

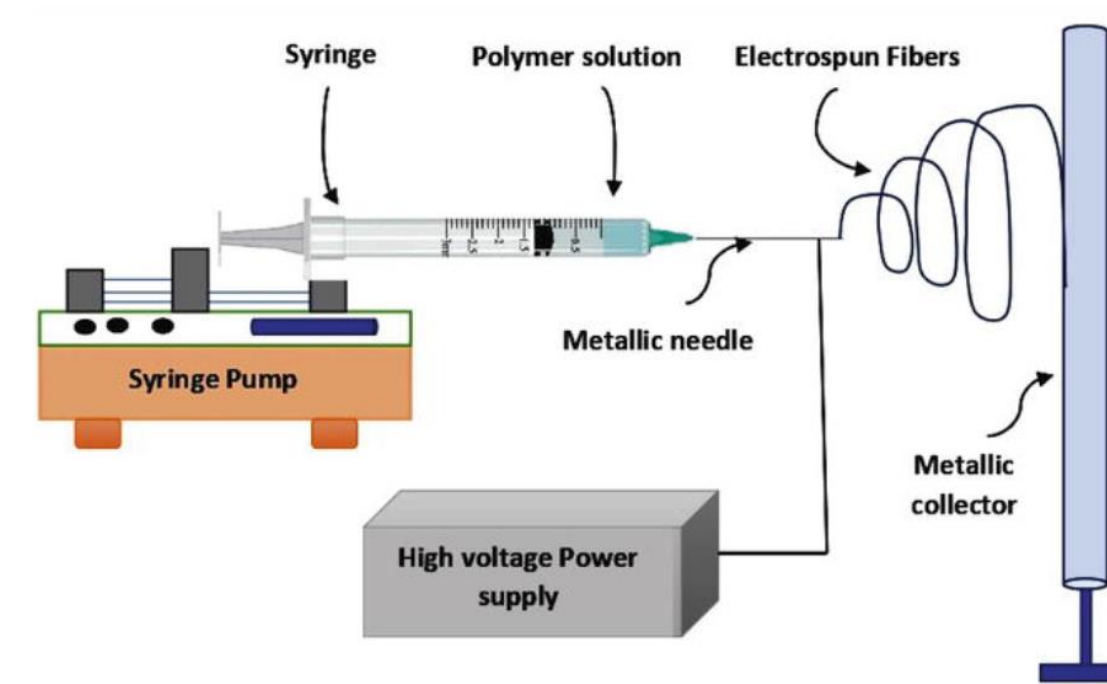
Background / Motivation

- **Nanoplastic pollution is increasingly detected in drinking water** and is difficult to remove with conventional treatment methods.
- **Water contamination can lead to serious health risks**, motivating improved purification technologies.
- **Clean-water access and water scarcity remain major challenges**, especially for underserved communities.
- **Climate change is intensifying water stress**, increasing drought frequency and degrading water quality.
- **Electrospun carbon nanofiber (CNF) filters are a promising solution** due to high surface area and tunable pore structure for nanoplastic capture.
- **CNF filters are scalable and deployable** in both point-of-use systems (home/portable) and large-scale water treatment (modular membrane units).

