



# Production and Characterization of Novel Nature-Friendly Organic Fertilizer Covers Based on Nanotechnology for the Agricultural Sector

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There are many different classifications of polymer usage areas in the agricultural sector. Film and greenhouse covers, super absorbent polymers, polymers with controlled drug release properties, polymers used to remove metal ions from soil and water, biodegradable polymers used in agriculture, polymers with friction-reducing effect are named in the main titles. Polymers are involved in all aspects of agricultural production in our daily life. Organic fertilizer covers facilitate planting and spacing in agriculture. It greatly increases the seed germination rate of efficient and efficient labor saving. It creates a high efficiency cover. Cotton, onion, carrot, burdock, cauliflower, spinach, etc. suitable for. These liquid fertilizer reinforced polycaprolactone (PCL) composites were made by electrospinning. Cycle by providing morphological (SEM, Scanning Electron Microscope) and mechanical (Tensile Test) characterization of the composite structure. The composite material obtained will be able to show nature friendly organic fertilizer cover that is healing for agriculture.

**Keywords:** Organic fertilizer cover, polycaprolactone, electrospinning, composite, nanofiber

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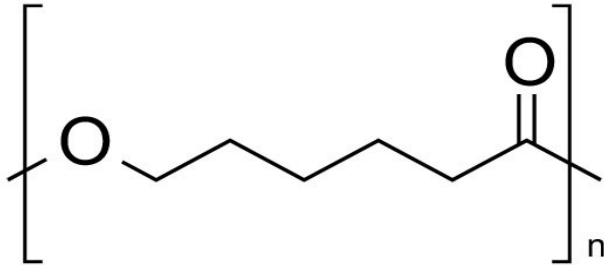
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## 1. Introduction

Organic fertilizer covers facilitate planting and spacing in agriculture. Reducing the amount of waste seed greatly increases the seed germination rate of smooth and efficient labor savings. It creates a high efficiency covering feature. Cotton, onion, carrot, burdock, cauliflower, spinach, etc. suitable for.

Polycaprolactone (PCL) is a semi-crystalline synthetic polymer with adjustable pores size, good mechanical properties and easy processing [1]. Since PCL has a hydrophobic structure, its degradation process progresses very slowly. The decay time can vary between 1 and 2 years. It is a preferred polymer in long-term drug release systems and intra-body implants due to its slow degradation and its ability to preserve its physical properties for a long time [2]. PCL, which is biocompatible and biodegradable, is frequently used in many medical fields such as wound dressing, surgical thread, tissue scaffolding. Along with this, PCL, which is widely used in drug release and medical fields; It is a very compatible polymer for cartilage, bone,

cardiovascular tissue, tendons and various tissues such as nerves [3]. The chemical structure of PCL is shown in Figure 1.1.



**Figure 1.1.** PCL chemical structure [3]

Composite defines a new material that has better properties than the materials it contains by combining the superior properties of two or more materials that are chemically and physically separate from each other [4]. It is important to benefit from the superior mechanical and biological properties of the components in composites produced as biomaterials [5].

Electrospinning mainly consists of combinations of the three main parts required. It consists of a power source, feeder parts and a layer that provides fiber collection. This joining center has joining centers in flat or cylindrical shapes, movable and immobile. With the electrospinning device having these functions, polymeric based nanofiber materials of various ranges can be produced. With the electrospinning method, with the electric field force provided to the solutions thanks to high voltage, the emergence of the fibers is provided [6].

In this study, liquid fertilizer reinforced polycaprolactone (PCL) composites were obtained by electrospinning technique. It was determined by providing morphological (SEM, Scanning Electron Microscope) and mechanical (Tensile Test) characterization of the composite structure. The composite material obtained will be able to show the characteristics of an environmentally friendly band organic fertilizer cover that is healing for agriculture.

## 2. Experimental Studies

### 2.1 Materials

80,000 g / mol polycaprolactone (PCL), liquid fertilizer, dimethylformamide (DMF) organic solvent and oil paper were used as support material in electrospinning medium to dissolve the polymer.

### 2.2 Preparation of composite solutions

PCL polymer solution was prepared according to the desired temperature and stirring speed with the help of a heated magnetic stirrer. 10 ml of PCL solution was taken in a beaker and four different compositions of 1%, 5% and 8% Liquid fertilizer were obtained. The solutions were subjected to the values given in Table 2.1 and formed into a form suitable for nanofiber production by electrospinning method. Table 2.1 shows the parameter values of composite solutions.

