MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 2, 2026, Pages 1388-1390

HEMOCOMPATIBILITY OF CELLULOSE- CHITOSAN COATED FOR ORTHOPAEDIC APPLICATION

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ABSTRACT:
Biodegradable magnesium (Mg) alloys have gained significant attention in orthopaedic applications because of their biocompatibility and controlled degradation properties. The present study evaluated the hemocompatibility of cellulose–chitosan (CC) coated Mg alloy for biomedical implant applications. Chitosan solution prepared using acetic acid was combined with cellulose solution to obtain a homogeneous coating mixture. The Mg alloy surface was polished, coated with the CC solution, and dried at room temperature. Surface morphology, hemolytic activity, Fourier transform infrared spectroscopy (FTIR), and biomineralization studies were performed. SEM analysis revealed petal-like surface morphology with interconnected structures. The hemolysis rate of the coated sample was below 5 %, indicating non-hemolytic behavior according to ASTM standards. FTIR confirmed the presence of hydroxyl, amide, and carboxyl functional groups. Biomineralization studies demonstrated calcium and phosphate deposition on the coated surface. The results suggest that CC-coated Mg alloy possesses good hemocompatibility and biomineralization potential for orthopaedic implant applications.
Keywords: Hemocompatibility, magnesium alloy, chitosan, cellulose, biodegradable implant, medicine.

1. INTRODUCTION

Biodegradable implants have emerged as promising alternatives to conventional metallic implants used in orthopaedic applications. Traditional implant materials such as stainless steel and titanium possess excellent mechanical strength; however, they remain permanently in the body and may require secondary surgeries for removal (1). Magnesium-based biodegradable implants have attracted considerable attention because of their favorable biocompatibility, biodegradability, and mechanical properties that closely resemble natural bone (2). One of the important factors influencing the clinical success of orthopaedic implants is hemocompatibility (3). Biomaterials that come in direct contact with blood should not induce adverse reactions such as thrombosis, hemolysis, or inflammatory responses (4,5). Therefore, improving the blood compatibility of biodegradable implants is essential for their safe biomedical application.

Surface modification techniques have been widely investigated to enhance the biological performance of magnesium alloys (6)(7). Chitosan is a naturally occurring biopolymer known for its excellent biocompatibility, biodegradability, and antimicrobial properties (8). Cellulose also exhibits good mechanical stability and biocompatibility (9). The combination of cellulose and chitosan coatings may improve the surface characteristics and blood compatibility of magnesium alloys (10) (11).Biodegradable implants, on the other hand, are designed to degrade over time, eliminating the necessity for removal procedures and potentially reducing the associated risks (12). This involves a comprehensive understanding of the interactions between the implant's surface and blood constituents, emphasising the need for meticulous research and testing (13)(14). Strategies such as coating the implant with bioactive materials or manipulating its topography can influence the hemocompatible nature of these implants (15).The present study aimed to evaluate the hemocompatibility of cellulose–chitosan coated magnesium alloy intended for orthopaedic implant applications. Surface morphology, hemolytic activity, FTIR analysis, and biomineralization studies were carried out to assess the biological performance of the coated alloy.

2. MATERIALS AND METHODS

2.1 Preparation of Cellulose–Chitosan Coating: A total of 0.5 g of chitosan was dissolved in 50 mL distilled water followed by the addition of 1 % acetic acid to obtain a homogeneous solution. Subsequently, 0.5 g cellulose solution was added to the chitosan solution and mixed thoroughly until a clear homogeneous coating solution was obtained.

2.2 Surface Coating of Magnesium Alloy: The magnesium alloy specimens were polished using 1200-grit abrasive paper and washed with distilled water and acetone for 5 min. The prepared cellulose–chitosan coating solution was applied onto the Mg alloy surface and dried at room temperature.

