

NDnano Summer Undergraduate Research 2024 Project Summary

1. Student name & home university:

Kyle Jordan, Ball State University

2. ND faculty name & department:

Dr. Kaiyu Fu and Dr. Matt Webber. Department of Chemistry and Biochemistry

3. Summer project title:

Developing Hydrogel Coatings for Biosensors with Long Term Antifouling Properties.

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

I better refined my skills in organic synthesis and developed new skills in product purification, which included vacuum distillation and column chromatography. I also developed skills and a greater knowledge of surface-initiated activators regenerated by electron transfer atom transfer radical polymerization (SI-ARGET ATRP). Which was an important technique for binding polymer brush layers to a gold surface. Subsequently, I learned about spin coating a thin film onto a designated surface and how to safely clean off the surfaces, using piranha solution. Then, in the process of collecting and analyzing data, I learned some brief knowledge in the plotting and data analysis software, RStudio.

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

One of the most important applications of this research is improving biosensor quality. The range of biosensors is large and they can be used to detect a multitude of things, but having proper coating on them improves the longevity, consistency, and reliability of their measurements while also being biocompatible. Also, the coatings we develop do not necessarily have to be used for biosensors, they can coat other surfaces that need to be protected.

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

Biofouling is a prevalent problem for biosensing technology, which can render a biosensor useless. This in turn costs more money and resources while also providing a less reliable and consistent measurement. An alginate hydrogel coating is biocompatible and can provide a barrier that will stop/slow foulants but allow the analyte to pass through. These coatings can be covalently bonded to a surface with an attached polymer brush layer via spin coating methods.

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

[1] Simonida Lj. Tomic, Marija M. Babić Radić, Jovana S. Vuković, Vuk V. Filipović, Jasmina Nikodinovic-Runic, and Marija Vukomanovic. Alginate-based hydrogels and scaffolds for biomedical applications. *Marine Drugs*, 21(3), 2023.

[2] K. Norrman, A. Ghanbari-Siahkali, and N. B. Larsen. 6 studies of spin-coated polymer films. *Annu. Rep. Prog. Chem., Sect. C: Phys. Chem.*, 101:174–201, 2005.

[3] Patrícia V. Mendonça, Saadyah E. Averick, Dominik Konkolewicz, Arménio C. Serra, Anatoliy V. Popov, Tamaz Guliashvili, Krzysztof Matyjaszewski, and Jorge F. J. Coelho. StraightforwardARGET ATRP for the synthesis of primary amine polymethacrylate with improved chain-end functionality under mild reaction conditions. *Macromolecules*, 47(14):4615–4621, 2014.

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

Biosensors are an important aspect for monitoring patients with chronic diseases, monitoring treatment progress, monitoring biomarkers to aid in disease diagnosis, and many more applications. One of the major problems hindering biosensors is biofouling. Biofouling is a problem anytime something enters the body, due to biological molecules accumulating on the sensors surface and preventing it from sensing the desired analyte. This prevents long term consistent real time monitoring that is easy for patients to use at home or at a medical institution.

A solution to this problem is making a coating that can attach to the surface of the biosensor, is biocompatible, allows the designated analyte to diffuse through, and prevents foulants from getting to the sensor. One option we are studying is alginate. Alginate is a known biocompatible hydrogel that is cost effective and easy to work with. Our goal is to be able to covalently attach alginate to the surface of a biosensor and be able to cross link it while it remains on the surface, ideally rendering a successfully coated biosensor.

Upon starting this project, we are initially attempting to optimize conditions to attach a cross-linked hydrogel coating to a planar gold slide. We first attached a polymer brush layer, with the monomer HEMA. This was done using the SI-ARGET ATRP technique. We targeted to get around 50-100 nm brush layer thickness but based on our atomic force microscopy (AFM) data, we were getting too thick of a brush layer. Also, the chemical properties of polymer brush layer were not compatible with alginate, so it could not successfully be coated onto the gold slide.

Our next attempt was to attach a monolayer with a free amine group on the end. We then activated the alginate using EDC/NHS, which modifies the alginate and allows it to bond with the amine group, resulting in a covalently attached alginate that can be cross linked on the surface. However, after spin coating the alginate onto the surface and rinsing it off with water to remove any non-bonded materials off the surface, most of the alginate was gone. This led us to believe that the monolayer could potentially be too dense and sterically hinders the bulky alginate molecules from bonding to the surface.

Our next step is to redo the SI-ARGET ATRP but use 2-aminoethyl methacrylate as the monomer. We will attach this monomer with shorter polymerization times to ideally yield a less dense polymer brush layer with multiple free amine groups that can bond with the EDC/NHS activated alginate. From there, we can attempt to spin coat and cross link the alginate onto the gold surface. In the future, we also plan on testing the specific biofouling properties of the alginate hydrogel by using fluorescently labeled biofoulants. At the end of the project, the main goal would be to combine everything we have gotten and apply it to a nanoporous gold biosensor and test its performance in harsh fouling conditions.