ABSTRACT

The aim of the present work centers on synthesizing and characterizing carbon fiber (C_f) reinforced silicon carbide matrix composites which are considered to have potential applications in aerospace and automobile industry. A series of composites like C_f-SiC, C_f-(SiC+ZrC), C_f-(SiC+ZrB_2), and C_f-(SiC+ZrO_2) have been prepared by a proposed soft-solution approach. This approach involves the use of water-soluble precursors of colloidal silica, sucrose, zirconium oxychloride, and boric acid as sources of silica, carbon, zirconia, and boron oxide respectively to achieve the desired matrices through drying, carbonization and carbothermal reduction. Prior to the preparation of the C_f-SiC composites with additional phases in the matrix, detailed studies have been carried out on the synthesis of the green powders. The prepared powders and the composites were characterized by thermal analysis, XRD, optical microscopy, SEM and EDX analyses to assess the phase formation and microstructure of the materials, apart from assessment of their tensile properties.

Thermal analyses of the green precursor powders suggest that the carbothermal reduction of the processed oxide powders occurs at temperatures between 1800 and 2000 K. The soft-solution process yields matrices with finer crystallite sizes, having homogeneous distribution of the constituent phases of either the powders or of the composite matrices. The approach is capable of yielding in-situ formation of additional phases like ZrC, ZrB_2 and ZrO_2 without any noticeable degradation of the carbon fiber. The tensile property of C_f-SiC prepared by this approach is better than that processed through the existing routes. The role of the additional phases on the tensile properties of the composites has been discussed using consideration of thermal stresses at fiber-matrix interface; whereas the role of the carbothermal reduction temperature on these properties has been explained using the interfacial characteristics of the fiber-matrix. Addition of ZrO_2 in the matrix of SiC has shown to improve the property of C_f-SiC composites considerably.

The results of this investigation unambiguously demonstrate that aqueous solution-based processing can be used for fabrication of these composites in relatively shorter time in an environmental friendly manner without using any expensive equipment. The approach is capable of yielding composites with different phases in the matrix by simple variation of precursor materials and solutions. The small crystallite sizes, fine particle distribution and low carbothermal reduction temperatures are some specific merits of the proposed method.

Key words: Carbon fiber, Silicon Carbide, Composites, Soft-Solution Approach, Carbothermal Reduction, and Tensile Strength.