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Experimental Investigation of Tritium Release Behavior from Li2TiO3 Pebbles Irradiated by D-T Neutron Source

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Solid-type tritium breeders are typically used in pebble form to ensure suitable packing behavior, stress distribution, thermal conductance, and purge gas flow. Beyond these physical characteristics, tritium release behavior is a key performance factor for breeder materials in fusion reactors. The Korea Institute of Fusion Energy (KFE) has developed the core technology for fabricating tritium breeder pebbles, while the Institute of Nuclear Energy Safety Technology (INEST) in China operates a D–T fusion neutron source and tritium handling facility. Leveraging these complementary capabilities, a Korea–China international collaboration has been initiated to investigate the tritium release behavior of breeder pebbles. This study presents the preliminary results of Li2TiO3 pebble fabrication, D–T neutron irradiation, and post-irradiation tritium release experiments.

Li2TiO3 pebbles with a diameter of 3.43 mm were fabricated by the Powder Injection Molding (PIM) process as a feasibility assessment, marking the first attempt by KFE to develop pebble manufacturing capability. Although breeder pebbles of around 1 mm in diameter are typically foreseen for breeding blanket, those with 3.43 mm in diameter were manufactured to validate the PIM process. The fabricated pebbles exhibited an average grain size below 1.00 μm and a porosity of approximately 39.7 %, predominantly consisting of open-pore structures. During 6 h of irradiation, a total of 1.104 x 1015 fusion neutrons were produced. After irradiation, the total tritium activity released from 274.1 g of pebbles was measured to be about 1866.4 Bq. The tritium release behavior, including the relative amounts of HTO and HT collected in water bubblers, was examined at elevated temperatures. Before heating, HTO and HT activities were 54.4 Bq and 23.6 Bq, suggesting surface-dominated tritium breeding. The released tritium increased gradually up to 400 oC and decreased at higher temperatures, reaching background levels after 4 h at 800 oC. At 400 oC, the HTO/HT ratio was approximately 79.3 % to 20.7 %. These results provide initial insight into the release characteristics of neutron-irradiated Li2TiO3 pebbles and contribute to future optimization of breeder pebble fabrication and evaluation.

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