



An enhancement on healing effect of wound dressing: Acrylic acid grafted and gamma-polyglutamic acid/chitosan immobilized polypropylene non-woven

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ABSTRACT

The wound dressing of acrylic acid-grafted and gamma-polyglutamic acid/chitosan-immobilized polypropylene non-woven fabric (PP-AAg-PGCI) was produced in this study. Gamma-polyglutamic acid (gamma-PGA) was first applied in this field to composed with chitosan. The PP-AAg-PGCI wound dressings were expected to enhance the water absorbing, water permeating and wound healing properties. The results showed that the immobilizing percentage, water absorbing value and water diffusion coefficient for PP-AAg-PGCI samples increased with the increase of the gamma-PGA in the immobilizing bath; whereas, decreased with the increase of the chitosan in the immobilizing bath. The immobilized chitosan was aggregating with the state of discontinuous and uneven mass materials on the surface of the immobilized gamma-PGA. The water absorbing, water permeating, and anti-bacterial properties of the PP-AAg-PGCI samples were much better than that of AA grafted and collagen/chitosan immobilized PP non-woven sample (PP-AAg-CCI) in our previous study. Anti-bacterial property for PP-AAg-PGCI samples was excellent. The effect on accelerating wound healing for PP-AAg-PGCI samples was strong. The product of the multi-layer material of PP-AAg-PGCI was expected to bestow better services for wound dressing.

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1. Introduction

During the mild 1990s, commercial wound dressings expanded into the following groups of products: vapour-permeable adhesive films, hydrogels, hydrocolloids, alginates, synthetic foam dressings, silicone meshes, tissue adhesives, barrier films, and silver- or collagen-containing dressings. Collagen-containing dressing was generally produced in the form of pad, which contained supporting layer (non-woven fabric) and collagen layer at least. Additionally, dressings should perform one or more of the following functions: maintain a moist environment at the wound/dressing interface, absorb excess exudates without leakage to the surface of dressing, provide mechanical protection, provide bacterial protection, allow gaseous and fluid exchange, and be non-toxic.

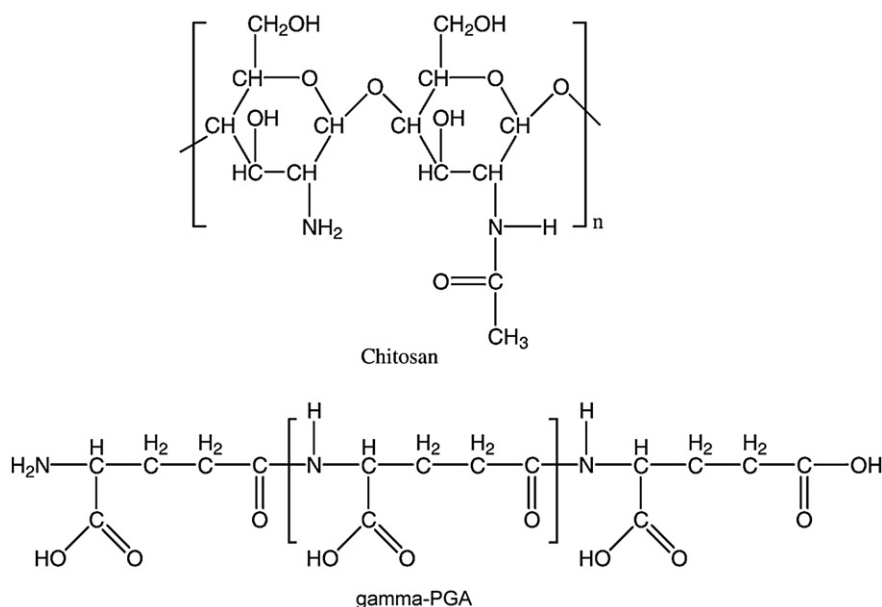
Chitosan, partially de-acetylated from chitin, possessed good anti-bacterial activities and cell adhesiveness [1]. Chitosan was used to impregnate on the acrylic acids (AA) or N-isopropyl acrylamide bi-grafted polypropylene (PP) non-woven fabrics for dressing wounds to possess higher values of water vapor transmission rates as well as anti-bacteria [2]. In the recent years, some of the products derived from chitosan and collagen for wound healing have been approved [3]. Nevertheless, the

improvement of water absorbing and water permeating properties is still necessary for the products derived from collagen and chitosan. For a large open wound, the dressing material is required to prevent bacterial infection and preserve moisture [4–6]. Therefore, it is integral to develop a wound dressing with excellent water permeating/absorbing abilities and excellent anti-bacteria activities [7,8]. Collagen is responsible for the functional integrity of such tissues as bones, cartilages, and skins. It emerges early during embryonic development and constructs the structural framework of most organs. Collagen was found to possess good biocompatibility [9]. On the other hand, previous study [10,11] indicated that gamma-polyglutamic acid (gamma-PGA) was a natural bio-polymer and possessed high water remaining, bio-degradable and non-toxic properties. The water remaining and anti-bacterial properties for gamma-PGA were higher than that for collagen [12]. However, the wound dressing prepared from gamma-PGA/chitosan is lacking.

