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Synthesis and Parametric Investigation of Nanofibers by Using Electrospinning Process

*Ghansham Firame **D.B. Jadhav ***S.S. Chavan

* Research Scholar Bharati Vidyapeeth University COE, Pune

** Assistant Professor Bharati Vidyapeeth University COE, Pune.

*** Associate Professor Bharati Vidyapeeth University COE, Pune

ABSTRACT

Nanotechnology has attracted the attention of the researchers due to their surface area to volume ratio. Addition of any nano materials in form of nano particle, fibers, tubes, flakes etc has enhanced the material properties. Here we have review the parameters which affects the dimension and properties of the nano fiber. The polymer nano fibers can be produced by using various processing techniques like drawing, self assembly, template synthesis, phase separation, electrospinning etc. Out of these processing techniques electrospinning is a best way to produce a polymer nano fiber with small diameter (10 nm to 1500nm). Due to large length to diameter ratio and small mass to volume ratio these nano- size fibers has many application in industry. The parameters affecting fiber diameter and properties can be varied by adjusting the concentration of the polymer solution, distance from tip to collector, applied electric field , flow rate, viscosity, surface tension, electrical conductivity of solution and temperature of solution, Ionic salt addition, Molecular weight etc.

Keywords : Electrospinning, Nano fiber.

INTRODUCTION

Drawing, Template Synthesis, Phase Separation and Self assembly are the methods useful for developing 1-D nano structures but these methods have limitations of scalability [1]. In contrast, Electrospinning is a simple and versatile process to generate uniform diameter fibers in random, as well as aligned fashion from wide variety of polymer, ceramic or composite solutions in cost effective manner. Low cost, scalability for mass manufacture, several areas of applications, wide variety of materials are the parameters that make electrospinning very popular process among research community associated with One Dimensional (1-D) nanostructures. Figure 1 demonstrates wide variety of applications of electrospun nanfibers. Currently, over one hundred polymers, mainly in dissolved form and some in melt form have been successfully electrospun[30] There are fundamental four components associated with the electrospinning process viz. spinneret, voltage supply, and collector and dispensing pump as seen in the schematic of Figure 1. There are basically three parts 1) A high voltage supplier, 2) A capillary tube with a pipette or needle of small diameter, and 3) Metal collecting screen. One electrode is placed into the polymer solution/melt and the other attached to the metal collector as indicated in Fig. 1. The electric field produces surface tension on the polymer, which induces a charge on the surface of the polymer. Further with increasing the electric field, a critical value is attained at which the repulsive electrostatic force overcomes the surface tension and the charged jet of the fluid is ejected in form of polymer nanofibers.

TYPES OF FIBERS BY ELECTROSPINING:

a) Natural polymer Nanofibers
b) Functional polymer Nanofibers
 -i) Natural ii) Synthetic polymer iii) Homo polymer iv) Syn thetic co-polymer
c) Ceramic Nanofibers
d) Composite Nanofibers
e) Norel nano Composite fibers

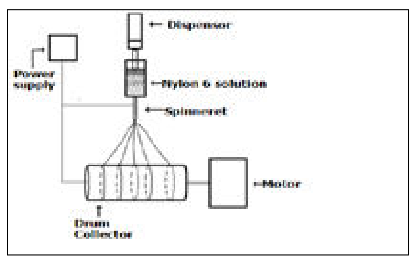

Fig 1. Schematic of Electrospinning Setup for . Aligned Fiber Deposition

Fig 2. Actual Setup for Electrospinning

TABLE NO.1 PARAMETERS EFFECT OF ELECTROSPINNING PROCESS:

Parameter	Solution and values	Morphology
Viscosity [3],[10]	Poly ethylene oxide (1-20poise)	· Beads –Higher the viscosity, lower are the beads and vice versa. · Diameter –As viscosity increase diameter increase and vice versa.
	Cellulose acetate (1.2 -10.2 poises) [20]	· Viscosity above 10.2 poises could not be electrospun into fibers · Fluid jet broke up to droplets due to too low viscosity Viscosity increased after solgel aging

