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Metal-Functionalized Membranes for Radioiodine Capture

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ABSTRACT:
This proposal addresses the main challenges associated with the effective capture of volatile iodine-129 in advanced tritium pretreatment off-gas (ATPTOG) streams generated during the aqueous-based reprocessing of used nuclear fuel (UNF) – namely, the need for a sorbent that is able to retain functionality in a highly corrosive off-gas, in a form suitable for implementation in a facility. To overcome these chemistry- and engineering-based challenges, the proposed research will focus on three main objectives:

1) Quantification of iodine sorption capacity of metal-functionalized membranes
Sorbents utilizing reactive metals for iodine capture have demonstrated suitable performance under expected off-gas conditions. While zeolite-based silver-loaded sorbents are currently utilized in reprocessing-plant operations, alternative metals would be more advantageous if loading capacities can be sustained after prolonged NO_2 exposure. The objective of quantifying the iodine sorption capacity of metals that may be more effective than silver in the ATPTOG streams will be accomplished by evaluating the iodine adsorption performance of membranes functionalized with these metals. The innovation in this objective is the use of membranes with high specific surface area (*SSA*) and interconnected porosity developed by the collaborators combined with metal functionalization techniques that have not yet been explored with the proposed substrates. HSC Chemistry software will be utilized to predict viable metal candidates under expected off-gas environments. Results will be compared against silver-loaded materials to enable a direct performance comparison under similar conditions.

2) ***Characterization of membrane performance under flow conditions***
Sorbents with high *SSA*s can often achieve high iodine loadings; however, they tend to lack the robustness needed to withstand the flow rates present in realistic off-gas environments. Additionally, the typical microstructure of these sorbents restricts their implementation to a packed bed configuration because the pressure drop would limit the flux if they were to be used as filters. In this objective, the collaborators will utilize the interconnected porosity of their membranes to characterize the performance under various flow conditions. Tasks will focus on evaluating the pressure drop dependence on volumetric flow rate and characterizing the mechanical properties of the membranes. The most robust membranes will then be functionalized with the most promising metals from the first objective (i.e., those that exhibit high iodine loading and retention once loaded) to determine the decontamination factor. Currently utilized materials and configurations will be evaluated to enable a direct comparison of performance (e.g., evaluating silver-loaded zeolite in a packed bed configuration).

3) ***Synthesis and characterization of consolidated waste forms***
The ability to transform the sorbent into a waste form suitable for geological disposal is a critical metric in determining its overall functionality. To address this objective, different consolidation methods will be performed to determine the parameters required to make a chemically durable waste form with minimal product volatilization. Potential consolidation techniques and waste form chemistries have been designed based on previously reported techniques and new formulations studied by the collaborators.