# Coating of graphene oxide on AZ91-Ca-Sn alloy for Orthopaedic Application

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**Abstract -** *This paper is on the applying of graphene oxide coating of new cast Mg alloy. Magnesium(Mg) and its alloys are increasingly explored as potential perishable implant materials for medical science applications, largely as a result of identical elastic moduli of Mg alloy as that of our bone. But, the fast corrosion of Magnesium-based alloys in traditional conditions has delayed their introduction for medical science applications until date. to reduce the corrosion of Mg alloys, totally different protecting treatments are acknowledged, like alloying various elements and surface coatings. Our work focuses on application and study of graphene compound coating on the perishable Mg alloy (AZ91+ 1%Ca+ 0.65%Sn).*

***Key Words***: Corrosion, Graphene Oxide, Coating, Magnesium Alloy, Orthopaedics.

## 1. INTRODUCTION

Magnesium (Mg) and its alloys are wide used for their wonderful physical and mechanical properties, like density, have very good ratio of strength / weight, high rigidity, mechanical melting capability and smart vibration damping. However, the low corrosion resistance of Mg alloys in common environmental environments attributable to high chemical activity limits their applications, particularly in marine environments. to cut back the corrosion of Mg alloys, numerous protecting treatments are studied, like elemental and surface film alloys. The latter strategies will cut back the corrosion rate of Mg alloys by some orders of magnitude by providing a barrier between the Mg substrate and its surroundings, that is a lot of economical than the alloy's development.

Biometers utilized in orthopaedic implants embrace surgical grade stainless-steel, chromium-cobalt in alloys, titanium, and Ti alloys. stainless-steel isn't appropriate for a permanent installation because of its low resistance to fatigue and therefore the responsibility for plastic deformation. Low corrosion resistance has prevented the utilization of this metal as a porous coating for contemporary biologically stationary systems. stainless-steel continues to be normally used for non-permanent implants, like internal fixation devices for fractures. In Ti and its alloys, plasticity permits preforming and prestressing throughout the operation. before the utilization of Ti, cobalt-based alloys (mainly Co-Cr-Mo and Co-Cr-Ni) had mostly replaced stainless-steel as permanent implant materials. These alloys are usually a lot of proof against corrosion because of the formation of a sturdy surface layer of Cr oxide, the supposed passivation layer. Despite a decent resistance to corrosion, the discharge of ions in vivo continues to be a priority.

Graphene compound (GO) may be a terribly fascinating selection as a coating because of its very big area, easy chemical functionalization, and smart biocompatibility. Moreover, GO shows fascinating dispersion behaviour in liquid solutions and possesses smart mechanical property. Consequently, there's growing interest within the scientific community to develop new and advanced technique for continue totally different metal surfaces, keeping in sight its exceptional properties to guard them from chemical process in harsh environmental conditions. The decrease in corrosion current density and also the positive shift in corrosion potential have each incontestible that GO films served as a corrosion inhibitor.

## 2. LITERATURE REVIEW

1.1. Y. Xin et al. studied the corrosion behaviour of biomedical AZ91 magnesium alloy in simulated body fluids(sbf) by which he concluded that pitting corrosion is a common behaviour of AZ91 magnesium soaked in sbf but is self-limited due to accumulation and stabilization of the corrosion products by $OH^-$.

1.2. G. L. Makar and J. Kruger investigated and reviewed about the corrosion in magnesium in which they discussed about the various corrosion problems and protection method to make the magnesium corrosion resistant, by which they concluded that surface modifications like ion implantation and laser treatment can improve the corrosion resistance, but it has not been examined and remains unproven.

1.3. M. Sohail et al. experimentally synthesised graphene oxide using modified and improved hummer method and by which they found out that materials obtained in both cases exhibit nearly similar physicochemical characteristics except a little bit difference in crystalline nature. The former method produced somewhat ordered structure of GO while the latter produced amorphous materials.

1.4. R.M.N.M. Rathnayake et al. synthesised graphene oxide and reduced graphene oxide by needle platy natural vein graphite. It is revealed here that the modified chemical oxidation and the reduction methods are effective processes to produce GO and rGO from the selected natural vein graphite.

1.5. Anshul Kamboj et al. who investigated on copper-graphene oxide composite coatings for corrosion protection of mild steel in 3.5% NaCl in which the chemically synthesised graphene oxide is used as the electrolyte along with copper sulphate for electrodeposition of graphene on magnesium mild steel which is kept as cathode.

