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Nanotechnological Wound Healing Bandage Production from Polymer Solutions Containing Tea Tree Oil, Echinacea, Spider Web and Aloe Vera

Gulseren Sakarya Bulus[1*], Erdi Bulus[2,3], Mehmet Akkas[4], Tayfun Cetin[5], Ezgi Yaman[6], Tugce Altindal[6]

[1]Silivri District Health Directorate, Istanbul 34570, Turkey
[2]Polymer Science and Technology Program, Institute of Science and Technology, Kocaeli University, Kocaeli 41000, Turkey
[3]ArelPOTKAM (Polymer Technologies and Composite Applications and Research Center), Istanbul Arel University, Istanbul 34500, Turkey
[4]Department of Mechanical Engineering, Faculty of Engineering and Architecture, Kastamonu University, Kastamonu 37150, Turkey
[5]Department of Electricity and Energy, Yüksekova Vocational School of Higher Education, Hakkari University, Hakkari, 30000, Turkey
[6]Department of Biomedical Engineering, Faculty of Engineering and Architecture, Istanbul Arel University, Istanbul 34500, Turkey

In this study; Nanofiber membrane is produced by nanotechnological electrospinning technique using Spider Web (SW) and Echinacea (E) doped polycaprolactone (PCL), wet tree oil (ATO) and polyvinyl alcohol (PVA) polymers containing Aloevera (AV) additives. Morphological (Scanning Electron Microscope (SEM)), mechanical (Tensile), biological (Cell Culture) characterization studies were carried out. nanofiber membranes produced. In the light of the values obtained, it can be a fast wound healing material in addition to many applications of the health sector.

Keywords: *Spider web, tea tree oil, echinacea, aloe vera, polycaprolactone, polyvinylalcohol, electrospinning, wound healing*

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**Corresponding author: sakaryagulseren1@gmail.com (Gulseren Sakarya Bulus) Tel: +905434461256*

1. Introduction

Spider web (SW) has been used as a wound healing material in the regions for many years. Age tree oil (ATO) is a natural antibacterial and antifungal agent. When 100% ATO was applied to the cut with the help of gauze, it showed a quick healing feature [1-5].

Echinacea (E) can help the wound heal in high stress processes, but it does not have such an effect in low or medium stress processes, in this case, it can affect wound healing for a long time with the help of polyvinyl alcohol (PVA) and polycaprolactone (PCL) polymers [6-9].
Thanks to its anti-inflammatory properties, aloe vera (AV) is great for soothing open wounds. If you have an aloe vera plant at home, you can cut the leaf, remove the sharp edges, and squeeze the juice. Before applying fresh aloe vera (AV) juice to an open wound, remember to do a little test [10-12].
Wound healing membranes are produced with electrospinning technique that does not contain chemicals and has the ability to form perfect films [13-16].

In this study; Nanofiber membranes are produced with nanotechnological electrospinning technique using polyvinyl alcohol (PVA) polymers containing spider web (SW) and Echinacea (E) additive polycaprolactone (PCL), green wood oil (ATO) and Aloevera (AV) additives. In the light of the obtained values, it is aimed to be used as a rapid wound healing material, besides many applications of the health sector.

2. Material and Method

2.1. Material

Spider web (SW), Age tree oil (ATO), Echinacea (E), Aloe vera (AV), Mw: 85.000-124.000 g/mol polyvinyl alcohol (PVA) and Mw: 80.000 g/mol polycaprolactone (PCL) polymers, distile water, dimetilyformamide (DMF), chloroform, wax paper are used. Sigma-Aldrich brand was preferred as reference.

2.2. Method

2.2.1. Anti-scar wound healing nanofiber membrane production with electrospinning system

Scar removal and healing nanofiber membranes Table 2.1. and it was prepared according to the values in Table 2.2. Production stages of Nanotechnology Additive Wound Preventive Bandage from Spider Web, Tea Tree Oil, Echinacea and Aloe Vera Additive Polymer Solutions are shown in Figure 2.1.

