Center for Scholarly and Creative Excellence Catalyst Grant for Research and Creativity Application

Applicant Information

First Name *
Shannon
Last Name *
Biros
Telephone *
616-331-8955
Email *
biross@gvsu.edu
Rank *
Associate Professor
Department *
Chemistry Department
Tenure *
Yes
Research Discipline *
Information is used for reporting to federal agencies by the university.
Physical Sciences - Chemistry
Research Type * (How would you describe this particular project?)
Information is used for reporting to federal agencies by the university.
Applied Research
Upload CV *
vitae_2017Sep

Collaborator Information

Are there any collaborators for this grant? *
No

Project Information

Project Title *
Developing new compounds for the extraction of lanthanides and actinides
Start Date *
11/1/17
End Date *
10/31/18
Will undergraduate or graduate students be involved in the research being

funded by this grant?*
Yes
How many students are involved in the research?
Undergrad
2
Graduate
0
How many students are funds are being requested for?
Undergrad
2
Graduate
0
Will you be requesting a Pre-tenure Supplement in the amount of 3,000? If yes, please make sure your budget and scope of work reflects the new award amount. *
No
Will you be requesting one-course reassigned time in conjunction with this grant? (requires your Dean's approval) *
No
Please provide justification for reassign time *
Semester *
Year *
Dean's Email *
Copy of this grant will be sent to your Dean for approval @gvsu.edu
Does your project involve human subjects? *
No
Does your project involve vertebrate animal subjects? *
No
Does your project involve any biological hazards? *
No
Does your project require radiological controls? *
Yes
Does this proposal contain proprietary information? *
Yes
Is your research project subject to export control law? www.gvsu.edu/export *
No
Please explain how this project is subject to export control law. *
Have you closed, and turned in your final report, for all previous research grants through CSCE?(faculty may only have one active CSCE grant at a time) *
Yes
Project Summary *
This project involves the organic synthesis of four new compounds designed to bind selectively to lanthanide and actinide metals. We will also determine the ability of each compound to extract lanthanide and actinide metals out of acidic, aqueous solutions. This work has applications in the area of nuclear waste remediation and the recycling of lanthanide containing materials.
Upload Project Description
Biros_2017CSCEproposal

Internal Grants

Have you received funding, not including travel grants, from GVSU within the last three years(CSCE (R&D), FTLC, S3, etc.)? *
Yes
Title of Project *
Development of a new method for the treatment of nuclear waste: Synthesis of compounds with soft donors
Date *
05/2017
Type *
Modified S3
Title of Project *
Development of Tripodal CMPO Ligands for Nuclear Waste Remediation
Date *
04/2014
Type *
CSCE Catalyst
Title of Project *
Synthesis of quaternary organic ligands for nuclear waste remediation
Date *
09/2017
Type *
OURS Project Supplies (Brandon Wackerle, student author)
Title of Project *
Synthesis of the Phosphine and Silane Derivatives of the TREN Molecular CMPOs for Improving Methods for the Recovery and Recycling of Lanthanide and Actinide Metals in Nuclear Fuel
Date *
09/2017
Type *
OURS Project Supplies (Michael Hudson, student author)

External Grants

Have you submitted an external grant application within the last three years?
Yes
Agency
National Science Foundation
Title of Project
MRI: Acquisition of a 400 MHz NMR Spectrometer for Research and Training at GVSU, GRCC and Aquinas College
Status
Submitted, and awarded
Date
01/2017
Agency
Arnold and Mabel Beckman Foundation
Title of Project

2017 Beckman Scholars Program - Grand Valley State University
Status
Submitted, and awarded
Date
06/2016
Agency
Department of Energy
Title of Project
Development of Multipodal Ligands for Selective f-Element Chelation
Status
Submitted, not awarded
Date
01/2016
Agency
NASA - Michigan Space Grant Consortium
Title of Project
Recovery and Recycling of Spent Nuclear Fuel Pu-238 for Sustainment of Nuclear Reactors Using Extraction Techniques
Status
Submitted, and awarded
Date
11/2016
Agency
National Science Foundation
Title of Project
The TIM Consortium: A Dispersed REU Site in Theoretically Interesting Molecules
Status
Submitted, and awarded
Date
08/2015
Agency
Arnold and Mabel Beckman Foundation
Title of Project
2016 Beckman Scholars Program - Grand Valley State University
Status
Submitted, not awarded
Date
07/2015
Agency
American Chemical Society Petroleum Research Fund
Title of Project
Systematic investigations of lanthanide and actinide complexes with phosphoryl, thiophosphoryl, and selenophosphoryl ligands: X-Ray crystallography, NMR and computational calculations
Status
Submitted, not awarded
Date
03/2015

Do you have any pending external grants?
No

Itemized Budget

Wages for Student workers

Description *
Brandon Wackerle
Cost *
$1,498.00
Outside Funding *
$0.00
Requested *
$1,498.00
Award
$0.00
Justification *
Brandon has two years of experience working in the area of organic synthesis, including a three month internship at Michigan State University's Bioeconomy Institute. Currently Brandon is working in my research group for CHM 499 credit (Fall 2017 semester). He is planning to graduate in December of 2017. For the Winter 2018 semester, Brandon has committed to working as an adjunct in the chemistry department where he will teach laboratory courses. He has also committed to working in my research group for the Winter 2018 semester. I would like to pay Brandon at the rate of $10.70/hour for 10 hrs/week for the 14 weeks of the Winter 2018 semester (Classification 4, Step B). Brandon has experience performing organic chemistry, can work independently but will require some supervision from me, and he will not be responsible for supervising others. Through Brandon's OUR Student Supplies Grant he has funds to purchase all of the specialty chemicals needed for the proposed work. My laboratory is already equipped with the appropriate glassware, consumables and other chemicals needed to complete this project. What I need is experienced hands in the laboratory to carry out the research - Brandon represents this level of experience. He began working on this project last May as part of my NSF-REU grant, and will continue to pursue the synthesis of the compounds described in this proposal until he leaves GVSU in April of 2018. Brandon's level of knowledge and experience in the area of synthetic chemistry is advanced for an undergraduate student. He is quite independent and has advanced the progress of my research program in the two years he has worked with me. Having him continue to work for me during the Winter 2018 semester will give me a head start on gaining results before the summer research season begins. In May 2018, I will be able to build upon the progress that Brandon will have made on this research project. This will give me more preliminary results to include in external grant proposals (to the NSF, DOE), as well as getting us one step closer to a publishable research story.

