Influence of Zn content in MgAl3 and MgAl9 alloys on initial corrosion behavior in human blood

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Statement of Purpose: Biodegradable magnesium alloys are considered as auspicious candidates for the next stent generation. Before launching a new stent material to clinical application, numerous in vitro tests have to be performed. However, at present the use of simulated body fluids (SBF) is insufficient to mimic in vivo conditions for reliable screening of potential Mg alloys. Blood is much more complex than most SBF solutions used in conventional, standardized corrosion testing. The **aim** of this in vitro study was to investigate the corrosion behavior of MgAl3 and MgAl9 alloys without and with 1 wt.% Zn after 6 h immersion in a modified Chandler-Loop model with fresh human whole blood.

Methods: Four experimental magnesium alloys (MgAl3, MgAl9, MgAl3Zn1, MgAl9Zn1) without Mn content were investtigated. As reference MgZn1 was used. From each alloy 12 samples with a diameter of 10 mm and a height of 1 mm were polished with SiC 1200 in ethanol on both sides and ultrasonically cleaned in ethanol for 3 minutes. In order to simulate blood flow the experiments were performed using a modified Chandler-Loop, which consists of a thermostated water bath (Q102, Haake, Berlin) and a rotating unit with attached polyvinyl chloride (PVC) tubes. From each alloy two samples were clamped inside the particular PVC tubes (l = 50 cm) which were closed with an outer silicon tube. Each tube was filled with 20 ml fresh human whole blood. The experiments were run for 6 hours with a rotation speed of 30 rpm and at a temperature of 37 °C. After the tests, the samples were cleaned in physiological saline, then in 1 % SDS solution for about 10 seconds and stored in pure ethanol. The blood of each loop was collected into tubes containing lithium heparin (S-Monovette®, Sarstedt, Germany). The measurements of magnesium concentration were done with the Advia® 1800 Chemistry System (Siemens Healthcare Diagnostics GmbH**,** Germany). The method is based on the modified xylidyl blue reaction by Mann and Yoe [1]. The recorded Mg release results were related to the surface area of the magnesium alloy samples. All tests were repeated 6 times. The surfaces were investigated by SEM and EDX spectroscopy. Statistical significance of results was evaluated using Student's t-test (level of significance: 5 %).

Results: The mean magnesium releases after 6 h in human blood are given in Figure 1. The magnesium release of MgAl3 and MgAl3Zn1 was not significantly different and were found to be in the same order of 2500 µg/cm² as the reference alloy MgZn1. Compared to MgAl3 the higher Al content in MgAl9 reduced the magnesium release by a factor of two in human blood during the first 6 hours of immersion under flow condition.

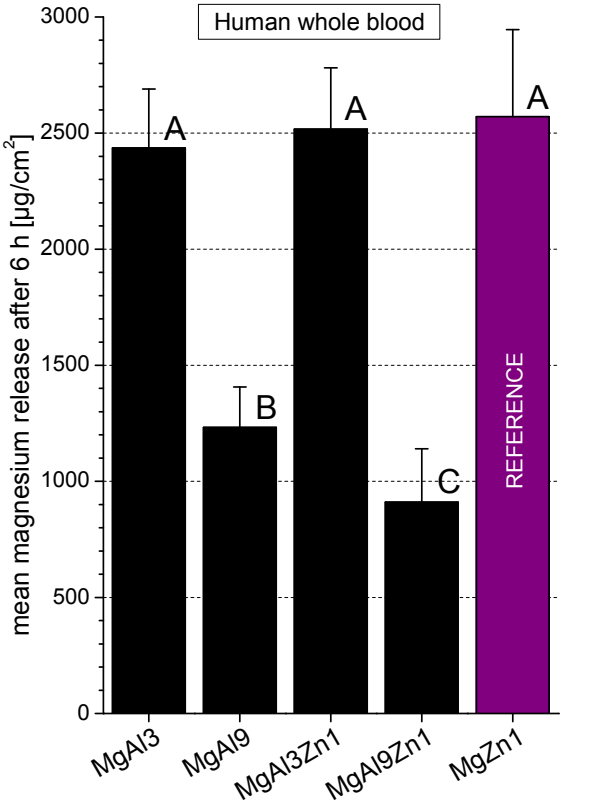

Figure 1: Magnesium release after 6 h in human blood. Statistically significant differences (p<.05) are indicated by unequal letters.

During corrosion in blood, a distinctive reaction layer was formed containing Ca und P, which could be determined by EDX spectroscopy.

Conclusions: The addition of 1 wt.% Zn to MgAl3 did not improve the corrosion resistance. However, with MgAl9, the addition of 1 wt.% Zn revealed a significant reduction of magnesium release.

References: [1] H. van den Bossche, R. J. Wieme: Use of the Mann and Yoe dye for automated determination of magnesium in biological fluids. Clin. Chim. Acta. 14 (1966) 112.

Acknowledgement: This study was partly supported by AiF (Project No: KF0548101PK7). The authors would like to acknowledge Dr. N. Hort from GKSS (Geesthacht, Germany) for casting the magnesium alloys.