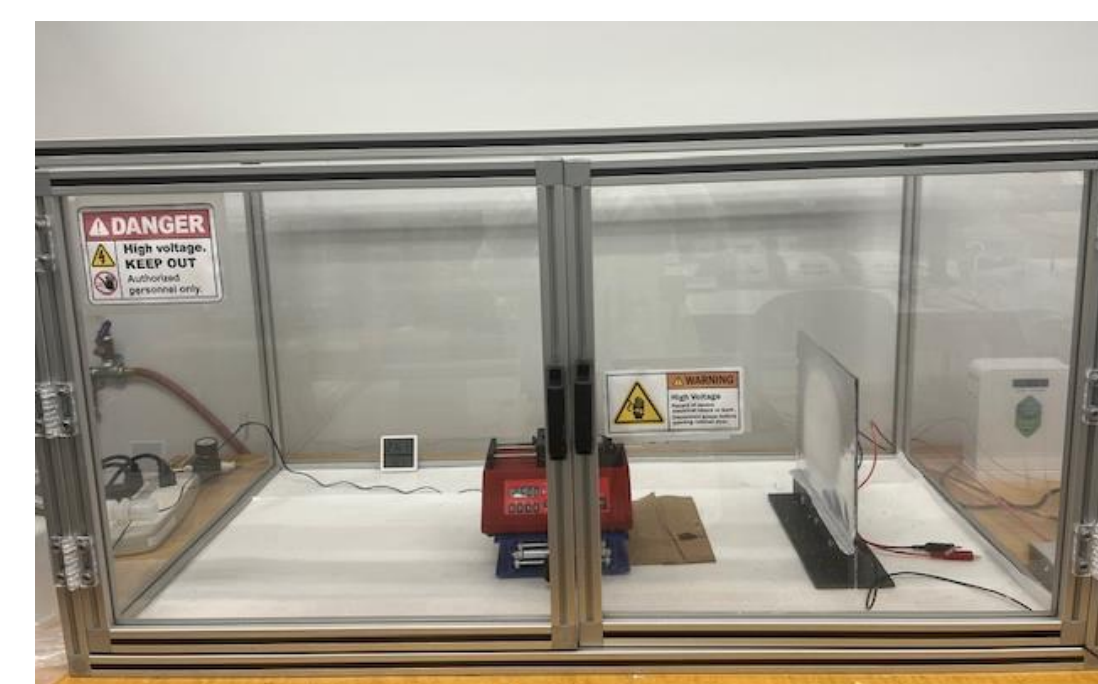
Materials and Methods

Electrospinning of Carbon Nanofiber Mats

- **Polymer solution preparation:** Polyacrylonitrile (PAN) was dissolved in N,N-dimethylformamide (DMF) to obtain a 10 wt% spinning solution.
- **Electrospinning setup:** The PAN solution was loaded into a syringe mounted on a syringe pump and dispensed through a metallic needle connected to a high-voltage power supply.
- **Collector configuration:** A grounded flat-plate collector was positioned 20 cm from the needle tip.
- **Environmental control:** Dry air was supplied to the chamber to reduce the relative humidity to approximately 20%.
- **Spinning conditions:** Electrospinning was performed at 25 kV with a flow rate of 2.5 mL/hr.
- **Thickness control:** Fiber mats were collected for varying spinning durations to produce membranes with different thicknesses.



Schematic of electrospinning process [1].



The electrospinning setup.

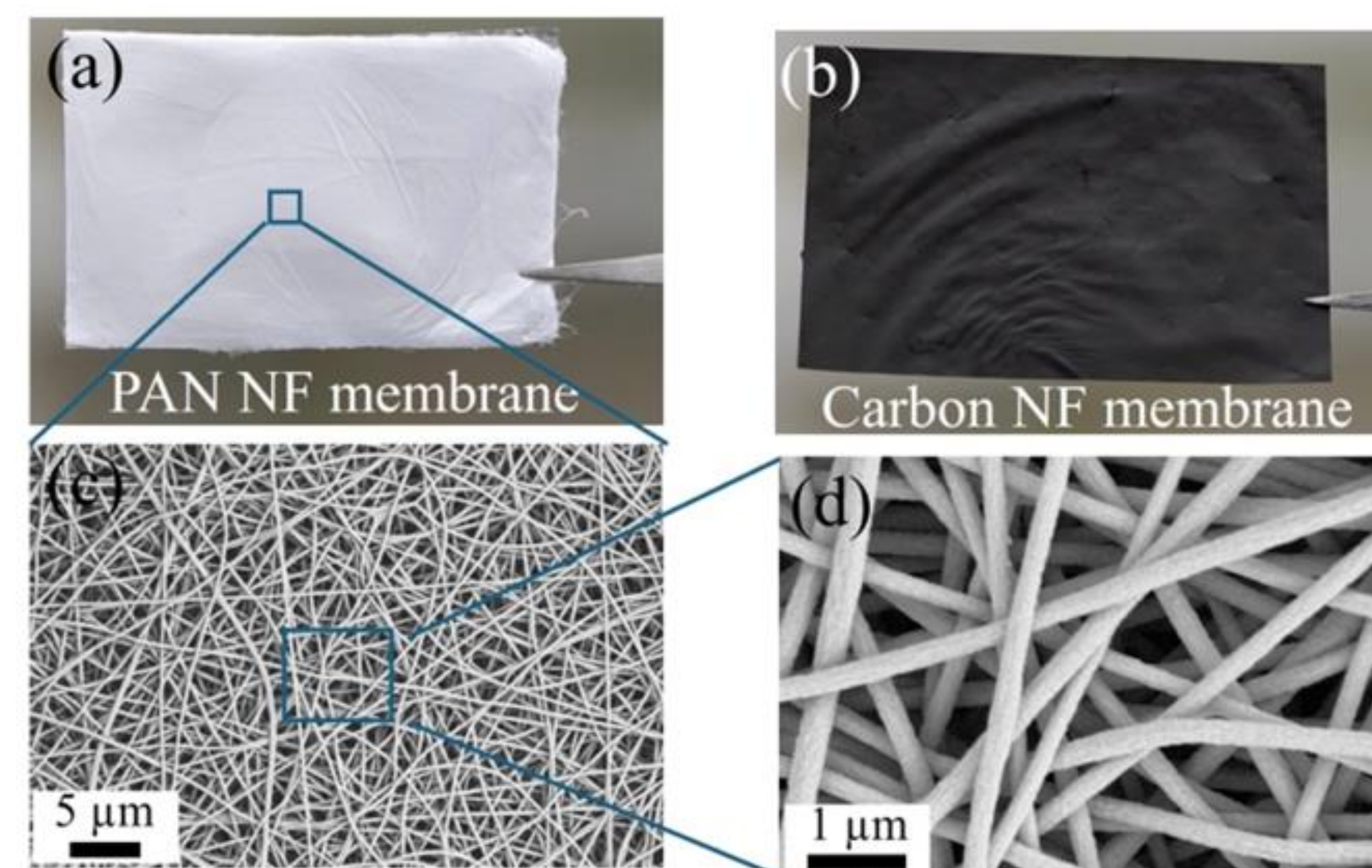
- **Filter fabrication:** Electrospun nanofiber mats were cut into 7 cm-diameter circular filters.
- **Stabilization (PAN → stabilized PAN):** Pure PAN filters were heat-treated to 280 °C at 2 °C/min, with a 2 hr dwell.
- **Carbonization (stabilized PAN → CNF):** Stabilized samples were carbonized to 800 °C at 5 °C/min, with a 1 hr dwell.



