Novel Nanofiber (NF) Filter Media for High Filtration Performance

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53rd CFR Review Meeting

Mystic Lake Conference Center, Prior lake, MN

April 25th, 2018

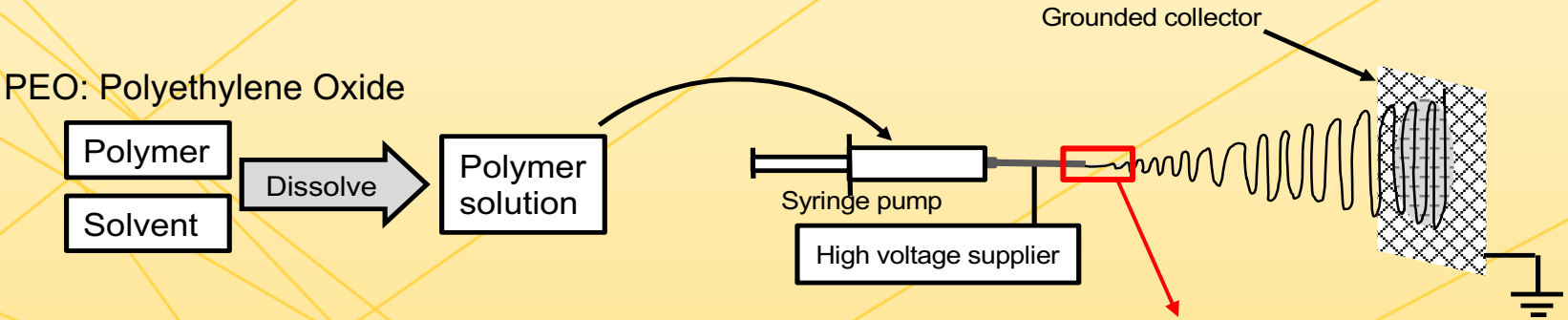
Background

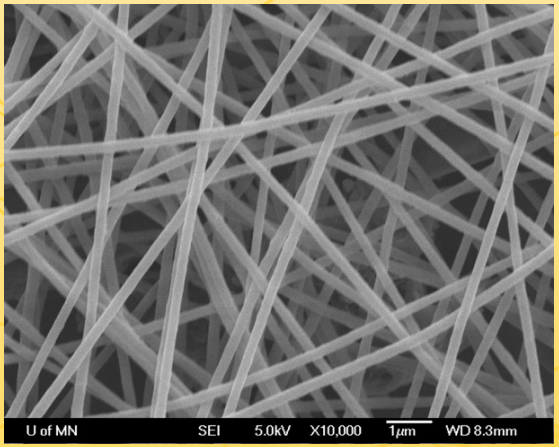
- Electrospinning has been a well-known simple method to fabricate nanofibers (NFs), which exhibits high filtration efficiency and low pressure drop across the filters. However, it is still required to improve its performance (Filtration efficiency, Pressure drop, Loading capacity) in order to expand its applications.

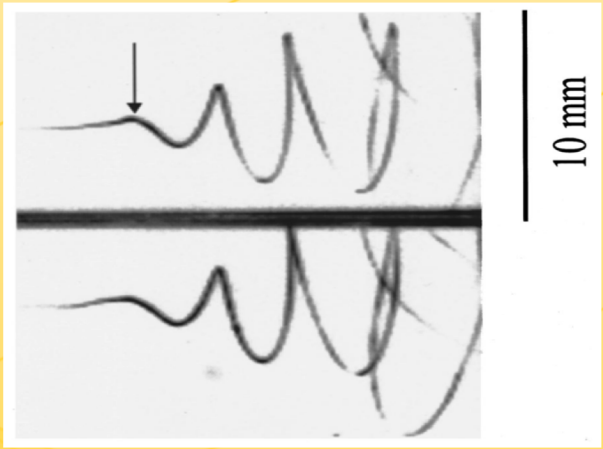
- In the last CFR meeting, preliminary test results presented that polymer beads on nanofibers can improve NF filter pressure drop and dust loading capacity.

- This presentation is to show
    1) Systematic study on NF bead formation
    2) Filtration/loading test results
    3) SEM images of dust cakes on various beaded NF filters

Nanofiber fabrication using electrospinning

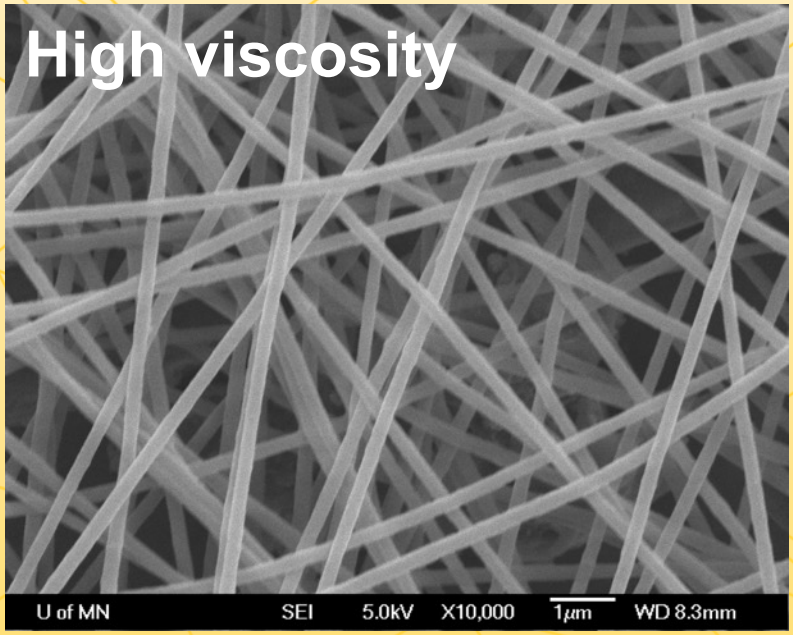


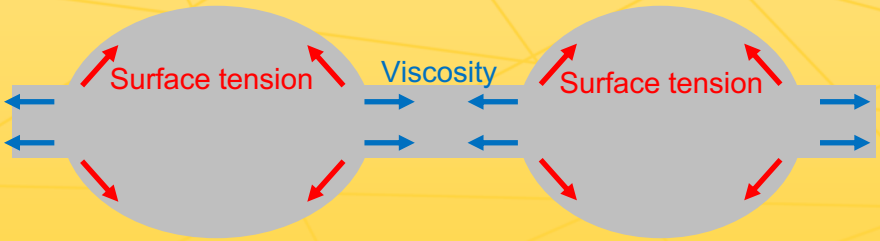




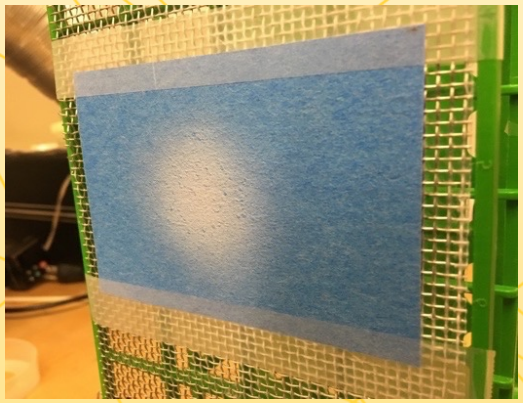
Reneker, D. H., Yarin, A. L., Fong, H., and Koombhongse, S. (2000). Bending instability of electrically charged liquid jets of polymer solutions in electrospinning. J. Appl. Phys. 87, 4531–4547.

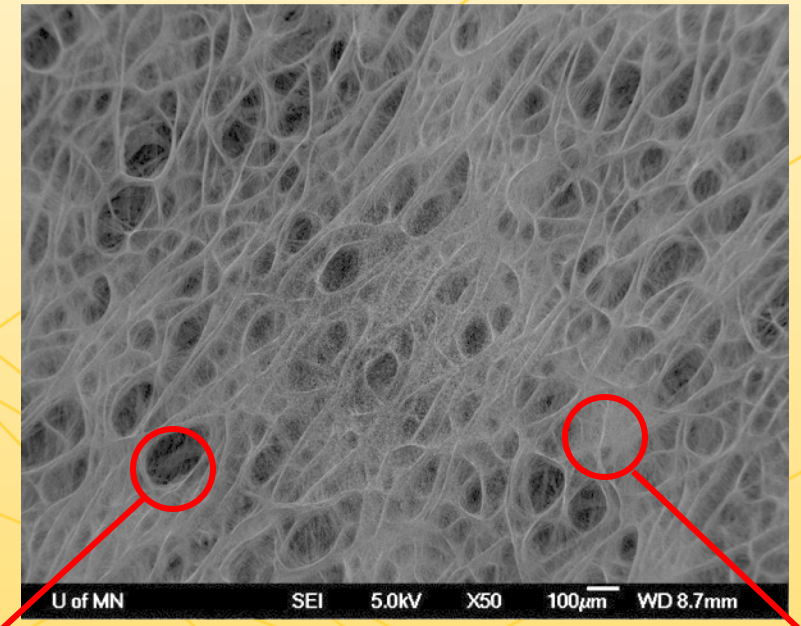
Beads forming on nanofiber

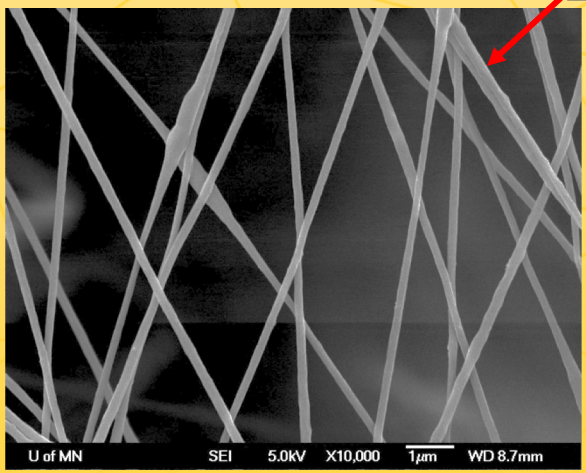


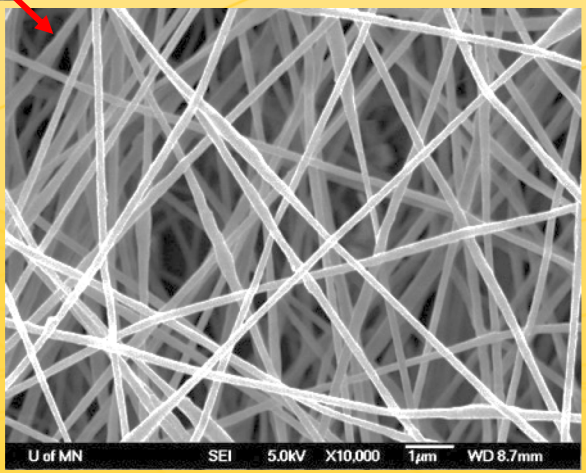


Nanofiber layer non-uniformity issue (Cellulose filter)