Description *
Michael Hudson
Cost *
$1,498.00
Outside Funding *
$0.00
Requested *
$1,498.00
Award
$0.00
Justification *
Michael has two years of experience working in the area of organic synthesis and analytical chemistry, including a one month internship at Lawrence Berkeley National Laboratory. Currently Michael is working in my research group for HNR 499 credit (Fall 2017 semester). He is planning to graduate in December of 2017. For the Winter 2018 semester, Michael has committed to working as an adjunct in the chemistry department where he will teach laboratory courses. He has also committed to working in my research group for the Winter 2018 semester. I would like to to pay Michael at the rate of $10.70/hour for 10 hrs/week for the 14 weeks of the Winter 2018 semester (Classification 4, Step B). Michael has experience carrying out the experiments described in this proposal, he can work independently but will require some supervision from me, and he will not be responsible for supervising others. Through Michael's OUR Student Supplies Grant he has funds to purchase all of the specialty chemicals needed for the proposed work. My laboratory is already equipped with the appropriate glassware, consumables and other chemicals needed to complete this project. What I need is experienced hands in the laboratory to carry out the research - Michael represents this level of experience. Michael has been working on the synthesis of some of the previous compounds described in this proposal since September of 2016, and spent the summer of 2017 carrying out the extraction experiments as part of his Honor's College Thesis project. Some of these results are shown in Table 1 of this proposal. Michael will continue to work on this project until he leaves GVSU in April, 2018. Michael's level of experience in the area of synthetic and analytical chemistry is advanced for an undergraduate student. He is quite independent and has advanced the progress of my research program in the two years he has worked with me. The synthetic and extraction results he has obtained over the past year are being included in a manuscript that we are currently writing. Having him continue to work for me during the Winter 2018 semester will allow him to take this research project to the next level and probe the next generation of molecules. This upcoming summer, I will be able to build upon the progress that Michael will have made on this research project and help bring it to completion. This will also give me more preliminary results to include in external grant proposals (to the NSF, DOE), as well as getting us one step closer to another publishable research story.

Total

Total Cost
$2,996.00
Total Outside Funding
$0.00
Total Need
$2,996.00
Total Requested from CSCE
$2,996.00
Total Awarded
$0.00

Supporting Documents

Upload Unit Head Support Letter: *
Biros_reference
Misc Upload:

Final Report

Outcome *
Dissemination *
Future Plans *

Application Status

Decision
Pending

Committee Notes

Developing new compounds for the extraction of lanthanides and actinides

Shannon M. Biros, Department of Chemistry: CSCE Catalyst Grant for Research and Creativity

Section IV: Project Description

Objectives The overarching goal for this CSCE Catalyst Grant for Research and Creativity proposal is to develop new methods for the purification of lanthanide and actinide metals, those elements found at the very bottom of the periodic table. My research group's approach to this problem involves the organic synthesis of new compounds (termed "ligands") that can bind selectively to lanthanide and actinide metals and separate them from other contaminants. This research has applications in the areas of alternative energy, recycling of materials, and isolation of these metals from ground ores. With the funds requested from this proposal, my research students and I will: (1) prepare four new target compounds (**5-8,** Figure 1**),** and (2) determine the ability of compounds **5-8** to extract lanthanide and actinide metals from aqueous solutions.

Background and context A recent resurgence in research on lanthanide and actinide chemistry stems from society's need for alternative energy sources.[1-3] One alternative energy source involving uranium (which is an actinide metal) is nuclear power,[1-3] and the efficient processing of spent nuclear fuel remains an unsolved problem.[4-6] One strategy to address this issue involves the removal of uranium from these waste solutions.[4, 5] Currently this removal, or extraction, process is carried out with organic compounds that bind selectively to the uranium metal and pull it away from other metals. While there are a number of commercial processes that are in current use, many suffer from limited selectivity or excessive cost.[7-9]

A second application of lanthanide chemistry comes from the incorporation of these metals into advanced materials such as visual devices (e.g. smart phones),[10-17] biosensors,[18-23] magnets

and hybrid car batteries.[10] Current efforts are focused on effective ways to purify lanthanide metals from raw sources[24] and to recycle materials that use these metals.[25, 26]

The overarching goal for the Biros research program is to synthesize new organic compounds that have the potential to act as *selective* extraction agents for lanthanide and actinide metals. My undergraduate research students and I have accomplished the synthesis of compounds **1-4**, shown in Figure 1a. Of these four organic compounds, both **1** and **4** demonstrated a marked ability to selectively extract one metal away from all others in water solutions. To determine this extraction ability, we measure the amount of metal that was removed from an aqueous solution using our ligands and report this number as an "extraction efficiency". Compound **1** prepared by our group demonstrated the ability to selectively extract terbium out of aqueous solutions away from the other metals with an extraction efficiency of 23% (blue number, Table 1).[27] While this number seems modest, this selectivity for the extraction of one lanthanide metal away from all others is unprecedented. Recent efforts by my research students have shown that increasing the hydrophobicity ("water hating" character) of ligand **1** through the installation of phenyl groups (ligand **2**) results in a small reduction in the extraction efficiency of terbium, but selectivity for elements in the middle of the lanthanide row is retained (orange numbers, Table 1). Increasing

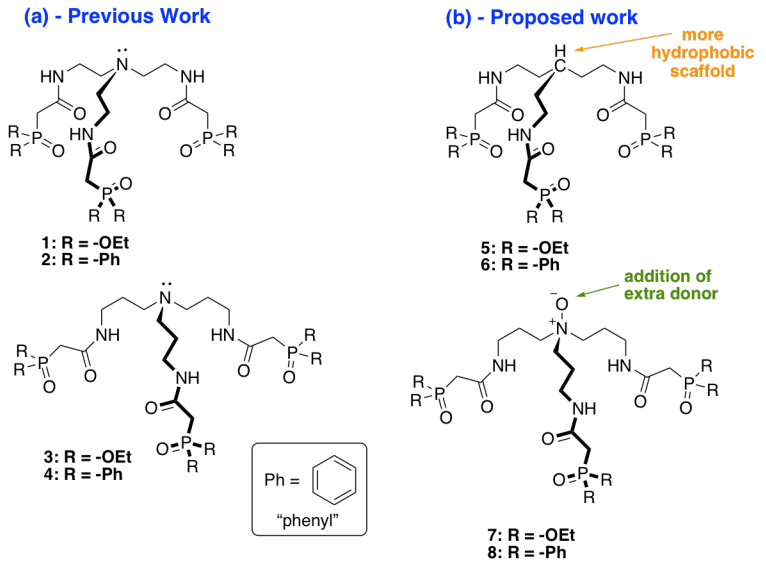

Figure 1. (a) Ligands **1**-**4** synthesized by the Biros group, and (b) the target compounds **5-8** proposed here.

the size of the ligand without changing the hydrophobicity (ligand **3**) results in complete elimination of extraction ability. However, increasing both the size and hydrophobicity of ligand **1** (ligand **4**) results in a compound with remarkable extraction selectivity for thorium (purple number, Table 1).

Table 1. Extraction efficiencies for compounds 1-4 (% extracted out of 1M HNO_3 with $[M(NO_3)_x]$ = $1.0x10^{-4}$ M and ligand = $1.0x10^{-3}$ M in CH_2Cl_2).

metal	ligand 1	ligand 2	ligand 3	ligand 4
La^{3+}	5 ± 1	6 ± 2	5 ± 1	3 ± 1
Ce^{3+}	4 ± 1	6 ± 1	6 ± 1	1 ± 1
Pr^{3+}	7 ± 1	2 ± 2	5 ± 1	4 ± 7
Nd^{3+}	2 ± 1	8 ± 1	4 ± 1	5 ± 1
Sm^{3+}	3 ± 1	8 ± 2	4 ± 1	3 ± 2
Eu^{3+}	6 ± 1	4 ± 2	5 ± 1	2 ± 1
Gd^{3+}	3 ± 2	**13 ± 3**	3 ± 1	2 ± 1
Tb^{3+}	**23 ± 0**	**11 ± 1**	3 ± 1	3 ± 2
Dy^{3+}	7 ± 1	**8 ± 1**	2 ± 1	2 ± 2
Ho^{3+}	4 ± 1	7 ± 2	5 ± 1	2 ± 1
Er^{3+}	5 ± 1	6 ± 2	3 ± 1	1 ± 1
Tm^{3+}	5 ± 1	4 ± 1	6 ± 1	3 ± 2
Yb^{3+}	7 ± 1	8 ± 3	5 ± 1	1 ± 1
Lu^{3+}	5 ± 1	10 ± 2	4 ± 1	2 ± 2
Th^{4+}	6 ± 2	7 ± 2	5 ± 1	**64 ± 1**
UO_2^{2+}	8 ± 2	3 ± 1	4 ± 1	12 ± 1

Current efforts within my research group are focused on determining the specific structural features of compound **1** and **4** that account for the extraction selectivity described above, so that we can continue to synthesize new compounds with improved extraction efficiencies.

