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Production and Characterization of Nanotechnological Wound Dressing Containing Ozone Oil

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Abstract: In this study, polyvinyl alcohol (PVA), which is very useful for the electrospinning method, was used in terms of its properties such as being easily dissolved in water, easy to spin, and forming qualified nanofiber surfaces. A mixture of 10% by mass of pure water and granular PVA was prepared by weighing on a precision scale. The mixture was stirred at 80 ˚C for 3 hours in a heated magnetic stirrer and left at room temperature for 24 hours. The resulting 10% PVA solution was mixed with a magnetic stirrer at 30 ˚C for 45 minutes by adding 5% ozone oil. 10% PVA, 10% PVA-5% Ozone Oil composites were obtained by electrospinning technique. Morphological characterization of the obtained composites was carried out with Field Emission Gun Scanning Electron Microscopy (FEGSEM). Membranes that we produce for chronic wounds, especially for diabetes patients, will be ideal material candidates with their rapid wound healing properties.

Keywords: Ozone oil, polyvinyl alcohol, electrospinning, wound dressing, diabetes

Ozon Yağı İçeren Nanoteknolojik Yara Örtüsü Üretimi ve Karakterizasyonu

Özet: Bu çalışmada suda kolay çözünebilmesi, kolay spinlenebilmesi, nitelikli nanofiber yüzeyler oluşturabilmesi gibi özellikleri bakımından elektroeğirme yöntemi için oldukça kullanışlı olan polivinil alkol (PVA) kullanılmıştır. Hassas terazide tartılarak granül haldeki PVA ile saf suyun kütlece %10'luk karışımı hazırlanmıştır. Karışım ısıtıcılı manyetik karıştırıcıda 80 ˚C sıcaklıkta 3 saat boyunca karıştırılmış ve 24 saat boyunca oda sıcaklığında bekletilmiştir. Oluşan %10'luk PVA çözeltisine %5 oranında ozon yağı maddesi katılarak 45 dakika 30 ˚C sıcaklıkta manyetik karıştırıcıda karıştırılmıştır. %10 PVA, %10 PVA-%5 Ozon Yağı kompozitleri elektroeğirme tekniği ile elde edilmiştir. Elde edilen kompozitlerin Alan Emisyon Tabancalı Taramalı Elektron Mikroskobu (FEGSEM) ile morfolojik karakterizasyonları gerçekleştirilmiştir. Diyabet hastaları başta olmak üzere kronik yaralara yönelik ürettiğimiz membranlar hızlı yara iyileştiri özellikleri ile ideal malzeme adayı olabilecektir.

Anahtar Kelimeler: Ozan yağı, polivinil alkol, elektroeğirme, yara örtüsü, diyabet

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1. INTRODUCTION

The deterioration of the integrity and functions of tissues or organs by various factors is called wound healing, and the restoration of this integrity through a series of intertwined processes is called wound healing. Wound healing is a dynamic and complex process consisting of successive periods. The use of appropriate dressings plays an important role in the wound healing process. The duties of wound dressings are to provide protective properties against infection and microorganisms, to absorb blood and wound fluid, to provide wound healing and in some cases to apply drug therapy on the wound. Other tasks of dressings include fluid control, odour removal, microbial control, physical barrier, space-filling effect, and complete cleaning (debridement) of foreign bodies and damaged and infected tissues in the wound [1].

A wide variety of wound care products are used in wound care today. These include composite dressings, transparent film dressings, hydrocolloids, alginate dressings and wound fillers, antibacterial dressings, and hydrogel dressings. There is no ideal wound care product to be used for every wound and at all times. Wound care products are selected according to the wound and are changed according to the need in different periods of the same wound. It is used in wound healing, regeneration, and healing of dermal and epidermal tissue. The materials used

in the preparation of the dressing protect the wound as a physical barrier against microorganisms and are permeable to moisture and oxygen. An ideal dressing should have the following features: It should accelerate wound healing, provide a moist environment for the wound, remove excess exudate and toxic substances from the environment without allowing the wound to dry, prevent odour, protect the temperature of the wound surface, not allow the passage of microorganisms from the air to the wound surface, allow oxygen exchange and gas exchange. It should aid cell migration and division by allowing [2].

Wound dressing is an important method to complete the wound healing process quickly and properly. Wound dressings are materials that act as a barrier to protect the wound. Due to the importance of wound protection, the development of appropriate wound dressings is extremely important. Purpose in the treatment of surgical wounds in the past; the wound was to bring the lips closer together to quickly heal the wound. Nowadays, the dressings are understood that a moist and warm environment created around the wound is more effective in wound healing. This current approach is based on the ideal environment for wound healing and the ability of epithelial cells to move easily [3].

