Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

Analysis of Corrosion Behavior, Reinforcements and Challenges in Magnesium-Based Composites : A Review

Didar Singh [1*], Sandeep Singh [1],
[1] Department of Mechanical Engineering, Punjabi University Patiala, 147002, Punjab
[1*]Corresponding author email: slaich83@gmail.com

***Abstract*: Magnesium alloys are widely studied as biodegradable implant materials because they reduce stress shielding and eliminate the need for secondary surgery. However, their rapid degradation can cause premature failure and structural instability. To address this, researchers have focused on controlling corrosion behavior, particularly by incorporating ceramic reinforcements into the magnesium matrix. These reinforcements enhance mechanical strength and corrosion resistance, making magnesium-based composites promising for biomedical applications. Nevertheless, achieving uniform dispersion of ceramic nanoparticles while maintaining desired properties remains challenging. Selecting suitable ceramic reinforcements based on specific biomedical requirements is essential to control corrosion effectively. This work reviews the influence of various ceramic reinforcements on the in vitro bioactivity and corrosion performance of magnesium composites, highlighting recent advances and future research directions.**

Keywords: Magnesium alloys; Degradation; Reinforcements; Corrosion Behaviour

1. INTRODUCTION

Heart valves, orthopaedic implants, stents, orthodontic appliances, biosensors, drug delivery systems, artificial skin, and tissue regeneration applications are just a few of the medical implants that make the substantial use of biomaterials [1-3]. As a result, these materials must have good mechanical qualities, corrosion resistance, osteoconductivity, a sufficient coefficient of friction, and outstanding biocompatibility, biofunctionality, and bio-adhesiveness [1]. Ceramics, polymers, metals, and composites are the general categories of biomedical materials (Fig.1). However, the commercial sector only offers very small amounts of biomaterials based on ceramics.

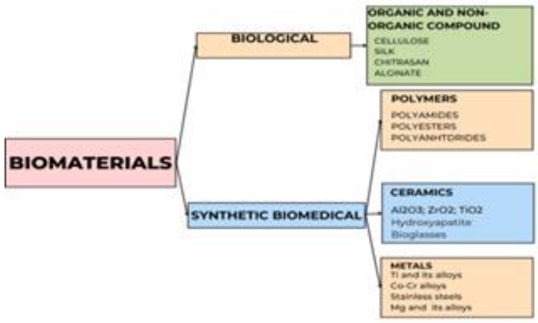

Figure 1: Different types of Biomaterials

1.1 Magnesium Alloy Application in Biomedicine

Magnesium-based alloys are widely used in biomedicine, aerospace, automotive, electronics, and energy storage applications. In the biomedical field, they are classified as third-generation biomaterials due to their biodegradability in simulated body fluids (SBF). Recent research focuses on cellular responses and the interaction between corrosion products and surrounding tissues [4,5]. Studies have examined the effect of reinforcements on the corrosion behavior of biodegradable orthopaedic implants[6]. Magnesium alloys promote bone strengthening and improved interfacial bonding and are used in fixation devices such as plates, screws, and fasteners. Recent findings also indicate that Mg-alloy implants do not damage vital organs and cause only minor changes in body fluid parameters after six months of implantation. [7]

2. DEVELOPMENT OF BIODEGRADABLE MATERIALS FOR IMPLANTS

Metallic biomaterials are increasingly used for temporary implants (screws, plates, pins, rods, and wires) and permanent implants (hip and joint replacements and prostheses).Magnesium has been used for over a century as a biodegradable implant material in both in vitro and in vivo studies. Biocompatibility evaluations show that magnesium-based biocomposites are more compatible than traditional metallic composites. As the fourth most abundant element in the human body and an essential nutrient, magnesium plays a vital role in developing biodegradable materials. [8-10].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

2.1. Biomaterials Based on Metals

Most studies focus on the corrosion behavior of magnesium composites. Modern approaches aim to control their degradation so fractured tissue can heal without secondary implant removal surgery. The rising demand for biodegradable magnesium materials, particularly for orthopaedic implants and cardiovascular stents, is driven by ageing and increasing obesity.
A reinforced composite contains a matrix and a reinforcement phase. Magnesium degradation products can be excreted through the urinary system, reducing toxicity and side effects. Therefore, choosing biologically suitable reinforcements is essential, as magnesium-based composites provide improved mechanical properties along with controlled corrosion in biological environments.

