SUPPLEMENTARY INFORMATION: Polymers for Near-field Electrospinning with Spatial Control

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Table 1: Electrospun Polymer Solutions - Solution and Process Parameters

Polymer(s)	Solvent(s)	NFES Variant	Process Parameters and Fiber Characterization	Ref.
Poly(ethylene oxide) (PEO; MW = 4,000,000 g/mol)	Deionized water	Low-Voltage NFES (LV NFES)	**Solution Concentration:** 1, 2, and 3 $wt\%$ PEO **Nozzle:** 27 gauge type 304; stainless steel needle **Solution deposition rate:** lower than $1\mu L/h$ **Nozzle-to-substrate distance:** $1mm$ **Substrate composition:** Pyrolyzed SU-8 carbon and Si **Applied voltage:** polymer jet initiated at 400-600 V and dispensed at 200-400 V **x-y stage velocity:** 10-40mm/s **Fiber Diameter:** 50-425nm **Distance between adjacent fibers:** *Not determined*	[1]

Continued on next page

Table 1 continued

| Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV; MW = 380,000 g/mol) with Poly(ethylene oxide) (PEO; MW = 300,000 g/mol) | acetonitrile toluene mixture (65/35); acetic acid toluene (17/83); pure toluene | Typical process | NFES | **Solution Concentration:** 10mg of MEH-PPV in 2mL of toluene; 500μL of MEH-PPV solution with 250mg of PEO in 3.5mL of acetonitrile / toluene (65 / 35); 500μL of MEH-PPV solution with 250mg of PEO in 3mL of acetic acid / toluene (17 / 83). The resulting MEH-PPV/PEO concentration is 0.08 $wt\%$
 Nozzle: mm-diameter tip Tungsten spinneret in a 26 gauge needle
 Solution deposition rate: 50$\mu L/h$
 Nozzle-to-substrate distance: 500μm
 Substrate composition: SiO2/Si (oxide thickness = 800 nm)
 Applied voltage: around 1.3kV
 x-y stage velocity: 50cm/s
 Fiber Diameter: 100nm
 Distance between adjacent fibers: around 100μm | [2] |

Table 1 continued

Poly(ethylene oxide) (PEO; MV = 300,000 g/mol)	Water	Scanning Tip Electrospinning and NFES	**Solution Concentration:** $7wt\%$ PEO **Nozzle:** Needle outer diameter of $200\mu m$ and inner diameter of $100\mu m$ **Solution deposition rate:** $0.1\mu L/h$ **Nozzle-to-substrate distance:** $500\mu m$ **Substrate composition:** *Not determined* **Applied voltage:** polymer jet initiated at 1.5 kV and dispensed at $600V$ **x-y stage velocity:** $120mm/s$ **Fiber Diameter:** $709\pm131nm$; $49\text{-}74nm$ when applied voltage is $800V$ **Distance between adjacent fibers:** *Not determined* **Notes:** $108m$ yield in $15min$ with a fiber diameter of $709\pm131nm$	[3]
Poly(vinylidine fluorid) (PVDF; MW = 440,000 g/mol)	N,N Dimethyl-formamide (DMF)	Helix Electrohydro-dynamic Printing (HE-printing)	**Solution Concentration:** $1.8g$ PVDF in $4.1g$ of DMF and $4.1g$ of acetone. The resulting concentration is 18% PVDF. **Nozzle:** Needle outer diameter of $510\mu m$ and inner diameter of $260\mu m$ **Solution deposition rate:** $400nL/min$ **Nozazle-to-substrate distance:** $10\text{-}50mm$ **Substrate composition:** Poly(dimethylsiloxane) (PDMS) on Ecoflex **Applied voltage:** $1.5\text{–}3kV$ **x-y stage velocity:** $0\text{-}400mm/min$ **Fiber Diameter:** about $1.5\text{-}3\mu m$ **Distance between adjacent fibers:** *Not determined*	[4]

