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Cellulose acetate/gelatin nanofibers fabricated by solution blow spinning

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Abstract

Solution blow spinning (SBS) is especially suited to fabricate nanofibers from a variety of materials. In this study, we employ SBS to produce nanofibers from cellulose acetate (CA) and CA/gelatin at different concentrations and feed rates. The successful fabrication was possible by optimizing the rheological properties of the solutions. The nanofibers are homogenous according to scanning electron microscopy (SEM) images, and the CA/gelatin combination can now be exploited in biomedical applications.
Keywords: nanofiber; solution blow spinning; cellulose acetate; gelatin.

Introduction

The use of nanofibers in biomedical applications has been grown to exploit their high area-to-volume ratio [1]. The techniques used to produce nanofibers include electrospinning and solution blow spinning (SBS). The latter is advantageous because it does not require electric fields and has a higher productivity [2,3]. SBS can be employed for a variety of materials. Of interest in the present work are cellulose acetate (CA) and gelation. CA is a biocompatible, biodegradable polysaccharide, largely used in medical applications [4]. Gelatin is obtained from denaturing of collagen type I, a protein found in human body which is also biocompatible and biodegradable [5]. The combination of these two materials has been reported [6], and they form a suitable environment for biological activity. Nanofibers from CA [7,8] and gelatin [9-11] have been produced with SBS, but the possibility to fabricate CA/gelatin has not been investigated. In this study, we evaluated rheological properties of CA/gelatin solutions and fabricated CA/gelatin fibers using SBS.

Experimental Procedure

CA (50.000 g/mol - Sigma-Aldrich)/poly (oxide ethylene) PEO (400.000 g/mol - Sigma-Aldrich) solutions were prepared using a mixture of formic acid and acetic acid as solvents (2:1). PEO is used as an easy-to-spin polymer. Solutions were stirred for 20 h at room temperature. Gelatin type B (Bloom 75 g – Sigma-Aldrich) was solubilized in formic acid/acetic acid (2:1) for 5 min. CA and Gelatin solution were mixed and stirred for 10 min. Rheological measurements were carried out using a rotational rheometer (MCR 301, Anton Paar GmbH, Austria) operating at 25 ºC varying shear rate from 1 to 1000 1/s. Solutions were placed in the SBS apparatus and the process was carried out using different feed rates. The morphology of nanofibers was analyzed with a scanning electron microscope (DSM960, Calrs Zeiss, Germany), under an acceleration voltage of 10 kV and a working distance of 10 mm. The nanofiber samples were covered with a thin gold layer, using a metallizer (SCD 050, Balzers, Germany).

Results and Discussion

The ability to form nanofibers of a given material using SBS depends on the solution viscosity. As demonstrated by Oliveira et al. [12], polymer solution of poly(D, L-lactic acid) with low viscosity formed fibers containing small beads. However, as the viscosity increases, the beads become less frequent and the fibers are smoother and more uniform. Higher viscosity values might also change fibers morphology. Figure 1 shows CA solution regimes when the shear rate reaches 100 1/s. Thus, the most suitable solutions to fabricate fibers are those with intermediate polymer mass concentrations (Figure 1 b) varying from 6 to 10 wt. % CA.

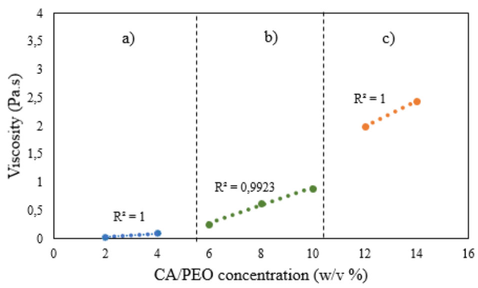


Figure 1 – Viscosity curve as a function of CA/PEO w/v % concentration at a shear rate of 100 1/s. Curve divided in three regions: a) dilute regime; b) semi dilute regime; c) concentrated regime.

Figure 2 shows the viscosity behavior for CA/gelatin solutions as the shear rate increases for 7, 8, 9, 10 w/v % and the CA/gelatin ratio varies from 100/0 to 50/50. As the amount of gelatin increases, the viscosity decreases owing to the lower entanglement of gelatin chains with PEO and CA. This is caused by the differences in molar mass - gelatin (20,000 to 25,000 g/mol) and CA (50,000 g/mol). There is an exception in 9 and 10 w/v % curves where 100/0 has a smaller viscosity than 90/10. The latter finding will have to be investigated further.

