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Production and Characterization of Nanotechnological Tape for Wounds Caused by Diabetes

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It is aimed to produce wound dressing from natural resources with electrospinning, which is a nanotechnological method for the rapid healing of wounds of diabetic patients. In this study, polyvinyl alcohol (PVA), which is very useful for electrospinning method in terms of its properties such as being easily soluble in water, easy spinning, and forming qualified nanofiber surfaces, was used. A mixture of 10% by mass of PVA in granular form and pure water was prepared by weighing on a precision scale. The mixture was stirred on a heated magnetic stirrer at 80 ^{o}C for 3 hours and left at room temperature for 24 hours. 5% St. John's Wort (*H. perforatum l.*) (S.J.W.) and Calendula (*Calendula officinalis*) (A.) additives were added to the 10% PVA solution formed and mixed in a magnetic stirrer at 30 ^{o}C for 45 minutes. 10% PVA, 10% PVA-5% S.J.W., 10% PVA-5% A. and 10% PVA-5% A.-S.J.W. composites were obtained by electrospinning technique. The body needs calories, protein, vitamin A-C and zinc to heal wounds. 10% PVA, 10% PVA-5% S.J.W., 10% PVA-5% A. and 10% PVA-5% A.-S.J.W. without causing possible allergic reactions composites have been successfully obtained.

Keywords: *Diabetes, polyvinyl alcohol, St. John's wort (H. perforatum l.), Calendula (calendula officinalis), electrospinning, wound healing*

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1. Introduction

Local factors such as trauma, wound condition, edema greatly affect wound healing. In addition to factors such as age, nutritional status, general health status can also affect wound healing. Conditions that reduce blood circulation or blood flow and blood oxygenation are very common causes of delayed wound healing or even poor healing. Factors such as diabetes, advanced age, high blood pressure and peripheral vascular disease can cause circulatory disorders. Chronic lung disease and anemia interfere with oxygenation of the blood. Obesity also lowers the healing rate of a wound. The condition and location of the wound affects the speed of wound healing. Continuous trauma and excessive pressure slow wound healing. Loss of water also causes the cells to dry and crusted. On the other hand, excessive water intake causes the cuts to become too moist and wear out. It is important to remove necrotic and dead tissue for wound healing. Drugs that have the ability to stimulate the inflammatory response, such as carticosteroids, delay wound healing. Chemotherapy stops the cells from growing and prevents this wound from healing. The body needs calories, protein, vitamin A-C and zinc to heal wounds. That's why a well-balanced diet is required. Vitamins play a big role in the healing process of wounds. Therefore, taking vitamin supplements is very important [1-3].

In this study, materials that can show rapid healing of the wounds of diabetic patients were obtained by electrospinning technique with 10% PVA, 10% PVA-5% S.J.W., 10% PVA-5% A. and 10% PVA-5% S.J.W.-A. made of composites. Characterization studies of the produced composites were carried out with the help of structural (FTIR, Fourier Transform Infrared Spectrophotometer) and morphological (SEM, Scanning Electron Microscope) analyzes. The body needs calories, protein, vitamin A-C and zinc to heal wounds. It is aimed to be used as an ideal wound healing material with the difference of nanotechnology that can meet this need and without causing possible allergic reactions.

2. Experimental Studies

2.1. Materials

Mw: 85.000-124.000 g / mol weight Sigma / Aldrich brand PVA polymer, pure water (distilled water) to dissolve the polymer, oil paper as backing material was used. Calendula (*Calendula officinalis*) and St. John's Wort (*H. perforatum l.*) plants were obtained from a herbalist in Eminonu.

2.2. Biocomposite production

PVA, which is very useful for the electrospinning method in terms of its properties such as being easily soluble in water, easy spinning, and forming qualified nanofiber surfaces, was weighed on a precision scale and a mixture of 10% by mass of pure water was prepared. The mixture was stirred in a heated magnetic stirrer at 80 ºC for 3 hours and left at room temperature for 24 hours to remove bubbles in the solution. In addition to pure PVA, 5% separately A., S.J.W. and A.-S.J.W. four different electrospinning solutions were obtained by adding plant powders [4-7]. The preparation of the solutions required for biocomposite production is given in Table 2.1.

