Fabrication And Characterisation Of Chitosan-Strontium Films For Biomedical Applications

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ABSTRACT:

BACKGROUND: Chitosan-strontium is a promising nano-material for bone tissue engineering. It improves biocompatibility and bone binding ability. Chitosan is a partially deacetylated version of chitin, is regarded a good stabilizer to be efficiently capped with metal oxide nanoparticles due to its unique structural features.Strontium oxide is recognized as an excellent catalyst for transesterification and is one of the most promising heterogeneous base catalysts among processable alkaline earth metal oxides.

AIM: To fabricate and characterize Chitosan- strontium films for biomedical applications.

MATERIALS AND METHODS: Chitosan complexed with strontium using simple complexation method. The chitosan-Sr complex is formed by the interaction of amino groups and hydroxyl groups of chitosan with strontium ions. It reduces the Sr ions into Sr nanoparticles due to the intrinsic reduction property.

RESULT: Chitosan-strontium complex was found to be non toxic to human osteoblastic cells. It had no effects on the metabolic activity (MTT Assay) and cell membrane integrity (LDH assay). The complex also promoted osteoblasts differentiation. It improved calcium deposition by the osteoblasts (Alizarin red staining). Therefore, the complex can be explored for bone tissue engineering applications.

CONCLUSION: Our results implicated that Chitosan-strontium films can be considered as a promising cost-effective nano- material for human bone regenerative applications...

Keywords - Chitosan, Innovation, Biomedical, Sustainability, Economic growth**.**

INTRODUCTION

A naturally occurring polycationic linear polymer generated from chitin, chitosan(1). Chitin is the second-most prevalent natural polysaccharide after cellulose and serves as a structural component of the exoskeletons of insects, crustaceans, and fungi as well as their cell walls. The low solubility of chitosan in neutral and alkaline solution limits its application(2). However, chemical transformation into hydrogels or composites results in the addition of additional functional characteristics for a variety of applications. Because of their non-toxicity, low allergenicity, biocompatibility, and biodegradability, chitosans are regarded as adaptable biomaterials(3). Osteogenesis, angiogenesis, and bone and tooth mineralization are all known to be improved by strontium (Sr), while osteoclast activity is known to be decreased(4). Strontium can be incorporated into hydroxyapatite (HA) to enhance its properties(5).

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A promising nanomaterial for bone tissue engineering is chitosan-strontium. It enhances bone binding capacity and biocompatibility(6). Strontium is osteogenic but at specific amounts/concentration, therefore it is necessary to achieve the desired biological activity through controlled delivery of strontium ions(7). Chitosan exhibits weak antibacterial activity and poor osteogenic activity. Therefore it's necessary to enhance its properties(8). Bone defects caused by fracture or bone tumor are serious problems for orthopedic health. Many various methods have been developed to repair the broken bone tissue(9). One of the methods is bone grafting, where donor bone tissue is implanted on the defected bone tissue. The most important aspect of bone tissue engineering is the presence of a biomimetic scaffold that acts as both temporary tissue replacement and supporting means of bone healing. Bone defects caused by trauma have become increasingly common in aged populations(10). Clinically, old bone defect repair remains difficult due to the considerably reduced bone healing potential compared to youth adults. A crucial aspect of bone-tissue engineering strategies is the creation of efficient biomaterials that are intended to treat bone abnormalities in elderly people(11).,

This research will fill the gaps identified in translating Chitosan based membranes for biomedical application. Sr is involved in a dual mechanism of coupling the stimulation of bone formation with the inhibition of bone resorption, as reported in the literature. Since the discovery of strontium ranelate (SrRan), an oral active substance that functions as an anti-osteoporosis medication, interest in Sr research has grown(12). However, because of its unfavorable side effects on patients' cardiac safety, the usage of SrRan was subject to some restrictions beginning in 2014(13). Despite strontium's well-known general biological role, strontium nanoparticles are still often utilized for bone regeneration, yet there are concerns about their safety. Consequently, using this procedure will make applying strontium both effective and safe(14).The aim of the study is to prepare and characterize Chitosan-strontium membrane and assess its potential for biomedical applications.

