

Updating our Organic Chemistry Laboratory Manual with a Focus on Green
Chemistry and Sustainability

Submitted by:

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1. Project Description:

Students in Organic Chemistry I (CHE-203) and II (CHE-204) must take the corresponding labs (CHE-203L and CHE-204L) in order to fulfill their requirements for their Biology, Chemistry, Biochemistry and Molecular Biology major. The labs meet once per week during the semester and last for three hours each. Organic Chemistry Laboratory (I and II) sequence courses are required courses for all Biology, Chemistry and Biochemistry and Molecular Biology majors. These lab experiments also generate organic waste which must be properly disposed. The disposal costs can be very costly to the Department and the University. Over the last several years, this investigator has made progress in reducing hazardous organic waste by introducing green organic chemistry principles. These include: Use of less hazardous and toxic chemicals; Waste prevention instead of remediation; Innocuous solvents; Design products to undergo degradation in the environment, and Energy efficiency by design. Inherently safer processes. The goal of this proposal is to thoroughly update our existing Organic Chemistry Laboratory Manual that includes more Green Chemistry experiments that do not generate large amounts of waste (solid and liquid) by increasing the content of green organic chemistry. Once it is completed, it would play an important role to maintain our American Chemical Society (ACS) accreditation and help the environment by reducing the amount of hazardous waste generated and reduce the disposal costs of the Department of Chemistry and Physics and the University. The ultimate goal is to update our Organic Chemistry Laboratory Manual with Green Chemistry Focus that engages the student in the learning process.

Proposal Design

At present, I have a) made experimental modifications in our methodology of our current organic chemistry experiment and b) written new experiments that employ green chemistry principles in full. Our experiment #3 in Organic Chemistry I lab course, **Acid and Base Extractions: Separation of Benzoic Acid, Benzocaine and Fluorene by Liquid-Liquid Extractions** (see Attachment). This experiment was developed at Lincoln with a green chemistry focus, 1) it makes uses **dichloromethane** as a solvent rather than ether which is highly flammable and 2) it employs benzocaine, a common anesthetic in place of hazardous *p*-nitroaniline. Now, we propose to replace **dichloromethane** with much safer solvent ethyl acetate (safer nail polish remover than acetone). After proper testing with ethyl acetate solvent, we will be able to complete this lab in one lab period instead of two lab periods.

The rational for incorporating green chemistry principles in our organic chemistry is twofold: a) sustainability and b) to be ready for American Chemical Society's (ACS) evaluation of our chemistry program to maintain our ACS accreditation. Due to COVID 19 pandemic, ACS has delayed its visit to **Lincoln University**. At present we are not meeting ACS standards but with the funding of this proposal we will be one step closer. At this time, we do not have any polymer chemistry based labs in our chemistry curriculum. We need these. I have written three polymer chemistry based **labs with a full green chemistry focus and I plan to write three more to evaluate their feasibility** for inclusion in our chemistry curriculum. These labs will employ very safe chemicals and environment friendly solvents.

All laboratory experiments will have updated Post-Laboratory questions to engage the student to

further understand and solidify the fundamental concepts and principles under investigation. The following laboratory experiments, including Post Laboratory Questions will be modified/or developed. **Please note that the lab experiments missing in sequence number are ready for inclusion in the Laboratory Manual.**

CHE 203 L Laboratory experiments:

Experiment # 3: Acid and Base Extractions: Separation of Benzoic Acid, Benzocaine and Fluorene by Liquid-Liquid Extractions. This lab will be revised as above.

Experiment # 7: Synthesis of Diphenylacetylene from Stilbene will be revised with green chemistry focus.

New Experiment #8: Synthesis of Bioplastics from Plant Starch with incorporation of Engineering. This laboratory exercise is interdisciplinary in nature and has characteristics related interactions among Chemistry, Technology, Engineering, Mathematics, and Society

CHE 204 L Laboratory experiments:

Experiment # 2: Diels-Alder Reaction: Preparation of S-Cyclohexen-cis -1, 2-dicarboxylic anhydride. This lab will be replaced with green chemistry lab on the same topic.