Methods/procedures/materials

Objective 1: Synthesis of compounds **5-8**. My research students and I will accomplish Objective 1 of this proposal by preparing derivatives of compound **1** and **4** that have had specific changes

to their structure in order to tease out the factors governing the observed extraction efficiencies. These target compounds are shown as ligands **5-8** in Figure 1. We will prepare these compounds using standard synthetic organic chemistry techniques in PI Biros' assigned research space (PAD 323). All necessary laboratory equipment, stock chemicals and consumable materials have been purchased by PI Biros using funds from her National Science Foundation REU grant. The undergraduate research students who will be supported by the funds from this proposal, Michael Hudson and Brandon Wackerle, have each secured funds for chemicals that will be used to accomplish the objectives of this proposal through individual OURS Student Supplies Grants.

The structures of the target compounds **5-8** of this proposal were designed by making small changes to successful ligands **1** and **4** (Figure 2). We plan to increase the hydrophobicity of ligand **1** by replacing the central amine nitrogen atom with a CH group to give **5**, with the prediction that this ligand will show greater extraction efficiency for all lanthanides and actinides, but will retain selectivity for Tb^{3+}. We also plan to make the phenyl derivative **6** so that we can have a direct comparison with compound **2**. To probe the structure of compound **4**, we are working to prepare compounds **7** and **8** that will contain one additional oxygen atom in the center of the ligand. We predict that these new ligands **7** and **8** will demonstrate higher extraction efficiencies for the lanthanide metals than precursors **3** and **4**, but selectivity will be retained for thorium.

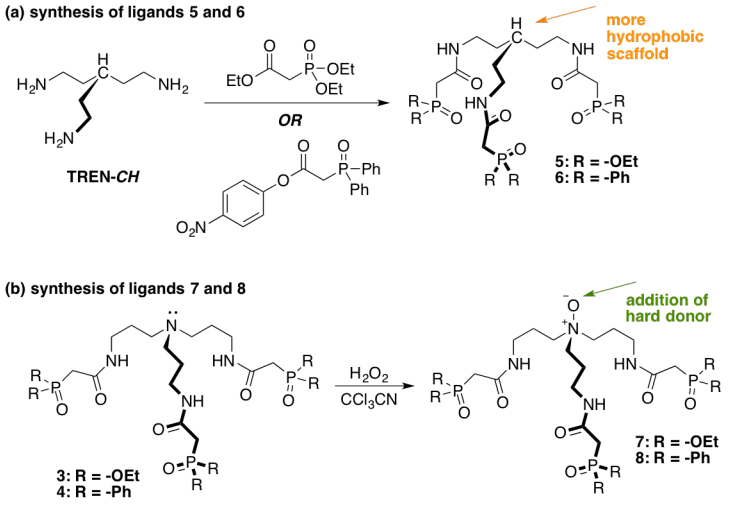

Figure 2. Proposed synthesis of target compounds **5-8**.

To accomplish the synthesis of compounds **5** and **6**, the starting compound TREN-*CH* will be prepared (Figure 2). The synthetic route to this compound has been published by Barnett,[28] and we will follow his procedure in our laboratory. At the time of proposal submission, undergraduate student Brandon Wackerle has made significant progress toward the synthesis of TREN-*CH*. Once this molecule is in hand, we will follow well-trodden paths that have been developed in our laboratory[27, 29] and others[30, 31] to synthesize compounds **5** and **6**.

For the synthesis of compounds **7** and **8**, we will begin with compounds **3** and **4** that have already been prepared by undergraduate student Michael Hudson in my research group. He will oxidize the central amine nitrogen of these compounds to a *N*-oxide using hydrogen peroxide and trichloroacetonitrile[32] to give the target compounds **7** and **8**.

Objective 2: Determination of extraction efficiencies of compounds **5-8**. Once the target compounds have been prepared, we will determine their ability to extract lanthanide and actinide metals out of acidic water. The Biros research group has carried out this experiment for many years[27, 29] and all of the necessary equipment, glassware and reagents are on hand. To do this analysis, we will prepare solutions of each metal in acidic water, along with solutions of each target compound in an organic solvent (e.g. methylene chloride). The solutions will be mixed at room temperature for twenty hours, and the amount of lanthanide or actinide extracted will be determined by the established Arsenazo Assay.[33, 34] Each extraction experiment will be performed in quadruplicate. These data will allow us to calculate an extraction efficiency for each target compound for each of the 16 metals listed in Table 1.

All personnel listed in this proposal have completed both laboratory safety and radioactive training (for the use of uranium and thorium) through Jim Seuffert's office in CLAS.

Timeline

Nov 2017: Brandon - synthesis of TREN-*CH*; Michael - synthesis of **7**

Dec 2017: Brandon - synthesis of TREN-*CH*; Michael - synthesis of **8**

Jan 2018: Brandon - synthesis of **5**; Michael - extraction studies with **7**

Feb 2018: Brandon - synthesis of **6**; Michael - extraction studies with **7**

Mar 2018: Brandon - extraction studies with **5**; Michael - extraction studies with **7**

- Brandon and Michael will present preliminary results from this project at the National Meeting of the American Chemical Society in New Orleans.
- PI Biros will give two invited, external seminars on this work at Wayne State University and Oakland University.

Apr 2018: Brandon - extraction studies with **5**; Michael - extraction studies with **7**

May - Sep 2018: Biros – extraction studies with **5** and **6**

Oct 2018: Biros –submit CSCE final report

Outcome

At the completion of the project I expect to have accomplished the synthesis of the four target compounds **5-8**, as well as completed the extraction studies for these compounds. To complete this story for publication in a high tier peer-reviewed journal, it will need to be combined with other experiments that will be carried out by PI Biros or other students in my research group. Together, this data will merit publication in a journal such as *Inorganica Chimica Acta* or *Dalton Transactions*. Thus, the "final product" of the proposed research will be at least one peer-reviewed publication, in addition to the poster and oral presentations my group will deliver at external venues.

Collaborations This research project has no external collaborators.

Section V. Future Plans

A selection of my previous scholarly efforts are summarized in Figure 1 and Table 1 of this proposal – the synthesis of compounds **1-4** along with the determination of the extraction efficiencies. The target molecules **5-8** of this proposal represent the beginning of the next generation of work for my research group. Our long-term goal has always been to learn about the structural requirements of organic compounds like those described here for the selective binding and extraction of lanthanide and actinide metals. With this knowledge we hope to build a library of organic compounds with demonstrated selectivity for one lanthanide or actinide metal. We also hope that the information we learn about structural requirements for lanthanide and actinide extraction will help other researchers develop systems for a variety of applications.

