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Chicago State University
9501 S.King Drive

Chicago, IL 60628 -1598

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UU	UU	UU	UU		19b. TELEPHONE NUMBER 773-995-2171

RPPR Final Report
as of 27-Sep-2021

Agency Code: 21XD

Proposal Number: 74307CHREP **Agreement Number: W911NF-19-1-0519**
INVESTIGATOR(S):

Name: Andrea Gay Van Duzor
Email: andrea.vanduzor@csu.edu
Phone Number: 7739954437
Principal: N

Name: Kristy L. Mardis
Email: kmardis@csu.edu
Phone Number: 7739952171
Principal: Y

Name: Robert Richter Ph.D.
Email: rrichter@csu.edu
Phone Number: 7739952182
Principal: N

Name: Valerie Goss
Email: vgoss@csu.edu
Phone Number: 7739953892
Principal: N

Organization: **Chicago State University**
Address: 9501 S.King Drive, Chicago, IL 606281598
Country: USA

DUNS Number: 108109182 EIN: 362580815
Report Date: 19-Dec-2020 Date Received: 31-Mar-2021
Final Report for Period Beginning 20-Sep-2019 and Ending 19-Sep-2020

Title: ExPo: Exploring Polymers in the Undergraduate Chemistry Curriculum at Chicago State University
Begin Performance Period: 20-Sep-2019 **End Performance Period:** 19-Sep-2020
Report Term: 0-Other

Submitted By: Kristy Mardis Email: kmardis@csu.edu
Phone: (773) 995-2171

STEM Degrees: 14 **STEM Participants:** 20

Major Goals: The purpose of this grant was to purchase equipment focused on polymer physical property determination, including ultraviolet and near IR spectrometers, two permanent magnet NMRs, a Differential Scanning Calorimeter, an accompanying Thermal Gravimetric Analyzer, and a High Performance Liquid Chromatography system. This equipment would then be used introduce polymer science across the undergraduate curriculum. This new instrumentation will strengthen and enhance our current research projects, open up new cross collaborations with our engineering studies and physics faculty, and offer students a multitude of new polymer science based senior thesis projects.

Accomplishments: We purchased the components and accessories needed to implement polymer experiments across our undergraduate teaching labs. The original grant award was for $470,796.00 and we spent $469,847.60 returning $948.00. A detailed table of expenditures is included in the upload as Table 1.

Lab Experiments Developing Involving Purchased Equipment

The equipment purchased from this project is currently being used to implement a polymer focused curriculum throughout our undergraduate curriculum. Unfortunately, due to COVID-19, the bulk of our laboratory classes have been remote since March and those that have met are only at 50% capacity (about 3-4 hours of lab every other week). Despite this, we have developed and implemented three experiments in fall 2020, two more will be

implemented in spring 2021, and an additional one will be implemented during the fall of 2021.

Bench Top NMR experiments developed and implemented for Fall 2020 Organic II lab
1. Introductory (Macromolecule Analysis) – This laboratory introduced the students to the basics of macromolecule analysis with a bench top NMR. The students extracted fat from corn chips and used 1H-NMR to calculate the amount of saturated, unsaturated, and polyunsaturated fat.
2. Introductory (Polymer Analysis) – This laboratory builds on the macromolecule analysis experiment. Students were introduced to the concept of polymer end group analysis, an important technique for determining monomer ratios and molecular weight. In this lab the students were tasked with determining if commercial sources of polystyrene were all produced by the same synthetic reaction.
3. Introductory (Synthesis Optimization) – This laboratory introduced the students to the concept of optimization of organic reactions. In industry, taking a compound from the research bench to commercial production is critical, but this is often overlooked in the undergraduate curriculum. In this lab, students used the fast synthetic capabilities of a laboratory microwave reaction system in combination with the two minute analysis time of the bench top NMR to optimize ester synthesis reactions in real time. To simulate the industrial setting students completed three complete synthetic reactions with analysis runs with new conditions during each 4 hour lab session.

HPLC experiment developed for upcoming Spring 2021 Analytical Chemistry II Lab
1. Introductory (Polymer Additive Analysis) – This laboratory will introduce the students to the concepts of additives incorporated into polymeric materials to enhance or alter their properties as well as the basic principles of HPLC analysis. The most common additives are anti-oxidants used to prevent polymer degradation in the presence of oxygen. In this lab students will use microwave extraction in combination with HPLC analysis to determine the identity and quantity of anti-oxidants in polypropylene, both low density polyethylene and high density polyethylene.