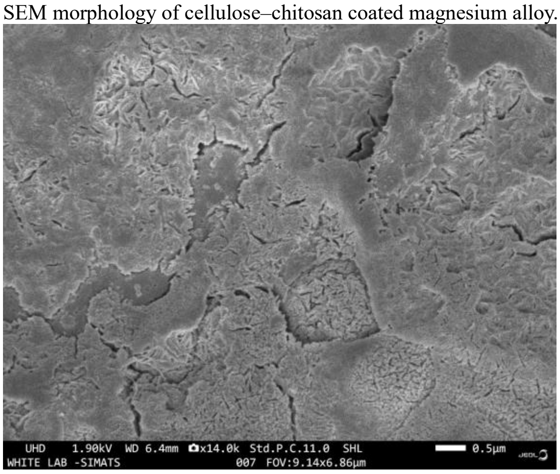
2.3 Hemolytic Activity Test: The hemolytic activity test was performed according to ethical guidelines. Blood samples were collected from healthy volunteers after obtaining informed consent. The collected blood was centrifuged at 3000 rpm for 5 min. The separated erythrocytes were washed three times using phosphate buffered saline (PBS) and diluted to pH 7.4.A suspension containing 5×10^8 erythrocytes was mixed with coated samples measuring 1 cm × 1 cm and incubated at 37 °C for 8, 16, and 24 h. Following incubation, the suspensions were centrifuged at 3000 rpm for 5 min and the absorbance of the supernatant was measured at 576 nm using an ELISA reader. Triton X-100 served as the positive control and PBS was used as the negative control. The percentage of hemolysis was calculated using standard procedures.

2.4 Surface Characterization: Surface morphology of the coated magnesium alloy was analyzed using scanning electron microscopy (SEM). FTIR analysis was carried out to identify the functional groups present in the coating. Biomineralization behavior was evaluated after immersion in simulated body fluid (SBF) for 7 d.

3. RESULTS

3.1 Surface Morphology Analysis: SEM analysis demonstrated the successful formation of cellulose–chitosan coating on the magnesium alloy surface. The coated surface exhibited petal-like morphology with interconnected structures. The coating distribution appeared non-uniform in certain regions, which may be associated with the drying behavior of the polymeric coating solution.

Figure 1.
SEM morphology of cellulose–chitosan coated magnesium alloy.



3.2 Hemolysis Analysis

The hemolysis rate of the coated magnesium alloy remained below 5 %, indicating non-hemolytic behavior according to ASTM standards. The obtained results suggest that the cellulose–chitosan coating improved the blood compatibility of the magnesium alloy surface. Chitosan contributes to enhanced biocompatibility, while cellulose provides structural stability to the coating.

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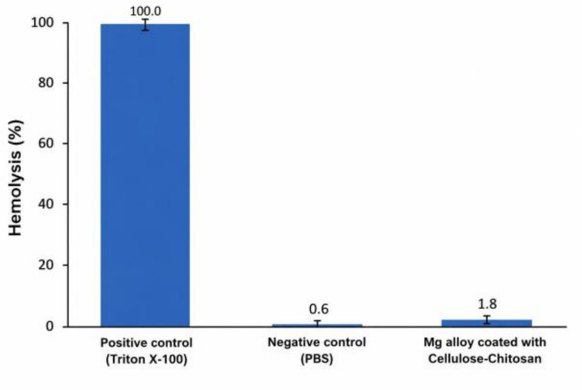
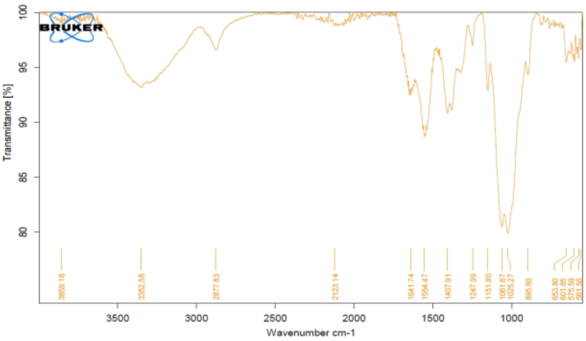
Figure 2.
Hemolysis analysis of coated magnesium alloy.



3.3 FTIR Analysis

FTIR analysis confirmed the presence of important functional groups associated with cellulose and chitosan coatings. The absorption band observed between 3500–3200 cm^{-1} corresponded to hydroxyl groups, while the peak at 1641 cm^{-1} indicated the presence of amide groups. The peak observed at 1061 cm^{-1} represented carboxyl functional groups. These findings confirmed successful coating formation on the magnesium alloy surface.

Figure 3.
FTIR spectrum of cellulose–chitosan coated magnesium alloy.



3.4 Biomineralization Study

Biomineralization studies carried out after immersion in simulated body fluid demonstrated calcium and phosphate deposition on the coated surface. SEM images revealed interconnected crack-like structures, while EDX analysis confirmed the presence of Ca, P, Mg, O, and Na elements. The formation of calcium phosphate deposits suggests favorable bioactivity and potential osteointegration capability of the coated material.