Table 2.1.: Preparation values of anti-scar wound healing nanofiber membrane solutions

Sample Name	Solution Mixing Time (min.)	Solution Mixing Temperature (°C)
10% PCL	60	60
10% PCL-5% SW	60	60
10% PCL-5% E	65	60
10% PVA	55	50
10% PVA-5% ATO	55	50
10% PVA-5% AV	60	60

Table 2.2.: Electrospinning parameters applied for anti-scar wound healing nanofiber membrane production

Sample Name	Flow Rate (ml/hr.)	High Voltage (kV)	Working Distance (cm)
10% PCL	1.5	27.0	15
10% PCL-5% SW	1.5	27.0	12
10% PCL-5% E	1.5	27.0	12
10% PVA	3.0	25.0	12
10% PVA-5% ATO	3.0	25.0	15
10% PVA-5% AV	3.0	30.0	15

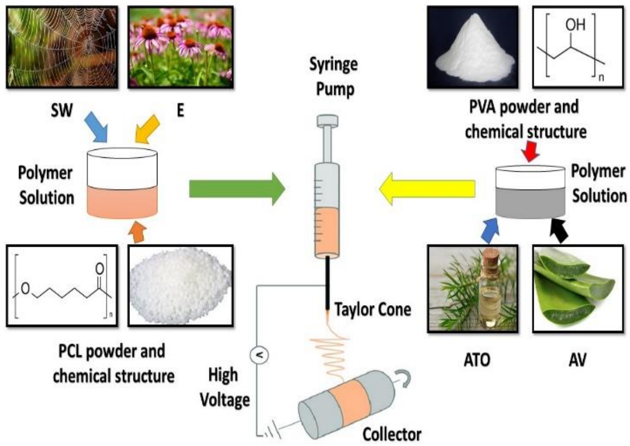

Figure 2.1. *Production of anti-scar wound bandages with nanotechnology additive from spider web, tea tree oil, echinacea and aloe vera additive polymer solutions*

2.2.2. Characterization studies

Tissues placed in the holders were examined and photographed with a ZEISS EVO SEM microscope. During the examination of the diameter and dimensions of the produced composite nanofibers, images magnified at x6000 times were examined for SEM analysis at 7 kV potential. The average diameter thickness of the nanofibers was measured on high resolution SEM photographs using Image j (National Health Organization) software. The mechanical (tensile) test was carried out by cutting the electrospun mats 1x5 cm in length according to the ASTM standard and repeating them 3 times under 500 Newton load. Membranes were placed in 96 plates and mesenchymal stem cells were added. Cell viability values were determined.

3. Result and Discussion

3.1. SEM analysis

Nanofiber was produced in all samples. When the fiber averages are examined, PCL samples and PCL-based samples have a thicker fiber structuring than PVA and PVA based samples, while a more homogeneous and more regular fiber structuring is observed in PVA and PVA based samples. The thinnest nanofibers in the study emerged in the 10% PVA + 5% AV sample [17-19]. SEM morphological images of nanofiber membranes are given in Figure 3.1.

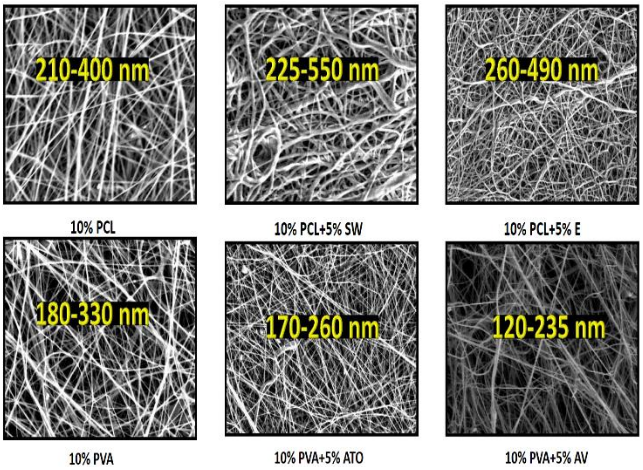

Figure 3.1. *SEM morphological images of nanofiber membranes*

3.2. Tensile test

Polymeric-based nanofiber membranes prepared according to ASTM standards were repeated in three centers and the arithmetic averages of the results were obtained and their tensile strength values were determined. In this study, PCL and PCL based samples have a more resistant structure than PVA and PVA based samples. The highest tensile strength value in the study was found in the 10% PCL + 5% E sample [20-24]. Figure 3.2. shows the tensile test values of nanofiber membranes.

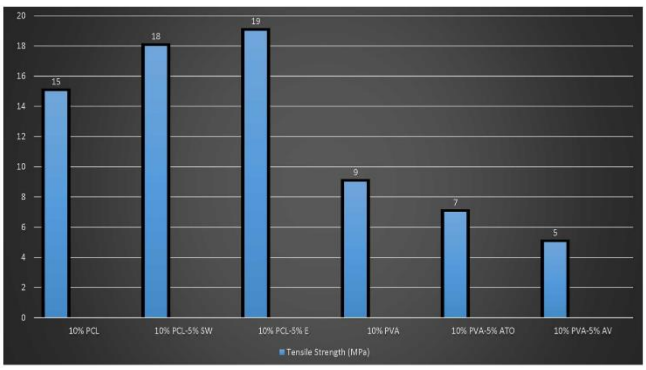

Figure 3.2. *Tensile test values of nanofiber membranes*

3.3. Cell culture test

All samples were placed in a 96-well container and the mesenchymal cell cultivation was kept for 24, 48 and 96 hours, and the cell was counted alive and dead. The sample with the highest viability value in the study appeared at 10% PVA + 5% AV [25-27]. Figure 3.3. shows cell viability values of nanofiber membranes.

