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Effect of Transition Element Addition on the Microstructure and Microhardness of (Al-Si-Cu) Aged Alloys

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The A319 alloy is based in Al-Si system, its principal characteristics are high castability to produce parts with complex forms due to Si content, good machinability, light weight and optimal combination of strength and ductility. Their major applications are in the automotive industry as a material to manufacture pistons, engine blocks and cylinder heads. The T6 heat treatment is used to improve the mechanical performance of such components due to the precipitation of θ' and θ''-Al_2Cu semi-coherent and metastable phases during aging treatment. Some transition metals like Ni and Fe, and some rare earths like Ce, have been used in aluminum alloys to reduce the coefficient of thermal expansion and improve the mechanical properties at relative high temperatures [1]. For example, additions of 1 to 2% Ni to 2xxx and 3xxx series alloys improve hardness and tensile properties at elevated temperatures [2]. Hayajneh et al. [3] and others investigations [4] have been reported the effect of Ni additions in the hardness properties in Al-Cu and Al-Si-Cu alloys respectively; they reported that the formation of the Al-Ni, Al-Ni-Cu intermetallic compounds have a direct relationship with mechanical properties and a significant delay in the loss of hardness values during the over-aging stage.

This investigation under takes the changes of microstructure by the Ni additions and heat treatments in A319 alloy. The evolution in the microstructure was characterized by TEM. The mechanical properties were evaluated using Vickers microhardness test in accordance with the ASTM standards The A319 alloy and those with Ni additions were solution heat treated at 495 °C for 7 h, quenching in water at 60 °C and aged at 170 °C for 0.5, 3, 5, 10 and 96 h.

Fig. 1 shows the behavior of the hardness values respect to Ni content and aging time in A319 alloy. It is observed increments of hardness values in function of increments of Ni, the hardness peaks are observed at 240 min (4 h) for 1-2 Ni (wt. %) and remain stable up to 10 h. The Ni additions in A319 alloy favors the increments in HV values and the peaks of hardness appear at shorter aging time. Additionally, in samples alloyed with Ni the HV values decreases slowly during over-aging stage. Furthermore, the Ni addition 1-2 Ni (wt. %) to the A319 alloy have an significant effect on the microstructure; principally in the morphology, size, distribution and number density of θ-Al_2Cu precipitates formed during aging heat treatment (Fig. 2).

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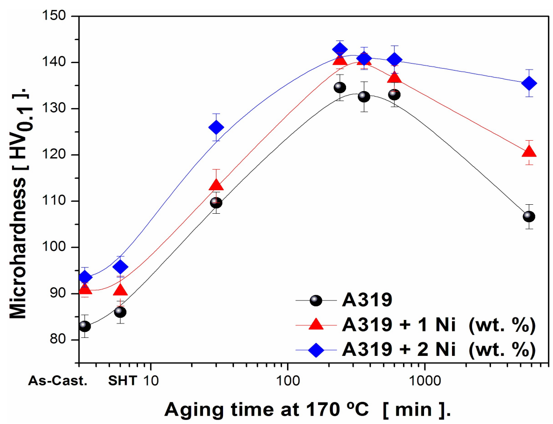

Figure 1. Vickers microhardness versus aging time for the A319 alloy and those with Ni additions, after 7 h of SHT at 495 °C and aged at 170 °C for different times.

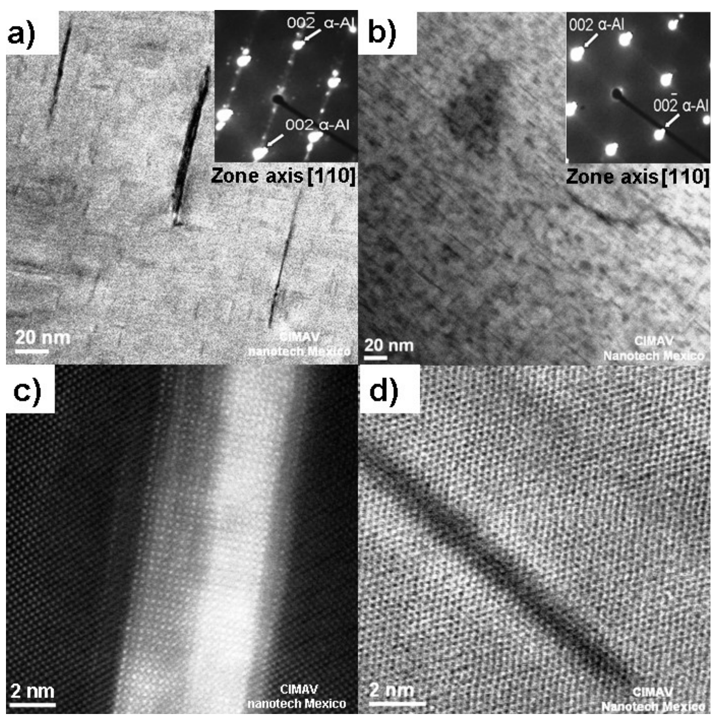

Figure 2. TEM Micrographs of A319 alloy and those with 2 Ni (wt. %) additions after 7 h of SHT at 495 °C and aged for 10 h at 170 °C. a) and b) Bright field (BF) STEM micrographs of reference alloy and with Ni addition respectively, c) Z-contrast HRSTEM micrograph of θ'-Al_2Cu precipitate in reference alloy and d) Bright field (BF) HRSTEM micrograph of full coherent θ''-Al_2Cu precipitate in alloy modified with Ni.

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