Experiment # 3: Relative Rates of Electrophilic Aromatic Bromination. This lab will be revised with green chemistry focus.

Experiment # 5: Sodium Borohydride Reduction of Aldehydes and Ketone. This experiment will be replaced with green chemistry lab

Experiment # 6: Isolation and Identification of Casein. This lab needs only minor revision.

New Experiments with Green Chemistry Focus:

Experiment # 7: Synthesis of (B)-D-Glucose Pentacetate

Experiment # 8. Synthesis of Polymeric Medical Sutures: An Exploration of Polymers and Green Chemistry. This lab will have the following three parts:

A: Drawing Threads Using Poly(ϵ -caprolactone)

B. Tie-Ability and Tensile Strength Testing using poly(ϵ -caprolactone) threads (from part A)

C: Degradability Testing Objective: To test the degradability of the poly(ϵ -caprolactone) threads and actual sutures in an ethanol/sodium hydroxide solution. Ethanol is the solvent of choice in green chemistry.

Experiment # 9. Guided Inquiry with Polylactic Acid (PLA) Objective: Design an experiment that systematically incorporates PLA into a poly(ϵ -caprolactone) (PCL) suture with the goal of modifying and improving the quality of suture prepared. Physical properties such as the draw-ability, tie-ability, tensile strength, and degradability will be studied.

Each laboratory experiment will be performed in the NCS 317 laboratory and revised, as needed.

2. Measurable goals and objectives:

A. Completion of above experiments with Post Laboratory Questions.

B. Compile these experiments as part of Organic Chemistry Laboratory I Manual by December 31, 2021 ready for distribution to Dr. Joseph and FDG committee members.

3. Timeframe: It is expected that 50% of the project will be completed from May 18 – June 25, 2021 and 50 % of the project will be completed from June 30 – July 31, 2021. Completion of Updated Organic Chemistry Laboratory I Manual, August 31, 2021.

4 and 5. How the project will enhance teaching and learning at Lincoln University and 5.

The number of people who will benefit, and how: All biology, chemistry and biochemistry majors and all other students who take Organic Chemistry I (CHE-203 L) and II (CHE-204 L) laboratory courses will benefit directly and immensely. Students will also benefit when they prepare for their MCAT or subject-specific GREs as they can use the Organic Chemistry Laboratory Manual as easy reference. The availability of an Organic Chemistry Laboratory Manual will undoubtedly motivate our STEM majors and enhance retention in STEM fields. Once completed, the published Laboratory Manual will enhance the name of the institution within the STEM community. I must add that availability of Lincoln University's own Organic Chemistry Manual has provided needed incentive for Lincoln University to attract those incoming students who are going to be successful in Chemical Sciences.

6. Success of the project: Organic Chemistry Laboratory I Manual available at University Book Store during fall 2021.

7. Sharing of project outcome: Updated Organic Chemistry Laboratory I and II Manuals and resultant publications in peer review Chemistry Journal e.g. Journal of Chemical Education (ACS). I must add that that our earlier Organic Chemistry Laboratory Manual resulting from a 2015 Faculty Development Grant has been made available to Academic Affairs and all of chemistry faculty members and CHE 203 and CHE 204 classes for the last 5 years. Chemistry for Health Science Laboratory Manual resulting from a 2017 Faculty Development Grant has been made available to Academic Affairs and all of chemistry faculty members and CHE 120 classes for the last 3 years

Budget and Budget Justification

Dr. Amar S. Tung – Funds are requested to write and perform the listed experiments. Each experiment will require **at least** 10 hours per week in laboratory preparation (3.0 hours), writing the laboratory experiment and Post-Laboratory Questions (2 hours), performing the experiment in the laboratory (4 hours), Wrap-up (0.5 hours) and revising the experiment and post-laboratory questions (1 hour). Time for ordering/receiving required chemicals/supplies =3 hours.

Amount Requested, two months summer salary: \$6500

Laboratory Supplies: Funds are requested for chemical supplies including catalysts from Sigma Aldrich needed to perform the experiments. To ensure the success of the experiment, the chemicals will be ordered by using personal credit card.

Amount requested: \$500

Total Amount Requested in this proposal - \$7000