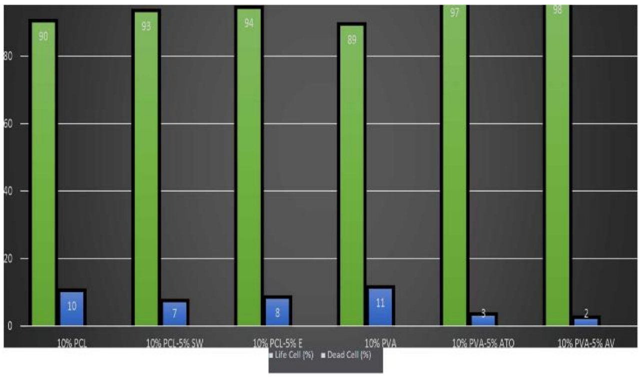

Figure 3.3. *Cell viability values of nanofiber membranes*

4. Conclusion

In all samples, trace removing nanofiber membranes were obtained by electrospinning technique. When morphological, mechanical and cell culture studies are examined, the ideal material properties are found in 10% PCL + 5% E, 10% PVA + 5% AV composites. As a result of the findings obtained, the nature of soluble wound healing tape with scar removal feature can be exhibited.

References

[1] Akhmetova, A., & Heinz, A. (2020). Electrospinning Proteins for Wound Healing Purposes: Opportunities and Challenges. *Pharmaceutics*, *13*(1), 4.

[2] Liu, L., Xu, W., Ding, Y., Agarwal, S., Greiner, A., & Duan, G. (2020). A review of smart electrospun fibers toward textiles. *Composites Communications*, 100506.

[3] E. Bulus, Fırat Üniversitesi Yüksek Lisans Tezi, (2017)

[4] Zahedi, E., Esmaeili, A., Eslahi, N., Shokrgozar, M. A., & Simchi, A. (2019). Fabrication and characterization of Core-Shell electrospun fibrous Mats containing medicinal herbs for wound healing and skin tissue engineering. *Marine drugs*, *17*(1), 27.

[5] Kotrotsos, A. (2020). An innovative synergy between solution electrospinning process technique and self-healing of materials. A critical review. *Polymer Engineering & Science*.

[6] Bulus, E., Sahin, Y. M., Darici, H., & Sener, L. T. Investigation of the Cellular Behavior of Polycaprolactone-Hydroxyapatite Tissue Materials Produced with Bioprinter, International Journal of

Scientific and Technological Research, 5(1), 148-161. ISSN (online) 2422-8702.

[7] Zhang, W., Huang, C., Kusmartseva, O., Thomas, N. L., & Mele, E. (2017). Electrospinning of polylactic acid fibres containing tea tree and manuka oil. *Reactive and Functional Polymers*, *117*, 106-111.

[8] Bulus, E., Mansiroglu, D. S., Ismik, D., Sahin, Y. M., Oktar, F. N., Gunduz, O., & Gokce, H. (2018). Bioceramic synthesis and characterization to be used in major tissue engineering applications. In 2018 Electric Electronics, Computer Science, Biomedical Engineerings' Meeting, EBBT 2018 (pp. 1–4). Institute of Electrical and Electronics Engineers Inc.

[9] Avci, H., & Gergeroglu, H. (2019). Synergistic effects of plant extracts and polymers on structural and antibacterial properties for wound healing. *Polymer Bulletin*, *76*(7), 3709-3731.

[10] Buluş, E., Buluş, G. S., & Yakuphanoğlu, F. (2020). Production of polylactic acid-activated charcoal nanofiber membranes for COVID-19 pandemic by electrospinning technique and determination of filtration efficiency. *Journal of Materials and Electronic Devices*, *4*(1), 21-26.

[11] Ge, Y., Tang, J., Fu, H., Fu, Y., & Wu, Y. (2019). Characteristics, Controlled-release and Antimicrobial Properties of Tea Tree Oil Liposomes-incorporated Chitosan-based Electrospun Nanofiber Mats. *Fibers and Polymers*, *20*(4), 698-708.

