Pertanika J. Sci. & Technol. 31 (5): 2441 - 2451 (2023)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Effects of UV Irradation on Electrospun PLLA and PAN in the Production of Short Electropun Fibres Using Ultrasonication Method

Marini Sawawi*, Cheryl Rinnai Raja, Shirley Jonathan Tanjung, Sinin Hamdan, Siti Kudnie Sahari, Rohana Sapawi, Ervina Junaidi, Mahshuri Yusof and Noor Hisyam Noor Mohamed

Faculty of Engineering Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia

ABSTRACT

This work showed that exposure of ductile electrospun polymers, namely poly-*L*-Lactide acid (PLLA) and polyacrylonitrile (PAN) to UV-Ozone, leads to the embrittlement of fibres. Young's modulus for PLLA and PAN increased by 39% and 78%, respectively. Meanwhile, the ductility was reduced by 23% for PLLA and 40% for PAN. The SEM images show that the UV irradiation resulted in a surface pitted of PLLA and no changes in PAN surface morphology. The ATR-FTIR results indicate that this treatment did not change the chemical structure of the electrospun PLLA and PAN fibres. The as-spun polymers that failed to be scission directly using ultrasonication can now be fragmented into micron-length short fibres after the UV irradiation treatment. The minimum time to produce the short fibres is 18 mins for PAN and 29 mins for PLLA. It indicates ultrasonication is suitable for producing short electrospun fibres, even for ductile materials.

Keywords: Electrospun fibres, short fibres, ultrasonication

ARTICLE INFO

Article history:
Received: 29 August 2022
Accepted: 06 December 2022
Published: 21 July 2023

DOI: https://doi.org/10.47836/pjst.31.5.21

E-mail addresses:
smarini@unimas.my (Marini Sawawi)
cheryl.raja@gmail.com (Cheryl Rinnai Raja)
jtshirley@unimas.my (Shirley Jonathan Tanjung)
hsinin@unimas.my (Sinin Hamdan)
sskudnie@unimas.my (Siti Kudnie Sahari)
srohana@unimas.my (Rohana Sapawi)
jervina@unimas.my (Ervina Junaidi)
ymashun@unimas.my (Mahshuri Yusof)
nmnhisyam@unimas.my (Noor Hisyam Noor Mohamed)
*Corresponding author

ISSN: 0128-7680
e-ISSN: 2231-8526

© Universiti Putra Malaysia Press

INTRODUCTION

Electrospinning is a technique that employs electrical charge and polymer solutions to generate tiny filaments. In comparison to other conventional approaches such as drawing, template synthesis, phase separation, and self-assembly, this method has since been recognised as a quick and straightforward technique for producing continuous sub-micron to nano-sized fibres (Huang et al., 2003; Ramakrishna et al., 2005). Natural polymers, synthetic polymers, polymer solutions, polymer melts, and biopolymers have all been employed to make fibre materials. Flexibility is one of the appealing characteristics of electrospinning. By adjusting the processing parameters, the morphology of the fibres can be easily altered with this technology, allowing the manufacture of solid, porous, and core-shell fibres (Bazilevsky et al., 2007; Sun et al., 2003).

Briefly, the electrospinning method uses the positive electric field to induce changes in the polymer solution, and once this charge build-up exceeds that of the surface tension, a Taylor cone is formed (He et al., 2008). A polymer jet erupts from the cone tip at this critical voltage, accelerating through the electric field towards the collector. The solvent evaporates as the jet travels towards the collector, and a solidified polymer fibre is collected. The electrospun fibres produced from this method have a wide range of applications, including tissue engineering, sensors, and composite reinforcement (Bhardwaj & Kundu, 2010; Huang et al., 2003; Li et al., 2019; Nakielski et al., 2022; Niemczyk-Soczynska et al., 2021; Ramakrishna et al., 2005; Zakrzewska et al., 2022).

There is little research on making individual, short nanofibres from commonly electrospun membranes. It would be useful to separate an electrospun membrane into distinct, short nanofibres because this would result in a method for making large amounts of these fibres. Short fibres are excellent for biomedical applications as injectable fibrous scaffolds for tissue engineering or drug-containment channels (Nakielski et al., 2022). Short electrospun fibres are produced quickly (in a few seconds to a few minutes) using ultrasonication (Niemczyk-Soczynska et al., 2021; Sawawi et al., 2013). Most laboratories utilise ultrasonic probes, which operate at a frequency of 20 kHz, for tasks including cleaning and mixing (Watmough, 1994). Bubbles in the fluid medium expand and contract during sonication, releasing energy as they do so. These bubbles begin with a diameter of approximately 1 µm and increase to approximately 50 µm under negative pressure (Suslick, 1988). The bubble expands under these sonication settings in 20 microseconds and collapses in nanoseconds. This technique has been used to help carbon nanotubes disperse in a solvent (Rennhofer & Zanghellini, 2021) and cause carbon nanotube scission (Hennrich et al., 2007).

There are varied degrees of success with several approaches to reinforced composite using the shortened, non-woven electrospun membrane. Mortar grinding (Deniz et al., 2011; Sancaktar & Aussawasathien, 2009) is a straightforward but unpredictable technique that is proven to work well for brittle electrospun membranes like carbonised polyacrylonitrile (Sancaktar & Aussawasathien, 2009). Better choices for scissioning electrospun membranes include rubber milling (Kim & Reneker, 1999) and cryogenic milling (Verreck et al., 2003), where the impactor of cycle and rate can be precisely regulated. Comparing the methods is challenging because the features of the resulting short fibres were not always accurately described. Short magnetic composite fibres such as methyl methacrylate-vinyl acetate