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The Effect of Different Process Parameters on Polyamide 66 Nano Fiber by Force Spinning Method

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Abstract: Nowadays, polymer Nano fibers have been extensively used in the industrial and research fields. At the present, products such as filters, wound healing, vessels, batteries, and many other types of products which are manufactured from polymeric Nano fibers are find in the markets. There are various methods for the polymeric nanofibers production. In this research, polyamide 66 nano fibers were produced by force spinning®. In this way, the effect of different parameters such as concentrations of polymer solution, chamber temperature and rotation speed (RPM) were investigated. In this research we find out the average diameter PA66 nanofiber it was within nanoscale. Also the production time was during few second and the speed flow rate was 6.5 meter over second.

INTRODUCTION:

Nowadays, nanofibers are highly researched by the researchers. There are several methods for producing Nano Fibers, One of these methods is ForceSpinning Method. The Force Spinning Method with the help of the inherent properties of the material, produces polymer fibers in the shortest possible time. Sarkar et al., in 2010 at the University of Texas introduced a project called Force spinning, This method has the capability to produce a very large volume of nano-fibers in little time, Dependent on the dielectric solution and the concentration used is very high and because of the high speed of production, the nozzle is not blocked [1]. G.L. Dotto, et al, have been developed with the Forcespinning technology of chitosan / polyamide nanofibres. The results showed that in the experimental conditions, chitosan / polyamide nanofibers with a diameter of 100 to 500 nm were obtained using the forcespinning technique at a rate of production of 3 gr per hour[2]. Polyamide 66 has many usage in the industry, It was the same thing to use this material in this research. The solvent of this formic acid polymer is presented in Table 1, combining the percentage of PA66 and formic acid. This polymer is made of 20, 25 and 30 Weight percent in formic acid.

Table 1: Weight percent of polyamide solutions 66

	Formic acid(gr)	PA66(gr)	Magnet stirrer temperature (°C)
a	100	20	95
b	100	25	95
c	100	30	95

Figure 1 shows the mean diameter of the fiber with the variable solution, In this system, the RPM, temperature and nozzle are constant And the concentration of the solution is variable .In solutions with concentrations of 20, 25 and 30 Weight percent, The average fiber diameter is 664, 74 and 59 nanometers, Therefore, by increasing the concentration of the polymer, the mean diameter of the fiber increases. In Figure 2, the system temperature, nozzle and constant solution and the only variable is the RPM. It is observed in this material that by increasing RPM, we

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can see nanofibers thicker. Respectively, at 6000, 9000 and 12000 RPM, the fiber diameter is 73, 114, and 135 nanometers. In Figure 3, Parameters such as nozzle, rpm and concentration are considered constant and only the temperature varies. Respectively, The temperatures at 70, 90 and 110 ° C were investigated, with a mean diameter of 148, 118 and 114 nm. We see that the diameter of the fiber decreases with increasing temperature. Images 1 and 2 show SEM images of nanofibers PA66. Figure 4 is captured with a magnification of 100 nm. The minimum diameter observed in this fiber is 18 nm, with a maximum diameter of 61 nanofibers and an average fiber diameter of 36 nm. Figure 5 is also shown with a magnification of 400 nm, with a minimum diameter of 55 nm and a maximum diameter of 231 nanometers, with an average fiber diameter of 114 nm, Using the Image j software, all of these fibers are measured. Figure 6 shows the rheometer test, which is carried out at a temperature range of 84 to 95 ° C, which increases the viscosity of formic acid evaporation from the polymer solution.

