Al-MWCNT Composites Obtained by Mechanical Milling

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Due the excellent mechanical properties of carbon nanotubes (CNT s), those are considered as promissory reinforcement materials for metal matrix composites (MMC) preparation. By the other hand, a unique combination of engineering properties makes aluminum, one of the most versatile materials used in the automotive, aeronautic and aerospace industry. Such reasons, has motivated the study of aluminum matrix composites (AMC) reinforced with CNT s, in order to make novel composites which present increased mechanical properties.

Al-based nanocomposites studied in this work were produced from pure aluminum powder and multi walled carbon nanotubes (MWCNT s). Figure 1(a-c) presents a general morphology of the raw materials. AMC with several compositions were studied, MWCNT additions were from 0.0 to 2.0 wt.%. A milling time of 5 h was used because previous results [1]. The as-milled products were compacted, sintered and finally extruded into 10 mm rods (in diameter).The microstructural characterization were carried out by scanning transmission microscopy (SEM) and by transmission electron microscopy (TEM). Mechanical properties for the composites were measured through tensile and microhardness test.

MWCNT s were homogeneous dispersed into the metallic matrix as one can see in Figure 2b. The image was taken from fracturated surface after the tensile test. Figure 2a shows the interaction between a CNT and the matrix aluminum. MWCNT s showed high mechanical and chemical stability; only some amorphization of the outer-shells were observed by TEM analysis in Figure 2c. Formation of aluminum carbide Al_4C_3 in samples high MWCNT concentration was found (Fig. 3a).

The yield stress ($_y$) and hardness values obtained in the nanocomposites (Fig. 3b), were considerably higher than those found in as-milled and un-doped sample. Hardness values increases as the MWCNT s concentration increases as-well. The most important strengthening mechanisms in Al-CNTs nanocomposites are strengthening by nanofiber dispersion and strengthening by aluminum carbide precipitation, and both interaction with dislocations.

MWCNT's were successfully used as reinforcement materials in order to create novel composites which present enhanced mechanical properties, but at the same time maintaining their structural properties.

[1] R. P rez-Bustamante, I. Estrada-Guel, W. Ant nez-Flores, M. Miki-Yoshida, P.J. Ferreira, R.

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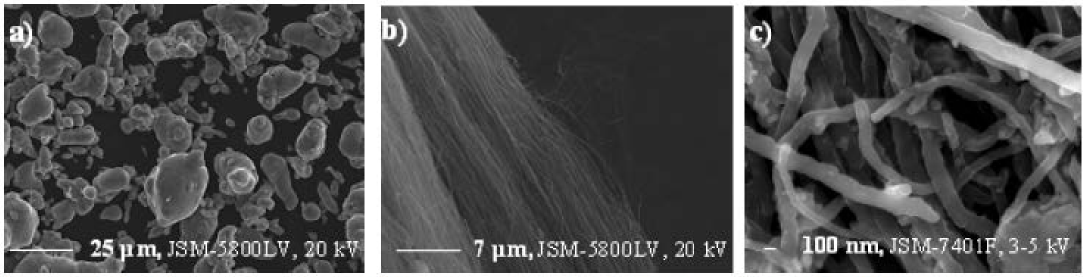

Figure 1. SEM micrographs. a) Aluminum powder. b) Some arrays of MWCNTs. c) Magnification image of MWCNT´s where diameter homogeneity is observed.

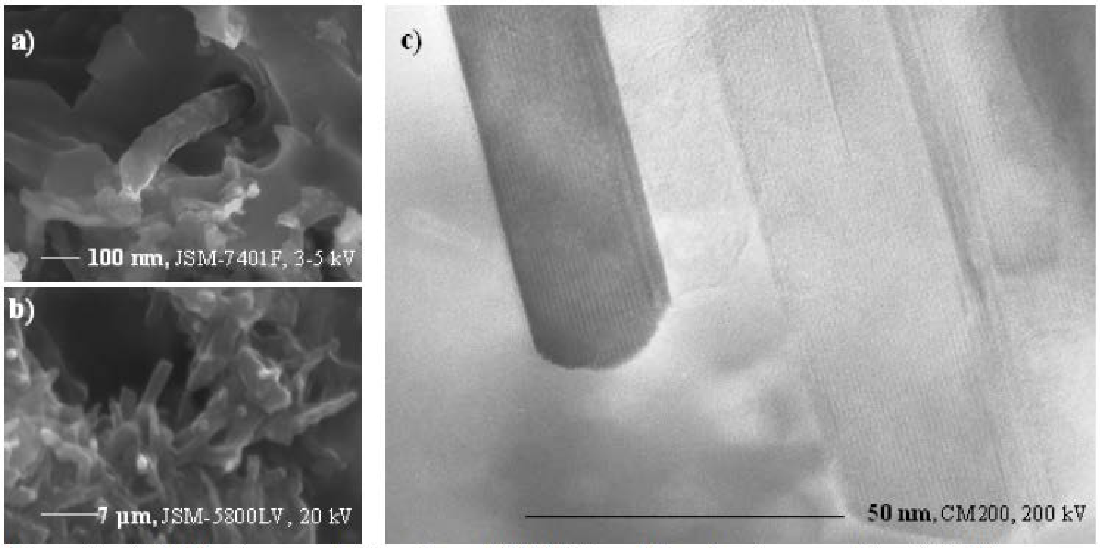

Figure 2. a) SEM micrograph showing a MWCNT and the aluminum matrix. b) SEM micrograph
where one can be observe several MWCNT¢s in the fracture zone after tensile test. c) Bright field TEM micrograph of a MWCNT dispersed into aluminium matrix.

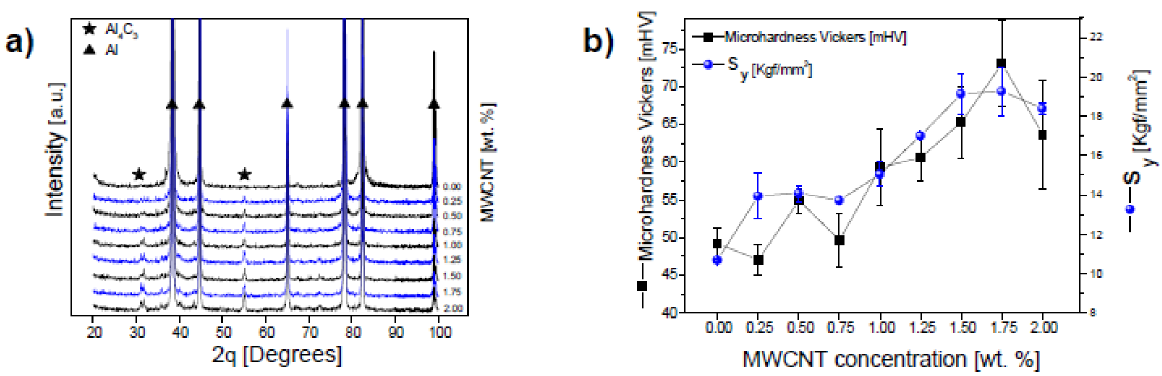

Figure 3. a) XRD spectra obtained from the Al-CNT composites after hot extrusion process at different MWCNT's concentrations. Detail of base line, showing the aluminium carbide presence. b) Yield Strength and micro-hardness plot of composites for all compositions studied.