INSTITUTO TECNONÓLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY

A Review on Nano-Fiber Fabrication Methods by Near-Field Electrospinning

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Abstract

Faculty: Nanotechnology

School of Engineering and Sciences

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keywords: nanotechnology, nano-fiber, near-field electrospinning, NFES

1 Summary

TABLE 1.1: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s):	Poly(ethylene oxide) (PEO)
Solvent(s):	Deionized water
NFES Variant:	Low-Voltage NFES
Polymer Solution and Process Properties:	• PEO Concentration: 1, 2, and 3 $wt\%$ • Rise in solution conductivity with the increase in PEO concentration • Solution Stirring: 24 h of free diffusion followed by 96 h of stirring at 30 rpm • 3 mL syringe • 27 gauge type 304 stainless steel needle • Solution deposition rate: lower than 1 $\mu L/h$ • needle-to-collector distance: 1 mm • Collector substrate: Pyrolyzed SU-8 carbon and Si • NFES process initiated by an air interference with a glass microprobe tip (1 to 3 μm tip diameter) to overcome the surface tension • Time to produce a stable continuous jet: 45 min • Polymer jet initiated at 400-600 V and dispensed at 200-400 V • Collector linear speed: 10-40 mm/s • The voltage turned on when the solution formed a full-sized droplet of 500 μm diameter at the needle tip.
Fiber Characterization:	• Diameter: 50-425 nm
Ref:	[1]

TABLE 1.2: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
Poly(ethylene oxide) (PEO)	Deionized water	Low-Voltage NFES	• PEO Concentration: 1, 2, and 3 $wt\%$ • Rise in solution conductivity with the increase in PEO concentration • Solution Stirring: 24 h of free diffusion followed by 96 h of stirring at 30 rpm • 3 mL syringe • 27 gauge type 304 stainless steel needle • Solution deposition rate: lower than 1 $\mu L/h$ • needle-to-collector distance: 1 mm • Collector substrate: Pyrolyzed SU-8 carbon and Si • NFES process initiated by an air interference with a glass microprobe tip (1 to 3 μm tip diameter) to overcome the surface tension • Time to produce a stable continuous jet: 45 min • Polymer jet initiated at 400-600 V and dispensed at 200-400 V • Collector linear speed: 10-40 mm/s • The voltage turned on when the solution formed a full-sized droplet of 500 μm diameter at the needle tip.	• Diameter: 50-425 nm	[1]

TABLE 1.3: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) with Poly(ethylene oxide) (PEO)	acetonitrile / toluene mixture (65 / 35); acetic acid / toluene (17 / 83); pure toluene	*Not determined.*	• Concentrations: – MEH-PPV solution: 10 mg of MEH-PPV in 2 mL of toluene – 500 μL of MEH-PPV solution with 250 mg of PEO in 3.5 mL of acetonitrile / toluene (65 / 35) – 500 μL of MEH-PPV solution with 250 mg of PEO in 3 mL of acetic acid / toluene (17 / 83) – The resulting MEH-PPV/PEO concentration is 1:100 • Solution Stirring: MEH-PPV solution stirred for 4 h; PEO solution stirred for 8 h; MEH-PPV/PEO solution stirred and ultrasonically agitated • Collector substrate: SiO2/Si (oxide thickness = 800 nm) • needle-to-collector distance: 500 μm • μm-diameter tip Tungsten spinneret in a 26 gauge needle • Solution deposition rate: 50 $\mu L/h$ • Electrostatic voltage: around 1.3 kV • x-y stage velocity: 50 cm/s	• Distance between adjacent fibers: around 100 μm • Fiber diameter: around 100 nm	[2]

TABLE 1.4: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
Poly(ethylene oxide) (PEO)	Water	Scanning Tip Electrospinning and NFES	• 7 wt % PEO aqueous solution • Under room temperature at 1 atm • needle-to-collector distance: 500 μm • needle diameter: outer: 200 μm; inner: 100 μm • applied voltage for jet initiation: 1.5 kV • applied voltage for fiber deposition: 600 V • Mechanical drawing is applied by using a tungsten probe with 1 μm tip diameter to poke inside the meniscus. • The probe is then rapidly pulled away from the polymer droplet to activate the continuous electrospinning process • polymer jet diameter: 3 μm • polymer feed rate: 0.1 $\mu L/h$ • x-y stage velocity: 120 mm/s	• 108 m yield in 15 min with a fiber diameter of 709 $\pm$ 131 nm • Fiber diameter: around 49-74 nm when applied voltage is 800 V	[3]

TABLE 1.5: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
Poly(ε-Caprolactone) (PCL)	*Not applicable.*	Melt Electro-spinning Writing (MEW)	• Collector substrate: NCO-sP(EO-stat-PO)-coated glass slide surfaces • Accelerating voltage 2.0–10.0 kV • Collector distance: 1–10 mm • Heating temperature: 80–120 $°C$ • Feeding air pressure 0.5–4.0 bar • Spinneret diameters: 21, 23, 25, 27, 30, and 33 G • Axis velocity: 1000–9000 mm/min • Fibre spacing: 100 μm	• Filament surface is smooth and homogeneous • The crystalline regions formed perpendicular to the filament • Fiber diameter: 817 $\pm$ 165 nm	[4]

TABLE 1.6: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
Poly(vinylidine fluorid) (PVDF)	N,N-dimethylformamide (DMF)	Helix Electrohydrodynamic Printing (HE-printing)	• 1.8 g PVDF in 4.1 g of DMF and 4.1 g of acetone to obtain a concentration of 18% • Solution kept at 35 °C for about 6 h until the solution was homogeneous. • Collector substrate: Poly(dimethylsiloxane) (PDMS) on Ecoflex • Solution feed rate: 400 nL/min • Needle diameter: inner 260 μm; external 510 μm • Applied voltage: 1.5–3 kV • Nozzle-to-collector distance: 10-50 mm • x-y stage velocity: 0-400 mm/min • At room temperature and 35–45% humidity	• Stretchable serpentine structures with specific wavelength and amplitude. • Wavelength: about 100-2000 μm • Fiber diameter: about 1.5-3 μm	[5]

TABLE 1.7: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Polymer Solution and Process Properties	Fiber Characterization	Ref.
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