Results

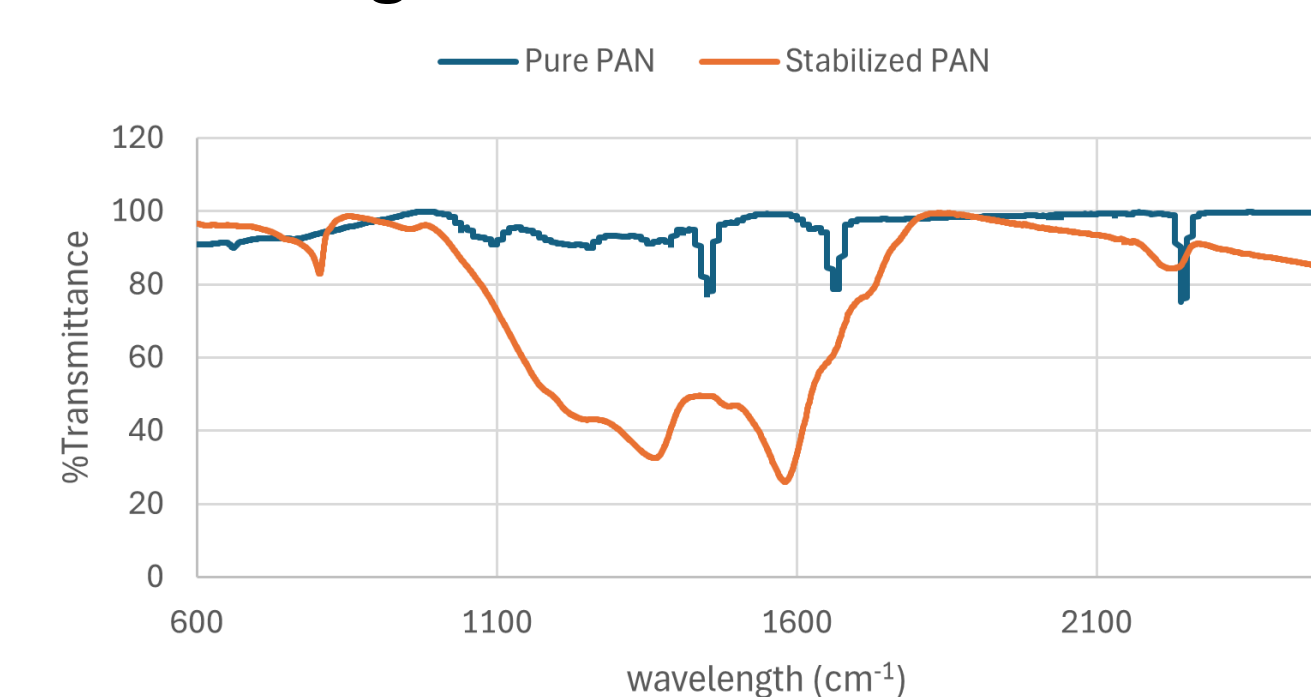
Morphology Characterization of nanofibers

