Tritium Release Characteristics of Neutron-irradiated Reference Beryllium Pebbles for the Helium Cooled Pebble Bed (HCPB) Blanket

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Beryllium pebble beds are considered as a neutron multiplier of the European Helium Cooled Pebble Bed (HCPB) tritium breeding blanket for future fusion power reactors. The tritium accumulated in the beryllium pebbles may cause operational and environmental problems, and therefore tritium release properties of the beryllium pebbles are an important factor for safe operation of the fusion reactor. Under the operating conditions of the HCPB, the beryllium pebbles will be under action of high neutron flux (10^{18} n m^{-2} s^{-1}), high temperature (up to 920 K) and intense magnetic field (up to 7-10 T) [1].

In this study, we present results on tritium release from the beryllium pebbles irradiated for 294 full power days from 17 April 2003 to November 2004 in the pebble-bed assemblies (PBA) experiment in the high flux reactor (HFR) at Petten, the Netherlands [2]. Two distinct stages of tritium release – a stage of gradual increase and a stage of abrupt release peaks are evident in the tritium release of the PBA Be pebbles at a temperature ramp of 2.4-4.8 K/min. The transition temperature from the first to second stage normally is 1173-1221 K. These two stages may be related to the tritium release by atomic diffusion and bubble venting respectively. The main maximum of the tritium release rate of the PBA Be pebbles was found to be in the temperature ranges of 1178-1309 K and 1178-1350 K at the temperature ramps of 2.4 and 4.8 K/min respectively.

Tritium release properties of the beryllium pebbles irradiated in the PBA, EXOTIC 8-3/13 and BERYLLIUM experiments are compared in this study. Total tritium activity in 1 g of sample increases in the sequence of pebbles: EXOTIC 8-3/13 (2.5-20 MBq/g) < BERYLLIUM (0.6-1.5 GBq/g) < PBA (4-10 GBq/g). Abundance ratios of chemical forms of tritium localized in the pebbles were determined with the method of chemical scavengers. A general trend can be concluded that tritium release from the EXOTIC 8-3/13 pebbles takes place at lower temperatures than that of the PBA and BERYLLIUM pebbles.

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