Dr. Bogdan Negru
Sonoma State University
Department of Chemistry
Sabbatical Report, Fall 2023

My sabbatical leave enhanced my personal and professional goals. My leave activities focused on four main projects in my research group. As proposed in my leave application, I worked on advancing the fabrication of gold nanoparticle oligomers for surface-enhanced spectroscopies and a nuclear chemistry project focusing on the electron capture processes. Furthermore, the flexible schedule afforded by the sabbatical leave gave me the opportunity to work on two more projects that involve a collaboration with the Department of Natural Sciences and Mathematics at Dominican University of California. One project focuses on increasing biochemistry/chemistry student exposure to mathematical concepts and another is an outreach program for California Gifted and Talented Education (GATE) students.

Fabrication of Polymer Stabilized Gold Nanoparticle Oligomers

This is a research project carried out by undergraduate students in my research group that resulted in the publication of a research paper. During my sabbatical leave we worked on furthering this project by fabricating polymer stabilized gold nanoparticle oligomers with a variety of Raman reporter molecules. In our previous publication we indicated that melting our polymer stabilized nanoparticle substrates is of interest because of the widespread implementation of 3D printing. In our previous work we found that the high temperatures used in the printing process drastically decrease the Raman reporter capability of our substrates. To further this work along we hypothesized that temperature stable reporter molecules will perform better during the melting process. As such, we investigated various reporter molecules and successfully identified our next target of interest.

With time, we found that tris (2,2′-bipyridyl) ruthenium(II) chloride ($[Ru(bpy)_3]^{2+}$) is much better at withstanding the high temperatures needed for melting the polymer substrate used to encapsulate our nanoparticle oligomers. Unfortunately, not all reporter molecules are effective at inducing nanoparticle aggregation, including $[Ru(bpy)_3].^{2+}$ We surpassed this hurdle by using salt aggregation as part of substrate synthesis. This allowed us to create substrates with low Raman reporter molecule concentrations. $[Ru(bpy)_3]^{2+}$ is a dye so large concentrations in solution can affect UV/Vis measurements. We are currently finetuning our substrate synthesis parameters while checking Raman reporter resiliency after the melting process.

Nuclear Chemistry and Electron Capture

My time was also spent developing materials for the nuclear chemistry project my group is developing. Nuclear chemistry concepts relate closely to quantum chemistry and they are, unfortunately so, usually left out of the undergraduate curriculum. In actuality, like all CSU

campuses except one, we do not specifically include nuclear chemistry as part of our undergraduate curriculum at SSU. For these reasons, we have

The project we have developed can be used as part of a quantum chemistry course to introduce students to nuclear chemistry concepts. The project was specifically designed to make it interesting and meaningful to quantum chemistry students. Our project is focused on nuclear stability and electron capture, which takes place when an electron reacts with a proton in the nucleus to produce a neutron. This project connects back to a question students are faced with early on in general chemistry about why the electron does not crash into the nucleus. The project packet is now complete and ready for use in the classroom.

The Casino of Life

Our group, in collaboration with Dominican University of California, has developed a new classroom project for undergraduate students that brings more mathematical rigor into the biochemistry classroom. The project introduces students to information technology and the importance of efficiently transcribing and storing information. More importantly, it introduces students to equivalence classes and shows them how they can be used to get a deeper understanding about the most efficient data storing and retrieving process, the genetic code. Lastly, students use dice to insert point mutations into short *mRNA* sequences and analyze the impact these mutations have on the amino acid sequence. The project packet contains student and instructor handouts and it has been used and evaluated in the classroom. The manuscript detailing this work is currently under preparation.

Storytelling in Science with Dominican

My sabbatical leave afforded me the time and energy to give back to the community and to work on developing a program that can make my group better suited for grant applications. With this in mind, in collaboration with Dominican University of California I developed a program for California GATE students. This program is geared toward gifted students in fourth through sixth grades, and it aims to challenge the scientist within. In this program, we view science as a story about the mysteries that surround us everywhere. Stories are powerful, and students in this age group can relate to stories a lot more than they can relate to the scientific method. We tell them stories, we show them surprising behaviors in the world around us, and challenge them to ask good questions. For example, the first lesson was titled “The Story of Water,” and it challenged students with concepts about temperature, density, acidity, and solubility. Students measured temperatures, mixed dyes, grew crystals, measured *pH*, and learned stories about water and its amazing properties.

The program contains five lessons carried out at the Maker Space at the SSU Schulz Library, and it contains strong “maker” and “explorer” components. Students are given the time to fail while also being taught skills about using and understanding the equipment in the Maker Space. This year, the program consists of five 2.5 hour lessons offered to 24 students from the Waugh School district. This program will end in May 2024.

Conclusion

My sabbatical leave gave me the opportunity to advance various projects in my research group and to start a new outreach collaboration with Dominican University of California. During this leave we were successful in identifying a clear direction for the fabrication of temperature stable Raman reporter substrates in our lab. Our group's collaboration with Dominican University of California and the manuscript we are now preparing for submission would likely not have happened without this leave. Additionally, the development of the Storytelling in Science program could not possibly have taken place without this type of leave. The amount of time and dedication needed to develop lessons, to write materials, and to obtain proper approvals is much too great.