Table 1 continued

Polyhedral Oligomeric Silsesquioxane-Poly(Carbonate-Urea)Urethane (POSS-PCU) and Polyhedral Oligomeric Silsesquioxane Poly(Caprolactone-Poly(Carbonate-Urea)Urethane) (POSS-PCL-PCU) (Dry Polycarbonate MW = 2000 g/mol)	Dimethyl acetamide (DMAC) and 1-Butanol	Electrohydro-dynamic 3D Print-patterning or Electrohydro-dynamic Jetting	**Solution Concentration:** POSS-PCU and POSS-PCL-PCU used in $20\%w/w$ concentration in DMAC **Nozzle:** needle of 750 μm in diameter **Solution deposition rate:** less than $1\mu L/min$ **Nozzle-to-substrate distance:** about between $500\mu m$ to $2mm$ **Substrate composition:** *Not determined* **Applied voltage:** 8.0-10.0kV **x-y stage velocity:** $10mm/s$ **Fiber Diameter:** 15-50μm **Distance between adjacent fibers:** $250\mu m$	[5]
Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	Distilled water	Electrohydro-dynamic Writing or Mechano-electrospinning (MES)	**Solution Concentration:** $6wt\%$ PEO **Nozzle:** *Not determined* **Solution deposition rate:** $1200nL/min$ **Nozzle-to-substrate distance:** $7.5mm$ **Substrate composition:** *Not determined* **Applied voltage:** polymer jet initiated at 2 kV and dispensed at 0.8-1kV **x-y stage velocity:** around $400mm/s$ **Fiber Diameter:** 200-350nm **Distance between adjacent fibers:** $5\mu m$	[6]

Table 1 continued

Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	Deionized water and ethanol with a volume ratio of 3:1	Airflow-assisted Electrohydrodynamic Direct-writing (EDW)	**Solution Concentration:** $8wt\%$ PEO **Nozzle:** Outer airflow passage diameter: $1mm$ Airflow gas pump pressure: $25kPa$ Inner liquid passage diameter: $0.21mm$ **Solution deposition rate:** $30\mu L/h$ **Nozzle-to-substrate distance:** $2mm$ **Substrate composition:** Silicon **Applied voltage:** about $2kV$ **x-y stage velocity:** 1-20mm/s **Fiber Diameter:** $3.73 \pm 1.37\mu m$ **Distance between adjacent fibers:** $5.13 \pm 6.67\mu m$	[7]
Poly(Vinylidene Fluoride) (PVDF; MW = 534,000 g/mol)	Acetone and Dimethyl Sulfoxide (DMSO)	3D Electrospinning	**Solution Concentration:** $17wt\%$ PVDF; $1.7g$ of PVDF, $5g$ of acetone, $0.5g$ of Capstone FS-66, $5g$ of DMSO **Nozzle:** Needle inner diameter of $100\mu m$ **Solution deposition rate:** $14\ nL/min$ **Nozzle-to-substrate distance:** $750\mu m$ **Substrate composition:** A4 size commercial printing paper (Double A) **Applied voltage:** $1.9kV$ **x-y stage velocity:** $10mm/s$ **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** *Not determined*	[8]

Table 1 continued

Poly(9-Vinyl Carbazole) (PVK; MW = 1,100,000 g/mol)	Styrene	Typical process	NFES	**Solution Concentration:** 3.96$wt\%$ PVK in styrene **Nozzle:** Needle inner diameter of 100μm **Solution deposition rate:** 500nL/min **Nozzle-to-substrate distance:** around 2.5mm **Substrate composition:** Si/SiO2 **Applied voltage:** 3-4kV x-y stage velocity: 13.3cm/s **Fiber Diameter:** 289.26 $\pm$ 35.37nm **Distance between adjacent fibers:** 50μm **Notes:** 15m yield in 2min	[9]
Polystyrene (PS; MW *Not determined*)	1,2,4-Trichloro benzene	Electrohydro-dynamic (EHD) jet printing		**Solution Concentration:** 1 to 5$wt\%$ PS **Nozzle:** Glass nozzle inner diameter of 2μm and outer diameter of 2.66μm **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance**: 20, 30, 40μm **Substrate composition:** Si **Applied voltage:** 500 to 400V in 25V increments **x-y stage velocity:** 0.01-10mm/s **Fiber Diameter:** about 60-170μm **Distance between adjacent fibers:** *Not determined*	[10]
Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	*Not determined*	Typical process	NFES	**Solution Concentration:** 3$wt\%$ PEO **Nozzle:** *Not determined* **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance:** 500μm **Substrate composition:** Si **Applied voltage:** 1000V **x-y stage velocity:** 20cm/s **Fiber Diameter:** 300nm **Distance between adjacent fibers:** 25μm	[11]