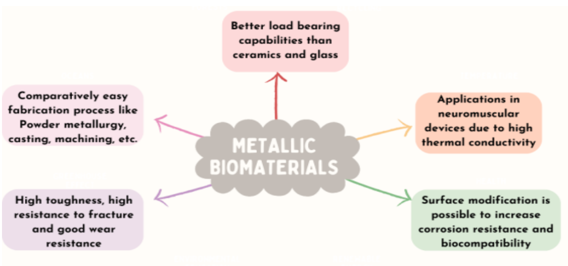

Figure 2: Key aspects related to metallic biomaterials

2.1.1. Stainless Steel

The maximum carbon percentage of biomedical-grade stainless steels is usually 0.02%. Corrosion resistance is greatly improved by adding 2-3 weight percent of molybdenum. Although research has shown that 316L stainless steel is suitable for medical implants, the amount of nickel in austenitic stainless steels has been linked to toxicity and allergic responses [11]. Additionally, 316L stainless steel has been observed to experience cracking due to stress corrosion and crevice corrosion, especially when nonmetallic impurities are present [12].

2.1.2. Alloys of Cobalt and Chromium

As cobalt-chromium (Co-Cr) alloys are more wear resistant than titanium and stainless steel alloys, so they are frequently utilised in load-bearing orthopaedic applications, such as hip and ankle joint implants [12]. In metal-on-metal (MoM) implant systems, where combined cobalt and chromium contribute to improved corrosion resistance, Co–Cr alloys are frequently used. Nanoscale wear particles with diameters that range from 20 to 60 nm are released by these implants at a rate of about 10^{12}–10^{11} particles annually.

2.1.3. Alloys of Titanium

Titanium has outstanding biocompatibility, high strength, and a density of about 48 g/cm^3.Titanium and its alloys are ideal for orthopaedic applications due to their great resistance to corrosion and nonmagnetic nature [13, 14]. However, there is still a lot of research being done to improve the tribological properties of titanium alloys [22].

2.1.4. Materials Based on Magnesium

Since 1878, magnesium and its alloys have been used in medical applications. [15]. Magnesium implants can fully biodegrade after fulfilling their mechanical role. For conditions such as fractures, dental defects, trauma, and coronary artery disease, materials must ensure controlled degradation, mechanical strength, and biocompatibility. Material selection depends on the specific use. Magnesium coronary stents have shown safe, complete degradation in about four months with good results [16-19]. Ideally, vascular stents should degrade over 6–12 months while maintaining arterial support [20, 21]. Several biodegradable magnesium stents are commercially available for restoring blood flow in damaged arteries. are depicted in Fig.3 [16, 22,23]

Figure 3: Mg-based biomedical devices are shown in Fig. 3: (a) Biodegradable magnesium bone implants [38]; (b–d) orthopaedic fixation components, (e) pure magnesium microclips used in laryngeal surgery [25]; (f) surgical sutures [26]; and (g) additional medical instruments and dental applications [27].

3. CONDITIONS FOR THE DEVELOPMENT OF MAGNESIUM COMPOSITES

Pure magnesium has been developed as a biodegradable metallic biomaterial. Recently, magnesium alloys with improved mechanical strength and corrosion resistance have gained attention for structural and biomedical uses. [28]. Alloys with controlled degradation rates are especially suitable for implants. To meet growing surgical demands, new magnesium-based composites have been introduced, particularly those reinforced with bioceramic particles due to concerns about the flammability of some alloying elements. [29,30]. Magnesium-based composites are highly biocompatible, as magnesium is a natural and essential element in the human body, supporting bone and soft tissue development. [31]. The recommended daily magnesium intake for adults is about 210–280 mg, with supplements typically ranging from 250–350 mg. [32]. Excess

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

magnesium is safely excreted through the urinary system, minimizing toxicity risk.

4. FREQUENTLY UTILISED REINFORCEMENTS

Various reinforcements are used to improve the mechanical performance of magnesium-based composites for biomedical applications. A key challenge in developing biodegradable metal matrix composites is selecting eco-friendly, bioactive, and biodegradable particles. The choice of reinforcement strongly affects the composite's strength and degradation rate in physiological conditions. [33,34]. Bioactive ceramic particles are widely used to enhance corrosion resistance, bioactivity, and tissue interaction. For hard tissue applications, materials often mimic the mineral composition of natural bone. [35,36]. Common ceramic reinforcements for magnesium-based biomedical composites include TiO_2, ZrO_2, hydroxyapatite (HAp), calcium pyrophosphate (CPP), bioactive glass (BG), ZnO, and MgO.