- **Fiber morphology (SEM):** Scanning electron microscopy confirmed a uniform, smooth fiber surface with minimal defects or bead formation.
- **Diameter reduction after carbonization:** Average fiber diameter decreased from ~450 nm (PAN) to ~210 nm (carbon nanofiber), indicating densification/shrinkage during thermal conversion.



Structural Characterization of nanofibers

- **Chemical Structural Characterization (ATR-FTIR):** Use both %Absorbance and %Transmittance to identify patterns and functional groups. The Relative Cyclization Index (RCI) gives us a "completion percentage" to see how much Nitrogen has burned out of the fibers.



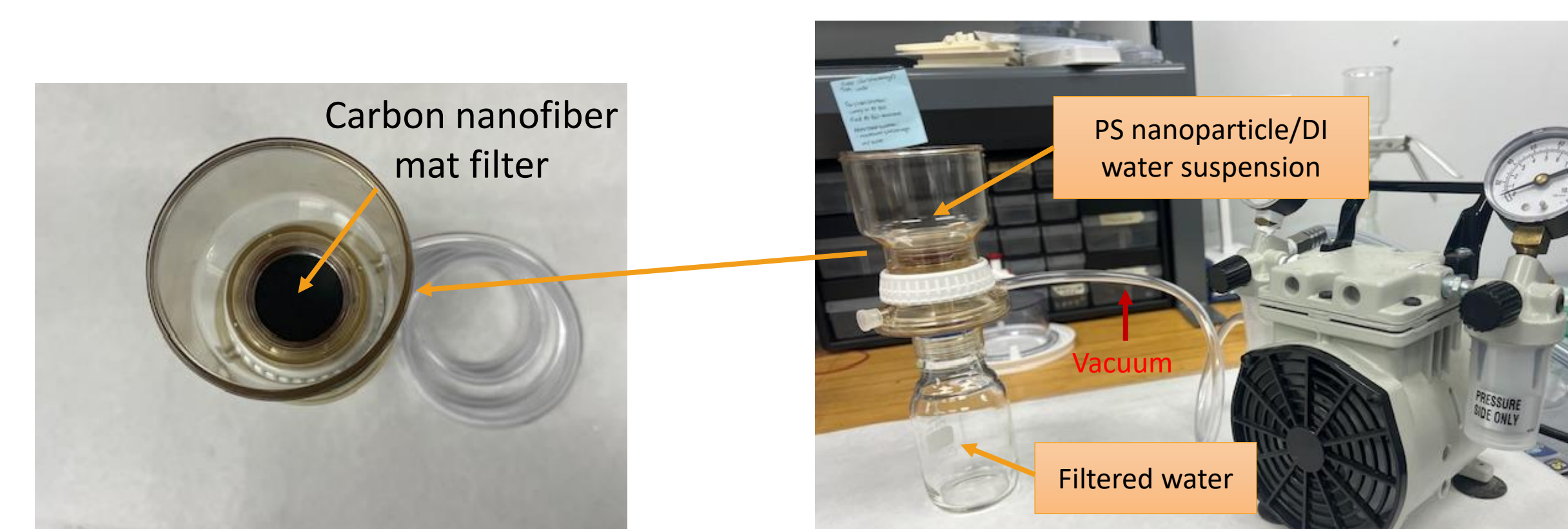
The %Transmittance curve for the pure PAN mat and the stabilized PAN mat highlighting the peaks for the functional groups. The RCI equation to determine the "completion percentage" of the Nitrogen burnout.

$$RCI = \frac{I_{C=N}}{I_{C=N} + I_{C≡N}}$$

RCI = 0.98, with PAN stabilized at 280 °C for 2 hours

Filtration Efficiency Testing

- **Vacuum-assisted filtration setup:** A vacuum-assisted filtration apparatus was used to drive flow through the nanofibrous mat filters.



