Pressure driven spinning: A multifaceted approach for preparing nanoscaled functionalized fibers, scaffolds, and membranes with advanced materials

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In this work we unveil a competing technique to electrospinning in order to fabricate a fiber, a scaffold and a membrane called as ***"pressure driven spinning (PDS)"***.The driving mechanism in this spinning process is the pressurized bypass flow. The PDS does not have specific for electrospinning limitations: hazardous high voltage and the inability to handle highly conducting suspensions (containing sensitive molecules) but still demonstrates the comparable performance. Thus, the PDS seems to be more suitable for various medical applications.

Materials and equipment

In this study two pressure driven devices were used: the single needle device (Figs.1a,b) and the coaxial device (Figs.1c,d), both autoclavable, as well as stainless steel needles and a chamber. Several polymers with some added nanomaterials were explored. Also cell suspensions with human embryonic kidney cells were prepared for assessing cell viability. Throughout these studies spinning behaviour was studied by means of a digital high speed camera in real time. The cell viability was ascertained by the well established approach *flow cytometry.*

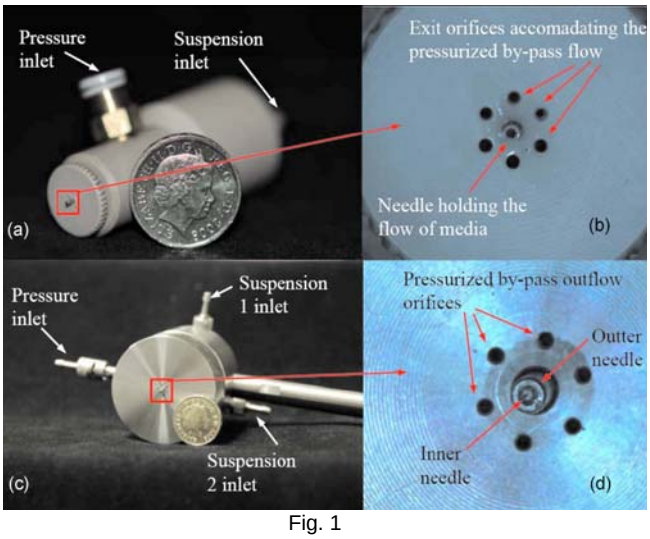

Fig. 1

Procedure and results

The prepared solution was syringed into the single needle device at the lowest possible flow rate. Once the polymer was seen to reach the exit of the single needle device, a pressure was applied to the chamber, which provided the pressurized bypass flow through the exit orifices (Fig.1b), place around the needle exit, which promoted the elongation or drawing of the polymer from the needle exit. Fibers were deliberately selected as goal for these experiments as they are most relevant to material sciences and engineering.

At very low flow rates for a pressure of ~1bar, the threading process was unstable (Fig.2a). But while altering the flow rate and elevating applied pressure the nanoscaled near uniform fibers were generated (Fig.2b). However, on further increasing the applied pressure to ~3bar and ~4bar the fibers became diverged at the needle exit with the forming of multiple fibers (Figs. 2c,d).

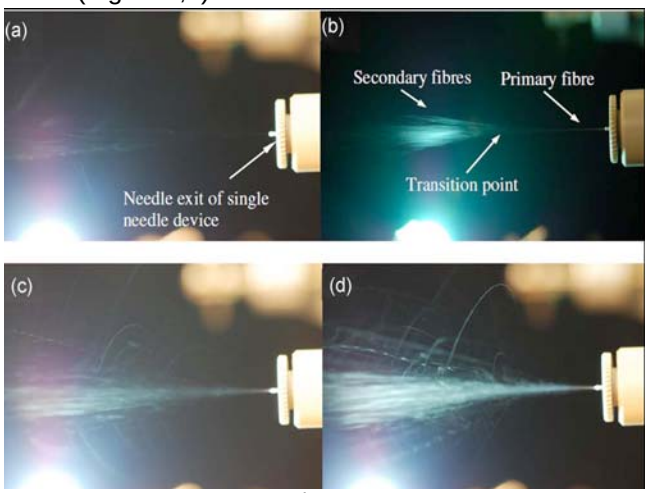

Fig. 2

During the experiments it was noted that the concentration of nanoparticles in the solution resulted in an increase in the fiber diameter. While working with the coaxial needle device in order to handle two immiscible media the phenomenon of the multiple fibers could be avoided and the formation of co-structured fibers was ensured. The studies showed that the flow rate within the outer needle had to have flow rate larger than that of the inner needle for complete and consistent encapsulation of the inner media. If the introduction of air to the inner needle was increased, continuous hollow and porous fibers were formed. The pore structure considerably depended on the pressurized air flow. Concerning the living cells, it was noted that the needle diameter and the rate of cell suspension being syringed through the needle had an effect on cell viability. Cytometry data demonstrated that the treated samples were indistinguishable from the controls.

Conclusions

Taking into consideration the advantages of the PDS approach compared to electrospinning and the promising results achieved within the bounds of these experiments this new technology seems to have the potential when generating size-controlled fibers, scaffold, and membranes for biomedical sciences.

This flyer is based on the following publication:

S. N. Jayasinghe and N. Suter, Pressure driven spinning: A multifaceted approach for preparing nanoscaled functionalized fibers, scaffolds, and membranes with advanced materials, BIOMICROFLUIDICS, 2010, 4, 014106 Issue 31.03.2010