MATERIALS AND METHODS:

Strontium nitrate and chitosan were obtained. A simple complexation procedure is used to combine strontium with chitosan. Strontium nitrate solution was combined with 2% chitosan solution (X-Molar). The solution is heated to 60°C and has its pH adjusted to 7. Chitosan's amino and hydroxyl groups bind with strontium ions to produce the chitosan-Sr complex. Due to the intrinsic reduction property, it converts the Sr ions into Sr nanoparticles.

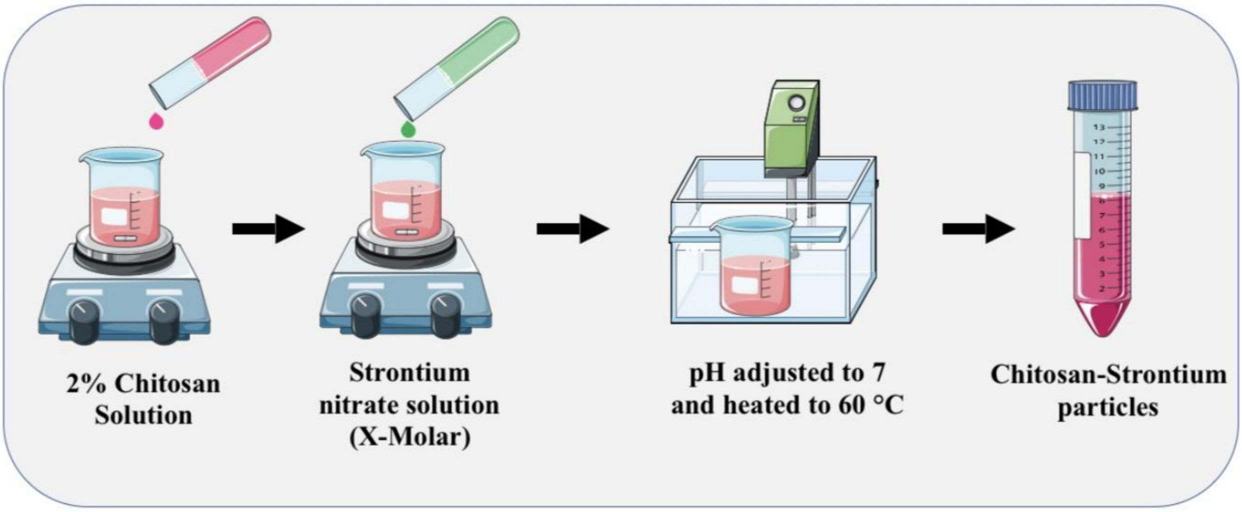

Figure 1: Pictorial representation of the steps involved in the preparation of CS-Sr complex using intrinsic reduction property of chitosan.

RESULT:

In our study, Chitosan-strontium complex was found to be non toxic to human osteoblastic cells. It had no effects on the metabolic activity (MTT Assay) and cell membrane integrity (LDH assay) [Figure 2]. The complex also promoted osteoblasts differentiation. It improved calcium deposition by the osteoblasts (Alizarin red staining) [Figure3]. Therefore, the complex can be explored for bone tissue engineering applications.