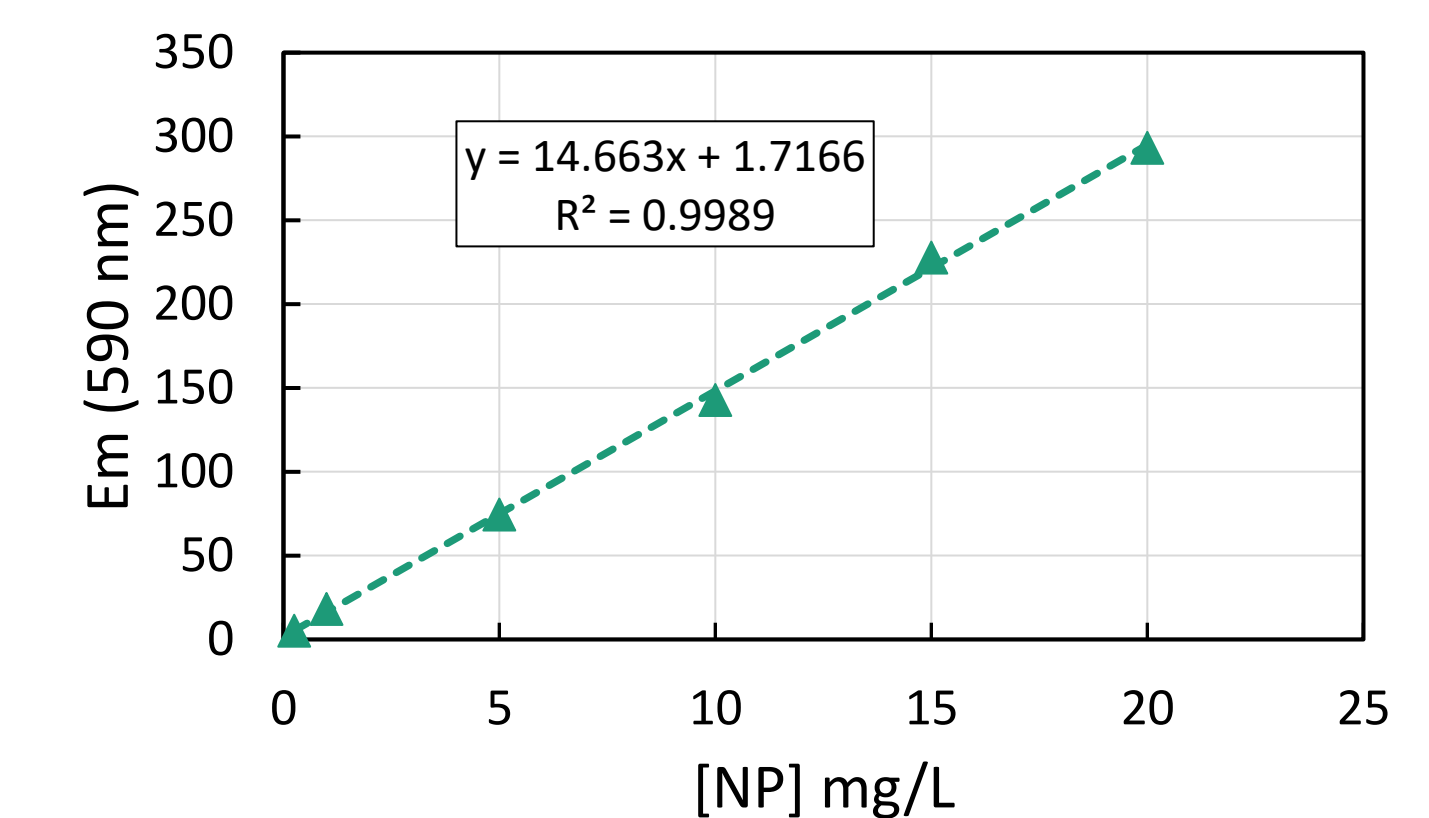
A top-down view of how the carbon nanofiber mat filter sits in the vacuum filtration set up.

The vacuum filtration set up used to filter the polystyrene (PS) nanoplastic suspension through the carbonized nanofiber mat filter.

Polystyrene Suspension Preparation

- **Filtration test:** 10 mL of 20.0 mg/L polystyrene (PS) nanoplastic (diameter of 50 nm) solution was passed through each filter under vacuum.

1. 0.5 μm fluorescent PS bead suspension (Diameter = 50 nm) was purchased from Sigma Aldrich.
2. Purchased suspension was diluted to 20 mg/L.
3. Performed four dilutions on aliquot of 20 mg/L suspension to build a standard curve.

