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The effect of process and solution parameters on the size of nanofibers produced by the electrospinning method

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ABSTRACT

Today, electrospinning is one of the most preferred methods to create nanofiber surfaces. There are many environmental, process, and solution parameters that affect the morphology and size of nanofibers produced by the electrospinning method. It is of great importance to know the effects of these parameters on the nanofiber size. In this study, scientific literature examining the effect of process and solution parameters on the size of nanofibers produced by the electrospinning method and their results were included.

Introduction

The electrospinning method is one of the leading methods used for nanofiber production from polymer, ceramic or metallic solutions. With the electrospinning method, it is possible to produce various materials consisting of nanofibers with diameters ranging from a few microns to less than 100 nm [1]. Nanofibers produced by the electrospinning method are used in filtration, biomedical, drug release, defense industry, space, electrical and optical applications.

Changes in the size of nanofibers alter their mechanical, electrical, optical, and thermal properties. For this reason, the parameters affecting the size of nanofibers should be known and kept under control. In this study, the effects of process and solution parameters on the size of nanofibers were investigated.

Nanofiber production by electrospinning method

The process steps of the electrospinning method were shown schematically in Fig. 1 [2]. The electrospinning method has four basic components: a metal collector, high voltage power supply, syringe pump and syringe. In this method, the solution is first taken into syringes and placed in the syringe pump. The pump is operated by adjusting the desired spray speed. Then the high voltage supply is turned on. When the high voltage applied between the metal collector and the syringe pump reaches the critical value, the solution that comes to the tip of the syringe and remains as a suspended droplet moves towards the collector in jet form and electrically charged. The droplet suspended at the tip of the syringe during movement forms a shape called a Taylor cone just before the voltage reaches a critical value. The resulting Taylor cone cannot resist the electrical force and the jet shoots from the cone-shaped droplet towards the collector. Due to the electrostatic repulsive forces, a curling motion is observed in the jet emerging from the tip of the syringe. Then, the thinned jet with the curling motion and the evaporation of the solvent in the jet accumulates on the collector as nano-sized randomly fibers [3].

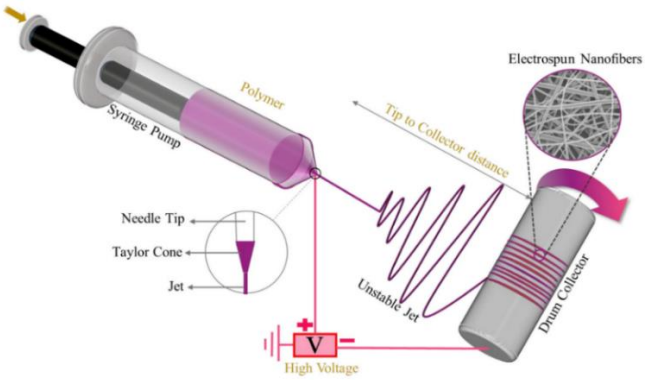

Fig. 1. Schematic representation of the electrospinning method [2]

The effect of process and solution parameters on the size of nanofibers

Electrospinning process is affected by many parameters, including solution, process and environmental parameters. While the solution includes parameters such as conductivity and concentration; The process includes parameters such as applied electric field, needle-to-collector distance, feed rate. These parameters, which significantly affect the size of the fibers obtained as a result of the electrospinning process, were given in Table 1. The results of the change in nanofiber diameter depending on the voltage obtained in the study conducted by Hussein et al. were shown in Fig. 2.

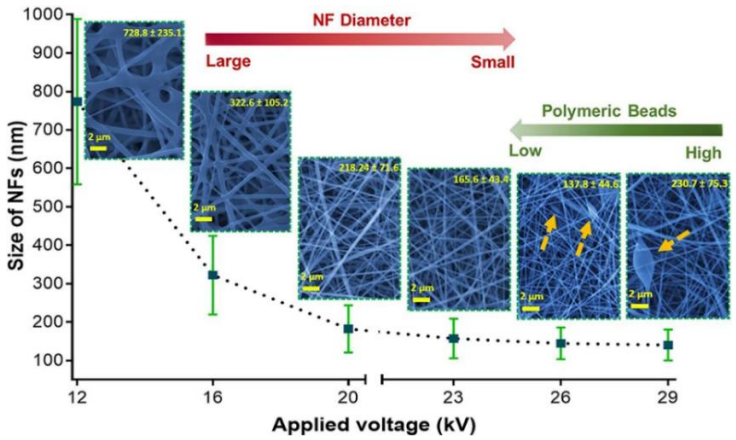

Fig. 2. The dependence of the nanofiber diameter and uniformity on the applied electrospinning voltage [4]

Table 1. Effects of electrospin parameters on fiber size

Parameter	Effect on fiber size	Reference
Solution conductivity	Fiber diameters decrease with increasing conductivity	[5-6]
Solution concentration	As the concentration increases, the fiber diameter increases and the bead formation decreases	[7-10]
Voltage	As the voltage increases, the fiber diameter decreases	[4,11-14]
Distance between needle tip and collector	As the distance increases, the fiber diameter decreases	[11,14]
Feed rate	As the feed rate increases, the fiber diameter increases	[7,9,13,14]

Conclusion

In this study, the effect of process and solution parameters on the size of nanofibers produced by electrospinning method was investigated. In studies examining the effects of solution parameters, it was concluded that fiber diameters decreased with increasing solution conductivity, while fiber diameters increased with increasing solution concentration. In studies examining the effects of process parameters, fiber diameters decreased with increasing voltage and distance between needle tip and collector; it was found that the fiber diameter increased with the increase of the feed rate.