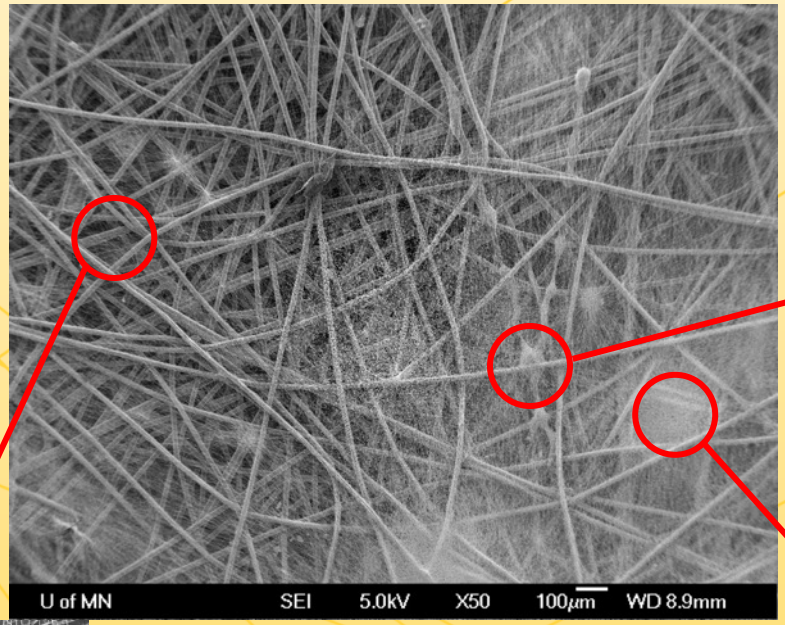


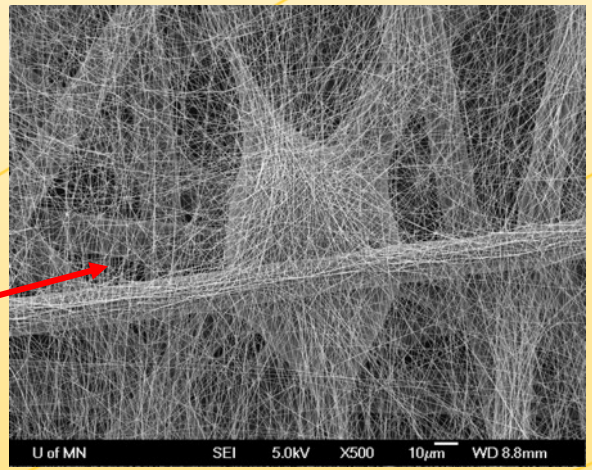


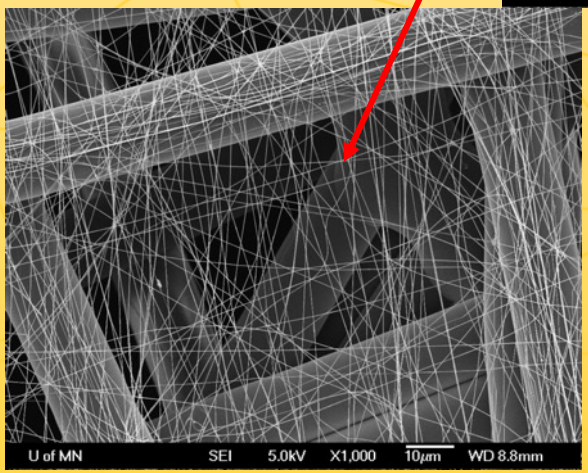


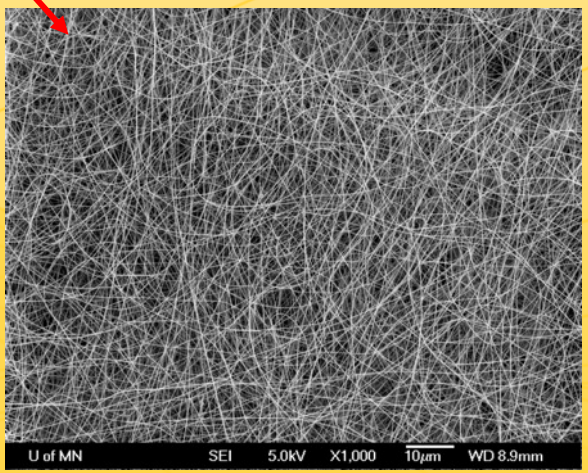


Nanofiber layer non-uniformity issue (Glass fiber filter)

