Iran Polym J (2014) 23:757–766
DOI 10.1007/s13726-014-0270-7

ORIGINAL PAPER

Preparation of porous PLLA/PCL blend by a combination of PEO phase and NaCl particulate leaching in PLLA/PCL/PEO/NaCl blend

Peyman Ezzati · Ismaeil Ghasemi · Mohammad Karrabi · Hamed Azizi · Ivan Fortelny

Received: 26 November 2013 / Accepted: 2 August 2014 / Published online: 22 August 2014

Abstract In this study, the ternary blends containing microporosity based on poly(L-lactic acid) (PLLA), poly(ε-caprolactone) (PCL) and polyethylene oxide (PEO) were prepared using an internal mixer via a polymer leaching technique. The particulate leaching is the most widely used technique to create porosity. To introduce macroporosity besides micropores, NaCl particulates were incorporated into the ternary blends at 40–80 wt % and macropores were formed by particulate leaching. Samples porosity were evaluated by calculating the ratio of porous scaffold density (ρ^*) to the non-porous material density (ρ_s). The results showed that with an increase in NaCl particulate content, the amount of porosity increased and the distribution of pore size was gradually transformed from monomodal into bimodal form. The porosity plays a key role in governing the compression properties. Mechanical properties are presented by Gibson–Ashby model. Compressive modulus decreased with an increase in NaCl particulate concentration due to the increase in porosity and thinning of pore wall that caused rupture at these weaker spots. Blending and forming of the bio-scaffold can be made using conventional polymer processing equipment. This process seems promising for a large-scale production of porous bio-scaffold of many sizes through an economic method.

P. Ezzati · I. Ghasemi (✉) · M. Karrabi · H. Azizi
Processing Faculty, Iran Polymer and Petrochemical Institute,
PO Box 14965/115, Tehran, Iran
e-mail: i.ghasemi@ippi.ac.ir

I. Fortelny
Institute of Macromolecular Chemistry AS CR,
Heyrovsky Sq. 2,162 06, Prague 6, Czech Republic

Keywords PLLA/PCL/PEO ternary blend · Bio-scaffold · Melts blending · Morphology · Compressive modulus · Porosity

Introduction

Porous materials with biocompatible and biodegradable polymers or their blends have found extensive use in tissue engineering and bio-scaffolds. An ideal scaffold [1, 2] in tissue engineering should have a highly porous structure with extensive interconnected pores and a high porosity content since the porosity and pore size are key factors to the scaffold's performance. For instance, adequate porosity promotes vascularization and encourages angiogenesis [3]. The ability to eliminate the degradation of scaffold will largely depend on the scaffold fabrication and the design will determine its structure, porosity and interface with the cells and surrounding materials [4, 5].

While intensive efforts have been made on developing processing techniques for polymer scaffolds, less attention has been paid on the fabrication and design of porous polymer scaffolds [6, 7]. Among a variety of polymer processing techniques, several methods have been used to incorporate polymers into porous materials suitable for tissue engineering applications, including solvent casting, phase separation, particulate leaching, fiber bonding, melt blending, gas foaming, solution casting and thermal-induced phase separation methods [4]. Majority of these techniques require the use of organic solvents where the residual solvent after processing may damage transplanted cells and tissues [8]. Additionally, some of them reduce the porosity content in bio-scaffolds.

To circumvent this problem, several researchers have proposed melt blending of bio-polymers. However, the