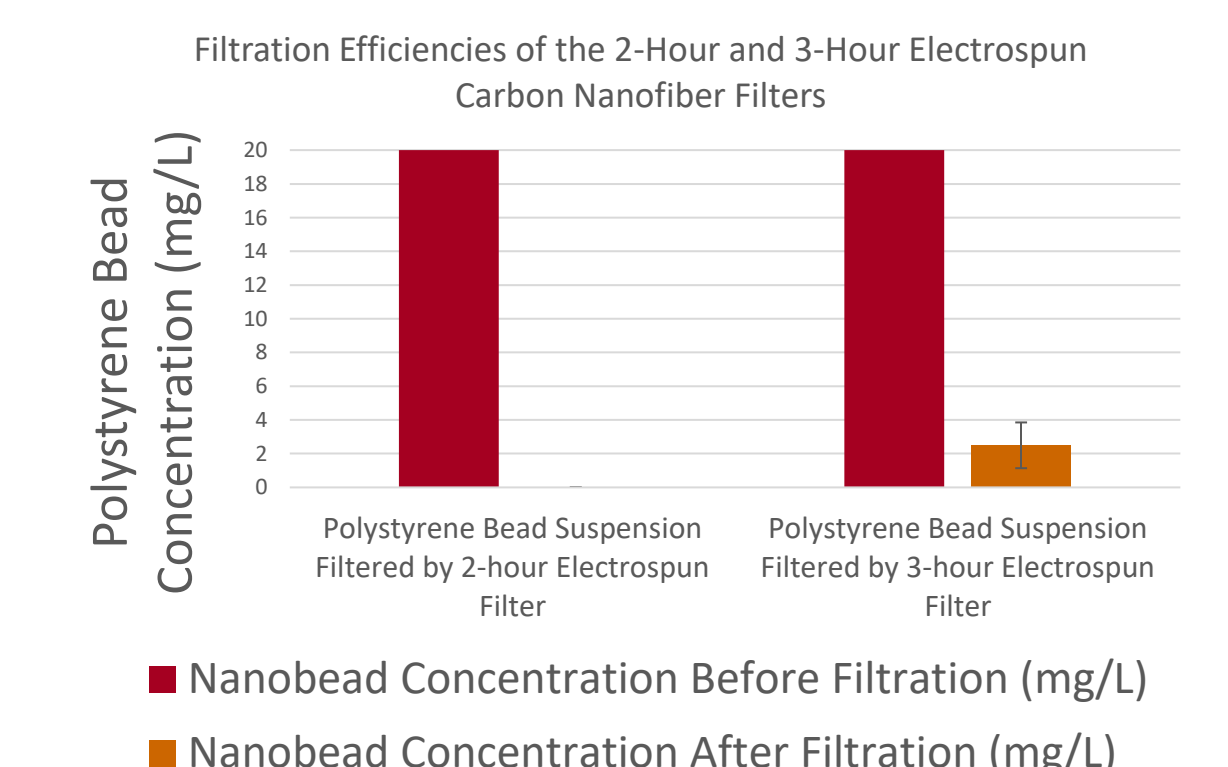


The standard curve from the four dilutions (20 mg/L, 15 mg/L, 20 mg/L, 5 mg/L, and 0.25 mg/L).

Filtration Efficiency Testing

- **Filtration analysis:** The filtrate concentration was quantified by fluorescence spectrophotometry, using a calibration (standard) curve to convert fluorescence intensity to concentration.

Filtration Efficiency Testing for 2 hour and 3 hour electrospun carbon nanofiber mat filters. Error bars show 90% confidence intervals.



Conclusion

- **Carbon nanofiber (CNF) mats were successfully fabricated** with an average fiber diameter of ~210 nm, maintaining a uniform nanofibrous morphology.
- **CNF mats demonstrated effective nanoplastic removal**, confirming their potential as filtration membranes for nanoplastic-contaminated water.

Future Works

- Investigate diameter and pore size of pure PAN nanofibers using SEM
- Investigate filtration efficiency on smaller diameter nanobeads
- Explore how filters perform on nanoplastics generated from real plastic waste
- Determine the relationship between filter thickness and filtration efficiency

Acknowledgements

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References

1. Sharma, G. K., & James, N. R. (2022, August 23). *Electrospinning: The technique and applications*. IntechOpen. <https://www.intechopen.com/chapters/83223>
2. CHAWLA, S. A. (2017). *MICROSTRUCTURE-MECHANICAL PROPERTY RELATIONSHIPS IN CARBON NANOFIBERS* (dissertation).