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Hardness Behavior in CNT/Al7075 RRA Heat Treated Composites

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The rapid development of the aerospace industry implies an intense research in different areas, related to technologies and materials. Particularly in the field of materials, the aerospace industry demands parts with better mechanical performance and lightness [1]. These improvements can be carried out by altering the chemical composition of the material, employing non-conventional manufacturing processes, through the use of thermal treatments, or a combination of all the previous methods [2]. Under these last conditions, certain aluminum alloys, susceptible to thermal treatments, present an attractive interest for the aerospace sector, as is the case of the 2xxx and 7xxx series alloys [3]. The synthesis of advanced materials, from these groups of thermally treated alloys, represents an interesting area of study towards the development of light and resistant materials. In particular, the use of a 7075 alloy, widely used in the aerospace sector, represents an excellent opportunity to study the combined effect on its hardness, derived from the dispersion of carbon nanotubes through solid routes, as well as the thermal heat treatment condition related with solution treatment, aging, retrogression and re-aging process (RRA).

In this work a CNT/Al7075 composites was synthesized by mixing metal chips from a commercial Al7075 with 5.0 wt.% of carbon nanotubes (CNTs). The process of mechanical alloying (MA) was carried out in a high energy E-max mill. The milling container and milling media considered in the experiments were made from D2 hardened steel. The mass of the powders was 50 g and a ball-to powder weight ratio was 4:1. All millings runs were performed with methanol as process control agent with argon was as inert milling atmosphere. The milling time was set 5 h. Powders were cold consolidated and then sintered for 3 h at 500 ˚C under argon atmosphere. Samples were hot extruded into bars of 10 mm-diameter. Sections of 1 mm of thickness from the bar were thermal heat treated by solution at 480°C and water quenched. Each sample was artificially aged at 120°C during 24 hours (T6 condition). The retrogression heat treatment of the samples was carried out at 170°C during 0.5 h and finally reaged at 120°C during 24 h (RRA condition). The microstructural analysis of the CNTs and the composite in the as-milled condition was carried out by scanning electron microscopy. The hardness behavior of the samples was carried out by Vickers microhardness tests. As reference a commercial Al7075 alloy was employed in this study.

Fig. 1a shows SEM micrographs of bundle arrays of CNTs used in the synthesis of the composites. CNT/Al7075 composites powders are shown in Fig. 1b. It is observed a narrow particle size distribution in the powder particles from 10 to 50 microns. Particles present an equiaxed shaped as result of their nature and the multiple fracture-welding cycles occurred in the milling process. The mechanical evaluation of the composites through Vickers microhardness tests is presented in Fig. 2. The relation between the materials and their respective solution, T6 and RRA heat treatments indicates noticeable change in the hardness behavior of the reference alloy from the quenched to the T6 condition, which suggest a solid solution derived from the heat treatment and the respective formation of precipitates. A slightly increase in the hardness behavior is observed in the reference alloy from the T6 to the RRA treatment which suggest intra and transgranular precipitation [4]. On the other hand, the CNT/Al7075 composite display a noticeable improved in hardness in comparison with the reference alloy. However, the homogeneous dispersion of CNTs along the aluminum matrix produces a decrement in their mechanical performance from the T6 to the RRA condition. This phenomena can be explained by the alteration of the kinetics of precipitation due to the presence of CNTs. In this regard, this research group is carrying out a deeper study related with the time and temperature involved in CNT/Al7075 RRA heat treated composites.

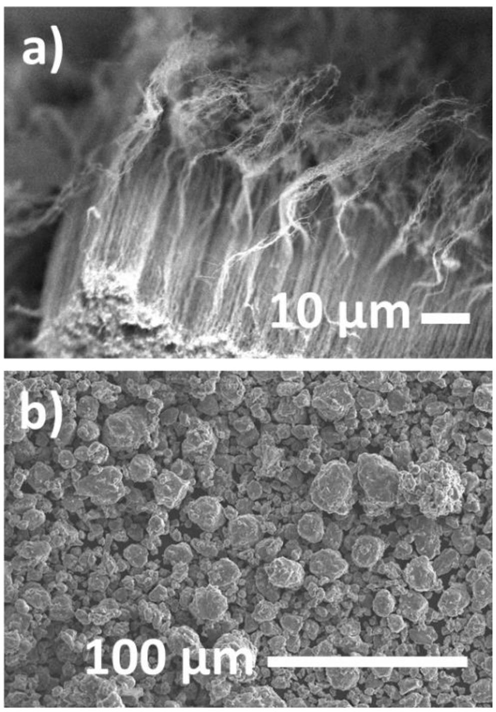

Figure 1. Secondary electron SEM micrographs of (a) CNTs used in the synthesis of the composites and (b) CNT/Al7075 composite in the as-milled condition

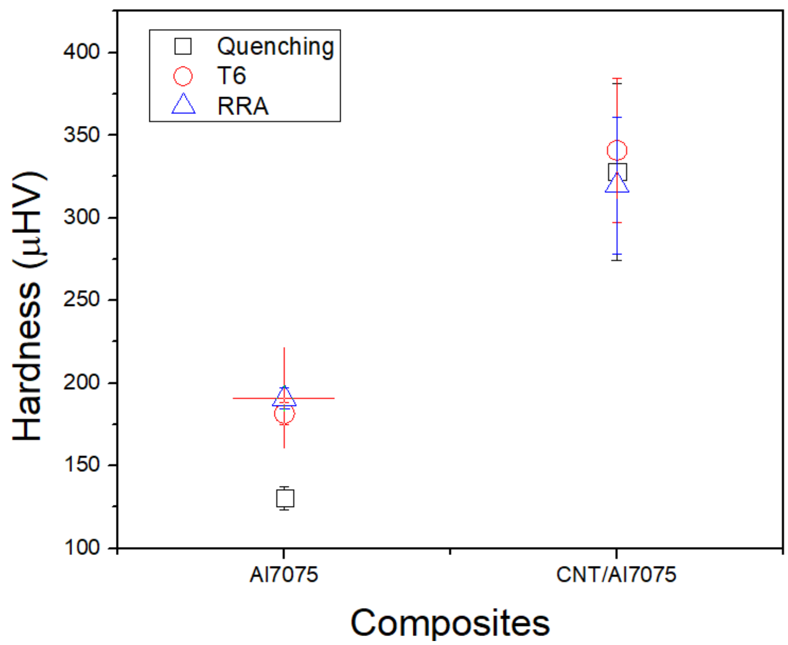

Figure 2. Hardness behavior of the CNT/Al 7075 composite under different heat-treated conditions. As reference the hardness performance of a commercial 7075 aluminum alloy is displayed.

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