Structural design of borosilicate-based nuclear waste glasses

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Abstract

Borosilicate glasses have a unique blend of processing and product characteristics, making them the most suitable materials for immobilizing nuclear waste worldwide. Historically, nuclear waste glasses have been designed using trial-and-error approaches followed by the development of data-driven empirical models to predict their properties and performance. However, this approach has two significant drawbacks: (1) the conservative nature of the empirical models does not allow the design of glass compositions with enhanced waste loadings over a broad composition space, and (2) being empirical in nature, this approach is unable to explain the deviation in results from a predicted trend. To overcome these challenges, we need to transition beyond the trial-and-error-based approaches and establish a fundamental understanding of the underlying compositional and structural drivers controlling the processing, properties, and performance of the borosilicate-based nuclear waste glasses. In this lecture, the structural design of borosilicate-based nuclear waste glasses will be discussed from the perspective of (1) suppressing the crystallization of aluminosilicate phases, (2) increasing sulfur (as SO42-) and molybdate solubility in the glassy matrix.

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