Powder Metallurgy of Zinc Alloys for High Strength and Retained Ductility

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Zinc and its alloys have recently attracted increasing attention as candidates for biodegradable medical devices due to their moderate corrosion rates and good biocompatibility. In particular, alloying zinc with magnesium enhances mechanical strength and refines microstructure, while also promoting osteogenic activity and favorable degradation behavior. These properties make Zn-Mg-based systems promising for temporary load-bearing implants, especially orthopaedic fixation devices.

In this study, we explored the synthesis and characterization of Zn-Mg-Ag materials processed via high-energy mechanical alloying followed by extrusion. By adopting the powder metallurgy route, we achieved ultrafine-grained microstructures with an average grain size below 700 nm stabilized by the presence of intermetallic phases like Mg_2Zn_{11} and dispersoids (MgO, ZnO). These structural features enabled the development of alloys with ultimate tensile strengths exceeding 400 MPa and fracture elongation near 12 %, surpassing most conventionally processed Zn-based materials. Detailed microscopy, including EBSD, TEM, and APT, revealed the refined grain structure and distribution of second-phase particles, correlating these with the observed mechanical and corrosion properties. Corrosion studies confirmed slow, uniform degradation and formation of stable surface layers. Furthermore, the addition of silver contributed to the antibacterial effect showing strong efficacy against S. epidermidis *in vitro.* The results demonstrate that combining mechanical alloying and extrusion may lead to the production of zinc-based materials with an excellent balance of strength, ductility, and biocompatibility.

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