Table 2.1: Preparation of solutions required for biocomposite production

Polymer/ Additive Name	Solvent Mix	Mix Ratio (w /v)	Mix Temperature (˚C)	Mixing Time (Minute)
10% PVA	Distile Water	9:1	30	240
10% PVA-5% A.	Distile Water	9:1	30	240
10% PVA-5% S.J.W.	Distile Water	9:1	33	255
10% PVA-5% A.-S.J.W.	Distile Water	9:1	35	260

Electrospinning parameters required for biocomposite production are shown in Table 2.2.

Table 2.2: Electrospinning parameters required for biocomposite production

Polymer/ Additive Name	Working Distance (cm)	Flow (ml/hour)	High Voltage (kV)
10% PVA	15	3.5	25.8
10% PVA-5% A.	15	3.5	25.8
10% PVA-5% S.J.W.	15	5	30
10% PVA-5% A.-S.J.W.	15	5	30

Suitable solvent / solvent systems for the electrospinning process were investigated. PVA and A., S.J.W., A.-S.J.W., pure water was used in PVA solutions with additives. The stages of biocomposite production by electrospinning method are given in Figure 2.1.

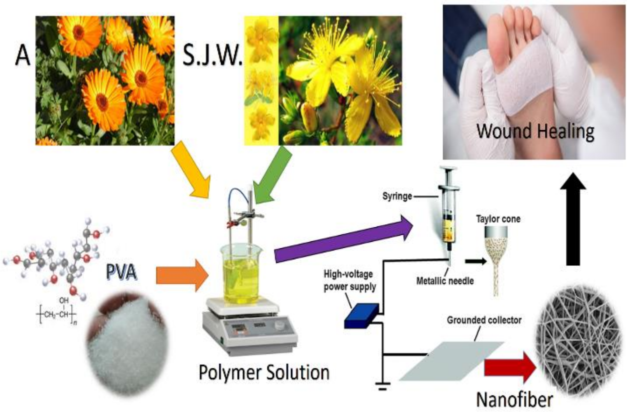

Figure 2.1. *Biocomposite production stages with electrospinning method*

2.3. Characterization of composites membrane

FTIR analyzes were determined in the Jasco brand 6600 model analyzer, depending on the percentage transmittance (% T) values between 400 and 4400 cm^{-1} wavelengths.
During the examination of the nanofiber diameters of the produced biocomposites in FEI FEGSEM QUANTA 450 brand device, images magnified at x6000 times were examined at 7 kV potential. By measuring 30 nanofiber diameters from the images, their arithmetic averages were obtained and average nanofiber diameter ranges were determined [4].

3. Result and Discussion

3.1. Structural (FTIR) analysis

In Figure 3.1., infrared spectra PVA, A., S.J.W., PVA-A., PVA-S.J.W. and PVA-A.-S.J.W. show its characteristics. PVA, A., S.J.W., PVA-A., PVA-S.J.W. and the peak seen at 3291 cm^{-1}-3294 cm^{-1} in biocomposites in PVA-A.-S.J.W. indicates the presence of hydroxyl group in the membrane. PVA, both containing hydroxyl groups, is A. and S.J.W.'s characteristics. However, the peak PVA at 2917cm^{-1} is A. and S.J.W. It was distinguished slowly when mixed with. Also, PVA-A., PVA-S.J.W. and PVA-A.-S.J.W.. When the peak in the composite shifts from 1711 cm^{-1} to 1726 cm^{-1}, PVA chains and A., S.J.W., A.-S.J.W. has been attributed to the intermolecular interaction between the carbonyl and the hydrogen group between thus, PVA and A., S.J.W., A.-S.J.W.. Functional groups of substances PVA-A.-S.J.W.. It has been observed to have distinct peaks in the biocomposite [5, 8-11].

