Contribution ID: **90** Type: **not specified**

LANTHANIDE-BASED NANOPARTICLES FOR MULTIMODAL MOLECULAR IMAGING AND TARGETED ALPHA THERAPY

Purpose: To assess the in vitro retention of therapeutically relevant radionuclides such as in vivo α-generators Ra-223, Ac-225, and Th-227 in lanthanide phosphate (LnPO4) and lanthanide vanadate (LnVO4) core-shell nanoparticles (NPs) towards their promising application as multifunctional platforms in nanomedicine.
Method and Materials: LnPO4 and LnVO4 core-shell NPs doped with either Eu-156, a radionuclide "cocktail"of Sr-85, Sr-89, Eu-156, or in vivo α-generators Ra-223, Ac-225, and Th-227 were synthesized in aqueous media. In vitro retention of radionuclides was assessed by dialyzing the radioactive NPs suspensions against deionized water and quantifying the activity in dialysate aliquots over time using a high purity germanium detector. The crystal structure, morphology, colloidal stability, luminescence and magnetic properties of LnPO4 and LnVO4 core-shell NPs were evaluated.
Results: Partial retention of Eu-156 (~70–95%) and Sr-85 (>80%) was evidenced in LnPO4 core NPs, while Th-227 and decay daughters were retained quantitatively (>99%) in LaPO4 core-shell NPs. Gd0.8Eu0.2VO¬4 and GdVO4 core-shell NPs showed partial retention of Ra-223 (~75 %), Ac-225 (75–95%), and Th-227 (>96%). Retention of decay daughters in LnVO4 NPs was enhanced after deposition of nonradioactive shells. Adjusting the lanthanide concentration provided luminescence and magnetic properties for fluorescence and magnetic resonance imaging. Emission intensities were higher for LnVO4 NPs with respect to LnPO4, whereas no significant difference was observed in the magnetic susceptibility. GdVO4 core NPs displayed enhancement of the signal intensity of T1-weighted images.
Conclusion: This work evidences the potential application of LnPO4 and LnVO4 core-shell NPs as platforms for multimodality molecular imaging and targeted alpha therapy. Partial retention of radionuclides may enhance the efficacy of treatment while minimizing the dose delivered to healthy organs. Radionuclide retention was influenced by the lanthanide concentration, the crystal structure, and the number of shells added.

Acknowledgments
This work was financed by the Virginia Commonwealth University (VCU) with the support of the Mechanical and Nuclear Engineering Department and NRC-HQ-84-14-FOA-002, Faculty Development Program in Radiation Detection and Health Physics at VCU. Work at ORNL was supported in part by (i) the U.S. Department of Energy Isotope Program within the Office of Nuclear Physics and (ii) an appointment to the Oak Ridge National Laboratory Nuclear Engineering Science Laboratory Synthesis Program, sponsored by the US Department of Energy and administered by the Oak Ridge Institute for Science and Education. We would like to thank the staff of Nuclear and Radiochemistry Group at ORNL for their help with radiochemistry and radioactivity measurements. The authors also wish to thank Dr. Joseph Turner from the Instrumentation Laboratory in the Department of Chemistry at VCU and the staff at the Nanomaterials Core Characterization Facility in the VCU College of Engineering.

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Presentation Type

Contributed Oral

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Track Classification: Targeting