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CHEMICAL COMPOSITION INVESTIGATION OF Zn-Mg ALLOY

Simona POPESCU (DOBRIȚĂ), Sergiu STANCIU, Ramona CIMPOEȘU, Dumitru Doru BURDUHOS NERGIS, Nicanor CIMPOEȘU

Gheorghe Asachi Technical University of Iasi, Faculty of Materials Science and Engineering, 41 D. Mangeron Blvd., 700050, Iasi, Romania

Abstract

Biodegradable materials represent a new class of medical materials used for specific applications. These materials tend to replace biomaterials in case of short time implantation situations. Among magnesium and iron based biodegradable alloys a new class, based on zinc, of degradable alloys have many applications because the degradation rate is situated between the rates of Mg and Fe alloys. In this article are presented preliminary results of obtaining a ZnMg alloy through classical melting operation. Also structural (scanning electron microscopy) and chemical (X-ray dispersive energy spectroscopy) analyze results are presented for melted and heat treatment by homogenization states of material.

Keywords*: biomaterials, medical materials, degradation rate.*

Introduction

Since antiquity people have been concerned with the restoration of parts of the body, damaged or lost as a result of accidents or illnesses [1, 2]. Among the first concerns of the people was the restoration of the tooth that first deteriorated due to the way of life and food [3, 4]. Thus, the earliest examples of dentures seem to have been the gold works of the Phoenicians, Etruscans, and later of the Greeks and Romans. Having an important role in the human body, as an intracellular element located in nuclei, cytoplasm, organisms and specialized vesicles as well as in the cell membrane, Zn is suitable for dissolution in aqueous solutions containing chlorine ions, such as electrolytes [5]. This behaviour has attracted a particular interest in the exploitation of these corroded metals for their possible use in the manufacture of biodegradable medical implants, such as bolts, nails or stents. Interest in Zn-based alloys has emerged after analysing and publishing favourable results obtained on Zn-Mg-Ca metallic bottles (containing at least 50% Zn), which show a significant reduction in gaseous hydrogen release during degradation in vivo and in vitro [6-8]. At the same time, Mg-based alloys have not yet found a suitable solution to reduce the high rate of degradation of these alloys, degradation limiting their practical applications as biodegradable implants [9, 10].

In this article the authors present the preliminary results from obtaining of a ZnMg experimental alloy analyze.

Experimental Details

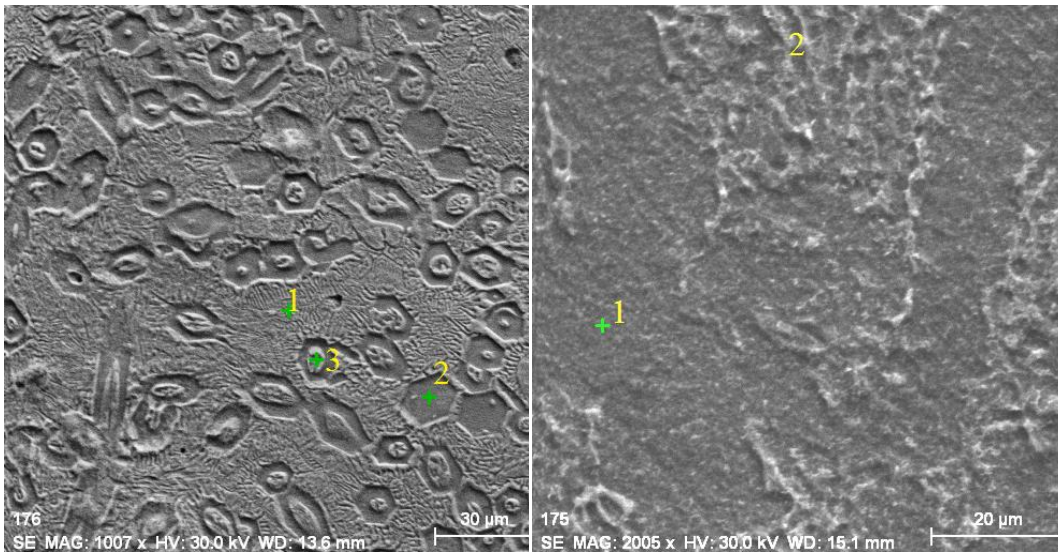
A zinc-based magnesium alloy was formed in an argon-induced furnace. The melting was done in a metallic crucible; initially a zinc metal bath (99.995% purity) was obtained without overheating, and after the magnesium (99.9%) which was incorporated in the metal bath and melted was introduced. After maintaining for 2-3 minutes at the same temperature of