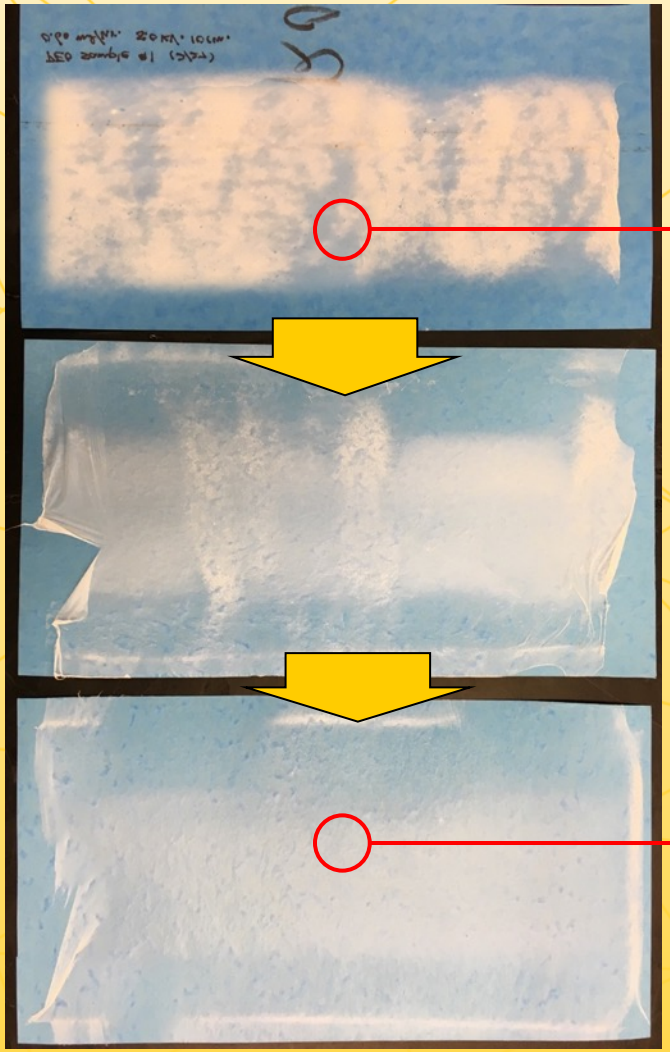


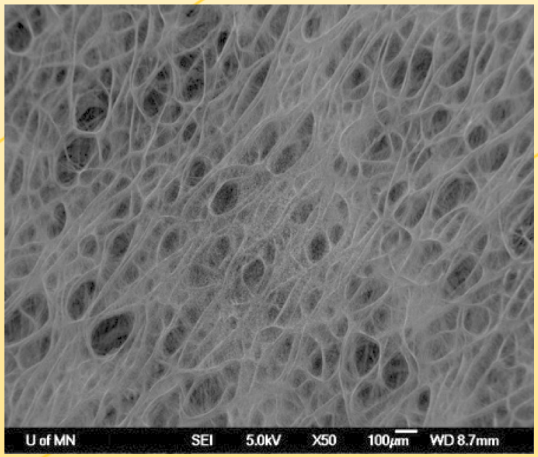


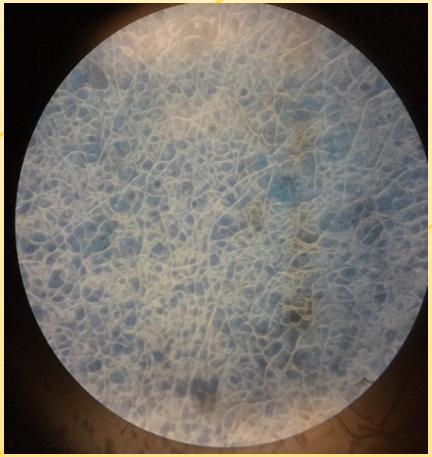


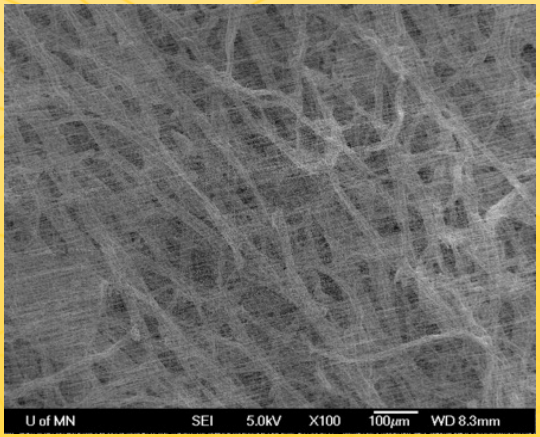


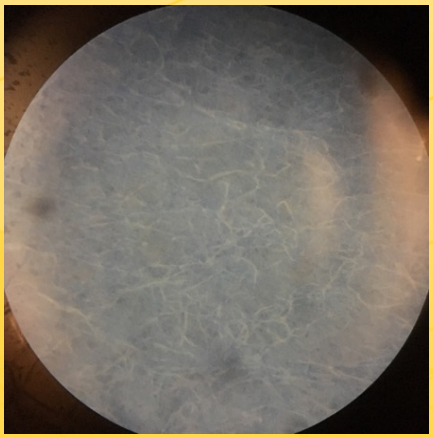
Nanofiber layer uniformity improvement



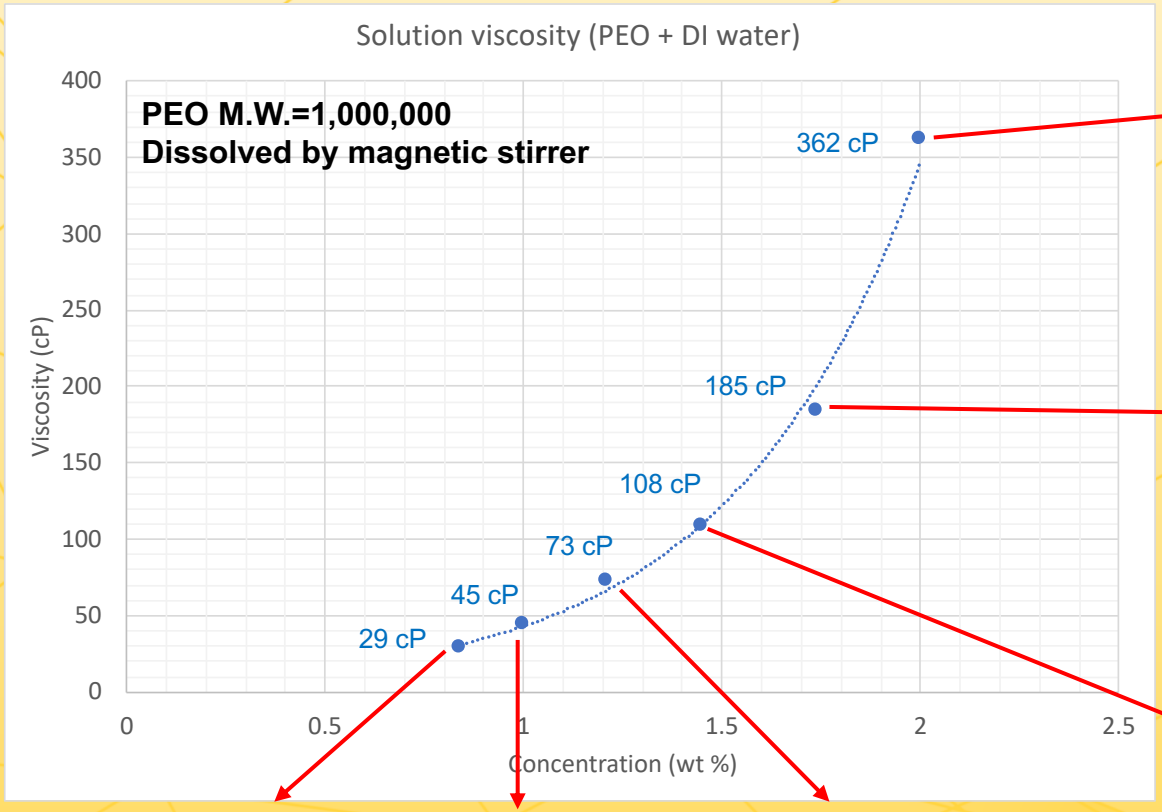


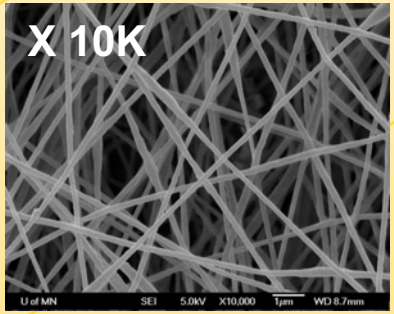


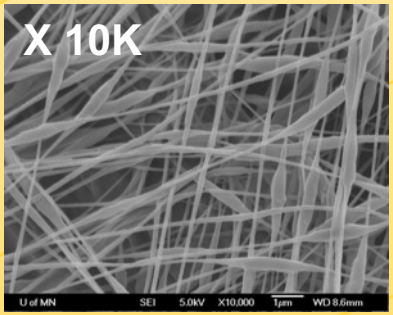


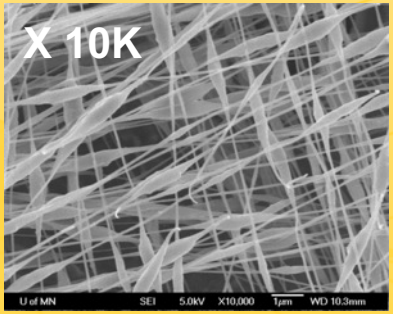


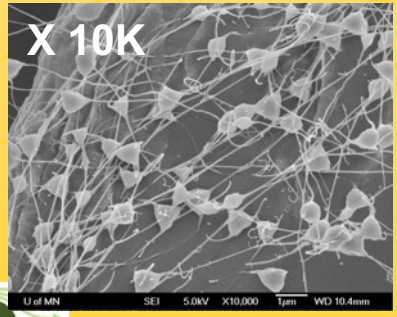
Electrospinning result (Fiber shape)

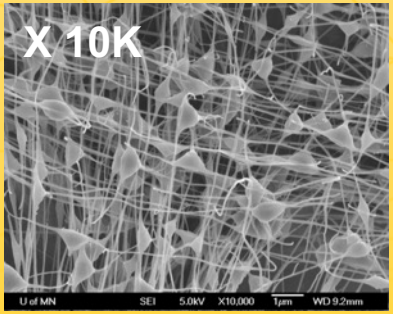


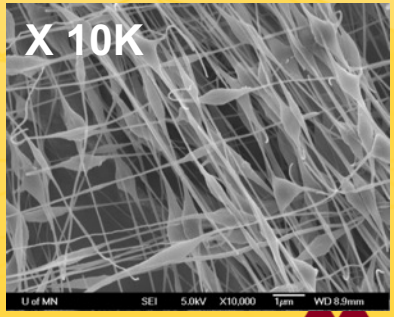




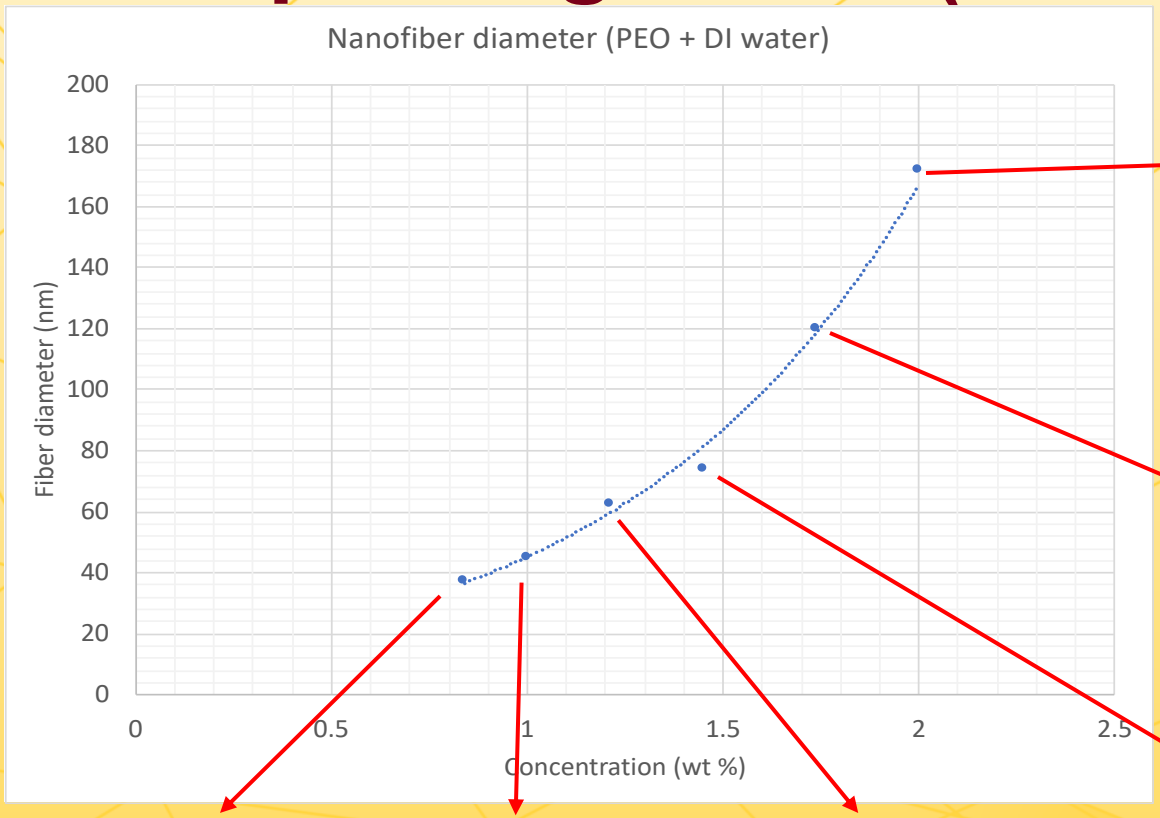


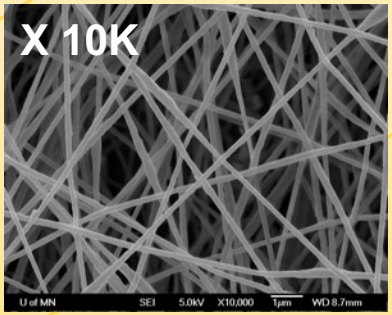


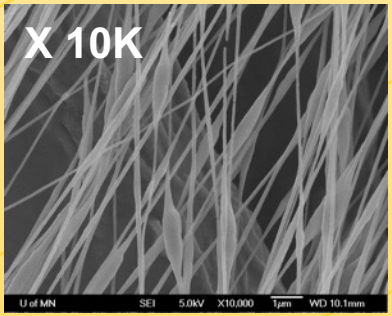


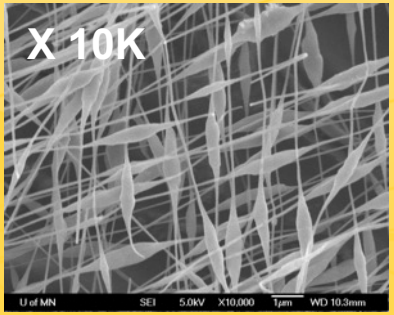


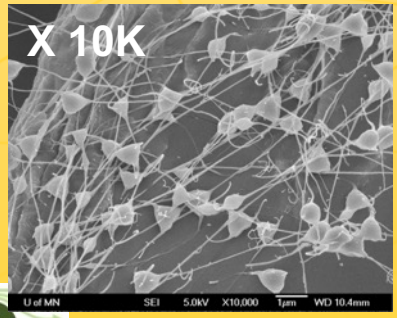
Electrospinning result (Fiber diameter)

