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Nano-Sized Silicon Dioxide Reinforced Aluminum Alloy 2024-T6

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The increasing demand for weight reduction and low fuel consumption in structural applications, particularly aerospace and automotive industries has had a marked effect on the judicious selection of materials. There has been a great upsurge in using aluminum alloys, the attractive physical and mechanical properties that can be obtained with MMC including high specific modulus, superior strength, long fatigue life, and improved thermal stability, which leads to the weight reduction resulting in a considerable economic advantage [1, 2]. MMC consists of a metallic base with a reinforcing constituent, usually ceramic. Communly, micro-ceramic particles are used to improve the yield and ultimate strength of the metal. However, the ductility of the MMC be deteriorated with high ceramic particle concentration. It is of interest to use nano-sized ceramic particles to strengthen the metal matrix, so-called metal matrix nano-composite (MMC), while maintaining good ductility [3].

The aim of this research was study the effect of the SiO_2 NP nanoparticle dispersion by milling process and its effect over the mechanical properties and microstructural evolution during T6 temper, by using aluminum alloy 2024 based composites.

The raw material used in this study was Al_{2024} commercial alloy and silicon oxide (SiO_2) particles which was synthesized according to Stober's method [4]; tetraethylorthosilicate (TEOS) reacted with water (H_2O) and ammonium hydroxide (NH_3OH) in an alcoholic medium. After washing and drying the particles, these were observed in the microscope. A spherical shape with a narrow size distribution and an amorphous microstructure was found. The chemical composition of Al_{2024} is shown in Table 1.

The Al_{2024} powder was produced by machining a solid extruded bar. The machined metal febris were mixed with SiO_2 NP in different concentrations (0.00, 0.50, 1.00, 1.50, 2.00, 2.50, 5.00 and 7.00 wt. % SiO_2NP). Mixtures were mechanically milled in a high- energy ball mill SPEX8000 under argon atmosphere. Milling products were cold consolidated at 330 MPa by a cylindrical steel die (compacting device) in order to obtain samples with 5 mm of diameter and 10 mm high. Green products were pressure-less sintered for 3 h at 500°C.

After sintering, the specimens were put to the test upon heat treated solution for 1h at 495°C and quenching in room temperature water. Then, samples were artificially aged (T6 Temper) for 12 h at 191°C.

Figure 1 shows the behavior of hardness for 2h of milling time, a considerable difference can be appreciated between mechanical milling conditios (green) and T6 condition, where 1.5% SiO_2NP composite in T6 condition show the highest hardness value.

There is an appreciable hardness saturation value of 98.26 HRF at 1.5% SiO_2NP concentration. At higher NP concentrations only a slight decreasement in the harness values was observed.

Figure 2 shows the morphology and size of SiO_2NP, which were employed as reinforcing material of aluminum alloy 2024. The average of the size was 60nm.

SiO_2NP can be incorporated into Al_{2024} matrix uniformly by milling process, AA2024-1.5 wt. % SiO_2NP composites showed the best mechanical properties and several strengthening mechanisms contributed in order to reach the outcomes.

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Table 1. Composition of the Al_{2024} used (wt.%) in this work.

Al	Cr	Cu	Fe	Mg	Mn	Si
Bal.	0.038	4.004	0.246	0.876	0.673	0.128

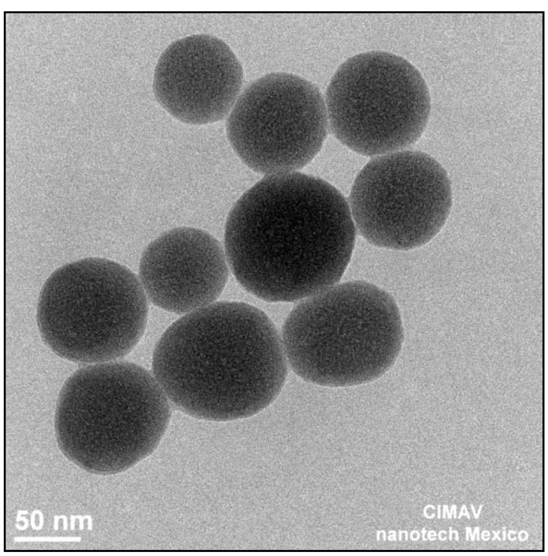

Figure 1. Micrograph from SiO_2 nanoparticles.

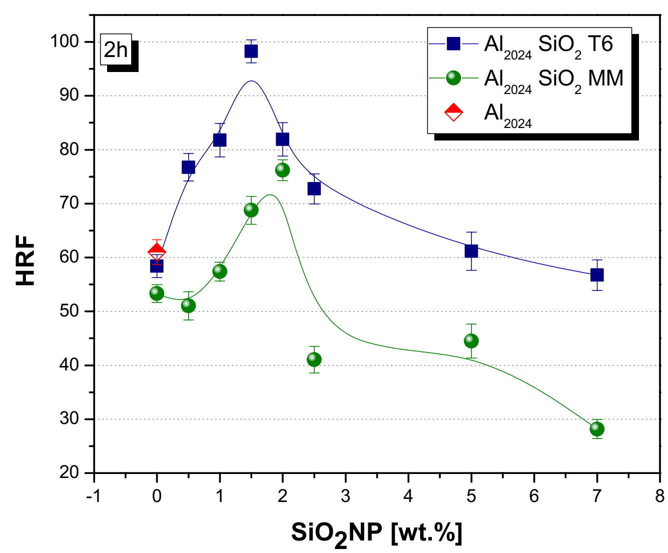

Figure 2. Hardness as a function of nano-SiC particles weight fraction

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