U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **James V. Beitz** **Proposal No.: 99-0219**

Institution: **Argonne National Laboratory**

Collaborators: **None**

Title: **A Single Material Approach to Reducing Nuclear Waste Volume**

Our work is focused on an innovative single material approach for the selective sorption of most metal ion radionuclides from aqueous waste solutions and creation of a minimum volume, final nuclear waste form that is suitable for long term storage or geological burial. This work addresses the "New Technologies for Management of Nuclear Waste" field of research and development of the Nuclear Energy Research Initiative.

Our approach will significantly reduce the cost of treatment and disposal of radioactive aqueous solutions generated during routine nuclear power plant operations, such as equipment decontamination, and be applicable to treatment of contaminated water in spent fuel storage pools. The basis of our approach is a chemically functionalized porous silica ion exchange medium known as Diphosil. This material has been shown to selectively sorb highly charged metal ions from acidic aqueous solutions. We will determine its effectiveness for treatment of weakly acid to near-neutral pH aqueous solutions typically generated in nuclear power plant operations. We expect enhanced sorption of important weakly charged metal ions species, such as $Tc0_4^-$ and $Np0_2^+$, while retaining exceptional removal effectiveness for more highly charge metal ions, such as Co^{2+}, $U0_2^{2+}$, Am^{3+}, and Pu^{4+}. Diphosil itself is a poor high level waste form candidate due to the potential for radiolysis of its organic content. Our approach eliminates this deficiency.

In preliminary studies, we have shown for the first time that heating metal ion-loaded Diphosil removes its organic content and thermally densifies it to vitreous silica at temperatures far below those needed to make present nuclear waste glasses. Thermal densification microencapsulates and chemically fixes the sorbed metal ions in phosphate-rich embedded nanophases. Our research will establish the optimum conditions for thermal densification and determine and model the state of sorbed metal ions. We will use a variety of screening protocols, including TCLP, to establish the suitability of thermally densified Diphosil as a minimum volume nuclear waste form for storage or geological disposal of longlived radionuclides such as Tc-99 or Pu-239.

In summary, our single material approach will remove most metal ion radionuclides from aqueous waste solutions and provide a final waste form volume that is the minimum necessary to withstand high radiolysis levels over prolonged periods. Our work addresses a principal technical and scientific obstacle to the future use of nuclear energy in the United States, namely nuclear waste disposal.
