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Abstract

The purpose of the present work was to develop high strength ZrO_2 based composites with the use of Al_2O_3 whiskers as reinforcement, which could be able to meet the modern needs of load bearing structural and biomedical materials. For this purpose, 3mol% Y_2O_3 doped tetragonal (TZ-3Y) was used as the matrix material. The alumina whiskers were formed in situ during calcination and sintering from Aluminum Ammonium Carbonate Hydroxide (AACH) whiskers, which were in turn produced by hydrothermal synthesis technique using urea and aluminum nitrate as precursor materials. It was found that the morphology of AACH structures was dependent on the urea content forming urchin like structures at lower urea concentration, which transformed into whiskers as the urea content was increased. After the preparation of alumina whisker reinforcement, the second most important study was the optimization of alumina whisker content in the $Al_2O_{3(w)}$-TZ-3Y composites to achieve best mechanical properties. With increasing the whisker concentration, the hardness increased up to 10 wt% addition and then decreased. It was because the higher concentrations of whiskers resisted particle rearrangement resulting in introduction of porosity in sintered products. Consequently, 10 wt% alumina whisker content was taken as optimum. To improve the uniform distribution of alumina whiskers in the matrix further, deflocculants were also employed and their optimized concentrations were determined. 1.0 wt% CTAB gave the best results as a dispersant. Optimization of sintering temperature was also very important. It was observed that 1400^oC was a too low temperature for complete sintering process and resulted in poor mechanical properties of the sintered product, which were attributed to incomplete removal of porosity. On the other hand, temperatures higher than 1500^oC were too high. At 1650^oC, the whiskers were diffused and formed alumina rich grains losing their whisker-like morphology. However, the best mechanical properties were observed for the sample sintered at 1500^oC, which was decided as the optimized sintering temperature for $Al_2O_{3(w)}$-TZ-3Y composite. Effect of sintering temperature on low temperature phase stability of the composite was also studied. Higher sintering temperatures were found useful for the hydrothermal stability of tetragonal phase in whisker-reinforced composites, although such sintering temperatures were deleterious for

tetragonal phase stability in monolithic TZ-3Y. A composition 10 wt% $Al_2O_{3(w)}$-TZ-3Y with 1wt% CTAB, sintered at 1500°C was concluded as the best composite having better reinforcement dispersion, high density, excellent mechanical properties and improved hydrothermal stability of tetragonal phase.

Furthermore, to investigate the possibility of using the aforementioned optimized composite as bioactive material, its biocompatibility was improved by incorporating the Hydroxyapatite (HAp) nanoparticles, synthesized through precipitation technique, into the composites. It was observed, that although the increase in the HAp content resulted in improving the biocompatibility but it was deleterious for mechanical properties of the composite. The optimized sintering temperature was also lowered due to decomposition of HAp at higher temperatures. Consequently, a composite with 30wt % HAp sintered at 1400°C was assessed as the optimized composition for bio-composite applications.