Surface tension [3]	Poly ethylene oxide (35-55 dyne /cm)	· Beads –Surface tension increases the beads formation increase and vice versa · Diameter –Surface tension increase diameter increase and vice versa.
Electric Field [3,10]	Poly ethylene oxide(5kv -7kv)	· Beads-Electric field increases the beads formation increases and vice versa . · Diameter-Electric field increase diameter decreases and vice versa.
Concentration [10,11]	PDLA (20%-40%)	· Beads- Higher the concentration, less the beads · Diameter –Power law relationship with exponent of about 0.5 and 0.3 is observed.
Ionic salt addition [10,11]	PDLA (1wt% salt)	· Beads- Addition of ionic salt reduces the beads. · Diameter –Addition of ionic salt gives the uniform diameter ,also helps in reducing the diameter .Fiber diameter depends on the radius of the ions.
Molecular weight [3,12]	PS solution 40-200 mg/ml for PMMA fibers	· Beads –Higher the molecular weight less the beads formation · Diameter –As molecular weight increase the diameter also increases.
Feed rate [12]	20-70	· Beads –As feed rate increases the beads increases. · Diameter –Higher the feed rate larger the diameter.

TABLE NO.02 PROCESS PARAMETER WHICH EFFECTS ON THE DIAMETER OF THE POLYMER :

Polymer Solution (Solvent)	Concentration	Electrical Field	Flow rate	Distance	Fiber Diameter	Reference
PCL (ACETONE)	6-20 %	10-25 kv	1-5 ml/hr	7-25cm	77-375 nm	[13]
PCL (ACETONE)	6 %	21 kv		15 cm	77 nm	[13]
SF (FORMIC ACID)	8-14 %	10-20 kv	20 ul/min	10 cm	77-207 nm	[14]
SF (FORMIC ACID)	10 %	10 kv	20 ul/min	10 cm	77.7 nm	[14]
PAN (DMF)	4-12 %	2.5 kv/cm	--	10 cm	116.8 nm	[15]
PAN (DMF)	4-12 %	2.5 kv/cm	--	10 cm	Below 100 nm	[15]
PAN (DMF)	6-12 %	10- 20 kv	--	10 cm	208-1170 nm	16]
PAN (DMF)	6 %	20 kv	--	10 cm	208 nm	[16]
CHITOSAN (AcOH)	7 %	17 KV	0.008 mg/h	16 cm	250 nm	[17]
PANCMA (DMF)	4 %	8 kv	3 ml/hr	18 cm	100 nm	[18]
PVA (Distilled water)	10 %	20 kv	--	15 cm	400-600 nm	[19]
CHITOSAN (ACETIC ACID)	7 %	5 kv/cm	--	--	100 nm	[20]
PPV (ETHANOL)	--	15 kv	--	40 cm	100 nm	[21]
POLY {DTE Carbonate}	15 % (w/v)	20 kv	--	10 cm	1.9 um	[22]
CHITOSAN/ PEO= 90/10 (ACETIC ACID)	--	20-25 KV	--	17-20 cm	38- 62 nm	[23]
PEO (distilled water)	5 %	10 kv	0.05 ml/min	30 cm	320 nm	[24]
Nylon 6 (formic acid)	--	40 kv	--	15 cm	145 nm	[25]
Nylon 6 (formic acid)	20 %	15 kv	--	8 cm	924 nm	[26]
PEO (distilled water)	1 %	700 v/cm	0.01 cm^3/min	--	80 nm	[27]
PEO (distilled water)	1.5 %	700 v/cm	0.01 cm^3/min	--	80 nm	[27]

EXPERIMENTATION:-

We make solution of Nylon 6 granules in formic acid (solvent) at 20 % concentration of nylon. Prepared solution is fill in to the syringe of electrospinning machine. Using optimum parameters as voltage in Kv, flow rate in ml/hr & distance between syringe and rotating drum is in cm. Nylon fibers are collected on aluminum foil sheet which is wound on rotating drum collector. The results after measurement of fiber diameter on SEM (scanning electron microscope) are as shown on figure below. SEM gives images of fibers collected on aluminum foil sheet by using this image the fiber diameter is calculated.