The results from the work described here will be included in a proposal to the National Science Foundation for renewal of our dispersed REU site (expected submission date, Aug 2018). I am also planning to seek funding through the National Science Foundation's RUI program, as well as through the US Department of Energy's Office of Basic Science Separations program. By having two generations of ligands prepared by my research group, along with the extraction efficiency results, this will strengthen my argument for funding and hopefully result in successful external proposals.

I am scheduled for research sabbatical during the 2021-22 academic year, during which time I plan to work for a lanthanide coordination chemist to learn more about this area of research. Again, having results from two generations of ligands from my research group will help me secure a sabbatical position with a prominent chemist in this discipline.

Section VI: Reference Cited

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GRAND VALLEY STATE UNIVERSITY
CENTER FOR SCHOLARLY AND CREATIVE EXCELLENCE

Applicant Information

Name: Department:

Title of Proposed Project:

Reference Information:

Name: Title:

This form provides the letter of support content suggested for the above-mentioned individual for the Faculty Research Support Program administered by the Center for Scholarly and Creative Excellence. It is expected that the applicant will supply you with information about his or her proposal. The review panel is particularly interested in your comments regarding:

a) The applicant's general scholarly competence, recent performance, and promise of distinction in his or her field of interest;
b) The value of the project in relation to scholarship in the field, outline the impact and significance;
c) The applicant's ability to complete the described project successfully in the time schedule and the budget presented;
d) Discuss the potential for external funding;
e) How does this research fit the near-term goals of the department? In case of junior faculty what effect will this have on his or her career? In case of senior faculty, is the faculty member fully engaged in scholarly activities of the department?

Recommendations should also address the originality of the project and the quality and concept of the plan. Evaluations, where possible, should compare this researcher not only with individuals in the same field and rank at Grand Valley State University. How does this proposal compare to others from the department. Please craft your letter on the next page and save this document as “applicant’s lastname_reference”
Letters should be returned electronically to the applicant for uploading.

GRAND VALLEY STATE UNIVERSITY
DEPARTMENT OF CHEMISTRY

September 28, 2017

Faculty Research Support Program Review Committee
Center for Scholarly and Creative Excellence
GVSU

Dear Committee Members,

I want to offer strong departmental support for Shannon Biros's application for a CSCE Catalyst Grant for Research and Creativity. This work will continue the progress of her already robust research program in the area of lanthanide and actinide coordination chemistry. This proposal requests salary for two student researchers to carry out work in her laboratory.

Shannon's general scholarly competence As shown in Shannon's CV, she has published 14 peer-reviewed journal articles in the past three years and currently has one manuscript under review. It should be noted that the majority of these publications have undergraduate co-authors. She has presented seminars on her research program at a variety of universities (she has two such seminars scheduled for March of 2018) as well as in symposia at national conferences. She has a demonstrated track record of productivity in this field and I am confident she will accomplish the objectives outlined in this proposal.

Value of the project in relation to scholarship in the field Shannon proposes to develop a new generation of organic compounds ("ligands") that will stick to lanthanide and actinide ions. Lanthanides and actinides are heavy metals from the bottom of the periodic table. Nuclear waste processing and several other technologies involving lanthanides and actinides depend on chemical processes that can separate mixtures of these metals. Since the 1920s this has been recognized as a difficult problem, because all of these metals have similar chemical behavior. One approach is to use organic molecules that will stick to some of the metals but not others; once an ion has a ligand stuck to it, its chemical properties are quite different from the other ions, and separating it from a mixture is easy.

This basic procedure is already in use in nuclear waste processing plants, recycling facilities, and businesses that purify these metals from ground ores. However, the ligands that are being used are not particularly selective; they will stick to lots of diferent metal ions. The key idea in Shannon's work is that it should be possible to

design a set of different ligands that are sensitive to subtle differences among ions; a particular ligand might stick to ions within a small range of sizes, for example. Constructing a "toolbox" of different ligands, each of which will stick to one or a few elements but not to others, requires skillful design and synthesis. She has been leading a successful project of this sort already and is well qualified to carry it to the larger scale described in the proposal.

Shannon's ability to complete the project successfully Shannon's track record of productivity with her research program is strong evidence for her ability to complete the work proposed here. Shannon has funds to support all supplies and chemicals needed for this work through her NSF-REU grant, and the student researchers have secured funds for the chemicals specific to their parts of the proposal through the OURS Student Supplies Program. The resource that is most valuable to her is student coworkers who have experience running the types of experiments described in this proposal. Since both Michael Hudson and Brandon Wackerle have worked with Shannon for the past two years on related projects in her group, they are trained in both the organic synthesis skills needed to prepare the molecules described in this proposal as well as the analytical techniques needed to measure the extraction efficiencies of each new ligand. Michael and Brandon are planning to graduate in December of 2017, and then work as adjunct faculty in our department teaching undergraduate laboratory sections. This represents a unique opportunity for Shannon to hire these experienced researchers for the Winter 2018 semester when they can work to forward the goals of her research program. They will require little direct supervision from Shannon, but she will of course work with them in the laboratory to trouble shoot problems as they arise or to offer advice when needed.

Potential for external funding Shannon's research program is currently supported by the National Science Foundation as part of a "distributed REU" award (CHE REU-1559886), and she recently received funding from the NASA Michigan Space Grant Consortium. She also led the group that was recently awarded a $290,000 grant from the National Science Foundation (CHE MRI-1725699) to purchase a new NMR spectrometer for our department. She clearly has the skills and experience to obtain substantial external funding. The results of the work described here will help to strengthen future proposals to external agencies for additional funding opportunities.

This research fits into the near-term goals of the department: Shannon's research program is doing everything we hope to accomplish in the chemistry department at GVSU. She incorporates undergraduate students into the high-impact practice of un-

dergraduate research, she disseminates her work often to the chemistry community, and she secures external funding to support her research program. Her success and generosity have spilled over into several other research groups in our department, raising its overall scholarly productivity and benefit to students.

Our department strongly supports her application for a CSCE Catalyst Grant.

Sincerely,

G. C. McBane

George C. McBane
Professor and Chair
Department of Chemistry

Shannon M. Biros, Ph.D.

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Grand Valley State University
Department of Chemistry
1 Campus Drive
Allendale, MI 49401

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Professional Experience

2014 – present **Associate Professor, Department of Chemistry**
Grand Valley State University, Allendale, MI

2008 – 2014 **Assistant Professor, Department of Chemistry**
Grand Valley State University, Allendale, MI

2007 - 2008 **Visiting Professor, Department of Chemistry**
Grand Valley State University, Allendale, MI

Education

2006 - 2007 **University of California, Berkeley**, Berkeley, CA
Advisor: Professor Kenneth N. Raymond
Postdoctoral Research Associate

2001 - 2006 **The Scripps Research Institute (TSRI)**, La Jolla, CA
Advisor: Professor Julius Rebek, Jr.
Ph.D. in Chemistry
"Molecular Recognition in Water: I. Design and Synthesis of α-Helix Peptidomimetics II. Binding Properties of a Deep, Water-soluble Cavitand"

1996 - 2001 **Grand Valley State University (GVSU)**, Allendale, MI
BA, Chemistry with a minor in Spanish, 2001
BS, Biomedical Sciences, 2001

Teaching Experience (at GVSU, since August 2007)

Course Number	Course Description	Student Level	Student major	Student career goals
115, 116	General Chemistry I and II	Freshman	BIO, BMS, CMB, CHM, PHY, ENG, Education	diverse
230	Introduction to Organic and Biochemistry	Freshman	Nursing	Nursing
241, 242	Organic Chemistry for the Life Sciences I and II	Sophomore	BIO, BMS, CMB, Education	Bachelor's level scientist, PA, MD, PhD, PharmD, Dental, secondary education
245, 247 (246, 248)	Principles of Organic Chemistry I and II (associated laboratory courses)	Sophomore	CHM	Bachelor's level chemist, PhD, MD, secondary education
344	Qualitative Organic Analysis	Junior/Senior	CHM	Bachelor's level chemist, PhD
441	Advanced Organic Chemistry	Junior/Senior	CHM	Bachelor's level chemist, PhD

Chapters in Books

Shannon M. Biros and Fraser Hof. "**Supramolecular Chemistry in Drug Design**" in *Supramolecular Chemistry: From Molecules to Nanomaterials*; Philip A. Gale and Jonathan W. Steed, Eds.; John Wiley & Sons, Ltd: Southern Gate, Chichester, **2012**, p 1909-1928.

