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Details of the Collaborative Activity

2020-21

Name of the Collaborating Institute: Oral Health Institute, Department of Dentistry, Hamad Medical Corporation, College of Dental Medicine, Qatar University, Qatar.

Name of the Collaborating Department: Yenepoya Research Center

Collaborative joint research and Publications:

1. Rajasekaran S, Rao SS, Dalavi PA, Prabhu A, Anil S, Venkatesan J, Bhat SS. Rapid microwave-assisted biosynthesis of chitooligosaccharide coated silver nanoparticles: assessments of antimicrobial activity for paediatric pulp therapy. *Advances in Natural Sciences: Nanoscience and Nanotechnology*, 2021; 11(4), p.045018.

2. GV, Yashaswini Devi, Prabhu A, Anil S, Venkatesan, J. Preparation and characterization of dexamethasone loaded sodium alginate-graphene oxide microspheres for bone tissue engineering. *Journal of Drug Delivery Science and Technology,* 2021. p.102624.

3. Murugan SS, Anil S, Sivakumar P, Shim MS, Venkatesan J. 3D-Printed Chitosan Composites for Biomedical Applications. In: Jayakumar R., Prabaharan M. (eds) Chitosan for Biomaterials IV. *Advances in Polymer Science*, 2021. 288. Springer, Cham. https://doi.org/10.1007/12_2021_101

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PAPER

Rapid microwave-assisted biosynthesis of chitooligosaccharide coated silver nanoparticles: assessments of antimicrobial activity for paediatric pulp therapy

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Published 28 January 2021 • © 2021 Vietnam Academy of Science & Technology

Advances in Natural Sciences: Nanoscience and Nanotechnology, Volume 11, Number 4

Citation Subhathira Rajasekaran *et al* 2020 *Adv. Nat. Sci: Nanosci. Nanotechnol.* **11** 045018

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Received 17 May 2020
Accepted 13 July 2020
Published 28 January 2021

https://doi.org/10.1088/2043-6254/abc757

Journal of Drug Delivery Science and Technology 64 (2021) 102624

Contents lists available at ScienceDirect

Journal of Drug Delivery Science and Technology

journal homepage: www.elsevier.com/locate/jddst

Preparation and characterization of dexamethasone loaded sodium alginate-graphene oxide microspheres for bone tissue engineering

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ARTICLE INFO

Keywords:
Alginate
Bone tissue engineering
Dexamethasone
Graphene oxide
Microspheres

ABSTRACT

Over 2.2 million bone graft transplantations are performed by clinicians worldwide annually. The development of synthetic bone graft substitute for the treatment of bone defects is still an utmost challenge in bone tissue engineering. In the current study, we have fabricated calcium ion cross-linked alginate (Alg), alginate-graphene oxide (Alg-GO) and alginate-graphene oxide-dexamethasone (Alg-GO-Dex) composite microspheres as an alternative bone graft substitute. Various properties of developed microspheres were investigated using appropriate characterization tools including Fourier transform infrared spectroscopy, X-ray diffraction, and scanning electron microscopy combined with energy dispersive X-ray diffraction. *In vitro* biomineralization study was performed using simulated body fluid (SBF) solution. Biocompatibility of the developed microspheres was studied with osteoblast-like cells (MG-63). The developed microspheres showed more than 80% of porosity and dispersion of GO in the alginate matrix was uniform. The size of developed microspheres is in the range of 1.5 ± 0.5 mm, and Dex drug was released from the microspheres in sustainable manner. Excellent apatite formation was observed on the surface of the microspheres using SBF solution which is useful for bone tissue regeneration. *In vitro* studies using osteoblast like MG-63 cells revealed profound biocompatibility. Thus, the developed Alg-GO-Dex composite microspheres have potential applications in drug delivery system towards bone tissue engineering applications.

1. Introduction

Bone is a hierarchical structure of osseous tissue composed of inorganic hydroxyapatite and organic collagen, which facilitates the structural framework and mechanical support to the body. Large bone defects can occur in the body by accidental trauma, aged population, birth defects and bone tumors, for which the treatments are still challenging for orthopaedic clinicians [1]. It is estimated that over 2.2 million bone graft transplantations are performed worldwide annually [2]. The current medical procedure to treat bone defects includes autograft, allograft, and synthetic bone graft. The autograft is still considered as a gold standard for bone defect treatment, but this procedure has limitations such as insufficient donor site, donor site morbidity, additional surgery, and chronic pain [3]. On the other hand, chances for spreading transmissible diseases like HIV and Hepatitis is one of the major issues in allograft technique. Hence, the research communities in this field are focusing on novel materials for synthetic bone graft which can replace the natural bone tissue. Bone tissue engineering (BTE) is a kind of paradigm where combination of materials, cells, and growth factors are used for the construction of artificial bone [4]. Materials play an important role in scaffolding system which can provide extracellular matrix for native tissue. Scaffolding system can be of any form including hydrogel, nanoparticles, fibers, films, microspheres, and nanospheres depending on the specific tissue. Microsphere-based scaffolding system in bone tissue engineering has drawn significant attention in recent times due to their diverse properties that includes porosity, stiffness, surface morphology, mechanical strength, and drug releasing capacity [5–7].

Alginate is a linear anionic polysaccharide that can be isolated from brown algae. It is composed of mannuronic and guluronic acid units, and the distribution of these units takes control over the properties like rigidity, gel-forming ability and degree of polymerization. Alginate microspheres can be formed with divalent cations like Ca^{2+} that widely increases its utilization in biomedical areas [8–11]. Despite its biocompatible and biodegradable property, alginate lacks to provide the mechanical strength and interlinking between the cell and materials for

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https://doi.org/10.1016/j.jddst.2021.102624
Received 2 September 2020; Received in revised form 4 May 2021; Accepted 23 May 2021
Available online 29 May 2021

3D-Printed Chitosan Composites for Biomedical Applications

Chitosan for Biomaterials IV pp 87-116 | Cite as

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Chapter
First Online: 18 June 2021

Part of the Advances in Polymer Science book series (POLYMER, volume 288)

Abstract

Regeneration of defective or diseased tissue by 3D-printed biomaterials is an emerging area of research, and 3D printing technology will meet the shortage of organ transplantation and therapeutic clinical applications. The development of novel bio-inks for 3D printing has challenges, including the rheological, physical, chemical, and biological properties of materials, the risk of an immune response, cytotoxicity, and regeneration rate. In recent years, chitosan and its composites as bio-inks for 3D bioprinting to develop artificial organs have been studied. The results infer that the regenerative capacity of the 3D printed chitosan composites varies depending on size, porosity, stimulating effect, cell interaction, cell adhesion, and the differentiation potential of stem cells. In this review, the types of 3D printing technology for the fabrication system and their role in tissue engineering applications are studied in detail.

Keywords

3D printing Bio-ink Growth factors Stimulators Tissue engineering