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High-Temperature Radiolysis of Modified Lithium Orthosilicate Pebbles with Additions of Titania

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In ITER (International Thermonuclear Experimental Reactor) several concepts of Test Blanket Modules (TBMs) will be tested and verified, because the tritium breeding is a key issue in future burning plasma machines, like, DEMO. The Helium Cooled Pebble Bed (HCPB) TBM, proposed by the European Union, will use lithium orthosilicate pebbles with 2.5 wt% excess of silica as reference tritium breeding ceramic. However, latest irradiation experiments showed that the reference pebbles may crack and form fragments under operation conditions as expected in the HCPB TBM. Therefore it may be favorable to change the chemical composition of the reference pebbles and to replace the excess of silica by titania to obtain lithium metatitanate as a second phase.

However, to develop a new chemical composition for the tritium breeding ceramic, it is critical issue to understand high-temperature radiolysis, i.e. radiation-induced chemical processes, microstructural changes and phase transitions which will occur during irradiation at elevated temperature. Therefore, the aim of this research was to investigate the high-temperature radiolysis of the modified lithium orthosilicate pebbles with different contents of titania for the first time.

The high-temperature radiolysis was performed with accelerated electrons by a linear electron accelerator ELU-4 ($E=5$ MeV) up to 5 GGy absorbed dose at 380-670 K in dry argon atmosphere. The formation of radiation-induced defects (RD) and radiolysis products (RP) was analyzed by electron spin resonance (ESR) spectroscopy. The phase transitions were detected by powder X-ray diffractometry (p-XRD) and Fourier transform infrared (FT-IR) spectroscopy. The microstructural changes were investigated by scanning electron microscopy (SEM). After irradiation of up to 5 GGy absorbed dose at 380-670 K, no major changes in the p-XRD patterns and FT-IR spectra of the modified lithium orthosilicate pebbles with additions of titania were observed. Using ESR spectroscopy it has been determined that in the modified pebbles several paramagnetic species of RD and RP are formed and accumulated. The obtained results indicate that by replacing the excess of silica with equal amounts of titania, the total concentration of paramagnetic RD and RP in the modified pebbles decreases.

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