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Communication

# A polarization method for quickly distinguishing the morphology of electro-spun ultrafine fibers

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ABSTRACT

In the fields of tissue engineering and controlled drug release, electro-spun fibers are often required to have structural characteristics such as high porosity and large specific surface area. The traditional scanning electron microscope can observe the microscopic appearance of the sample clearly, but it damage to the polymer electro-spun fiber, and the detection takes a long time. In view of this, we have tested a polarization method to quickly distinguish different morphological features of the samples, such as smooth surface, microporous, and beaded microspheres using the depolarization parameter MMD-Δ, which is obtained by the Mueller matrix polar decomposition. The preliminary results show that this method is simple, fast, and potentially capable of non-destructive evaluation of the microstructure properties of the object surface.



The ultrafine fibers prepared by electro-spinning method have been widely used in the fields of filtering materials, composite reinforcing materials, and biomedicine [1,2]. This method can help us to produce fiber with porous morphology quickly and efficiently, which will greatly promote its application in these above-mentioned fields [3]. Scanning electron microscopy (SEM) is often used to observe the microstructure of fiber materials, but the disadvantages of this method are high cost and time-consuming, therefore, it is very urgent to find a method that can quickly distinguish different morphologies [4–7]. It has been known that optical techniques based on polarized photon scattering are sensitive to the microstructure of complex biological tissues [8–11]. Considering this, we obtained a large number of ultra-fine fibers with different morphologies, such as beaded surface, smooth surface and microporous through electro-spinning technology and binary blending method [12]. Then we made comparison analysis on these different fibers using both the electron microscopy and Mueller matrix which represents the comprehensive polarization properties of the samples [13–15]. The result showed that the depolarization parameter MMD-Δ from the Mueller matrix decomposition is very sensitive to the surface mesh and beading, providing an effective method for quickly differentiating the different micro-structures of electro-spun fibers.

Scanning electron microscope (SEM, S3400 N), provided by School of Materials Science and Engineering, Sichuan University. Polarized light microscope, 1/4 wave plate, polarizer (Wuhan You Guang Technology Co., Ltd., labview 2014), CCD (qimaging, q42720), Sorabot motors, provided by Shenzhen Key Laboratory for Minimal Invasive Medical Technologies, Institute of Optical Imaging and Sensing. PLLA (Mw: 100000, provided by Chengdu Hang Feng Chemical Reagent Co.,). PCL (Mw: 50000, provided by Chengdu Hang Feng Chemical Reagent Co.,). DMF (*N*, *N*-dimethyl-formamide, Mr: 73.09, Ar, provided by Chengdu Chang Liao Chemical Reagent Company). $CH_2Cl_2$ (Mr: 84.93, Ar, provided by Chengdu Chang Liao Chemical Reagent Co.,). Fig. 1 is a schematic of a polarized light microscope.

The PLLA and PCL were mixed in different proportions and dissolved in methylene chloride. After a certain amount of DMF was added, a spinning solution of 4 wt%–8 wt% was prepared. After the above-mentioned solution was sealed, the solution was stirred at room temperature for 4 h and 30 mL of it was taken out as an electro-spinning solution. The electro-spinning parameters are as follows. The voltage: 15 kV; the receiving roller speed: 100 r/min;

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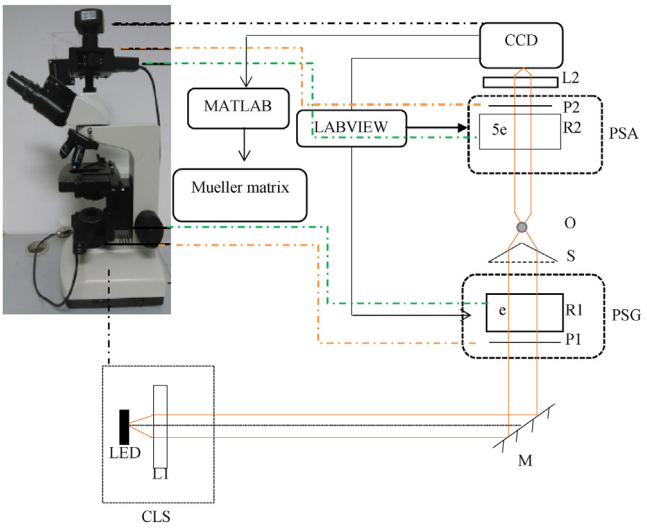


**Fig. 1.** The schematic diagram of polarization microscope. CLS, monochromatic light source; P1 and P2, polarizers; R1 and R2, quarter-wave plates; L1 and L2, lenses; O, 4×, 10×, 20×, 40× objectives.

