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Hardness Behavior in Al7075 Aged Alloys Modified with Ce/La Rare Earths

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The plastic injection industry have been supported by the use of steel molds in the manufacturing of a wide range of products; however, lighter materials with excellent mechanical performance, and incomparable heat exchange capabilities, are promising mold materials for increasing the numbers in the manufacturing of products with high quality in a fraction of time [1]. This is the case of high-strength aluminum alloys, originally developed for aircraft applications. The use of the T6 grade Al7075 aluminum for the fabrication of molds, offers a multitude of advantages over those presented by steel. Improved and uniform heat dissipation, good machinability and lightness are attractive characteristics highly valuable in manufacturing processes [2].

However, the life span of the aluminum molds highly depends on their mechanical performance under working conditions, where hardness behavior is a parameter to be considered for their improvement. The hardness behavior can be enhanced by several methods; however altering or adding new elements in its chemical composition are suitable routes for this purpose. Of special interest is the use of rare earth elements, where noticeable results have been reported at low contents (0.1 to 0.3 wt.%), producing a mechanical enhancement in the alloy, specifically on its tensile strength and hardness [3].

In this work, the Al7075 aluminum alloy was modified with the additions of rare earths. Raw materials were the commercial Al7075 aluminum alloy and Al_6Ce_3La (ACL) master alloy. The Al7075 alloy was melted at 740°C. The ACL was added to obtain Al7075-0.2 and al7075-2.0 wt.% ACL alloys. Specimens were solution heat treated at 480°C during 3h and water quenched at 60°C. Aging heat treatments were done at 120 and 140°C during 8, 12 and 16h, and water quenched at 25°C. Microstructural characterization was carried out by scanning electron microscopy on samples in the heat treated condition. The mechanical performance of the experimental alloys was evaluated by means of microhardness test at room temperatures in the aging-heat treated condition.

Fig. 1 shows SEM micrographs of the cross-section of the ACL, the Al7075 and the modified Al7075 alloys. The microstructure of as-received ACL alloy shows a bright phase composed by large Ce/La needles dispersed in the aluminum matrix (Fig. 1a). At a content of 0.2 wt.%, no visible effects on the microstructure of the modified Al7075 alloy are observed (Fig.1c); however the microstructure of the secondary phases observed in the Al7075 modified with 2.0 wt.% of ACL displays squared bright phases, which EDS elemental analysis indicates the presence of Ce. The increased presence of Ce/La leads to an improved mechanical performance over that reinforced with 0.2 wt.% of ACL. This improvement at the aging temperatures of 120 and 140°C, with the maximum hardness at 8h of aging at 120°C. Despite this increment in harness, the effect of rare earth on the mechanical performance of modified alloys is magnified when alloys are evaluated under hot working conditions. In this respect, deeper studies are being carried out about the effect of rare earths on experimental alloys under different work temperatures [4].

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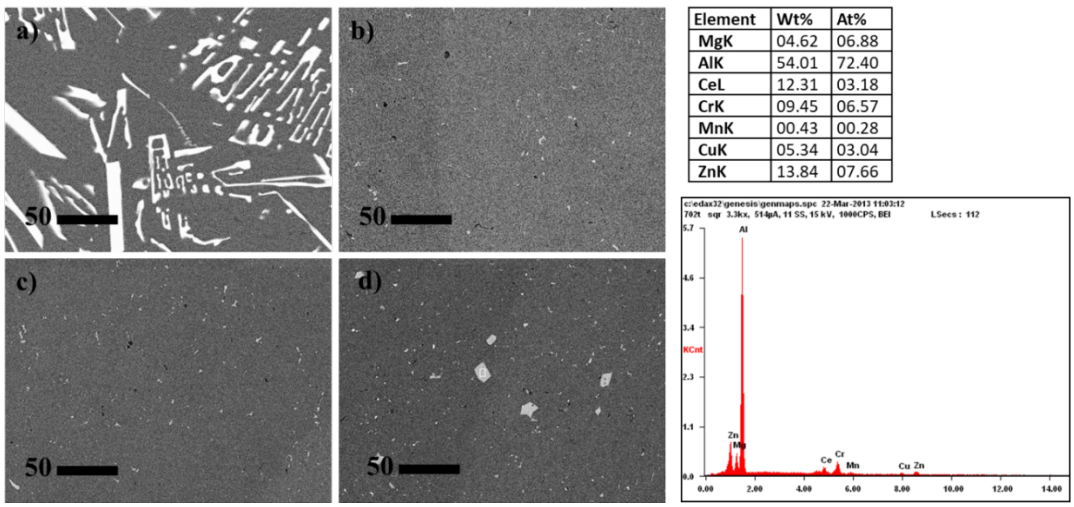
[4] Thanks K. Campos-Venegas for their valuable technical assistance.



Element	Wt%	At%
MgK	04.62	06.88
AlK	54.01	72.40
CeL	12.31	03.18
CrK	09.45	06.57
MnK	00.43	00.28
CuK	05.34	03.04
ZnK	13.84	07.66

Figure 1. Backscattered SEM micrograph of the microstructure of the (a) Al-3La-6Ce (b) Al7075, (b) Al7075-0.2 ACL and (c) Al7075-2.0 ACL.

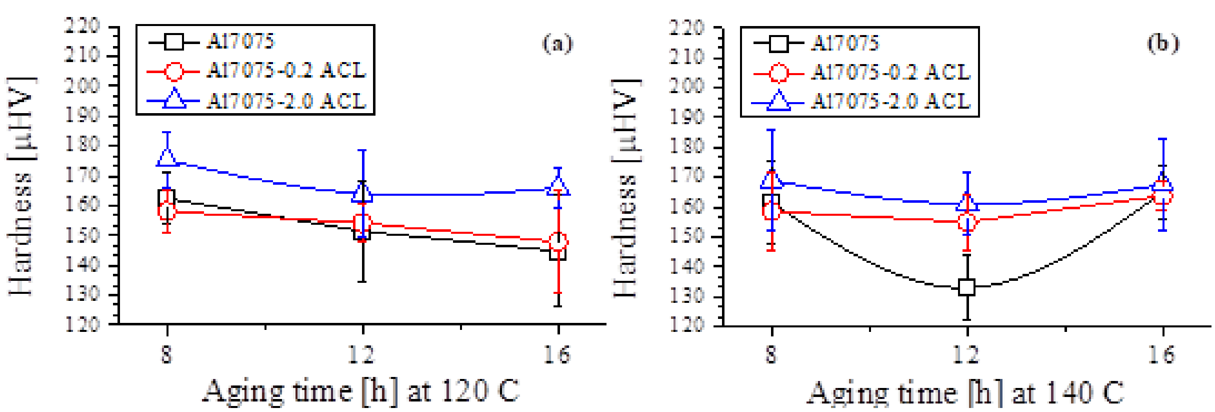


Figure 2. Vickers microhardness results from the Al7075 modified with Ce/La. (a) Aging curves at 120 and (b) 140 °C

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