Flibe Energy
partnered with
Pacific Northwest National Laboratory

NE-19-18706, Metal Organic Frameworks for Noble Gas Management in the Lithium Fluoride Thorium Reactor

YEAR AWARDED: 2019

TOTAL PROJECT VALUE: $500k (DOE: $400k, Flibe Energy: $100k)

STATUS: Completed

PRINCIPAL LAB INVESTIGATORS: Praveen Thallapally (PNNL), Parker Okabe (Flibe Energy)

DESCRIPTION: By utilizing a liquid fuel form with active removal of the fission product xenon from the fuel, Flibe Energy aims to offer its Lithium Fluoride Thorium Reactor (LFTR) as an asset for integration into a mixed energy generation portfolio that includes variable-generation sources such as wind and solar. The main challenge to the facility design involves active removal of noble gas fission products from the fuel salt. Using solid sorbents at near-room temperature, Flibe and Pacific Northwest National Laboratory (PNNL) have developed and demonstrated nanostructured materials called metal-organic frameworks (MOFs) for selective removal of xenon and krypton from process off-gases. The work done under this GAIN vouchers helps establish the viability of designing a dramatically improved approach to noble gas management as compared to activated carbon.

BENEFIT: PNNL and Flibe demonstrated the fabrication of metal organic frameworks (MOFs) into engineered beads to manage off-gases released from molten salt reactors. Among the many MOF options, SBMOF-1, originally synthesized at Stony Brook University in 2012, was selected as an ideal sorbent to manage off-gases released from a molten salt reactor because of its optimal pore size.

IMPACT: The SBMOF-1 was synthesized and fabricated into engineered particles using three different methods, with and without polymers. All the engineered particles were exposed to Co-60 radiation to demonstrate their radiation stability. Single column breakthrough experiments were performed at different temperatures, activation conditions, flow rates, and off-gas compositions to optimize the Xe capacity at the breakthrough point and at saturation.

SIGNIFICANT CONCLUSIONS: Based on the single column experiments, SBMOF-1 outperforms NUCON carbon at all the temperatures and reduces the mass (to as little as 55%) of sorbent needed to achieve the same performance as carbon. The bed volume is also reduced to 48% when the MOF is used. These results clearly demonstrate improvement in the amount of adsorbent needed and show a reduction in bed volume compared to traditional sorbent material.

NEXT STEPS: Though the MOFs identified as part of this program look very promising, several areas need significant improvement and would benefit from the following:

- Develop a mechanically robust particle with minimal loss in capacity.
- Optimize the desorption temperatures.
- Test the effects of particle size and effect of relative humidity on noble gas adsorption.
- Develop a radiation tolerant composite.
- Examine the effects of decay heat on MOF sorbent.
- Continue to improve the noble gas capacity and selectivity.
- Construct a bench-scale off-gas system and optimize SBMOF-1, then evaluate its performance in comparison with leading sorbent materials.