ARTICLE IN PRESS

ASIAN JOURNAL OF PHARMACEUTICAL SCIENCES ■■ (2017) ■■–■■

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Original Research Paper

Preparation of glutinous rice starch/polyvinyl alcohol copolymer electrospun fibers for using as a drug delivery carrier

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ARTICLE INFO

Article history:
Received 5 June 2017
Received in revised form 20 August 2017
Accepted 25 August 2017
Available online

Keywords:
Electrospinning
Drug release
Nanofibers
Biomaterials
Glutinous rice starch

ABSTRACT

Glutinous rice starch (GRS) is commonly produced in the Northeast of Thailand. GRS is a biopolymer which is widely used in the food industry but not yet commonly applied within the pharmaceutical industry as an alternative resource. GRS exhibits a branch chain structure which is not feasible to fabricate as nanofiber. Therefore, combining GRS with polyvinyl alcohol (PVA) in hybrid form can be a potential platform to produce GRS-PVA nanofibers. Smooth nanofibers of 2% (w/v) GRS combined with 8% (w/v) PVA were fabricated by an electrospinning process. A scanning electron microscope (SEM) revealed an average diameter size of the GRS-PVA nanofibers equal to 191 ± 25 nm. A highly water soluble model drug, Chlorpheniramine maleate (CPM), was incorporated into the GRS-PVA electrospun fibers to prove a drug delivery carrier concept and drug release control of the nanofibers. The GRS-PVA nanofibers exhibited a biphasic CPM release in which approximately 60% of the drug immediately released in 10 min, and it reached 90% drug release in 120 min. This study demonstrated a potential application of GRS combining with PVA as an oral drug delivery carrier. Therefore, it can be a promised step that expands the application GRS in pharmaceuticals and related areas.

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Peer review under responsibility of Shenyang Pharmaceutical University.
http://dx.doi.org/10.1016/j.ajps.2017.08.008

1. Introduction

Electrospinning is a fiber production technique which can fabricate fibers with diameters ranging from microscale to nanoscale [1–5]. The electrospinning process has gained more attention in the past decade because of its versatility in spinning with a wide variety of polymeric fibers and its ability to consistently produce fibers in the submicron range that is otherwise difficult to achieve by using standard mechanical fiber-spinning techniques [6]. In addition, the electrospun fibers sizes are smaller than the fibers that are produced by other processes. The nanofibers which are obtained from electrospinning demonstrate higher surface areas to volume ratio. It is possible to manipulate electrospun fibrous diameter and their shape by altering the parameters in electrospinning process [5,7,8]. Electrospun fibers show versatile applications in numerous fields such as filtration techniques, analytical chemistry, tissue engineering and drug delivery [9]. Electrospun nanofibers have been reported that they are fabricated from various sources including synthetic polymers, natural polymers or a blend of proteins, nucleic acids and even polysaccharides [5]. In addition, the desired physical properties of the fibrous matrices can be obtained by blending different types of polymer in a suitable proportion. For example, fibrous matrices that are prepared by blending a water-soluble and water-insoluble polymer can be used as controlled release carriers for drug delivery application [10–12]. Recently, starch, a natural polymer, has been applied to the electrospinning process increasingly, especially in a hybrid form with synthetic polymers.

Starch is a well-known material that has been globally used in various industries such as textile, paper, plastic, food, cosmetic and pharmaceuticals. It shows many advantages including bio-sourced, renewable, biodegradable, biocompatible and inexpensive [13,14]. There are varieties of starch commercially available, for instance, maize starch, potato starch, rice starch and glutinous rice starch. Starch is a common pharmaceutical excipient which functionalizes as a glidant, diluent, disintegrant, and binder in solid formulations [15]. However, starch is a poor electrospun fiber forming agent as the starch fibers are brittle and water-sensitive [14]. The literature reported that blending starch with linear chain polymer can improve the overall spinnability of the blends [14]. Polyvinyl alcohol (PVA) is a synthetic polymer which shows a wide range of applications such as polymer industrials, pharmaceuticals, and foods. Its monomer unit is illustrated in Fig. 1A. PVA is a hydrophilic semi-crystalline polymer which shows a good chemical and thermal stability. Additionally, it is a biocompatible material which is used in tissue engineering area. PVA has a low acute oral toxicity with LD_{50} in a range of 15–20 g/kg. Furthermore, it is poorly absorbed into the body through a gastrointestinal tract [16]. PVA shows an excellent spinnability [17–20]. Therefore, blending starch and PVA in an optimal proportion can enhance the spinnability of starch. Glutinous rice starch (GRS) is a new alternative material to be combined with synthetic polymer especially with PVA.

