Arabian Journal of Chemistry (2015) 8, 1–14

King Saud University

Arabian Journal of Chemistry

www.ksu.edu.sa
www.sciencedirect.com

REVIEW

Crosslinked poly(vinyl alcohol) hydrogels for wound dressing applications: A review of remarkably blended polymers

Elbadawy A. Kamoun [a,*], **Xin Chen** [b], **Mohamed S. Mohy Eldin** [a], **El-Refaie S. Kenawy** [c]

[a] *Polymer Materials Research Department, Advanced Technology & New Materials Research Institute (ATNMRI), City of Scientific Research and Technological Applications (SRTA-City), New Borg Al-Arab City, P.O. Box 21934, Alexandria, Egypt*
[b] *State Key Laboratory of Molecular Engineering of Polymers, Department of Macromolecular Science, Laboratory of Advanced Materials, Fudan University, Shanghai, 200433, People's Republic of China*
[c] *Polymer Research Group, Department of Chemistry, Faculty of Science, University of Tanta, Tanta 31527, Egypt*

Received 13 January 2014; accepted 6 July 2014
Available online 15 July 2014

KEYWORDS

Poly(vinyl alcohol);
Hydrogel membranes;
Polymer blended hydrogels;
Natural polymers;
Synthetic polymers;
Wound dressing

Abstract A series of excellent poly(vinyl alcohol) (PVA)/polymers blend hydrogel were reviewed using different crosslinking types to obtain proper polymeric dressing materials, which have satisfied biocompatibility and sufficient mechanical properties. The importance of biodegradable–biocompatible synthetic polymers such as PVA, natural polymers such as alginate, starch, and chitosan or their derivatives has grown significantly over the last two decades due to their renewable and desirable biological properties. The properties of these polymers for pharmaceutical and biomedical application needs have attracted much attention. Thus, a considered proportion of the population need those polymeric medical applications for drug delivery, wound dressing, artificial cartilage materials, and other medical purposes, where the pressure on alternative polymeric devices in all countries became substantial. The review explores different polymers which have been blended previously in the literature with PVA as wound dressing blended with other polymeric materials, showing the feasibility, property change, and purpose which are behind the blending process with PVA.

* Corresponding author.
E-mail address: badawykamoun@yahoo.com (E.A. Kamoun).

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.arabjc.2014.07.005

Contents

1. Introduction . . . 2
2. Crosslinking of PVA polymer . . . 2
3. Determination of water content in PVA hydrogels . . . 4
4. Blended polymer types with PVA hydrogels for wound dressing . . . 4
4.1. Wound dressings based on PVA/natural polymers . . . 4
4.1.1. PVA/sodium alginate (SA) . . . 4
4.1.2. PVA/dextran (Dex) . . . 6
4.1.3. PVA/starch and hydroxyethyl starch (HES) . . . 6
4.1.4. PVA/glucan . . . 7
4.1.5. PVA/chitosan . . . 7
4.1.6. PVA/chitosan derivatives . . . 8
4.1.7. PVA/gelatin (GE) . . . 9
4.2. Wound dressings based on PVA/synthetic polymers . . . 9
4.2.1. PVA/poly(N-vinylpyrrolidone) (PVP) . . . 9
4.2.2. PVA/poly(N-isopropylacrylamide) (NIPAAm) . . . 10
4.2.3. PVA/polyethylene glycol (PEG) . . . 10
4.3. Wound dressings based on PVA/composite polymers or (blended polymers with nanoparticles) . . . 10
5. Conclusions . . . 11
Acknowledgements . . . 12
References . . . 12

1. Introduction

In 1960s, for over fifty years ago hydrogels have been innovated by Wichterle and Lim (1960) and have been applied in numerous biomedical disciplines e.g. contact lenses, absorbable sutures, osteoporosis, asthma treatment, and as neoplasm (Queiroz et al., 2001). In 1980s, Lim and Sun (1980) have revealed calcium alginate microcapsules for cell engineering, while Yannas' group modified synthetic hydrogels with some natural polymers e.g. collagen to obtain novel dressing materials, showing optimal conditions for healing burns and wound dressing (Yannas, 1985; Yannas et al., 1981, 1983; Yannas and Forbes, 1982). Since this date; polymer hydrogels continue to interest scientists. For example, millions of people are suffering annually from chronic diseases, accidents arising from trauma, burns, and bone fracture or defects and unfortunately some of them are dying due to insufficient ideas of alternative polymeric organs and/or treatment (Pighinelli and Kucharska, 2013). Thus, much attention has been given to the use or modification of different polymeric materials that can be used currently for biomedical devices to fulfill the over increased need for those materials in medical applications.

Every year, millions of people are exposed to burns by hot water, flames, accidents, and boiling oil, and these accidents result in major disabilities or even sometimes death. Especially in adults, and overaged people dermis regeneration cannot occur spontaneously again (Çiğdem and Senel, 2008). Since autologous skin has limited availability and associated with additional scarring, this traditional approach for a substantial loss of dermis cannot meet the requirements, and dressing materials became inevitable for skin tissue or healing (Çiğdem and Senel, 2008). Prior to 1960s, wound dressing materials have been regarded to be only passive materials that have a minimal role in the healing process. Winter (1962) has announced the first generation of wound dressing polymeric materials and showed optimal environments for wound repair. This awareness has revolutionized the approaches to wound dressing and paved the way for the development of wound dressing from the passive to active material and functionalized ones. The desirable wound dressing materials should fulfill the following conditions: (a) maintain a local moist environment, (b) protect the wound from side-infection, (c) absorb the wound fluids and exudates, (d) minimize the wound surface necrosis, (e) prevent the wound dryness, (f) stimulate the growth rate, and (g) be elastic, non-toxic, non-antigenic, biocompatible and biodegradable dressing materials (Jakubiak et al., 2001; Kannon and Garrett, 1995; Kokabi et al., 2007).

At present, PVA is one of the most frequent and the oldest synthetic polymer hydrogels that due to its good biocompatibility has been applied in several advanced biomedical applications e.g. wound dressing (Kenawy et al., 2014), wound management (Zhao et al., 2003), drug delivery systems (Muggli et al., 1998), artificial organs (Yang et al., 2008), and contact lenses (Hyon et al., 1994). However, PVA hydrogel possesses insufficient elastic, stiff membrane, and very limited hydrophilicity characteristics which restrict its use alone as a wound dressing polymeric material. Among the various hydrogels described in the literature, hydrogels prepared using PVA blended with polysaccharides and some other synthetic polymers are attractive because of the abundance of such polymers, easy for chemical derivatization or modification, and in most cases good biocompatibility (Coviello et al., 2007).

2. Crosslinking of PVA polymer

Peppas and Merrill (1977a,b) have revealed in their earliest effort in considering PVA hydrogels as biomaterials. Generally, hydrogels were obtained by a crosslinking process of polymers, which might be done by a chemical reaction (e.g. free-radical polymerization, chemical reaction of complementary groups, using high energy irradiation, or enzymatic reaction) or by a physical reaction (e.g. ionic interaction,