**Table 2.1:** Preparation values of composite solutions

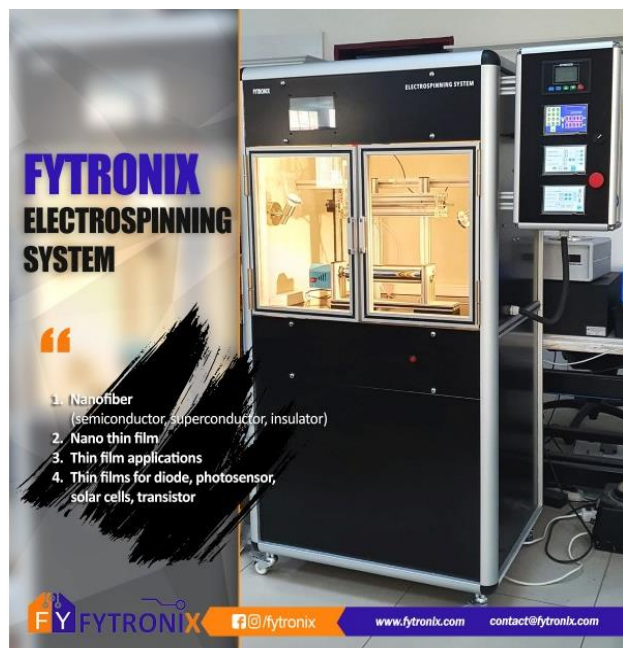
Sample Name	Solution Mixing Time (min.)	Solution Mixing Temperature (°C)
10% PCL	60	60
10% PCL-1% Liquid fertilizer	60	60
10% PCL-5% Liquid fertilizer	65	65
10% PCL-8% Liquid fertilizer	65	65

### 2.3 Composite production using the electrospinning method

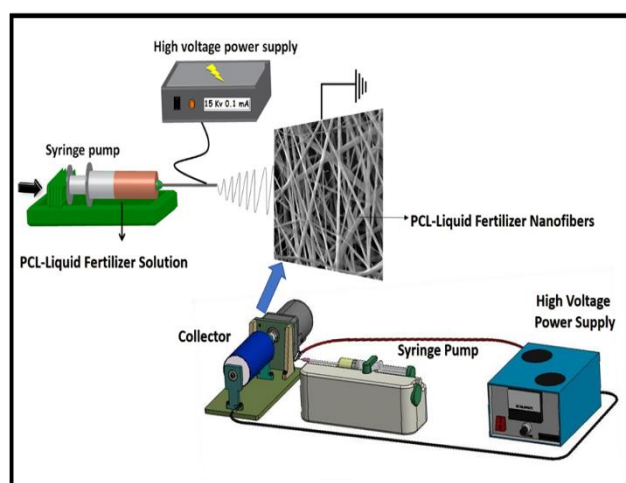
Prepared 10% PCL, 10% PCL-1% Liquid fertilizer, 10% PCL-5% Liquid fertilizer and 10% PCL-8% Liquid fertilizer composite mats were obtained by electrospinning method according to the values in Table 2.2. The device image of FYTRONIX ELECTROSPINNING SYSTEM is given in Figure 2.1. Production stages of composites with electrospinning technique are shown in Figure 2.2.

**Table 2.2:** Electrospinning process parameters

Sample Name	Flow rate (ml/hr.)	High voltage (kV)	Working distance (cm)
10% PCL	3.0	30	15
10% PCL-1% Liquid fertilizer	3.0	30	15
10% PCL-5% Liquid fertilizer	3.5	35	15
10% PCL-8% Liquid fertilizer	3.5	35	15



**Figure 2.1.** Device image of FYTRONIX ELECTROSPINNING SYSTEM



**Figure 2.2.** Process stages of composite production using electrospinning technique

## 2.4 Characterization of composites

The nanofiber membranes placed in the holders were examined and photographed with the Thermoscientific Phenom XL G2 Desktop microscope. For SEM analysis of composite nanofiber membranes, x12000 times magnified images at 15 kV potential were examined. The fiber dimensions of the nanofibers were determined by measuring an average of 200 nanofibers with the device software on the images obtained.

Samples of 1x4 cm were prepared for the mechanical characterization studies of composite nanofiber membranes. Digital micrometer (795.1 MEXFL-25,

Starrett, USA) was used for thickness measurements of composite nanofiber membranes cut in appropriate sizes. The thickness values obtained were entered into the analysis program before mechanical analysis and used to determine the elastic modulus. The mechanical properties of the nanofibers formed were determined with a Zwickline (Zwick / Roell Ltd., Germany) analyzer. Studies have been done in room conditions. The samples are separated from the litter material and attached to the device clamps. The device is 5 mm / min under 500 N load. Mechanical properties were determined by adjusting the drawing speed and 10 mm jaw spacing.

