Electrospun Nanofibers

Background:
A nanometer is a measurement of length one billionth the size of one meter, one thousandth the size of a human hair, or about three or four times wider than an atom. Nano fibers are very small polymer fibers that measure less than 1/10 microns, or less than 100 nanometers in width. Nanofiber technology has several applications, including the manufacture of filters for submicron particles in air or water, stain and moisture barriers in clothing, a matrix for cell growth for tissue regeneration in wounds or use as dielectrics in capacitors. Applications in industry, medicine, information and aerospace technology are being studied at university and research centers around the world.

Electrospinning technology originated in the 1930's but has only recently been applied to the production of nano-sized polymer fibers. In this activity, a polymer will be exposed to a very large voltage over a distance of from 15 to 25 centimeters. As the potential builds, the polymer will acquire an electrostatic charge opposite that of a collector plate some distance away. When the electrostatic forces between the charged polymer and the collector plate over come the surface tension of the polymer, a Taylor's cone will form, and the liquid will be drawn out across the distance to form very small threads or nanofibers. A Taylor's cone is the name given the cone that is typically observed when charged droplets emit a very thin jet of liquid in a strong electric field. As the solution is drawn across the potential, the solvent will evaporate and the polymer will form a nonwoven mat of randomly oriented, very small fibers.

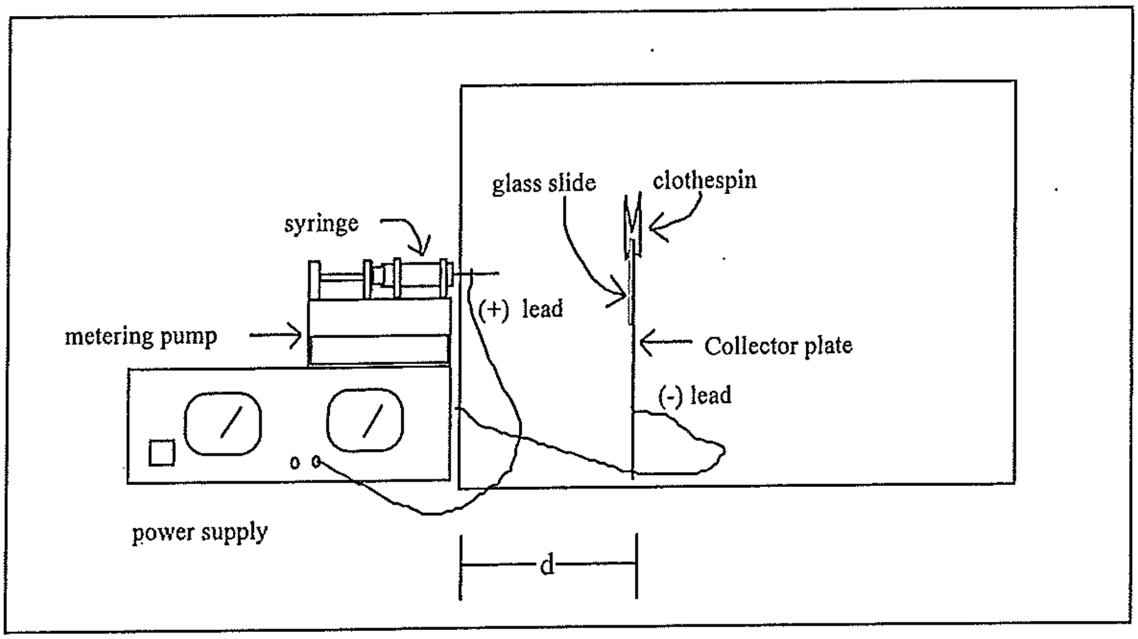
Purpose:
The purposes of this activity are threefold: One is to demonstrate the effects of voltage, solution concentration, distance and time on the manufacture of nanofibers from a simple, water-soluble polymer. Secondly, students will learn to calculate different solution concentrations of polymer by weight, and to operate the metering pump and power supply necessary to provide the electrostatic force. Finally, students will get hands-on experience in cutting edge technology and a better understanding of the relative size of a nano sized object (the fibers) as compared to a very familiar very small object, the width of a human hair.