DSC/TGA experiment developed for upcoming Spring 2021 Advanced Chemistry Lab
1. Model lipid bilayer systems will be used to study phase transitions in the presence of alcohols. In these experiments, alcohols having 6 to 16 carbon-chain length will be added to membrane-like solutions of dipalmitoyalphosphatidylcholine (DPPC). Using differential scanning calorimetry (DSC), lipid thermograms will be obtained in the presence of organic solvents at varying concentrations. Students will determine the phase transition temperature, Tm, (melting temperature), ΔCp and ΔH as a function of temperature of the model membranes. We will perform standard TGA experiments on DPPC. The students will prepare a poster presentation, as well as a report of their results.

NIR experiment developed for upcoming Fall 2021 General Chemistry Lab
1. Introductory (Polymer Identification) - This laboratory will introduce students to the chemical and physical properties of the six commonly recycled polymers. Students will use a variety of chemical, physical and spectroscopic (NIR) tests to discriminate between the polymer types.

Training Opportunities: Laboratory experiments developed were described under main accomplishments.

Two faculty (Mardis and Van Duzor) completed the POGIL Activity Clearinghouse (PAC) training so they are authorized to submit the created labs to the POGIL site for future distribution.

Faculty (Richter and Goss) completed training offered by the vendors on the NIR, NMR, and TGA/DSC instrumentation.

Results Dissemination: The equipment purchased was also used to write a POGIL SPUR+ grant proposal which was awarded to Drs. Mardis, Van Duzor, and Van Opstal (Instructor at a local community college) to further develop introductory level polymer experiments suitable for implementation across multiple institutions. Laboratory experiments written and beta tested with this additional funding will be submitted to the POGIL Activity Clearinghouse , where once accepted, will be available for use by any POGIL practitioner or instructor (there are an estimated 10,000 POGIL instructors world-wide).

Honors and Awards: Nothing to Report

Protocol Activity Status:

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as of 27-Sep-2021

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Kristy Lynn Mardis
Person Months Worked: 3.00 **Funding Support:**
Project Contribution:
National Academy Member: N

Participant Type: Co PD/PI
Participant: Valerie Goss
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
National Academy Member: N

Participant Type: Co PD/PI
Participant: Robert Richter
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
National Academy Member: N

Participant Type: Co PD/PI
Participant: Andrea Van Duzor
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
National Academy Member: N

Partners

,

RPPR Final Report
as of 27-Sep-2021

I certify that the information in the report is complete and accurate:
Signature:
Signature Date:

List of Equipment

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Table 1. Equipment, Supplier, and Cost Summary

Item	Supplier	Unit price	Quantity	Total Cost
GENESYS 180 UV-VIS Spectrometer	Fisher Scientific	$5,965.25	9	$53,687.29
Poly-NIR (Near- Infrared Diffuse Reflection System)	D&N Scientific	$10,170.00	7	$71190
Spec Analysis Software for Poly-NIR	D&N Scientific	800	5	$4000
Spect-Print Network Printers for Poly-NIR	D&N Scientific	$500	2	$1000.00
Pico-Spin 80 Series II NMR	Thermo Electronic NA	$36902.11	2	$73804.21
GPC HPLC system complete with RI detector	Agilent Technologies	$48,606.20	1	$48606.20
Standard HPLC system complete with ELS and VWD detectors	Agilent Technologies	$75,134.46	1	$75134.46
Discovery DSC 2500	TA Instruments	$84,662.72	1	$84,662.72
Discovery TGA 5500	TA Instruments	$57,762.72	1	$57,762.72
Total				**$469,847.60**

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Conclusion

The equipment purchased from this grant is allowing us to implement polymer training throughout our curriculum. At the introductory levels, we will introduce the NIR, UV-VIS, and NMR instrumentation. As students advance to upper-level coursework, they will continue to use these instruments, but on more open-ended laboratory projects while also introducing TGA/DSC and HPLC techniques. By the time students graduate, they will have been exposed to multiple types of polymers and have learned to apply multiple experimental techniques to their synthesis and characterization. We thank the Department of Defense for assisting us in the purchase of these instruments. It is clear that we will benefit from this grant for many years to come!

[1] http://pac.chem.pitt.edu/index.php/pac/index