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Evaluation of material and mechanical properties of mullite bonded porous SiC ceramics prepared by an infiltration technique and conventional powder processing route

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Abstract

Porous SiC ceramics has been a focus of current research in the field of porous materials and has been exploited in numerous applications such as catalyst supports, hot gas or molten metal filters, particulate filters, high temperature membrane reactors, thermal insulating materials, etc. It is difficult to sinter SiC ceramics at moderate temperatures due to the strong covalent nature of the Si-C bond. For the fabrication of porous SiC ceramics at low temperatures, secondary phase(s) are used to bond SiC particles[1]. Oxide bonding is one of the easy, simple and less expensive techniques of preparing porous SiC ceramics. In the present paper properties of porous mullite bonded SiC (MBSC) ceramics synthesized by an infiltration technique and conventional powder processing route are studied and compared. MBSC ceramics were synthesized by infiltrating a SiC porous compact with a liquid precursor of mullite followed by sintering at 1300°C in air. The similar materials were also synthesized by conventional powder route ~ a compact of SiC and Al_2O_3 was heat treated at 1500°C in air when oxidation derived silica react reacted with Al_2O_3 to form mullite that acted as a bond for SiC. In both the cases, different volume fractions of petroleum coke powder were used as pore former. The material properties (density, porosity and pore size distribution), phase composition, microstructure and mechanical properties of MBSC ceramics prepared by both the methods were investigated. Porosity varied in a range of 36-49 and 29-56 vol. % respectively for MBSC ceramics prepared by infiltration and conventional method. The porous MBSC ceramics exhibited variations of pore size from 6-8 µm and 5-11 respectively for samples prepared by infiltration method and conventional method. Microstrucural studies revelled that SiC particles bonded both by mullite and oxidation derived SiO_2 formed an interconnected porous network. XRD analysis confirmed the presence of SiC, mullite and cristobalite as the major crystalline phases in both the cases. For MBSC ceramics the oxidation degree of SiC was observed to be significantly dependant on the sintering temperature and was independent of amount of pore former. The flexural strength and the Young's modulus of the porous ceramics varied in the ranges of 19-33 MPa and 17-38 GPa and 9-34 MPa and 7-28 GPa respectively for MBSC ceramics prepared by infiltration and conventional method. The flexural strength and elastic modulus of the porous ceramics had exponential relations with porosity and the mechanical property-porosity relationship is explained by the minimum solid area (MSA) model. It was observed that mullitization was achieved at low temperatures (1300°C) in the infiltration technique whereas same was achieved at higher temperatures (1500°C) in the powder processing route. The MBSC ceramics prepared by infiltration technique showed a narrow range of pore diameter with improved mechanical properties compare to the MBSC ceramics prepared by conventional route. Hence the materials prepared by infiltration technique could be explored as a filter support for hot gas filtration and nano particle filtration application.