

Biodegradable Fibrillar Polysaccharide Membranes

Hung Nguyen, Christopher Johnson, Chinedum Osuji

hungn@sas.upenn.edu, chriswj@seas.upenn.edu, cosuji@seas.upenn.edu

Introduction

Industries are making conscious steps in choosing materials with sustainability in mind. Materials that are biodegradable are now preferred by consumers, but products made with these materials compare to similar products on the market.

A novel polysaccharide, both biodegradable and developed to be readily produced bulk, was investigated for membrane usage. This process explored both fabrication and analysis of the novel polysaccharide. Depending on the properties, this material could be used as a biodegradable alternative to commercial membranes for water filtration, bacterial filtration, etc.

Methodology

Fabrication

The polysaccharide is originally in a powder state. In order to handle the polysaccharide and create membranes, it was mixed with water and sodium hydroxide to make a doping solution.

Thick film membranes of the polysaccharide were fabricated by **blade coating** and **solvent precipitation**.

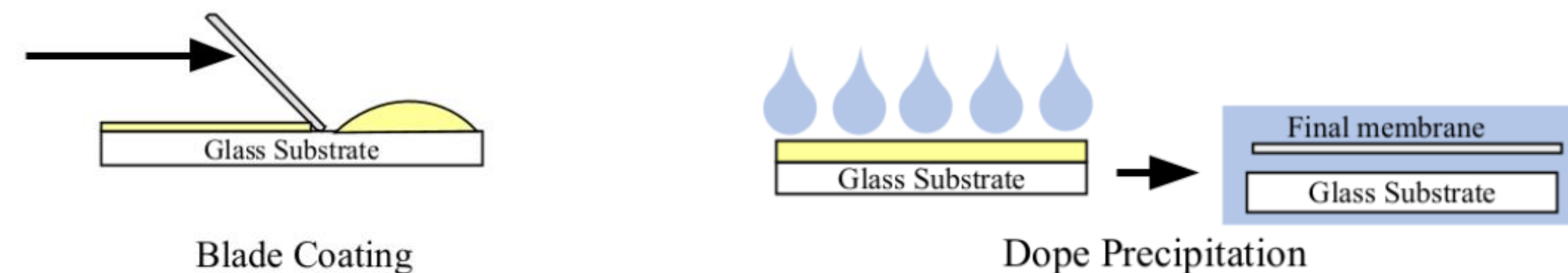


Fig (b). A blade is dragged across the substrate at fixed height, leaving behind a thin layer of material. Fig (c). Following the blade coat, the substrate is submerged in an antisolvent. The material on top of the substrate coagulates and lifts from the substrate.

Effective Pore Size Selectivity

Fabricated membranes were placed into **unidirectional flow cells**, which passed solution through the membrane under pressure. The solutions contained **particles** of polyethylene glycol (PEG), which are useful in that they are available in a wide range of molecular weights. Including higher molecular weights¹.

