INFLUENCE OF ELONGATIONAL PROPERTIES OF POLYMER SOLUTIONS ON NANOFIBRE PROPERTIES PROCESSED BY ELECTROSPINNING

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Electrospinning is an efficient and versatile process to produce microscale to nanoscale sized polymer fibres from polymer solutions. The application of an intense electric field, of about 10^5 V/m, between the tip of a capillary and the collector leads to charge the pendent drop of polymer solution (see Fig. 1). The charged drop is deformed into a "Taylor's cone" due to mutual charge repulsion. At a critical field, when the force due to the electric field overcomes the surface tension forces holding the droplet, a charged jet is emitted at the apex of the Taylor Cone. Electrostatic forces at the air/fluid interface stretch the jet and lead to its drastic narrowing. Concurrently, the solvent evaporates, leaving a solid fibre of 100 nm to few micrometers in diameter after an air path of few centimetres.

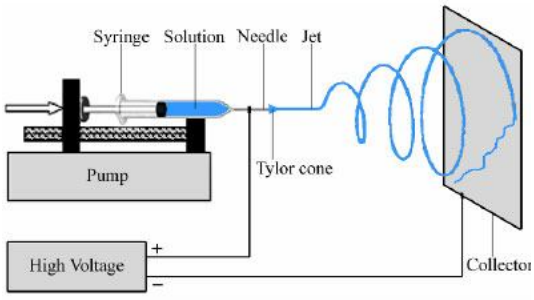

Figure 1: Electrospinning setup

Concentration regimes determined through zero shear viscosity (η_0) measurements are generally considered as key parameters of the solution governing the fibre diameter and morphology of electrospun fibres and consequently the mechanical properties of the scaffold. [1-2] Very low viscous polymer solutions in the dilute regime are electrosprayed in thin droplets. On the contrary, ejection of jets from very high viscous solutions is difficult and an optimal viscosity range is required. Beaded nanofibres are formed for solutions with moderated viscosity corresponding to the entanglement concentration (*C*e) and defect-free fibres are obtained with 2 to 2.5 times *C*e. Surprisingly, the fibre diameter has shown to increase with η_0 according to the following relationship

$$D \propto \eta_0^{0.8}$$

However, steady shear flow at low shear rate is far from the process condition and, the polymer jet undergoing an intense elongation strain. The consideration of elongational viscosity is more representative of the material parameter for the process.

The aim of this work is to evaluate the influence of the elongational properties of polymer solutions in the electrospinning process. For this purpose, elongational strain during process have been measured by particle tracking after the “Taylor cone” and elongational stress are estimated using excitation of electrically driven jets by single lateral pulses. [3] Elongational properties are correlated with fibre morphologies.

References

[1] Mc Kee M. G.; Wilkes G. L.; Colby R. H. and Long T. E. *Macromolecules* **2004,** *37,* 1760-1767.

[2] Gupta P.; Elkins C.; Long T. E. and Wilkes G. L., *Polymer* **2005**, *46*, 4799-4810.

[3] Han T., Yarin A. L. and Reneker D. H., *Polymer* **2008**, *49*, 1651-1658.