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Effect on Microstructure and Hardness of A2024 Aluminum Alloy Doped Cerium Oxide Nanoparticle.

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Aluminum alloys possess interesting properties that attract much attention due to their light weight, high specific mechanical resistance, high thermal conductivity, and moderate casting temperature. Automotive and aircraft parts of aluminum alloys such as A2024 are reinforced with oxides for its superior properties such as refractoriness, high hardness, high compressive strength, wear resistance etc., and make them suitable for use as reinforcement material in metallic matrices. Incorporating ultra-fine particles of metal-oxides significantly improves mechanical properties of the metal matrix by reducing the inter-particle spacing and providing their inherent properties to the metal matrix since they get uniformly embedded into it. In aluminum alloys a hardening mechanism is promoted by the homogeneous dispersion of low solubility or total insolubility particles. Several kinds of ceramic materials, e.g. SiC, Al_2O_3, MgO and B_4C, are extensively used to reinforce aluminum and its alloys [1]. On the other hand, rare-earth compounds have been used mainly as corrosion inhibitors for aluminum alloys. Several studies have been realized in terms of cerium oxide protective coatings to improve the corrosion resistance of the A2024 alloy. The contribution of cerium oxides in the particle-dispersion hardening has not been explored in the aluminum alloys; nevertheless the increase of hardness and wear resistance of Sn by the incorporation of CeO_2 nanopowders was reported [2]. On the basis of this report and the knowledge about the capability of aluminum alloys to be hardened by particle-dispersion, the aim of this work is focused on the potential effect of cerium oxide nanoparticles (nanoceria) on the strengthening of the A2024 alloy synthesized by two routes: casting and mechanical milling followed by sintering. Microstructural and hardness analyses (in samples with and without cerium oxide additions) were conducted in order to determine the combined effect of nanoceria and processing route on hardness behavior of A2024 alloy.

Nanoceria powders were dispersed into A2024 alloy by high energy mechanical milling during 1 h under argon atmosphere followed by cold-compacted. The bulk samples were obtained by two routes: sintering at 500°C during 2 h and melting at 750°C; both under argon atmosphere.

The results show the presence of Ce-Cu-rich needles in the microstructure of the as-cast condition, while CeO2 nanoparticles were identified in the sintered condition and the fabrication process (sintering vs. casting) has a significant effect on the microstructure and mechanical properties of the final alloy. And one may conclude that by MA and sintering was possible to avoid the excessive growth of cerium needles.

References:

[1] Y Ansary, *et al.*, J Alloys and Comp. **484** (2009), p.400-404.
[2] A. Sharma, *et al*., J Alloys and Comp. **574** (2013), p.609-616.

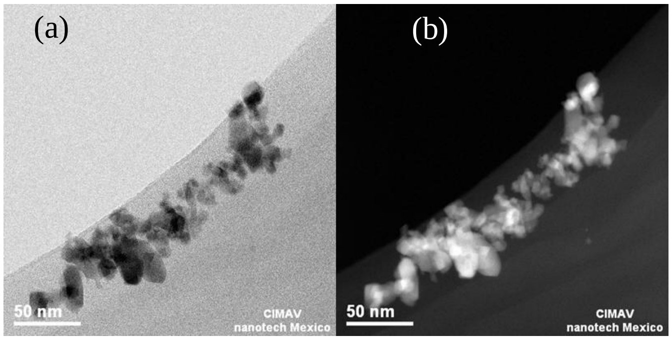

Figure 1. TEM images of the nanoceria: (a) dark field, (b) bright field.

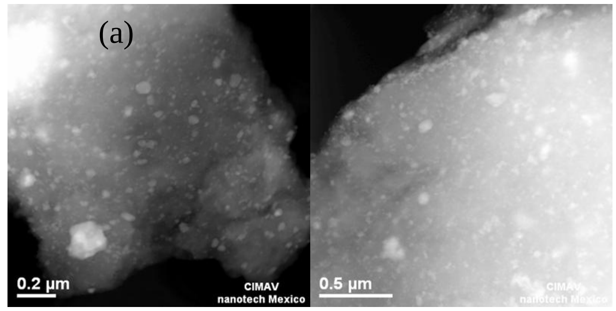

Figure 2. TEM dark field images of the powders: (a) Al+CeO2 and (b) A2024+CeO2.