Pablo Ballester and Shannon M. Biros. "**CH-pi and pi-pi Interactions as Contributors to the Guest Binding in Reversible Inclusion and Encapsulation Complexes**" in *The Importance of Pi-Interactions in Crystal Engineering (Frontiers in Crystal Engineering 3)* Edward Tiekink and Julio Zukerman-Schpector, Eds.; John Wiley & Sons; **2012**, p 79-105.

Journal Articles

Erin G. Leach,* Justin R. Shady,* Adam C. Boyden,* Anne-lise Emig,* Alyssa T. Henry,* Emily K. Connor,* Richard J. Staples, Stephanie Schaertel, Eric J. Werner, Shannon M. Biros. "**X-ray crystallographic, luminescence and NMR studies of phenacyldiphenylphosphine oxide with the Ln(III) ions Sm, Eu, Gd, Tb and Dy**" *Dalton Trans.*, **2017**, *under review*.

Jia Li, Monika A. Molenda, Shannon M. Biros, Richard J. Staples, Ferman A. Chavez. "**Assembly of a mononuclear ferrous site using a bulky aldehyde-imidazole ligand**" *Inorg. Chim. Acta*, **2017**, *464*, 152-256. *doi: 10.1016/j.ica.2017.05.028*.

Katherine M. Coburn,* David A. Hardy,* Michael G. Patterson,* Shelby N. McGraw,* Michael T. Peruzzi,* Felix Boucher,* Bethany Beelen,* Hope T. Sartain,* Thomas Neils, Christopher L. Lawrence, Richard J. Staples, Eric J. Werner, Shannon M. Biros. "***f*-Element coordination and extraction selectivity using a multipodal carbamoylmethylphosphine oxide ligand on a tridentate phosphoryl scaffold**" *Inorg. Chim. Acta* **2016**, *449*, 96-106*; doi: 10.106/j.ica.2016.05.003.*

Sean Riley,* Richard J. Staples, Shannon M. Biros, Felix N. Ngassa. "**Crystal structure of phenyl 2,4,5-trichlorobenzenesulfonate**" *Acta Cryst.* **2016**, E**72**, 789-792. *doi:10.1107/S2056989016007325.*

Evan P. Beaumier,* Brennan S. Billow, Amrendra K. Singh, Shannon M. Biros, Aaron L. Odom. "**A Complex with Nitrogen Single, Double and Triple Bonds to the Same Chromium Atom: Synthesis, Structure and Reactivity**" *Chem. Sci.* **2016**, 7, 2532-2536; *doi: 10.1039/C5SC04608D, Edge Article.*

Paul T. Morse,* Richard J. Staples, Shannon M. Biros. "**Th(IV) complexes with cis-ethylenebis(diphenylphosphine oxide): X-ray structures and NMR solution studies**" *Polyhedron – Special Issue on Undergraduate Research*, **2016**, *114*, 2-12*; doi: 10.1016/j.poly.2015.05.016*.

Felix N. Ngassa, Shannon M. Biros, Richard J. Staples. "**Crystal structure of *N*-[(1*S*,2*S*)-2-aminocyclohexyl]-2,4,6-trimethylbenzenesulfonamide**" *Acta Cryst.* **2015**, E**71**, 1521-1524.

Tyler A. Cooley,* Sean Riley,* Shannon M. Biros, Richard J. Staples, Felix N. Ngassa. "**Crystal structure of 2,4-dinitrophenyl 4-methylbenzene sulfonate: A new polymorph**" *Acta Cryst.* **2015**, E**71**, 1085-1088.

Tsvetelina P. Atanasova,* Sean Riley,* Shannon M. Biros, Richard J. Staples, Felix N. Ngassa. "**Crystal structure of 3,5-dimethylphenyl 2-nitrobenzenesulfonate**" *Acta Cryst.* **2015**, E**71**, 1045-1047.

Alyssa A. Kulesza,* Richard J. Staples, Shannon M. Biros. "**Crystal structure of bis(3,3-dimethyl-2-oxobutyl)diphenyl phosphonium bromide chloroform solvate (1/1)**" *Acta Cryst.* **2015**, E**71**, o339-o340.

Erin G. Leach,* Alyssa A. Kulesza,* Richard J. Staples, Shannon M. Biros. "**Crystal structures of 1-(4-chlorophenyl)-2-(diphenylphosphoryl)ethan-1-one and 1-(diphenylphosphoryl)-3,3-dimethylbutan-2-one**" *Acta Cryst*. **2015**, **E**71, 523-527.

Hope T. Sartain,* Shelby N. McGraw,* Christopher Lawrence, Eric J. Werner, Shannon M. Biros. "**A Novel Tripodal CMPO Ligand: Affinity for *f*-Elements, Computational Investigations and Luminescence Properties**" *Inorg. Chim. Acta* **2015**, *426*, 126-135.

Hope T. Sartain,* Richard J. Staples, Shannon M. Biros. "**Crystal structure of pentakis (ethylenediamine-[kappa]2*N*,*N*')lanthanum(III) trichloride-ethylenediamine (1/1) dichloromethane solvate**" *Acta Cryst.* **2014**, **E***70*, 424-426.

Nathan H. Murray,* Shannon M. Biros, Robert L. LaDuca. "**Crystal structure of [propane-1,3-diyldbis(piperidine-4,1-diyl)]bis[(pyridin-4-yl)methanone]-isophthalic acid (1/1)**" *Acta Cryst.* **2014**, **E***70*, 298-300.

Julie A. Stoscup,* Richard J. Staples, Shannon M. Biros. "**Crystal Structure of a Samarium(III) nitrate Chain Cross-linked by a bis-Carbamoylmethylphosphine oxide ligand**", *Acta Cryst* **2014**, **E70**, 188-191.

Laurie A. Witucki, William R. Winchester, Shannon M. Biros. "**Investigation of ^{1}H NMR Chemical Shift in Various Systems: A Set of Advanced 1D ^{1}H NMR Undergraduate Laboratory Projects**", *Chemical Educator*, **2014**, *19*, 471-476.

Courtney J. Hastings, Michael D. Pluth, Shannon M. Biros, Robert G. Bergman and Kenneth N. Raymond. "**Simultaneously Bound Guests and Chiral Recognition: A Chiral Self-Assembled Supramolecular Host Encapsulates Hydrophobic Guests**", *Tetrahedron* **2008**, *64*, 8362-8367.

