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BULK METALLIC GLASSES BASED ON MAGNESIUM TO POTENTIAL BIOMEDICAL APPLICATION

Abstract: The paper presents some informations about materials for biomedical application. The study was performed on ternary Mg-based alloys. The $Mg_{66}Zn_{30}Ca_4$ glassy alloy was prepared in the form of rods by pressure die casting method of molten alloy into water cooled copper mold. This alloy is potential material for biomedical application.

1. Introduction

The development of medicine and especially implantology is based on research of materials accepted by an organism, which during implantation do not evoke undesired reactions e.g. allergic ones. Depending on a kind of an implant and a place of its insertion (e.g. dental, orthopaedic) change also requirements for them and different production technologies are applied. The main tasks of implants are i.a. replacement of a body part or an organ, restoration of bodily functions or improvement of an esthetic aspect. We call implants all medical tools, which are inserted into an organism for a longer time, partially or completely under the surface of epithelium. Medical implants are created with one or more biomaterials and their main role is to assure proper conditions to enable reconstruction of a damaged bone tissue in case of orthopedic implants or to take over its functions. The composition of a biodegradable alloy, from which an implant will be produced, should include such elements as: Magnesium and Calcium, as they are present in a human body in the highest concentration and Zinc, which as a significant microelement in an organism. Other elements, which may be considered as alloys additives for the Magnesium base, are Potassium and Phosphorus. There play a basic biological role in a human body. Their deficit or excess may cause dysfunction of a correct body functioning. During selection of proper elements it is necessary to consider the pace Magnesium material dissolving in a living organism. Too fast dissolving may cause impediment in bone fracture healing whereas too slow dissolving may cause a necessity of a subsequent intervention to remove an implant. Initially researches were performed on two-component alloys in the Mg-Ca and Mg-Zn phase equilibrium system. A group of Mg-Ca alloys is characterized with a possibility to regulate mechanical properties and biocompatibility by means of increasing or decreasing of Calcium

share in an alloy. Their main disadvantage is low corrosion resistance and unfavourable mechanical qualities. The second alloys groups Mg- Zn was thoroughly examined, especially by research groups from China.

2. Materials for biomedical application

Research on calcium, magnesium and zinc alloys are currently perfomed, which could be materials of a potential application as biodegradable orthopedic implants. These alloys due to their chemical composition presumably would not have a toxic impact on an organism. It is necessary to mention that both magnesium and calcium are microelements, which are present in a human body in high concentration (magnesium 20-28 g in a body of an adult, magnesium 1,4-1,6 % of a body mass of an adult) and take part in many bodily functions. Zinc is a microelement, which is present in lower concentration (zinc: 1,5 – 2,2 g) in a human body, however, it has i.a. healing properties (stimulates wounds healing). The main advantage of magnesium and calcium alloys would be a possibility of gradual biodegradation (dissolving) in a human body, which is connected with no need of subsequent surgical intervention after having inserted an implant. The biggest problem with this conception is an exact selection of a chemical composition and properties of a surface layer to assure that period of bones fracture healing and biodegradation of implant is proper [1, 4].