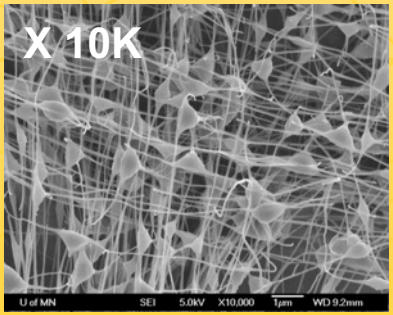


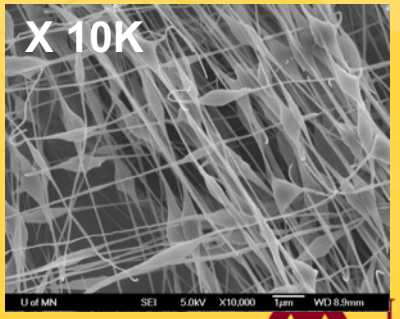




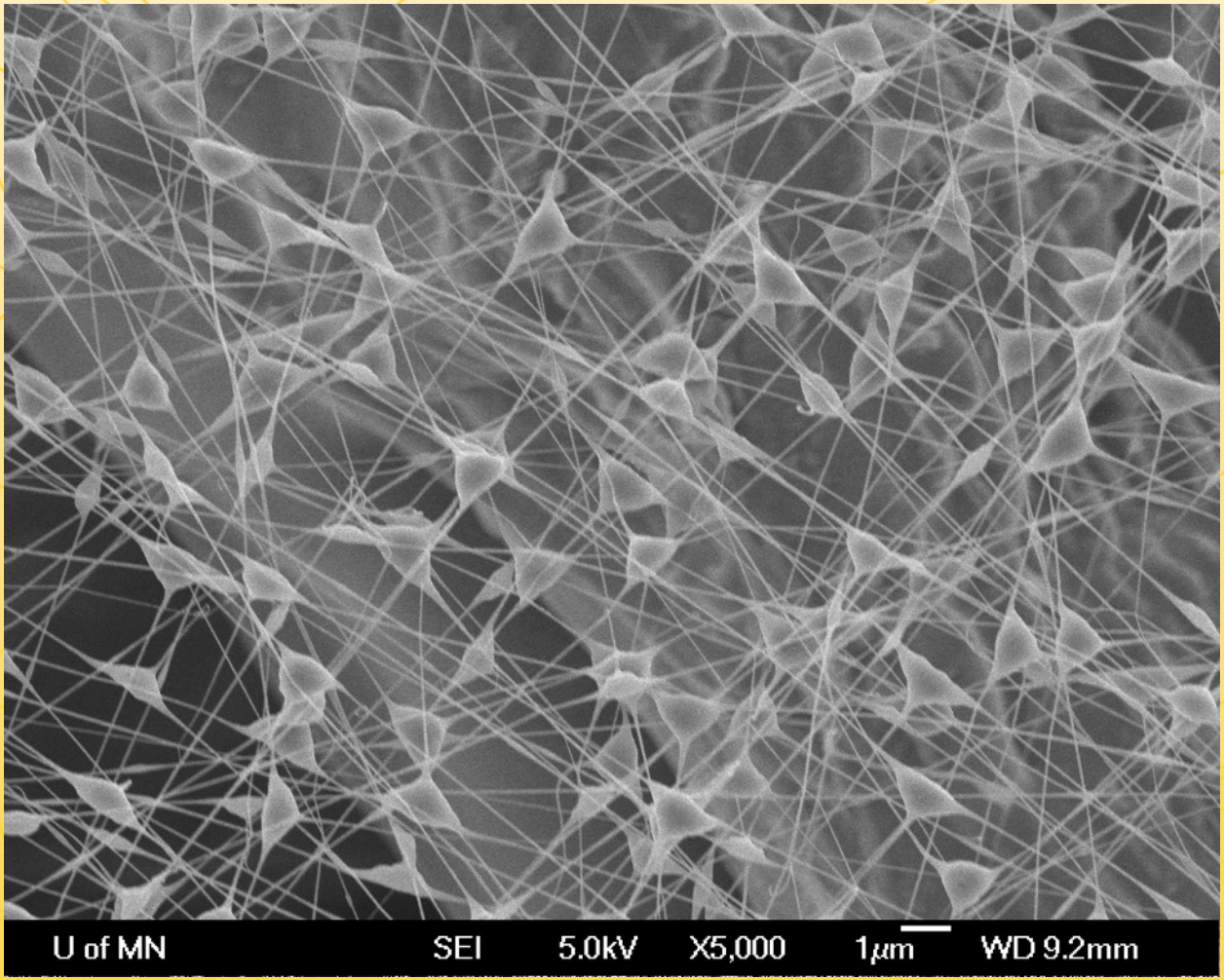


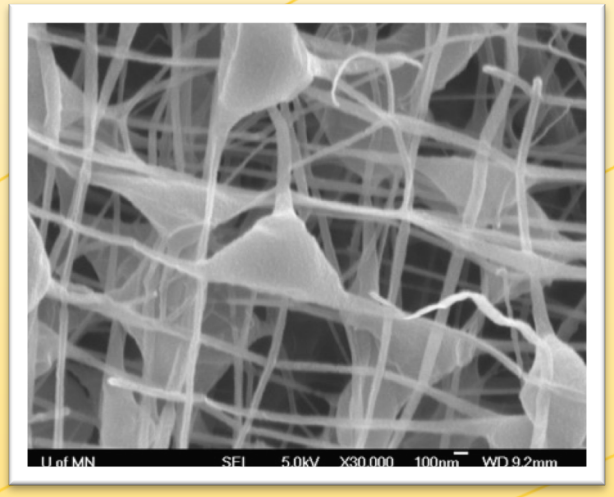


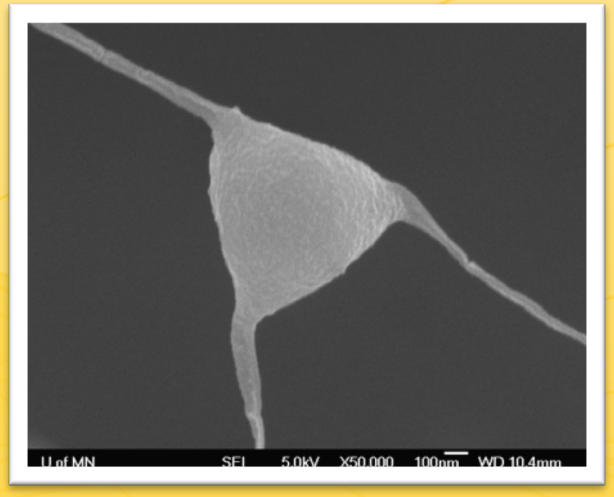




Triangular beads on NF (Sample #5)

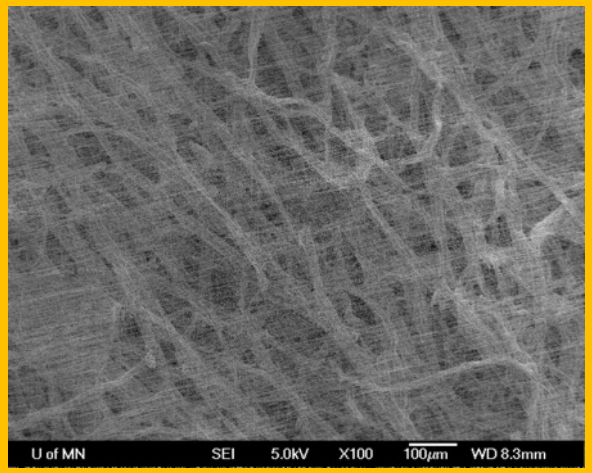


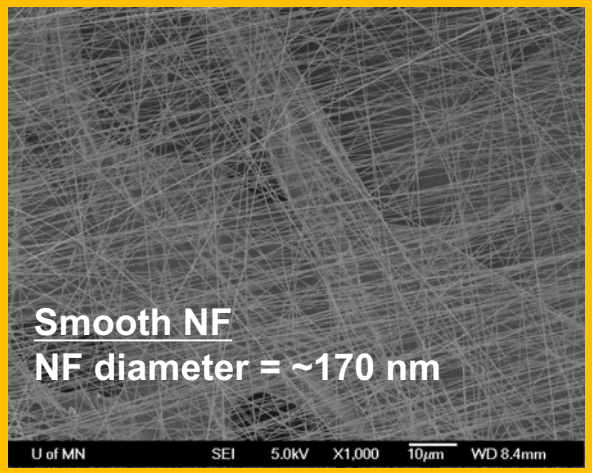




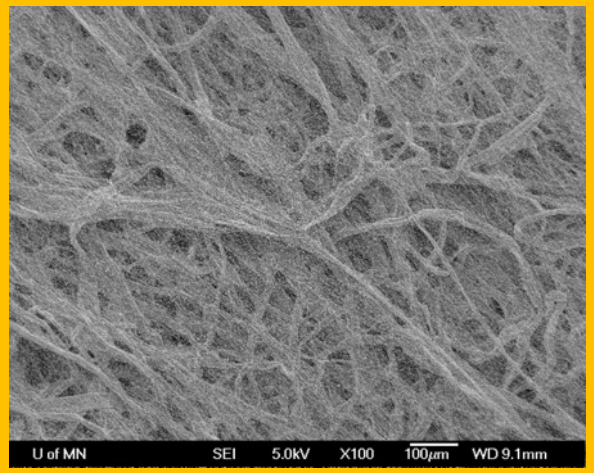
NF samples from various PEO concentration

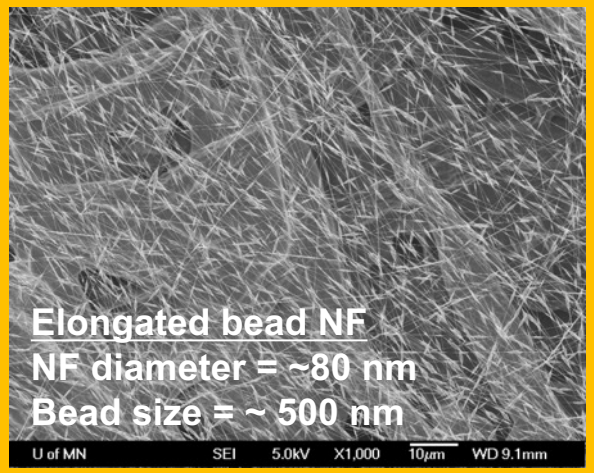
Sample #1 (2.00 wt. %)



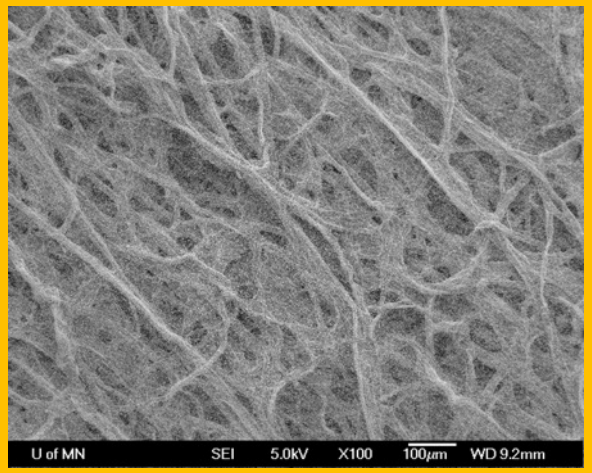


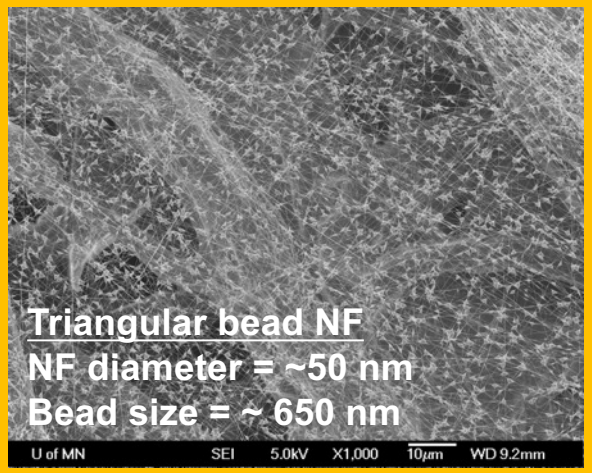
Sample #3 (1.45 wt. %)



