

Volatilization of B₄C control rods in Fukushima Daiichi nuclear reactors during meltdown: B-Li isotopic signatures in cesium-rich microparticles

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Boron carbide control rods remain in the fuel debris of the damaged reactors in the Fukushima Daiichi Nuclear Power Plant, potentially preventing re-criticality; however, the state and stability of the control rods remain unknown. Sensitive high-resolution ion microprobe analyses have revealed B–Li isotopic signatures in radioactive Cs-rich microparticles (CsMPs) that formed by volatilization and condensation of Si-oxides during the meltdowns. The CsMPs contain 1518–6733 mg kg⁻¹ of ¹⁰⁺¹¹B and 11.99–1213 mg kg⁻¹ of ⁷Li. The ¹¹B/¹⁰B (4.15–4.21) and ⁷Li/⁶Li (213–406) isotopic ratios are greater than natural abundances (~4.05 and ~12.5, respectively), indicating that ¹⁰B(n,α)⁷Li reactions occurred in B₄C prior to the meltdowns. The total amount of B released with CsMPs was estimated to be 0.024–62 g, suggesting that essentially all B remains in reactor Units 2 and/or 3 and is enough to prevent re-criticality; however, the heterogeneous distribution of B needs to be considered during decommissioning.