Electrospun Pretreatment Membranes

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RESEARCH OBJECTIVE

Fabricating hydrophilic pretreatment membranes is a sustainable approach in the Reverse Osmosis (RO) technology since it will reduce operational cost compared to other conventional methods like chlorination, flocculation etc., that are more energy intensive. Moreover, the proposed electrospinning technique is a cost-effective technique to fabricate controlled and targeted ultra/microfiltration membranes. The proposed research proposal aligns well with Ira. A. Fulton Schools of Engineering Research theme of sustainability and falls under the research foci of water purification.

INTRODUCTION

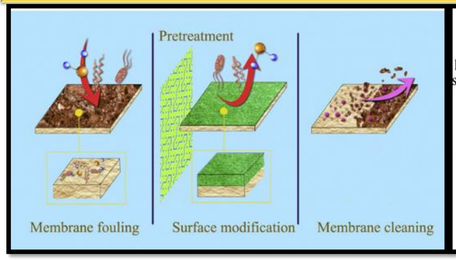


Fig 1. Representation of membrane treatment process. [1]

- **Fouling** is the accumulation of microscopic contaminants.
- **Scaling:** precipitation due to increase in concentration of inorganic matter.

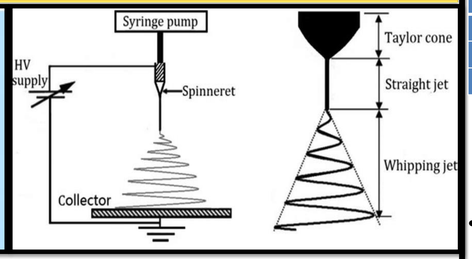


Fig 2. Schematic of a typical electrospinning setup. [2]

- **Electrospinning** is scalable technique to produce nanofibers by electric force.
- Basic setup consists of **high voltage system (V), collector distance (T/C) & flow rate (F)**.

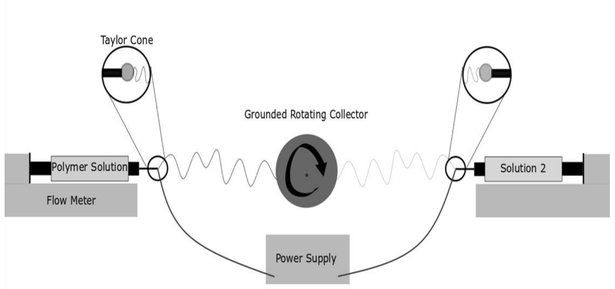


Fig 3. Dual electrospinning setup consisting of a rotary drum collector to collect two different polymers onto the same collection foil.

Materials:

- Poly(vinyl chloride) (PVC) a hydrophobic polymer is dissolved in 50:50 tetrahydrofuran:N,N-dimethylformamide solvent to make a 15% solution.

- Poly(vinyl alcohol) (PVA) a hydrophilic polymer dissolved in DI water and a surfactant Triton X-100 [3] to make a 12% solution.

[1] Jiang et. al,. *Science of the Total Environment*, *595*, 567–583 https://doi.org/10.1016/j.scitotenv.2017.03.235
[2]Yao, L. et. al, Chem. Mater. 2003, 15, 1860-1864. https://doi.org/10.1021/cm0210795
[3] Yan et. al, *Nanoscale*, *11*(41), 19166–19178. https://doi.org/10.1039/c9nr02802a
[4] Quinn et. al,. *Polymer*, *134*, 275–281. https://doi.org/10.1016/j.polymer.2017.11.023
[5] https://blog.phenom-world.com/edx-analysis-sem

RESULTS AND ANALYSIS

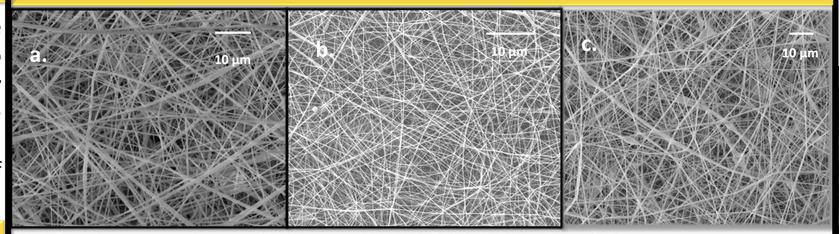
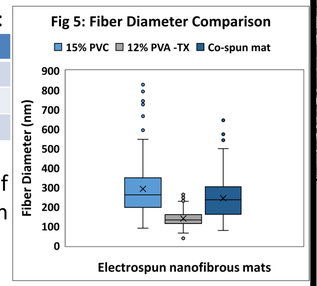


Fig 4: Scanning electron microscopy (SEM) images of (a) 15% PVC, (b) 12% PVA –TX and (c) Co-spun mat

- Optimized electrospinning parameters from DOE:

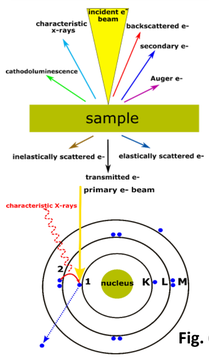
Polymer	F(ml/hr)	T/C (cm)	V (kV)	FD (nm)
15 % PVC	1	12	12	293 ± 132
12% PVA -TX	0.75	12	23	150 ± 38
Co-spun				245 ± 106

Table 1: Electrospinning parameter



- Mixing Triton X-100 enhanced electrospinning of PVA avoiding blob formation on needle, beads on string fiber configuration & improved mass balance.