*) Corresponding author: nicanornick@yahoo.com

the furnace to homogenize the melt, the casting was carried out in a metallic form. The alloy was cast into cylindrical shapes of 100 mm in length and 12 mm in diameter. From these experimental samples were drilled with a diameter of 10 mm and a length of 10 mm for analyses. The experimental alloy was analysed by electronic scanning microscopy (SEM VegaTescan LMHII) and X-ray dispersion energy spectroscopy (EDAX Bruker).

Experimental Results

The alloy, after casting, mechanical machining and mechanical polishing, was analysed for chemical composition by spectroscopy of characteristic X-rays (EDS) using the Bruker detector on a VegaTescan SEM equipment from the Faculty of Materials Science and Engineering from Iasi. Tests were performed both on the entire surface of the alloy (4 mm2) and on narrower areas by point analysis (Point) (spot of 90 nm ≈ 0,0064 μm^2). The samples were polished on metallographic paper, polished on felt and chemically etched with Nital. The material was analysed both in moulded state and after heat homogenization (heating at 300 °C and holding 12 hours). Fig. 1 shows the surface of the ZnMg experimental alloy in two a) cast moulds, and b) homogenized.



a) b)

Fig. 1. The surface of the ZnMg experimental alloy in two conditions a) poured, b) homogenized

For the analysis of the chemical composition in point were selected 3 points on the moulded sample, Fig. 1.a) and 2 points on the homogenized sample, Fig. 1.b). Table 1 presents the experimental results obtained from the chemical analyses on the ZnMg alloy in the casting state and in the heat treatment state of homogenization. In the casting state, magnesium is found in proportions of 5, 10 and 6% wt depending on the area under consideration, Fig. 1.a), the higher magnesium compounds in hexagonal form, point 3, with no central points of material with less magnesium dissolved. Since an alloy of about 5% Mg has been proposed and the metallic charge has been appropriately calculated using high purity materials it can be assumed that a zinc loss has occurred during the heating of the metal bath, melting or casting, in Fig. 1.b) can observe the oxides of the formed material - probably zinc - because the percentage of magnesium is more than 5%.

Table 1. Chemical composition of the cast alloy experimental alloy and after the homogenization heat treatment (wt% and at% are weight respectively atomic percentage)

Element /	**Zinc**		**Magnesium**	
area	wt%	at%	wt%	at%
melted (4 mm^2)	92.28	81.6	7.72	18.38
point 1 (90 nm spot)	94.81	87.16	5.19	12.84
point 2	89.23	75.49	10.7	24.51
point 3	93.79	84.88	6.21	15.11
homogenized (4 mm^2)	94.47	86.39	5.53	13.61
point 1	94.60	88.18	5.39	12.78
point 2	93.05	83.27	6.95	16.73
error EDS %	1.01		0.4	

After the homogenization heat treatment applied to the moulded ZnMg alloy. a further dilution of the two phases is observed. the magnesia decreasing from 10 to 6-7 wt%.

Fig. 2 present the distributions of the Zn. a) and c) and Mg b) and d) elements in the cast ZnMg alloy and in the same alloy after the homogenization heat treatment to highlight the effect of heat treatment.