**Table 1**
Main process of different fibers.

| Numbering | Substance ratio | Morphology and average diameter |
|---|---|---|
| 1# | 6 wt% PLA/PCL (0:100) | Football shaped beads (0.51 μm) |
| 2# | 6 wt% PLA/PCL (25:75) | Porous microspheres (0.67 μm) |
| 3# | 8 wt% PLA/PCL (25:75) | Porous microspheres (1.05 μm) |
| 4# | 4 wt% PLA/PCL (50:50) | Smooth surface (1.33 μm) |
| 5# | 6 wt% PLA/PCL (50:50) | Smooth surface (1.86 μm) |
| 6# | 8 wt% PLA/PCL (50:50) | Smooth surface (2.61 μm) |
| 7# | 4 wt% PLA/PCL (100:0) | A large number of sieve holes (2.88 μm) |
| 8# | 6 wt% PLA/PCL (100:0) | A large number of sieve holes (4.29 μm) |
| 9# | 8 wt% PLA/PCL (100:0) | A large number of sieve holes (6.32 μm) |

the injection propulsion rate: 10 mL/h; the receiving distance: 15 cm; the temperature: 15 °C, the humidity: 45%, the spinning time: 30 min [16]. The following Table 1 is the main process of the electro-spun fiber we have prepare.

The scanning electron microscopy (SEM) was used to observe the fiber morphology of different components at 5 kV and the fiber was imaged with a polarizing microscope. The total magnification was ×400, the exposure time was 9000 μs, and it was corrected by the air. Fig. 2 shows the fiber preparation and characterization in this experiment.

The electro-spun fibers prepared under different ratios have completely different morphologies [17–19]. The surface of the fiber in Fig. 3a is smooth and its diameter is about 0.67 μm. A large number of beaded microspheres appear, and the surface of the microspheres has many micro-porous openings. In Fig. 3b, the surface of the fiber is smooth and this fiber is regular in appearance, with a diameter of about 1.86 μm. The fiber in Fig. 3c is very orderly, with a diameter of about 4.29 μm, a large number of micro-porous on the surface of the fiber, and a micro-porou diameter of about 300 nm. These three completely different fibers basically represent the morphology of common fibers. The purpose of preparing these three types of fibers are to prepare for the rapid detection of polarized light.

Although Mueller matrix contain all the polarization properties of a sample, its 16 elements luck explicit connections to the

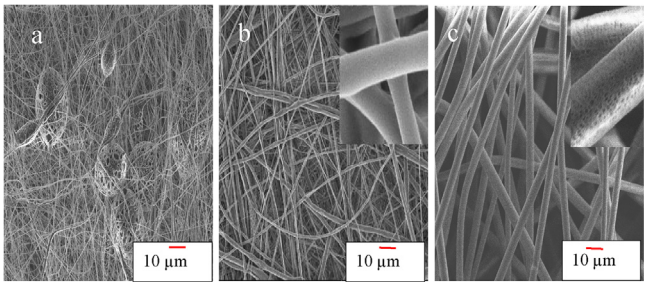


**Fig. 3.** SEM of different morphology electrospun fibers (a: 6 wt% PLA/PCL (25:75); b: 8 wt% PLA/PCL (50:50). c: 6 wt% PLA).

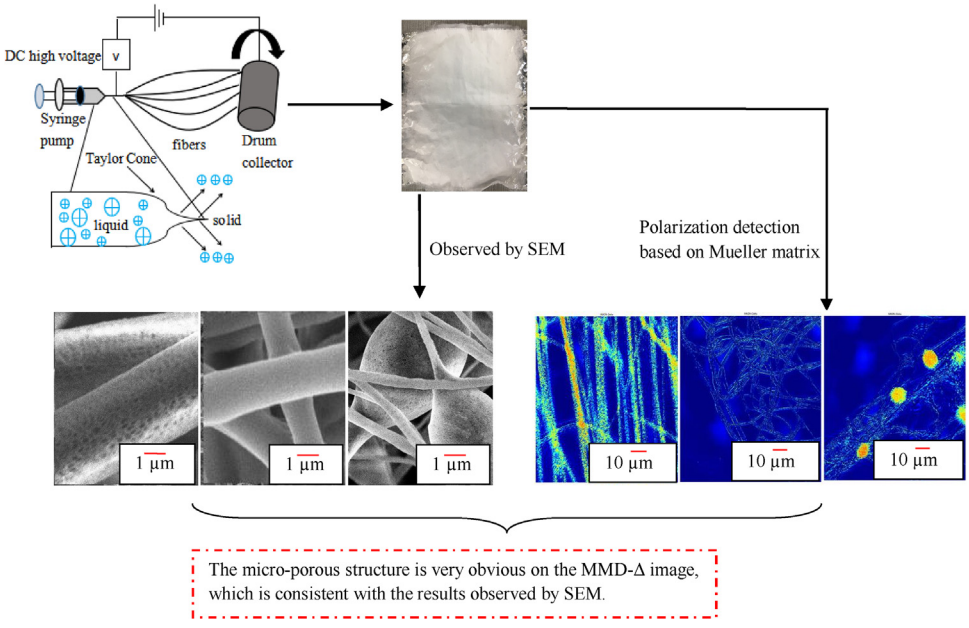


**Fig. 2.** Preparation and testing results of electrospun fibers.

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