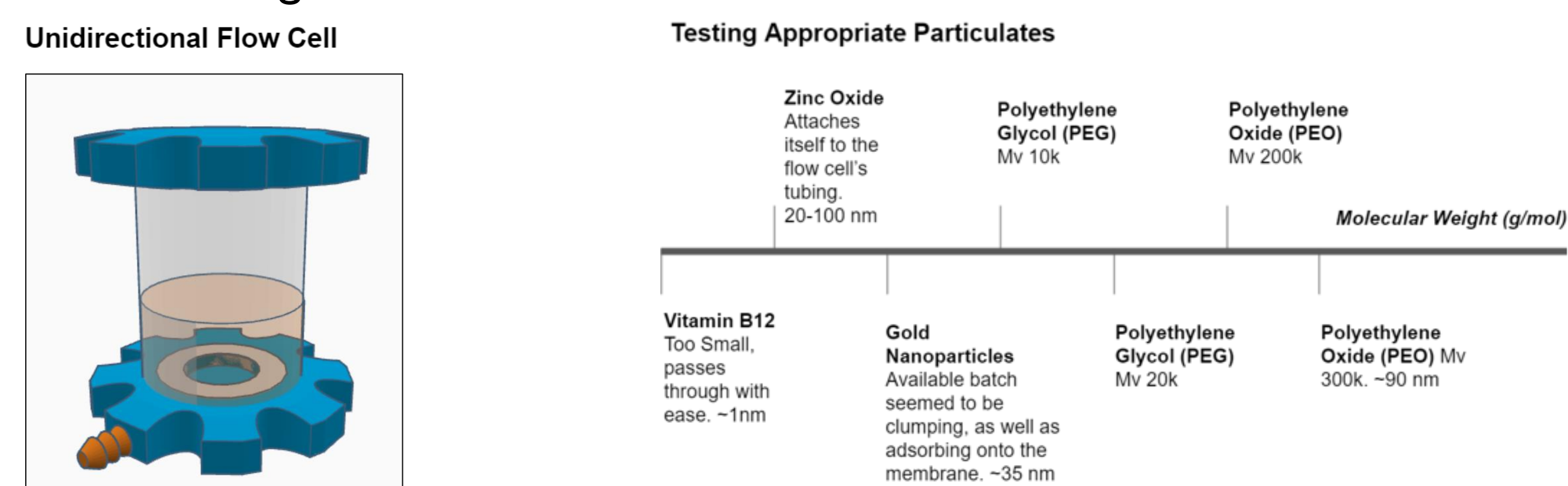
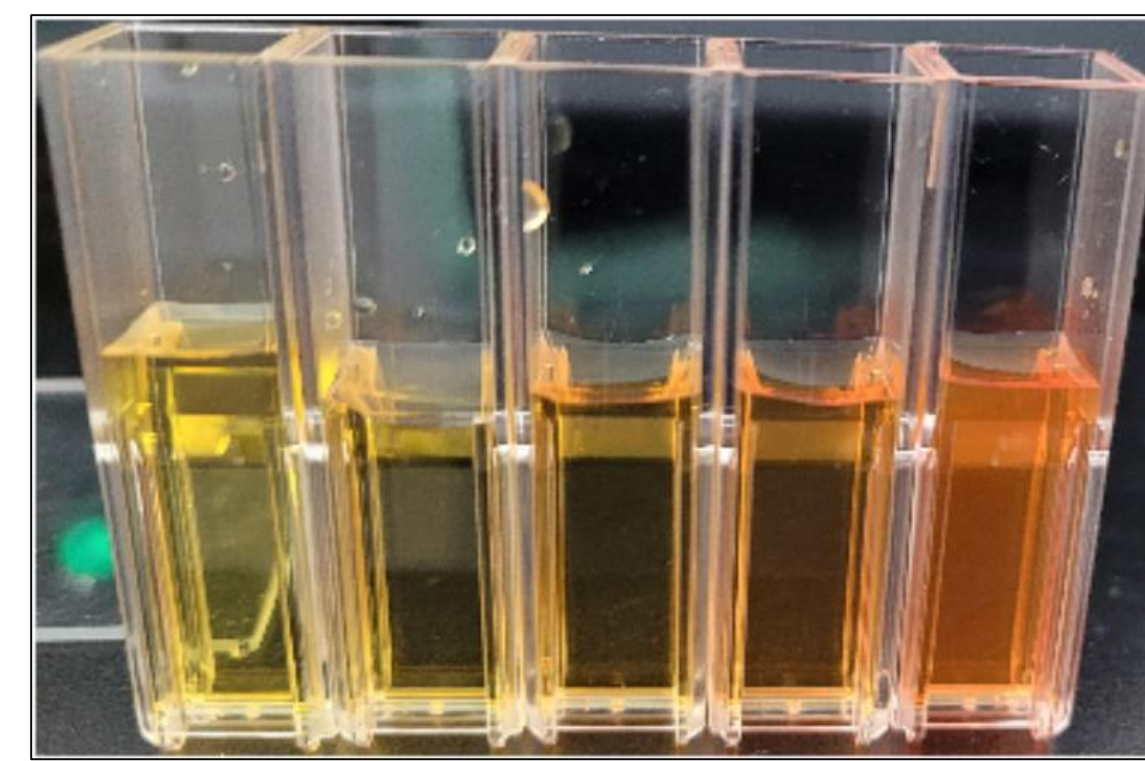


Fig (d). The membrane sits at the the bottom as flow cell is pressurized, passing liquid through the membrane and out the exit tube.

