Gas-Modified Electrospinning with a Portable Device

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Gas-Modified Electrospinning with a Portable Device

Emily A. Kooistra-Manning, Lane G. Huston, Jack L. Skinner, & Jessica M. Andriolo

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.

R=(\kappa_2)\cdot\tan(11.8^\circ)\cdot(5r+x)

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.

<table>
<thead>
<tr>
<th>Fitting Factor (\kappa_2)</th>
<th>8 kV</th>
<th>9 kV</th>
<th>10 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 VAC (4.59 m/s)</td>
<td>1.59</td>
<td>1.54</td>
<td>1.14</td>
</tr>
<tr>
<td>30 VAC (6.89 m/s)</td>
<td>1.63</td>
<td>1.47</td>
<td>1.18</td>
</tr>
<tr>
<td>35 VAC (7.26 m/s)</td>
<td>1.87</td>
<td>1.36</td>
<td>1.42</td>
</tr>
<tr>
<td>40 VAC (9.47 m/s)</td>
<td>2.15</td>
<td>1.69</td>
<td>1.44</td>
</tr>
</tbody>
</table>

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 \(\kappa_2\) 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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Emily A. Kooistra-Manning

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.