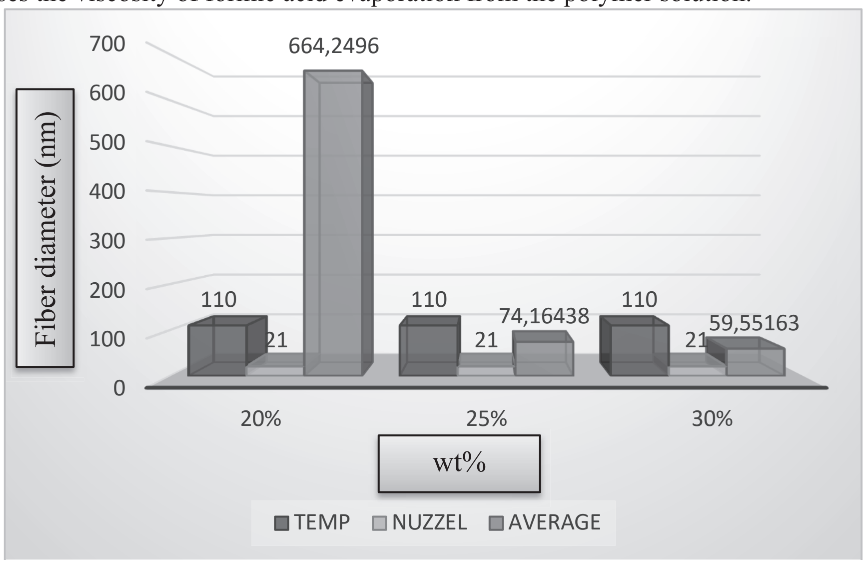

Figure 1: Average fiber diameter with variable PA66 solution

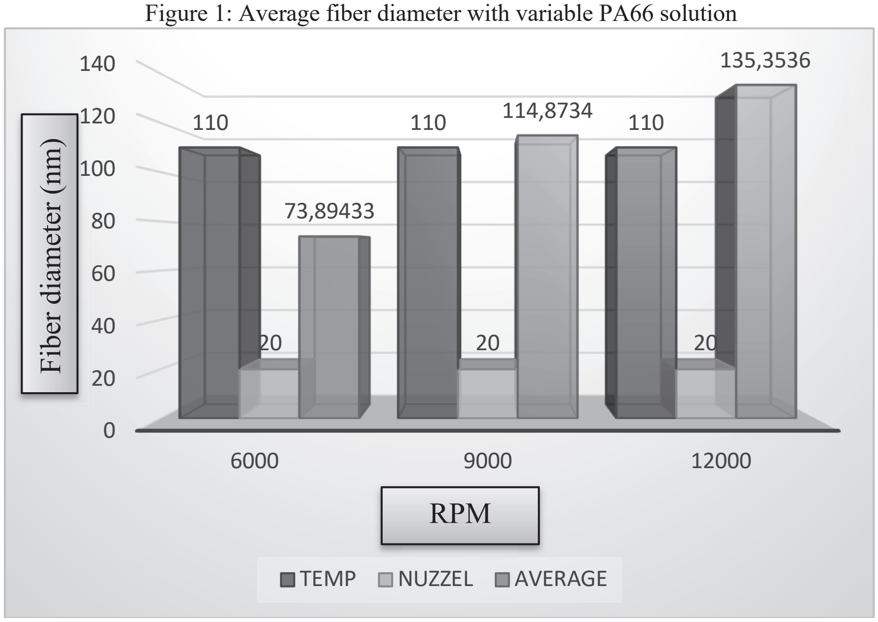

Figure 2: Average fiber diameter with varying variable speed PA66

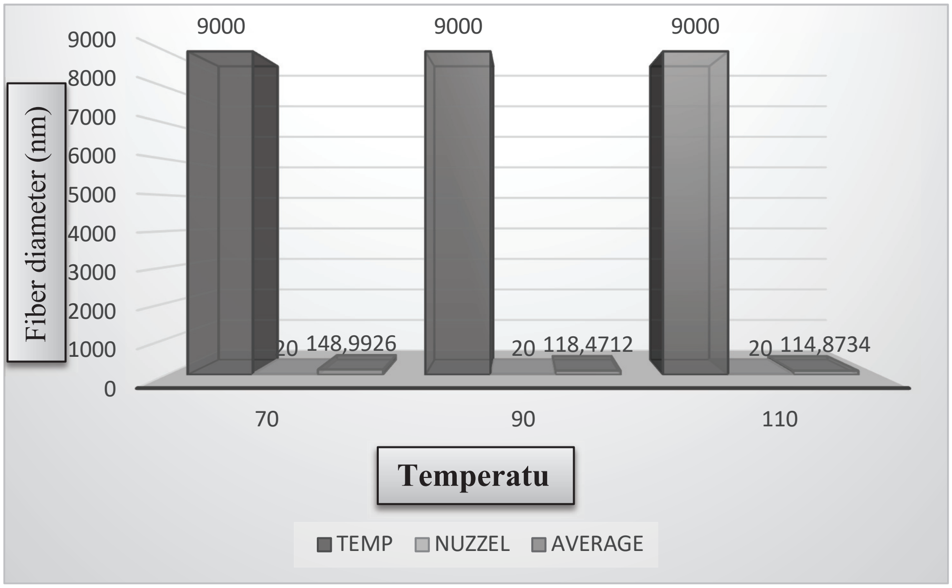

Figure 3: Average fiber diameter with variable temperature PA 66

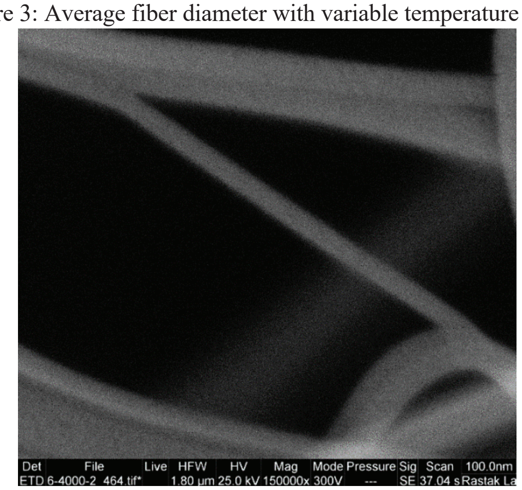

Figure 4: SEM image - PA66

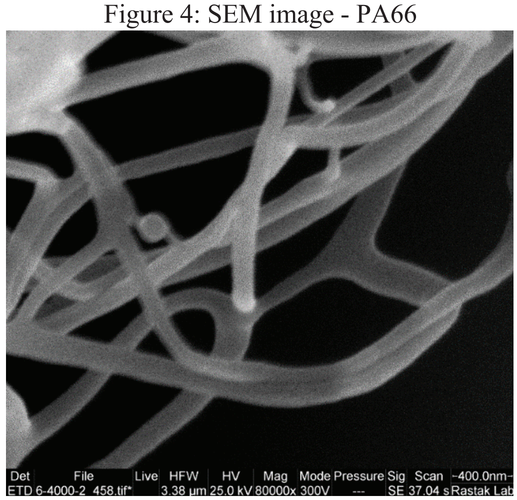

Figure 5: SEM image - PA66

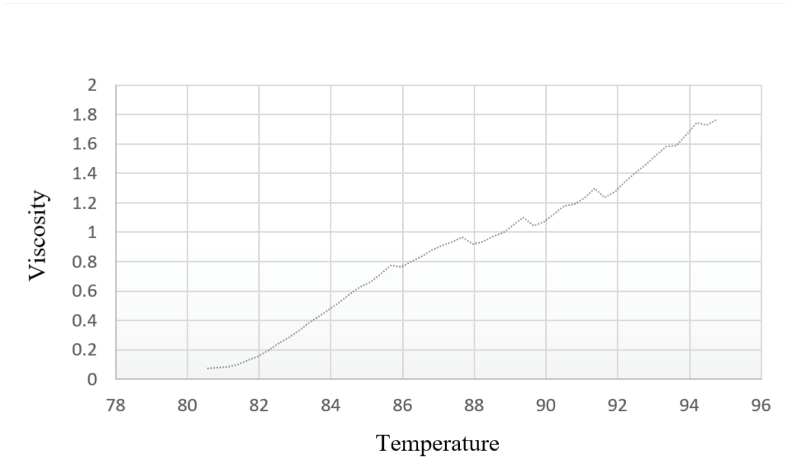

Figure 6: Rheometer Test 66 PA

In this study, considering the viscosity and the various factors involved in the fiber production process, we examined the rate of discharge of the solution from the spinneret and the volumetric flow rate of each of the materials, and we arrive at the following results. First, using the following formula for each material, the speed of the solution of the spinneret is calculated and, given the velocity obtained, we obtain the volume of discharge [3]:

$$U= - \frac{8L\mu}{\rho r^2} + \frac{1}{2}\sqrt{256(\frac{L\mu}{\rho r^2})^2 + 4\Omega^2[D^2 + 2L(C - \frac{L}{2})} \quad (1)$$

$L=$ 3.8 cm
