Advanced reactor wastes: Forms and distributions

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Molten salt and sodium-cooled fast reactors have been touted to “burn” radioactive waste, and as a result, financial and political support for these technologies has recently broadened. However, the metrics that underlie these waste reduction claims (e.g. total radiotoxicity) are of little relevance to long-term safety in a geologic repository. This study characterizes backend material flows for advanced reactors in the context of repository geochemistry.

If advanced fuel cycles can actually increase the fission of the actinides, including long-lived alpha-emitters, then the ingestion toxicity of spent fuel may decrease. Nevertheless, many repository assessments show that long-lived, non-sorbing, and highly soluble fission products pose a more significant long-term risk than the actinides. These results are related to the reducing geochemical conditions of most repository sites, which serve to stabilize the UO_{2+x} fuel matrix.

Fuel discharged from molten salt and sodium-cooled fast reactors will be in the form of UF_4 and Na-bonded U-alloys, which are water-soluble and highly susceptible to radiation damage. Natural analogues for these compounds are non-existent. Degradation of the fuel discharged from test reactors in the 1960s indicates that these fuels are poorly qualified for safe storage and direct disposal. It will be necessary to “condition” these highly radioactive materials into acceptable waste forms. If conditioning efforts are successful, they will generate significant volumes of intermediate-level waste, which also requires geologic disposal.

To minimize the backend burden associated with these reactors, we urge the development of detailed models of waste products and their repository implications during the reactor development.