Materials Letters 189 (2017) 180–183

Contents lists available at ScienceDirect

Materials Letters

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

Preparation and properties of poly(lactic acid) fiber melt blown non-woven disordered mats

Jianyong Feng

College of Materials and Textiles, Zhejiang Sci-Tech University, Hangzhou, Zhejiang 310018, China

ARTICLE INFO

Article history:
Received 9 March 2016
Received in revised form
6 November 2016
Accepted 3 December 2016
Available online 6 December 2016

Keywords:
Disordered mats
Melt blown non-woven
Poly(lactic acid) fiber
Polymers

ABSTRACT

Non-woven fabric with porous structures and good mechanical properties can be widely used in tissue engineering. To achieve superior properties, poly(lactic acid) (PLA) melt blown non-woven disordered mats (MBNDM) at different die-to-collector distances (DCD) were prepared and was conducted to study the effect of DCD on surface and internal morphology, fiber diameter, alignment degree, apparent contact angle, pore diameter, porosity and stress-strain. It can be found that fiber diameter, pore diameter, porosity, stress and strain along length direction decrease while alignment degree and apparent contact angle have no obvious change as the increasing of DCD. By control of DCD, the structure and properties of MBNDM can be regulated and optimized. PLA melt blown non-woven fabric prepared at 75 mm DCD has better properties of larger pore diameter, porosity and stress potentially suitable for cell culture studies.

1. Introduction

Non-woven fabric with porous structure can be widely applied in tissue engineering [1,2]. Melt blow spinning is a one-step process for producing polymers into microfiber non-woven fabric, in which the polymers are extruded from the die by screw extruder and then stretched by high velocity hot air-jet [3]. Due to turbulent air flow in the process of airflow, the fibers are entangled in a random overlaid arrangement and then formed non-woven fabrics with disordered fiber arrangement. These non-woven fabrics can be applied in filtration, medical science, oil adsorbent and thermal insulation [4]. As for MBNDM, there are many factors that affect fiber diameter, i.e. polymer flow rate and temperature, air velocity and temperature, angle between slot and spinneret axis, die head width and slot width [5].

PLA derived from renewable energy sources is a kind of degradable and biocompatible polymer, which can be applied in implants, scaffolds and sutures [6]. PLA non-woven fabrics can be prepared from polymers and fibers. Liu et al. [7] used PLA resin to prepare MBNDM and research filtration properties. Puchalski et al. [8] prepared PLA spun-bonded non-woven fabric at different calendar temperatures. Sztajnowski et al. [9] produced PLA spun-bonded non-woven to study the agricultural application. Bhat et al. [10] adopted PLA stapled-fibers to prepare non-woven fabric by means of carding and thermal bonding. In this paper, we prepared PLA MBNDM at different DCD for agricultural applications. We studied the effect of DCD on surface and internal morphology, fiber diameter, alignment degree, apparent contact angle, pore diameter, porosity and stress-strain.

2. Experiment

2.1. Preparation of MBNDM

The PLA (poly(L-lactic acid) type) pellets which had 170 kDa weight-average molecular weight (M_W) was provided by Nantong Jiuding biological engineering Co., Ltd. (Rugao, China). Before melt spinning, PLA pellets need to be dried at 60 °C for 4 h via a dessicator to remove excess water. The SJ-30/28 single screw plastic extruder manufactured by Shanghai Yabao Plastic Equipment Co., LTD. was used to extrude fiber. The proportion of length (L) and diameter (D) of screw was L/D=28:1. The screw speed was 5.65 rpm, spinneret diameter was 0.02 mm, spinning die temperature was 250 °C, hot air temperature was 320 °C, and hot air pressure was 0.3 MPa. Rotation and traverse speed of collector (60 cm diameter) were 21.0 rpm and 38.8 cm/min, respectively. In the case of other same preparation conditions, the DCD was controlled to 75 mm, 100 mm and 200 mm, respectively (Fig. 1). The specific gravity of PLA MBNDM measured by BS 224S electronic balance, manufactured by Dolly scientific instrument Co., Ltd. (Beijing, China) was $0.014 \pm 0.0002 g/cm^2$ (mean value ± standard derivation), $0.009 \pm 0.0015 g/cm^2$, and $0.01394 \pm 0.0008 g/cm^2$, respectively.

E-mail address: mydream1109@163.com

http://dx.doi.org/10.1016/j.matlet.2016.12.013
0167-577X/

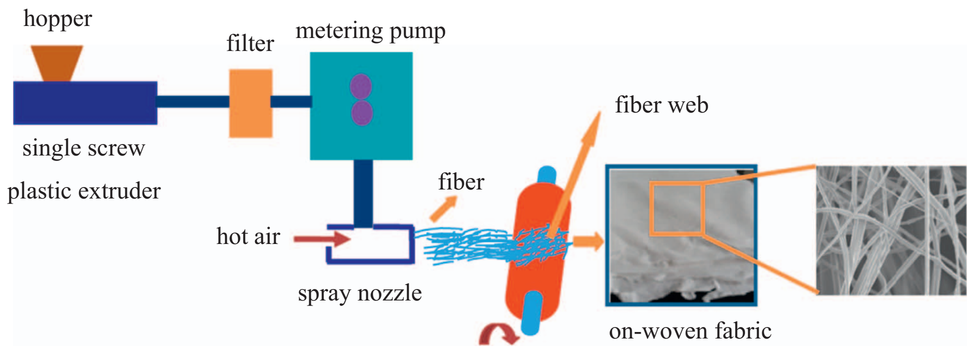

Fig. 1. Schematic of melt blown device used to prepare PLA MBNDM.

