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Gas-Modified Electrospinning with a Portable Device

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Slater Family Research Trust

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Project Objective

- The objective of this work was to construct a miniaturized, portable electrospinning (ES) device for deposition on surfaces regardless of charge.
- We hope this device can be used by doctors in rural areas to deliver drug delivery bandages.
- Mathematical modeling was used to improve predictability of the completed portable ES device.

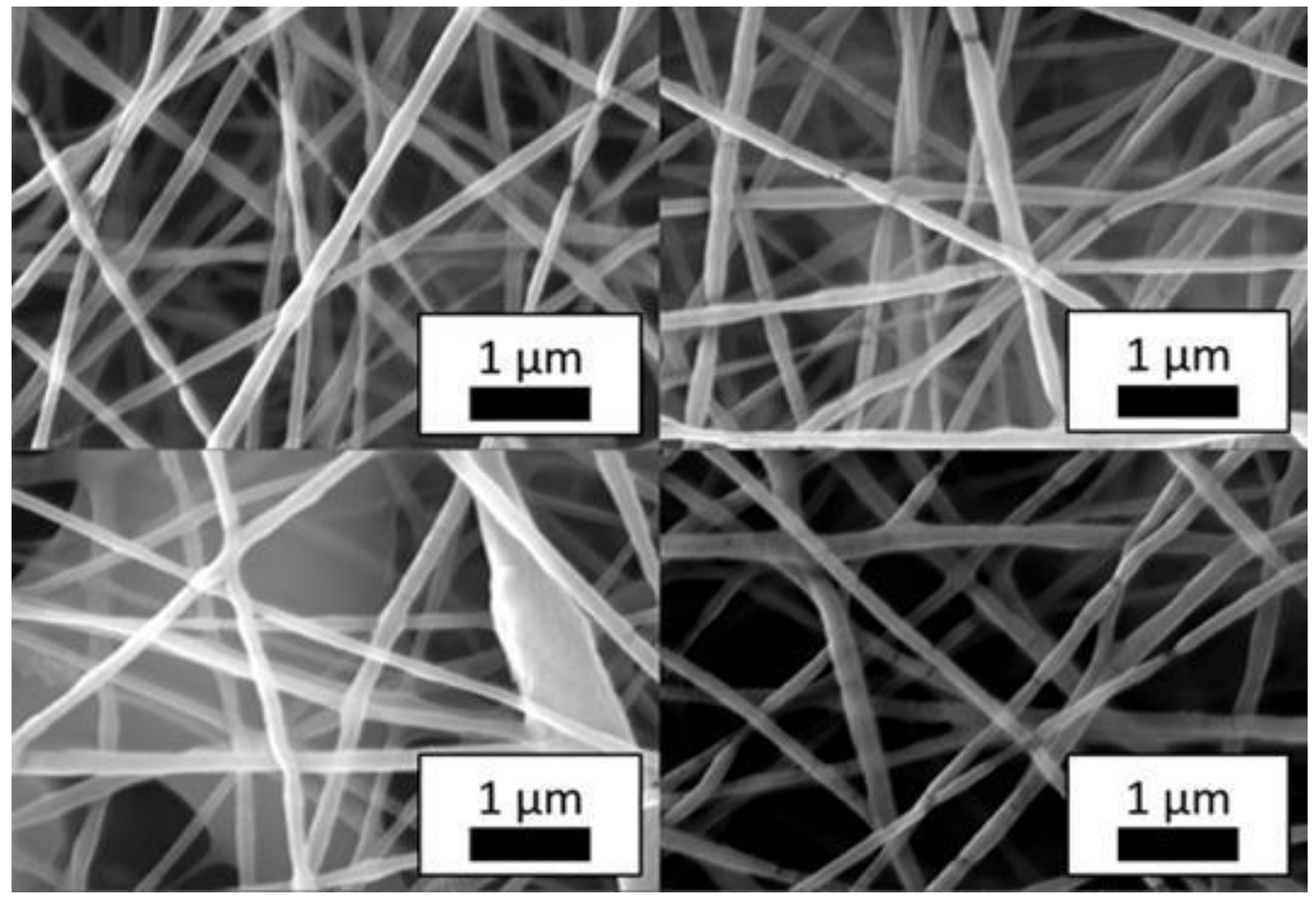
Background

- ES relies on the voltage potential between spinneret and deposition surface to create electrostatic force.
- Electrostatic force draws polymer from spinneret to deposition surface in fiber form.
- Depending on flow rate, voltage, polymer type, etc., microscale and nanoscale fibers are produced.

Methods

- Developed a parametric test matrix to consider the three main parameters: applied voltage, separation distance, and gas velocity.
- Each fiber mat created was imaged and an image threshold adjustment was applied to analyze resulting fiber mat spot size.
- Optical microscopy and SEM imaging were used to better understand the surface features of the fibers.

Results



SEM images of fibers with an applied voltage of 10 kV, 10-cm separation distance, and air outputs from top-left in clockwise rotation: 4.59, 6.89, 7.26, & 9.47 [m/s].

