

EFFECT OF ZINC ADDITION ON THE PROPERTIES OF MAGNESIUM  
ALLOYS

SAMIR SANI ABDULMALIK

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To my mother for her tireless prayers

To Engr Isyaku Jibrin Sani for his Financial Support

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## ABSTRACT

Magnesium alloys are currently used in many structural applications. It is believed that magnesium and its alloys may also find applications in biomedical application. In this study, the effects of Zinc (Zn) addition on the properties of magnesium (Mg) alloys, i.e. Mg-xZn (x = 2, 4, 6, 8, and 10) were investigated. Optical microscopy, scanning Electron Microscope (SEM), tensile and Vickers hardness testing were used for the characterization and evaluation of the microstructure and mechanical properties of the alloys. Electrochemical corrosion measurement was also employed to determine the corrosion resistance of the alloys. The results show that magnesium alloy with 6 wt. % zinc content (denoted as Mg- 6Zn) shows good corrosion resistance and mechanical properties).

## ABSTRAK

Pada masa ini aloi magnesium (Mg) telah digunakan dalam pelbagai aplikasi struktur. Dipercayai bahawa magnesium dan aloinya telah digunakan dalam bidang bioperubatan. Dalam kajian ini, kasan pertambahan zink (Zn) (2, 4, 6, 8 dan 10% berat) terhadap sifat mekanikal dan kakisan aloi magnesium, Mg-xZn telah dikaji. Analisis menggunakan mikroskop optik, *Scanning Electron Mikroskopy (SEM)*, ujian ketegangan dan kekerasan Vickers telah digunakan bagi pencirian dan penilaian mikrostruktur dan sifat mekanikal aloi yang dikaji. Ujian kakisan electrokimia juga telah digunakan untuk menilai sifat rintangan kakisan aloi. Keputusan ujikaji menunjukkan bahawa aloi magnesium dengan kandungan 6% berat zink (diwakili dengan Mg-6Zn) memberikan sifat kakaisan dan mekanikal yang baik.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Biomaterial implants are used as a replacement of a bone part or as a support in the healing process. Replacement of a bone part requires implants to stay in the body permanently, while support only requires that the implant remain in the body for a shorter period. When permanent implant is used for a temporary application, additional surgeries are required to remove these devices after the healing process. Thus, removal process increases the patient grim and cost of health care. In contrast, biodegradable materials require no additional surgeries for removal as they dissolve after the healing process is complete. This also eliminates the complications associated with the long-term presence of implants in the body. Finally, after these materials degrade within the body, it is important that the body can metabolized the degradation products, and thus are bioabsorbable.

The first materials to be used as commercial biodegradable and bioabsorbable implant materials were polymers. The most commonly and earliest used absorbable materials include polyglycolic acid (PGA), poly-lactic acid (PLA), and poly-dioxanone (PDS). However, low mechanical properties and radiolucency are the limitation with these materials. Applications of polymeric materials in load-bearing and tissue

supporting applications is severely restricted due to low strength, because the mechanical needs of the body required a greater amount of material.

Metals due to their relatively high strength and fracture toughness possess desirable mechanical properties, however, most of the metals are biologically toxic. Studies revealed that conventional implants, like cobalt, stainless, chromium, and nickel-based alloys produce corrosion products, which are harmful to the human body [1] [2] [3] [4].

Magnesium and its alloys are biodegradable metals and exhibit improved mechanical properties and corrosion resistance. However, most of the reported biomedical magnesium alloys contain aluminum and/or rare earth (RE) elements. It is well known that Al and rare earth elements are harmful to neurons, osteoblasts, and also associated with dementia and could lead to hepatotoxicity. Consequently, Al and RE are unsuitable alloying elements for biomedical magnesium materials, particularly when they are above certain levels [5]

Pure magnesium was indicated as a suitable candidate for temporary implants; however, the major drawback of Mg is its low corrosion resistance which results in low mechanical strength in the physiological environment. Alloying elements can be added to increase the strength of pure Mg but alloying elements should be selected carefully to maintain the Mg's biocompatibility.

With the purpose of searching for suitable alloying elements for biomedical magnesium alloys, researchers demonstrated that Calcium (Ca), Manganese (Mn), and Zinc (Zn) could be appropriate candidates. Zinc is one of the essential elements in the human body that also provides mechanical strengthening in Mg-based alloys.

Zinc can improve the corrosion resistance and mechanical properties of magnesium alloys, Zinc additions increase the strength of Mg-based alloys primarily through precipitation strengthening. Furthermore, zinc is one of the most abundant

nutritionally essential elements in the human body, and has basic safety for biomedical applications [6] [7].

## **1.2 Statement of Problem**

The mechanical properties and corrosion resistance of magnesium alloys must be sufficiently investigated for medical application. Magnesium is essential to human metabolic functions and is the fourth most abundant cation in human body. In vitro cytotoxicity of pure magnesium metal showed positive cell proliferation and viability with no sign of growth inhibition. The fracture toughness of magnesium is greater than that of ceramics, but pure magnesium corrodes too quickly in the physiological environment (pH 7.4–7.6), losing mechanical integrity before tissue healing. In an effort to maintain the mechanical integrity, and biocompatibility, more alloying compositions are necessary.

## **1.3 Objectives**

The objectives of this project are:

1. To establish optimum material composition Mg-Zn
2. To establish the effect of Zinc addition on the properties of Mg alloy as biodegradable material



## 1.4 Scopes

This project was conducted within the following boundaries:

1. Mg-Zn alloys was prepared and cast using gravity die casting process
2. The effect of zinc addition was characterized and measured through:
  - (a) Microstructure observation
  - (b) Mechanical properties test, and
  - (c) Electrochemical corrosion tests