## 3. METHODOLOGY

### 3.1. Preparation of Graphene Oxide

For the preparation of graphene oxide, the Tour method is selected, which is an efficient method for preparing graphene oxide. The Tour method, which is an improvement of hummers method, can be used for preparing graphene oxide. In this method the sodium nitride with phosphoric acid in a mixture of $H_2SO_4/H_3PO_4$(9:1) and increasing the amount of $KMnO_4$. This method holds a variety of advantages which includes no toxic gasses such as $NO_2$, $N_2O_4$ or $ClO_2$, and an easy temperature control. With the presence of phosphoric acid generates a more intact graphite basal plane. It has also had a higher hydrophobic degree thus, this results in more oxidized and soluble graphene oxide


**Fig -1**: Graphene oxide synthesis

Steps involved are mentioned as follows:

- Mix 3g of graphite with 18g of potassium permanganate (in ratio 1:6) and add sulphuric acid (360 ml 96%) and phosphoric acid (40ml 75%).
- This mixture is stirred for 12 hours at 50˚C, which results in a brown coloured liquid.
- The mixture is then allowed to cool to room temperature. After the mixture is cooled down it is then poured into 400ml deionized water(ice) and then 3ml of 35% hydrogen peroxide is added.
- Then, stir the mixture to get a nice bright yellow mixture. This produces a large amount of heat and it is brought down to room temperature.
- After the appearance of bright yellow colour, 350ml of DI water is added.
- Acids are separated out by removing some amount of solution from the top of the beaker using a dropper.
- The solution is washed again and again using deionized water until it reaches a pH value of 2.7.

### 3.2. Application of graphene oxide

After the preparation of graphene oxide, we added 0.1g of sodium lauryl sulphate (SLS) in the solution for increasing the surface area of coating.

The alloy was polished using a SiC abrasive, then using platinum electrode as anode and magnesium alloy as cathode we gave a supply of 5.0V with a coating time of 40 minutes.

**Fig -2**: Graphene oxide coating using electrodeposition

### 3.3. Test and Experiments

The coated magnesium alloy was subjected to optical testing. The optimum coating was determined by polishing the end face of the material and optical test was conducted on the same section.

After the optical testing of the alloy, we performed the XRD test on the X-ray diffraction machine.

## 4. RESULT AND DISCUSSION

**Fig -3**: Optical imaging of coated alloy

The optical image of the coated alloy was taken and it was found there is a slight dark colouration of the magnesium alloy's surface due to the graphene oxide coating.

Further the magnesium alloys were coated for varying voltage and time and the pieces were polished and the optimum coating time and voltage were determined, the figure 4 shows the dark black colouration in the cross-section of the face of the alloy.

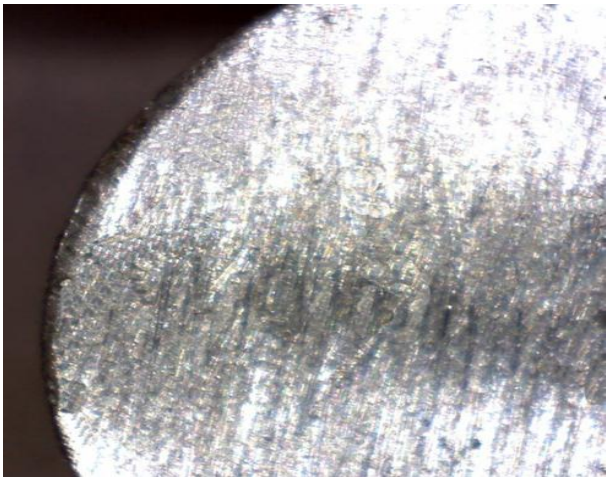

**Fig -4:** Cross-section area of the coated alloy

From the optical microscope the optical image of the cross-sectional area was taken and the end sections the thickness of the coating was seen.

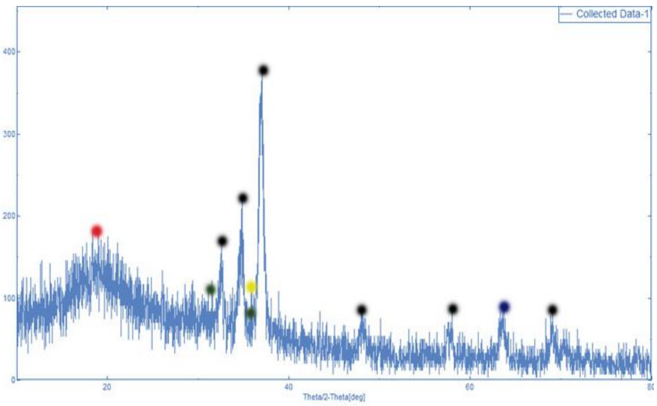


**Fig -4**: XRD imaging of coated alloy

The XRD graph of the coated alloy, where Y intercept represents intensity and X intercept represents angle 2ϴ. Thus, at an angle of 10 degrees we see a jump in graph due to the presence of amorphous compounds due to graphene, the other peaks shown represents the different elemental phases of magnesium and its alloys.

## 5. CONCLUSION

From the optical testing the upper portion of the alloy showed a slight variation in the colour with a dark black texture and the XRD test also revealed the presence of graphene as there is a peak at 10 degrees. The coating of graphene oxide could be very useful where there is a need of thin layer, the problems held with magnesium alloy that is corrosion resistance will be economically resolved and this study will give a thrust for the applications of magnesium alloy in more areas and could prove an effective alternative for the present expensive orthopaedic materials.

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