An ideal dressing should have the following properties:

- Providing a moist environment for the wound,
- Removing exudates,
- Preventing microorganisms from entering the wound,
- Allowing gaseous exchange,
- Must be sterile,
- Must not be toxic and allergic,
- Minimal frequency of dressing exchange,
- Thermal insulation,
- Easy of application,
- Comfortable and conformable [4,5].

Biomaterials are defined as materials that can adapt to the human body, perform the functions performed by the human body, support and heal. Biomaterials science is an interdisciplinary branch that studies the physical and biological studies of materials and their interactions in the biological environment [6].

PVA, a biocompatible and water-soluble hydroxy polymer, has very good chemical resistance, flexibility, mechanical strength, and biodegradability. Chemical stability at room temperature with very good physical and mechanical properties, ability to form very good fibrous material alone or mixed with other polymers [7].

The oil known as ozone oil is actually ozone-enriched pure olive oil. Although the ozonisation process is usually done with olive oil, it can also be done with other natural oils such as argan oil, hemp oil. The main feature of ozone molecules is the ability to destroy organic compounds such as bacteria and viruses with a high purification process. One of the most important benefits of ozone oil is that it provides rapid healing of wounds. It is a product that should be used by diabetics who have wounds for no reason. It is a type of oil that works with its positive effects in the treatment process of foot fungus and other diseases. Ozone oil is often used in the treatment of skin problems such as psoriasis, varicose veins, wrinkles, eczema, and acne [8].

Nanofibers is a designation used for fibers with a diameter of 100 nanometers or less. Its properties such as flexibility, high porosity, small pore size, axial strength have caused it to find many different and wide application areas [9].

It is a method applied by drawing the polymer from a specially prepared solution using an electric field. In addition, nanofibers can be produced from polymers, metal oxides and ceramics with this method. With this method, one-dimensional nanostructures are formed [10].

Nanostructured wound dressings, which can be described as a new generation wound dressing, consist of nanofibers. The nanofibers with large surface have three-dimensional surface area. They have anti-bleeding feature thanks to their high surface area. Since they are nano-sized fine fibers, they can mimic the natural extracellular matrix structure (ECM), and provide a favorable environment for the attachment, development and proliferations of cells. Its high porosity gives the dressing a breathable structure that prevents the passage of bacteria and infection [11].

The electrospinning technique is one of the most used to produce nanofibers due to its simplicity and effectiveness. Electrospinning is a spinning technique which is using electrostatic force to fabricate fine fibers from polymer solutions. In this technique, the polymer is electrically charged using a high potential voltage to induce the formation of a liquid jet. The polymer jet formed by this method flows towards the grounded source. During this flow, the polymer jet is scattered around as very thin fibers and as a result, nano-scale fine fibers are formed [12].

In the electrospinning process, many different polymers have been used to produce nanofibers. The polycaprolactone (PCL) which is synthetic polymer, is used in nanofiber production. This polymer is used in the dressings because it supports wound healing. PCL is a polymer that has some superiorities related to physicochemical aspects which covers hydrophobicity, high spinnability, preferable mechanical effects. Beside these, it degrades gradually that makes desirable for purpose of matrix to load natural products [13].

In this study, PVA nanofiber composites containing ozone oil were obtained by electrospinning technique, and the obtained membranes will be able to show ideal material properties that can appeal to all people with chronic wounds, especially diabetes patients.

2. MATERIAL AND METHOD

2.1. Materials

ANKA Biological Implant Medical Software Tourism Defense Industry and Trade Limited (Erzurum/Turkey) Sigma/Aldrich brand PVA polymer: 85,000-124,000 g/mol weight, pure water (distilled water) was used to dissolve polymer and used as fatty paper. Ozone oil was obtained from Mediazon (Istanbul/Turkey).

2.2. Method

2.2.1. Preparation of Wound Dressing Solutions

PVA, which is very useful for electrospinning method in terms of its properties such as being easily soluble in water, easy to spin, and creating quality nanofiber surfaces, was weighed on a precision balance and a 10% mass mixture of pure water was prepared. The mixture was stirred at 80 ˚C for 3 hours in a heated magnetic stirrer and left at room temperature for 24 hours to remove the bubbles in the solution. In addition to pure PVA, 2 different electrospinning solutions were obtained by adding 5% ozone oil to the PVA solution. Preparation of necessary solutions for dressing production is given in Table 2.1.

