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# Manufacturing of Nylon 6,6 Nanofibers using Electrospinning

***Abstract*— In the following paper manufacturing of nylon6,6 nanofibers using electrospinning and its experimental work is presented. Nanofibers were manufactured by electrospinning its solution. Fibers diameter were determined by electron microscope. The solvent used in the electrospinning solution of formic acid under the electric field of 22kv with flow rate of 0.4ml/hr. distance between syringe and drum 13cm. For 25ml of formic acid 3.6grams of nylon 6,6 was used, without altering room conditions.**

***Index Terms*—** Characterization, Electrospinning, Nylon6,6

## I. INTRODUCTION

The process of electrospinning is used extensively in fiber forming process. To manufacture nanofibers various methods some of them are template synthesis and self-assembly but their major limitation is scalability [1].Not only electrospinning overcomes this limitation but also reduces the diameters of fibers to Nano scale. Cost effective manner to obtain aligned as well as random fibers offering wide choices of materials are highlighting characteristics of electrospinning process in modern science community [2,3].

### *A. Electrospinning process and setup*

Polymeric solution is immersed in high voltage electric field generated by grounded voltage supply. This solution is filled in syringe. [3] Electrically charged jet is generated of polymeric solution by overcoming the solution's surface tension, resulting the Taylor's cone. An electrical tension is applied. During the jet's trajectory to the collector, the solvent evaporates; thus, we get nanofibers on the metallic collector. Solutions Viscosity, applied electrical field, solvent type, ionic salts addition (which increases the electrical conductivity), temperature and flow rate, others are the variables of this process [4,5].

This work is used for alignment of nanofibers with the help of rotating drum collector [6]. Logically, if the fibers are being rolled on the rotating drum at the same speed that they are being elongated [7].

High voltage contains one electrode is connected to syringe which contains polymer solution/melt and the second one is connected to collector as indicated in Fig. 1 and actual setup at Bharti Vidyapeeth, Pune is shown in Fig 2.

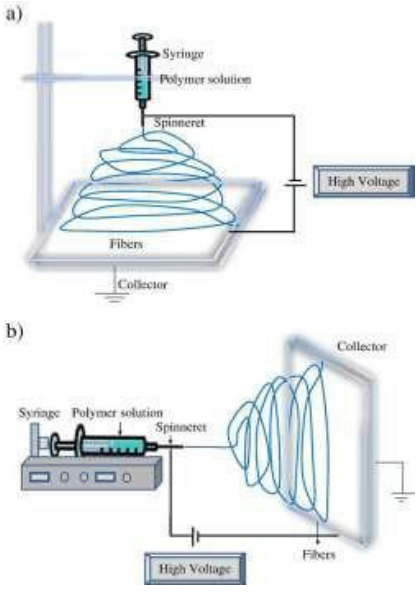


Figure 1. Schematic diagram of set up of electrospinning apparatus
a) typical vertical set up, b) horizontal set up [6]


Figure 2: Actual set up for Electrospinning process at BVUCOE, Pune

## II. Experimental Work

### A. *Materials:*

For preparation of solution the solvent used for the electrospinning solution was formic acid (98%-100%, from Rankem®) with density of –

1.14 g.mL–1 at 25 °C, molar mass of 46.03 g.mol–1, melting point of 250-260 °C.

Nylon 6,6 from Sigma Aldrich® of molecular weight 262.35- were used.

### B. *Solution preparation:*

The Nylon 6,6/formic acid solutions were prepared at room temperature. The polyamide concentration in the formic acid was 3.6 grams in 25ml of formic acid. Then the solution was stirred with the help of magnetic stirrer for 90 minutes for homogenous mixture and then kept idle for 15 hours prior to electrospinning.

Figure 3. Actual weight measurement of nylon 6,6 and formic acid 25ml

## III. Electrospinning And Characterization

### A. *Electrospinning*

The electrospinning equipment was consist of a syringe (2 mL), a cylindrical collector and a high voltage supply, as shown in figure 1[6]. The distance between collector and syringe was maintained at 13cm while the electrical field was at 22kV with flow rate of 0.4ml/hr. The polymer nanofibers were collected on aluminium foil which was wounded on drum.

The solution of electrospinning was done by without changing room condition.

### B. *Characterization*

Scanning Electron Microscope (SEM) was used for characterization of Nylon 6,6 at facility at ICON Analytical Equipment Pvt. Ltd., Mumbai . To determine the diameter of fiber obtained through electrospinning.

### C. *Scanning Electron Microscopy*

High energy beam of electrons is used to image the sample surface. While light-based microscopes use glass lenses in series to bend light waves and create a magnified image while the SEM images are by using electrons instead of light waves[8]. The SEM shows much detailed three-dimensional images at high magnifications (up to ×300000) as in case of conventional microscope (up to × 10000).Black and White images are due to absence of light waves[9].

The surface structure of polymer nanofibers can be captured through SEM with great clarity. [7,9].

### D. *SEM images of characterization :*

Figure 5: Images of fiber obtained on foil

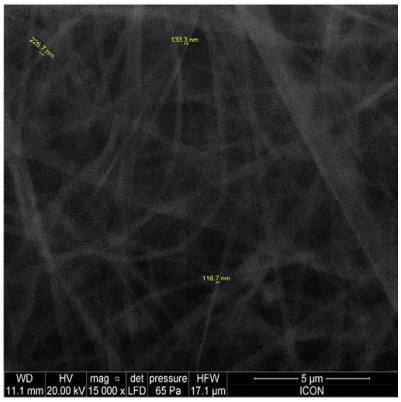


Figure 6: SEM of Nylon 6,6(116.7nm) –Distance-13cm, Voltage- 22kV Flow rate-0.4ml/hr.

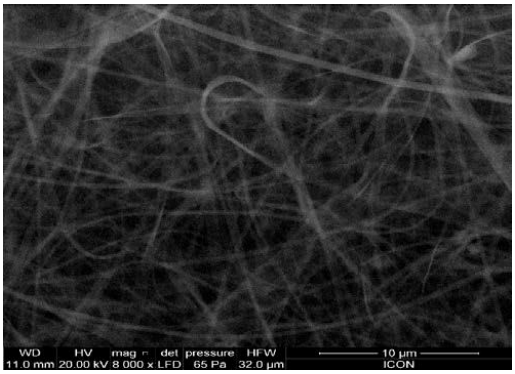


Figure 7: SEM image of Nylon 6,6

## III. Applications

Nanofibers of nylon 6,6 are used for harvesting microalgae from water which in turns feedstock into biodiesel.

Applications such as sportswear, protective clothing and orthopedic dressing have wide use of waterproof clothes, clothing comfort comprises breathability as important factor. Due to high porosity and large surface area to volume ratio nanofibers are topic of interest in above industries[8].

Combining various properties like abrasion resistance,strength,flexibility and toughness offers consumer applications. While some engineering applications in automobile sector [4,6].

## IV. Conclusions

- Fibers of wide variety of solutions can be obtained through Electrospinning process.
- Minimum diameter of 116.7nm with parameters Distance 13cm, Voltage 22kV Flow rate- 0.4ml/hr. for nylon 6,6 nanofibers was manufactured.
- Distance plays a very importance role in optimizing diameter, diameter can be reduced by increasing distance parameter.

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