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***Шади Мохаммед Хуссейн,***

***Аспирант колледжа химической и нефтяной инженерии***

***Университет Аль-Баас***

***сирийско-Хомс***

***Газаль Тахмаз,***

***Кандидат технических наук в колледже химического и нефтяного машиностроения***

***Университет Аль-Баас***

***сирийско-Хомс***

# A STUDY OF THE GRADUATION IN THE ORIENTATION AND ALIGNMENT OF ELECTRICALLY SPUN NANOFIBERS USING AN ELECTRO SPINNING DEVICE WITH A CONICAL ASSEMBLER

**Annotation:** *This paper aims to study the effect of the rotational speed of a conical complex on the orientation of nanofibers within the electrically spun network on this complex, and include this orientation according to velocity values, then study the effect that the conical complex has on the gradual alignment of the fibers to each other to reach a parallel state between them And obtain a different fibrous structure.*

**Key words:** *conical assembler, electric yarn, orientation and alignment, gradient.*

# ИССЛЕДОВАНИЕ ГРАДУИРОВКИ В ОРИЕНТАЦИИ И ВЫРАВНИВАНИИ ЭЛЕКТРИЧЕСКИ ЗАКРУЧЕННЫХ НАНОВОЛОКОН С ИСПОЛЬЗОВАНИЕМ ЭЛЕКТРОПРЯДИЛЬНОГО УСТРОЙСТВА С КОНИЧЕСКИМ АССЕМБЛЕРОМ

***Аннотация:*** *Целью данной работы является изучение влияния скорости вращения конического комплекса на ориентацию нановолокон в электрически закрученной сети на этом комплексе. и включите эту ориентацию в соответствии со значениями скорости, затем изучите влияние, которое конический комплекс оказывает на постепенное выравнивание волокон друг с другом, чтобы достичь параллельного состояния между ними и получить другую волокнистую структуру.*

***Ключевые слова:*** *конический ассемблер, электрическая пряжа, ориентация и выравнивание, градиент.*

## 1-Introduction:

Nanofibers have three main characteristics that make them unique for use in many applications. These characteristics are: high specific surface area, high specifications in terms of (length and diameter) and the possibility of biological simulation. This led to the presence of many potential applications of the electric spinning fibers resulting in non-woven networks, as these networks can be used in filter membranes[6,c.200], nanomaterials, chemical catalysts, protective fabrics and tissues, among others. It is known that these fibers are formed randomly within the electrically spun network, and with the development of studies and research related to this field, an interest in alignment and parallelization of nanofibers has emerged in order to produce networks with unique electrical[7,c.72], optical and mechanical properties [8,c.30].

Fiber orientation means grouping them into a specific formation (parallel or curved) [4,c.215]. Studies have shown many ways to obtain directed nanofibers[5,c.199], such as applying a high rotational velocity of the collector[9,c.156], gap alignment method[10,c.345], metal wire alignment[11,c.200], and a rotating disc method [12,c.20].

Several applications have emerged that are concerned with the alignment of fibers to each other. In the field of medicine and tissue engineering, human stem cells have been successfully cultivated on two different types of cell carriers and tissues with electrolytic and woven polycrystalline PCL nanoparticles. A quantitative determination of the direction of cells has been made in relation to a fiber network Supportive nano. By testing the efficacy and alignment of human stem cells in the direction of directed fibers, the cultured cells demonstrated a more accurate and consistent alignment of the cells, and their ability to survive and multiply on cell carriers during the 18-day planting period was tested [3,c.393].

The researcher Camila flor used parallel collagen nanofibers to manufacture an artificial cartilage to protect the knee. The researcher showed that by increasing the parallelism of the fibers and the decrease in their diameter, an artificial cartilage similar to the natural cartilage could be obtained in terms of work [13,c.234].

In the field of electron and optical structures, scientists have discovered how to align silver nanowires in an exact manner with an electric field [14,c.2379].

