Journal of Photochemistry and Photobiology A: Chemistry 353 (2018) 101–107

Contents lists available at ScienceDirect

Journal of Photochemistry and Photobiology A: Chemistry

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

Invited paper

From small molecules to polymer fibers: Photopolymerization with electrospinning on the fly

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ARTICLE INFO

Article history:
Received 20 September 2017
Received in revised form 31 October 2017
Accepted 1 November 2017
Available online 10 November 2017

Keywords:
Electrospinning
Photopolymerization
Fibers

ABSTRACT

The electrospun fibers were manufactured from multifunctional small molecules through in-situ photopolymerization during the electrospinning process. In this study, Tetrabutylammonium Bromide (TBAB) was added to enhance the conductivity of the solution in order to improve spinnability. The synchronous matching of photopolymerization and electrospinning was investigated by real-time Infrared Spectroscopy (RTIR). The surface morphology of fibers was studied by SEM, and the chemical structure of fibers was characterized by FTIR. The residual of photoinitiator was investigated using UV–vis absorption spectroscopy, and the solvent resistance of fibers was characterized by soaking in different solvents. It provides an approach to prepare electrospun fibers from small molecules without using any solvents or heat.

1. Introduction

Electrospinning, a fascinating fiber fabrication technique has drawn significant attention in recent decades. The fibers possess high specific surface areas and high porosities, which make them very useful in a broad range of applications such as biomaterials [1], filter materials [2], and sensing materials [3]. Generally, electrospinning is of two types: melt and solution electrospinning. Melt electrospinning which requires high viscosity, high heating temperature, and more complicated equipment is incapable to obtain nanoscale fibers that limits its scope of application [4]. For solution electrospinning, the organic solvents used in solution are generally toxic to environment and always tough to recovery [5]. The common ground of these two electrospinning methods is that both are based on macromolecules or polymers, which are commonly used in the traditional electrospinning process. But in order to be electrospun into fibers, high molecular weight, high viscosity, and good flexibility are required for macromolecules or polymers. It is supposed that whether small molecules could be fabricated fibers via integrating electrospinning and other techniques without using any solvents or heat.

Photopolymerization is an emerging and rapidly developing technology. It is the rapid formation process of cross-linked macromolecules or polymers from small molecules under the ultraviolet radiation within several seconds. The most striking features of photopolymerization are rapid polymerization rate in air, high chemical stability, solvent-free, and can be conducted at ambient conditions [6,7]. The principle of this technology is based on the photoinitiator absorbing suitable UV light to convert small molecules into macromolecules or polymers via cross-linked networks [8].

Notably, the integration of electrospinning and photopolymerization has gained much attention in recent years. In most cases, photopolymerization is employed to design cross-linked fibers that possess high performance or special structure, which is limited to macromolecules or polymers [9–11]. In some studies, UV-activated thiol-ene photopolymerization during the electrospinning process is reported [12–15]. Thiol-ene photopolymerization is not significantly sensitive to oxygen compared to traditional acrylic photopolymerization [16]. But the thiol compounds smell unpleasant, the price is higher, and the polymerization products have a short storage period. However, there are relatively few studies devoted to fabricate fibers from small molecules through

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https://doi.org/10.1016/j.jphotochem.2017.11.011
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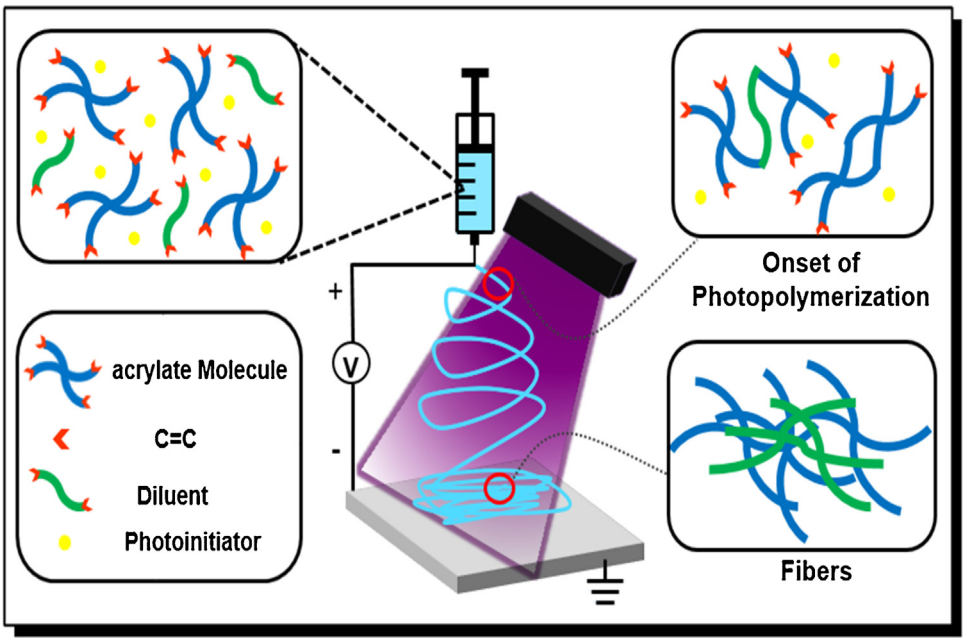

