PREFACE: NANOSCALE FLOW
AND THERMAL EFFECT
FOR NANOFIBER FABRICATION

This special issue covers nanoscale flow, with an emphasis on nanofiber fabrication. The thermal property of the nanoscale flow plays an important role in controlling the spinning process and morphology of productions, especially in the bubble electrospinning (see Yong Liu's paper) and the melt blown process (see the paper by Ting Chen). There are many fascinating phenomena in this field, which can be heuristically explained by modern mathematics including fractal theory (see the paper by Jie Fan), q-calclulus, and fractional calculus (see papers by Guocheng Wu). The application of mathematics and mechanics to the modern textile engineering, especially to nanotextiles, attracted much attention recently.

The charged jet in the electrospinning process or the jet in the melt blown process can be considered as a nanoscale flow, when applied to nanofiber fabrication. Here, a very simple mathematical treatment of the process of nanoporous material fabrication is presented.

We consider the mass conversion of a jet in the spinning process (He, 2012):

$$\pi r^2 \rho u = Q \ , \tag{1}$$

where r is the radius of the jet, ρ is the density, u is the velocity, and Q is the flow rate which is constant.

The velocity depends upon the applied voltage. A mathematical experiment shows that the applied voltage tends to infinity:

$$u \rightarrow \infty \ . \tag{2}$$

According to Eq. (1), we have

$$r \rightarrow 0 \ . \tag{3}$$

It means that the jets disappeared completely. This, of course, contradicts the law of mass conversion. Now, a question arises, what will happen if the jet radius reaches a threshold while the jet is still accelerated? In order to follow the law of mass conversion, Eq. (1), the only way is to decrease ρ, that is to enlarge the volume of the jet, resulting in porous nanomaterials. Readers can refer to papers by Lan Xu and Fu-Juan Liu in the special issue for detailed experimental process.

The traditional approach to fabrication of nanofibers is electrospinning, which uses electronic force to overcome the surface tension of a polymer solution or a melt. In this special issue we introduce a new concept for nanofiber fabrication

using a polymer bubble. It is interesting to note that the surface tension of a bubble does not depend upon any properties of the solution, but depends geometrically on the bubble size (He, et al., 2012):

$$\sigma = \frac{1}{4} r \, (P_i - P_o) \, ,$$ (4)

where σ is the surface tension, r is the bubble radius, and P_i and P_o are the air pressures inside and outside the bubble, respectively.

If we can produce extremely small polymer bubbles, then it is very easy to pull the bubbles upward, using the electronic force to form multiple charged jets for nanofiber fabrication, the readers can refer to papers by Yong Liu for detailed information. It is interesting that air pressures inside and outside of the bubble can be best controlled by temperature according to the state equation

$$\frac{P}{\rho} = RT \, .$$ (5)

The bubble electrospinning is now becoming a main tool for mass-production of nanofibers.

Included herein is a collection of original refereed research papers by well established researchers in the field of applied mathematics and nanotechnology. We hope that this issue will prove to be a timely and valuable reference for researchers in nanotextile.

Finally, we would like to express our appreciation to all reviewers who took the time to review articles in a very short time, and we here also thank Dr. Yong Tao for providing us with the opportunity to produce this special issue.

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