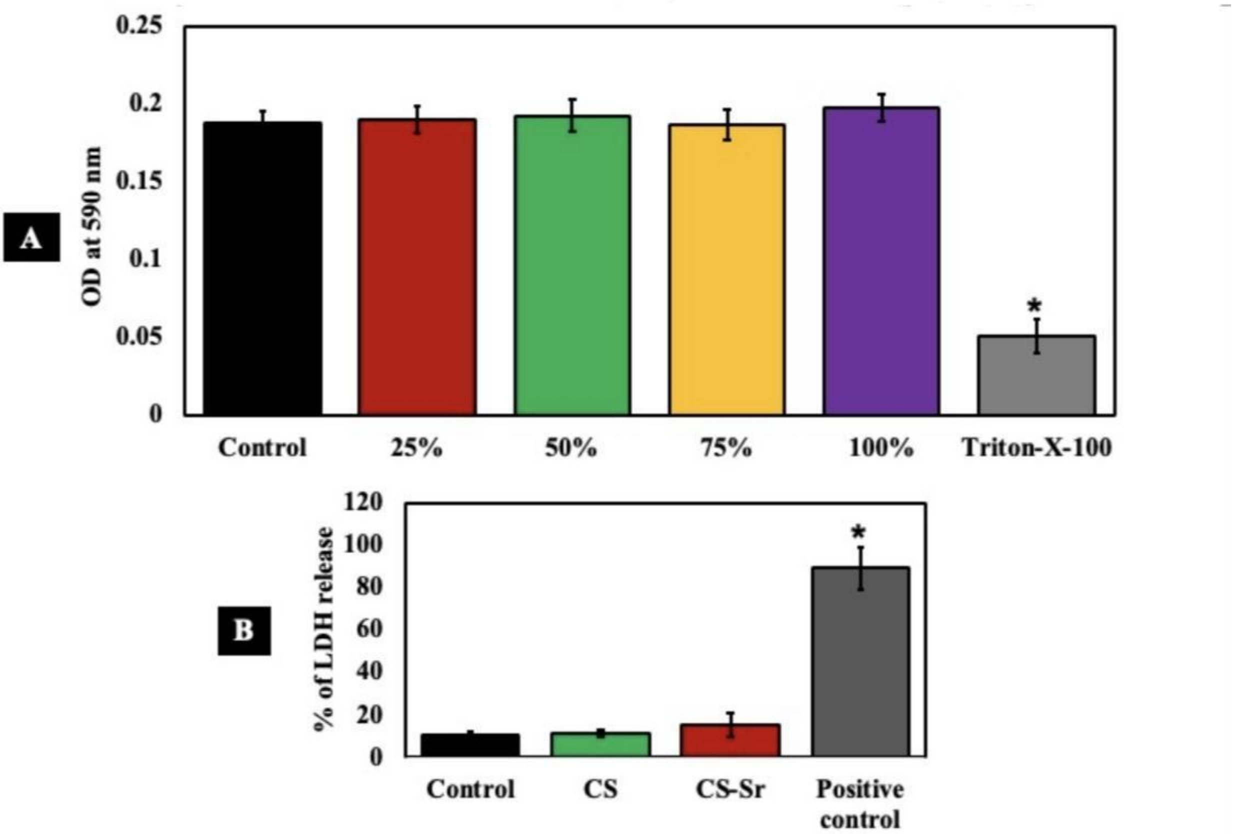

Figure 2: Biocompatibility assessments of CS-Sr membrane with human osteoblastic cells (MG-63) (A) MTT assay and (B) LDH release measurements. *- indicates significant changes compared to control. p < 0.05. n=4.