Table 2.1. Preparation of necessary solutions for dressing production

Polymer/Addetive Matter	Solvent	Mixture Temperature (˚C)	Mixture Time (Min.)
10% PVA	Distile water	30	240
10% PVA-5% Ozone Oil	Distile water	30	240

2.2.2. Biocomposite Production by Electrospinning Method

Nanofibers were obtained by depositing the nanofibers on a collecting wax paper at room temperature using a NANOFEN brand N100 model electrospinning device. Electrospinning parameters required for biocomposite production are shown in Table 2.2.

Table 2.2. Electrospinning parameters required for the production of biocomposites

Polymer/Addetive Matter	Working Distance (cm)	Flow Rate (ml/hour)	Voltage (kV)
10% PVA	15	3.5	25.8
10% PVA-5% Ozone Oil	15	5	30

Suitable solvent/solvent systems for electrospinning were investigated. Pure water was used in PVA and ozone oil added PVA solutions. The stages of wound dressing production by the electrospinning method are given in Figure 2.1.

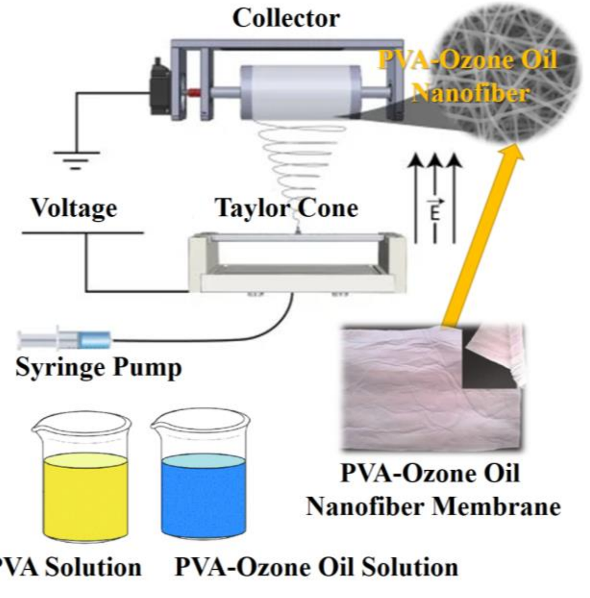


Figure 2.1. Wound dressing production by electrospinning method

2.2.2. Characterization Method

2.2.2.1. FEGSEM Analysis

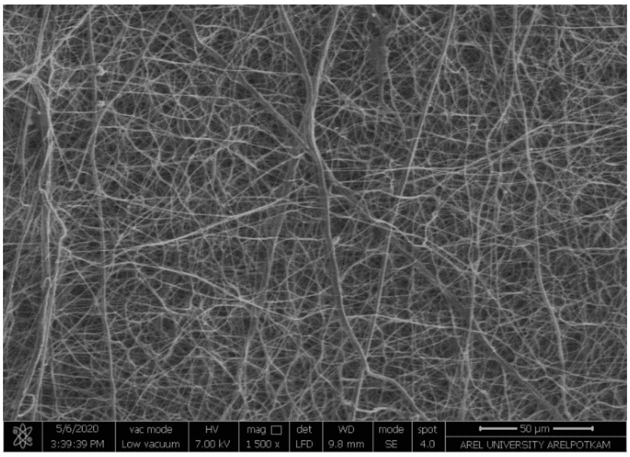
During the examination of nanofiber diameters of the membranes produced on FEI FEGSEM QUANTA 450 device, the images of x1500 and x3000 enlargements were examined in the potential of 7 kV. The average nanofiber diameter ranges were determined by measuring 30 nanofiber diameters over the images and taking their arithmetic averages [14].