A. Hydroxyapetite-Based Magnesium Composites

Hydroxyapatite (HAp) is widely used in magnesium-based implants due to its strong osteoconductive properties. It can chemically interact with surrounding bone tissue to produce a strong interfacial connection because of its exceptional biocompatibility, non-toxicity, and capacity to promote bone cell adhesion and proliferation [37]. Mg–3Zn/HAp composites have been studied for their biological behavior, corrosion resistance, and mechanical performance [28]. SEM images show that HAp promotes the formation of apatite layers during immersion in simulated body fluid, with thicker layers forming over time [28].
Compared to pure magnesium, composites with 5 wt. % HAp developed a thicker apatite layer and exhibited slower degradation. However, composites with 10 wt.% HAp showed localized corrosion after 28 and 56 days, leading to partial detachment of the apatite layer. [28].

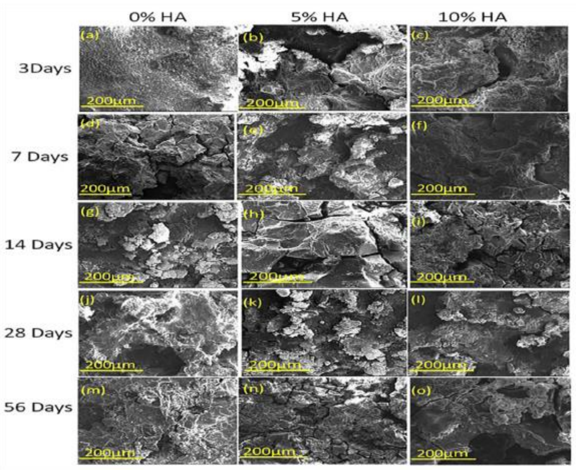

Figure 4: Presents SEM micrographs of magnesium composite structures after immersion for different time intervals: 3 days (a–c), 7 days (d–f), 14 days (g–i), 28 days (j–l), and 56 days (m–o) [28].

B. Composites made of magnesium and bioactive glass (BG):

Bioactive materials such as fluorapatite, hydroxyapatite, and especially bioactive glass (BG) are widely used to reinforce magnesium-based implants due to their excellent osteocompatibility. Among them, BG is superior because of its higher solubility and biocompatible degradation products. [38]. Incorporating BG into magnesium alloys (e.g., ZK30) significantly improves corrosion resistance, bioactivity, microhardness, and cell viability, with 10 wt.% BG often showing optimal performance.[39]

C. Composites made of magnesium and calcium poyphosphate

Calcium polyphosphate (CPP) is a bioactive calcium phosphate material structurally composed of linear phosphate chains and is an essential inorganic component of bone and teeth. When used as reinforcement in magnesium-based composites, CPP enhances compressive strength by refining grain size and provides controlled in vivo degradation[40,41]. Mg/CPP and ZK60A/CPP composites show good mechanical properties suitable for load-bearing orthopedic implants and can withstand high temperatures [34,42]. However, higher CPP content (10%) may cause interfacial debonding and pore formation, affecting fracture behavior.

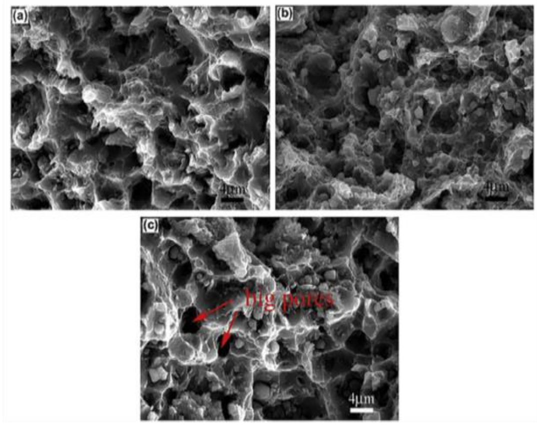

Figure 5: SEM micrographs of the tensile fracture surfaces of (a) the ZK60A alloy and its composites reinforced with (b) 5 weight percent and (c) 10 weight percent calcium polyphosphate (CPP) [42]

D. Composites of magnesium and zinc oxide (ZnO)

In biological applications, such as bioimaging, zinc oxide (ZnO) has generated substantial interest. It has been demonstrated that nano-ZnO has potent antibacterial qualities and increases osteoblast development and bone formation [43,44]. Powder metallurgy methods have been used to create Mg/ZnO composites. Research shows that adding ZnO particles improves overall mechanical properties and hardness. Ductility was marginally decreased by 1.43% when 20 weight percent ZnO was added [91].