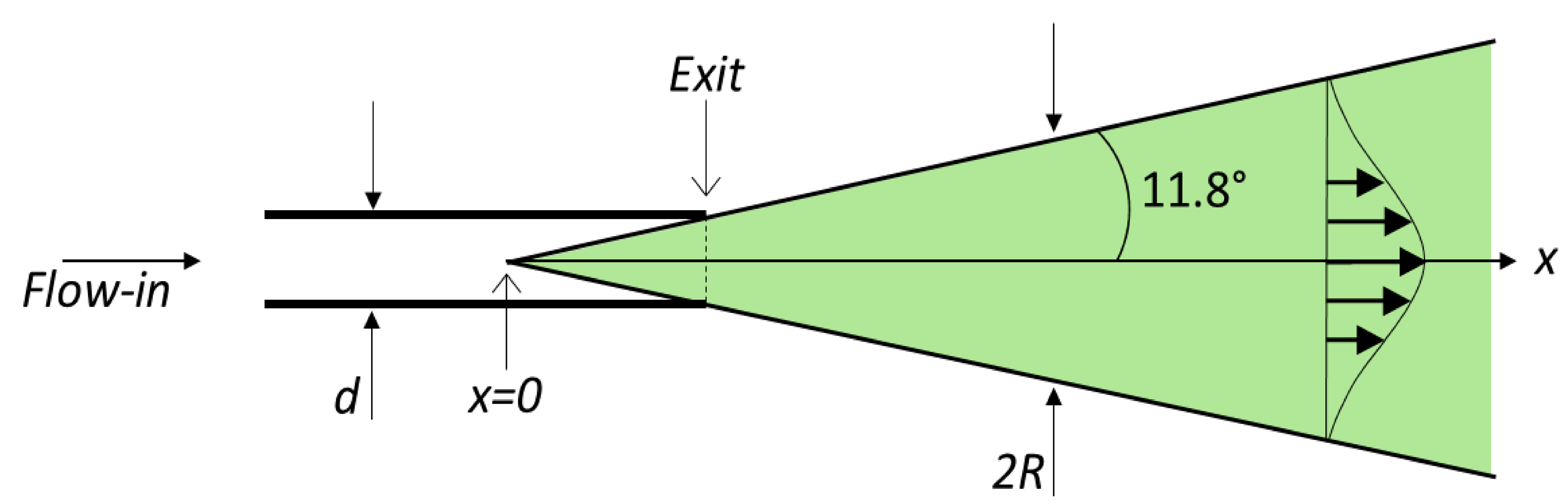


Illustration of jet profile after leaving a cylindrical orifice. Boundary of jet can be assumed to be linear and increasing with an angle of 11.8 degrees.

Fitting Factor (κ_z)	8 kV	9 kV	10 kV
25 VAC (4.59 m/s)	1.59	1.54	1.14
30 VAC (6.89 m/s)	1.63	1.47	1.18
35 VAC (7.26 m/s)	1.87	1.36	1.42
40 VAC (9.47 m/s)	2.15	1.69	1.44

$$R=(\kappa_z)\cdot\tan(11.8°)\cdot(5r+x)$$

Where:
R = jet radius (fiber mat radius)
κ_z = fitting factor
r = radius of the orifice
x = separation distance

Fitting factors were determined from spot size data and a modified jet profile equation was derived to predict resulting fiber mat radius depending on studied ES parameters.

Conclusions

- Parametric analysis was performed to determine effect of applied voltage, separation distance, and air speed on electrospinning with portable ES device.
- Spot size radius increased with increasing separation distance and air velocity but decreased with an increase in applied voltage.
- The radius of the spot can be estimated using a modified jet profile equation that takes into account testing parameters in the form of a fitting factor κ_z ranging from 1.14 to 2.15.
- Fiber morphology showed droplets of polymer present on fiber mats that increased with increasing air velocity and decreasing applied voltage.
- ES fiber diameters increased with increasing air velocity, potentially due to an increase in solvent removal rate during the time of flight of the polymer fiber.

Acknowledgments

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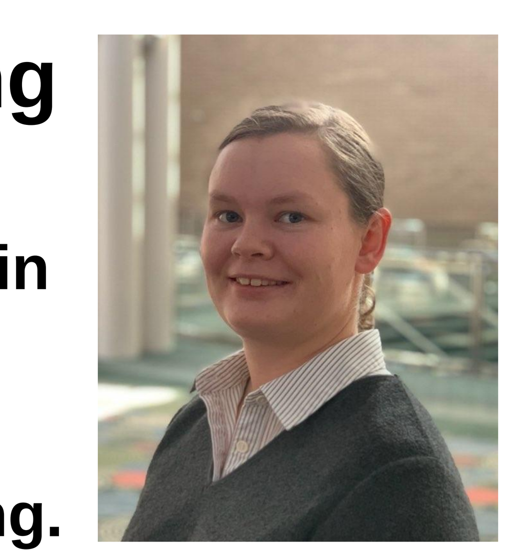

I am a Masters student studying General Engineering with a focus in Mechanical Engineering. Upon graduation, I plan to work in mechanical design and engineering.