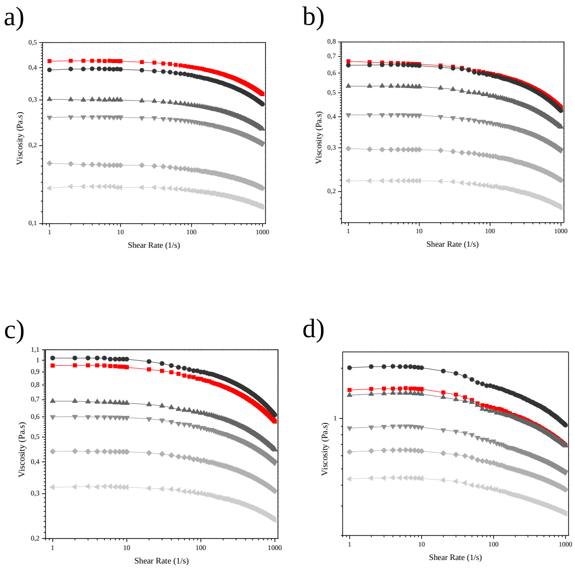
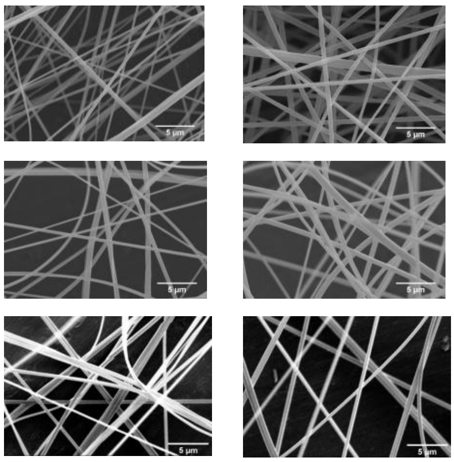


Figure 2 – Viscosity curves as a function of shear rate of CA/Gelatin solutions a) 7; b) 8; c) 9; d) 10 mass/volume %. Solution mass ratios are identified by colors: 100/0, 90/10, 80/20, 70/30, 60/40, 50/50.

Figure 3 shows SEM images from 8 and 9 w/v % nanofibers for two CA/gelatin mass ratios. Homogeneous and randomly packed fibers are shown for both feed rates (3 ml/h and 13 ml/h). The sample 8 w/v % - 60/40 CA/gelatin at higher feed rate (close to 13 ml/h) was chosen as the best option for further analysis.



9 w/v %

- 60/40

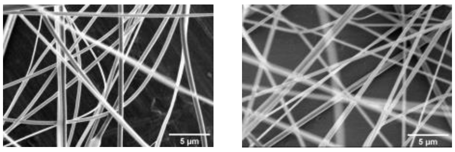


Figure 3 – SEM images for 5,000x magnification of CA/gelatin fibers fabricated by SBS using 8 and 9 w/v % at a mass ratio of 100/0 and 60/40 with a feed rate of 3 and 13 ml/h.

Conclusions

CA/gelatin nanofibers were fabricated using SBS in different solutions concentrations and feed rates. The concentrations for successful fabrication were chosen on the basis of rheological analyses, since solution viscosity plays an important role. It was chosen 8 w/v % - 60/40 CA/gelatin sample as the best option for further studies. The fibers were homogeneous and apparently defect-less.

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References

[1] Kenry et al. "Nanofiber technology: current status and emerging development", Progress in Polymer Science, v. 70, 2017.
[2] J. Daristotle et al., "Review of the Fundamental Principles and Applications of Solution Blow Spinning", ACS Applied Polymers &Interfaces, v. 8, n. 51, 2016.
[3] Y. Gao et al., "Recent progress and challenges in solution blow spinning", Materials Horizons, v. 8, n. 2, 2021.
[4] M. Wsoo et al. "A review on the properties of electrospun cellulose acetate and its application in drug delivery systems: A new perspective", Carbohydrate Research, v. 491, 2020.
[5] A. Bello et al., "Engineering and Functionalization of Gelatin Biomaterials : From Cell Culture to Medical Applications", Tissue Engineering Part B: Reviews, v. 26, n. 2, p. 164-180, 2020.
[6] H. Samadian et al, "Electrospun cellulose acetate/gelatin nanofibrous wound dressing containing berberine for diabetic foot ulcer healing: in vitro and in vivo studies", Scientific Reports, v. 10, n.1, 2020.
[7] G. Dadol et al, "Solution blow spinning–polyacrylonitrile–assisted cellulose acetate nanofiber membrane", Nanotechnology, v. 31, n. 34, 2020.
[8] P. I. C. Claro et al., "Ionic Conductive Cellulose Mats by Solution Blow Spinning as Substrate and a Dielectric Interstate Layer for Flexible Electronics", ACS Applied Materials and Interfaces, v. 13, n. 22, 2021.
[9] F. Liu et al., "Preparation of fish skin gelatin-based nanofibers incorporating cinnamaldehyde by solution blow spinning", International Journal of Molecular Sciences, v. 19, n. 2, 2018.
[10] F. Liu et al., "Solution Blow Spinning of Food-Grade Gelatin Nanofibers", Journal of Food Science, v. 82, n. 6, 2017.
[11] R. D. Greenhalgh et al., "Hybrid sol–gel inorganic/gelatin porous fibres via solution blow spinning", Journal of Materials Science, v. 52, n. 15, p. 9066–9081, 2017.
[12] J. E. Oliveira et al., "Nano and submicrometric fibers of poly(D,L-lactide) obtained by solution blow spinning: Process and solution variables", Journal of Applied Polymer Science, v. 122, n. 5, 2011.