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ARTICLE

Large-scale and highly efficient synthesis of micro-and nano- fibers with controlled fiber morphology by centrifugal jet spinning for tissue regeneration

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Supplemental information

The influence of spinneret orifices sizes on fiber morphology

In order to study the influence of spinneret orifice sizes and collector distance influence on fiber morphology, 10 wt% polyvinylpyrrolidone (PVP, M_w=1,300,000 Da, Sigma-Aldrich) in ethanol (100%, Sigma-Aldrich) was used as the spinning solution. The rotational speed of the spinneret was set up to 9000 rpm. All the fiber products were collected on the collector with the distance of 15 cm from collection rods to the centre of the spinneret. The rotating chamber has an outer diameter of 15 mm and inner diameter 10 mm. The orifice sizes studied are 400 μm, 1000 μm and 2000 μm. The fiber diameter change with different orifice sizes was shown in Fig.sup_1. The average fiber diameter increases with increasing orifice size. The distribution of fiber diameter became wider as the orifice size increases. When the orifice size is as large as 2000 μm, the product contains large number of beads and defects as shown in Fig.sup_2. The increase of fiber diameter owes to an increase in the initial spinning solution liquid jet diameter (equal to the orifice size). Since the liquid jet is subjected to the same centrifugal forces, the liquid jets with different initial size experience the similar thinning process before the solidification of liquid jet with the evaporation of solvent. Thus, the initial liquid jet diameter is one determinant factor to the fiber diameter. When the size of initial liquid jet is sufficiently large, the Rayleigh Plateau instability of the liquid jet comes to play because of the increasing surface tension experienced by the liquid jet. The Rayleigh Plateau instability of the liquid jet before solidification induced the formation of beads on continuous fiber.

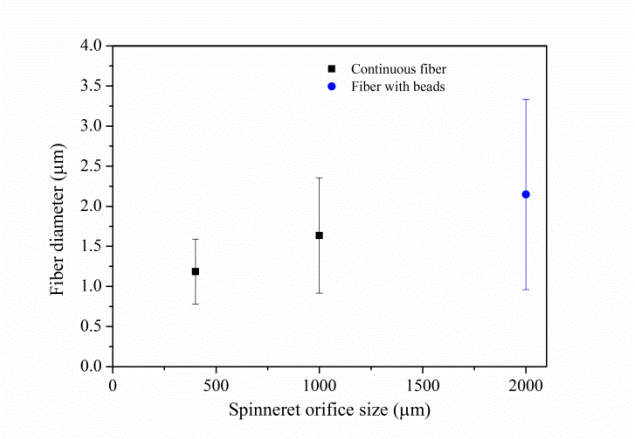

Fig.sup_1. Fiber morphology change with different orifice sizes

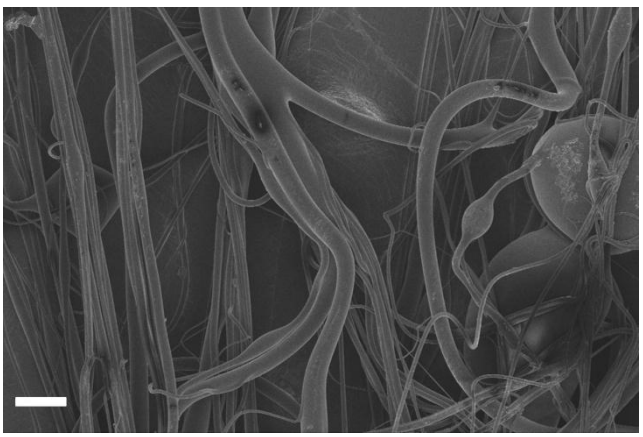

Fig.sup_2. SEM image of fiber morphology with 2000 μm spinneret orifice (scale bar: 10 μm)

The influence of collector distance on fiber morphology

The influence of collector distance on fiber morphology was studied in 10 wt% PVP-ethanol solution with the spinneret size of 400 μm. The rotational speed of 9000 rpm was used in this study. The rotating chamber has an outer diameter of 15 mm and inner diameter 10 mm. Four different collector rods to the spinneret distance were investigated. Changes in fiber morphology are

shown in Fig.sup_3. With a decrease in the collector distance, the diameter of the fiber decreases, and the formation of beaded fibers is less likely. The average diameter of the fiber assembly remains similar when the collector distance is larger than 15 cm. During liquid jet thinning process by centrifugal forces, the liquid jet also experiences solvent evaporation which solidifies the liquid jet as well as providing the thinning effect. As the collector distance to spinneret distance increases, the liquid jet needs a longer time to reach the collection rods. When the liquid jet arrives at the collection rods before it is solidified, the collection rods can break the liquid jet into droplets. These droplets may be subsequently caught on the partially wet fiber mat formed between the collection rods. When the collector distance is far enough, the liquid jet experiences longer thinning process both by centrifugal force and solvent evaporation. This contributes to obtaining thinner fiber assembly with continuous morphology. However, the thinning process of liquid jet is not unlimited. The collected fiber diameter doesn't change with the collector distance once the liquid jet is fully solidified into continuous fiber when the evaporation of the solvent is complete.

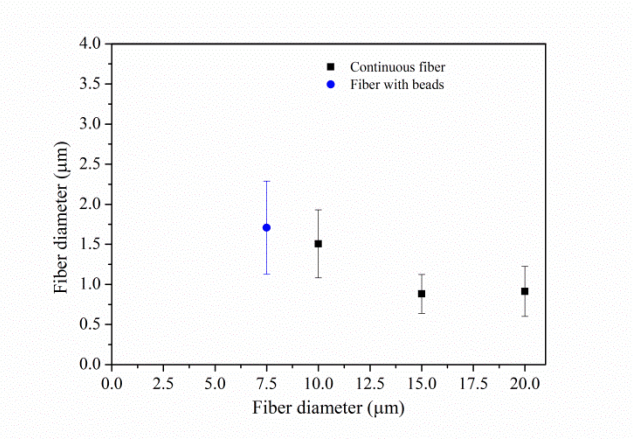

Fig.sup_3. Fiber morphology change with collector distance to spinneret

Notes

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† Electronic Supplementary Information (ESI) available.