The problem with this study lies in the presence of some disparate biological structures that require different degrees of alignment such as cartilage and bone structure, Thus, this research aims to study the gradient in the alignment of the fibers to each other from their random shape to the parallel between them, depending on changing the rotational speed of the complex In addition to the use of a conical fiber assembler, which will cause variation in: (the surface velocity of the collector along its length - the distance of the needle tip from the surface of the charged collector - the distribution of electrical charges [1,c.200].

**2- Materials and method:**

**2-1.Materials:**

Electrophoresis was performed using a chemical formula PVA solution: $C_2H_4O$ at a concentration of 7%.

**2-2.The method of work:**

Initially, the variables of the electric spinning device were adjusted to suit the spinning process to obtain nanofibers according to studies previously conducted on the following values: applied voltage (25 KV), distance between the needle and the collector axis (21 cm), the flow rate of the solution (0.1 ml / h). Then, adapt the spinning room for 30 minutes to reach temperature (25 ℃) and humidity (60%) [2,c.104].

After that, an electric spinning process was performed for five samples using five different values of collector rotational speed, which are, respectively: (0 - 1500 - 3000 - 4500 - 6000 rpm).

**2-3.Devices used:**

**- Electric spinning device**

In this study, an electric spinning device (designed by the researcher) was used, equipped with a cone-shaped stem assembly, whose tilt angle is 10 degrees from the axis.

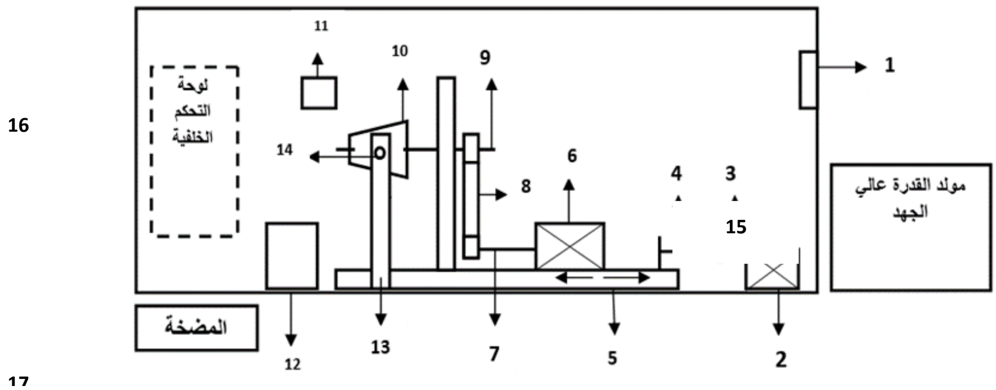



*Figure 1: The electric spinning device used*

1- Cooling Fan 2- Reciprocating Motion 3- Attachment 4- Arm 5- The rail within which the collector moves linearly 6- The Rotational Motion Engine 7- The Axis of the Engine 8- Conveyor (Belt) 9- The Collector Axis 10- The Conical Complex 11- Sensitive For humidity and temperature 12- Humidifier Evaporator 13- Needle Holder 14- Needle 15- High Voltage Power Generator 16- Back Control Panel 17- Pump.

**- Scanning Electron Microscope SEM:**

The samples were examined using the scanning electron microscope located in the Atomic Energy Authority in Damascus, which takes magnified pictures of the samples.

*Figure (2) Scanning Electron Microscope in Atomic Energy Authority, Damascus, VEGA II XMU*

It is worth noting that our study relies on a gradual study in the alignment of fibers between the two conical compound bases, so two areas of each sample were examined, one of which was taken from the side of the major base of the cone trunk, and the other from the side of the lower base, and a distance of (1 cm) from the side of the sample. Then choose sample 5 to check the alignment gradient within it along the length of the compound, where five parts of it were taken in different regions and at equal distances.

