

Application of Spark Plasma Sintering to Simulate Volatile Fission Products in High Burn-Up Spent Nuclear Fuel

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Waste management remains an important issue in nuclear energy. To safely handle spent nuclear fuel (SNF), it is important to study the behaviour of volatile fission products (FP) in it, which is challenging, particularly regarding Cs and I, because the relatively low boiling point of CsI makes traditional sintering of CsI-included UO_2 pellets impossible. In contrast, spark plasma sintering (SPS) can be used here to synthesise such pellets, avoiding the evaporation of CsI due to lower temperatures and shorter sintering times. The latter also allows the sintering process to be optimised more quickly to achieve the desired microstructure. In the current study, the combined effect of different factors on the chemistry and release of Cs and I was investigated by optimising the SPS parameters to achieve a nanostructure relevant to high burn-up and homogeneous CsI distribution. Ceramic samples sintered using the optimised parameters were studied employing various methods to analyse the CsI chemistry. The results showed that the presence of certain FP in nanostructured UO_2 leads to CsI speciation. Further analysis using Knudsen effusion cell mass spectrometry revealed that this in turn affects the temperature-induced release of Cs I and CsI gaseous fractions. This study highlights the advantages of SPS for investigating how various factors can influence the behaviour of volatile FP, which is critical for monitoring radioactive isotopes and ensuring the safety of SNF management.

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