Methodology (cont'd)

Analyzing Concentration After Filtration

600 mL 0.1 molar Hydrochloric Acid
150 mg Dragendorff's Reagent
750 mL of 8x Diluted Effluent



10 minutes after mixing, UV-Vis Spectrophotometry can be used to find the samples absorption of light at different wave lengths which corresponds to PEG concentration (see figure below).

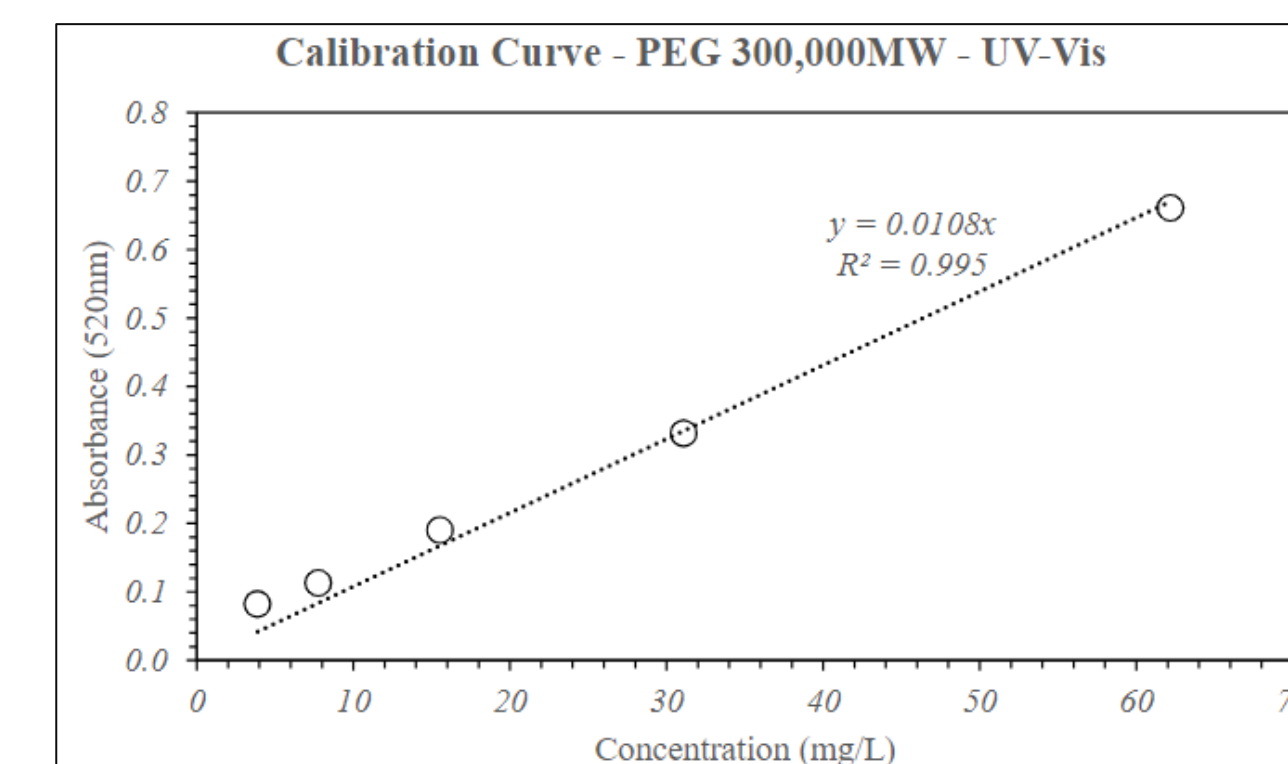


Fig (f) and (g). Calibration curve of 300,000 Mw at 3.91 mg/L, 7.81 mg/L, 15.63 mg/L, 31.25 mg/L, 62.50 mg/L (left to right)