$\mu=$ 1.764 Pa.s
$\rho=$ 1.14 g/ml
$r=$ 0.03 cm
$\Omega=$ 9000 RPM
$D=$ 4 cm
$C=$ 7.8 cm

U = 650.03 cm/s
or
U = 6.5 m/s

Here, taking into account the production conditions s in two processes of electrospinning and force spinning, we will have a comparison with the production process of these two methods. In an electrospinning method, different values of 0.8 ml of polymer solution are obtained per hour, which can be obtained according to the following formula:

$$Q_V = \frac{V}{t}$$
$$Q_{V(ES)} = \frac{0.8\ cm^3}{3600s} = 0.0002\ \frac{cm^3}{s} \quad (2)$$

and in spurting forwards, according to the achieved fluxes, the slowest production time was observed to be about 30 seconds. Due to the volume of 25 ml of the reservoir, we can obtain the volumetric flow as follows:

$$Q_{V(FS)} = \frac{25\ cm^3}{30s} = 0.8333\frac{cm^3}{s}$$

With respect to the values obtained, we can compare the rate of production of the force spinnig system with electrospinning as follows:

$$\rho_{Fluid} = \frac{Q_{V(FS)}}{Q_{V(ES)}} \approx 4000 \quad (3)$$

As can be seen, the speed of force spinning fibers production is at least 4000 times greater than that of electrospinning.