Mg–xZnO composites exhibit better resistance to corrosion than pure magnesium, according to corrosion tests [45].

E. Composites of magnesium and magnesium oxide (MgO)

Magnesium oxide (MgO) is biodegradable in the body and mainly breaks down into $Mg(OH)_2$. Due to its good mechanical strength, thermal stability, antibacterial properties, and biodegradability, MgO is an effective reinforcement for magnesium composites.[46]Adding MgO improves mechanical strength, corrosion resistance, and biological performance. Even a small amount (1 vol.%) of MgO nanoparticles significantly increases tensile strength and hardness.[47]

F. Composites of magnesium and titanium dioxide (TiO_2)

The enhanced resistant to corrosion and bioactivity of magnesium/TiO_2 composites have drawn a lot of interest [101]. The Mg/TiO_2 combination is extremely useful for biomedical applications since both Mg and TiO_2 are bio-inert and Mg is biocompatible. After creating an AZ80-1 weight percent TiO_2 nanocomposite, Khosroshahi et al. [49] found that the addition of TiO_2 decreased grain size and raised ultimate tensile strength. Similarly, adding 2.5 vol.% TiO_2 to pure magnesium increased ultimate tensile strength by 9% and fracture strain by 31% [50].

G. Composites of magnesium and zirconium dioxide (ZrO_2)

Adding ZrO_2 particles to magnesium composites improves their mechanical properties and makes them more suitable for biomedical use.[51] ZrO_2 is strong, tough, and resistant to fracture, making it an effective ceramic reinforcement.[105] Studies show that ZrO_2 addition enhances grain refinement, tensile strength, and cell compatibility; for example, friction stir processing of AZ31 Mg with ZrO_2 improved strength and microstructure. [52].

5. EVALUATION OF MG-BASED ALLOY CORROSION

Biodegradable magnesium implants must remain mechanically stable for at least three months to match the stages of bone healing. However, rapid corrosion often leads to hydrogen evolution, swelling, and reduced mechanical integrity, with degradation behavior differing between in vitro and in vivo conditions. Challenges include high electrode potential, localized and galvanic corrosion, and complex physiological effects. Alloying with Ca and Zn, grain refinement, and ceramic reinforcement can significantly lower corrosion rates and improve mechanical properties.[29,30].In order to maximise both mechanical characteristics and corrosion resistance, it is crucial to design Mg-based composites reinforced with ceramics. For example, compared to Mg-Ca/HA-TCP composites, H_2 evolution is higher in Mg-Ca alloys. While nanoscale holes are seen in reinforced composites (Fig.6b), morphological analyses reveal corrosion pits in Mg-Ca (Fig.6a).

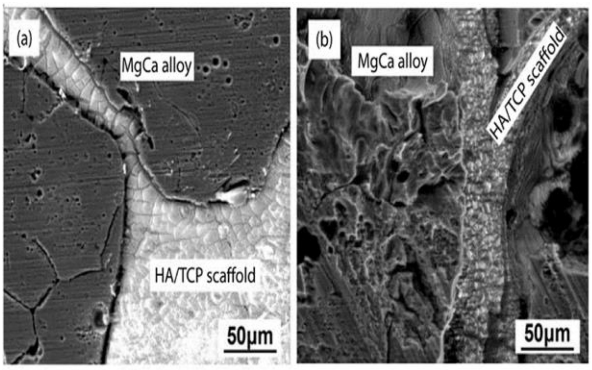

Figure 6: MgCa/HA-TCP composite immersion during (a) one day and (b) twenty days [53]

6. DIFFICULTIES AND PROSPECTS

Magnesium alloys are used in automotive, aerospace, and biomedical fields. In biomedical applications, controlling their degradation rate—especially in SBF—is a major challenge because rapid degradation reduces strength before bone healing is complete. Since degradation mainly occurs at the surface, improving surface quality is important. Adding reinforcement particles changes mechanical and corrosion properties, so improving one property should not harm others, especially biocompatibility. For example, aluminium increases strength but is harmful to health, while rare earth elements improve strength but are costly. Future research should focus on better interfacial bonding, optimized processing conditions (temperature and holding time), cost-effective RE-based composites, and solutions to prevent bacterial infections in orthopaedic implants.