Results

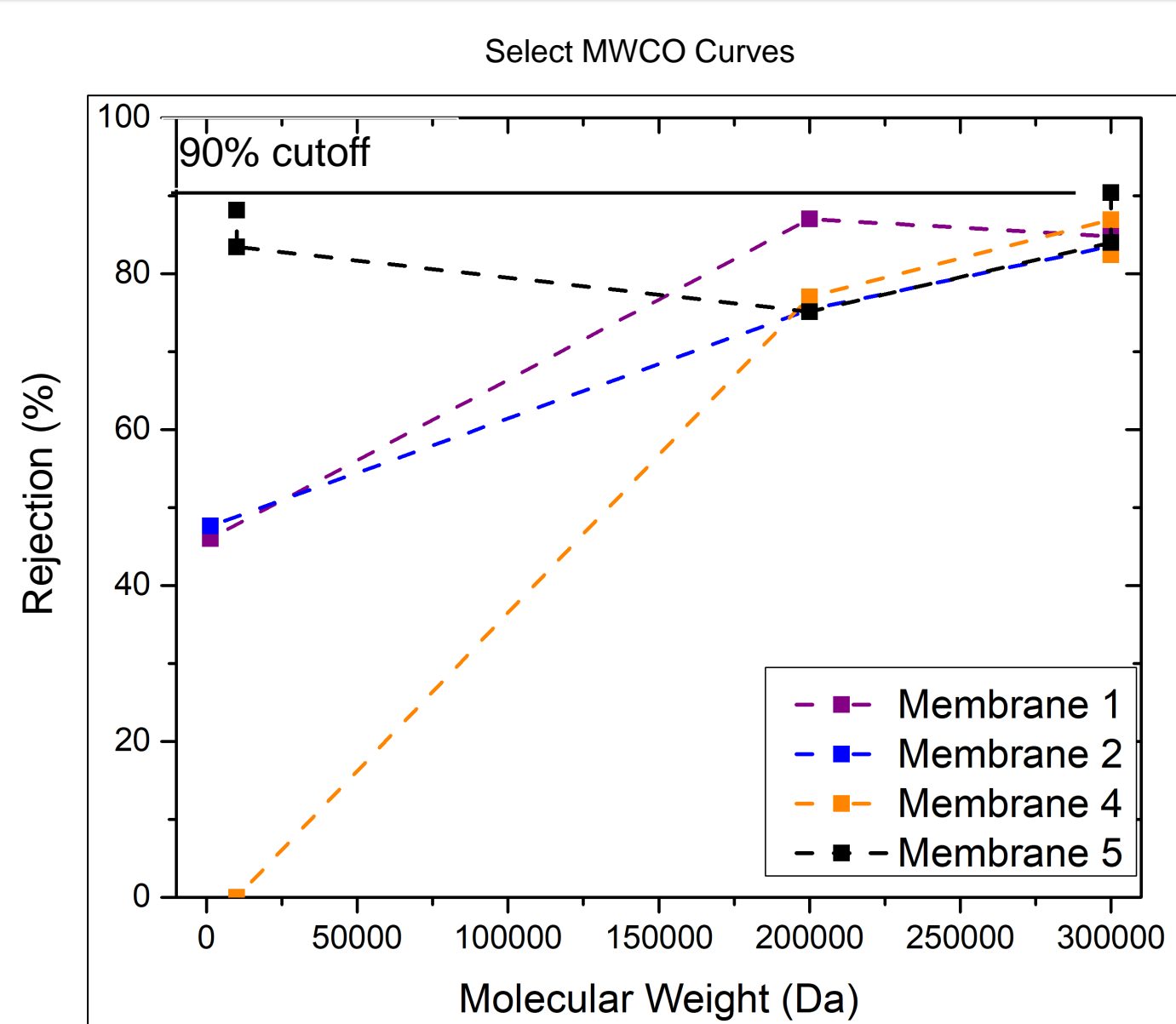


Fig (i). Values of rejection of membranes with most successful rejection

We saw significant rejection from our membranes from a range of molecular sizes, however, these values fall short of the 90% cutoff. This value of 90% is the industry standard for labeling the effective pore size selectivity of membranes.

