

Coiled Fibers for Medical Applications

Electrospinning is a direct method to produce continuous nanofibers. It has a lot of advantages and is a good method to make new objects. This is a cooperated project with Dr. Lannutti at Ohio State University. I am trying to make a mat with as many coiled fibers as possible. And Dr. Lannutti is focusing on the medical applications.

Buckling of highly viscous Newtonian liquid jets were studied experimentally in the seminal work of Taylor. Further experiments on buckling of highly viscous liquid jets were published by Timoshenko et al. In these works, jet buckling occurred when a jet impinged on motionless surfaces or liquid-liquid interfaces (Fig. 1¹). In other words, this is the process of how the coiled fiber is formed.

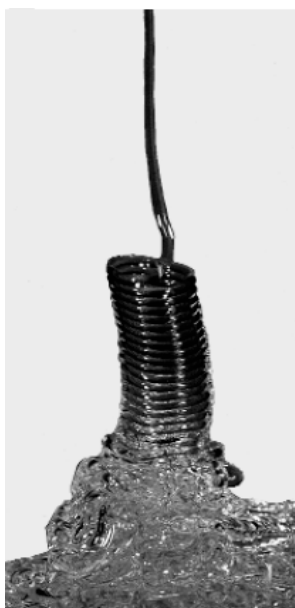


Figure 1. The formation of coiled fiber

Experiment

The material is nylon-6, 25 wt% solution in formic acid, FA, (88%). The experimental setup for electrospinning is similar to those used previously. Here, water is used as the grounded collector (Fig. 2). The glass microscope slides are used to take the fibers out of the water.

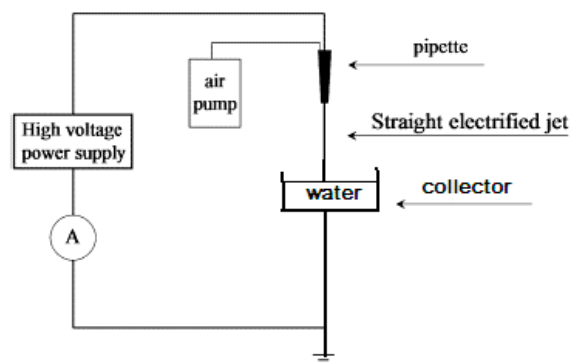


Figure 2. Sketch of experimental setup

The experiments were conducted under ambient conditions at room temperature and a relative humidity of about 23%. The inner diameter of the pipette was around 30 μm . A copper wire was immersed in the solution and connected with a high voltage power supply that could generate a DC voltage up to 13 kV. The applied voltage was 3.5 kV. The collected solidified electrospun fibers were observed with optical microscopy (Olympus 51BX).

Experimental results

Figure 3 shows some buckling fibers made in our lab². The material is PLLA. The fibers were collected on a horizontally moving collector in the direction shown by the black arrow in Figure 3a. As shown in the Figure 3, the fibers have different morphologies. The fibers can be zigzag (a) or coiled (b). And sometimes the zigzag patterns can be twisted (c) and large (d).

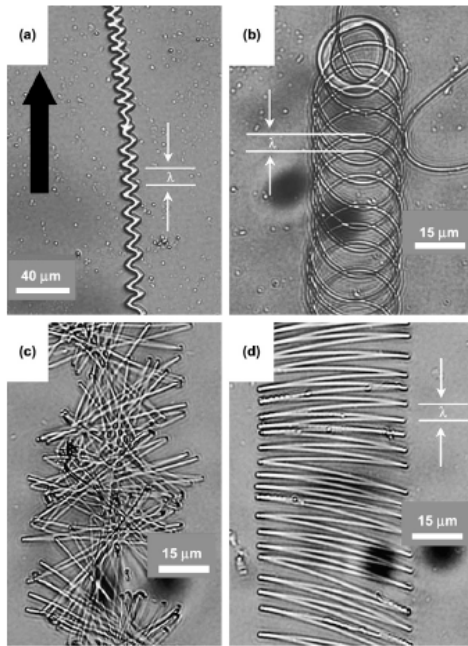


Figure 3. Optical images of buckled solidified PLLA patterns. In all images the horizontal collector was moved in the direction indicated by the black arrow in Figure 3a. (a) Zigzag patterns; (b) coiled patterns; (c) zigzag patterns in twisted rows; (d) zigzag patterns in flat arrays.

Figure 4 shows the preliminary results of my experiments. The material is 25 wt% Nylon 6 in formic acid. The experimental conditions have been described in the experimental section. As shown in the pictures, I have already obtained samples with a lot of coils. The distance from capillary orifice to the water surface was 2.7 cm.

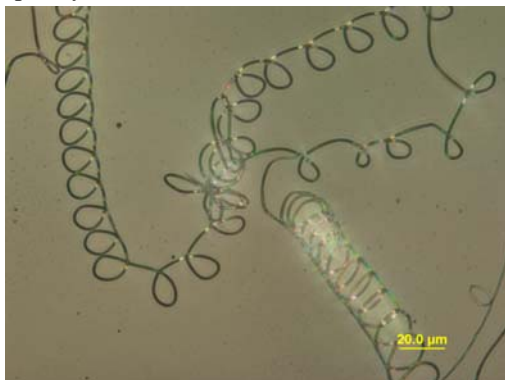


Figure 4. Optical image of buckled solidified Nylon 6 patterns collected on water. (Taken out with glass microscope slides)

In the future, two motors will be used to produce the fiber mat. One is used to make the pipette move horizontally. Another one is used to make the collector go perpendicularly to the pipette. In this way, uniform mats can be produced.

Reference

1. Mahadevan L., Ryu W. S., Samuel D. T., *Nature* 1998, 392, 140.
2. Han, T.; Reneker, D. H.; Yarin, A. L. *Polymer* 2007, 48, 6064.