Scheme 1. Schematic illustrating the synchronous matching process of photopolymerization and electrospinning.

photopolymerization with electrospinning on the fly. Most recently, Long et al. reported an ultrathin colorful fibers made by solvent-free electrospinning assisted with UV-crosslinking, which was based on oligomers with lower viscosity and functionality [17,18].

In this study, we combine the advantages of photopolymerization and electrospinning techniques, fabricating fibers from small molecules with high functionality and viscosity. More importantly, the photopolymerization kinetics of small molecules was systematically studied by real-time Infrared Spectroscopy, and the mechanism of synchronous matching of photopolymerization and electrospinning was proposed. The chemical structure, morphology, and solvent resistance of fibers were studied. It

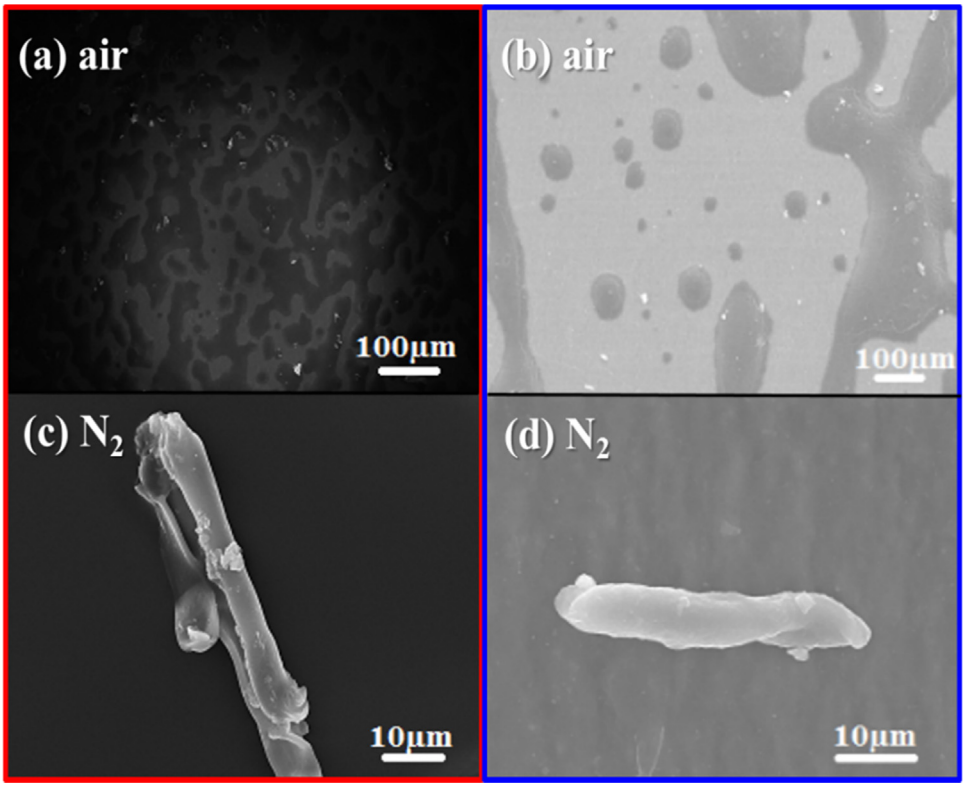

Fig. 1. SEM images of (a), (c) CN293 (5 wt% HDDA) and (b), (d) 6008 (30 wt% HDDA).