Study of Fe-Mn-Si alloys for biodegradable implant application

D. Spandana

JNTUH College of Engineering Hyderabad, India

International Advanced Research Center for Powder Metallurgy and New Materials (ARCI), Hyderabad, India

spandana19996@gmail.com

R. S. Rama Devi[1], D. Chakravarty[2], Kaliyan Hembram[2*], Hemin Desai[2] and R. Vijay[2]

1. JNTUH College of Engineering Hyderabad, India

2. International Advanced Research Center for Powder Metallurgy and New Materials (ARCI), Hyderabad, India

ABSTRACT

Metallic implants that are being used will remain permanently in the body and causes some long term side effects like systemic toxicity, chronic inflammation, thrombosis which necessitates a second surgical intervention. To avoid these complications, next generation biodegradable implants are being developed worldwide. The biodegradable metallic materials participate in healing and then dissolve in a body by corrosion process. Zn, Mg, Fe are known to be biodegradable metallic implants which exhibit good biocompatibility within the body. Magnesium received wide attention in the past for the implant; however it is not considered for practical application because of high corrosion rate. Iron has a better strength and a low cost compared to Mg and Zn. Iron-Manganese-Silicon alloy is a promising biodegradable metallic implant with a special property of shape memory effect. Fe-Mn alloy having greater than 29wt%Mn exhibits a single austenitic phase which shows anti-ferromagnetic and MRI compatibility.

In this study, three different compositions (Fe-35Mn-5Si, Fe-33Mn-5Si, and Fe-31Mn-5Si) are considered to find the stability of austenite phase with Mn content. Powders were synthesized by high energy ball milling and sintered by spark plasma sintering followed by annealing. The phase, microstructure, mechanical strength and corrosion properties of the samples(powders and alloys) were investigated by advanced characterization techniques such as X-ray diffraction, C-S analyzer, O-N analyzer, ferriscope, DLS particle size analyzer, FE-SEM, EBSD, micro-tensile and hardness testing, electrochemical impedance analyzer. Degradation rates of the alloys were studied in standard Hanks solution. It is found that austenitic phase stability is increased with Mn content and among all the compositions Fe-35Mn-5Si exhibited best mechanical properties of Y.S 500MPa, UTS 712MPa, Young's modulus 110GPa, elongation 8% and hardness 381HV which is comparable with Ti and 316L stainless steel permanent metallic implants. The alloy with 33wt%Mn revealed higher corrosion rate of 0.13 mm/year compared to other compositions.

Key words: Fe-Mn alloys; Biodegradable Implant; Spark plasma sintering; Mechanical Properties; Electrochemical properties