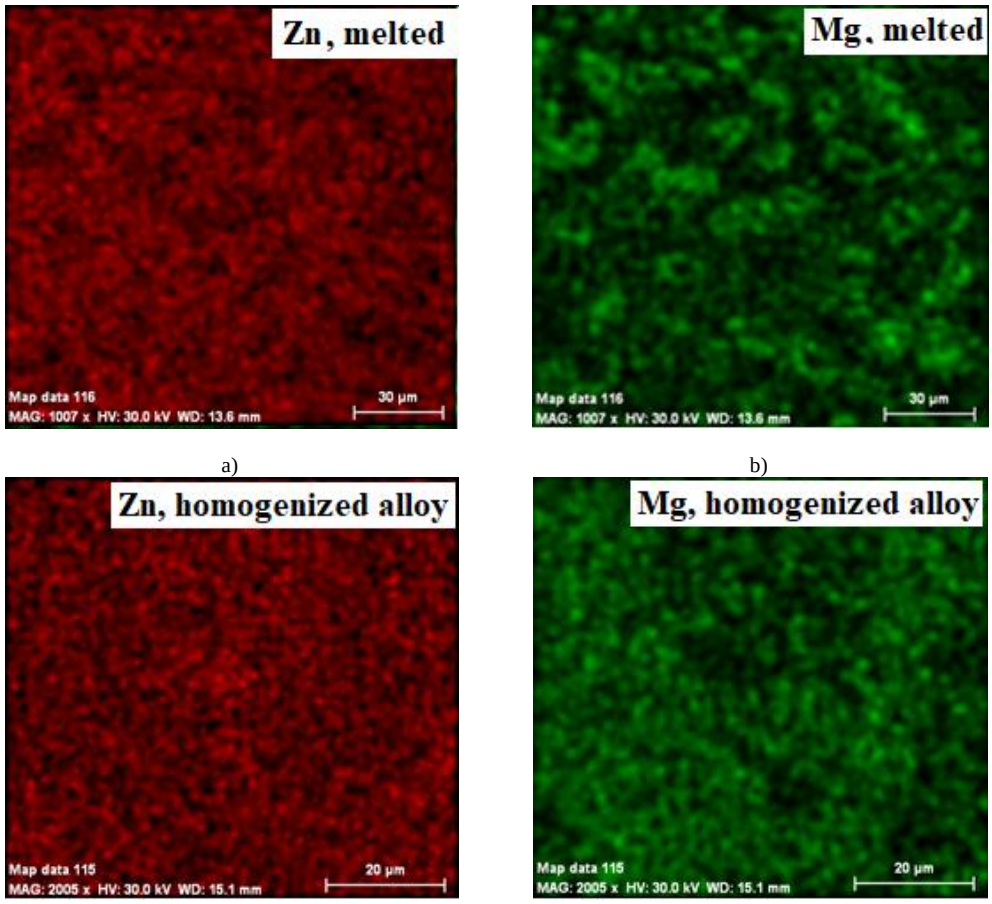


Fig. 2. The distributions of the Zn. a) and c) and Mg b) and d) elements in the cast ZnMg alloy and in the same alloy after the homogenization heat treatment

For the distribution of the zinc element no great differences are observed between the cast and the homogenized alloy. its distribution depending largely on the magnesium distribution. The magnesium element in the moulded alloy forms a phase of material agglomerated in clusters of dimensions between 10 and 20 μm. This is a disadvantage for the behaviour of these materials in the medical applications for which this material is proposed leading to a preferential corrosion of the alloy on or in addition to these magnesium agglomerates.

Conclusions

An experimental ZnMg alloy was obtained by conventional casting in an induction furnace of high purity elements (Zn and Mg). The alloy in the casting state and after the heat-homogenization treatment was analysed from chemical composition point of view and from the microstructural point of view. The alloy is biphasic (both Zn-Mg phases with a different Mg content) and the homogeneous heat treatment (300 ˚C for 15 hours) alters both structurally and chemically. The degradation period of zinc alloys is different of that of magnesium alloys and iron based alloys. this making Zn alloys suitable for degradable materials industrial and medical applications. The behaviour of zinc alloys in electrolyte solutions can be modified by introducing of different degradable chemical elements.

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