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# Effects Of Processing Parameters On Morphology Of Polyvinyl Alcohol Based Electrospun Nano Fiber

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**Abstract**—Electrospinning is a process that is used to produce nano scale fibers from the melted polymer solution under high electric field. Nanofiber is used in many application such as for smart textile, filtering, food packaging, sensors and energy etc. Because of its mechanical strength, it is also used in synthesis of composite polymer. Process variables such voltage across spinneret and collector, distance between spinneret and collector, flow rate of polymer solution for electrospinning make effect on the nanofiber such as diameter of nanofiber, uniformity in diameter and bead formation of nano fiber.

Synthesis of nanofiber using electrospinning technic was used on poly vinyl alcohol (PVA) polymer solution with Poly(4-styrenesulfonic acid) (PSSA). An additional material used as surfactant was added in this polymer solution. Effects of variables were observed on the responses like diameter, uniformity in diameter & beads formation of nanofiber. Interactive and individual responses of variables were observed. In this paper, effects of above mentioned variables were investigated on PVA with PSSA based nano fiber.

**Index Terms**—Electrospinning, nonofiber, composite polymer, design of experiment

## 1 INTRODUCTION

Electrospinning is a technic used to produce fiber from polymer solution. The diameter of polymer fiber is in nano scale (in the range of 100 nm) that is why it is called as nano fiber. Being very small in size develop new characteristics such as very large surface area to volume ratio (this ratio for a nanofiber can be as large as $10^3$ times of that of a microfiber), mechanical strength (tensile strength, stiffness).These properties make polymer a very versatile material in various applications.

Electrospinning process is not a new one. It can be considered as a variation of well known electrospray process. It is possible to use electrostatic fields to form and accelerate liquid jets from the tip of a capillary[1], [2].The electrospinning process has regained more attention in recent years, probably due surging interest in nanotechnology, as ultrafine fibers or fibrous structures of various polymers with diameters down to submicron's or nanometers can be easily fabricated with this process.

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## 2 EXPERIMENTAL

### 2.1 Materials

Poly(vinyl alcohol)(polymerization degree of 2400, hydrolysis degree of 98–99) was supplied by Sinopharm Chemical Reagent Co., Ltd. Poly(4-styrenesulfonic acid) solution (Mw ~75,000, 18 weight % in $H_2O$) was purchased from Sigma Aldrich.Polyethylene glycol hexadecyl ether i.e. Brij 58 (nonionic, average $M_n$ ~1124) surfactant was purchased from Sigma Aldrich. All the materials were used as received.

### 2.2 Selection of Factors

After going into different papers and literature survey [3]–[7] , five factors that influences in electrospinning have been chosen for screening. These factors are; (1) Distance between spinneret and collector, in cm (2) Applied Voltage of electrospinning (KV) (3) Flow rate of solution via syringe pump (ml/hr), (4)Concentration of surfactant in polymer solution (weight % of solution) (5) Concentration of PSSA in PVA solution (weight % of PVA). After deciding factors, two level for each factors has been selected for screening analysis. Table 1 showed the screening chart that has been prepared for experiment.

Table 1 Factors with low & high level

| Code | Factors | Unit | Low Level (-1) | High Level (+1) |
|---|---|---|---|---|
| A | Distance between spinneret and collector | cm | 10 | 15 |
| B | Applied Voltage of electrospinning | KV | 15 | 18 |
| C | Flow rate of solution | ml/hr | 0.03 | 0.06 |
| D | Concentration of surfactant | w/w | 0.00 | 0.02 |
| E | Concentration of PSSA | w/v | 10.0 | 20.0 |

### 2.3 Preparation of PVA-PSSA-Brij58 Solution

PVAwas dissolved in distilled water with stirring for 4 hrs to make PVA solution. A homogeneous mixture was obtained after 4 hrs. Poly(4-styrenesulfonic acid) i.e. PSSA was added in PVA solution with specified concentration mentioned in screening table and stirring for 3 hrs to make homogeneous solution of PVA-PSSA.

Nonionic surfactant Polyethylene glycol hexadecyl ether i.e. Brij 58 was also added in the PVA-PSSA solution. This mixture is again agitated for 2 hrs to become a homogeneous solution of PVA-PSSA-Brij58.

### 2.4 Electrospinning

Polymeric solution was transferred to the nozzle spinneret by the precise syringepump. High voltage was applied at nozzle spinneret and distance between spinneret and collector was set. All the values of factors had been set as per screening table. Aluminum foil was used to collect the nanofiber. The time of electrospinning was set as 30 minutes for all the samples. Experiment was run as per order develop in the design.