Table 1 continued

Poly(ethylene oxide) (PEO; MW = 2,000,000 g/mol)	Distilled water	Multinozzle NFES	**Solution Concentration:** $5wt\%$ **Nozzle:** four-nozzle and six-nozzle array with needle spacing changes from $1.5mm$ to $3.5mm$ **Solution deposition rate:** $1\text{-}3\mu L/min$ **Nozzle-to-substrate distance:** $2mm$ **Substrate composition:** *Not determined* **Applied voltage:** $1.7\text{-}2.7kV$ **x-y stage velocity:** *Not determined* **Fiber Diameter:** $5.47\mu m$ **Distance between adjacent fibers:** 3-5 mm	[12]
Poly(ethylene oxide) (PEO; MW = 2,000,000 g/mol)	Distilled water	Multinozzle NFES	**Solution Concentration:** $5wt\%$ **Nozzle:** Dual-28G-needle array with needle inner diameter of $0.18mm$ and outer diameter of $0.36mm$; with needle spacing changes from $2.0mm$ to $3.0mm$ **Solution deposition rate:** $0.2\mu L/min$ **Nozzle-to-substrate distance:** $3.0\text{-}4.0mm$ **Substrate composition:** *Not determined* **Applied voltage:** $2.0\text{-}3.0kV$ **x-y stage velocity:** $20mm/s$ **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** $218\text{-}326\mu m$	[13]

Table 1 continued

Poly(ethylene oxide) (PEO; MW = 2,000,000 g/mol)	Distilled water	Multinozzle NFES	**Solution Concentration:** 5 $wt\%$ **Nozzle:** Dual-28G-needle array with needle inner diameter of $180\mu m$ and outer diameter of $360\mu m$; with needle spacing changes of $2.0mm$ **Solution deposition rate:** $0.2\mu L/min$ **Nozzle-to-substrate distance:** $4.0mm$ **Substrate composition:** chromium-plated glass **Applied voltage:** $2.5kV$ **x-y stage velocity:** $20mm/s$ **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** 2.3002-$2.7224mm$	[14]
Poly(ethylene oxide) (PEO; MW = 4,000,000 g/mol)	*Not determined*	Typical process NFES	**Solution Concentration:** $2wt\%$ **Nozzle:** G30 needle with inner diameter of $0.15mm$ **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance:** 1-$3mm$ **Substrate composition:** Silicon **Applied voltage:** $1250V$ **x-y stage velocity:** *Not determined* **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** $20\mu m$	[15]

Table 1 continued

Gelatin (porcine skin; MW *Not determined*)	Acetic Acid and Ethyl Acetate	Typical process	NFES	**Solution Concentration:** $11wt\%$ gelatin, $30wt\%$ water, $35.4wt\%$ acetic acid, $23.6wt\%$ ethyl acetate **Nozzle:** 19G needle tip with outer diameter of $1.08mm$ **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance:** $1.25mm$ **Substrate composition:** Poly(Dimethylsiloxane) (PDMS) films **Applied voltage:** $1000V$ **x-y stage velocity:** *Not determined* **Fiber Diameter:** around 2-3μm **Distance between adjacent fibers:** $40\mu m$	[16]
Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	Water/Ethanol (v/v = 60/40)	Typical process	NFES	**Solution Concentration:** PEO concentrations of 16% and 18% **Nozzle:** $40\mu m$ **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance:** $1mm$ **Substrate composition:** Planar silicon **Applied voltage:** $1.7kV$ **x-y stage velocity:** $0.36m/s$ **Fiber Diameter:** $5.15\mu m$ **Distance between adjacent fibers:** *Not determined*	[17]