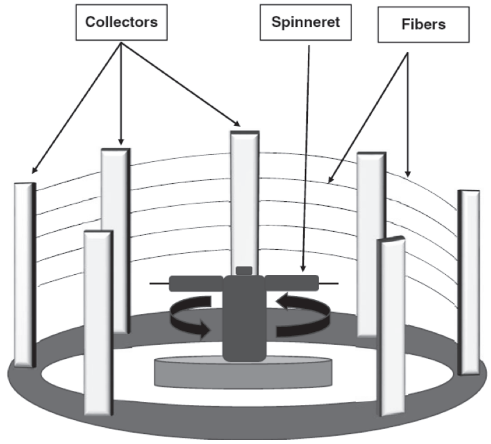

Figure 7: force spinning schematic [4]

CONCLUSION

The Force spinning machine (Figure 7) has the ability to produce polymer nanofibers, The speed of fiber production in this process is at least 4000 times greater than that of electrospinning, which is a factor in reducing production costs. In addition, the Forcespinning system has the ability to produce nanoscale nanoparticles at the nanoscale. The device also has the ability to receive at different temperatures different fibers of different diameter, which indicates the effect of temperature on the concentration of polymer solution and evaporation of solvent from the fiber at different times. Also, the nozzle type changes the conditions for the fiber that can be obtained with different diameters. The high speed of this system has the ability to produce more fiber at a low cost, which can be used to prepare and use non-woven fabrics for sale to the market. The minimum diameter received was 18 nm, and the production speed was calculated to be 6.5 m / s.

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