After examining the samples under the microscope, the microscopic images were processed using Image j.

## 3- Results and discussion:

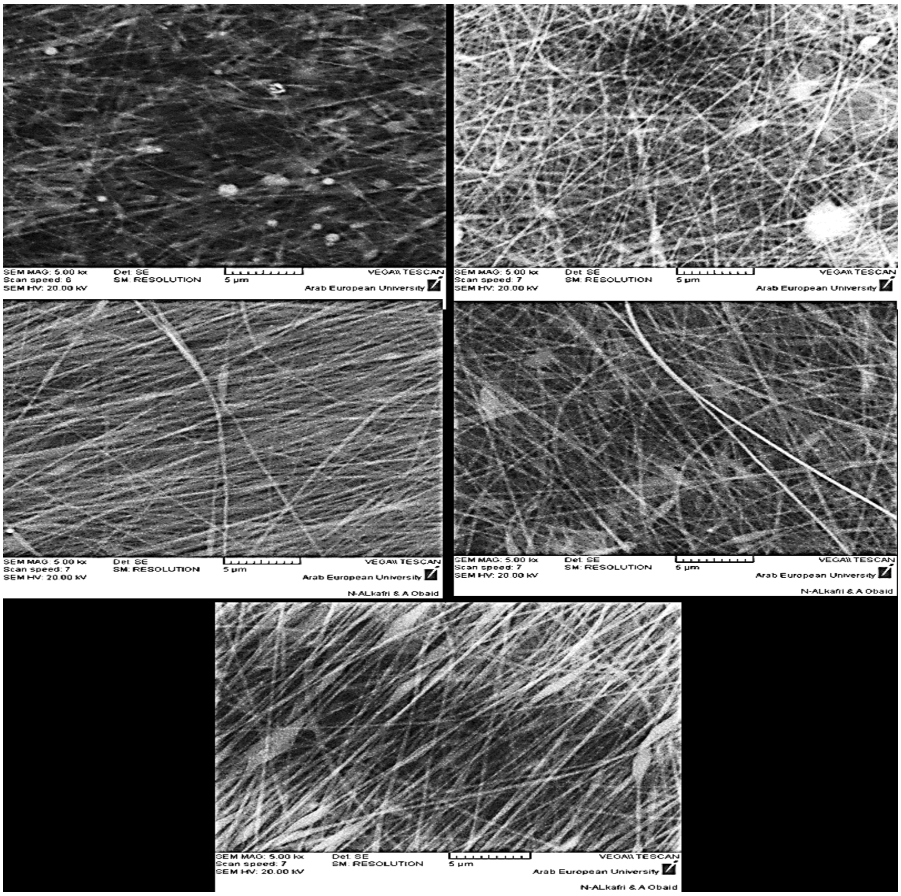


*Figure 3: Images of major base samples under a microscope*

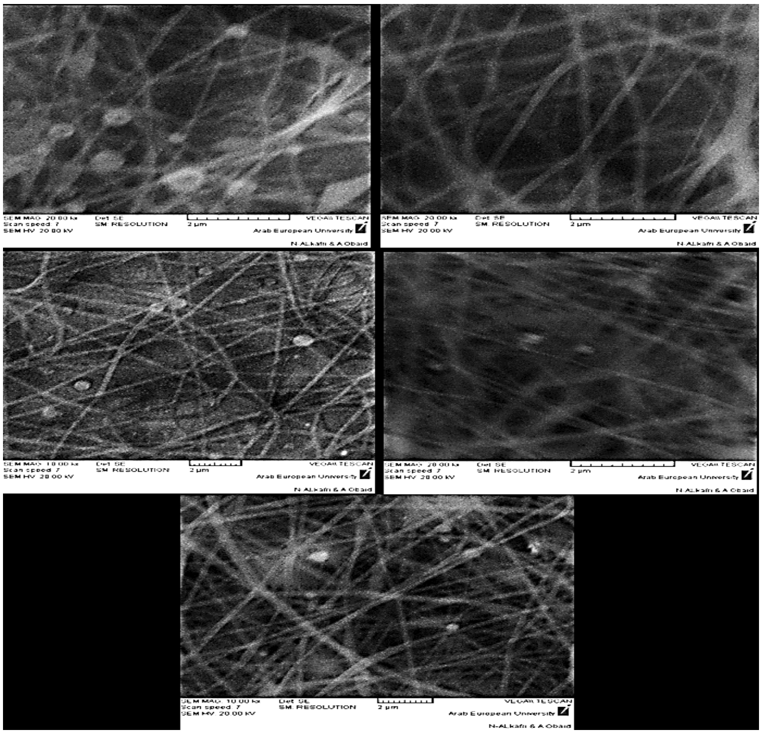
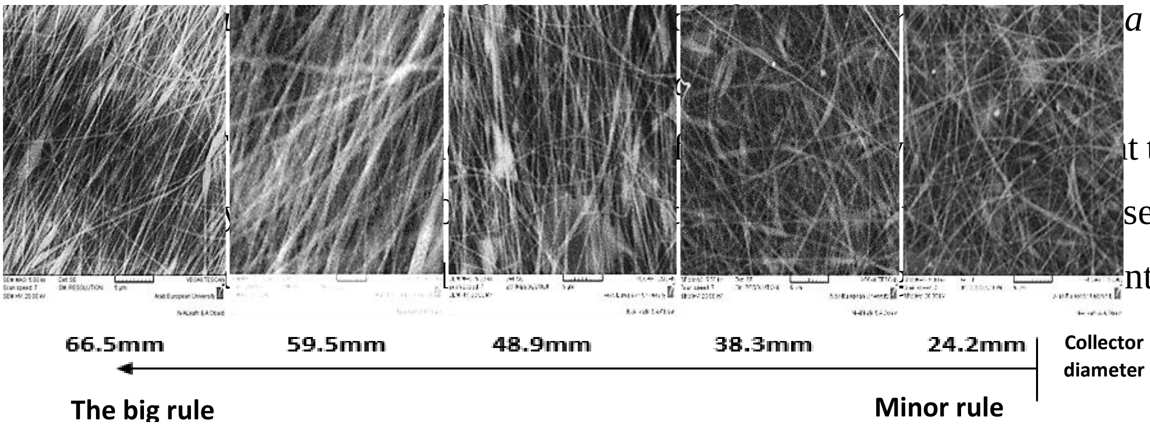
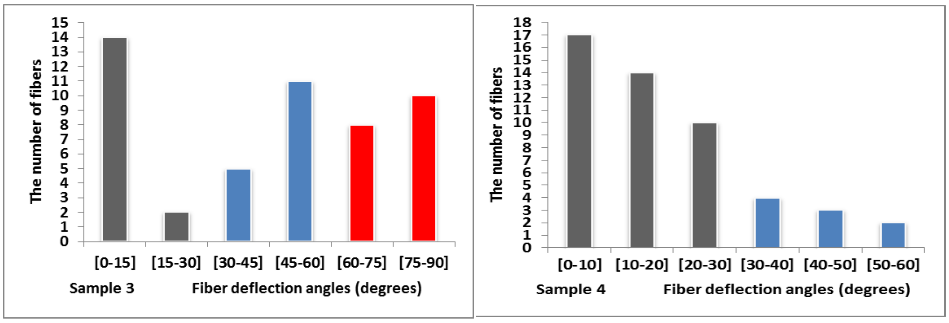


*Figure 4: Images of micro-base samples under a microscope*



The emergence of the trend was confirmed gradually starting from the sample -3- by




calculating the 50-fiber deviation angles from each of them for each of the last three samples as shown in Figure (6).