GRS is produced from *Oryza sativa* var. *glutinosa* which is commonly cultivated in the Northeast of Thailand. GRS contains two types of glucose polymers which are amylose and amylopectin. Amylose contains 250–2000 glucose units that are mostly arranged in essentially linear chains of α-1,4-linked glucose units. However, there are some amyloses that link by α-1,6-glucosidic bonds. Amylose is a minority component in GRS which presents less than one percent. Amylopectin is a glucose polymer that has a branched chain of 25–30 glucose residues which are linked by α-1,4-glucosidic bonds and α-1,6-glucosidic bonds. GRS contains more than 99 % of amylopectin [21–23]. Thus, it exhibits a branch chain structure (as seen in

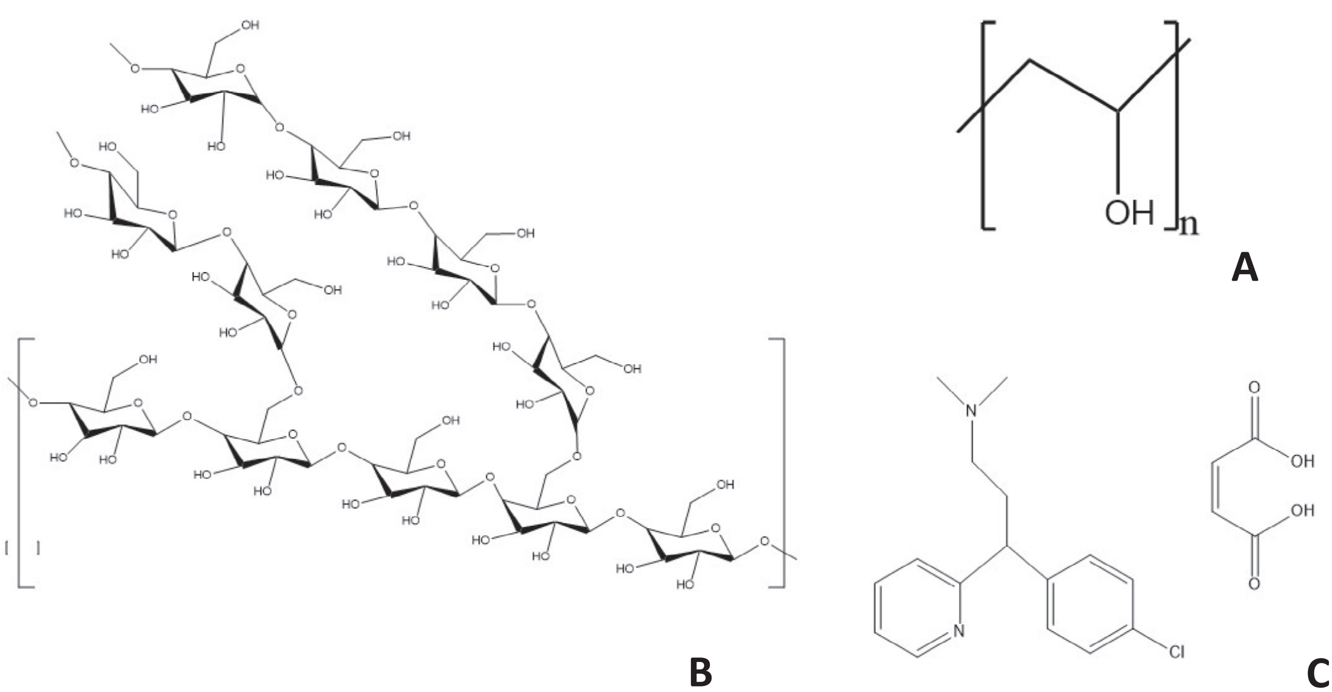

Fig. 1 – Molecular structure of (A) PVA monomer, (B) GRS and (C) CPM.

Please cite this article in press as: Patthanakorn Jaiturong, et al., Preparation of glutinous rice starch/polyvinyl alcohol copolymer electrospun fibers for using as a drug delivery carrier, Asian Journal of Pharmaceutical Sciences (2017), doi: 10.1016/j.ajps.2017.08.008