Figure 4.
Surface morphology after biomineralization study.

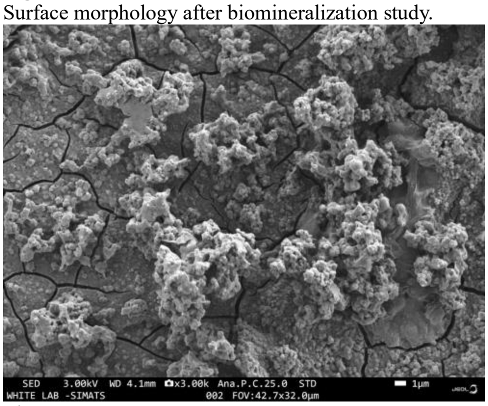
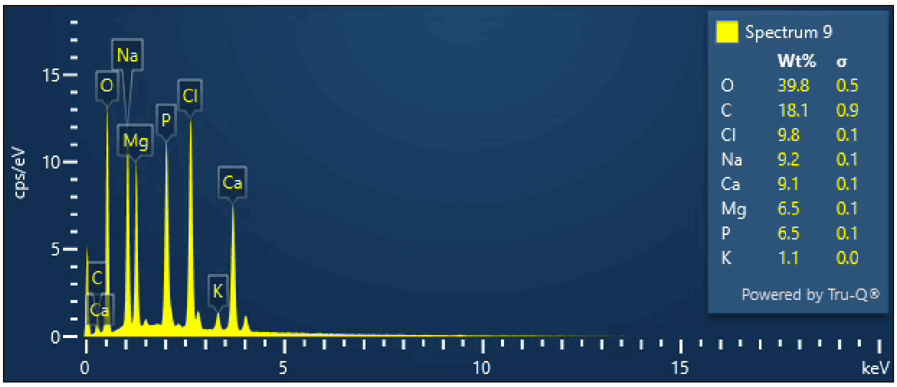


Figure 5.
EDX spectrum of coated magnesium alloy after SBF immersion.



4. DISCUSSION

The obtained results indicate that cellulose–chitosan coated magnesium alloy possesses favorable hemocompatibility and biomineralization characteristics. Magnesium alloys are considered promising biodegradable implant materials because they gradually degrade within the physiological environment, thereby eliminating the need for secondary implant removal surgeries. However, rapid degradation and poor blood compatibility remain important challenges (16).

Surface modification using biopolymer coatings represents an effective strategy to overcome these limitations (17). Chitosan is widely recognized for its excellent biological properties including biocompatibility and antimicrobial activity (18). Cellulose contributes to improved coating stability and surface integrity. The combination of these natural polymers may improve both biological and surface properties of magnesium-based biomaterials (19).

Even with the use of antiplatelet and anticoagulant medication, the biocompatibility of cardiovascular stents can present with common and persistent clinical symptoms (20) (21). Biodegradable materials commonly used in orthopaedic implants include polymers such as polylactic acid (PLA), polyglycolic acid (PGA), and their copolymers. These materials are chosen for their mechanical strength and biocompatibility (22). Based on the biological validation of biodegradable implants, some study has been conducted. Although metal plating first appeared in 1895, the use of orthopaedic implants for internal fracture repair dates back more than a century (23). Internal fracture repair plate variations were first presented in 1912, and these were the true first generation of plates (24).

The hemolysis results obtained in the present study demonstrated values below the acceptable ASTM limit of 5 %, confirming good blood compatibility. FTIR analysis further verified the successful deposition of cellulose–chitosan coating on the Mg alloy surface. In addition, biomineralization studies demonstrated calcium phosphate formation, which is an important indicator of potential bone integration.

Although the present study demonstrated promising findings, additional investigations including corrosion studies, mechanical analysis, and in vivo evaluation are necessary to further establish the clinical applicability of the coated magnesium alloy.

5. CONCLUSION:

The present study demonstrated that cellulose–chitosan coated magnesium alloy exhibited good hemocompatibility and biomineralization properties. The hemolysis rate remained below 5 %, confirming the non-hemolytic nature of the coated material. FTIR analysis verified successful coating formation, while biomineralization studies indicated calcium and phosphate deposition on the surface. These findings suggest that the coated magnesium alloy may serve as a promising biodegradable material for orthopaedic implant applications.

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