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Designing tragacanth gum based sterile hydrogel by radiation method for use in drug delivery and wound dressing applications

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ABSTRACT

Present article discusses synthesis and characterization of the sterile and pure hydrogel wound dressings which were prepared through radiation method by using polyvinyl alcohol (PVA), tragacanth gum (TG) and sodium alginate (SA). The polymer films were characterized by SEM, Cryo-SEM, FTIR, solid state C^{13} NMR and XRD, TGA, and DSC. Some important biological properties such as O_2 permeability, water vapor transmission rate, microbial permeability, haemolysis, thrombogenic behavior, antioxidant activity, bio-adhesion and mechanical properties were also studied. The hydrogel film showed thrombogenicity ($82.43 \pm 1.54\%$), haemolysis ($0.83 \pm 0.09\%$), oxygen permeability (6.433 ± 0.058 mg/L) and water vapor permeability (197.39 ± 25.34 g/m^2/day). Hydrogel films were found biocompatible and impermeable to microbes. The release of antibiotic drug moxifloxacin occurred through non-Fickian mechanism and release profile was best fitted in Hixson-Crowell model for drug release. Overall, these results indicate the suitability of these hydrogels in wound dressing applications.

1. Introduction

Generally, wound is a disruption of normal anatomical structure and function of the skin and wound healing is the complex and dynamic process that results in the restoration of its anatomical continuity and function [1]. Effective wound dressing not only protects the wound from surrounding environments but also provides moist environment for continuous tissue reconstruction process. Besides this, a wound dressing must be easily removable and properly adhered [2,3]. Hydrogels are crosslinked network of hydrophilic homopolymers or copolymers and consisting of a three-dimensional network of polymer chains and can retain large amount of water or wound fluid. The intermolecular interactions among the chains control the physical, chemical and mechanical properties of the hydrogels [4,5]. Hydrogel wound dressings can meet the requirements of an ideal wound dressing [6].

Gamma ray irradiation is a very convenient method for synthesis of hydrogels for biomedical applications and this method allows the formation of sterile, non-contaminated and additive free hydrogels [7]. Further, the degree of crosslinking, which strongly determines the extent of swelling of hydrogels, can be easily controlled by varying the radiation dose [8]. The gel fraction has been found to be increased with irradiation dose and gel strength enhanced by addition of natural polymer like starch to the polyvinyl alcohol [PVA] [6,9]. In the present work, an attempt has been made to design the hydrogel wound dressings by radiation induced grafting/crosslinking of PVA onto tragacanth gum and alginate.

Tragacanth gum (TG) is non-allergenic, non-mutagenic, non-teratogenic, non-carcinogenic and non-toxic natural hydrophilic polysaccharide and it makes a suitable medium for cell growth [10]. It is a complex, highly branched, heterogeneous polysaccharides and comprising of two fractions; 'tragacanthic acid' (or 'bassorin') and tragacanthin' (or 'arabinogalactan'). The primary and secondary hydroxyl and carboxylic acid groups present in tragacanth gum TG molecules provide positions for reacting with monomers and crosslinking reagents [11,12]. After hydrolysis, TG has also showed presence of galacturonic acid, xylose, arabinose, galactose and fucose [13]. The gum is used in ointments which are applied on infected wound and ulcers. The paste of tragacanth gum has been used on fracture and weak joints [14]. On the other hand sodium alginate (SA) is a hydrophilic, high molecular weight, linear anionic hetero-polysaccharide extracted from the sea weeds [15]. It is a copolymer of α-L-guluronic acid (G) and β-D-mannuronic acid (M) having 1,4 glycosidic linkages between them [15,16]. It has been used in various pharmaceutical applications due to its non-toxicity, biocompatibility and biodegradability [17]. The alginate-polyvinyl

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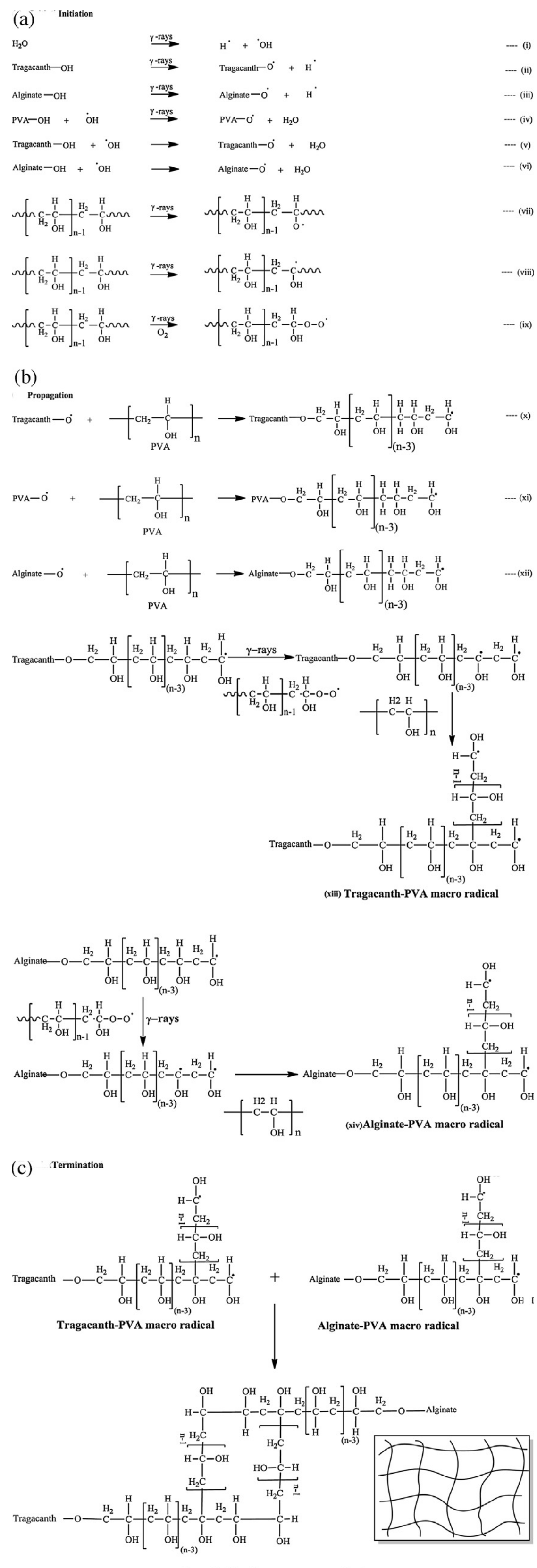

Scheme 1. Plausible mechanism of radiation induced grafting in Tg-*co*-SA-*cl*-PVA hydrogel film.

pyrrolidone (PVP) based hydrogel prepared by radiation induced crosslinking showed efficient fluid handling capacity and antimicrobial activity. Further, the degree of cross-linking can easily be controlled by altering the irradiation conditions [18,19]. While in case of PVA- alginate blend, upon addition of sodium alginate to PVA, led to remarkable increase in rigidity of PVA, the melting