U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Novel Methods for Domestic Stable Isotope Production

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Pathway: Advanced Reactor Development

Abstract

3M Company proposes to develop and evaluate separation processes for the stable isotopes of lithium and chlorine, enabling existing and future nuclear reactor designs. Current domestic nuclear reactors rely on a sole-source Russian supply of lithium-7 hydroxide to maintain water chemistry due to the low neutron cross section of this lithium isotope. Next-generation molten salt reactors (MSRs) will also require large quantities of lithium-7 or chlorine-37 salts, depending on the reactor design. Notably, the Molten Chloride Fast Reactor (MCFR) currently under development by Southern Company in collaboration with TerraPower and Idaho National Laboratory will require metric tons of chlorine-37 for the fuel and coolant salts in its planned demonstration and commercial-scale reactors.

Currently there is no commercial production of chlorine-37 beyond gram quantities, and there is very little published research applicable to industrial-scale separation methods. Although significant scientific literature does exist on the topic of lithium isotope separation by complexation-based methods, none of these methods have been demonstrated on an industrial scale. The development of a cost-effective, environmentally-friendly, and continuous process capable of producing enough lithium-7 to meet the entire domestic PWR demand and scalable to meet future MSR demands for both lithium-7 and chlorine-37 would be a transformative technology for advanced nuclear power in the United States.

3M Company is proposing to evaluate three different potential solutions for chlorine-37 and lithium-7 production:

1. Liquid-liquid extraction [chlorine-37 and lithium-7]
2. Isotachophoresis [chlorine-37 and lithium-7]
3. Microchannel distillation [chlorine-37]

3M will develop the liquid-liquid extraction process in-house and partner with Pacific Northwest National Laboratory (PNNL) to develop isotachophoresis and microchannel distillation for chlorine isotope separation. Following preliminary investigations, 3M Company will downselect to the best technologies for chlorine and lithium isotope separation based upon scalability, predicted unit cost, and capital outlay. The implemented technologies will be scaled and optimized in order to further refine the economic assessments for each process in order to inform the design and construction of a future pilot-scale manufacturing process. The selected process will be low-cost, extensible to additional elements, and environmentally-friendly compared to the traditional mercury-based ELEX and COLEX methods. These technologies will have the potential to revolutionize isotope separation due to their significantly higher performance compared to conventional approaches.

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