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Immobilization of simulated high level nuclear waste with magnesium-zinc-phosphate glasses

Toshinori Okura[1], Takaaki Imai[1], Kunio Watanabe[2], Keiji Awata[2], Akio Ishida[2] and Naoya Yoshida[1]
[1]Kogakuin University, Japan
[2]Ube Material Industries, Japan

The disposal of radioactive waste generated by the nuclear fuel cycle is among the most pressing and potentially costly environmental problems. The high level nuclear wastes (HLW) are immobilized in a stable solid state and completely isolated from the biosphere. Nuclear waste glasses are typically borosilicate glasses, and these glass compositions can experience phase separation at elevated concentrations of P_2O_5. For some waste streams, this can require considerable dilution and a substantial increase in the volume of the waste glass produced. Magnesium and Zinc phosphate glasses are classified as 'anomalous phosphate glasses', which exhibit anomalies in the relationship between physical properties, such as density and refractive index, and MO/P_2O_5 (M/P) (M=Mg, Zn) molar ratio around the metaphosphate composition (M/P=1). Most of the phosphate glasses form high polyphosphate consisting of chains of phosphate ions, while the structures of M-P glasses and Z-P glasses are of 2 types, one includes 4 membered rings of PO4 tetrahedra at M/P<1 (type T) and the other contains dimers of PO4 tetrahedra at M/P>1 (type P). In this study, M-P, Z-P, M-Z-P glasses are chosen as the base glass. Simulated HLW was incorporated into the base glass to study its effects on the leaching behavior of M-P, Z-P, M-Z-P glasses for nuclear waste immobilization. The gross leach rates and the leach rates of each constituent element of the sample in water at 90°C were determined from the total weight loss of the specimen and chemical analysis of leachate solution.

okura@cc.kogakuin.ac.jp

Characterization and mechanical properties of hot-pressed tantalum carbide without sintering additives

Vahideh Shahedifar, Firouz Rezaei, Mahdi Ghassemi Kakroudi and Mehdi Golrokhsari
University of Tabriz, Iran

The increasing interest and need for materials used in extremely high temperature applications such as rocket nozzles has inspired research into the behavior of ultra-high temperature ceramics (UHTCs). Tantalum carbide (TaC) is one of these materials which has the operating temperatures excess of 3000°C. Unfortunately, monolithic TaC is difficulty densified due to its highly covalent bonding character, low self-diffusion coefficient, and high activation energy for viscous flow. In this study, ultrafine starting powder (0.1-0.5 µm) and high pressure (40 MPa) were used to improve TaC sintering. Densification was performed by hot pressing at temperatures of 1700°C to 1900°C under vacuum with a hold time of 45 min. A lattice parameter of 4.4460 Å was determined for the starting powder by XRD analysis, which corresponds to $TaC_{0.93}$ calculated based on the relationship between lattice parameter and composition. The relative density increased from 96% at 1700°C to 97.7% at 1900°C. The average grain size of the TaC grains increased significantly with sintering temperature. As the temperature enhanced, SEM micrographs of TaC ceramics microstructures revealed extensive transgranular fracture. Moreover, mechanical properties including Young's modulus, Vickers' hardness, and fracture toughness were studied.

va_shahedifar@tabrizu.ac.ir

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