7. CONCLUSIONS

Magnesium composites are widely applied in the biomedical field, particularly for bone implant applications, due to their good mechanical strength, natural biodegradability, and in vitro bioactivity. Their performance largely depends on the proper selection of biocompatible reinforcements such as HA, ZrO_2, TiO_2, ZnO, bioactive glass (BG), CPP, and Al_2O_3, which can enhance mechanical properties, corrosion resistance, and biological response.
Research shows that bioactive additives like hydroxyapatite and bioactive glass help control degradation and improve corrosion behaviour and tissue compatibility. However, selecting the most suitable in vitro degradation method and ensuring long-term biocompatibility still require further investigation. Since most in vivo studies have been limited to small animal models, additional long-term experimental research—especially for load-bearing orthopaedic applications—is necessary before advancing to preclinical and human trials.

REFERENCES:

[1] Bhat S V and Bhat S V 2002 Overview of biomaterials *Biomaterials* 1–11
[2] Zheng Y F, Gu X N and Witte F 2014 Biodegradable metals *Mater. Sci. Eng. R Reports***77** 1–34

[3] Xu L, Pan F, Yu G, Yang L, Zhang E and Yang K 2009 In vitro and in vivo evaluation of the surface bioactivity of a calcium phosphate coated magnesium alloy *Biomaterials* **30** 1512–23

[4] Witte F, Fischer J, Nellesen J, Crostack H-A, Kaese V, Pisch A, Beckmann F and Windhagen H 2006 In vitro and in vivo corrosion measurements of magnesium alloys *Biomaterials* **27** 1013–8

[5] Castellani C, Lindtner R A, Hausbrandt P, Tschegg E, Stanzl-Tschegg S E, Zanoni G, Beck S and Weinberg A-M 2011 Bone–implant interface strength and osseointegration: Biodegradable magnesium alloy versus standard titanium control *Acta Biomater.* **7** 432–40

[6] Browner B D, Levine A M, Jupiter J B, Trafton P G and Krettek C 2008 *Skeletal Trauma E-Book: 2-Volume Set* (Elsevier Health Sciences)

[7] Witte F, Abeln I, Switzer E, Kaese V, Meyer A and Windhagen H 2008 Evaluation of the skin sensitizing potential of biodegradable magnesium alloys *J. Biomed. Mater. Res. Part A An Off. J. Soc. Biomater. Japanese Soc. Biomater. Aust. Soc. Biomater. Korean Soc. Biomater.* **86** 1041–7

[8] López H Y, Cortés-Hernández D A, Escobedo S and Mantovani D 2006 In vitro bioactivity assessment of metallic magnesium *Key Eng. Mater.* **309** 453–6

[9] Ng W F, Chiu K Y and Cheng F T 2010 Effect of pH on the in vitro corrosion rate of magnesium degradable implant material *Mater. Sci. Eng. C* **30** 898–903

[10] Chiu K Y, Wong M H, Cheng F T and Man H C 2007 Characterization and corrosion studies of fluoride conversion coating on degradable Mg implants *Surf. Coatings Technol.* **202** 590–8

[11] Niinomi M 2008 Metallic biomaterials *J. Artif. Organs* **11** 105–10

[12] Niinomi M 2002 Recent metallic materials for biomedical app. *Metall. Mater. Trans. A* **33** 477–86

[13] Henriques V A R, Galvani E T, Petroni S L G, Paula M S M and Lemos T G 2010 Production of Ti–13Nb–13Zr alloy for surgical implants by powder metallurgy *J. Mater. Sci.* **45** 5844–50

[14] Ribeiro A L R, Junior R C, 2009 Mechanical, physical, and chemical characterization of Ti–35Nb–5Zr and Ti–35Nb–10Zr casting alloys *J. Mater. Sci. Mater. Med.* **20** 1629–36

[15] Kirkland N T, Birbilis & Staiger 2012 Assessing the corrosion of biodegradable magnesium implants: A critical review of current methodologies and their limitations *Acta Biomater.* **8** 925–36

