Stress corrosion cracking and hydrogen embrittlement of an ultra-light BCC structural Mg-Li-Zn alloy

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Abstract Magnesium-lithium alloys, as the lightest structural metal materials, have demonstrated broad application prospects in fields such as 3C products, automotive, and aerospace. However, their low mechanical properties and environmental sensitivity restrict their widespread application. This work delves into the stress corrosion cracking (SCC) and hydrogen embrittlement (HE) behaviors of Mg-11Li-xZn (x=0, 1, 3, 6 wt%; L11, LZ111, LZ113, and LZ116) alloys. The results indicate that all four alloys exhibit cleavage fracture in NaCl solution. For alloys with low zinc content (L11, LZ111, and LZ113), transgranular stress corrosion cracking (TGSCC) is predominant, while the LZ116 alloy with high zinc content shows a mixed characteristic of transgranular and intergranular stress corrosion cracking (TGSCC+IGSCC). After cathodic hydrogen charging, the alloy surfaces are covered with metal oxides, metal carbonates, and MgH_2 hydrides. The L11 alloy possesses the most brittle MgH_2 on the surface, which almost disappears when the zinc content reaches 3 wt%. Through static and dynamic cathodic hydrogen charging, it is found that the hydrogen embrittlement sensitivity (I_ε) of all alloys shows a similar trend under different hydrogen charging conditions. With the increase of Zn content, the hydrogen embrittlement sensitivity first decreases and then increases, with LZ111 alloy exhibiting the lowest sensitivity. Moreover, fracture analysis of the four hydrogen-charged alloys reveals that the fracture of all alloys transitions from ductile to quasi-cleavage fracture. The fracture surface morphology of the L11 alloy shows numerous hydrides and slip band cracks, indicating a mixed mechanism of delayed hydride cracking (DHC) and hydrogen-enhanced local plasticity (HELP). For LZ111 and LZ113 alloys, the fracture surface morphology is characterized by slip band cracks and intergranular cracks, suggesting a mixed mechanism of hydrogen-enhanced local plasticity (HELP) and hydrogen-enhanced decohesion embrittlement (HEDE). For the LZ116 alloy, the trend of intergranular cracking increases, and the slip band cracks transform into cracks extending perpendicular to the tensile stress direction, indicating a mixed mechanism of hydrogen-enhanced decohesion embrittlement (HEDE).

Keywords Mg-Li; Stress corrosion cracking; Hydrogen embrittlement; Cathode hydrogen charging