- **Energy dispersive X-ray analysis:**



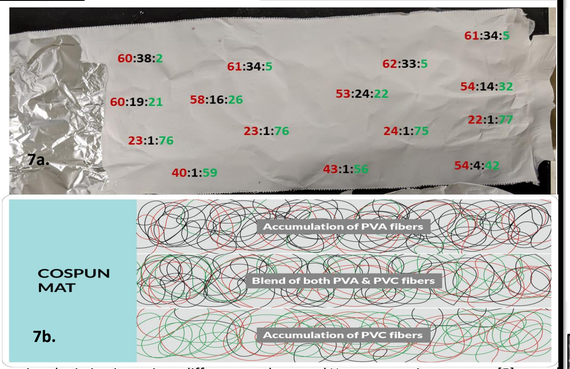


Fig 6. Illustration of electron-matter interaction depicting its various different products and X-ray generation process. [5]
Fig 7. Carbon (-C) is represented by **red**, **oxygen (-O)** by **black** & **chlorine (-Cl)** by **green**. The data mapped in **fig 7a**, gives the weight percent composition in the format (**C**:**O**:**Cl**). **Fig. 7b**, shows problems associated with partial accumulation of PVA and PVC fibers on either sides of the mat.

- **Fourier-transform infrared spectroscopy (FTIR)**

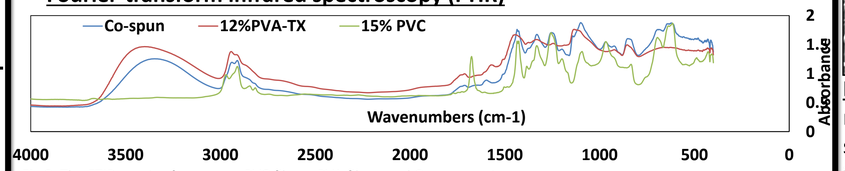


Fig 8. The FTIR spectra for as spun PVC fibers, PVA fibers and Co-spun mats.

- **Crosslinking PVA/Tuning porosity**

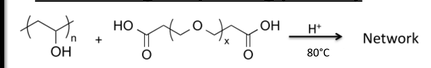
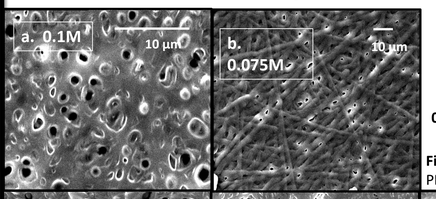


Fig 9. Crosslinking of PVA mat with poly(ethylene glycol) diacid in methanol (PEGDA-MeOH). [4] (Mn = 600g/mol)



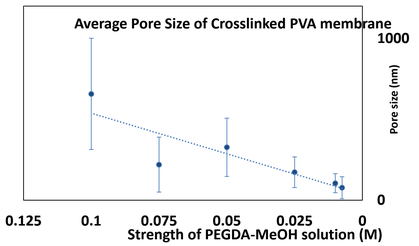


Fig 10. Tuning porosity of PVA mats by crosslinking with varying PEGDA-MeOH concentrations (0.1-0.0075M)

Fig 11. SEM images of PVA mats crosslinked with 0.1M – 0.0075M PEGDA-MeOH solution from (a)-(f).

- Membrane Performance Test: M-1,M-2 & M-3 prepared using gas assisted electrospinning for PVA with PVA/PVC mass flow ratio of 1.8, 1.4 & 0.9, where PVC was kept constant and compared to crosslinked PVA (CL-PVA).

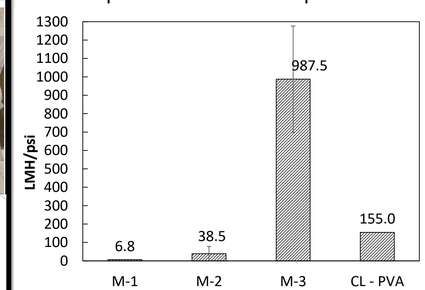


Fig 12. Water flux (LMH/psi) for the crosslinked PVA and co-spun mats collected of the dead-end cell filtration setup.

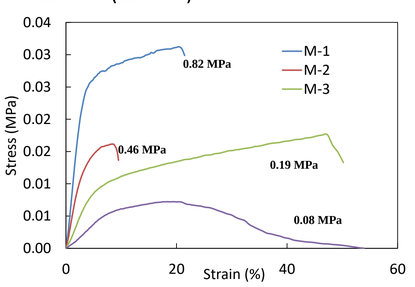


Fig 13. Stress vs strain plots for crosslinked co-spun M-1, M-2, M-3 and PVA mats labelled with Young's Modulus (E)

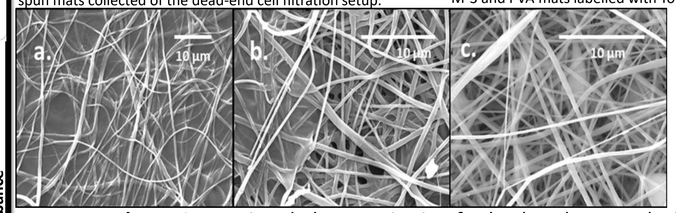


Fig 14. Crosslinked co-spun mats showing different morphologies responsible for negative correlation of flux and positive correlation of tensile strength with increased PVA concentration for M-1 (a), M-2(b) and M-3(c).

Future work: a. Gas assisted electrospinning for both polymer solutions to achieve a more disperse and uniform composition, **b.** perform anti-fouling performance tests to substantiate the hypothesis of preventing fouling with hydrophilic and **c.** introduce functional groups on PVA such as to facilitate selective removal of heavy metal atoms.

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