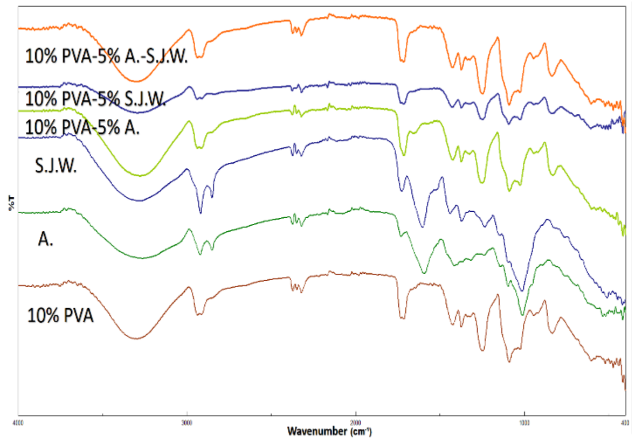

Figure 3.1. *FTIR spectra of biocomposites*

3.2. Morphological (SEM) analysis

Morphological structures of biocomposites are shown in Figure 3.2., Figure 3.3., Figure 3.4. and Figure 3.5. Nanofiber formation was observed in all samples. PVA, PVA-A., PVA-S.J.W. and PVA-A.-S.J.W.. The fineness of the nanofibers obtained from the solutions by electrospinning process is thinner than the pure PVA polymer. This is because; It is thought to result from the increased conductivity of the solution with the additive in the mixture. Fiber diameters in the samples were measured with the SEM device. Looking at the fineness of nanofibers, PVA-A., PVA-S.J.W. and PVA-A.-S.J.W. It has been determined that the material produced in the mixtures is formed as fine fibers. A., S.J.W. and A.-S.J.W. its additives enveloped the PVA polymer homogeneously without clumping. PVA-A.-S.J.W. sample was composite with the thinnest fiber structuring compared to other samples. The average diameter of the fibers was 150-300 nm, measured on SEM images obtained in the device and determined by taking the arithmetic average of 30 calculated fibers [9].