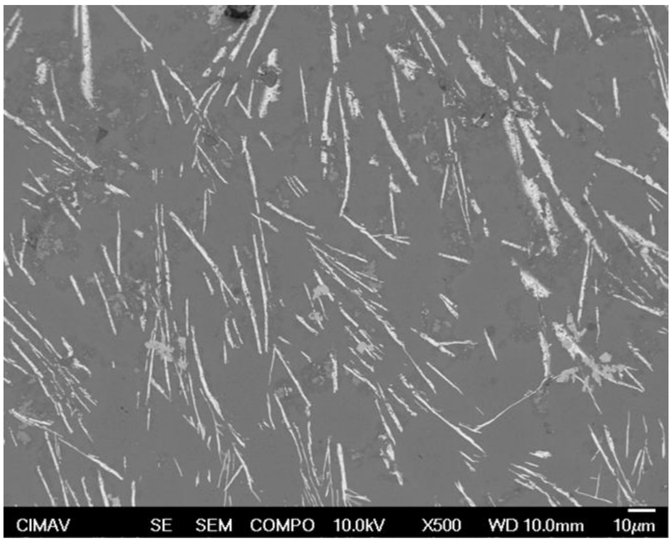

Figure 3. SEM image of the A2024+CeO2 as-cast alloy.

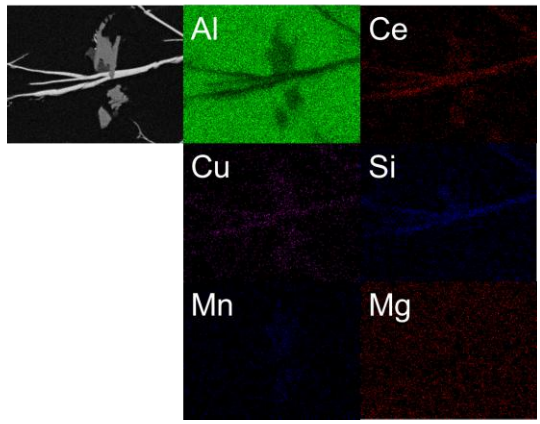

Figure 4. EDS-SEM mappings of the as-cast alloy matrix.

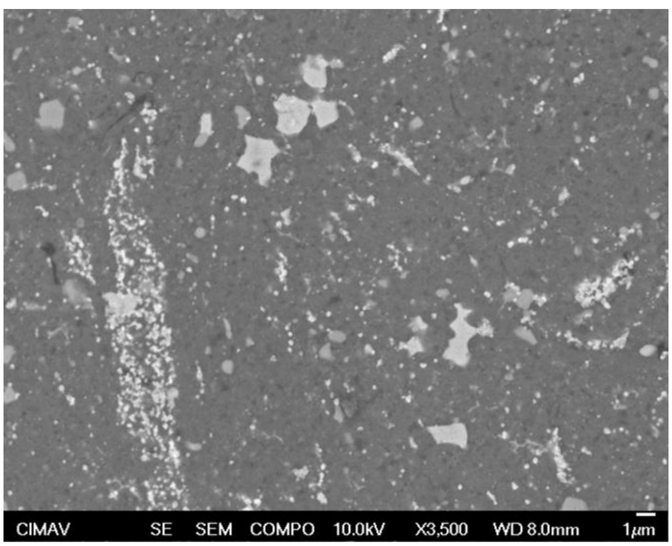

Figure 5. SEM image of the sintered A2024+CeO2 alloy.

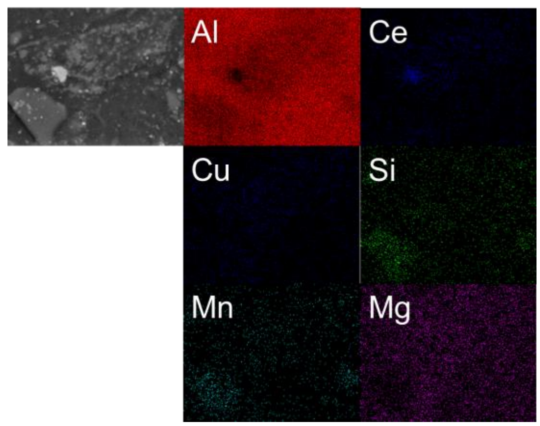

Figure 6. EDS-SEM mappings of the sintered alloy matrix.

Table 1. Microhardness of A2024 aluminum alloy doped.

Sample	Hardness (HV)
A2024	64.86 ± 12.79
A2024 + 5%CeO_2	81.36 ± 5.64
Al + 5%CeO_2	103.12± 15.20

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