IMMOBILIZATION OF NUCLEAR WASTE IN CERAMICS AND GLASS MATERIALS: INCT EXPERIENCE AND FUTURE CHALLENGES

TOMASZ SMOLIŃSKI*, MARCIN ROGOWSKI, KATARZYNA KIEGIEL, ANDRZEJ G. CHMIELEWSKI

Institute of Nuclear Chemistry and Technology,16 Dorodna Str, Warsaw, Poland

** Corresponding author email: t.smolinski@ichtj.waw.pl*

Poland's evolving nuclear energy program necessitates the development of safe and efficient nuclear waste immobilization strategies. Among the globally recognized approaches, vitrification in glass and immobilization in ceramic materials have been extensively studied for their long-term stability, chemical durability, and capacity to accommodate radioactive waste. Institute of Nuclear Chemistry and Technology (INCT) has actively explored borosilicate glass and ceramic waste forms such as perovskite, zirconolite, and hollandite, called synthetic rock (synroc) as potential hosts for immobilizing radionuclides. A complex sol-gel process has been used for the synthesis of silica glasses and ceramic matrixes designed to contain high-level nuclear wastes. Cs, Sr, Co, and Nd (generically denoted Me) were used as nuclear waste surrogates, the last as a surrogate for actinides. Gels in the form of powders and sintered compacts were prepared by sol-gel routes from nitrate solutions. Thermal treatment studies were conducted on the resulting gels. Transformation to final products was studied by thermogravimetric analysis and X-ray diffraction. Laboratory studies have demonstrated the chemical durability and thermal stability of these materials, as well as their ability to incorporate a wide spectrum of radioactive elements. Additionally, under a strategic Polish program called GOSPOSTRATEG – GoHTR the materials have been recognized as potential future waste forms for HTR technology. Despite promising results, challenges remain in scaling up these technologies for industrial application, ensuring regulatory compliance, and integrating waste immobilization strategies with future nuclear energy developments in Poland. Addressing these challenges will be key to establishing a robust nuclear waste management strategy that aligns with Poland's energy transition and nuclear expansion plans.

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