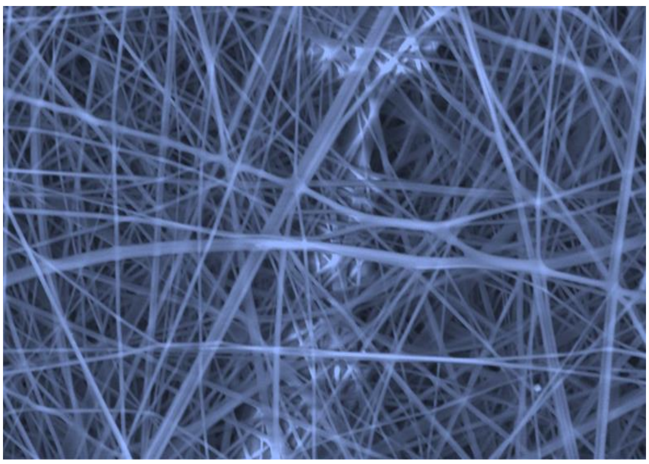

Figure 3.2. *10% PVA SEM image at x6000 magnification*

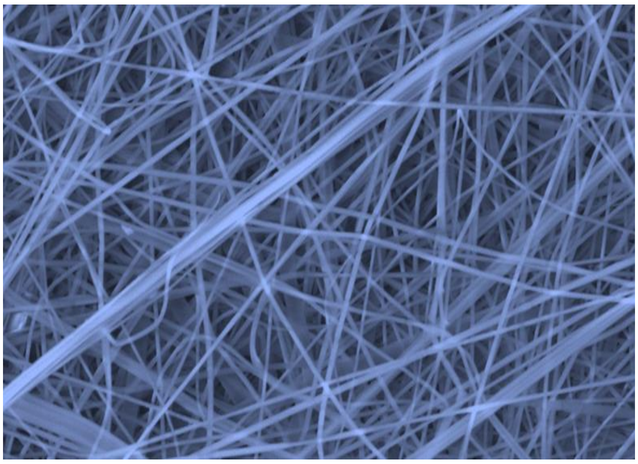

Figure 3.3. *10% PVA-5% A. at x6000 magnification SEM image*

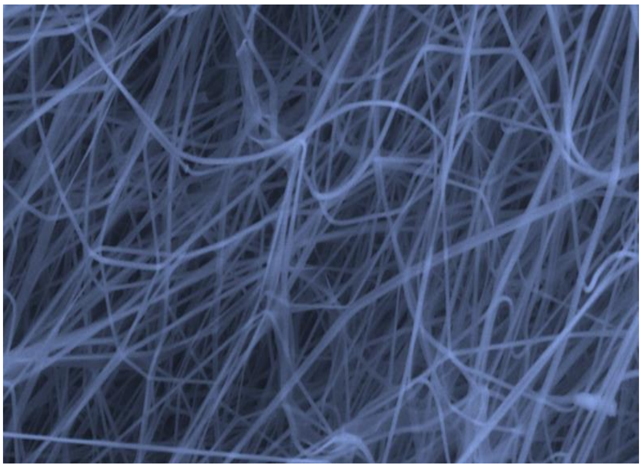

Figure 3.4. *10% PVA-5% S.J.W. at x6000 magnification SEM image*

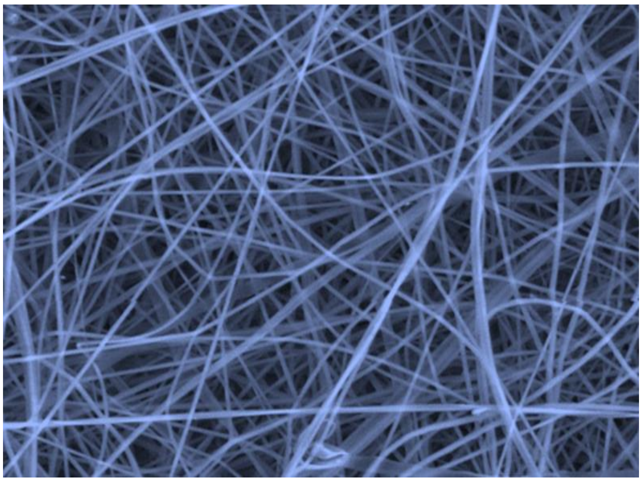

Figure 3.5. *10% PVA-5% A.-S.J.W. at x6000 magnification SEM image*

4. Conclusion

With electrospinning technique, PVA, PVA-A., PVA-S.J.W. and PVA-A.-S.J.W. composites have been successfully obtained. Wound healing tape production has been achieved by adding 5% individual plant powders to the PVA solution. When the structural (FTIR) analysis results of the produced materials are examined, PVA, A. and S.J.W.. The overlap of the functional groups of the materials and their content in the composite structure were determined by the characterization and literature-supported studies. When the morphological (SEM) characterization tests of the composites are examined, the fiber structuring of the calendula, sarikaron and calendula-sarikaron doped composites is thinner than pure PVA polymer. The thinnest fibers PVA-A.-S.J.W. composite, the average fiber thickness is 150-300 nm. The values obtained will be able to exhibit the feature of wound healing tape for tissue engineering and biomedical applications.

As a continuation of the work done;

- Application areas can be expanded as a result of the values obtained by carrying out mechanical, thermal and biological (antimicrobial, cell culture) characterization studies of the produced biocomposites.
- The properties of the material can be increased by using different polymer and solvent systems.
- Considering the polymer and additives used, it can be used as an edible food product and food packaging material.
- Its usability as drug production can be investigated by conducting controlled drug release studies. Studies can be done to remove skin inflammations that occur in cancer patients after radiotherapy treatment.

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References

[1] H. S. Mansur, R. L. Oréfice, A. A. Mansur, Polymer, 45(2004), 7193
[2] X. M. Suı, C. L. Shao, Y. C. Lıu, Applied Physics Letters, 87(2005), 113
[3] E. Bulus, Fırat Üniversitesi Yüksek Lisans Tezi, (2017)
[4] B.T. Duymaz, F.B. Erdiler, T. Alan, M.O. Aydogdu, A.T. Inan, N. Ekren, M. Uzun, Y.M. Sahin, E. Bulus, F.N. Oktar and S.S. Selvi, European Polymer Journal, 119 (2019), 426

[5] E. Buluş, G. S. Buluş and F. Yakuphanoğlu, Journal of Materials and Electronic Devices, 4(2020), 21

[6] E. Buluş, Y.M. Şahin, D. Ismık, D.S. Mansuroğlu, M.S. Fındıkoğlu, B. Bozkurt, E. Doğancı, M. Doğancı Dandan ve G. Sakarya, Scientific Meeting on Electrical-Electronics & Biomedical Engineering and Computer Science (EBBT), (2019)1

[7] N. Yucel, E. Buluş, G. S. Bulus, A. Khan, F. Xhibo, S. Turan and F. Yakuphanoglu, Journal of Materials and Electronic Devices, 4(2020), 38

[8] E. Bulus, D. Ismik, D. S. Mansuroglu, Y. M. Sahin and G. Tosun, In 2017 Electric Electronics, Computer Science, Biomedical Engineerings' Meeting (EBBT), (2017),1

[9] E. Bulus, G. S. Bulus and F. Yakuphanoglu, Journal of Materials and Electronic Devices, 4(2020), 32

[10] E. Bulus, G. S. Bulus, H. Çelik, İ. Somunkıran and E. Çelik, Journal of Materials and Electronic Devices, 5(2020), 1

[11] E. Bulus, Y. M. Sahin, H. Darici and L. T. Sener, International Journal of Scientific and Technological Research, 5 (2019), 148