## 3 Result & Discussion

### 3.1 Morphology of Sample by SEM

Sixteen sample ware prepared for nano fiber. Morphological analysis of all samples were carried out by scanning electron microscopy (SEM) (Model JSM6510LV, JEOL, Japan). SEM images were used for diameter analysis of nanofibre using "ImageJ" software. Fig 1 shows the SEM image of sample no 1.

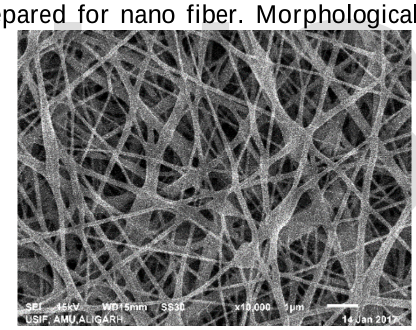

*Fig 1 SEM image for sample 01 (X10000)*

### 3.2 Nanofiber diameter analysis

SEM images were used to analyze the diameter of nanofiber. Diameters of nanofiber were evaluated by image processing method using "ImageJ" software. Normally more than 70 fibers were observes in each image. Diameter analysis of all the samples were carried out. Fig 2 showed the variation in average diameter of all the samples. Majority of samples showed average diameter between 100-200 nm.

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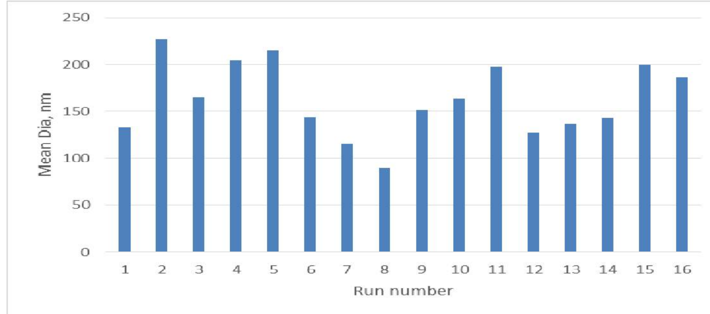


### 3.3 Nanofiber beads formation

Beads formation, which is undesirable in naofiber, lowers the quality of nanofiber. Beads formation of SEM image also investigated by image j software. Fig 3 shows the beads forma-

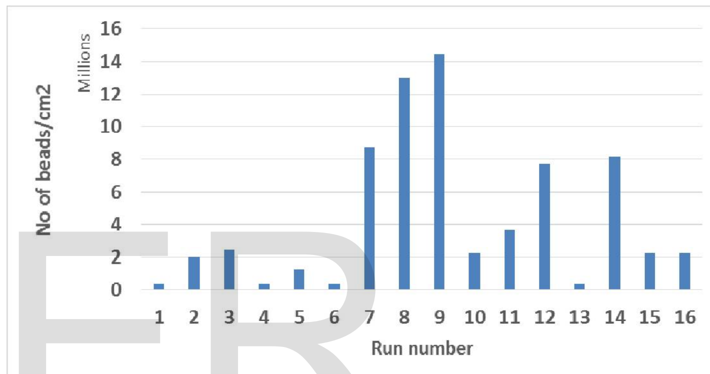


*Fig 3 Beads formation*

tion for all samples.

### 3.4 Effect of Parameters on responses

#### 3.4.1 Effect of Voltage

Voltage is an important factor in nanofiber fabrication. Fig 4 shows the effect of voltage on mean diame-ter as well as no of beads formation. On increasing voltagedecreases diameter of

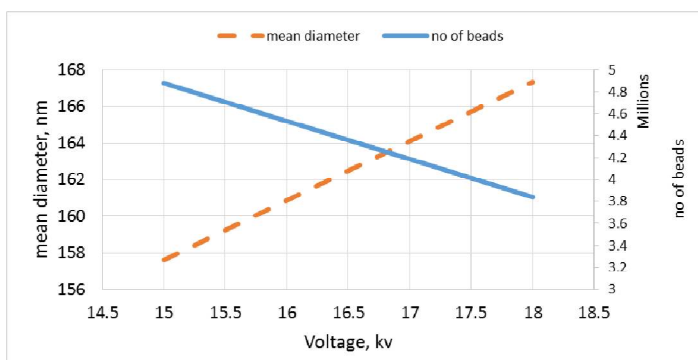


*Fig 4 E ffect of voltage on responses*

nanofibers and increases beads. Decrease in diameter can be attributed at high voltage as more potential created between needle tip to collector then more force is observed. High beads formation can also be explained in same way as high potential cause high beads.

