Abstract

Boron carbide is one of the ceramic materials has extreme hardness with low specific gravity; zirconia has high fracture toughness. These properties promote to prepare boron carbide – zirconia composite. In this study, boron carbide (B_4C) has been prepared using boric acid as boron source, and three types of polymer materials as carbon source (glucose, polyvinyl alcohol (PVA) and corn starch) by utilizing the carbothermal process with using reduced gas (Ar/H_2) flow. Aqueous solutions of boric acid in the presence of one polymeric materials take a gel form. Pyrolysis temperature 350°C was used after obtained the gel. Then, the pyrolysed product is calcined at a range of (600 – 900)°C for (1 – 2) hours. XRD analyses show that B_4C is detected by using boric acid and PVA as raw materials after calcination at 800°C. Also, the addition of magnesium sulfate into the mixture of reactants promotes the reaction and resulted in an increase of the boron carbide content.

Some of the produced B_4C powders have been coated with yttria stabilized tetragonal zirconia polycrystalline (YTZP) (ZrO_2 – 6 wt% Y_2O_3) by using sol-gel method in order to obtain composite powder (B_4C core/ YTZP shell, 1/1 wt%). Zirconium oxychloride ($ZrOCl_2.8H_2O$) and yttrium nitrate ($Y(NO_3)_3.6H_2O$) have been used as the precursors for the synthesis of the YTZP compound. Several characterizations such as, particle size distribution, XRD, SEM and EDX have been studied for both of prepared B_4C powder and the composite powder. The characterization results show that the prepared B_4C powder has a median size of 460 nm, and the SEM images of the composite powder show the YTZP shell compound on the surface of B_4C particles are well distributed.

The prepared boron carbide and composite powders were mixed with different percentages to produce B_4C – YTZP composite materials. The

YTZP was added to B_4C are in the range (0 – 12.5) wt%. The samples are sintered using spark plasma sintering technique at (1800 and 1900)°C for 5 minutes. Microstructure examinations after the sintering are revealed by XRD, SEM and EDX. The physical and mechanical properties (density, porosity, Vickers hardness, Young's modulus, fracture toughness and splitting tensile strength) for the sintered samples are then measured.

The results showed that the YTZP addition to B_4C enhance the physical and mechanical properties. Furthermore, the YTZP addition as composite powder has an obvious effect on sintering and mechanical properties of B_4C. The best YTZP additions are ranged 5 – 7.5 wt% at 1900°C sintering. When the YTZP content in B_4C increases more, the most properties of the samples will be reduced as a result of the residual pores.

A statistical analysis has been implemented for the experimental part data during this work and regression equations for the ceramic composite properties are obtained by using SPSS software. The results show, that the SPSS software creates regression equations for the ceramic composite properties with high regression accuracy, through comparison with the measured values.