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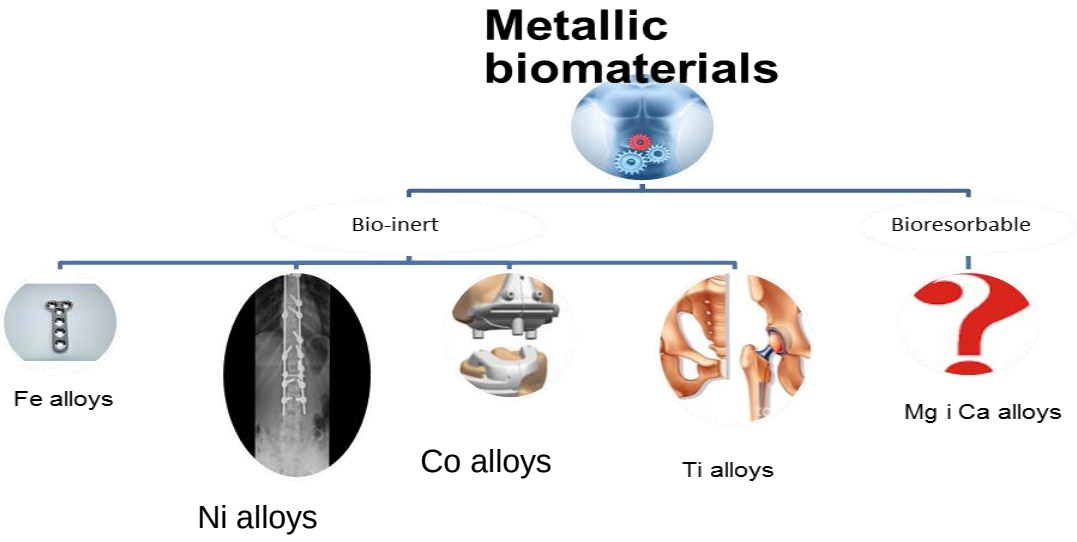

Fig.1. Schematic illustration of metallic biomaterials application

3. Mg-Zn-Ca alloy

To study chosen Mg-Zn-Ca alloy as the qualitative chemical composition satisfies the condition biocompatible chemical composition, which not only allows the complete reconstitution of a melt in the environment of tissues and body fluids of human without any harmful effects on the health of the recipient, but also corresponds to a bioactive alloy characteristics increased bone tissue at the implantation site (Fig. 2) [1, 2].

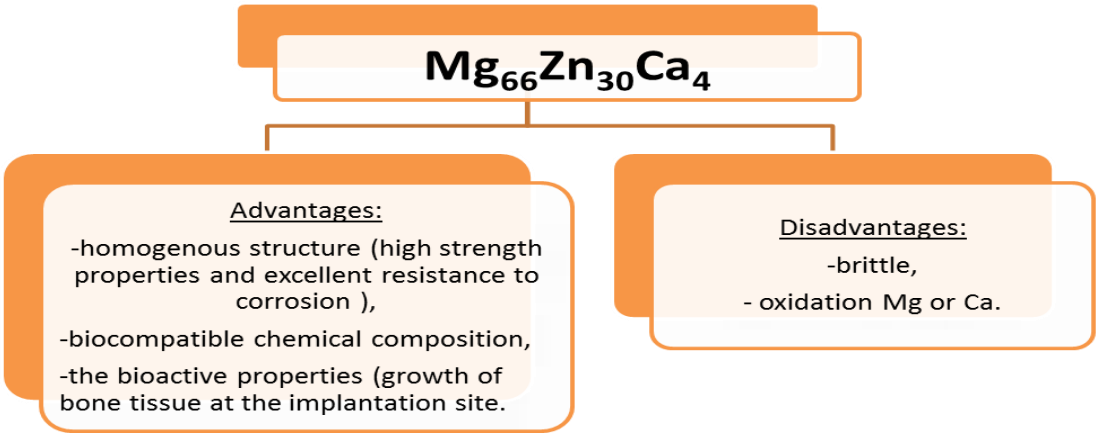

Fig.2. Schematic illustration advantages and disadvantages of Mg-Zn-Ca alloy.

To produce $Mg_{66}Zn_{30}Ca_4$ bulk metallic glasses is used pressure die casting method of molten alloy in the copper mold.
High-Pressure Die casting is a most common method to produce bulk metallic glasses. Presented sample were produced by the pressure die casting method in form of plate (Fig. 3).