[12] Buluş, E., Bulus, G. S., & Yakuphanoglu, F. (2020). Production and Characterization of Novel Nature-Friendly Organic Fertilizer Covers Based on Nanotechnology for the Agricultural Sector. *JOURNAL OF MATERIALS AND ELECTRONIC DEVICES*, *5*(1), 12-16.

[13] Solaberrieta, I., Jiménez, A., Cacciotti, I., & Garrigós, M. C. (2020). Encapsulation of Bioactive Compounds from Aloe Vera Agrowastes in Electrospun Poly (Ethylene Oxide) Nanofibers. *Polymers*, *12*(6), 1323.

[14] Ismik, D., Mansuroglu, D. S., Buluş, E., & Sahin, Y. M. (2020). The Use of Chitosan Nanoparticles Obtained by Ionic Gelation Method as a Drug Delivery System. *JOURNAL OF MATERIALS AND ELECTRONIC DEVICES*, *5*(1), 6-11.

[15] Bulus, E., Bulus, G. S., & Yakuphanoglu, F. (2020). Production and Characterization of Rechargeable Composite Nanofiber Membranes. *JOURNAL OF MATERIALS AND ELECTRONIC DEVICES*, *4*(1), 32-37.

[16] Tang, Y., Zhou, Y., Lan, X., Huang, D., Luo, T., Ji, J., ... & Wang, W. (2019). Electrospun gelatin nanofibers encapsulated with peppermint and chamomile essential oils as potential edible packaging. *Journal of agricultural and food chemistry*, *67*(8), 2227-2234.

[17] Duymaz, B. T., Erdiler, F. B., Alan, T., Aydogdu, M. O., Inan, A. T., Ekren, N., … Gunduz, O. (2019). 3D bio-printing of levan/polycaprolactone/gelatin blends for bone tissue engineering: Characterization of the cellular behavior. European Polymer Journal, 119, 426–437. https://doi.org/10.1016/j.eurpolymj.2019.08.015

[18] Buluş, E., Sakarya Buluş, G., & Şahin, Y. M. (2020). Production and Characterization of Nanotechnological Tape for Wounds Caused by Diabetes. JOURNAL OF MATERIALS AND ELECTRONIC DEVICES, 5(1), 20-24.

[19] Mele, E. (2020). Electrospinning of Essential Oils. *Polymers*, *12*(4), 908.

[20] Shanmugavel, S., Reddy, V. J., Ramakrishna, S., Lakshmi, B. S., & Dev, V. G. (2014). Precipitation of hydroxyapatite on electrospun polycaprolactone/aloe vera/silk fibroin nanofibrous scaffolds for bone tissue engineering. *Journal of Biomaterials Applications*, *29*(1), 46-58.

[21] Suganya, S., Venugopal, J., Ramakrishna, S., Lakshmi, B. S., & Dev, V. R. (2014). Aloe vera/silk fibroin/hydroxyapatite incorporated electrospun nanofibrous scaffold for enhanced osteogenesis. *Journal of Biomaterials and Tissue Engineering*, *4*(1), 9-19.

[22] Yin, J., & Xu, L. (2020). Batch preparation of electrospun polycaprolactone/chitosan/aloe vera blended nanofiber membranes for novel wound dressing. *International Journal of Biological Macromolecules*.

[23] Abbasi, N., Soudi, S., Hayati-Roodbari, N., Dodel, M., & Soleimani, M. The Effects of Plasma Treated Electrospun Nanofibrous Poly (ε.

[24] Sofi, H. S., Rashid, R., Amna, T., Hamid, R., & Sheikh, F. A. (2020). Recent advances in formulating electrospun naofiber membranes: Delivering active phytoconstituents. *Journal of Drug Delivery Science and Technology*, 102038.

[25] Maver, T., Kurečič, M., Pivec, T., Maver, U., Gradišnik, L., Gašparič, P., ... & Kleinschek, K. S. (2020). Needleless electrospun carboxymethyl cellulose/polyethylene oxide mats with medicinal plant extracts for advanced wound care applications. *Cellulose*, 1-22.

[26] Ambwani, S., Tandon, R., Ambwani, T. K., & Malik, Y. S. (2018). Current knowledge on nanodelivery systems and their beneficial applications in enhancing the efficacy of herbal drugs. *J Exp Biol Agric Sci*, *6*(1), 87-107.

[27] Rho, K. S., Jeong, L., Lee, G., Seo, B. M., Park, Y. J., Hong, S. D., ... & Min, B. M. (2006). Electrospinning of collagen nanofibers: effects on the behavior of normal human keratinocytes and early-stage wound healing. *Biomaterials*, *27*(8), 1452-1461.