

PROCESSING OF SUB-MICRON POLYMER FIBERS

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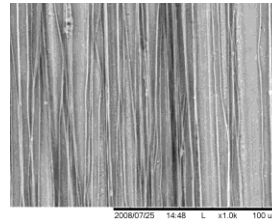
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ELECTROSPINNING

- ◆ Create nano-scale polymer fibers through the use of electric charge
 - ◇ Induce charge on polymer solution through applied voltage
 - ◇ When electrostatic forces overcome solution surface tension, a charged jet erupts from needle
 - ◇ Normally undergoes 3 phases
 - Taylor Cone
 - Linear extension
 - Bending Instability
 - ◇ There are different ways to gather fibers depending on desired fiber orientation
 - ◇ Current methods that yield oriented fibers are low output

LOW DIELECTRIC SOLVENT

- ◆ Solutions normally undergo bending instability, leading to randomly oriented fiber mats
- ◆ Difficult to obtain oriented fibers even with extremely high drum rotation speeds
- ◆ Use of a low dielectric solvent such as chloroform can eliminate bending instability
 - ◇ Effectively less charge carried by the solution
- ◆ Produce oriented fibers on a rotating drum

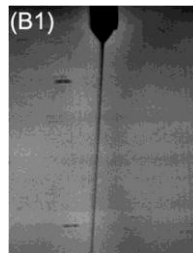


EXPERIMENTAL

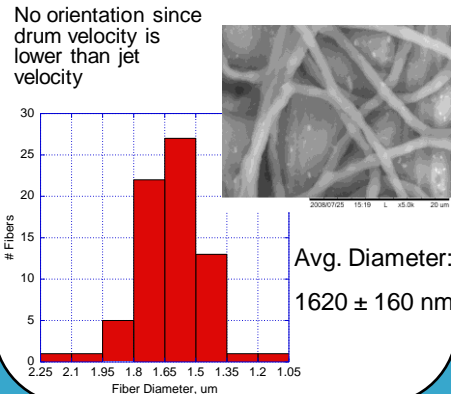
- ◆ Objective
 - ◇ Determine the effect of take-up rate on fiber diameter for fibers spun from low dielectric solvents
- ◆ Experimental Plan
 - ◇ Find drum RPM and associated face velocity using a digital tachometer
 - ◇ Electrospin 3 wt% poly(ethylene oxide), PEO, in chloroform at different drum speeds
 - ◇ Keep all other spinning conditions constant
 - Applied voltage
 - Spinning distance
 - Volumetric flow rate
 - ◇ Determine Fiber Diameter as a function of take-up rate

JET VELOCITY

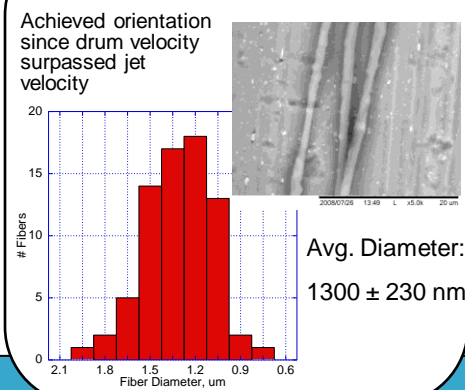
- ◆ Estimate initial jet velocity in order to determine at what speed fibers are drawn by the rotating drum
- ◆ Use high speed image of jet to estimate dimensions
 - ◇ Initial jet velocity ~ 1 m/s