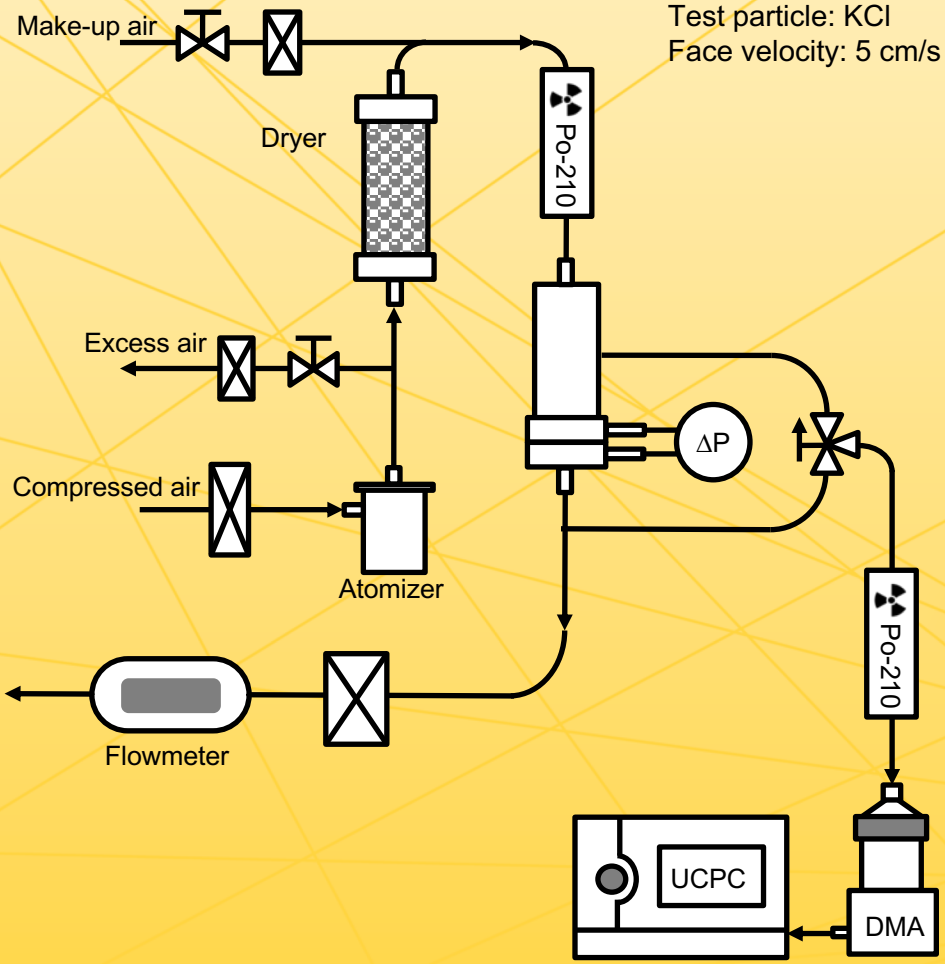


Sample #5 (1.00 wt. %)

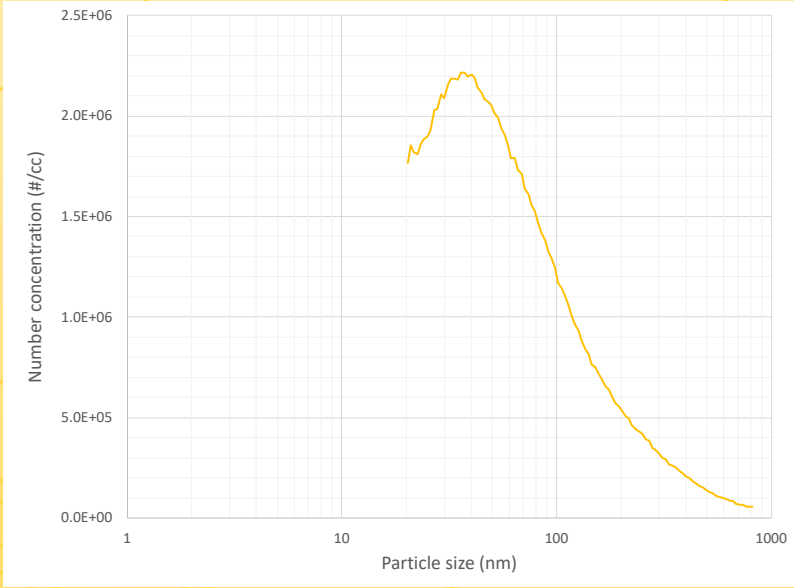




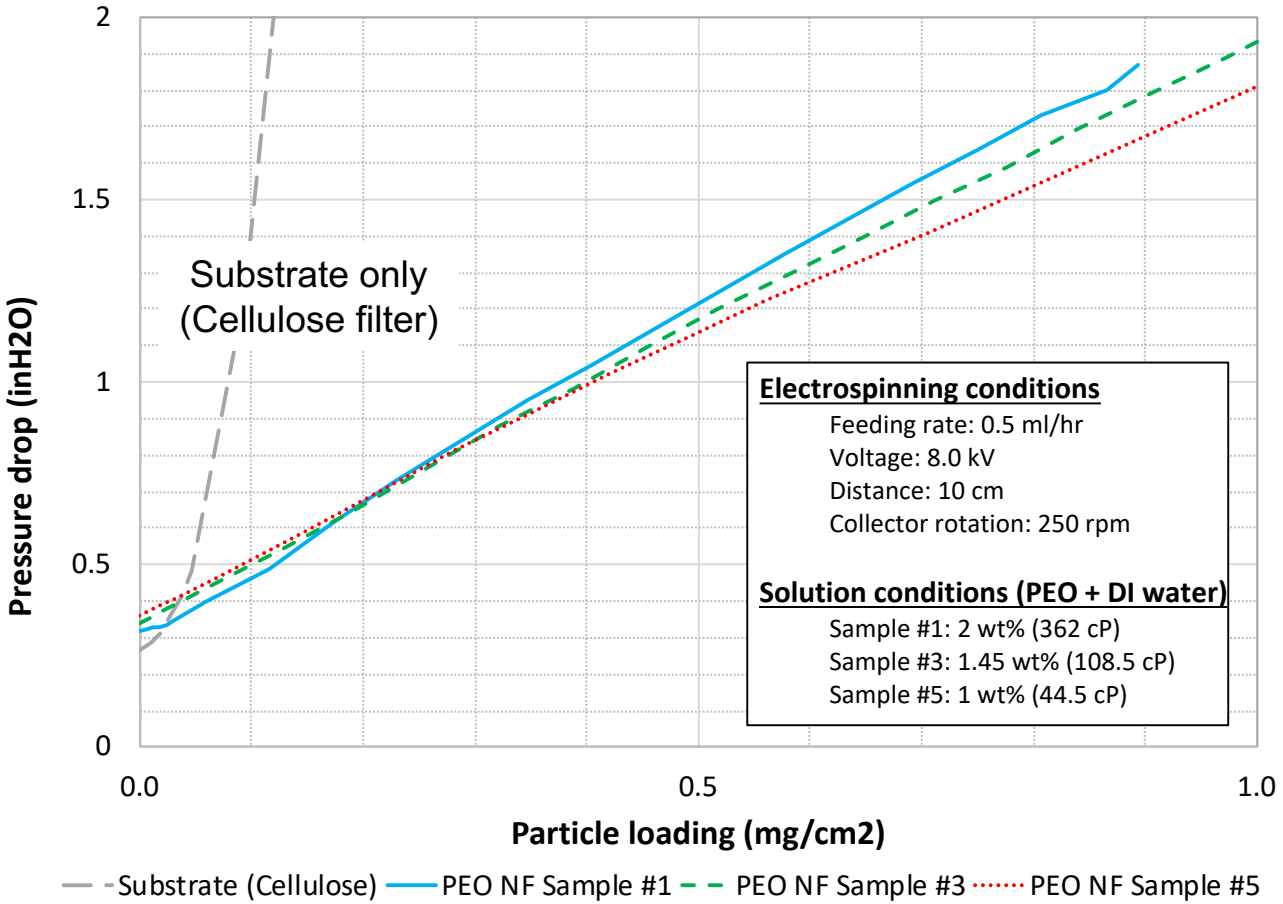
Nanofiber filter efficiency & loading test

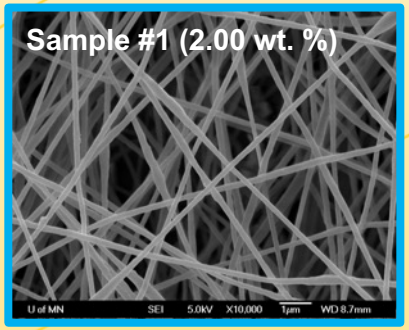


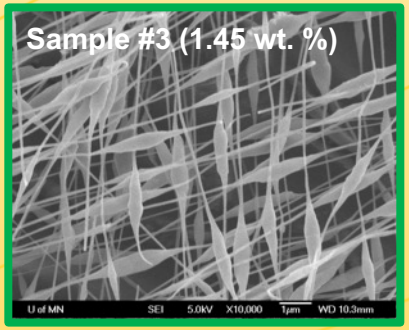
Test particle: KCl
Face velocity: 5 cm/s