#### 3.4.2 Effect of Distance

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Distance between needle tip to collector also affect the diameter and beads formation of nanofiber. Fig 5 shows the effect of

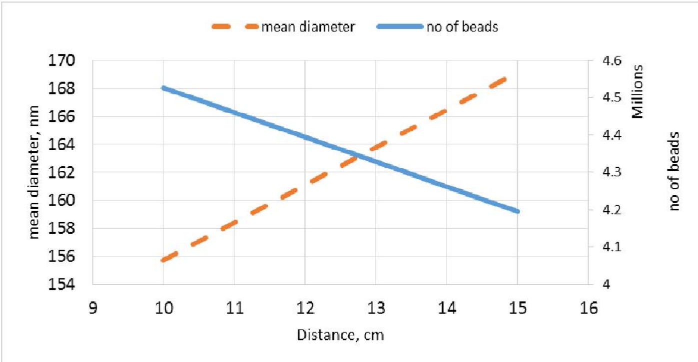


*Fig 5 Effect of distance on responses*

distance for mean diameter and beads. Increasing distance decreases diameter and increase beads formation.

**3.4.3 Effect of flow rate**

Flow rate of polymer solution is also analyzed for responses. Fig 6 shows the effect of flowrate on responses. Increasing

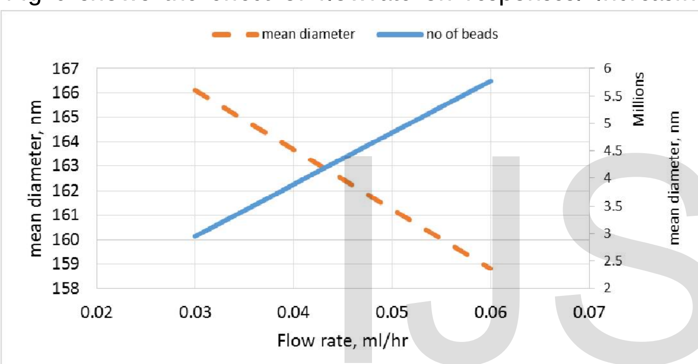


*Fig 6 Effect of flowrate*

flowrate increases beads formation which is not desirable and decreases mean diameter of nanofiber.

**3.4.4 Effect of Surfactant**

Surfactant play an important role in nanofiber synthesis. Fig 7 shows the effect of surfactant in poly-mer. On increasing amount of surfactant increases beads formation but decreases mean diameter.

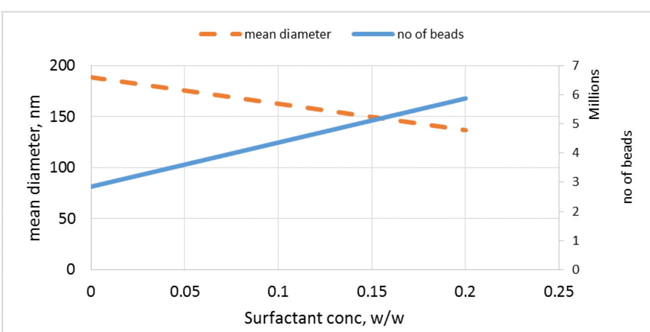


*Fig 7 Effect of surfactant*

**3.4.5 Effect of PSSA**

Amount of PSSA in PVA also influence the nanofiber in terms of mean diameter and beads formation. Increasing amount of PSSA increases both responses in similar fashion as shown in Fig 8.

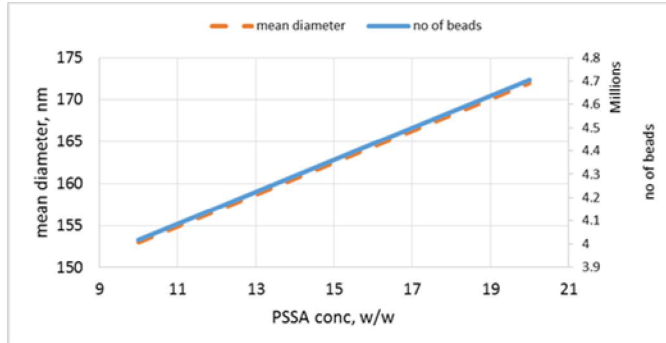


*Fig 8 Effect of PSSA*

## 4 Conclusion

Processing and solution parameter greatlyinfluence the synthesis of nanofibers. Some important processing parameters and solution parameters are used to find out effect on diameter and beads formation of the nanofibers. Highest effect on diameter shown by use of surfactant and beads formation is mainly influenced by flow rate and surfactant. Low flowrate with low surfactant are desired fow less bead formation.

## 5 Acknowledgment

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