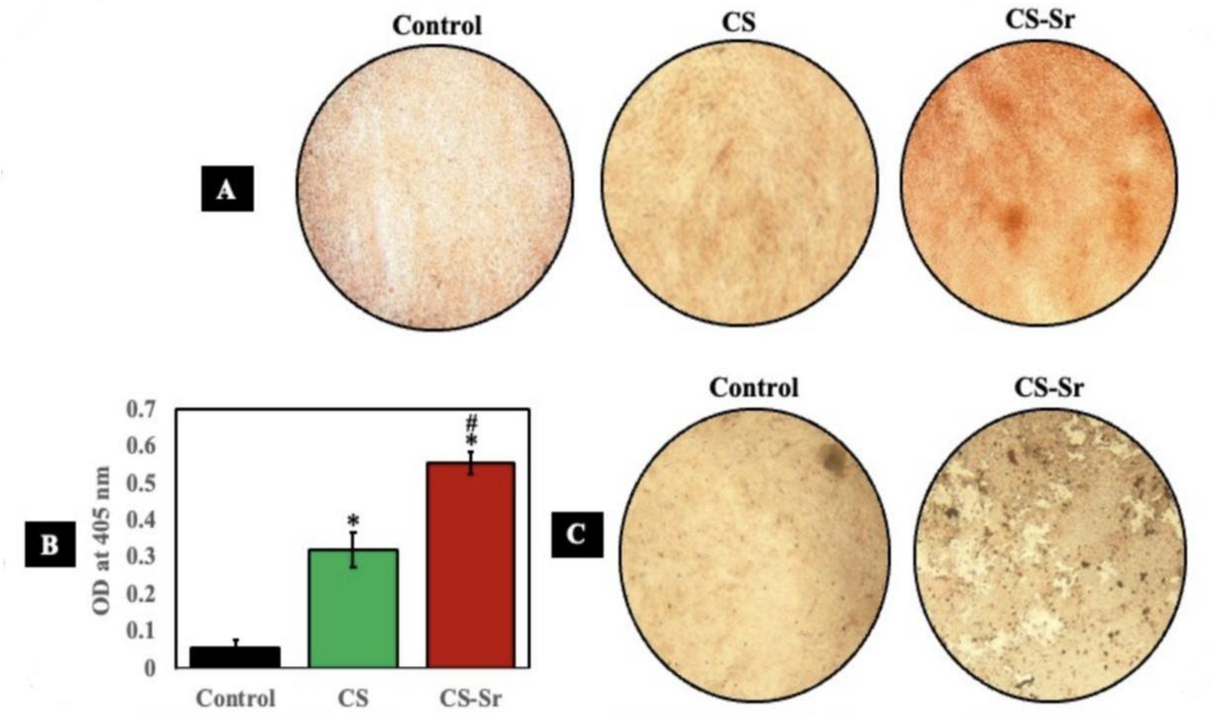

Figure 3: Osteogenic ability measurement using Alizarin red staining. (A) Optical micrographs of human osteoblasts grown on respective membranes under osteogenic induction for 7d. (B) Quantification Plot of alizarin red stained cells and (C) Von-Kossa Stained micrographs of cells grown with or without CS-Sr.*-indicates significant changes compared to control.*-indicates significant changes compared to CS.p<0.05.

n=4.

DISCUSSION:

An emerging technology at the moment is the functionalization of materials with biologically active ions, such as Sr. Inorganic trace elements are added to biomaterials to enhance their biological and physico-mechanical performance and to encourage the regeneration of skeletal tissue.Biocompatibility is one of the essential requirements for materials used in tissue engi- neering applications(15). Biocompatible substances do not cause the body to react toxically or immunologically(16). Chitosan is described as a non-toxic and biocompatible biopolymer safe for usage in the human body as a scaffold or drug carrier in practically all publications that have been published.(17). In the article(18),a new scaffold made of chitosan and strontium chondroitin sulfate (CH-SrCS) and assessed how well bone regeneration was improved by it. They discovered that the CH-SrCS scaffold had favorable effects on the downregulation of inflammatory and osteoclastogenesis-related mRNA expressions and significantly increased BMP2 expression levels.

In article(19), a composite for wound healing was created using commercial passive gauzes, chitosan, and bioactive glass doped with Sr2+, Mg2+, and Zn2+ ions. It was discovered that wound dressings made from the acquired composite material displayed more bioactivity than wound dressings made entirely of chitosan(20). According to the in vivo results, CS-SrCSH has a long-lasting capacity to inhibit osteogenesis, angiogenesis, and bone metabolism. The repair of bone defects, notably in osteoporotic bone, may benefit from the regulated degradation of CS-SrCSH-based cements described here(21).For pro-osteogenesis, the Sr2+ released from the Sr100nHA/CDH was in the ideal concentration range. The inclusion of Sr-nHA greatly increased osteoblasts' cell growth and osteogenic differentiation(22).

In our research, it was discovered that the chitosan-strontium compound was not hazardous to human osteoblastic cells. Both cellular metabolic activity (MTT assay) and cell membrane integrity showed no impacts (LDH assay). Strontium-chitosan complex displays osteoblastic differentiation. Von-kossa and Alizarin red stains were used to assess osteoblastic capacity. Human osteoblasts develop on CS-Sr membranes during osteogenic stimulation compared to controls because of calcium deposition of CS-Sr in the membrane (Figure 3A). Alizarin red stained cells' quantification plot shows the contrast between CS-Sr and the control in the membrane (Figure 3B). Cells with or without CS-Sr are depicted in micrographs stained with Von Kossa in Figure 3C. The development of osteoblasts is aided by this complex. This compound can be investigated for bone tissue engineering applications because it is biocompatible and nontoxic to human bone cells.

CONCLUSION:

It has been demonstrated that the functionalization of biomaterials with the Chitosan-strontium complex for bone regeneration techniques enhances osteoblast development by calcium deposition. Since chitosan-strontium degrades at a tolerable rate without inducing an inflammatory response or creating hazardous byproducts when new tissues are created, it can be extensively researched as a viable tissue engineering biomaterial. Chitosan-strontium films can be considered as a promising cost-effective nano- material for human bone regenerative applications.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest in the present study.

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