Despite 300k PEG (~90nm) being just short of the size that our membranes can successfully reject, our permeability seems low. For comparison, our membranes are 12x slower than a commercial membrane (NF90-400/34i) that can reject salt (0.0007 nm).

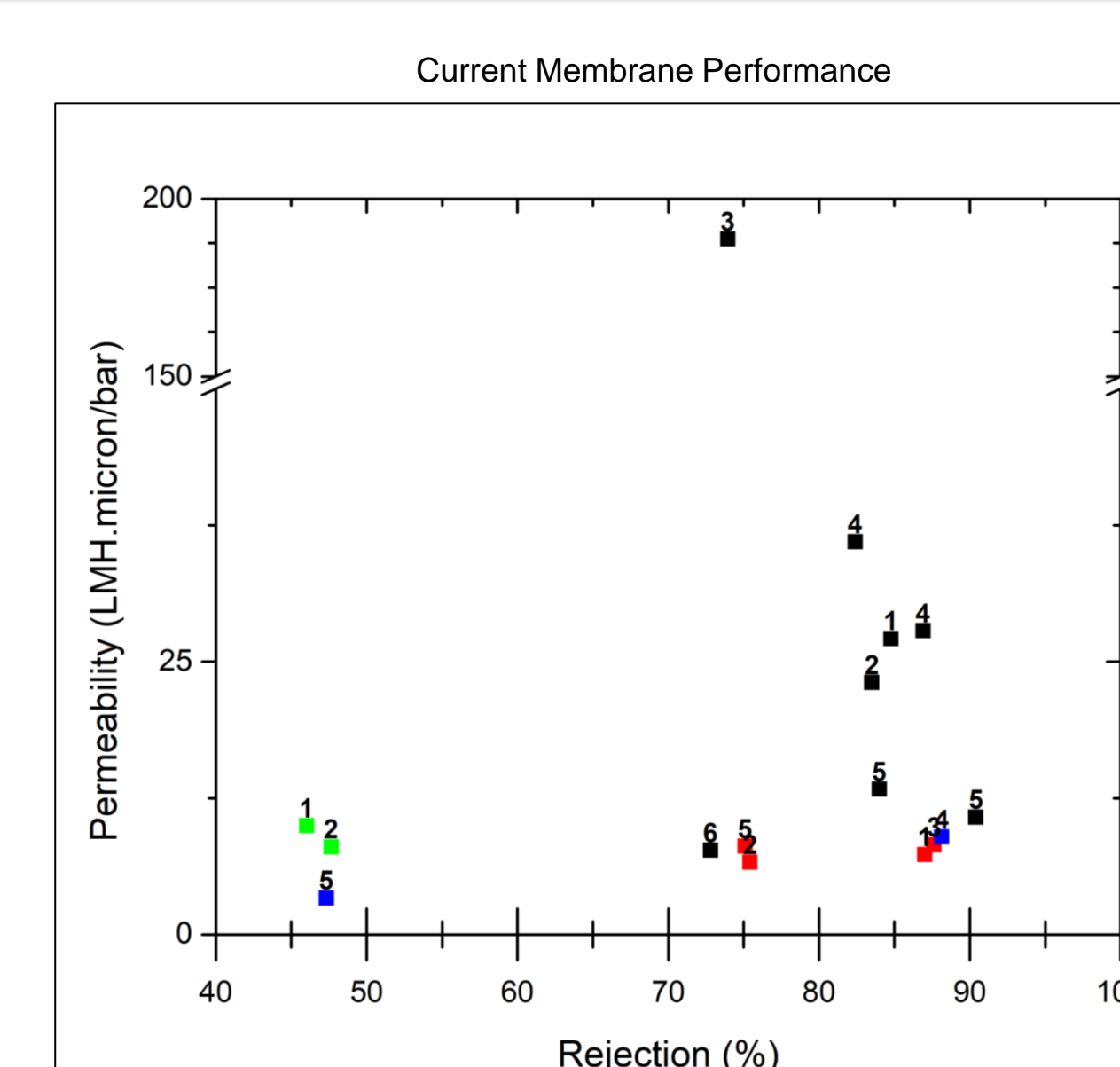
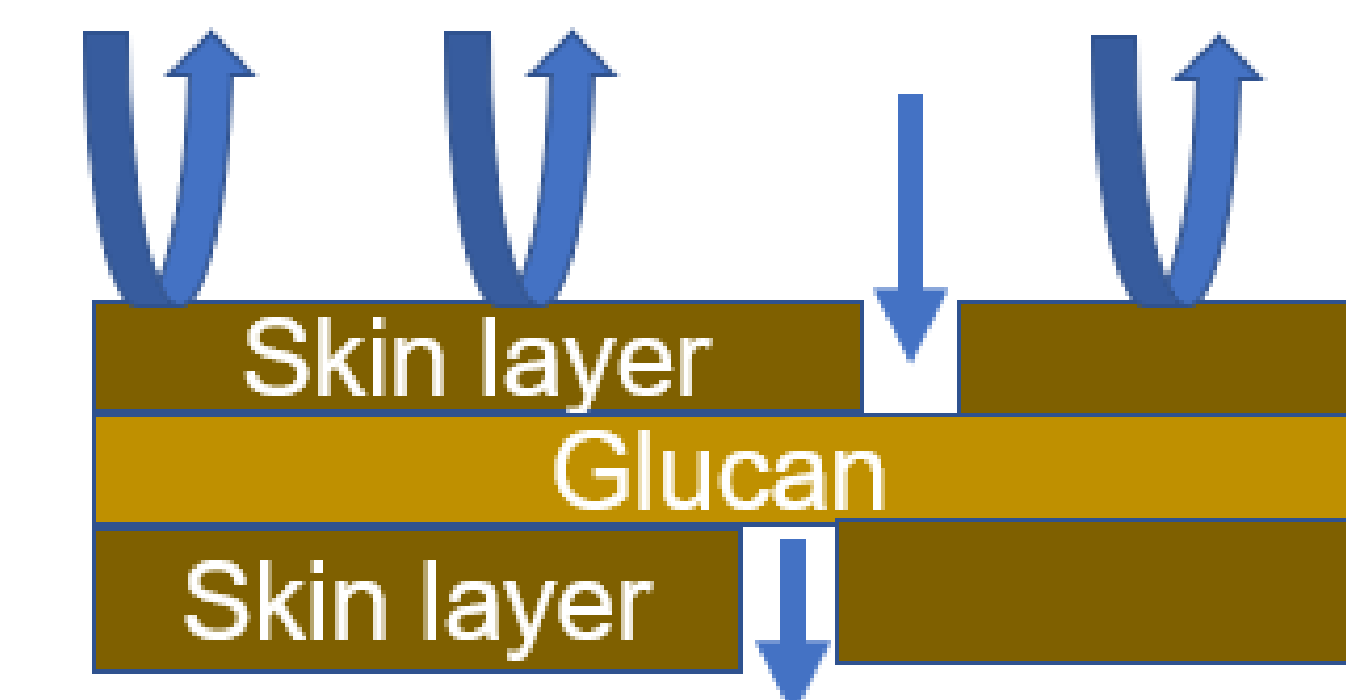
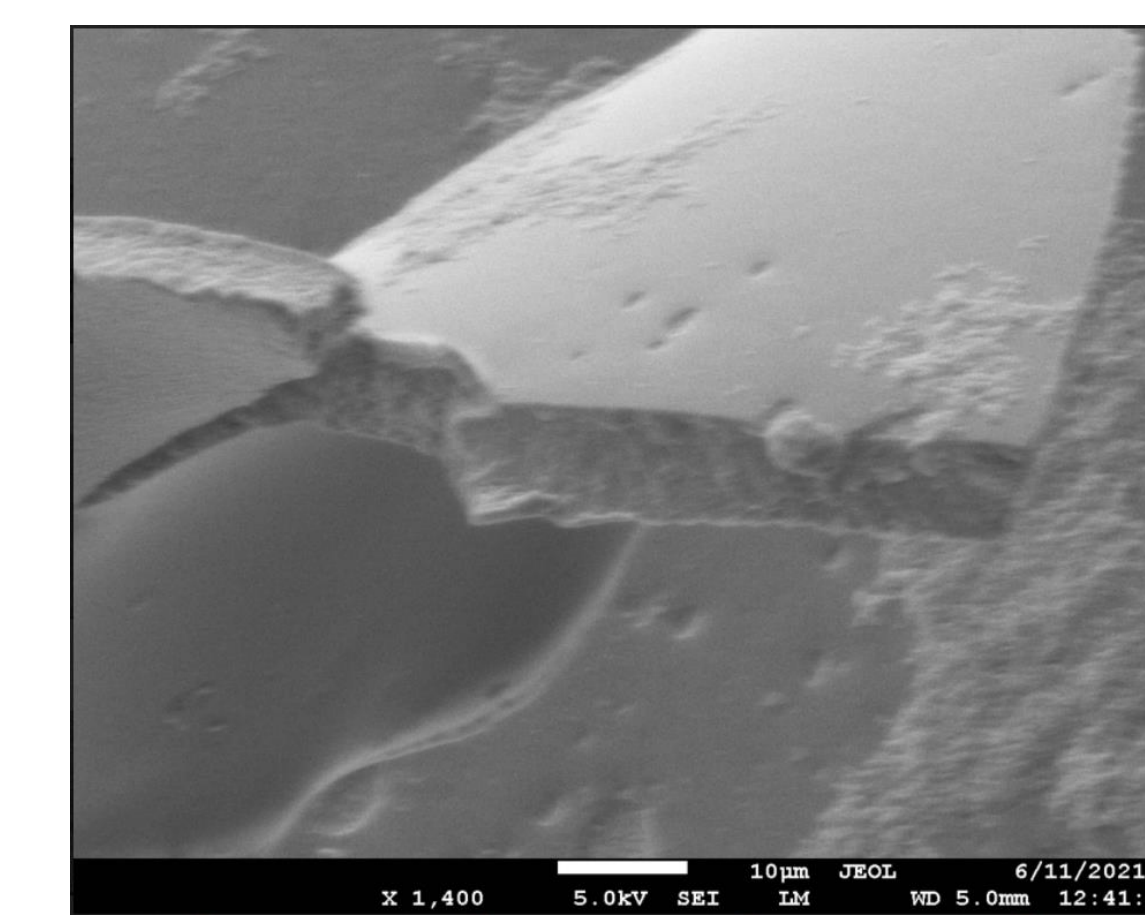


