Electrospinning: a promising technology for discontinuous and continuous nanofibers

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Preface

ELECTROSPINNING: A PROMISING TECHNOLOGY FOR DISCONTINUOUS AND CONTINUOUS NANOFIBERS

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Although there are many methods of fabricating nanofibers, electrospinning is perhaps the simplest, the cheapest, the most straightforward way to produce discontinuous nanofibers /1-3/ and continuous nanofibers /4,5/ by forcing a polymer melt or solution through a spinnerette with an electric field.

Due to its ultra high specific surface, discontinuous and continuous nanofibers have attracted much attention as the most promising material in nanotechnology, and served as a highly versatile platform for a broad range of applications in widely different areas such as carbon nanofibers, photonic structures, microfluidic channels (nanofluidics), catalysis, sensors, medicine, pharmacy, drug delivery, invisibility devices (e.g. stealth plane, stealth clothes), radioprotection, and tissue engineering, just to mention a few /6-9/.

BioMimic production of electrospun nanofibers has also become the focus of much attention /4/. Spider-spun fiber is of extraordinary strength and toughness, in comparable to those of electrospun fibers. The latter needs a very high voltage (from several thousands voltage to several ten thousands voltages) applied to water-soluble protein “soup” that was produced by spider, furthermore, its mechanical strength dramatically decreases when compared to spider silk. A possible mechanism in spider-spinning process is worth studying systematically. The distinct character in spider-spinning is that its spinneret consists of millions of nano scale tubes, and a bubble can be produced at the apex of each nano-tube. The surface tension of each bubble is
extremely small such that it can be spun into nanofibers with an awfully small force, either by the spider's body weight or tension created by the rear legs. We can mimic the spider-spinning in electrospinning using an aerated solution /4,10/, which leads to various small bubbles on surface with very small surface tension, as a result the bubble can be easily electrospun into nanofibers with low applied voltage. This fabrication process possesses features of high productivity, versatility, in addition, the minimum diameter of nanofibers produced by this process can reach as small as 50 nm.

Spider-spinning process reproduced with the permission of Dennis Kunkel Microscopy, Inc. The diameter of a single nanofiber is about 20 nanometer.
We are only just beginning to understand the depth and complexity of how nanofibers behave unusually well in many aspects; to explain the many fascinating phenomena arising in the electrospinning process and applications, we should develop a new theory linked to both deterministic classic mechanics and chaotic quantum mechanics /11-15/. There should be a law controlling the change from a classical object like a stone to a quantum object like an electron. Somewhere between these two scales these changes happen, but this does not happen suddenly. There is a grey area between these two scales which is neither classical nor quantum. And E-infinity theory /16/ provides a strong candidate theory to deal with this grey area.

This special issue on Electrospun Nanofibers and Applications covers theoretical analysis, experimental verification, and new applications, in an order to bring together the researchers from academia and industry to share ideas, problems and developments related to the multifaceted aspects of electrospinning, thereby capturing both the interest and imagination of the wider communities in various fields, such as in mathematics, physics, material science, biologics, medicine, and others.

We hope that this issue will prove to be a timely and valuable reference for researchers in this area. Special thanks go to the referees for their valuable work. I here thank Prof. Ica Manas-Zloczower for providing us with the opportunity to produce this special issue on this promising technology. I should also thank co-guest editors of this special issue, Dr. Lan Xu of Donghua University and Dr. Santi Maensiri of Khon Kaen University, for their careful preparation of this special issue. The financial support from National Natural Science Foundation of China under the grant No. 10372021, the 111 project under the grant No. B07024 and the Program for New Century Excellent Talents in University is very much appreciated.

REFERENCES

10. Liu Yong, Ji-Huan He, Lan Xu, Jian-Yong Yu, The principle of bubble electrospinning and its experimental verification, Journal of Polymer Engineering, submitted