## 3. Result and Discussion

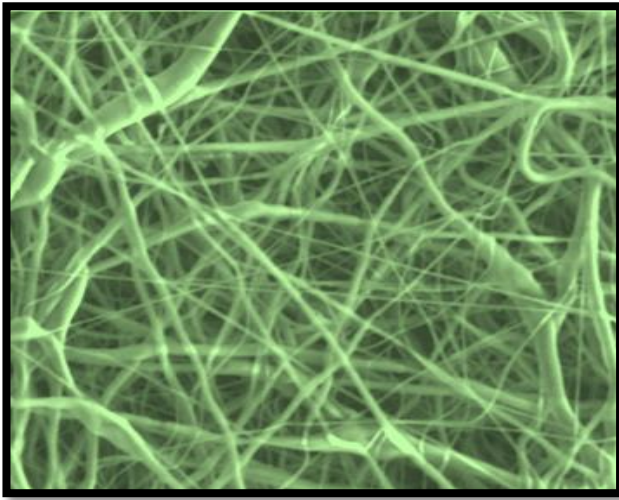
### 3.2 Morphological (SEM) analysis

Nanofiber formation was observed in all samples. The average fiber diameters of PCL mats were determined to be in the range of 150-300 nm. As the amount of liquid fertilizer increased, PCL fibers gradually became thinner. The Thermoscientific Phenom XL G2 Benchtop microscope image is shown in Figure 3.1. SEM morphology images of the composites are given in Figure 3.2, Figure 3.3, Figure 3.4 and Figure 3.5.

