International Journal of Biological Macromolecules 180 (2021) 339–354

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: http://www.elsevier.com/locate/ijbiomac

Newer guar gum ester/chicken feather keratin interact films for tissue engineering

Aatrayee Das [a], Ankita Das [b], Aalok Basu [a,c], Pallab Datta [b], Mradu Gupta [d], Arup Mukherjee [e,*]

[a] Division of Pharmaceutical and Fine Chemical Technology, Department of Chemical Technology, University of Calcutta, 92, A.P.C. Road, Kolkata 700009, West Bengal, India
[b] Centre for Healthcare Science and Technology, Indian Institute of Engineering Science and Technology, Shibpur, Howrah 711103, West Bengal, India
[c] Dr. B.C. Roy College of Pharmacy and Allied Health Sciences, Bidhannagar, Durgapur 713206, West Bengal, India
[d] Dravyaguna Department, Institute of Post Graduate Ayurvedic Education and Research, 294/3/1, A.P.C. Road, Kolkata, 700009, West Bengal, India
[e] Department of Biotechnology, Maulana Abul Kalam Azad University of Technology, NH 12, Haringhata, Nadia 721249, West Bengal, India

ARTICLE INFO

Article history:
Received 10 December 2020
Received in revised form 3 March 2021
Accepted 6 March 2021
Available online 9 March 2021

Keywords:
Guar gum
Chicken feather keratin
Guar gum indole acetate
Tissue engineering
Protein-polysaccharide interactions

ABSTRACT

This work intends to synthesis newer guar gum indole acetate ester and design film scaffolds based on protein-polysaccharide interactions for tissue engineering applications. Guar gum indole acetate(GGIA) was synthesized for the first time from guar gum in presence of aprotic solvent activated hofmeister ions. The newer biopolymer was fully characterized in FT-IR, ^{13}C NMR, XRD and TGA analysis. High DS (Degree of Substitution, DS = 0.61) GGIA was cross-linked with hydrolyzed keratin, extracted from chicken feather wastes. Films were synthesized from different biopolymer ratios and the surface chemistry appeared interesting. Physicochemical properties for GGIA-keratin association were notable. Fully bio-based films were non-cytotoxic and exhibited excellent biocompatibility for human dermal fibroblast cell cultivations. The film scaffold showed 63% porosity and the recorded tensile strength at break was 6.4 MPa. Furthermore, the standardised film exerted superior antimicrobial activity against both the Gram-positive and Gram-negative bacteria. MICs were recorded at 130 μg/mL and 212 μg/mL for *E. coli* and *S. aureus* respectively. In summary, GGIA-keratin film scaffolds represented promising platforms for skin tissue engineering applications.

1. Introduction

Advanced synthesis of biomaterial devices from protein-polysaccharide interaction chemistry is fascinating. Association of protein and polysaccharide macromolecules through co-valent bonding and applications of non-covalent attractive forces like electrostatic interactions, van der Waals forces and hydrophobic interactions can lead to highly ordered structures. Similar scaffoldings present biosafe constructs with tailored characteristics, ready for applications in biomedical and pharmaceutical areas [1–4]. Protein-polysaccharide chain interactions can thus be tuned into distinctive structural associations in order to develop bio-mimetic materials and economically viable devices. Similar interactions were applied earlier for developing conjugated vaccine against infectious disease and for delivering bioactive molecules [5–8]. Artificial biomaterials mimicking natural extracellular matrix were useful as cell factories and in tissue engineering [9,10]. Biopolymers having both the hydrophobic and hydrophilic moieties in chain can interact further due to soft matter characteristics [11,12].

Protein and polysaccharide, the most abundant naturally occurring polymers are attractive templates in tissue engineering arenas since their chain to chain interaction provides a suitable three dimensional framework setting that mimics the extracellular matrix(*ECM*)of biological tissues constituting sugar-based molecules, several amino-acids and proteoglycans [13–15]. One of the most stupendous features is that the engineered ECM holds reproducible mechanical strength and facilitates the transport of nutrients and bio-wastes from their aqueous milieu during cellular activities. Thus, the ECM system composed of designed macromolecules acts as a reservoir to supply bioactive cues for cell attachment, migration, proliferation and subsequently stimulating the autogenic tissue regeneration process. A few of them exhibits excellent biocompatibility and controlled biodegradability with minimum immunogenic response in physiological environment [16,17]. Hence, this kind of natural polymers like keratin, collagen, chitosan, guar gum, alginate, cellulose etc. have been extensively studied for their potential contribution in tissue specific restoration and reconstruction process [18,19].

Synthesis of bio-inspired ECM material based on keratin has emerged as a captivating strategy in tissue engineering due to its innate cell growth and proliferation capacity, fibroblast growth factors, biodegradability, biocompatibility and natural profusion [20]. Keratin, a subset of fibrous protein molecules largely present in poultry feathers, epithelium, hairs, wool and horns of animals, expresses moderate

* Corresponding author at: Department of Biotechnology, Maulana Abul Kalam Azad University of Technology, NH 12, Haringhata, Nadia 721249, West Bengal, India.
E-mail address: arupm1234@gmail.com (A. Mukherjee).

https://doi.org/10.1016/j.ijbiomac.2021.03.034
0141-8130/