2.2. Properties testing and characterization

The glass transition temperature (T_g) and melting point (T_m) were measured by Q20 differential scanning calorimetry (DSC), manufactured by TA Instruments (USA) with 40–220 °C temperature range at a rate of 10 °C/min.

Samples were gold sputter coated using a ETD-2000 twice, for 50 s. Then S-4800 scanning electron microscope (SEM, Hitachi) was used to observe surface morphology. To observe cross-sectional morphology, samples needed to be frozen in liquid nitrogen about 3 min and cut by a blade along longitudinal direction.

Fiber diameter was measured by Image J software (National Institutes of Health, USA) [11] from surface SEM ($N=10$). Image J software was also applied to measure the distance between two adjacent fibers, which could be considered as the pore diameter ($N=50$). The value of alignment degree could be measured by Image J software from SEM images ($N=50$). Before the experiment, it was necessary to draw a straight line which parallel to x

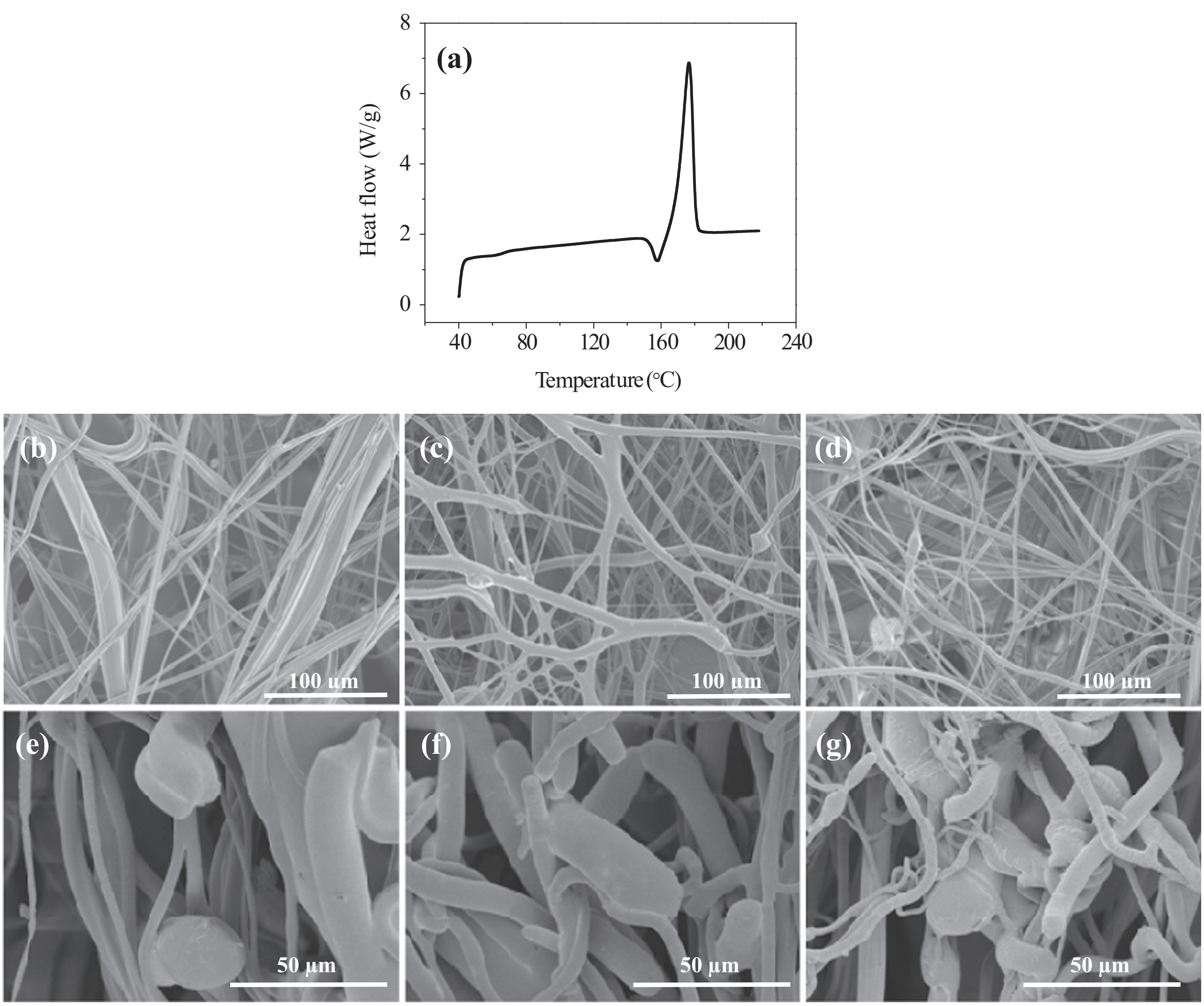

Fig. 2. (a) DSC curve of PLA pellets, and SEM of PLA MBNDM at DCD of 75 mm (b) and (e), 100 mm (c) and (f), 200 mm (d) and (g).