Shannon M. Biros, Robert M. Yeh and Kenneth N. Raymond. "**Design and Formation of a Large, Tetrahedral M_4L_6 Supramolecular Cluster using 1,1'-Binaphthyl Ligands**", *Angew. Chem. Int. Ed.* **2008**, *47*, 6062-6064.

Shannon M. Biros, Robert G. Bergman and Kenneth N. Raymond. "**The Hydrophobic Effect Drives the Recognition of Hydrocarbons by an Anionic Metal-Ligand Cluster**", *J. Am. Chem. Soc.*, **2007**, *129*, 12094-12095.

Lionel Moisan, Trevor J. Dale, Naran Gombosuren, Shannon M. Biros, Enrique Mann, Jun-Li Hou, Fernando P. Crisostomo and Julius Rebek, Jr. **"Facile Synthesis of Pyridazine-Based α-Helix Mimetics"**, *Heterocycles*, **2007**, *73*, 661-671.

Shannon M. Biros, Lionel Moisan, Enrique Mann, Alexandre Carella, Dayong Zhai, John C. Reed and Julius Rebek, Jr. **"Heterocyclic α-Helix Mimetics for Targeting Protein-Protein Interactions"**, *Bioorg. Med. Chem. Lett.*, **2007**, *17*, 4641-4645.

Shannon M. Biros and Julius Rebek, Jr. "**Water-soluble Cavitands and Capsules**", *Chem. Soc. Rev.*, **2007**, *36*, 93-104.

Richard J. Hooley, Shannon M. Biros and Julius Rebek, Jr. "**The Use of a Deep, Water-Soluble Cavitand as a Phase-Transfer Catalyst**", *Angew. Chem. Int. Ed.* **2006**, *45*, 3517-3519.

Alasdair M. Barr, Jefferson W. Kinney, Matthew N. Hill, Xiaoying Lu, Shannon M. Biros, Julius Rebek, Jr., Tamas Bartfai. "**A Novel, Systemically Active, Selective Galanin Receptor Type-3 Ligand Exhibits Antidepressant-like Activity in Preclinical Tests**", *Neurosci. Lett.*, **2006**, *405*, 111-115.

Richard J. Hooley, Shannon M. Biros and Julius Rebek, Jr. "**Normal Hydrocarbons Tumble Rapidly in a Deep, Water-Soluble Cavitand**", *Chem. Commun.* **2005**, 509-510.

Clemens H. Haas, Shannon M. Biros and Julius Rebek, Jr. "**Binding Properties of Cavitands in Aqueous Solution – The Effect of Charge on Guest Selectivity**", *Chem. Commun.* **2005**, 6044-6045.

Shannon M. Biros, Elke C. Ullrich, Fraser Hof, Laurent Trembleau, and Julius Rebek, Jr. "**Kinetically Stable Complexes in Water: The Role of Hydration and Hydrophobicity**", *J. Am. Chem. Soc*. **2004**, *126*, 2870-2876.

Shannon M. Biros,* Brian M. Bridgewater, Adriel Villeges-Estrada, Joseph Tanski, Gerard Parkin. "**Antimony Ethylene Glycolate and Catecholate Compounds: Structural Characterization of Polyesterification Catalysts**", *Inorg. Chem.*, **2002**, *41*, 4051-4057.

Patents

Julius Rebek, Jr.; Shannon M. Biros; Lionel Moisan; Severin Odermatt. "**Oxazole-Pyrrole-Piperazine Alpha-Helix Mimetic**" U.S. Patent Appl. Publ., **2009**, No. 12/362,934.

Julius Rebek, Jr., Shannon M. Biros, Lionel Moisan, Alessandro Volonterio, Enrique Mann and Trevor Dale. "**Pyridazine Based Alpha-Helix Mimetics**" International Patent Appl. Publ., **2008**, PCT/US2008/009730.

Julius Rebek, Jr., Shannon M. Biros, Lionel Moisan, Alessandro Volonterio, Enrique Mann and Trevor Dale. "**Pyridazine Based Alpha-Helix Mimetics**" US Patent Appl. No. 12/228,559, filed Aug. 13, 2008., **2008**, PCT/US2008/009730.

Julius Rebek, Jr. Shannon M. Biros, Lionel Moisan. "**UPP Amphiphilic α-Helix Mimetics**" International Patent Appl. Publ., **2008**, PCT/US2008/009417.

Julius Rebek, Jr., Shen Gu and Shannon M. Biros. "**Functionalized Pyridazine Derivatives as Novel Scaffolds for β-helix Mimicry, and their Preparation and Pharmaceutical Composition**" US Patent Appl. Publ., **2006**, US 2006205728.

Shen Gu, Shannon M. Biros and Julius Rebek, Jr. "**Novel Scaffolds for α-helix Mimicry**", US Patent Application Number 60/660,939, filed Mar. 03, **2006**.

Presentations denotes presenter

"*Tripodal CMPO Ln and An Extraction Agents*" Eric J. Werner and Shannon M. Biros. 254th National Meeting of the American Chemical Society, INOR, Washington, DC, Aug 19-24, 2017, *oral presentation*.

"*TIM Consortium: A dispersed REU site in theoretically interesting molecules"* K.C. Russell, Jeffrey L. Katz, Peter M. Iovine, Kristine A. Nolin, Joan Schellinger, Ellen J. Yezierski, Shannon M. Biros. 254th National Meeting of the American Chemical Society, CHED, Washington, DC, Aug 19-24, 2017, *poster*.

"*Nuclear Waste Remediation: Engaging Undergraduate Students in Research*" Shannon M. Biros. Keynote Address: 2016 College of Natural Health and Sciences Undergraduate Research Symposium, The University of Tampa, April 22, 2016; *oral presentation.*

"*Lanthanide and actinde coordination chemistry with multidentate CMPO compounds*" Shannon M. Biros. Organic Chemistry Research at Primarily Undergraduate Institutions, Joint Great Lakes/Central Regional Meeting, May 28, 2015; *oral presentation*.

"*From Grand Haven, MI (USA) to Tarragona (Spain)*" Shannon M. Biros. Bojos per la Química (Crazy about Chemistry), Institut Catala d'Investigacio Quimica (ICIQ), Tarragona, Spain, February 21, 2015; *oral presentation*.

"*Chelation of rare earth elements with carbamoylmethylphosphine oxides*" Shannon M. Biros. Ballester/van Leeuwen Group Meeting, Institut Catala d'Investigacio Quimica (ICIQ), Tarragona, Spain, January 22, 2015; *oral presentation*.

"*Chelation of rare earth elements with carbamoylmethylphosphine oxides: Applications in nuclear waste remediation and lanthanide luminescence*" Shannon M. Biros. Inorganic Chemistry Seminar, Michigan State University, East Lansing, MI, November 10, 2014; *oral presentation*.

"*Chelation of rare earth elements with carbmoylmethyl phosphine oxides: Applications in nuclear waste remediation"* Shannon M. Biros. Natural Sciences Seminar, New College, Sarasota, FL, November 7, 2014; *oral presentation*.

"*Selective Recognition of f-elements: Applications in Nuclear Waste Remediation*" Shannon M. Biros. Chemistry and Biochemistry Departmental Seminar Series, Andrews University, Berrien Springs, MI, October 23, 2014; *oral presentation*.