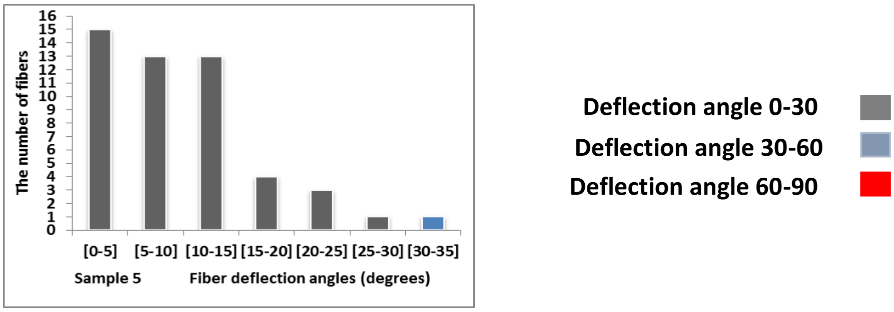



*Figure 6: Skew angle diagrams for the last three samples*

The explanation for the reason for this directive occurring can be explained by the fact that the fiber reaches the surface of the collector at a moment when its surface velocity is large and consequently a tensile strength of the fiber toward rotation [5,c.199].

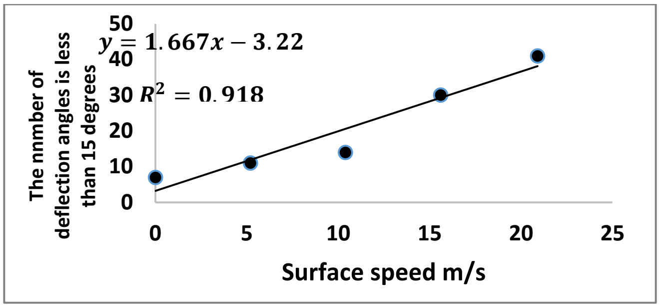



*Figure 7: The relationship between surface velocity and the number of fibers directed from the major base side*

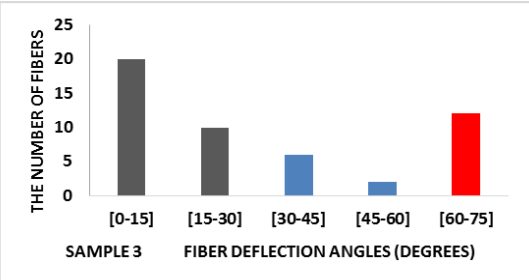
Figure (7) shows the relationship between the surface velocity and the alignment gradient between the fibers taken from the side of the larger base, where we find that the increase in the surface velocity of the complex within the field (0-20.9 m/s), the reason for the gradual increase in the orientation of the fibers up to the highest degree of orientation represented by 82% align. The linear mathematical equation expressing this relationship:

$$y = 1.667x-3.22$$

The correlation coefficient Pearson 0.918. It expresses a linear direct relationship between the surface velocity and the number of directed fibers.

As for Figure 4, it appears that the fibers taken from the base of the lower base showed no direction or alignment. This is due to the fact that the surface velocity of the minimum base of the collector was not sufficient to induce direction, since the lowest surface velocity caused the orientation in the samples of the largest base was 10.4m / s in the third sample, and the largest surface velocity reached by the minimum base of the complex is 7.6 m / s.

Figure (5) shows the results of a gradual study in the appearance of the alignment of the fibers together within the sample-5-, and its relationship to the diameter of the conical complex. As the collector diameter was calculated at each point from which the five parts were taken and it was found that by increasing the diameter of the collector the surface velocity increases and consequently the degree of orientation increases, which was also expressed by the column diagrams of the 50-fiber deviation angles from each of them for each sample from the number-3- .