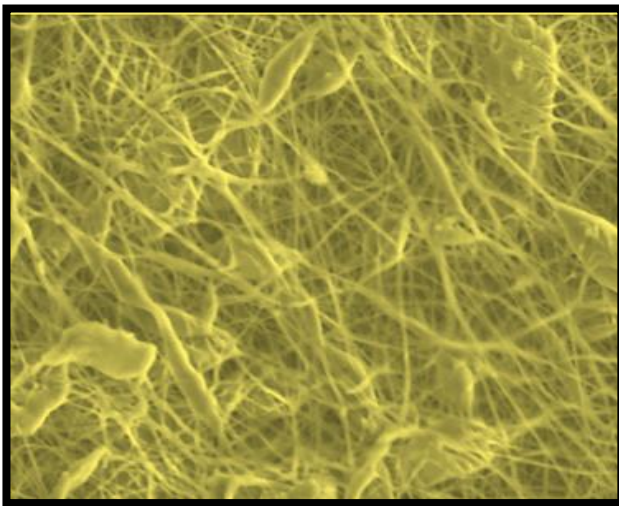


**Figure 3.1.** Thermoscientific Phenom XL G2 Benchtop microscope image

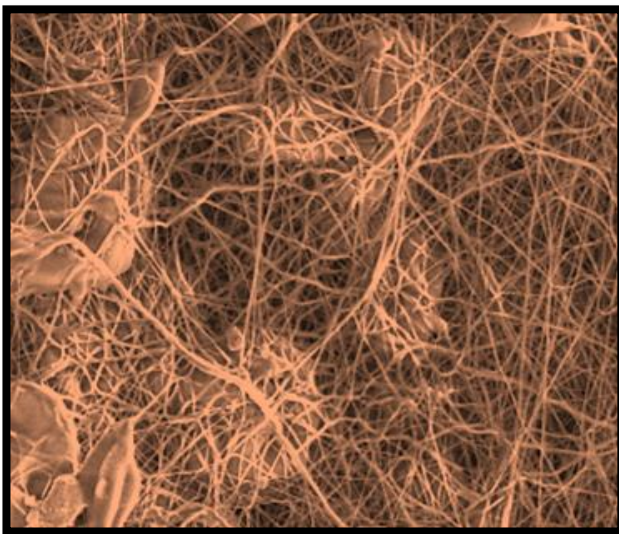




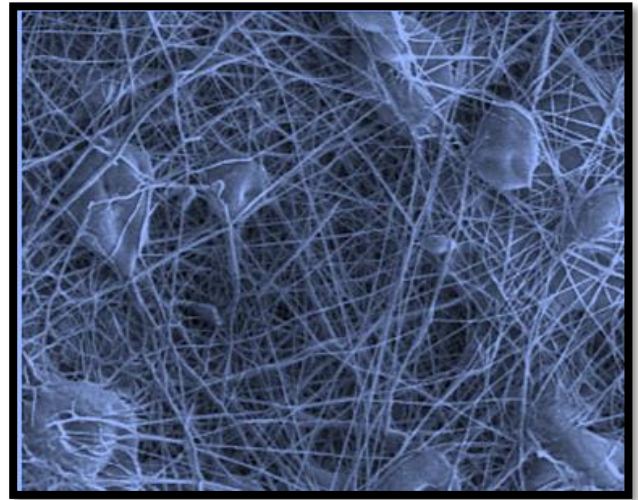
**Figure 3.2.** SEM morphology image of 10% PCL



**Figure 3.3.** SEM morphology image of 10% PCL-1% Liquid fertilizer composites



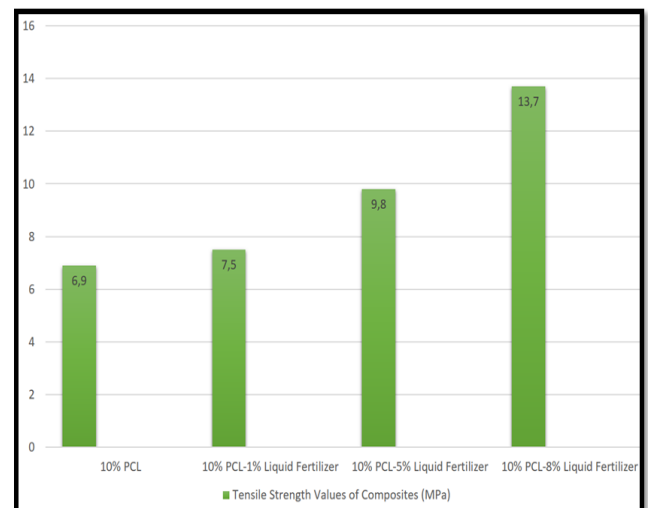
**Figure 3.4.** SEM morphology image of 10% PCL-5% Liquid fertilizer composites



**Figure 3.5.** SEM morphology image of 10% PCL-8% Liquid fertilizer composites

### 3.3. Mechanical (Tensile) analysis

According to the nanofiber thickness measurement results made before the mechanical test, it was determined to be in the range of 0.01-0.18  $\mu\text{m}$ . Test operation was carried out in 10 cm jaw range at a constant tensile speed of 5 mm / min, and strength values are shown in Figure 3.6.



**Figure 3.6.** Tensile test values of composites

As the amount of liquid fertilizer increases, the strength increase in composites is a result of both the high load-bearing capacity polymeric (PC) matrix, the additive of different substances and the homogeneous distribution in the composite [7].

#### 4. Conclusion

When the results of the study were evaluated, the composite production was successfully achieved by electrospinning technique. It was observed that PCL fibers became thinner and the surface area increased with the increase in the amount of liquid fertilizer. This situation overlaps with the tensile tests applied to composites. Thanks to the composite structure obtained, a healing organic manure cover material properties will be provided for agriculture in the agricultural sector. As a continuation of our work; By providing drug loadability tests, researching the possibility of use in the pharmaceutical industry, conducting nanoparticle studies, preliminary studies can be carried out on other problems in the agricultural sector, The continuation of the work will be provided on different applications, and the field of applicability will be determined.

#### Acknowledgements

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#### References

- [1] E. Bulus, Fırat Üniversitesi Yüksek Lisans Tezi, (2017)
- [2] E. Bulus, Y. M. Sahin, H. Darici, L. T. Sener, International Journal of Scientific and Technological Research, 5 (2019) 148
- [3] E. Buluş, G. S. Buluş and F. Yakuphanoglu, Journal of Materials and Electronic Devices, 4(2020) 21
- [4] N. Yucel, E. Bulus, G. S. Bulus, A. Khan, F. Xhibo, S. Turan, A. Qureshi, J. Kolkar and F. Yakuphanoglu, Journal of Materials and Electronic Devices, 4(2020) 38
- [5] E. Buluş, G. S. Buluş and F. Yakuphanoglu, Journal of Materials and Electronic Devices, 4(2020) 32
- [6] E. Buluş ve G. Sakarya Buluş, Putech&Composites, (2020) 16
- [7] E. Buluş ve G. Sakarya Buluş, Putech&Composites, (2020) 12