RESULTS:-

Following Nylon-6 nanofibers are spun to optimize the diameter with the three parameter i.e Distance between spinneret and collector, voltage and flow rate of solution

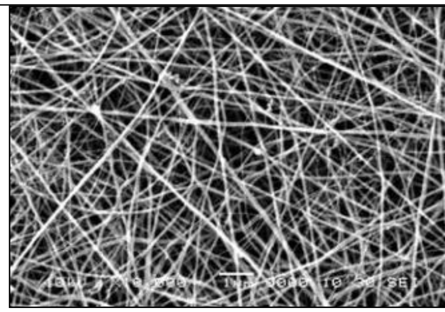

Fig.3 SEM of Nylon 6 (47 nm) –Distance-15cm,Voltage 20KV Flow rate-0.2ml/hr

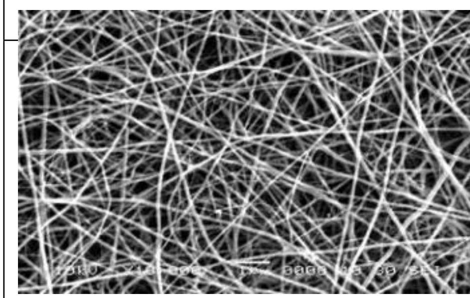

Fig.4 SEM of Nylon 6 (25 nm) –Distance-15cm,Voltage 20KV Flow rate-0.1ml/hr

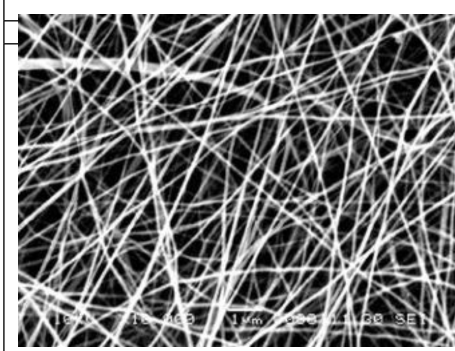

Fig.5 SEM of Nylon 6 (42 nm) –Distance-15cm,Voltage 15KV Flow rate-0.2ml/hr

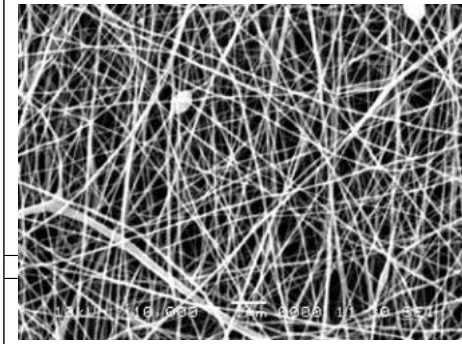

Fig.6 SEM of Nylon 6 (35 nm) –Distance-15cm,Voltage 15KV Flow rate-0.1ml/hr

CONCLUSION:

1. Electrospinning is found to be really cost effective method to synthesis 1-D nanostructures from wide variety of poly-

mers, ceramics,composite solutions.

2. Due to reduction in diameter of the fiber there is exponential improvement in surface area of the fiber mesh. this Charactertics for medical ,automobile, defense ,aerospace, sensory etc. applications.
3. make eletrospun nanofibers very effective With the innumerable combinations of materials possibilities and effectiveness of electrospun nanofibers sheets for prospective applications ,there has been proliferation of research related to eletrospinning .only drawback looks to be is that this process is yet to click research community in India.

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