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Development of nanofibrous scaffolds containing gum tragacanth/poly (ε-caprolactone) for application as skin scaffolds

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ABSTRACT

Outstanding wound healing activity of gum tragacanth (GT) and higher mechanical strength of poly (ε-caprolactone) (PCL) may produce an excellent nanofibrous patch for either skin tissue engineering or wound dressing application. PCL/GT scaffold containing different concentrations of PCL with different blend ratios of GT/PCL was produced using 90% acetic acid as solvent. The results demonstrated that the PCL/GT (3:1.5) with PCL concentration of 20% (w/v) produced nanofibers with proper morphology. Scanning electron microscopy (SEM) and differential scanning calorimetry (DSC) were utilized to characterize the nanofibers. Surface wettability, functional groups analysis, porosity and tensile properties of nanofibers were evaluated. Morphological characterization showed that the addition of GT to PCL solution results in decreasing the average diameter of the PCL/GT nanofibers. However, the hydrophilicity increased in the PCL/GT nanofibers. Slight increase in melting peaks was observed due to the blending of PCL with GT nanofibers. PCL/GT nanofibers were used for in vitro cell culture of human fibroblast cell lines AGO and NIH 3T3 fibroblast cells. MTT assay and SEM results showed that the biocomposite PCL/GT mats enhanced the fibroblast adhesion and proliferation compared to PCL scaffolds. The antibacterial activity of PCL/GT and GT nanofibers against *Staphylococcus aureus* and *Pseudomonas aeruginosa* was also examined.

1. Introduction

Skin is the first line of physical barrier from the external factors. Its form and function can be degenerated due to several reasons such as burns, accidents, and diseases, and recovery to its original form can take several weeks or months [1]. Depending on the healing ability and type of wounds, suitable skin substitute system should be applied for providing an extracellular matrix for the natural infiltration of surrounding cells [2]. An ideal skin substitute should provide an optimal healing property with sufficient exudate absorbability, oxygen permeability and controlled fluid loss in which healing and cosmetic appearance of the injured part can occur at a maximum rate [3].

Nanofibrous scaffolds due to their pore-size distribution, high surface-to-volume ratio and most importantly, morphological similarity to natural extracellular matrix (ECM) may be used as wound dressing scaffolds [4–6]. Among the different ways of nanofiber production, electrospinning appears to be a simple, superior, smart and scalable technique to fabricate polymeric nanofibers [7]. Natural and synthetic polymers cannot provide all the requirements of a perfect nanofibrous scaffold exclusively for application as wound dressing or skin scaffold. Natural polymers lose their mechanical properties very quickly during degradation while synthetic polymers, such as polyesters are usually hydrophobic, have less binding sites for cell adhesion and release acidic products during degradation. To overcome the aforesaid problems and provide desirable new biomaterials, hybrid materials which are blends of two or more types of polymers have been fabricated by researchers that assimilate the desirable characteristics of component materials [8].

Gum tragacanth (GT), a natural polymer, is known for its excellent biological properties such as biodegradability, biocompatibility, antibacterial and wound healing activity [9]. This hydrocolloid has been accepted since 1961 as GRAS at the level of 0.2–1.3% and in Europe has E-number E413 on the list of additives approved by the Scientific Committee for Food of the European Community [10]. Mucilage of GT is used in lotions for external applications and, at higher concentrations, as a base for jelly lubricants and in medicinal oil emulsions. As an emulsifier, it facilitates the absorption of poorly soluble substances such as steroid glycosides and fat-soluble vitamins. This gum is also used in various types of elixirs and syrups where low-calorie intake is required [9,11]. In our previous work, GT was blended with poly(vinyl alcohol) to improve the spinnability of GT solution, then nanofibers were chemically cross-linked with glutaraldehyde. The smooth surface nanofiber showed good antimicrobial property against gram-negative bacteria (*Pseudomonas aeruginosa*), however human fibroblast cells had well attachment and proliferation on these scaffolds [12]. There is no available report on the production of electrospun GT composite scaffolds with PCL, PLGA, etc.,

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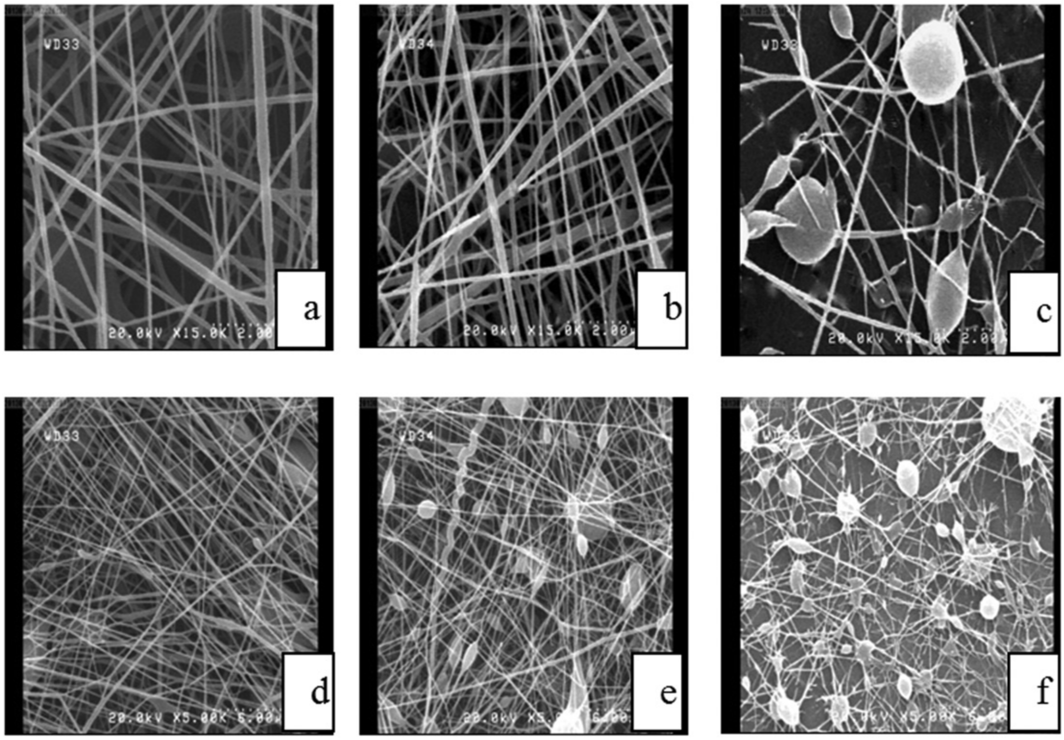

