Materials Letters 129 (2014) 61–64

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

Effect of modified cellulose nanocrystals on microstructural and mechanical properties of polyvinyl alcohol/ovalbumin biocomposite scaffolds

Anuj Kumar [a], Yuvraj Singh Negi [a,*], Veena Choudhary [b], Nishi Kant Bhardwaj [c]

[a] Department of Polymer and Process Engineering, Indian Institute of Technology Roorkee, India
[b] Centre for Polymer Science and Engineering, Indian Institute of Technology Delhi, India
[c] Avantha Centre for Industrial Research and Development (ACIRD), Yamuna Nagar, Haryana, India

ARTICLE INFO

Article history:
Received 25 October 2013
Accepted 3 May 2014
Available online 10 May 2014

Keywords:
Ovalbumin
Cellulose nanocrystals
Biomaterials
Microstructure
Freeze drying
Compressive strength

ABSTRACT

In order to improve the functional compatibility and mechanical performance of biocomposite scaffolds, two different biocomposite scaffolds based on ovalbumin (OVA)/polyvinyl alcohol (PVA) reinforced with unmodified and aminated cellulose nanocrystals (CNCs) cross-linked with glutaraldehyde (GA) were fabricated by a freeze drying process. It was observed that the microstructure and mechanical properties of the biocomposite scaffolds were not affected to a great extent by the presence of aminated CNCs. At a compressive strain of 70%, the compressive strengths of PVA/OVA (porosity: ~85%) (a), PVA–CNCs/OVA (porosity: ~87.4%) (b), and PVA–CNCs–NH_2/OVA (porosity: ~87.7%) (c) were 0.08 MPa, 0.21 MPa and 0.26 MPa, respectively.

1. Introduction

For the development of porous polymeric scaffolds, many biomaterials have extensively been studied but ovalbumin (OVA) has not been studied well for reconstruction of organs. Recently, OVA based biocomposite has attracted considerable attention as a substitute for bone tissue engineering [1,2]. The OVA (a glycoprotein found in chicken egg whites) comprises 386 amino acids with 10% of the amino acid sequence conserved when compared with human serum albumin and comprises mainly α-helix and β-sheet structures [3,4]. It can be used to produce biocompatible scaffolds that support in osteoblast adhesion and mineralization into 3D porous structures [5].

Recent studies revealed the application of OVA with hydroxyapatite (HA) [2,6] for bone tissue engineering applications. Also, the properties of OVA based scaffolds [1] and the effect of cellulose nanocrystals (CNCs) on OVA based porous scaffolds [7] were studied for improving mechanical properties to prevent immediate failure upon implantation. Hence, the fabrication of OVA based scaffolds is attempted to improve their properties through the freeze drying method. Among different fabrication techniques used, freeze drying has been a promising technique to fabricate porous structures with controlled porosity such as scaffolds [8,9]. CNCs have remarkable properties (unique strength, low density, biocompatibility, biodegradability and surface properties) which make them ideal reinforcing agents in polymer matrices [10] and mainly serve to increase the mechanical performance of the scaffold. PVA as a biomaterial is used in different biomedical applications [11,12].

In this work, we proposed to fabricate PVA/OVA/(CNCs or CNCs–NH_2) biocomposite scaffolds using the freeze drying method to study the functional compatibility of the cellulose nanocrystals (CNCs or CNCs –NH_2) and OVA–NH_2. PVA was used as a binder into composite solution of OVA and CNCs because it renders the segregation of CNCs in OVA solution and gives nearly homogenous and stable solution. The effect of CNCs and aminated CNCs (creating amino (–NH_2) groups on nanocrystals like OVA) on morphological, structural and mechanical properties was investigated in PVA/OVA based biocomposite scaffolds. This study provides the primary insight if modification of CNCs is necessary or not to fabricate the biocomposite scaffolds which may promisingly be used in bone tissue engineering.

2. Experimental

Materials: Egg albumin (flakes) and PVA (PVA: 85–89% degree of hydrolysis) were supplied by HiMedia Laboratories Pvt. Ltd. and Fisher Scientific, respectively.

* Corresponding author. Tel.: +91 132 2714303.
E-mail address: yuvrajnegi@gmail.com (Y.S. Negi).

http://dx.doi.org/10.1016/j.matlet.2014.05.038
0167-577X/

Preparation of porous biocomposite scaffolds: An aqueous suspension of CNCs was prepared from chemically purified cellulose as previously reported [13]. The surface of the CNCs was chemically modified as described elsewhere [14]. The final concentration of the CNCs and CNCs–NH_2 suspension was made to 1 wt%. OVA solution (5 wt%) was prepared as described elsewhere [1]. 10 g of PVA was prepared in distilled water at 65–75 °C for 3 h. The final solution was prepared in two successive steps: (1) aqueous

