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Micro egg-shaped product via electrospinning

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Abstract. A new product, micro egg-shaped, was observed in an electrospinning process. The formation of this structure might be caused by hierarchy circle motion and buckling instabilities of electrospinning jets.

It has been about 100 years since the electrospinning process was invented. This process has not been paid much attention until recent decade when nanoscience and nanotechnology took off [1-8]. Nanofibers via electrospinning has become a topic of great interest to scientists and engineers all over the world[9-13]. Besides ordinary round-section nanofibers, microspheres[14, 15], micro-beads[16], micro-cups, and various shapes and forms of nanofibers such as branched fibers, flat ribbons, ribbons with other shapes, based on various natural or synthetic polymer are observed in electrospun products, which make a tremendous impact on many applications that range from healthcare, biotechnology, environmental engineering, defense and security, etc[17]. In this presentation, we report a new product, micro-eggs in micro-nest, which has not been observed in electrospinning process in any previous opened literatures.

Polyacrylonitrile (PAN, molecular weight $M=70,000g/mol$) was purchased from Sinopec Shanghai Petrochemical Company Ltd., and N, N-dimethylformamide (DMF) was bought from Shanghai Chemical Co. All the chemicals were used as received without further purification. The polymer was dissolved in DMF solvent and the weight concentration was adjusted to 12 wt%. Electrospinning process was done in the vertical mode in a 20ml plastic syringe with a syringe pump(AJ-5803, Shanghai Angel Electronic Equipment Co.) at 2.0 ml/h via a gauge stainless steel needle(Φ = 0.9mm) at 20kV in this experiment. The distance between the needle orifice and the grounded aluminum foil was 6 cm. The morphology of the PAN nanofibers in this experiment was determined by a scanning electron microscope (SEM, JSM-5610, Japan). The samples were collected on an SEM disk and coated with gold before being observed through SEM.

During the electrospinning process, a straight jet was formed at the primary spinning stage, from a Taylor cone suspending at the needle orifice. After the initiation from the cone, the jet was then whipped and elongated continuously by electrostatic repulsion until it was deposited as a nonwoven mat on a grounded collector. Whipping due to a bending instability in the electrified jet and concomitant evaporation of solvent are considered as the main reason that the jet is stretched to nano-scale diameter. Additionally, buckling instabilities of some electrospinning jets caused themselves coiled or looped and the bending instability resulted in disorder of nanofibers. Some circles were formed from only a single nanofiber which was called coiled or looped fiber. The formation of these

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coiled and looped nanofibers might be owed a great deal to several hierarchy circles and buckling of jets occurred in bending instability stage observed by Reneker et al. [18, 19]. Meanwhile, the beads-on-a-string structure is a common phenomenon in electrospun products. A non-beaded segment of a jet might be buckled and became a series of spiraling loops, which has the shape of a nest. If there were some beads in the jet, the bead segment of the jet would have a coiled or looped shape with fewer diameters during the bending instability stage because of gravity. As a result, micro egg-shaped product was formed when the beads just deposited into the nest (see Figure 1). This phenomenon help us to understand the buckling of jet and the bending instability in electrospinning process better. Its mathematical model and theoretical analysis worth further studying.

![SEM photography of coiled and looped fibers and micro egg-shaped product.](image)

Figure 1. SEM photography of coiled and looped fibers and micro egg-shaped product.

References
[1] Reneker D H and Chun I 1996 Nanotechnology 7 216
[17] Ramakrishna S, Fujihara K, Teo W-E, et.al 2006 Materials Today 9 40
[18] Han T, Reneker D H and Yarin A L 2007 Polymer 48 6064