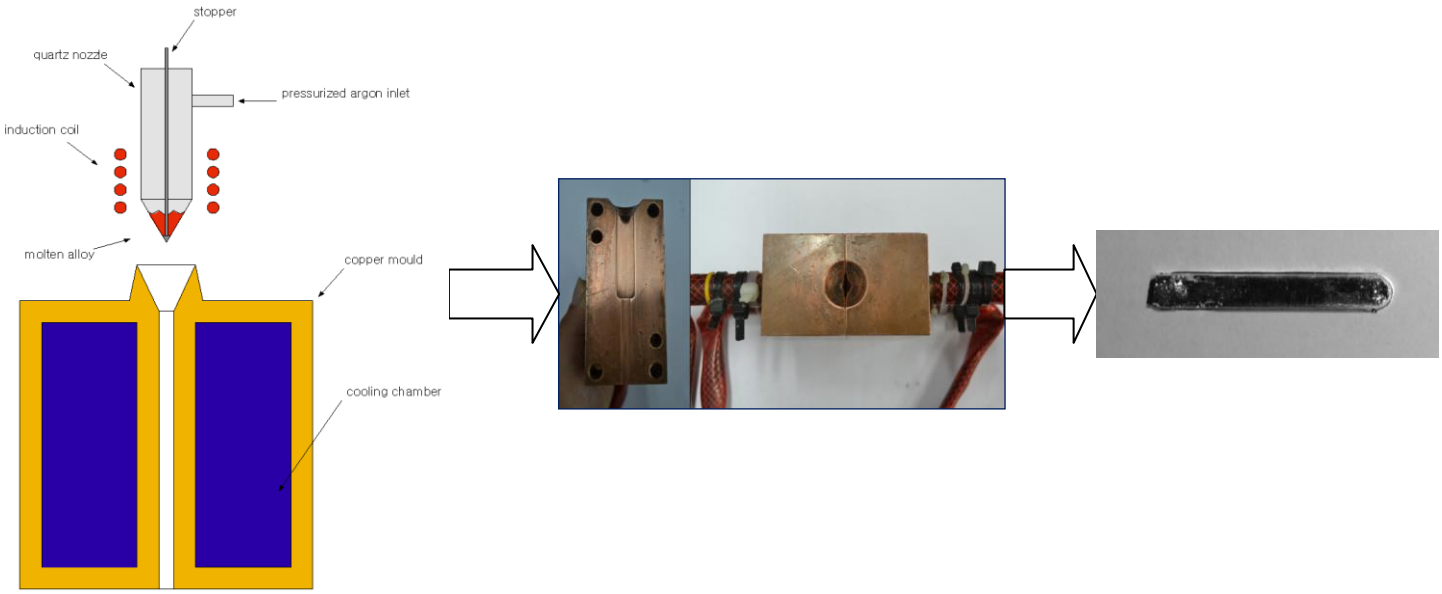

Fig.3. Schematic illustration bulk metallic glasses in form of plate [3]

Similar physical and mechanical properties of Magnesium amorphous alloys to these properties of a human bone are an argument confirming correctness in considering them a potential biomaterial for implantology applications. In comparison to applied orthopaedic materials i.e. Titanium and Cobalt alloys they are characterized with lower values of linear elastic modulus, which amounts to 40÷45 GPa and lower density located in a range of 1,7 ÷ 2,0 g/cm3. Additional advantage of Magnesium alloys is a possibility of biodegradation in the organism, owing to which a subsequent intervention of surgeons due to remove implants after a bone fracture healing is not necessary [4].

4. Conclusions

Mg-based bulk metallic glasses represent an alternative metallic biomaterial, which has applications in medicine, especially in implantology. Biodegradation of Magnesium alloys solves a problem of toxic implants corroding in the human organism after a given use period. Alloys of Mg-Zn-Ca system were chosen for research as their quality composition meets the requirements of a biocompatible chemical composition, which not only allows a complete solubilization of an alloy in a tissues environment and body fluids of a human without harmful side health effects on a recipient, as well as it is responsible for bioactive properties of an alloy evinced by growth of bone tissue on a implantation area.

References

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