3. RESULTS AND DISCUSSION

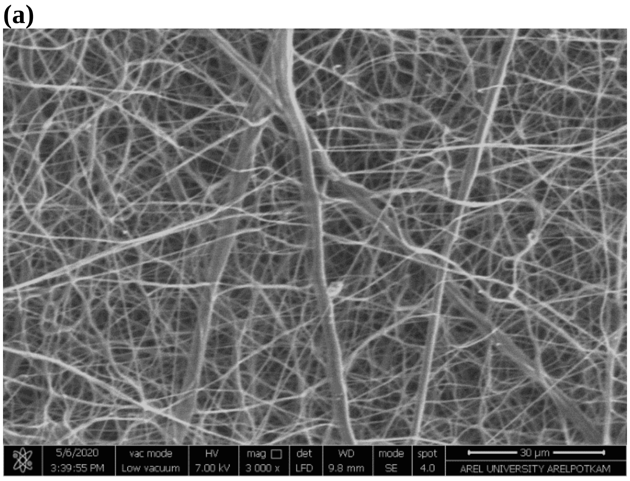
3.1. Morphological Analysis

3.1.1. FEGSEM Analysis

Nanofiber formation was observed in all samples. The fineness of nanofibers obtained by electrospinning from PVA and PVA-Ozone Oil solutions was even finer compared to pure PVA polymer. This is because; It is thought that the solution conductivity increases with the additive in the mixture. The fiber diameters in the samples were measured with the FEGSEM device. Looking at the fineness of nanofibers, it has been determined that the material produced in PVA-Ozone Oil mixtures is formed in the form of fine fibers. The PVA-Ozone Oil sample was the composite with the thinnest fiber structure compared to the PVA sample. The average diameter of the fibers was 150-300 nm, measured on the FEGSEM images obtained within the device and the arithmetic average of 30 calculated fibers was determined [15]. Figure 3.1. PVA and Figure 3.2. PVA-Ozon Oil FEGSEM images of nanofiber membranes in different magnitues are shown.

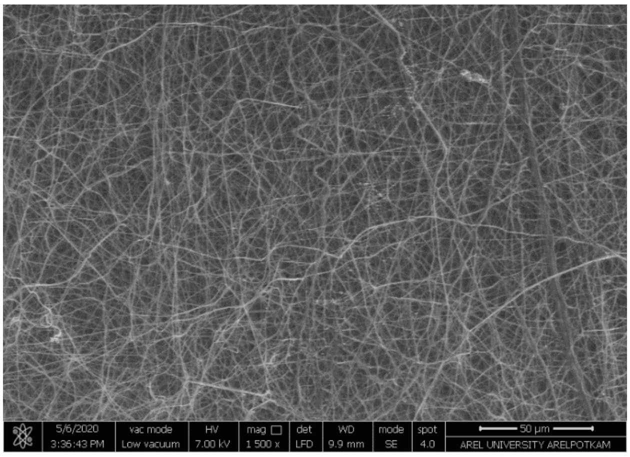


(a)

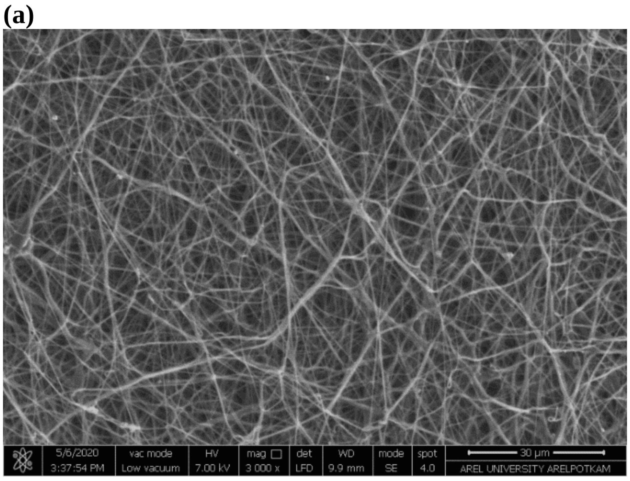


(b)

Figure 3.1. (a) x1500, (b) PVA Nanofiber FEGSEM image in x3000 magnification



(a)



(b)

Figure 3.2. (a) x1500, (b) PVA-Ozone Oil Nanofiber FEGSEM image in x3000 magnification

Table 3.1 shows the nanofiber diameter distribution range of the samples.

Table 3.1. Nanofiber diameter distribution range of samples

Sample Name	Fiber Thickness (nm)
10% PVA	180-330
10% PVA-5% Ozone Oil	150-300

4. CONCLUSIONS

PVA and PVA-Ozone Oil composites were successfully obtained by electrospinning technique. Wound healing tape was produced by adding 5% ozone oil to the PVA solution. When the morphological (FEGSEM) characterization tests of the produced composites are examined, the fiber structure of the ozone oil added composite is thinner compared to the pure PVA polymer. The thinnest fibers were obtained in the PVA-Ozone Oil composite, and the fiber thicknesses are 150-300 nm on average. The obtained values may exhibit wound healing tape properties for tissue engineering and biomedical applications. The fields of application 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.

5. CONFLICT OF INTEREST

The authors declare no competing financial interest.

Ethical Approval: Ethics Approval is not required for this study.

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