Microstructure and mechanical properties of biodegradable Mg-SiO_2 nanocomposite

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Abstract:

Conventional metals such as titanium, stainless steel and platinum possess high strength, corrosion-resistant and biocompatibility features, therefore, widely used in producing orthopedic implants required during the surgery of fractured bones. However, these materials are not biodegradable and the implants produced by these materials are usually present in the body, even after the healing of the fractured tissue causes infection due to the corrosion of the implant material at the physiological condition. Another drawback of these metallic materials is their high elastic moduli that leads to stress-shielding effect. Therefore, in most cases, a revision surgery is needed to remove the implant and hence causes a lot of inconvenience to the patients. Therefore, it becomes a prime concern to develop a state-of-the-art biodegradable implant material that can maintain the mechanical properties of the bones. In recent years, Magnesium (Mg) and its alloys have attracted significant interest to be potential alternatives to conventional orthopedic implant materials owing to their excellent biodegradable and mechanical properties. This is the lightest metal having a density range from 1.74 to 2.0 g/cc and maintains a great strength-to-weight ratio. Besides, the elastic modulus of magnesium alloys ranging from 41-45 GPa, close to that of cortical bone which would reduce the possibility of stress shielding effect. More importantly, these materials are biodegradable and hence, completely absorbed in the human body after regeneration of the bone tissue. However, Mg is highly corrosive in the biological environment and degraded severely. Therefore, in this study, silica (SiO_2) nanoparticle reinforced magnesium (Mg)-based nanocomposites have been developed by powder metallurgy method and the effect of SiO_2 on the microstructure and mechanical properties have been evaluated. Pure Mg was used as the matrix material while SiO_2 nanoparticle with three different weight % was applied as the reinforcement. Pure Mg powder and SiO_2 nanoparticle was blended in a planetary ball mill, compacted in a uniaxial hydraulic press and then sintered in a tube furnace to obtain the nanocomposite material. A distinct Mg_2Si phase was observed in the microstructure of the nanocomposite. The mechanical properties revealed that the addition of 5% SiO_2 significantly increased the microhardness and tensile strength, nevertheless keep the elastic modulus same as the pure Mg. The enhancement of mechanical properties is attributed due to the formation of Mg_2Si phase in the nanocomposite.