Fig. 1. SEM micrographs of PCL (10 w/v %)–GT (7 w/v %) blend nanofibers with different blend ratios: a, d) 3:0, b, e) 3:1, and c, f) 3:1.5 electrospun under applied voltage 15 kV, extrusion rate 0.5 mL/h and nozzle to collector distance 20 cm; (a, b, c) 15,000×, (d, e, f) 5000×.

and their applications in either skin tissue engineering or wound healing. Poly (ε-caprolactone) (PCL) is an aliphatic polyester, often used in biomedical applications because of its biocompatibility, slow biodegradability, low-cost, non-toxicity and good mechanical properties. However, it is hydrophobic [13] which may severely limits its use in certain applications. The aim of this work is to fabricate composite scaffolds from PCL and the natural biopolymer GT at varying ratios. Further we investigated the mechanical properties, hydrophilicity, biocompatibility and fibroblast cell proliferation of nanofibers for wound dressing application.

2. Materials and methods

2.1. Materials

Gum tragacanth used in this study was a high quality ribbon type, collected from the stems of floccosus species of Astragalus bushes, growing in central areas of Iran. The raw gum was ground into fine powder. The moisture content of the gum powder was measured using the standard method of AOAC [14]. The density of GT was measured by

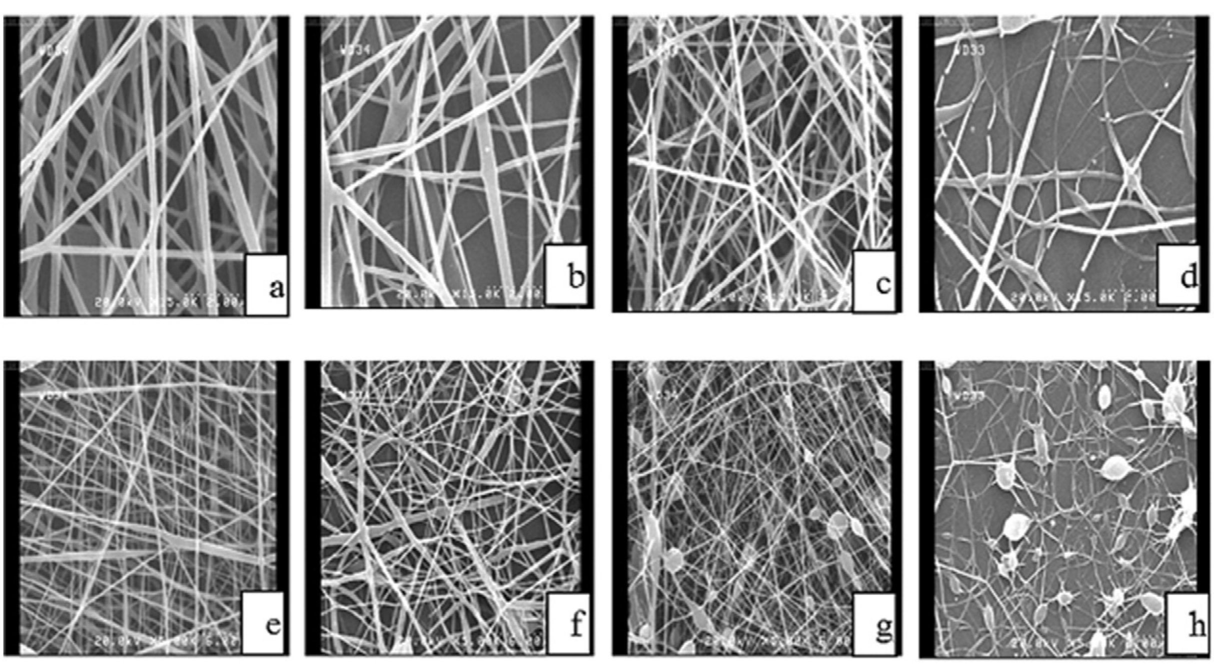

Fig. 2. SEM micrographs of PCL (15 w/v %)–GT (7 w/v %) blend nanofibers with different blend ratios: a, e) 3:0, b, f) 3:1, c, g) 3:1.5, and d, h) 3:3 electrospun under applied voltage 15 kV, extrusion rate 0.5 mL/h and nozzle to collector distance 20 cm); (e, f, g, h) 5000×, (a, b, c, d) 15,000×.