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ORIGINAL RESEARCH

Poly(vinyl alcohol) membranes in wound-dressing application: microstructure, physical properties, and drug release behavior

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Abstract

Poly(vinyl alcohol) (PVA) hydrogel membranes were prepared through three different preparation methods including freeze-thawing (FT), solution casting (SC) followed by thermal annealing, and phase separation (PS). The prepared hydrogels were characterized by Fourier transform-infrared spectroscopy, X-ray diffractometry, and scanning electron microscopy. Nitrofurazone (NFZ) was then loaded in the hydrogels. FT and SC methods led to obtaining dense membranes, while PS method resulted in an asymmetric one. The effects of hydrogel preparation method on water absorption, gel fraction, water vapor and oxygen permeabilities, bacterial barrier, tensile properties, and drug release profiles were investigated. The water vapor permeability of the hydrogel prepared through PS method was about 1.5 times higher than those obtained through FT and SC methods. Gel formation in PS method is probably responsible for the highest degree of crystallinity, and consequently the maximum gel fraction for the corresponded membrane. The elongation-at-break for this membrane in wet state was 41% higher than that made by FT method and 18% greater than that of SC method. Membranes prepared by all three methods showed excellent barrier property against bacterial penetration during 1 week. The results showed that PS membrane could control the release of NFZ more effectively as compared with the other two samples.

Keywords Poly(vinyl alcohol) · Hydrogel membrane · Drug release · Solution casting · Freeze-thawing · Phase separation

Introduction

Poly(vinyl alcohol) (PVA) is a polymer of great interest because of its many desirable characteristics such as hydrophilicity, biodegradability, and biocompatibility, specifically its application in various biomedical and pharmaceutical applications such as artificial cartilage and meniscus, soft contact lenses, eye drops, tissue adhesion barriers, drug delivery devices, and wound dressing [1–3]. The main physical characterizations of hydrogels especially in the form of membrane for wound-dressing applications are water absorption, water vapor permeability, gas permeability, tensile strength, and elasticity properties [4].

Poly(vinyl alcohol) is synthesized through the polymerization of vinyl acetate to poly(vinyl acetate) followed by the hydrolysis reaction. Since PVA is a water soluble polymer, chain crosslinking is necessary to make it a hydrogel useful in a wide variety of applications [1–3]. PVA hydrogel is stable at room temperature and exhibits the ability to absorb water, swell, and hold a significant fraction of water within its structure. It can be expanded to several times of its initial size while retaining its original shape [5, 6]. In the PVA hydrogel structure, the crosslinks may be provided chemically (by covalent bindings) or physically (by hydrogen bindings). Since the chemical crosslinking agents like glutaraldehyde are toxic for pharmaceutical applications, the physical crosslinking methods are usually preferred [7]. The physical crosslinks may also lead to better mechanical properties due to the distribution of mechanical load along the crystallites of three-dimensional structure that are formed by hydrogen bonds [8].

Morphology, crystallinity, and porosity of PVA membranes can affect their physical and mechanical properties. Alves et al. provided a comprehensive review on relation between sub-molecular PVA chemistry to fine-tuned supramolecular association of chains that in turn define the macroscopic properties of the polymer [9]. The method of preparation of these hydrogel membranes is an important

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