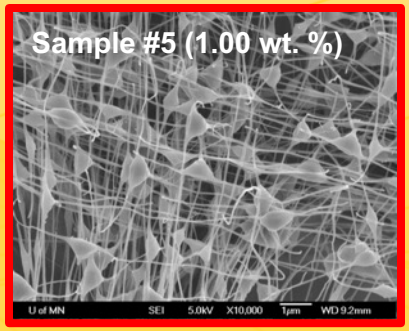


Particle loading test results

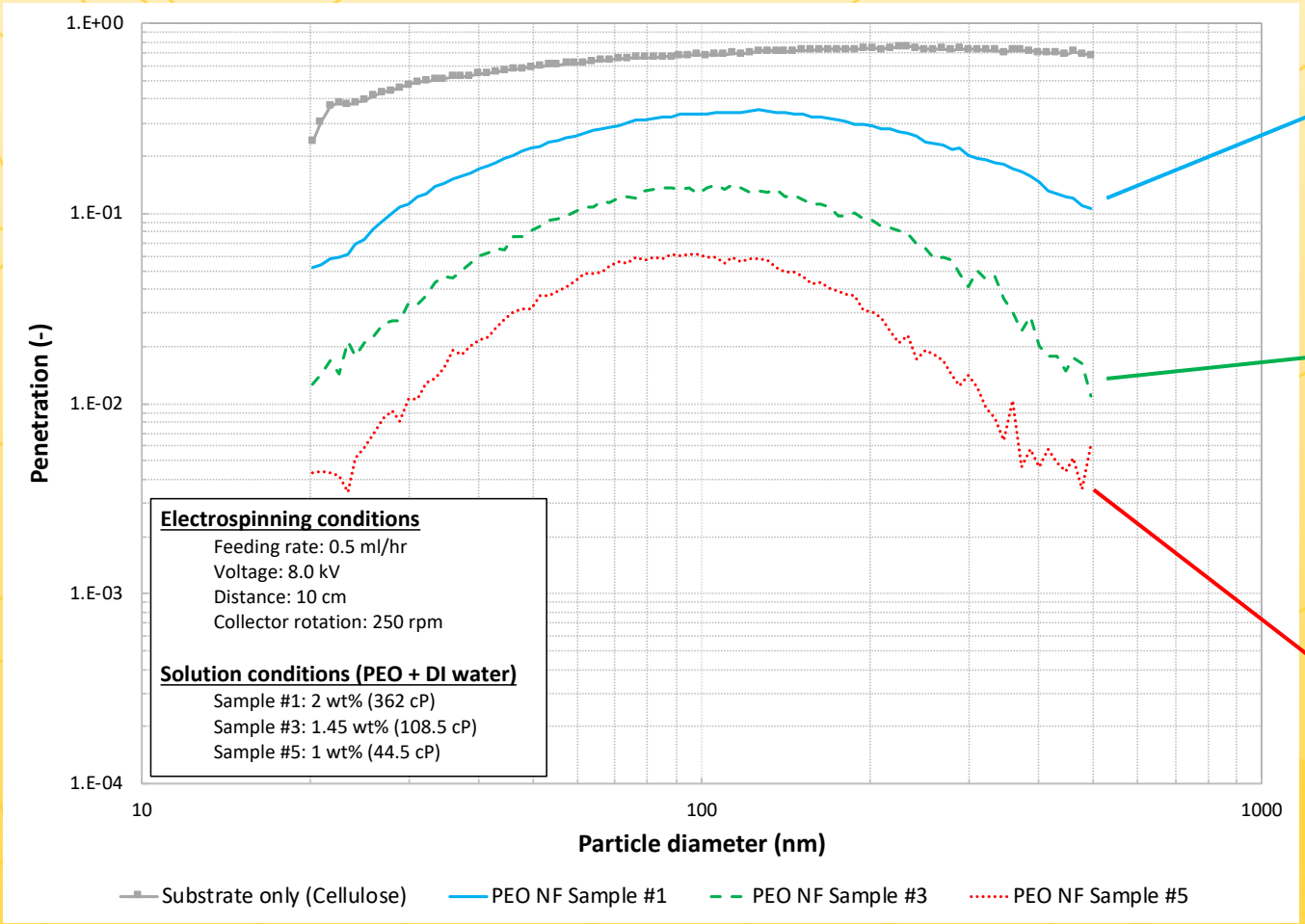


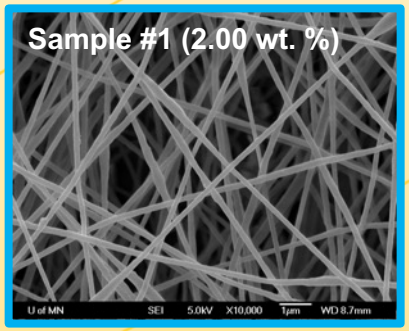


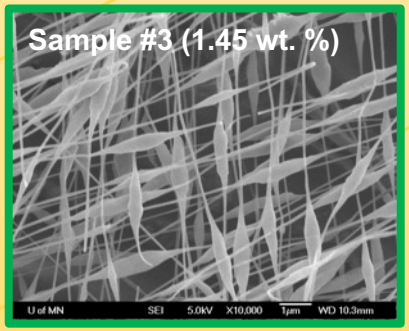


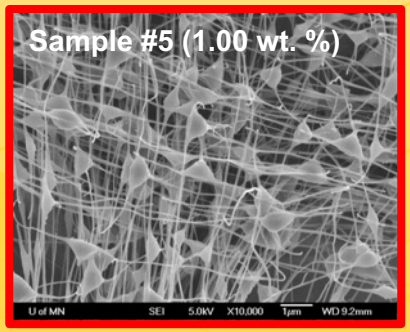


Particle penetration results

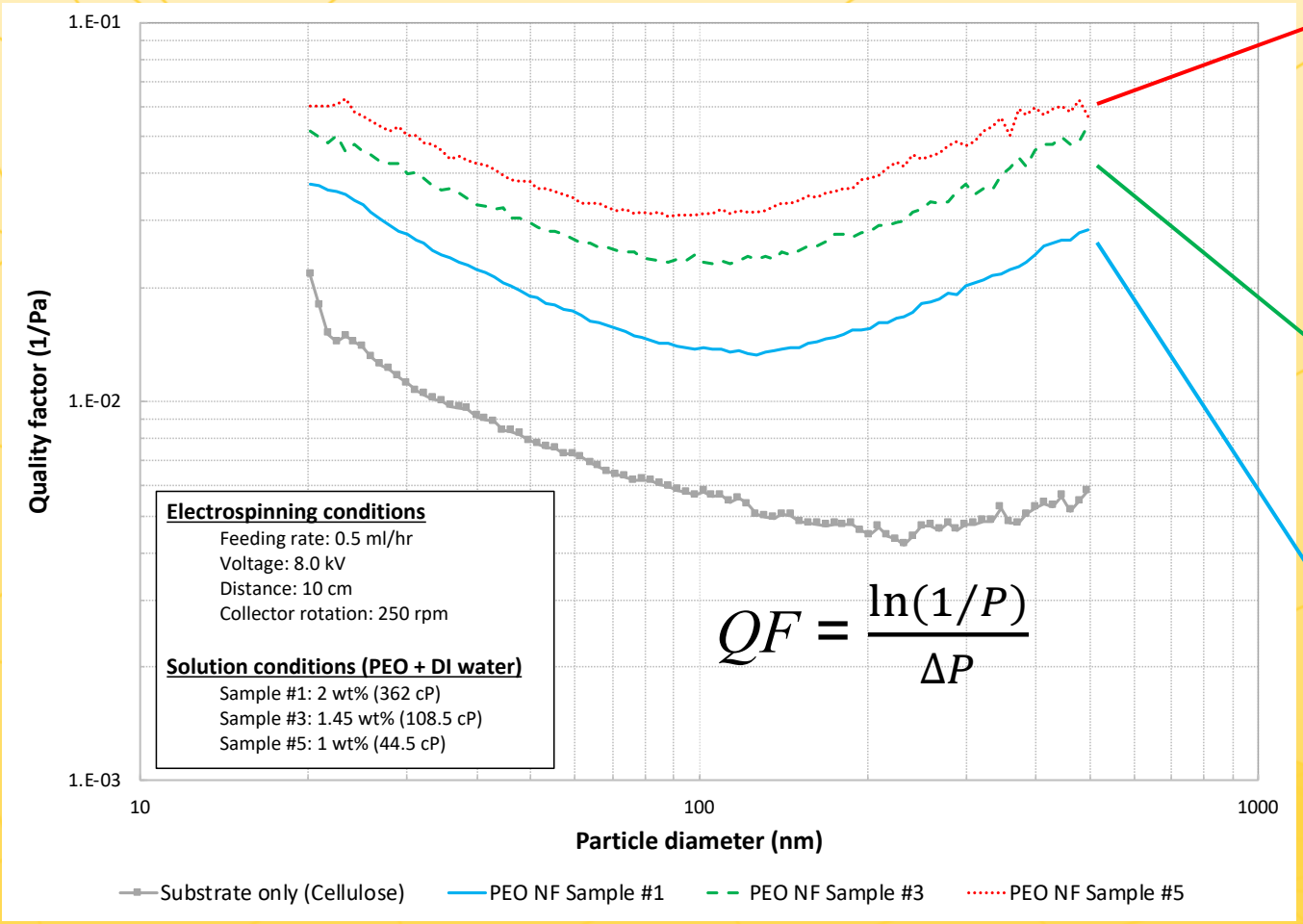


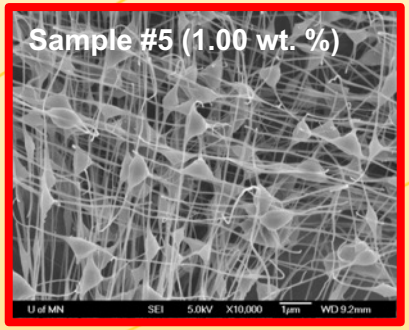


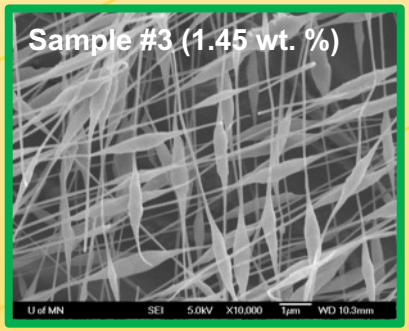


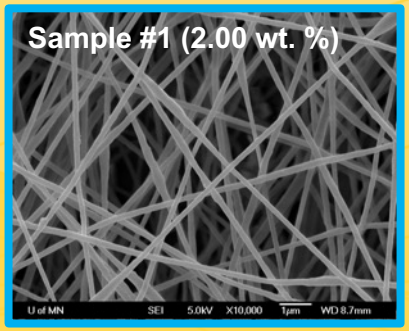


Filter quality factors