Table 1 continued

Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	Water/Ethanol (v/v = 3/1)	Electrohydro-dynamic Direct-Write (EDW)	**Solution Concentration:** $14wt\%$ PEO **Nozzle:** Stainless needle with inner diameter of $210\mu m$ and outer diameter of $400\mu m$ **Solution deposition rate:** $50\mu L/h$ **Nozzle-to-substrate distance:** $2mm$ **Substrate composition:** Poly(ethylene terephthalate) (PET) **Applied voltage:** $3kV$ **x-y stage velocity:** $700mm/s$ **Fiber Diameter:** 15-35μm **Distance between adjacent fibers:** $70\mu m$	[18]
Poly(ethylene oxide) (PEO; MW = 300,000 g/mol)	Deionized water	Mechano-Electrospinning	**Solution Concentration:** $3wt\%$ PEO **Nozzle:** Stainless steel nozzle with inner diameter of $160\mu m$ and outer diameter of $310\mu m$ **Solution deposition rate:** $50nL/min$ **Nozzle-to-substrate distance:** 2-5mm **Substrate composition:** Silicone **Applied voltage:** polymer jet initiated at $2kV$ and dispensed at $1kV$ **x-y stage velocity:** 200-400mm/s **Fiber Diameter:** from 344±32 to 214±27nm **Distance between adjacent fibers:** *Not determined*	[19]

Table 1 continued

Poly(co-Glycolic) acid (PLGA; MW *Not determined*)	Dimethyl Carbonate (DMC)	Tethered Pyro-Electrohydro-dynamic Spinning (TPES)	**Solution Concentration:** *Not determined* **Nozzle:** nozzle-free **Solution deposition rate:** The drop reservoir is placed directly on a flat substrate **Nozzle-to-substrate distance:** Taylor's cone is focused and put in direct contact with the collector **Substrate composition:** Poly(tetrafluoroethylene) (PTFE) coated glass slide **Applied voltage:** pyro-electric field of between 2.7 $x10^7$ V/m and $5.5x10^7$ V/m **x-y stage velocity:** *Not determined* **Fiber Diameter:** $304.7nm$ **Distance between adjacent fibers:** *Not determined*	[20]
Poly(ethylene oxide) (PEO; MW = 4,000,000 g/mol) with Tetrabutylammonium tetrafluoroborate (TBF; MW *Not determined*) and SU-8 2002	N,N Dimethyl-formamide (DMF)	Typical process NFES	**Solution Concentration:** SU-8/PEO/TBF blend with $0.75wt\%$ PEO, $1wt\%$ TBF; the blend is diluted with $30vol\%$ DMF $\mu m \mu m$ **Solution deposition rate:** *Not determined* **Nozzle-to-substrate distance:** *Not determined* **Substrate composition:** Brass disk with a diameter of $38mm$ **Applied voltage:** $980V$ **x-y stage velocity:** *Not determined* **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** *Not determined*	[21]

Table 1 continued

Poly(ethylene oxide) (PEO; 200,000 g/mol)	Water:Ethanol (3:2)	Suspension	NFES	**Solution Concentration:** $14wt\%$ PEO **Nozzle:** stainless steel needle (25 G) with inner diameter of $0.25mm$ **Solution deposition rate:** $3nL/s$ **Nozzle-to-substrate distance:** between 0.5 and $10mm$ with $0.5mm$ increments **Substrate composition:** Planar silicon electrodes **Applied voltage:** $1.6kV$ **x-y stage velocity:** 50, 150, and $250mm/s$ **Fiber Diameter:** $300nm$ **Distance between adjacent fibers:** 0.1 and $0.5mm$	[22]
Poly(ethylene oxide) (PEO; MW = 400,000 g/mol)	Deionized water	Typical process	NFES	**Solution Concentration:** $10wt\%$ PEO **Nozzle:** 32G metal needle **Solution deposition rate:** (Jet impact speed of $5mm/s$) **Nozzle-to-substrate distance:** $0.5mm$ **Substrate composition:** p-type silicon wafer **Applied voltage:** $400V$ **x-y stage velocity:** $5mm/s$ **Fiber Diameter:** *Not determined* **Distance between adjacent fibers:** $50\mu m$	[23]

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