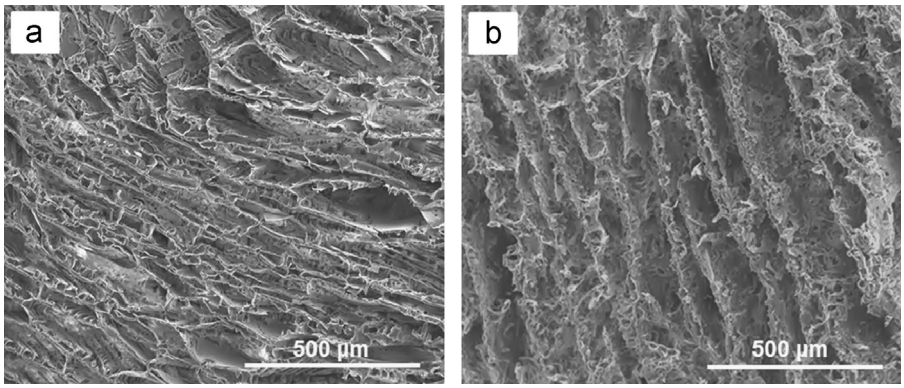

Fig. 1. FE-SEM micrographs of (a) neat PVA scaffold and (b) PVA/OVA biocomposite scaffold.

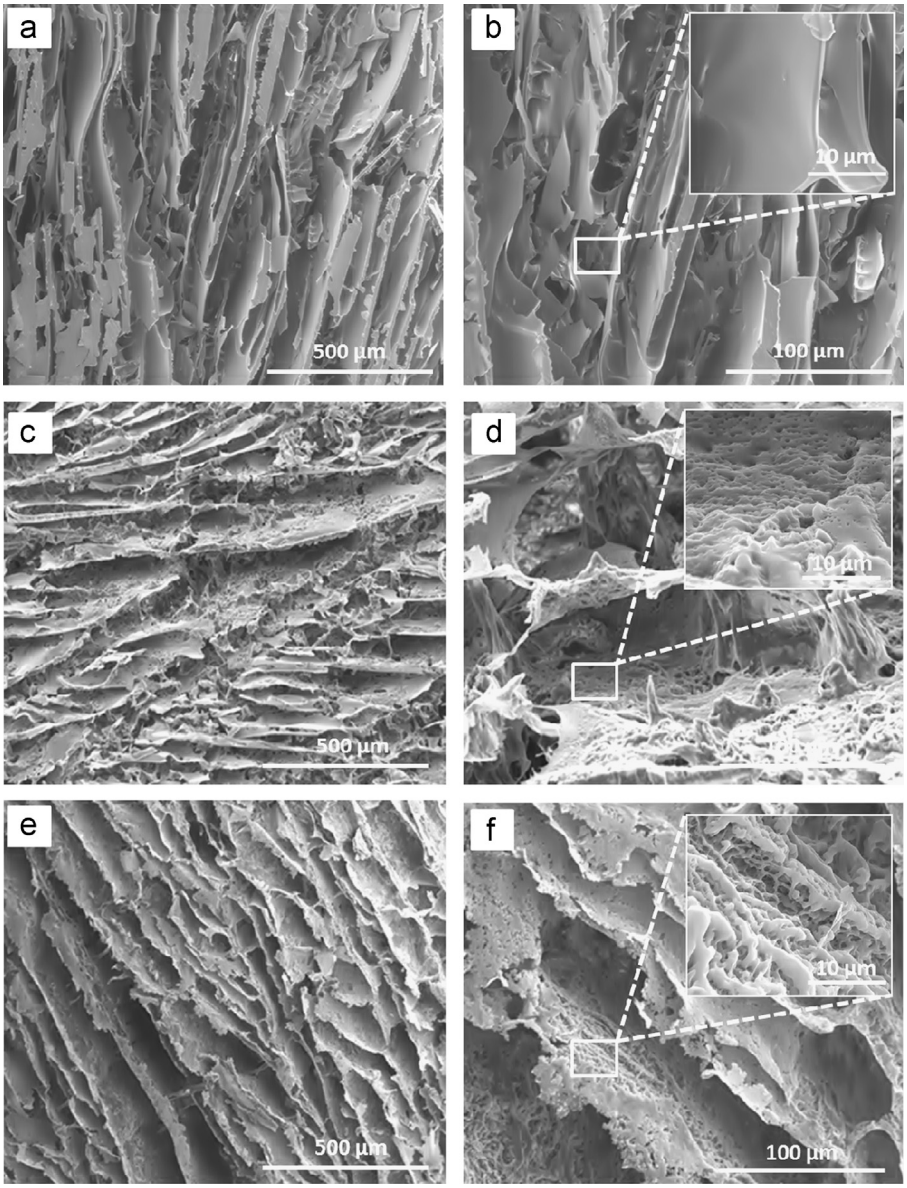

Fig. 2. FE-SEM micrographs of (a,b) OVA, (c,d) PVA–CNCs/OVA, and (e,f) PVA–CNCs–NH_2/OVA biocomposite scaffolds.