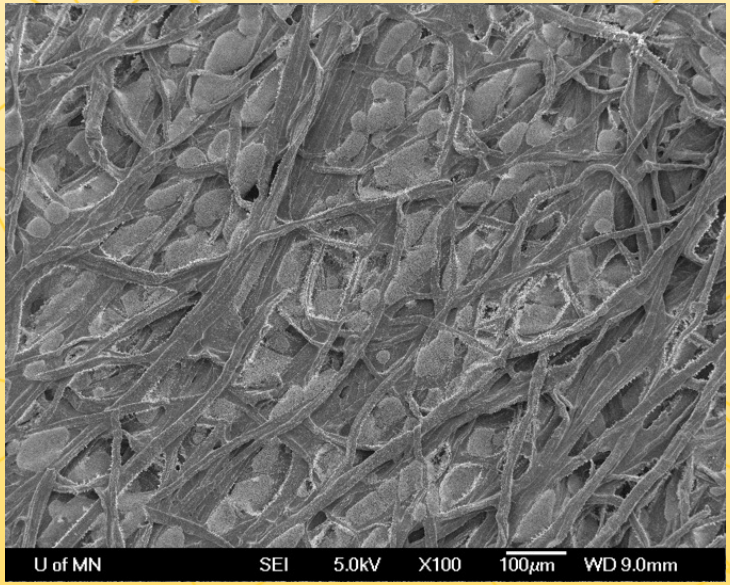




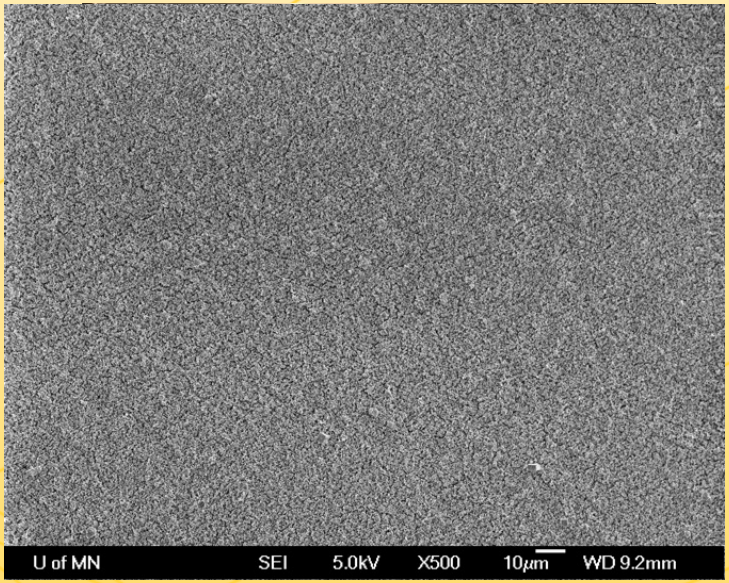


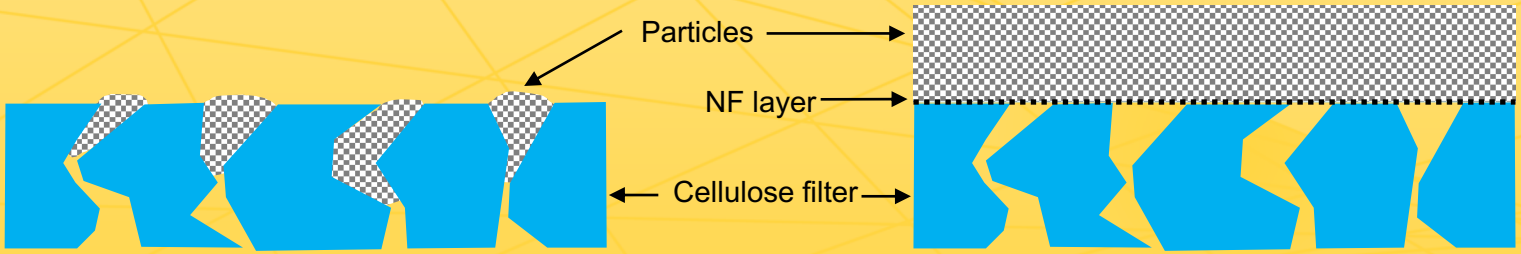
Particle loaded filter images (SEM)

Substrate only (Cellulose filter)



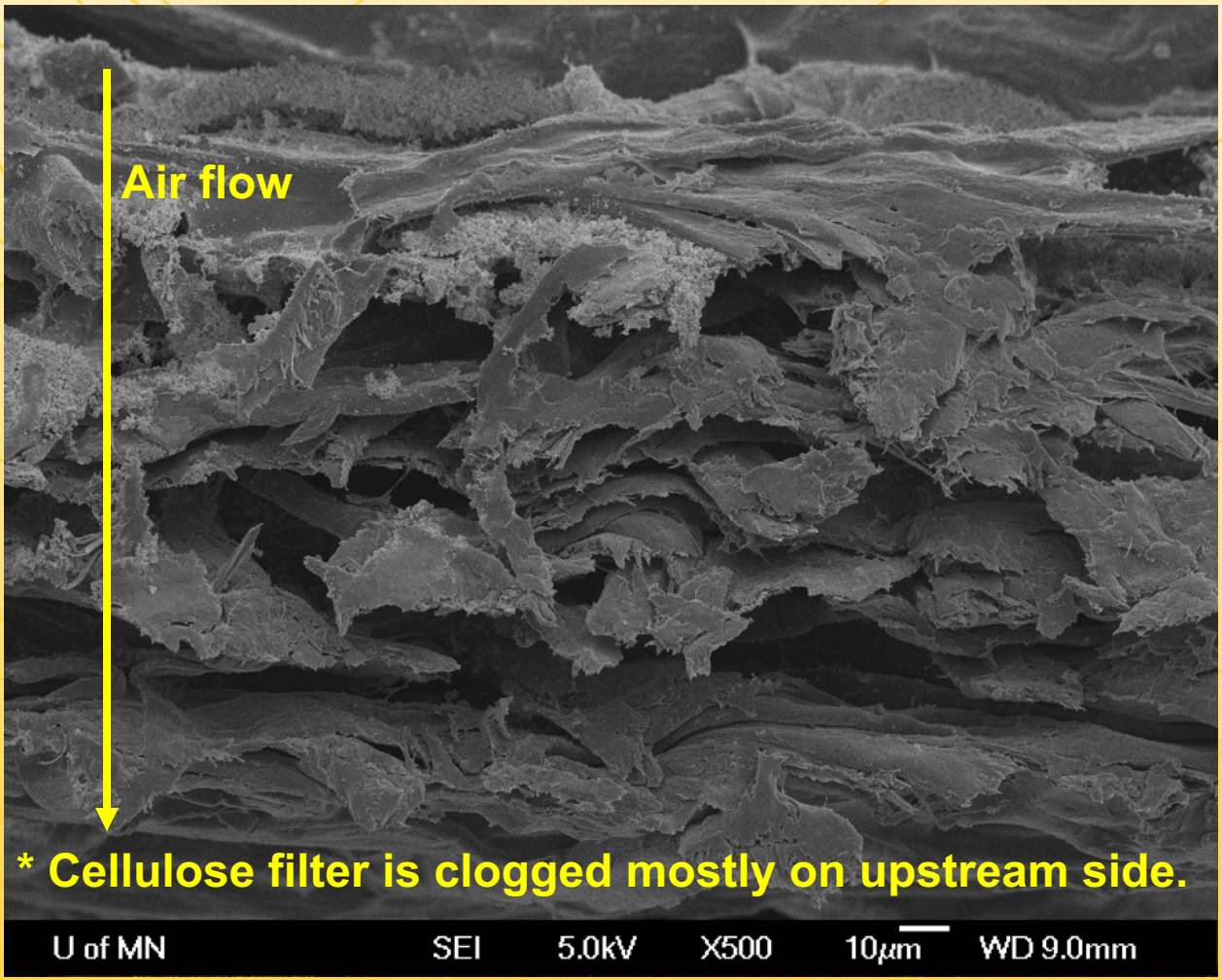
Nanofiber layer on substrate

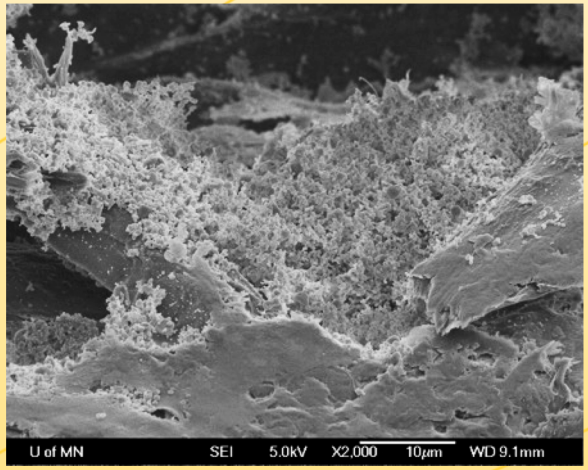


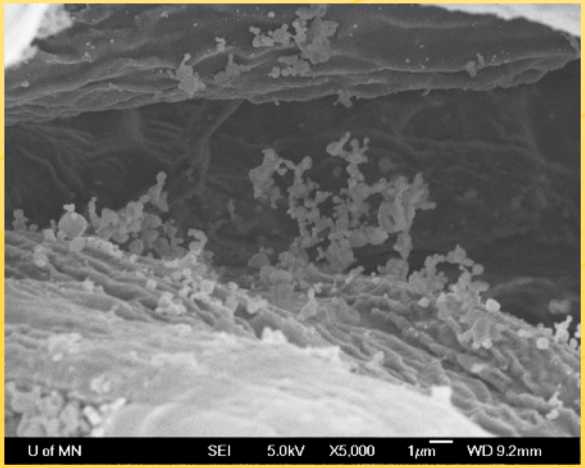


*Images were taken at the same final pressure drop (5 inH2O)

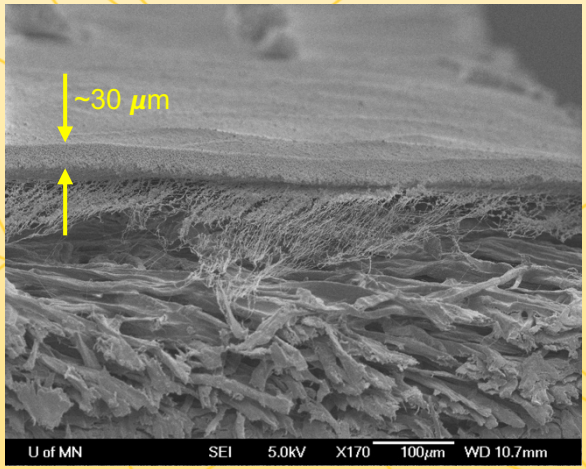
Cross section images (Loaded substrate)

