10 m2/g). Experiments were conducted to elucidate the impact of optical properties on light collection efficiency of heterogeneous scintillation flow-cell detectors. The optical transport Monte Carlo computer code, DETECT, is being used to model the experimental set-up. These experiments compliment earlier experiments where the charged particle energy deposition was measured and modeled. Significant effort was expended working with the model which was later determined to have a programming error. The latest version of the software, DETECT2000, has been obtained and is currently being utilized to model the experimental set-up.