[16] Erbel R, Di Mario C, Bartunek J, Bonnier J, de Bruyne B, Eberli F R, Erne P, Haude M, Heublein B and Horrigan M 2007 Temporary scaffolding of coronary arteries with bioabsorbable magnesium stents: a prospective, non-randomised multicentre trial *Lancet* **369** 1869–75

[17] Peeters P, Bosiers M, Verbist J, Deloose and Heublein 2005 Preliminary results after application of absorbable metal stents in patients with critical limb ischemia *J. Endovasc. Ther.* **12** 1–5

[18] Di Mario C, Griffiths H U W, Verbist J A N, Bosiers M, Deloose K, Heublein B, Rohde R and Kasese V 2004 Drug-eluting bioabsorbable magnesium stent *J. Interv. Cardiol.* **17** 391–5

[19] Zartner P, Cesnjevar R, Singer & Weyand 2005 First successful implantation of a biodegradable metal stent into the left pulmonary artery of a preterm baby *Catheter. Cardiovasc. Interv.* **66** 590–4

[20] El-Omar M M, Dangas G, Iakovou I and Mehran R 2001 Update on in-stent restenosis. *Curr. Interv. Cardiol. Rep.* **3** 296–305

[21] Schömig A, Kastrati A, Mudra H, Blasini R, Schühlen H, Klauss V, Richardt G and Neumann F J 1994 Four-year experience with Palmaz-Schatz stenting in coronary angioplasty complicated by dissection with threatened or present vessel closure. *Circulation* **90** 2716–24

[22] Heublein B, Rohde R, Kaese V, Niemeyer M, Hartung W and Haverich A 2003 Biocorrosion of magnesium alloys: a new principle in cardiovascular implant technology? *Heart* **89** 651–6

[23] Ding W 2016 Opportunities and challenges for the biodegradable magnesium alloys as next-generation biomaterials *Regen. Biomater.* **3** 79–86

[24] Waizy H, Seitz , Reifenrath, Weizbauer, Bach , Meyer-Lindenberg , Denkena and Windhagen 2013 Biodegradable magnesium implants for orthopedic applications *J. Mater. Sci.* **48** 39–50

[25] Chng C B, Lau D P, Choo J Q and Chui C K 2012 A bioabsorbable microclip for laryngeal microsurgery: design and evaluation *Acta Biomater.* **8** 2835–44

[26] Hänzi A C, Metlar A, Schinhammer M, Aguib H, Lüth T C, Löffler J F and Uggowitzer P J 2011 Biodegradable wound-closing devices for gastrointestinal interventions: degradation performance of the magnesium tip *Mater. Sci. Eng. C* **31** 1098–103

[27] Windhagen H, Radtke K, Weizbauer A, Diekmann J, 2013 Biodegradable magnesium-based screw clinically equivalent to titanium screw in hallux valgus surgery: short term results of the first prospective, randomized, controlled clinical pilot study *Biomed. Eng. Online* **12** 1–10

[28] Jaiswal S, Kumar R M, Gupta P, Kumaraswamy M, Roy P and Lahiri D 2018 Mechanical, corrosion and biocompatibility behaviour of Mg-3Zn-HA biodegradable composites for orthopaedic fixture accessories *J. Mech. Behav. Biomed. Mater.* **78** 442–54

[29] Liao J, Hotta M, Motoda S and Shinohara T 2013 Atmospheric corrosion of two field-exposed AZ31B magnesium alloys with different grain size *Corros. Sci.* **71** 53–61

[30] Liao J, Hotta M and Yamamoto N 2012 Corrosion behavior of fine-grained AZ31B magnesium alloy *Corros. Sci.* **61** 208–14

[31] Dubok V 2000 Bioceramics—yesterday, today, tomorrow *Powder Metall. Met. Ceram.* **39** 381–94

[32] Witte F, Ulrich H, Rudert M and Willbold E 2007 Biodegradable magnesium scaffolds: Part 1: appropriate inflammatory response *J. Biomed. Mater. Res. Part A* **81** 748–56

[33] Sharma S K, Saxena K K, Dixit A K, Singh R and Mohammed K A 2024 Role of additive manufacturing and various reinforcements in MMCs related to biomedical applications *Adv. Mater. Process. Technol.* **10** 231–48