Materials:
1 electro-spinning apparatus including power supply, metering pump and protective case.
5, 1oz. glass vials with lids that seal
1 permanent marker
Digital or hanging pan balance that can weigh to within 0.01 g.
**syringes
5 mL pipette
Distilled water
Polyvinylchloride polymer

CAUTION: VERY HIGH VOLTAGES WILL BE APPLIED TO THE APPARATUS.
Do not plug in or turn on the power supply until after the leads have been connected to and the door to the protective case is closed.

Procedure:

1. Do a preliminary set up of the apparatus to set the power supply to the proper voltage. Insert a needle in an empty syringe and place it in the metering pump so that the needle Is inside the protective case. Using a vertical support and right angle clamp, fix a metal plate about 15 cm away from the needle. Attach electrodes to the needle and the metal plate, close the door to the protective case and turn on the power supply. Adjust the voltage to the desired amount. Leave the setting, turn off the power supply and disconnect the electrodes. Remove the syringe.



2. Calculate the mass of polymer necessary to make 5mL of solution. Measure exactly 5mL of distilled water into the glass vial and, using a permanent marker, mark the location of the bottom of the meniscus. Pour out the water and dry the inside of the vial thoroughly.

3. Weigh the exact amount of polymer on weight paper and transfer it to the marked vial. Add distilled water to the polymer until it is filled to the proper level. Using a hot plate, heat the polymer mixture while stirring constantly until the mixture becomes clear and the polymer is completely dissolved.

4. Cool the polymer solution to room temperature and add about 3 mLs to the syringe. Clean off the excess with a paper towel and attach the needle. Hold the syringe vertically with the needle up and tap the sides to jog any air bubbles to the surface of the solution. Gently depress the syringe until the air is gone and the polymer solution fills but does not drip out of the end of the needle.

4. Put the syringe in the metering pump and set the volume and flow rate. Using a

vertical support and right angle clamp, fix a metal collector plate a fixed distance from the tip of the needle. Cover the metal plate tightly with a sheet of aluminum foil.

5. Using a wooden clothespin, clamp a clean, dry microscope slide on the metal plate, directly across from the tip of the needle.

6. Attach the electrodes, replace the door to the protective case, plug in the power supply and then turn it on. Watch for the formation of a Taylor's Cone and the eventual cloudy appearance on the microscope slide and surrounding aluminum foil. Begin timing when the Taylor's cone appears.

7. Turn off and then unplug the power supply. Remove the leads from the collector plate and the needle and carefully remove the glass slide from the clothespin.

8. Examine the microscope slide using 40X and 100X magnification. Describe the appearance of the fibers in the space provided on the data sheet. If you have a camera that attaches to the microscope, take a picture of the fibers to include in the final report.

9. Remove the microscope slide and place a human hair vertically across the slide on top of the nanofiber mat. Tape each end of the hair to opposite ends of the slide so that it is flat against the fibers. Make sure the tape is at the ends of the slide and not under the viewing area.

Name ____________________

Section ________________

Date __________________

Data Page

Flow Rate (µl/hr)	% Solution	Potential (V)	distance (cm)	Time (min)	observations
40					
50					
60	25	20k	15	15	visible matt of fibers each approx. 50nm
70					
	18				
	20				
	25				
	28				
		15k			
		18k			
		20k			
		22k			
			15		
			18		
			20		

Name ________________________ Section ________________

Date ___________________

Questions:

1. What is a Taylor's Cone?

2. How does the width of the human hair compare to the width of the nanofibers?

3. What differences were seen as the voltage was increased?

4. What differences were seen as the solution concentration was increased?

5. What differences were seen as the distance between the needle end and the collector plate was increased?

6. Why did you unplug the power supply each time you changed the apparatus?

Insight: ____

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