In vitro study on the modified ZK60 alloy with the addition of 0.2wt.% Ca

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INTRODUCTION: As very promising biodegradable metals, the main challenges for the wide biomedical application of magnesium and its alloys lies in retarding their high degradation rates in physiological environment and enhancing their biocompatibility. In the present study, industrial ZK60 alloy is tried to be modified with the addition of Ca in order to obtain the combination of good mechanical property, corrosion resistance and biocompatibility.

METHODS: ZK60-0.2Ca alloys were prepared from high-purity Mg (99.95%), Zn (99.9%), Ca (99.9%) and Mg–20Zr (wt%) master alloy. The microstructure and constituent phases were observed by metallurgical microscope and measured by XRD respectively. The mechanical properties were investigated through the tensile test. The corrosion behavior in Hank’s solution were characterized by immersion test, and electrochemical measurement. The L-929 cells were used to evaluate the cytotoxicity of the alloy with indirect assay.

RESULTS: The constitutional phase of the ZK60-0.2Ca alloy was α-Mg and Mg₄Zn₇, as shown in Fig. 1. The ultimate tensile strength and yield strength of ZK60-0.2Ca were 72.02 ± 14.60 MPa and 117.65 ± 15.62 MPa, respectively, while the elongation was 3.28 ± 0.35%. Corrosion rates calculated from mass loss, ion release and electrochemical measurement were 0.176 ± 0.018 mm/yr, 0.121 ± 0.005 mm/yr and 0.187 ± 0.050 mm/yr, respectively, which were quite close. The cell viability was determined with extracts for 1, 2, 4 days and the results were shown in Fig. 2. With the 100% extract in culture medium, the ZK60-0.2Ca showed quite lower cell viability which means that the ions concentration of ZK60-0.2Ca was too high for culturing L-929 cell line. After diluted extract to 10%, the degree of toxicity was almost grade 0 according to ISO 10993-5:2009.

DISCUSSION & CONCLUSIONS: The degradation rate of currently-reported biodegradable magnesium alloys ranged from 0.1 to 2.5 mm/yr [1]. ZK60-0.2Ca is among the group with best corrosion resistance. Moreover, the mechanical properties and corrosion resistance can be further improved through hot working and surface modification. Thus ZK60-0.2Ca can be regarded as a promising biodegradable materials.


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