Microwave-induced substitutional-combustion reaction of Fe3O4/Al ceramic matrix porous composite

Abstract

Microwave processing and substitutional-combustion reaction have been utilized to fabricate ceramic matrix porous composite from the thermite reaction of Fe3O4/Al system. Stoichiometric and mixtures with lower and over aluminum were tested. As this system was highly exothermic, the melting of reaction products and destruction the porous structure may occur. In order to avoid that, reaction coupled with a smaller driving force by controlling the microwave (MW) ignition condition at low temperature exotherm, where substitutional reaction occurs has been investigated. The phase and microstructure evolution during the reaction is analyzed by differential thermal analysis (DTA), X-ray diffraction (XRD), and scanning electron microscopy (SEM). Thermogram of the DTA analysis, irrespective of their mole ratio, recorded two exothermic peaks, one at ~1310 °C and another one at ~1370 °C. Fe and α-Al2O3 were the main products for the combusted mixture. Hercynite appeared as the major phase in the stoichiometric and slightly lower Al content mixtures due to incompleteness of reaction. In contrary, over aluminized mixture revealed the presence of Al3.2Fe. When heated at 1360 °C, an additional FeO phase was observed. Mixtures with extremely low Al content showed the presence of unreacted Fe3O4 and some free Al due to the decrease of combustion velocity associated with a decrease in the sample exothermicities. Sample heated in electric furnace was dense. When heating by microwave, controlling the reaction progress at low temperature exotherm allowed the achievement of porous structure composite consisting of micron size iron particles well distributed and embedded in the hercynite and/or Al2O3 matrix.