"*NSF WIDER (EAGER) Program: GVSU Inventory of Instructional Practices*" Shannon M. Biros, Shaily Menon, Robert Talbert, Scott Grissom. Biennial Conference on Chemical Education, P240, Allendale, MI, August 4, 2014; *oral presentation*.

"*Preparing students from PUIs for graduate school: One step at a time*" Shannon M. Biros. Biennial Conference on Chemical Education, P70, Allendale, MI, August 3, 2014; *oral presentation*.

"*Sensitizing Lanthanide Luminescence with CMPOs*" Shannon M. Biros. 247th ACS National Meeting and Exposition, INOR, Dallas, TX. March 16-20, 2014; *oral presentation*.

"*Multidentate carbamoylmethyl phosphine oxides (CMPOs) as chelating agents for lanthanides and actinides*", LaNora L. Herrema,* Adam C. Boyden,* Shannon M. Biros, Eric J. Werner**.** 245th ACS National Meeting and Exposition, American Chemical Society, CHED, New Orleans, LA, April 2013; *poster presentation*.

"*Molecular recognition of f-elements*", Shannon M. Biros. Hope College - Departmental Seminar, Department of Chemistry, Hope College, Holland, MI, March 1, 2013; *oral presentation*.

"*Molecular recognition of f-elements*", Shannon M. Biros. University of Tampa - Departmental Seminar, Department of Chemistry and Physics, The University of Tampa, Tampa, FL, October 12, 2012; *oral presentation*.

"*Carbamoylmethyl Phosphine Oxides as Chelating Agents*", Shannon M. Biros, Eric J. Werner. 243rd ACS National Meeting and Exposition, ORGN, American Chemical Society, San Diego, CA, March 26, 2012; *oral presentation*.

"Formation and Studies of Kinetically Stable Complexes in Water." Shannon M. Biros, Clemens H. Haas, Richard J. Hooley and Julius Rebek, Jr. Pacifichem 2005, Honolulu, Hawaii, December 15-20, 2005; *oral presentation*.

"Synthesis of Alpha-helix Proteomimetics based on Inverse Electron Demand Diels-Alder chemistry." Shannon M. Biros, Shen Gu, Lenz Kroeck and Julius Rebek, Jr.
229 National ACS Meeting, ORGN, San Diego, California, March 13–17, 2005; *poster*.

"Formation of Thermodynamically and Kinetically Stable Complexes in Water with a Tetraanionic Host." Shannon. M. Biros, Fraser Hof, Elke C. Ullrich, Laurent Trembleau and Julius Rebek, Jr. International Conference on Supramolecular Science and Technology, Institute of Chemical Technology, Prague, Czech Republic, September 5-9, 2004; *poster*.

"Investigations into Host-Guest Exchange Processes using Fluorescence Resonance Energy Transfer." Shannon M. Biros, Liam C. Palmer, Shirley Lin, Julius Rebek, Jr. 227th National ACS Meeting, ORGN, Anaheim, California, March 28 – April 1, 2004; *poster*.

"Kinetically Stable Host-Guest Complexes in Water." Shannon M. Biros, Elke C. Ullrich, Fraser Hof, Laurent Trembleau and Julius Rebek, Jr. Gordon Research Conference, Chemistry of Supramolecules and Assemblies; Proctor Academy, Andover NH; July 6-11, 2003; *poster*.

"The Activity of Antimony Compounds in Polyesterification Reactions." Shannon M. Biros,* Gerard Parkin and Brian Bridgewater. Research Experience for Undergraduates, Summer Seminar, Columbia University, New York, NY; August 4, 2000; *oral presentation*.

"Synthesis of Antimicrobial Derivatives of Psicofuranine" Shannon M. Biros,* Robert Smart, William Schroeder. National Conference for Undergraduate Research, University of Montana, Missoula, MT; April 26-30, 2000; *poster*.

"Synthesis of Antimicrobial Derivatives of Psicofuranine", Shannon M. Biros,* Robert Smart, William Schroeder. Great Lakes College Chemistry Conference, Michigan State University, East Lansing, MI; April 8, 2000; *poster*.

"Molecular Recognition of Sugars Using Boric Acid Probes", Shannon M. Biros,* Aaron Derdowski,* Robert P. Smart. Great Lakes College Chemistry Conference, Michigan State University, East Lansing, MI; April 17, 1999; *poster*.

Presentations by students

*denotes undergraduate student denotes presenter

"*Exploring New Methodologies for the Treatment of Nuclear Waste using Ligands Containing Soft Donors*" Andrew R. LaDuca,* Thomas Neils, John E. Bender, Shannon M. Biros. National Organic Symposium, UC Davis, CA, June 25-29, 2017, *poster.*

"*Synthesis of Derivatives of the Tripodal TREN-CMPO Ligand to Increase Ln and An Extraction Efficiency*" Brandon G. Wackerle,* Michael Hudson,* John E. Bender, Shannon M. Biros. National Organic Symposium, UC Davis, CA, June 25-29, 2017, *poster.*

"*Synthesis of Tri-substituted Benzene Compounds Used in Nuclear Waste Remediation*" Brandon G. Wackerle,* Shannon M. Biros. GVSU Student Scholars Day, GVSU. April 12, 2017; *poster*.

"*Development of a New Method for the Treatment of Nuclear Waste: Synthesis of Compounds with Soft Donors*" Andrew LaDuca,* John Bender, Shannon M. Biros, Thomas Neils. GVSU Student Scholars Day, GVSU. April 12, 2017; *poster*.

"*Synthesis and Characterization of Bidentate Phosphine Ligands Containing Chalcogenides*" C'arra Miller,* Shannon Biros. GVSU Student Scholars Day, GVSU. April 12, 2017; *poster*.

"*Recycling of Lanthanide and Actinide Metals from Spent Nuclear Fuel*" Michael Hudson,* Hunter Pearson,* Shannon M. Biros. GVSU Student Scholars Day, GVSU. April 12, 2017; *poster*.

"*Design and synthesis of tri-substituted benzene compounds used as extractants in nuclear waste remediation*" Brandon G. Wackerle,* Shannon M. Biros. 253rd ACS National Meeting and Exposition, INOR 974, San Francisco, CA. April 2-6, 2017, *poster*.

"*Development of bidentate ligands containing soft donor atoms for actinide chelation*" C'arra C. Miller,* Shannon M. Biros, John E. Bender. 253rd ACS National Meeting and Exposition, INOR 975, San Francisco, CA. April 2-6, 2017, *poster*.

"*Hyp3Sb for separation of heavy metals*" Erin G. Leach,* Shannon M. Biros, John E. Bender. 253rd ACS National Meeting and Exposition, INOR 976, San Francisco, CA. April 2-6, 2017, *poster* (*also accetped for SciMix*).

"*Synthesis and characterization of (2-methoxyphenyl)diphenylphosphine derivatives for nuclear waste remediation*" Evan Christoffersen,* Shannon M. Biros, John E. Bender. 253rd ACS National Meeting and Exposition, INOR 977, San Francisco, CA. April 2-6, 2017, *poster*.

"*Phosphine ligands for the extraction of f-block elements: Use in nuclear waste remediation*" Anthony R. Spyker,* Shannon M. Biros, John E. Bender. 253rd ACS National Meeting and Exposition, INOR 978, San Francisco, CA. April 2-6, 2017, *poster*.