Fig (h). Results of rejection for several different particles: Green – VB12, Blue – 20k, Red – 200k, Black – 300k

Results



The membrane behavior was odd as it has high molecular weight cutoff implies larger pore size and flow, yet it had low permeability. Using SEM, we discovered the presence of the dense skin layer. We suspect this skin layer is limiting flow to the porous filtering portion of the membrane.

Conclusion

The effective pore size selectivity of the fibrillar polysaccharide membrane with our method of fabrication was determined to be between 80-100 nm, which is within the ultrafiltration range. The permeability of the membranes is low compared to membranes with the same or smaller molecular weight cut off. This suggests that there exists a skin layer on the surface of the membrane that is limiting flow. Flow which passes through defects of the skin layer are then filtered by the portion of the membrane underneath. These thoughts are supported by cross-sectional images from SEM of the membranes.

Continuing Work

Work can be continued in researching effective ways of removing or minimizing the effects of the skin layer and shortening the solvent precipitation speed (current process takes 2 hours to precipitate). The membrane is also fragile while wet, requiring additional hours for drying.

References

Zhiqian Jia, Chunai Tian, Quantitative determination of polyethylene glycol with modified Dragendorff reagent method, Desalination, Volume 247, Issues 1-3, 2009, Pages 423-429, ISSN 0011-9164, <https://doi.org/10.1016/j.desal.2008.09.004>. (<https://www.sciencedirect.com/science/article/pii/S0011916409005244>)