MgO Doped Carbon Nanotube-reinforced Al₂O₃ Nanocomposite.

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ABSTRACT

Carbon nanotubes (CNTs) are probably the strongest material ever known with outstanding mechanical, electrical and physical properties [1, 2]. It is postulated that by transferring these fabulous properties as reinforcements in inorganic matrices, a new class of nanocomposite to meet the requirement of advanced applications will be generated. Al₂O₃ ceramics have been widely used for structural, electrical and optical applications [3]. Thus, the investigation of CNT-reinforced Al₂O₃ ceramic composites is an interesting subject for the production of high performance materials for high temperature applications. During the fabrication of CNT-reinforced ceramic composites, the agglomeration of CNTs and high sintered densities are two main challenges. Recent studies have shown that CNTs can help matrix grain refinement but increase the sintering temperature, thus becoming a new hurdle to achieve near theoretical density [4].

In this study, to overcome the agglomeration problem, CNTs were dispersed in an aqueous solution with the help of surfactant, sodium dodecyle sulphate (SDS), and after 2 weeks of incubation period a well-dispersed stable CNT suspension was achieved. The CNT (1~2 wt% of Al₂O₃) suspension was then mixed with Al₂O₃ nanopowder doped with various amount of MgO (lower range between 200-300ppm and higher between 1-3wt% of Al₂O₃) using an ultrasonic probe accompanied with a magnetic stirrer. MgO was added in order to reduce the sintering temperatures and grain size [5]. The dry mixture was later compacted at various pressures to obtain green composite tablets which were then subject to pressureless and hot pressed sintering at different temperatures. The resulting nanocomposites were appraised by combined techniques, such as SEM, XRD, TEM and micro hardness testing.

SEM investigation showed that the CNTs were retained in the nanocomposite with a homogenous dispersion within the Al₂O₃ matrix, as shown in Fig. 1. The addition of a very small quantity of MgO (200~300ppm) resulted in the CNTs/Al₂O₃ nanocomposite achieving a maximum density of 94% and 99% of theoretical using pressureless and hot pressed sintering, respectively, at 1600°C for 1 hr, as shown in Fig. 2. The MgO-doped nanocomposite manufactured by hot pressing exhibited higher mechanical properties i.e. flexural strength and hardness as compared to those of the composite prepared by pressureless sintering. After the high temperature sintering, the CNTs not only maintained their original shape and structural characteristics but also exhibited a good interface connection with the Al₂O₃ matrix. At low CNT additions, the nanocomposite exhibited an increase in flexural strength and hardness as compared to the monolithic Al₂O₃ processed under identical conditions. However, a decrease in hardness and flexural strength was observed for high CNTs addition and it is suggested that the higher contents of CNTs have higher tendency of agglomeration leading to a mechanically weak nanocomposite. MgO and CNTs were observed to cumulatively participate in producing nanocomposites with a uniform and fine grain structure.

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Figure 1 The dispersion of CNTs in MgO doped alumina.

![Image of CNT dispersion in MgO doped alumina](image)

Figure 2 Effect of MgO contents on relative density of alumina-1wt% CNTs sintered at 1600°C.

![Graph showing effect of MgO contents on relative density](image)

**REFERENCES**