[34] Dutta S, Gupta S and Roy M 2020 Recent developments in magnesium metal–matrix composites for biomedical applications: A Review *ACS Biomater. Sci. Eng.* **6** 4748–73

[35] Luz G M and Mano J F 2010 Mineralized structures in nature: Examples and inspirations for the design of new composite materials and biomaterials *Compos. Sci. Technol.* **70** 1777–88

[36] Weinkamer R and Fratzl P 2011 Mechanical adaptation of biological materials—The examples of bone and wood *Mater. Sci. Eng. C* **31** 1164–73

[37] Siddiqui H A, Pickering K L and Mucalo M R 2018 A review on the use of hydroxyapatite-carbonaceous structure composites in bone replacement materials *(Basel).* **11** 1813

[38] Sergi R, Bellucci D and Cannillo V 2020 A review of bioactive glass/natural polymer composites: State of the art *Materials (Basel).* **13** 5560

[39] Dutta S, Devi K B, Mandal, Mahato, Gupta, Kundu ,2019 In vitro corrosion and cytocompatibility studies of hot press sintered magnesium-bioactive glass composite *Materialia* **5** 100245

[40] Pilliar R M, Kandel R A, Grynpas M D, Hu Y, Allo B 2017 Calcium polyphosphate particulates for bone void filler applications *J. Biomed. Mater. Res. Part B Appl. Biomater.* **105** 874–84

[41] Wang Q, Wang Q and Wan C 2011 Effect of porosity on the structure and properties of calcium polyphosphate bioceramics *Ceramics-Silikáty* **55** 43–8

[42] Feng A and Han Y 2011 Mechanical and in vitro degradation behavior of ultrafine calcium polyphosphate reinforced magnesium-alloy composites *Mater. Des.* **32** 2813–20

[43] Xi Y, Pan W, Xi D, Liu X, Yu J, Wen J, Wang W and He H 2020 Optimization, characterization and evaluation of ZnO/polyvinylidene fluoride nanocomposites for orthopedic applications: Improved antibacterial ability and promoted osteoblast growth *Drug Deliv.* **27** 1378–85

[44] Ullah I, Ou P, Xie L, Liao, Zhao F, Gao A, Ren X, Li Y, Wang G and Wu 2024 Diffusion-driven fabrication of calcium and phosphorous-doped zinc oxide heterostructures on titanium to achieve dual functions of osteogenesis and preventing bacterial infections *Acta Biomater.* **175** 382–94

[45] Lei T, Tang W & Feng F-F 2012 On the corrosion behaviour of newly developed biodegradable Mg-based metal matrix composites produced by in situ reaction *Corros. Sci.* **54** 270–7

[46] Wang Y, Cen, Chen & Fu L 2020 MgO/carboxymethyl chitosan nanocomposite improvesthermal stability, waterproof & antibacterial perf. for food packaging *Carbohydr. Polym.* **236** 116078

[47] Goh C S, Gupta M, Wei J and Lee L C 2007 Characterization of high performance Mg/MgO nanocomposites *J. Compos. Mater.* **41** 2325–35

[48] Rahim S A, Rabeeh V P M, Babu S, Joseph M A and Hanas T 2023 Advancements in Magnesium Metal-Matrix Composites for Degradable Implant Applications *Advances in Corrosion Control of Magnesium and its Alloys* (CRC Press) pp 135–55

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

[49] Khosroshahi , Saniee and Abedi H R 2014 Mechanical properties improvement of cast AZ80 Mg alloy/nano-particles composite via thermomechanical processing *Mater. Sci. Eng. A***595** 284–90

[50] Meenashisundaram G K, Nai M H and Gupta M 2015 Development of high performance Mg–TiO2 nanocomposites targeting for biomedical/structural applications *Mater. Des.***65** 104–14

[51] Keerthana L, Sakthivel C and Prabha I 2019 MgO-ZrO2 mixed nanocomposites: fabrication methods and applications *Mater. Today Sustain.***3** 100007

[52] Navazani M and Dehghani K 2016 Fabrication of Mg-ZrO2 surface layer composites by friction stir processing *J. Mater. Process. Technol.***229** 439–49

[53] Gu X & Miao X 2011 Microstructure and characteristics of the metal–ceramic composite fabricated by liquid metal infiltration *J. Biomed. Mater. Res. Part B Appl. Biomater.***99** 127–34