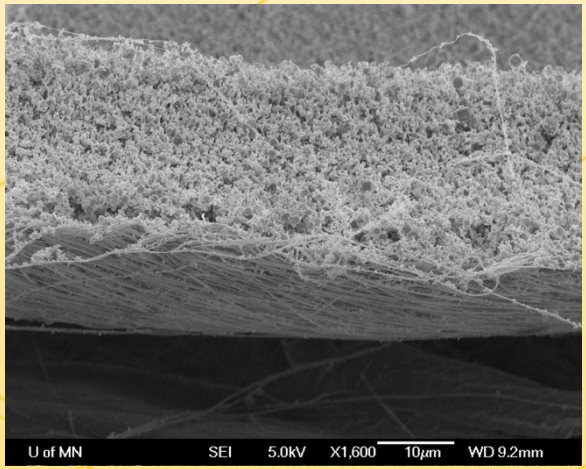


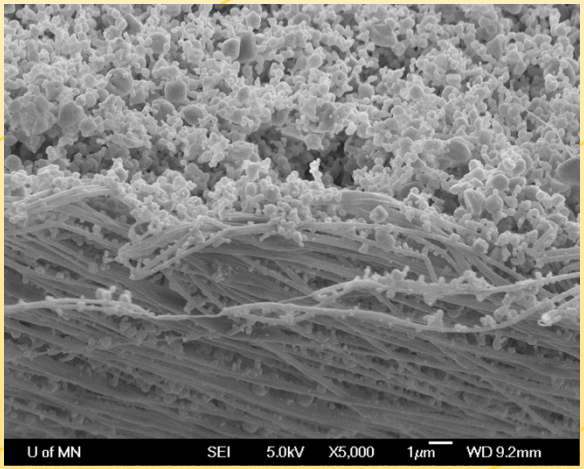


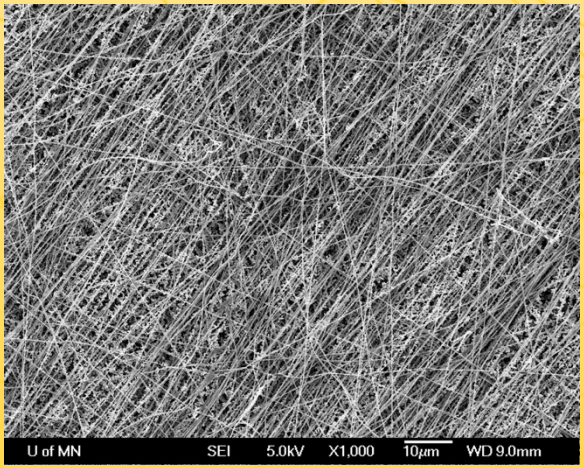


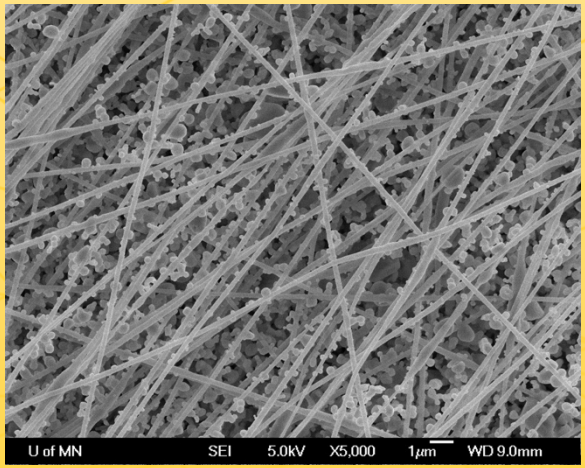
Cross section images (Loaded NF sample #1)



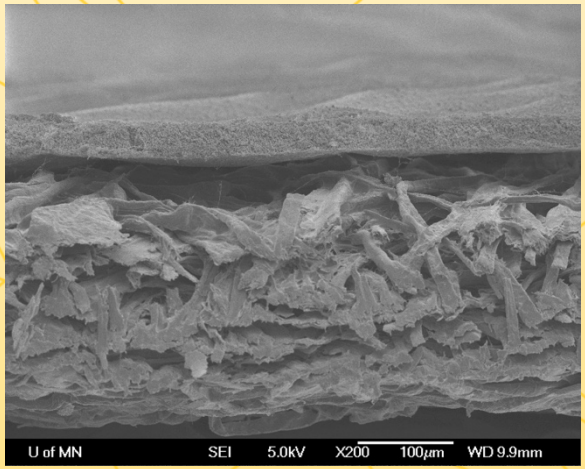


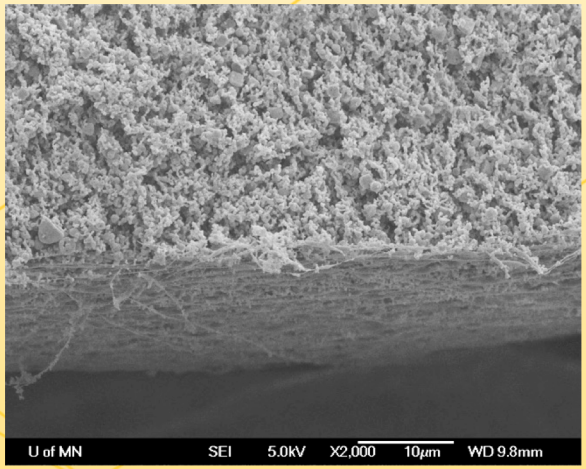


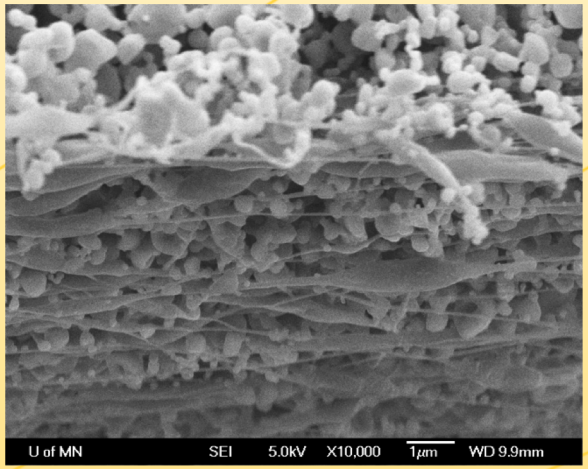


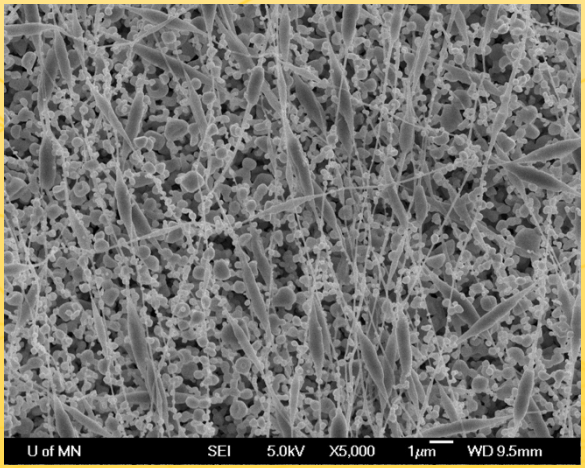


Cross section images (Loaded NF sample #3)

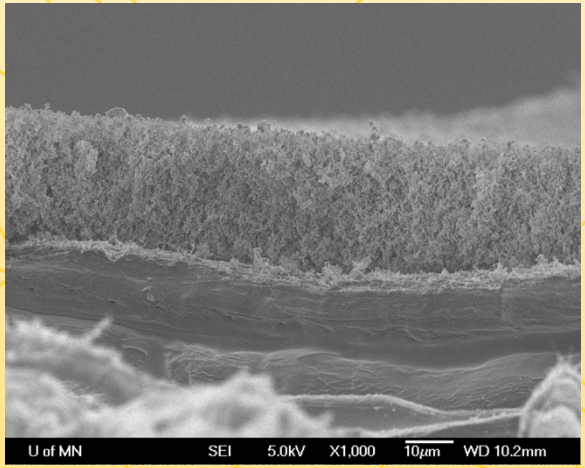


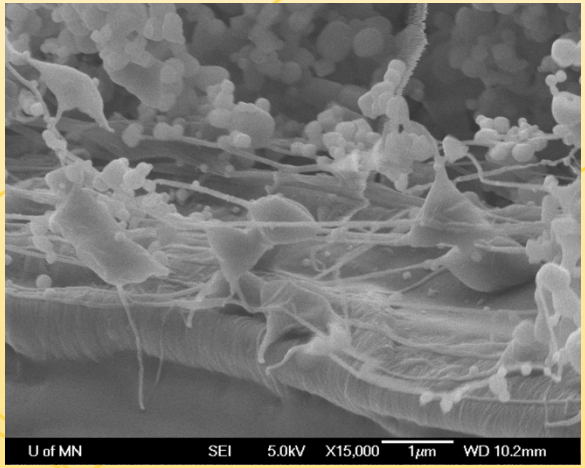


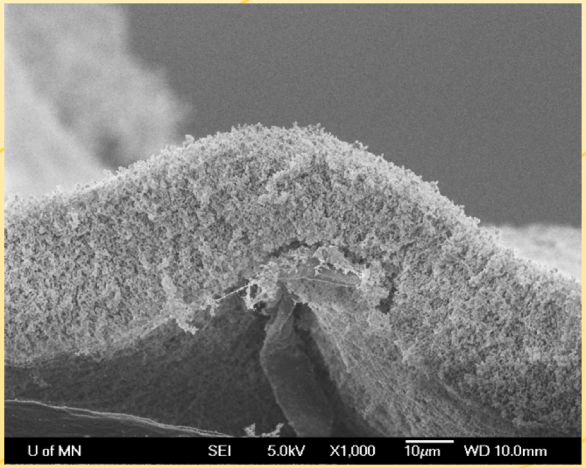


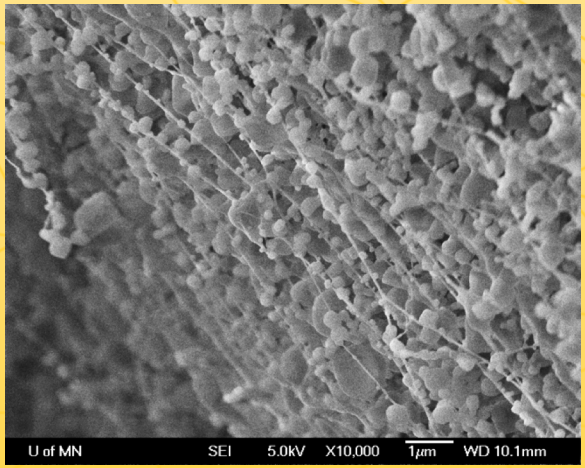


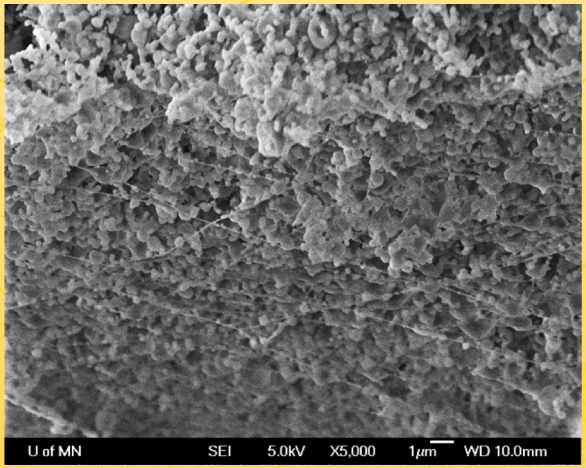
Cross section images (Loaded NF sample #5)











Conclusions

1. Polymer solution viscosity is a main factor to control fiber diameter and morphology.
    - Higher viscosity: Smooth NF with larger diameter
    - Lower viscosity: Beaded NF with smaller diameter

2. Triangular bead NF improves overall filter performances.
    - Longer inter-fiber distance
    - Smaller fiber diameter
    - Additional fibers

3. Most of particles are filtered on NF layers (Surface filtration) and NF layers are strong enough to support dust cakes.

Thank you