In this study, gamma-PGA/chitosan was employed to immobilize on the surface of AA-grafted PP non-woven fabric. In this study, the layer of grafted AA (poly-AA) was used to play a connecting role between the mechanical durable PP fabric and the healing layer of gamma-PGA/chitosan. The parameters on water absorbing and water permeating properties and the anti-bacterial activity for those composite materials were examined. At the same time, the micro-photographs obtained from scanning electron microscope (SEM) of the AA-grafted and gamma-PGA/chitosan-immobilized polypropylene (PP-AAg-PGCI) and the healing

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Scheme 1. The chemical structures of chitosan (80% de-acetylation) and gamma-polyglutamic acid.

effect for the wound dressing of PP-AAg-PGCI were examined. This study aims to produce a non-antigenic wound dressing, which possesses high water absorbing and permeating properties, high anti-bacteria activities and excellent healing effect on a large open wound.

2. Experimental

2.1. Materials

Polypropylene non-woven fabric, 50 g/m², was supplied by Industrial Technology Research Institute, Taipei, Taiwan. The average denier of the melting blown fiber was about 0.4–0.5 (7–8 μm). Polyglycerol polyglycidyl ether (Nagase ChemteX Co., Japan) and glutaraldehyde (Acros Organics, Geel, Belgium) were employed as crosslinking agent for gamma-Polyglutamic acid and chitosan, respectively. Gamma-polyglutamic acid was obtained from Vedan Enterprise Co., Taichong, Taiwan). Acrylic acid (AA) was obtained from Acros Organics, Geel, Belgium. Chitosan (Sigma H-6279) was obtained from SIGMA Co., Louis, USA. The degree of de-acetylation for this commercial product was 80%. Other chemicals used were all reagent grade. The chemical structures of chitosan and gamma-PGA were listed in Scheme 1.

2.2. Methods

2.2.1. Preparation of grafting materials

The initial PP non-woven fabric samples were pre-treated with pure acetone and grafted with AA by the same method as used in the previous study of ours [12]. Then, the AA-grafted non-woven fabric samples were dried at 105 °C for at least 1.5 h to clear the residual water and toluene on the grafted samples, and weighed to obtain the grafting percentage as the following [13].

$$\text{Grafting percentage(\%)} = \frac{[(\text{dry weight after grafting} - \text{dry weight before grafting}) / \text{dry weight before grafting}] \times 100}{(1)}$$

The grafting percentage of the AA-grafted PP non-woven fabric for this study was controlled at 15 wt.%. This sample was assigned as PP-AAg.

2.2.2. Preparation of Immobilizing Materials

The immobilizing was proceeded under a two-step process for the different immobilizing method, in which the crosslinking agents used were different for the two immobilizing agents (gamma-polyglutamic acid and chitosan, respectively).

First step: the AA-grafted fabric samples was immersed in the glass dish containing specific concentrations of gamma-PGA (1.0, 2.0, and

Table 1

The data of water absorbing, water diffusion coefficient, bacteria inhibition percentage, and bacteria inhibition zone of the various AA-grafted and gamma-polyglutamic acid/chitosan-immobilized PP nonwoven fabrics.

Sample	Step 1		Step 2		Properties			
	Gamma-polyglutamic acid (%)	Immobilizing percentage (%),	Chitosan (%)	Immobilizing percentage (%),	Bacteria inhibition percentage (%)	Bacteria inhibition zone (mm)	Water up-take(%)	Water diffusion coefficient ($\times 10^8$ cm ² /s)
1	1.0	69.2	1.0	58.4	97.3	4.6	230.8	–
			2.0	73.7	98.3	7.3	211.5	–
			3.0	87.4	99.0	7.8	195.6	2.4
2	2.0	76.5	1.0	44.3	93.8	4.3	253.7	–
			2.0	60.1	96.6	7.0	237.5	–
			3.0	77.4	98.2	7.6	222.1	3.0
3	3.0	81.3	1.0	40.3	90.3	4.2	280.9	–
			2.0	51.4	94.0	6.8	277.2	–
			3.0	70.1	96.7	7.4	250.2	3.8

The grafting percentage of AA was 15 wt.%.

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