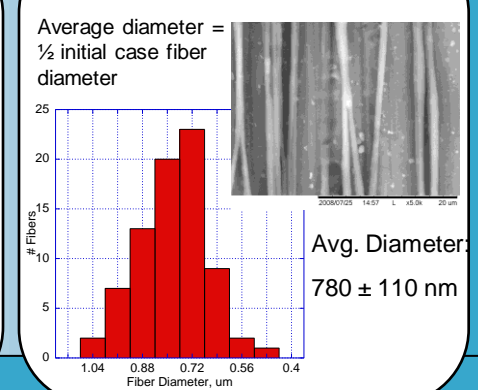
71 RPM, ~.6 m/s



445 RPM, ~3.6 m/s



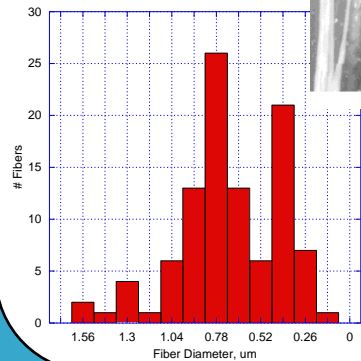
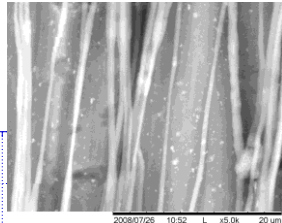
990 RPM, ~8 m/s



(Continued)

1465 RPM, ~12 m/s

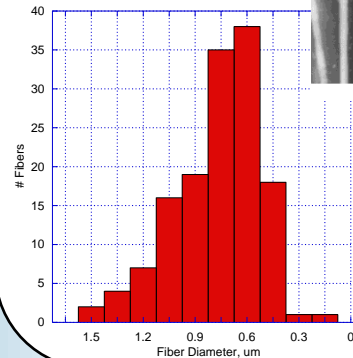
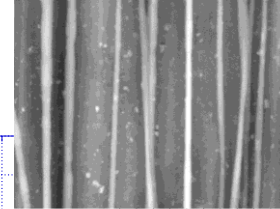
Bi-modal distribution of fiber diameters appeared, likely caused by necking



Avg. Diameter:
 670 ± 190 nm

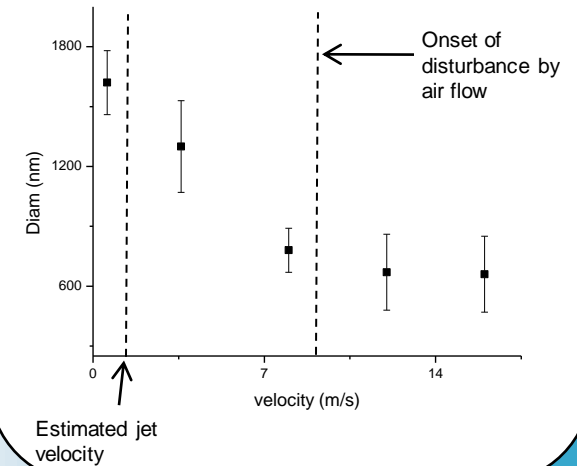
1960 RPM, ~16 m/s

High velocity air flow caused by drum at high RPM impacted fiber diameter

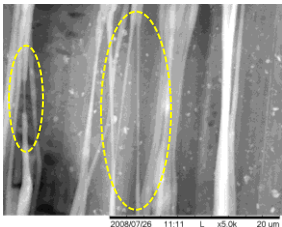


Avg. Diameter:
 660 ± 190 nm

FIBER DIAMETER vs. DRUM LINEAR VELOCITY



NECKING



- ◆ Necking of polymer fibers appeared at higher RPM
- ◆ Necked fiber diameters as low as 200 nm
- ◆ Air flow generated by the drum transiently affected the fiber drawing process
- ◆ **No indication of breakage!**

SUMMARY

- ◆ Use of low dielectric solvent allows for collection of highly oriented electrospun polymer fibers on rotating drums
- ◆ Fiber diameter was reduced with increasing drum velocity
- ◆ Fibers could be easily drawn to one half their initial diameter
- ◆ Necking of fibers showed that if the effects of air flow on the jet can be negated fibers of around 200 nm or less could be produced

FUTURE WORK

- ◆ Confirm effect of air flow on disturbance on polymer jet
- ◆ Develop production method to eliminate air flow at high RPM
 - ◆ Perforated drum under vacuum?
- ◆ Obtain more diameter measurements at higher drum RPM once the effects of air flow can be mitigated
- ◆ Use high speed video to measure jet velocity throughout its path to the collector

ACKNOWLEDGEMENTS

Dr. Joe Deitzel

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