## ABSTRACT

Magnesium (Mg) based biomaterials have gained significant attention in past few decades as degradable internal fracture fixation devices applications due to their comparable mechanical properties to natural bone as well as favourable biodegradability and good biocompatibility. However, rapid degradation of pure Mg in physiological solution hinders its applicability as degradable fracture fixation devices. A rapid degradation of Mg, can lead to loosening of the implant leading to loss of mechanical integrity before tissue has successfully healed.

In this present work, bioactive glass (BG) incorporated Mg/BG composite was prepared through pressure assisted sintering such as spark plasma sintering and hot press sintering. Simultaneous application of pressure and temperature during pressure assisted sintering, allows BG to flow around the Mg particles and partially coat it. As a result, corrosion resistance of Mg/BG composite increased where 10wt.% BG was found to be at optimum. Higher BG content resulted in interfacial crack formations in the composite and deteriorated its corrosion resistance. The improvement in corrosion resistance of Mg/10BG composite resulted in lower pH rise and hydrogen evolution rate that directly influenced the cytocompatibility of the material. Cell proliferation assay through Alamar Blue and Live/Dead imaging, indicated highest cell proliferation and cell viability for Mg/10BG composite. In addition, Mg-MgP composite was prepared through casting route and evaluated in terms of mechanical properties, corrosion resistance and biological behaviours. Mg-3wt.%MgP exhibited controlled degradation rate and favourable *in vivo* biocompatibility.

In another approach, Mg-2Sr-1Zr-xCe (JK21/xCe, x= 0.5, 1.0, 1.5 wt.%) alloy was developed through casting route and post processed through hot forging. Cast samples were characterized by large $Mg_{17}Sr_2$ and $Mg_{12}Ce$ precipitates with grain size ranging from 23±4.07 µm to 35.4±5.9 µm. Hot forging reduced the grain size of the alloys in the range of 7.15±2.01µm to 10.2±2.75µm due to dynamic recrystallization. Additionally, solution treatment and forging resulted in reduced amount of second phase precipitation. Increasing the Ce content in the alloy from 0 to 0.5 wt.% suppressed the formation of continuous network of $Mg_{17}Sr_2$ precipitates and forms a protective $CeO_2$ layer. A combination of both the phenomena leads to higher corrosion resistance of the ternary alloy. Beyond 0.5 wt.% Ce addition $Mg_{12}Ce$ starts to precipitate and deteriorated the corrosion further. Reduced precipitate and refined grain structure also improved the mechanical properties of hot forged Ce added Mg alloys. Due to better corrosion resistance of forged JK21/0.5, it showed favourable condition, such as pH and ion release, for in vitro cell growth. Cell proliferation, as determined through Alamar blue assay and LIVE/DEAD imaging, showed highest cell growth at day 1 and 3 at all the extract concentrations (10, 50, 100%) for this optimized sample. When implanted in rabbit femur, the forged JK21 samples showed in vivo degradation but correlating to their in vitro counterpart degradation was lowest for JK21/0.5Ce samples. Large amounts of precipitate in JK21/1.5Ce samples resulted in accelerated corrosion in vivo as well and showed considerable degradation at 2 months when studied using micro-CT. After 2months of implantation in rabbit femur, enhanced new bone formation (60.79±2.72%) and good osseointegration were noticed for JK21/0.5Ce sample in comparison to other alloys as indicated by Micro-CT (µ-CT) and histological analysis.

On a different note, porous Mg scaffold was developed for non load bearing small scale bone defects. Scaffolds were processed by simple powder metallurgy route with porosity ranging from 30-63 µm. Compressive strength of the scaffold varied from 184±9.9 MPa to 24±4.54 MPa,

while porosity increases from 6% to 40%. Mg/10wt.% Naphtalene exhibited least corrosion rate among all the prepared scaffold.

Finding a balance between corrosion, mechanical property and biocompatibility is one of the most demanding challenges of Mg based fracture fixation devices. The present work provides some insight on how a specialized processing route and addition of an optimum amount of bioactive reinforcements (10 wt.% BG 5and 3 wt.% MgP) in Mg composite and specific alloy composition (0.5 wt.% Ce) with post processing, can address these critical challenges. Also, the possibility of use of Mg, other than fracture fixation device, as non-load bearing bone scaffold was described.

**Keywords:** Mg Composite, Bioactive glass**,** Mg Alloy**,** Cerium**,** Porous scaffold, μ-CT