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Corrosion Behaviour of Magnesium Alloys AZ31, AZ91 and Pure Magnesium for Bio Medical Implants - A Review

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***Abstract*: Medical implants are man-made devices which is used as a replacement original biological structure. In earlier days, bone implants were done by replacing another bone from dead human, later the scenario changed and get replaced by titanium alloys. Titanium alloys are most commonly used for dental and bone implants. The basic concept of using titanium alloys in dental implants is scientifically accepted and successfully going on. However, the development of undesirable allergic reactions, cellular sensitization and aesthetics grey hue have raised demands for more aesthetic and bio-compatible implant material. This review was based on the comparison of corrosion [8]-[11] rate of magnesium alloys AZ31 and AZ91 and to suggest which one is good corrosive resistant, so that the alloy cane be used for medical implants system.**

***Keywords*: magnesium alloys, bio medical implants**

1. Introduction

For bio medical implants magnesium alloys [12, 13] satisfies all the properties that needed when compared to titanium. Magnesium has an excellent aesthetic, mechanical and optical properties. Magnesium based implants are chemically inert biomaterials with good cell adhesion and exhibit a high degree of biocompatibility [7] with surrounding bones, blood cells and tissues.

The magnesium alloys AZ31,AZ91 and pure magnesium [4,5,27] with Nacl solution are tested and the corrosion test is made, then the corrosion rate of materials is founded by weight loss measurement and the microstructural behaviour [21] of magnesium alloys are studied through scanning electron microscope (SEM) [6] and the microscopic structure is observed.

The results of the tests were tabulated for the magnesium alloys AZ31, AZ91 and for the pure magnesium.

2. Search strategy

A. Focus question

Which magnesium alloy as good corrosion resistance for bio medical implants AZ31 or AZ91 or pure Mg?

3. Materials and methods

A. Magnesium alloys

Magnesium alloys are mixtures of magnesium with other metals called alloy often aluminium, zinc, manganese, silicon, copper, and zirconium. Magnesium is the lightest structural metal. Magnesium alloys have hexagonal lattice structure, which affects the fundamental properties of these alloys plastic deformation of the hexagonal lattice is more complicated than in cubic latticed metals like aluminium, copper and steel; therefore, magnesium alloys are typically used as cast alloys, but research of wrought alloys has been more extensive since 2003. Cast magnesium alloys are used for many components of modern automobiles have been used in some [25] high-performance vehicles; die-cast magnesium is also used for camera bodies and components in lenses.

Magnesium alloys are referred to by short codes which denote approximate chemical compositions by weight. For example, AZ31 has 3% aluminium and 1% zinc; AZ91 is 9% aluminium and 1% zinc. As like this there are many types of magnesium alloys, but here we are going to deal with AZ31and AZ91 magnesium alloys.

1) Magnesium alloy AZ31

The AZ31 alloy is one of the most popular magnesium alloys with aluminium. Due to its low mass density and good mechanical properties and aesthetic properties, this structural material offers considerable potential for the aircraft manufacturing industry. The AZ31 alloy is used in the aircraft industry to produce flat parts with ribs, such as brackets. Magnesium alloy AZ31 is also biocompatible so it is used in medical implants.

2) Magnesium alloy AZ91

As like magnesium alloy AZ31, AZ91 also exhibit good aesthetic properties and mechanical properties, because of these alloys low melting point it is easily melted and casted into different shapes. Also it has good machining property [9] so it can be machined as well.

Table 1
Results

S. No.	Author	Published Year	Studied Material	Result Assessment Method	Result
1	I.B. Singh, M. Singh, S. Das.	April 2015	Pure magnesium metal, AZ31 alloy (Al 3%, Zn 1%, balanced Mg), AZ91 alloy (Al 9%, Zn 1 %, balanced Mg) having dimensions of 2.5*2.5*0.25 cm.	A comparative corrosion behaviour [19,20,28] of Mg, AZ31 and AZ91 alloys in 3.5% NaCl solution.	Weight loss measurement shows initially an increase of corrosion rate in order of Mg < AZ91 < AZ31 in 3.5% NaCl solution. After 3h of immersion, the corrosion rate of AZ91 becomes much more than AZ31 alloy due to start of localized corrosion [33].
2	Zhongyu Cui, Feng Ge, Yi Lin, LiweiWang, Li Lei, Huiyun Tian, Mingdong Yu, Xin Wang.	May 2018	Magnesium alloy (Al 3%, Zn 1%, and balanced Mg) with a dimension of 2*2*0.3 cm.	Corrosion behaviour [30] of AZ31 magnesium alloy in the chloride solution containing ammonium nitrate.	Corrosion of AZ31 alloy is initiated from localized corrosion and evolves into general corrosion in NaCl without and with 0.001 and 0.1 of NH4NO3 [3].
3	WUDaogao, YAN Shihong, WANG Zhiqiang, ZHANG Zhiqi, MIAO Ruiying, ZHANG Xiaowei, CHEN Dehong	April 2014	The AZ91 [24] alloy having pure magnesium (99.95 wt.%), pure aluminium (99.95 wt.%), pure zinc (99.99 wt.%), Mg-30Sm having Samarium(wt.30%).	Effect of samarium on microstructure [1, 18] and corrosion resistance of aged as-cast AZ91 magnesium alloy in 3.5% of Nacl solution.	According to electrochemical tests and weight loss measurements, minor addition of Sm increased the corrosion resistance of re-aged AZ91 alloy. When content of Sm was 0.5 wt.%, the corrosion resistance of AZ91 alloy tended to be the best, reduced the corrosion rate of it by 54%, whereas further addition of Sm over 0.5 wt.% made the corrosion resistance decrease lightly [34].
4	Alireza Sadeghia, Ehsan Hasanpura, Ahmad Bahmanib, Kwang Seon Shinb	June 2018	Magnesium alloy (Al 3%, Zn 1%, balanced Mg) [31].	Corrosion behaviour of AZ31 magnesium alloy containing various levels of strontium in 3.5% of Nacl solution.	With increasing Sr concentration, the volume fraction of Al-Mg-Sr precipitates increases. This increases the area fraction of galvanic cells and hence accelerates the localized corrosion and increases the corrosion rate [2].

4. Experimental procedure

The materials used in the study, were commercial grade Mg (~99% pure) metal and as cast AZ31 (Al 3%, Zn1%, balanced Mg) and AZ91 (Al 9%, Zn 1%, balanced Mg) alloys [33]. The casting of the alloys was made in the oxygen protective atmosphere. In weight loss measurement rectangular samples of dimension (2.5*2.5*0.25) cm and (2*2*0.3) were used. Samples were polished well with different grades of emery paper. Before immersing, samples were degreased using trichloroethylene solution. In weight loss measurement, pre-weighted samples were immersed vertically in 3.5% NaCl with the help of polypropylene make thread tightened at one end of the sample through drilled hole. Immersed samples were removed from the solution after different intervals of time. After removing, samples were washed carefully, dried in air and again re-weighted. The corrosion rate was derived using following equation [33].

Corrosion rate (mm/year) = 87.6 * W/DAT

Where, corrosion rate is in mm/year,
W - Weight loss in mg,
D - Density
T - Time in hour.

5. Conclusion

Weight loss measurement of magnesium alloys AZ31, AZ91 and pure magnesium in Nacl solution shows there is increase of corrosion rate in 3hours of immersion, The corrosion rate of AZ31 is maximum than the AZ91 and Mg due to start of localized corrosion.

Later when general corrosion starts corrosion takes uniformly in every areas of alloy and corrosion rate is maximum in pure magnesium compared to other three alloys.

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