NDnano
Notre Dame Nanoscience and Technology

NDnano Summer Undergraduate Research
2023 Project Summary

1. Student name & home university:

Sofia Granieri – University of Notre Dame

2. ND faculty name & department:

Dr. Kaiyu Fu, Chemistry and Biochemistry
Dr. William Phillip, Chemical and Biomolecular Engineering

3. Summer project title:

Biocompatible Membrane Coated Nanoelectrode for Sweat Analyte Measurements

4. Briefly describe new skills you acquired during your summer research:

This summer I learned how to produce HEMA copolymer and cast membranes using a blade casting technique. I also learned how to functionalize membranes as well as run filtration and diffusion experiments on them. Through these experiments I became familiar with analyzing samples through total organic carbon tests (TOC). I was also able to gain experience with the spin coater which is an instrument that can coat membranes onto a surface differently than blade casting. Throughout this experience I learned how to work in a lab environment and how to better read research papers to understand the topics that related to my project. Group meetings and the Summer Research Symposium gave me the opportunity to understand how to explain my research in different settings.

5. Briefly share a practical application/end use of your research:

Antifouling and functional membranes that attach onto a nanoscale sensing element will facilitate the creation of a wearable biosensor that enables the measurement of sweat analytes, such as cortisol, yet does not fail when in the presence of proteins or other foulants in sweat.

6. 50- to 75-word abstract of your project:

Proteins and other molecules present in biofluids can non-specifically adsorb onto sensor surfaces, reducing their performance. Studies have shown that membranes functionalized with zwitterions exhibited antifouling characteristics. In this project, permeabilities of functionalized and nonfunctionalized membranes were characterized and demonstrated that surface functionalization can affect the way membranes interact with species in solution. Further protein diffusion tests and spin coating for thinner membranes will give insight to design a better bio

interface with antifouling properties and long-lasting method for attaching membranes onto sensor surfaces.

7. References for papers, posters, or presentations of your research:

[1] Li, Q., Wen, C., Yang, J., Zhou, X., Zhu, Y., Zheng, J., Cheng, G., Bai, J., Xu, T., Ji, J., Jiang, S., Zhang, L. and Zhang, P., Zwitterionic Biomaterials, *Chemical Reviews* 2022, 122 (23), 17073-17154.

[2] Dunbar P. Birnie, III 2005, *Coating Quality and Spin Coating*, Accessed 11 July 2023, <http://www.coatings.rutgers.edu/index.htm>.

[3] Yang, C., Nuxoll, E.E. and Cussler, E.L. (2001), Reactive barrier films. AIChE J., 47: 295-302.

One-page project summary that describes problem, project goal and your activities / results:

Sensors that are meant to measure biomolecules like those in sweat or in blood can undergo fouling caused by the deposition of material on its surface. Biocompatible membranes, which act as a protective barrier between the body and sensor can help prevent this fouling. Fouling occurs when proteins and other molecules present in biofluids non-specifically adsorb onto the sensor surface, impairing its performance. In order to reduce fouling, sensors need to be protected by an antifouling membrane. There have been studies that have shown that membranes functionalized with compounds such as zwitterions display both antifouling and antibacterial properties, which could be of use for protecting the sensor and interfacing with the body. The goal in this project was to develop a thin antifouling membrane that would facilitate target solute transport and prevent fouling while interfacing with the sensor.

In lab we synthesized 2-hydroxyethyl methacrylate (HEMA) copolymer membranes from 3 monomer units by free radical polymerization. These membranes were cast onto a PVDF support using a blade casting technique at a set height of 70 µm. After casting, HEMA membranes were then functionalized with the zwitterion DMAPS for one hour using atom transfer radical polymerization.

The permeability of the membranes was characterized using filtration experiments. Four different molecular sizes of poly(ethylene oxide) (PEO) were driven through the membrane with pressure. The permeability was calculated using mass, time, and pressure data collected during experimentation. The average permeability of the HEMA membranes was 2.811 $Lm^{-2}h^{-1}bar^{-1}$ while the functionalized membranes had a much lower permeability of 0.3167 $Lm^{-2}h^{-1}bar^{-1}$. The varied permeabilities for each run of the functionalized HEMA is thought to be due to lack of cleaning the membranes after functionalization. By running total organic carbon tests on the permeate and retentate solutions from the filtration experiments, % rejection was found for the membranes. Using this, the HEMA membrane's pore size diameter was estimated to be around 4 nm.

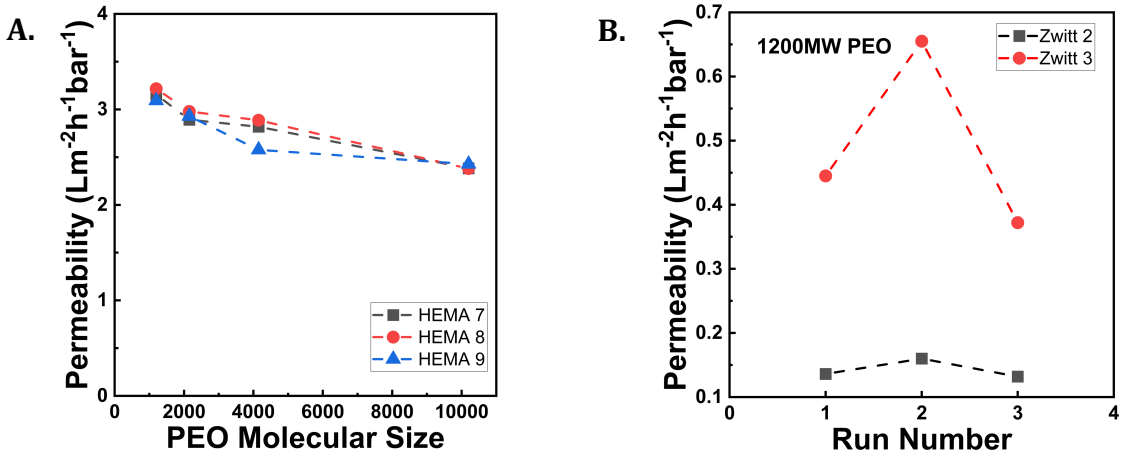

Figure 1. Lines are meant to guide the eye and do not represent any data. **(A)** Permeabilities of three HEMA membranes at four different PEO molecular sizes. **(B)** Permeabilities of functionalized HEMA membranes from three filtration runs at 1200 molecular size PEO.

To investigate how to produce thinner membranes in order to facilitate target solute transport, we began looking at spin coating as a way to coat the membranes onto a surface. HEMA was spin coated onto a silicon substrate and spun at various rpm, accelerations, and for different lengths of time. Preliminary findings suggest that the color of the spin coated membrane may be related to its thickness, but this is yet to be quantified.

Future work will include continuing spin coating to determine a technique that provides uniform coating. Spin coating onto surfaces such as gold could give insight as to how well the membrane would attach to other surfaces. Other experiments will focus on the diffusion of small molecules in the presence of proteins such as fibrinogen and BSA through the membranes to observe potential antifouling effects of the functionalized HEMA.