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Author contributions:

Alper Gunoz: Conceptualization, Investigation, Methodology, Writing-Original draft preparation. **Yusuf Kepir:** Investigation, Visualization, Writing-Original draft preparation. **Bünyamin Demir:** Conceptualization, Visualization, Writing-Reviewing and Editing. **Memduh Kara:** Conceptualization, Methodology, Writing-Reviewing and Editing. **Uzay Gezer:** Investigation, Writing-Original draft preparation.

Conflicts of interest:

The authors declare no conflicts of interest.

References

[1] Dinç, H. (2013). Polyvinyl borate synthesis; preparation of nanofiber by electrospinning technique and characterization of the prepared nanofiber. Master's Thesis, Selçuk University, Konya.
[2] Salehi, M., Sharafoddinzadeh, D., Mokhtari, F., Esfandarani, M. S., & Karami, S. (2021). Electrospun nanofibers for efficient adsorption of heavy metals from water and wastewater. Clean Technologies and Recycling, 1(1), 1-33.
[3] Arıcı, A. (2018). Investigation of the effect of MWCNT diameter and length on properties of polymer/MWCNT nanofiber prepared by electrospinning method. Master's Thesis, Necmettin Erbakan University, Konya.
[4] Hussein, M. A. M., Ulag, S., Dena, A. S. A., Sahin, A., Grinholc, M., Gunduz, O., ... & Megahed, M. (2021). Chitosan/Gold Hybrid Nanoparticles Enriched Electrospun PVA Nanofibrous Mats for the Topical Delivery of Punica granatum L. Extract: Synthesis, Characterization, Biocompatibility and Antibacterial Properties. International Journal of Nanomedicine, 16, 5133.
[5] Meyva-Zeybek, Y., & Kaynak, C. (2021). Electrospinning of PLA and PLA/POSS nanofibers: Use of Taguchi optimization for process parameters. Journal of Applied Polymer Science, 138(3), 49685.
[6] Ponrasu, T., Chen, B. H., Chou, T. H., Wu, J. J., & Cheng, Y. S. (2021). Fast dissolving electrospun nanofibers fabricated from jelly fig polysaccharide/pullulan for drug delivery applications. Polymers, 13(2), 241.
[7] Abdillah, U., Yazid, H., Ahmad, S., Makhtar, N., Zaubidah, S., Chen, R. S., & Syafiqaz, N. (2021, March). The effect of various electrospinning parameter on preparation of alumina nanofibers. In IOP Conference Series: Materials Science and Engineering (Vol. 1106, No. 1, p. 012019). IOP Publishing.
[8] Al-Dhahebi, A. M., Saheed, M. S. M., & Mustapha, M. (2021). Effects of solution concentration on the synthesis of polyvinylidene fluoride (PVDF) electrospun nanofibers. Materials Today: Proceedings.
[9] Kim, W. T., Park, D. C., Yang, W. H., Cho, C. H., & Choi, W. Y. (2021). Effects of Electrospinning Parameters on the Microstructure of PVP/TiO2 Nanofibers. Nanomaterials, 11(6), 1616.
[10] Devadas, S., Al-Ajrash, S. M. N., Klosterman, D. A., Crosson, K. M., Crosson, G. S., & Vasquez, E. S. (2021). Fabrication and Characterization of Electrospun Poly (acrylonitrile-co-Methyl Acrylate)/Lignin Nanofibers: Effects of Lignin Type and Total Polymer Concentration. Polymers, 13(7), 992.
[11] Fatahian, R., Mirjalili, M., Khajavi, R., Rahimi, M. K., & Nasirizadeh, N. (2021). Effect of electrospinning parameters on production of polyvinyl alcohol/polylactic acid nanofiber using a mutual solvent. Polymers and Polymer Composites, 09673911211027126.
[12] Topuz, F., & Uyar, T. (2020). Electrospinning of cyclodextrin nanofibers: The effect of process parameters. Journal of Nanomaterials, 2020.
[13] Topuz, F., Abdulhamid, M. A., Holtzl, T., & Szekely, G. (2021). Nanofiber engineering of microporous polyimides through electrospinning: Influence of electrospinning parameters and salt addition. Materials & Design, 198, 109280.
[14] Ziyadi, H., Baghali, M., Bagherianfar, M., Mehrali, F., & Faridi-Majidi, R. (2021). An investigation of factors affecting the electrospinning of poly (vinyl alcohol)/kefiran composite nanofibers. Advanced Composites and Hybrid Materials, 1-12.