Ultrafine Nanofiber Fabrication through Centrifugal Spinning

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Abstract

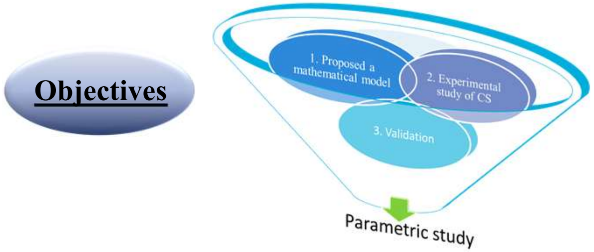
Large surface to volume ratio, good mechanical properties and good handling characteristics make nanofibers highly attractive in a broad spectrum of medical and industrial applications. The Centrifugal Spinning (CS) approaches have recently attracted many attentions [1].

Low operating costs and high production rates to fabricate nanofibers.
Possibility of working with both polymer solutions and melts.

Considering the effects of different operational and geometrical parameters on the CS process.

The effects of rotation speed and nozzle diameter are considered here experimentally.
The effects of rotational and surface forces are studied numerically.

Suggestions to increase the CS process performance.



Centrifugal Spinning (CS)

A technique to extrude fibers through high speed, rotating polymer solution jets.

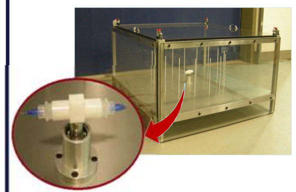


Figure 1. Experimental setup

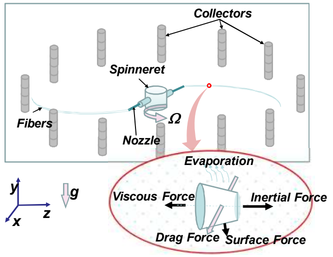


Figure 2. Schematic diagram of CS setup

Figure 3. Different samples produced using our CS setup in different conditions. The solution was PVP solved in ethanol.

Experimental results

Effect of rotation speed and nozzle diameter are considered here experimentally.

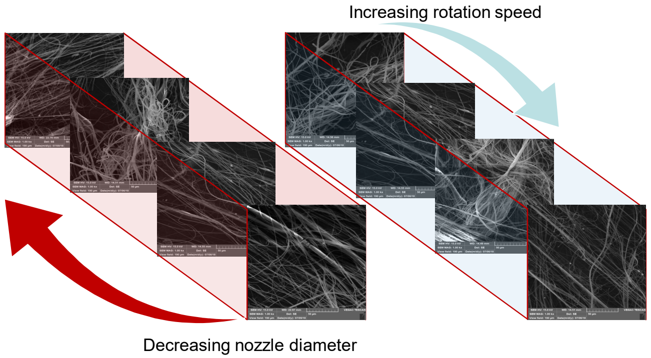


Figure 4. SEM images sequences in different rotation speeds (right) and nozzle diameter (left).

Governing Equations

Momentum and continuity equations [2-5]:

$$\frac{\partial \mathrm{v}}{\partial t}+\mathrm{v}.\nabla\mathrm{v}=-\frac{1}{\mathbf{Re}}(\nabla\mathrm{p}+\nabla.\Pi)+\frac{G(x,y,z)}{Fr}+F(Rb,x,y,z),\ \ p=f(We,R),$$

$$\nabla.\mathrm{v}=0.$$

Numerical RESULTS

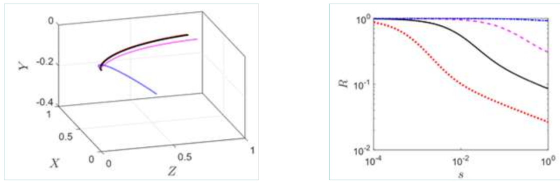


Figure 5. The fiber trajectory and radius for different Rb numbers; In all cases (Fr = 1, We = ∞, Re = 1). Rb=0.001 (red dotted line), =0.01 (black solid line), =0.1 (pink dashed line) and =1 (blue dash-dot line).

Numerical RESULTS

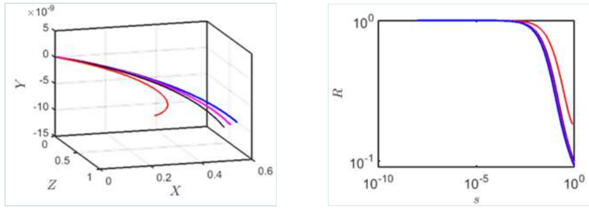


Figure 6. The fiber trajectory and radius for different We numbers; In all cases Fr = 1, Re = 1, Rb = 0.01). We=0.001 (red dotted line), =0.005 (black solid line), =0.01 (pink dashed line) and =0.1 (blue dash-dot line).

CONCLUSIONS

- Ex. • Increasing the rotation speed results in thinner fiber with more beads.
- Ex. • Decreasing the nozzle size Gives rise to thinner fiber; however, it does increase the instability and thus beads formation.
- Nu. • By Increasing *Rb* (decreasing the rotation speed) the fiber falls more Rapidly and its radius decreases at a lower rate .
- Nu. • By Increasing *We, the* jet curvature increases leading to thicker fibers.

References

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NOMENCLATURE

F: Rotation function
f: pressure function
G: Gravitational function
p: Pressure
R: Radius of the fiber
s: Arc length
t: Time

v: Velocity vector
(x,y,z): Centerline position
μ: Solution viscosity (Pa.s)
∏: Deviatoric stress tensor
Ω: Rotation speed (rad/s)
ρ: Solution density (Kg/m^3)
σ: surface tension coefficient (N/m)

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