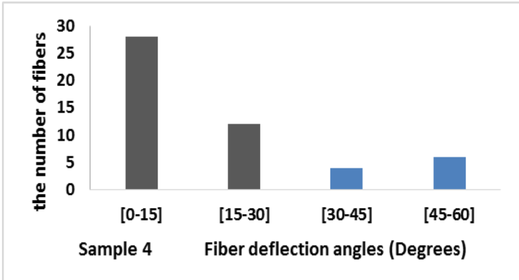
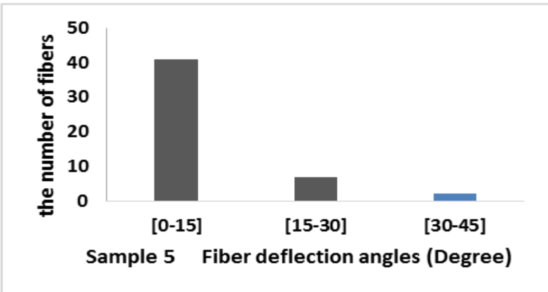




*Figure 8: Skew angle diagrams for the three gradient samples*

It is clear that the thrust began at the diameter of 48.9mm for the conical complex, as the surface velocity value at this point is 15.3 m / s.



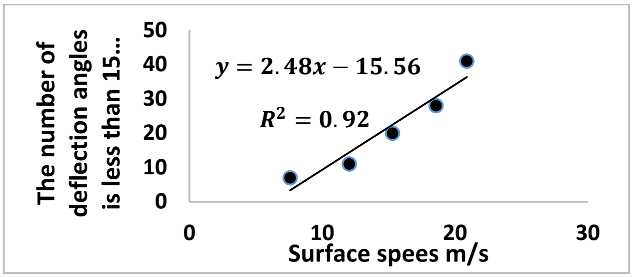



*Figure 8: The relationship between the surface velocity and the number of fibers whose deviation angles are less than 15 degrees*

Figure (8) shows the relationship between the surface velocity and the alignment gradient between the fibers, where we find that the increase in the surface velocity of the collector within the field (7.6-20.9 m/s), the reason for the gradual increase in the fiber orientation to reach the highest degree of orientation represented by 82% alignment. The linear mathematical equation expressing this relationship:

$$y = 2.48x-15.56$$

The Pearson correlation coefficient is 0.92. Which expresses a linear direct relationship between the surface velocity and the number of directed fibers, and thus an inverse relationship between the surface velocity and the deviation angles. Depending on the previous equation, the surface velocity can be expected, which can cause a complete parallel between the fibers.

## 4- Conclusion:

In this study, work was done to know the gradual transformations in the morphology of fibers and put them up to reach the full orientation among them, and define the mathematical relationship that expresses this gradient. The gradient is expressed mathematically by the orientation angles (the angles of the deflection of the fibers from each other).

The study included two parts: The first is the study of the decrease in the angles of the deviation of the fibers from each other by increasing the values of rotational speed from 0 to 6000 rpm, between the two ends of the complex (the major and minor bases), with the stability of the rest of the process parameters, where this decrease was explained by increasing the surface speed of the complex gradually Which caused the gradient to appear in alignment from the speed value of 10.4 m / s to the maximum value of 20.9 m / s.

Mathematical relationship expressing this gradient:

$$y = 1.667x-3.22$$

x: the surface velocity of the collector Y: number of directed fibers

The second part of the study included a study of gradual shifts in fiber morphology within a single sample that started at a surface velocity of 15.3 m / s and increased with increasing cone diameter. The relationship between the surface velocity of the collector and the number of fibers whose deviation angles are less than 15 degrees has been reached, through which the appropriate speed can be expected for the occurrence of a complete parallel between the fibers, namely:

$$y = 2.48x-15.56$$

x: the surface velocity of the collector Y: number of directed fibers

The previous study of the gradient in the alignment of fibers, whether resulting from the variable rotational speed of the complex or the diameter of the variable conical complex, helps us to know the surface speeds appropriate for the occurrence of direction, as well as the percentage of steering within the network.

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