Microstructural and Mechanical Behavior in the Al₂₀₂₄ Alloy Modified With Addition of CeO₂

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The 2xxx series aluminum alloys are important advanced functional materials due to their high yield strength, good fracture toughness and excellent fatigue properties [1]. Due to the extremely important role that the 2xxx series aluminum alloys play in the aviation industry, much attention has been devoted to understanding their structures and properties [1-2]. Particularly, comprehensive investigations have been made to elucidate the morphological dependence of the precipitates on material composition, thermal treatment history, and impurity elements to optimize the materials performance for designed applications [1-2].

By another hand, in the last decades, the use of metallic matrix composites of two or more different metals, intermetallic compounds or second phases has been researched widely. They are produced by controlling the properties of the constituent phases, their relative amount, dispersed phase geometry including particle size, shape and orientation in the matrix to achieve optimum combination of microstructural and mechanical properties [3, 4]. Reinforcing particle such as SiC, Al₂O₃, and MgO, have emerged as a potential alternative for conventional aluminum-base composites because of their high mechanical properties. Additionally, because the effects on microstructure, mechanical properties, electrical conductivity and corrosion resistance the use of rare earth, especially La, Ce, Nd, Y and Sc have called attention, recently. Thus, the present work evaluates the effect of CeO₂ nanoparticles on the microstructure, precipitation sequence and hardening mechanisms of the Al₂₀₂₄ alloy.

A compound of Al-16.66% by weight of CeO₂ (CMAICeO₂) was prepared by mechanical milling (Fig.1). Subsequently, the CMAICeO₂ was added in proportions of 0.1, 0.5,3 and 5 wt. % of CeO₂ to the Al₂₀₂₄ alloy by conventional casting. Finally, the material obtained was extruded and aged. The characterization of CMAICeO₂ suggests a reaction of the chemical reduction of CeO₂ and the formation of a layer of Al₂O₃ that covers the elemental Ce during the process (Fig.2). On the other hand, the hardness tests indicate that the lower content of CMAICeO₂ (0.1, 0.5% weight of CeO₂) obtained hardness superior to the commercial alloy Al₂₀₂₄. In addition, the preparation of the CMAICeO₂ composite material by powder metallurgy is an alternate route for homogeneously dispersing CeO₂ nanoparticles in an aluminum matrix. However, long sintering times are not recommended since this favors the formation of elongated Ce rich phases.

References:


**Figure. 1** Micrographs obtained by SEM of CeO$_2$ nanoparticles (a-b) and MCAI CeO$_2$ powders (c-d)

**Figure. 2** Micrographs obtained by TEM of MCAI CeO$_2$

**Figure. 3** Hardness curve (Rockwell B) for the Al$_{2024}$ alloy reinforced with 0.1, 0.5, 3 and 5% of CeO$_2$ by the addition of MCAI CeO$_2$. 