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Microstructural Evolution of (Al_{2024}-CNTs)-T6 Composites Produced by Mechanical Alloying and Hot Extrusion.

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The use of carbon nanotubes (CNTs) as raw material for the production of metal matrix composites has attracted the attention of crescent numerous or researchers. This is due to the exceptional mechanical properties that CNTs possess [1]. Their use in the production metal-based composites is being widely investigated. Several routes for the CNTs dispersion into aluminum matrix composites have been employed, nevertheless, it is by mechanical milling (MM) process that a well dispersion has been achieved [2].

In this work, an Al-2024 (Al_{2024}) alloy fabricated from elemental powders, and CNTs produced by chemical vapor deposition (CVD) were employed to produce Al_{2024}-CNTs composites. CNTs were dispersed into the matrix by means of MM. For this purpose, different types of nanocomposite compositions were studied through CNTs addition of 0.0, 0.5, 2.0 and 5.0 (wt. %). Each mixture (80 g) was mechanically milled in an inert argon atmosphere for 0.5 h and 5 h in a high energy mill (Simoloyer). Milled products were compacted under 60 ton during 1 min. Compacted samples were pressure-less sintered under vacuum at 723 K for 2 h. Sintered products were hot extruded to form a rod of 10 mm in diameter with a extrusion ratio of 16. Extruded products were termically treated: first solution at 478 K for 3 h followed by artificial ageing process at 464 K (T6 treatment). The microstructural analysis was carried out by scanning electron microscopy (SEM, JEOL JSM5800-LV) and transmission electron microscopy (TEM, JEOL JEM-2200FS).

Fig. 1 displays some SEM micrographs of the composites reinforced with 5.0 wt.% of CNTs. Figs. 1a and 1b shows the particle size for the composite with 0.5 h and 5 h of milling respectively. The inset in Fig. 1a shows some CNTs dispersed on the particles surface, however the inset displayed in Fig. 1b shows a complete integration of the CNTs into the Al matrix. The effect of plastic deformation induced by the mechanical alloying processing is observed in Figs. 1 (c, d) where it is evident the formation of a lamellar structure characteristic of ductile systems for the composite with 5 h of milling. The morphology of extruded products is displayed in Figs. 1(e, f). The observed precipitates are mainly constituted by Cu and Mn and are obtained after a low cooling during sintering stage. Figs. 1 (g, h) present the microstructure of the composites after heat treatment (solution and artificial ageing steps). On the other hand, Fig. 1g presents precipitates constituted mainly by Cu forming circular phases with different concentrations and an apparently segregation. However, in the case of composites milled for 5 h in the same condition (Fig. 1 h) Cu precipitates have been dissolved and only Mn precipitates are visible. Deep studies about microstructural evolution by TEM as well as the mechanical performance of the Al_{2024}-CNTs composites produced in this work are being investigated.

[1] R. George et al., *Scr. Mater.* 55 (2005) 1159-1163.
[2] A. Esawi et al., *Composites: Part A*. 38 (2007) 646-650.
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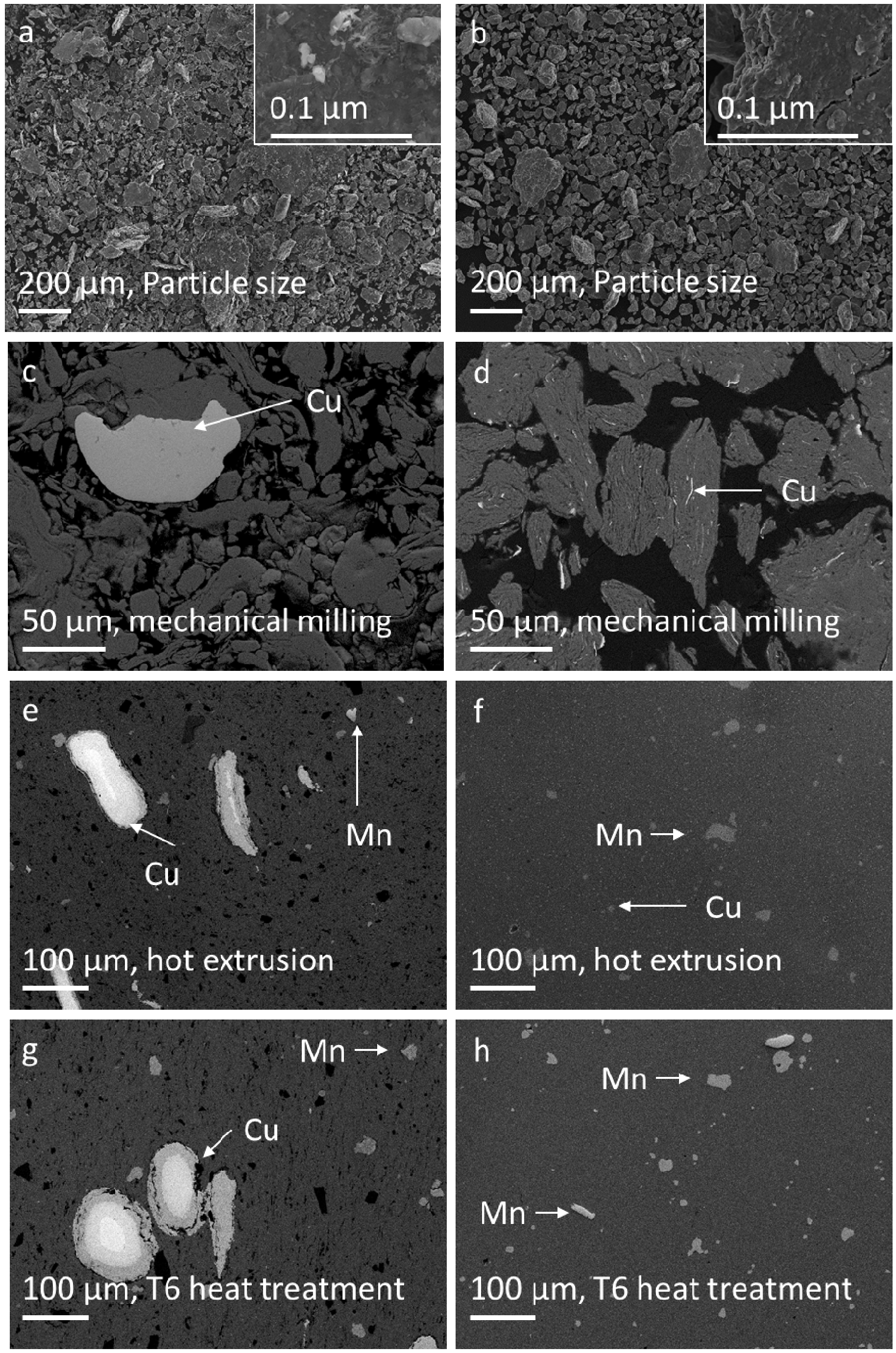

FIG.1. SEM micrographs of the Al_{2024}-CNTs reinforced with 5.0 wt. % of CNTs under different processing conditions. (a, c, e and g) composites with 0.5 h of milling. (b, d, f and h) composites with 5 h of milling.