Université de Lille
Faculté des sciences et technologies
Département Chimie

Dr. Rajashekhara SHABADI, Ph.D. HDR
Tel: +33-320 43 6224
rajashekhara.shabadi@univ-lille.fr

Magnesium based multicomponent bulk metallic glasses for biomedical applications

(Thermodynamic, alloy design, corrosion/ bio-compatibility and Invitro/invivo studies)

Magnesium (Mg)-based metallic glasses are considered as possible candidates in orthopedic implant applications. Alloying with proper elements can be an effective method to improve the electrochemical corrosion and mechanical properties of pure magnesium. Suitable alloying elements that are proven to be non toxic to the human or living cells are Silver, zinc, manganese, Calcium Zirconium and some rare earth elements. Rare earth elements such as cerium, lanthanum and neodymium are considered toxic for lung tissues. Earlier trials have shown that Zn and Ca along with some rare earths have a nontoxic influence on the living cells. Earlier a ternary system based on Mg-Zn-Ca[iii] have been studied and although the results were promising, the degradation rate was much faster[iii] (4 weeks in vivo). For any surgery related to orthopedic involving an implant, a minimum of 10 to 12 weeks of healing time is required. The rapid dissolution of MgZnCa has limited its application and is the bottleneck in the present case. The present research proposes to involve two different strategies to improve the corrosion/dissolution and increase its bio-adaptability, surface treatment and alloying. There are sub challenges that needs to be treated such as peeling-off of coatings, adhesion properties with the tissue and applications processes. However, that is the challenge this thesis would like to address.

In recent years, bulk metallic glasses and high-entropy alloys have both unique properties that conventional metals and alloys are unlikely to match. The present research exploit this very nature of these alloys in order to easily form the metallic phases that are useful in enhancing the bio-application of mg alloys.

This research involves initial thermodynamic calculations that are to be validated with the experimental analysis. These calculations will be based on thermodynamic parameters such as enthalpy of chemical mixing, elastic enthalpy, and configurational entropy, thus incorporating the pivotal effects, i.e., electron transfer effects, effect of atomic size mismatch, and effect of randomness. In essence, this will help us visualize as the energy barrier that exists between the transformations of random atomic structure of glass to ordered crystalline structure. These calculations forms the basis for further elaboration of the specific alloys for the experimental validation. Experimental challenges include the fabrication of such a multicomponent alloy (Induction and/or Arc melting furnace), metallurgical characterization involving the microstructural, mechanical and the corrosion properties. Further, the final validation on the selected alloy will be evaluated for its biological behaviour.

Participants: Bio-corrosion/vaidity bio application (Dr. Feng Hildebrand, INSERM)

Dr. Rajashekhara SHABADI
Faculty of Science and Technology
UMET, Faculty of Science and Technology
University of Lille
59650 – Villeneuve d'Ascq

<u>All interested candidate send your letter of motivation, detailed curriculum vitae and the degree certificates</u>

---

[i] SudeepPaul, Parthiban Ramasamy, Mitun Das, Durbadal Mandal, Oliver Renk, Mariana Calin, Jürgen Eckert, Supriya Bera, New Mg-Ca-Zn amorphous alloys: iocompatibility, wettability and mechanical properties, Materialia, Volume 12, August 2020, 100799.

[ii] H.F. Li, Y.B. Wang, Y. Cheng, Y.F. Zheng, Surface modification of Ca60Mg15Zn25 bulk metallic glass for slowing down its biodegradation rate in water solution, Mater Lett, 64 (2010), pp. 1462-1464

[iii] Y. Wang, X. Xie, H. Li, X. Wang, M. Zhao, E. Zhang, et al., Biodegradable CaMgZn bulk metallic glass for potential skeletal application, Acta Biomater, 7 (2011), pp. 3196-3208