Contribution ID: **342**

Type: **Poster**

Removal of Cs, Sr, Pu and Am from contaminated solutions by inorganic sorbents

Thursday, 22 April 2010 12:00 (20 minutes)

Recently growing concern about contamination of the environment with radioactive and non-radioactive pollutants resulted in intensive studies related to the development of new technologies for separation of radionuclides from liquid waste. These new technologies should be based on highly selective materials (e.g., crystalline titanium silicates) which are hard to decompose over a wide range of pH, which remain stable at high temperatures, which are resistant to ionizing radiation and which are able to operate in the presence of a great excess of competitive ions, organic solvents and oxidants. However, complicated technologies, high capital and regeneration costs stimulated studies to develop low-cost and efficient technologies based on naturally occurring minerals such as zeolites and clay minerals. Another option could be an application of amorphous porous mixed oxides - a rapidly developing class of materials prepared by sol-gel procedures, the main benefit of which are very simple procedures conducted under mild reaction conditions in the ambient atmosphere. Ferrites and a variety of iron-containing minerals such as akaganeite, feroxyhyte, ferrihydrite, goethite, hematite, lepidocrocite, maghemite and magnetite are also a promising class for the treatment of liquid wastes containing radioactive and hazardous metals.
The aim of this study was to prepare amorphous TiSi by sol-gel procedures, to synthesize various iron oxides, to characterize them using IR, XRD, Mössbauer spectroscopy and to carry out a comparative assessment of possible application of these low-cost synthetic inorganic sorbents with conventional and natural sorptive materials in liquid waste treatment technologies to remove long-lived radionuclides such as Cs, Sr, Pu and Am.
Results obtained using a bath method, ICP-MS, gamma;, alpha; spectrometry and beta; counting revealed that titanium silicates, synthesized using TiOSO₄ without reference to the chosen method - a precipitation or sol-gel, showed the highest sorption ability towards studied radionuclides. Magnetite and clay minerals showed better sorption ability towards americium. The highest Pu K_d values and better Pu sorption kinetics were found for synthetic iron oxides. An increase in the Pu K_d value by a factor of 6.8 found for magnetite/hematite composite in comparison with the pure magnetite suggests that this sorbent is efficient for plutonium removal and it is promising for its separation from contaminated solutions. TiSi tested in this study showed close sorption ability towards studied radionuclides in comparison with crystalline TiSi, whereas they were synthesized under mild conditions using cheaper materials. In addition, TiSi prepared by the sol-gel method has certain advantages in comparison with the fine powder TiSi because of a huge potential for tailoring of chemical composition, porosity and surface properties, as well as for the production in the granular form, which is especially important for practical purposes.

The research was supported by the Ministry of Education and Science of the Republic of Lithuania and the Lithuanian State Science and Studies Foundation projects V-19/2009.

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Session Classification: Poster Session - Chemistry of Nuclear Fuel Cycle, Nuclear Waste Management

Track Classification: Chemistry of Nuclear Fuel Cycle, Radiochemical Problems in Nuclear Waste Management