Vaporization property of lithium metatitanate and orthosilicate pebbles by high temperature mass spectrometry

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The vaporization behavior of the breeder candidate material at high temperature is one of the most important properties because the vaporizations of Li containing species from breeder pebbles in a fusion blanket change its chemical composition during operation. In this study, the vaporization properties of lithium metatitanate and orthosilicate were studied by the atmosphere controllable high temperature mass spectrometry.

Stoichiometric lithium metatitanate pebbles and lithium orthosilicate pebbles with SiO_2 (2.5 weight percent SiO_2 excess), which were fabricated by JAEA and KIT, respectively, were used for the measurements. The equilibrium vapor pressure from the pebbles in D_2 atmosphere was measured by a magnetic scanning mass spectrometer. The measurements of lithium metatitanate below phase transformation temperature (1155 °C) and lithium orthosilicate below melting temperature (1020 °C) were carried out.

Equilibrium gas pressure P was determined from the relation $P = kIT/\sigma\beta\gamma$, where k is the equipment constant, I the ion intensity per second, σ the relative ionization cross-section , β isotope abundance and γ the multiplier gain. Third-low enthalpies ΔH°_{298} of the following vaporization reactions were calculated with the experimental equilibrium constants and free energy function obtained from JANAF thermochemical tables.

$$Li_2TiO_3(s) \rightleftarrows 2Li\,(g) + 0.5O_2\,(g) + TiO_2\,(s) \quad (1)$$
$$Li_2TiO_3(s) + D_2O\,(g) \rightleftarrows 2LiOD\,(g) + TiO_2\,(s) \quad (2)$$
$$Li_4SiO_4(s) \rightleftarrows 2Li\,(g) + 0.5O_2\,(g) + Li_2SiO_3\,(s) \quad (3)$$
$$Li_4SiO_4(s) + D_2O\,(g) \rightleftarrows 2LiOD\,(g) + Li_2SiO_3\,(s) \quad (4)$$

These experimental enthalpies were compared to the calculation data from thermodynamics database MALT2. Finally, by calculating the total pressure of lithium containing species $P_{Li}^{total} = P_{Li} + P_{LiOH}$ under D_2 sweep gas condition ($P_{D2} = 0.1\%$) from the equilibrium constants of equation (1)-(4), the maximum allowable temperature of each breeder material was estimated.