ABSTRACT

The present work deals with the comprehensive characterization of microstructure and texture evolution in a Mg-4Zn-0.5Ca-0.16Mn (wt.%) alloy during different stages of processing *viz.*, casting, homogenization, forging, and annealing. Further, the implication of the microstructure and texture evolution on the mechanical and *in-vitro* bio-corrosion properties of the alloy is critically established. The cast alloy has been prepared through a conventional melting-casting route in an open-air atmosphere using cover fluxes. The cast specimen exhibits appreciable strength (YS~175 MPa) but limited elongation (<1%) due to the networks of coarse $Ca_2Mg_6Zn_3$ particles along the grain boundaries. The cast alloy is thereby homogenized to dissolve these particles and subsequently improve the ductility and work hardening (WH) response. The specimen homogenized at 633 K for 24 h exhibits better ductility and WH response owing to the grain size heterogeneity and presence of nano-sized Mn and β_1' precipitates. Interestingly, the evolutions of β_1' precipitates lead to an age-hardening kind of response in the homogenized specimens. The homogenized specimen is further thermomechanically processed employing a novel 'hard plate hot forging' method to improve the strength-ductility combination. The coarse $Ca_2Mg_6Zn_3$ particles facilitate dynamic recrystallization (DRX) through the particle stimulated nucleation process, which leads to typical bimodal grain size distributions in the forged specimens. The specimen forged at 573 K shows strong basal texture due to the higher DRX fraction, as most of the DRX grains exhibit typical basal orientations. This specimen exhibits high strength (YS ~259 MPa, UTS ~304 MPa) with moderate ductility (e_f ~6.5 %) due to the higher basal texture intensity, bimodal grain size distribution, and the presence of fine Mn precipitates. The forged specimens show a better combination of strength-ductility after annealing at 623 K for 5 min owing to the synergistic contributions from typical grain size heterogeneity, basal texture, residual dislocations, and nano-size precipitates (Mn and β_1'). During isothermal annealing treatment of the specimen forged at 573 K, the grain growth exponent is observed to be high (n ~9) due to the pre-existing higher percentage of particles ($Ca_2Mg_6Zn_3$ and Mn) and higher basal texture intensity in the corresponding forged specimen. The yield strength decreases, while the ductility and WH improve with time during isothermal annealing due to the increase in grain size and its heterogeneity. The *in vitro* bio-corrosion studies (immersion and electrochemical tests) are carried out on the high-strength forged specimens in Kirkland's bio-corrosion medium. A uniform and compact product layer is formed on the specimen forged at 573 K due to higher DRX fraction, uniform particle distribution, and smaller deformed grains. The uniform corrosion product layer and strong basal texture intensity significantly lower the pH change, hydrogen evolution, and corrosion rate in this specimen during the long-term immersion test.

Keywords**:** Mg-Zn-Ca-Mn alloy; Homogenization; Precipitation; Grain size heterogeneity; Hard plate hot forging; Dynamic recrystallization; Particle stimulated nucleation; Texture; Annealing; Tensile properties; Immersion test; Electrochemical test; Corrosion product.