"*Investigations into the Recovery and Recycling of Pu-238 in Spent Nuclear Fuel to Increase the Sustainability of Nuclear Reactors*" Michael Hudson,* Shannon M. Biros. 2016 NASA MSGC Conference, NASA Michigan Space Grant Consortium, Ann Arbor, MI. October 8, 2016; *poster*.

"*Phosphine Ligand Synthesis: A Tale of Heavy Metals*" Anthony Spyker,* Troy Luster,* Shannon M. Biros, John E. Bender, 36th Reaction Mechanisms Conference, St. Louis, MO. June 27, 2016; *poster*.

"*Synthesis of Bidentate Phosphine Ligands*" C'arra Miller,* Alan Lear,* Shannon M. Biros, John E. Bender, 36th Reaction Mechanisms Conference, St. Louis, MO. June 27, 2016; *poster*.

"The Hyp3X Ligand for use in f-block Metal Extraction from Spent Nuclear Fuel" Erin G. Leach,* Shannon M. Biros, John E. Bender, 36th Reaction Mechanisms Conference, St. Louis, MO. June 27, 2016; *poste*r.

"*Antimony, Bismuth, and Phosphorous Based Compounds for Nuclear Waste Remediation*" Erin G. Leach,* Brandon Wackerle,* Shannon M. Biros, John E. Bender, GVSU Student Scholars Day, GVSU. April 13, 2016; *poster*.

"*Recovery and Recycling of Lanthanides and Actinides in Spent Nuclear Fuel for Sustainment of Nuclear Reactors*" Michael Hudson,* Shannon M. Biros, GVSU Student Scholars Day, GVSU. April 13, 2016; *poster*.

"*Synthesis and Characterization of Diphenyl(2-methoxyphenyl)phosphine Chalcogenides*" Alan Lear,* Evan Christoffersen,* Shannon M. Biros, John E. Bender, GVSU Student Scholars Day, GVSU, April 13, 2016; *poster*.

"*How do dipodal CMPO ligands bind to lanthanides? An experimental and computational study*" Andrew I. VanderWeide,* Shannon M. Biros. West Michigan Regional Undergraduate Science Conference, The Van Andel Institute, Grand Rapids, MI. November 21, 2015; *poster*.

"*Synthesis, Characterization, and Extraction Studies of CMPO Derivatives for f-Element Coordination Chemistry*" Alan R. Lear,* Shannon M. Biros. West Michigan Regional Undergraduate Science Conference, The Van Andel Institute, Grand Rapids, MI. November 21, 2015; *poster*.

"*The Sensitization of Lanthanide Luminescence Through Coordination of Carbamoylmethylphosphine Oxide Ligands*" Erin G. Leach,* Shannon M. Biros. West Michigan Regional Undergraduate Science Conference, The Van Andel Institute, Grand Rapids, MI. November 21, 2015; *poster*.

"*Synthesis and Characterization of cis-1,2-bis(diphenylphosphino)ethylene diselenide for the Selective Extraction of Actinides in Aqueous Media*" Jeremy Cunningham,* Shannon M. Biros. West Michigan Regional Undergraduate Science Conference, The Van Andel Institute, Grand Rapids, MI. November 21, 2015; *poster*.

"*Influence of the aryl carbonyl group in CMPO ligands for the sensitization of lanthanide luminescence*" Erin G. Leach,* Alyssa A. Kulesza,* Shannon M. Biros. 250th ACS National Meeting and Exposition, INOR 200, Boston, MA. August 16-20, 2015, *poster* (*also accepted for Sci-Mix*).

"*Experimental and computational study of lanthanide-CMPO ligand complexes*" Andrew I. VanderWeide,* Richard L. Lord, Shannon M. Biros. 250th ACS National Meeting and Exposition, INOR 201, Boston, MA. August 16-20, 2015, *poster*.

"*Series of rigid, bidentate ligands with varying degrees of hardness for the selective extraction of actinides from aqueous solutions*" Jeremy A. Cunningham,* Shannon M. Biros. 250th ACS National Meeting and Exposition, INOR 202, Boston, MA. August 16-20, 2015, *poster*.

"*Synthesis and characterization of multidentate CMPO ligands for use in the complexation and extraction of f-elements*" Alan R. Lear,* Shannon M. Biros. 250th ACS National Meeting and Exposition, INOR 203, Boston, MA. August 16-20, 2015, *poster*.

"*Modification of Aromatic Groups on Carbamoylmethylphosphine Oxide ligands for Sensitizing Lanthanide Luminescence*" Alyssa A. Kulesza,* Erin G. Leach,* Shannon M. Biros. GVSU Student Scholar's Day, GVSU OURS, Grand Valley State University, Allendale, MI. April 8, 2015; *poster*.

"*Determination of Lanthanide Extraction Efficiencies of Multipodal CMPO Ligands*" Hardy, D. A.,* Patterson, M. G.,* McGraw, S. N.,* Biros, S. M., Werner, E. J. Florida Undergraduate Research Conference 2015, Embry-Riddle Aeronautical University, Daytona Beach, FL, February 28, 2015; *poster*.

"Investigation of the Placement and Modification of Aromatic Groups for Sensitizing Lanthanide Luminescence" Alyssa Kulesza,* Erin Leach,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 15, 2014; *poster*.

"*Synthesis, characterization and extraction studies of CMPO analogs for nuclear waste remediation*" Alan Lear,* Andrew VanderWeide,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 15, 2014; *poster*.

"*The Change in Extraction Efficiency with the Variation of Electron Donor Atoms in Bidentate Ligands*" Jeremy Cunningham,* Brian Rawls,* Paul Morse,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 15, 2014; *poster*.

"*Nuclear waste reprocessing: The use of O- and S-donating ligands for selectivity toward lanthanides and actinides*" Brian Rawls,* Paul T. Morse,* Shannon M. Biros. Midwestern Symposium on Undergraduate Research in Chemistry, Michigan State University, East Lansing, MI. Oct. 11, 2014; *poster*.

"*Investigation of a novel multidentate ligand for extraction of f-elements*" Katherine M. Coburn,* Michael T. Peruzzi,* Shannon M. Biros. Midwestern Symposium on Undergraduate Research in Chemistry, Michigan State University, East Lansing, MI. Oct. 11, 2014; *poster (recipient of Best Inorganic Poster award).*

"*Differences in bridge length of bidentate phosphoryl ligands regarding f-element complexes*" Paul T. Morse,* Shannon M. Biros. 248th ACS National Meeting and Exposition, INOR 301, San Francisco, CA. August 10-14, 2014; *poster*.

"*Investigation of a multidentate carbamoylphosphine oxide compound and its ability to separate lanthanide and actinide metals*" Katherine M. Coburn,* Shannon M. Biros. 248th ACS National Meeting and Exposition, INOR 302, San Francisco, CA. August 10-14, 2014; *poster (also accepted for Sci-Mix).*

"*Separation of lanthanides and actinides with CMPOs*", Bethany Beelen,* Shannon M. Biros. TIM 2014 End-of-Summer Research Meeting, NSF-REU (TIM Consortium), Trinity University, San Antonio, TX, Jul. 26, 2014; *oral presentation*.

"*Synthesis and f-block Metal Extraction of Two CMPO Compounds* ", Andrew VanderWeide,* Shannon M. Biros. TIM 2014 End-of-Summer Research Meeting, NSF-REU (TIM Consortium), Trinity University, San Antonio, TX, Jul. 26, 2014; *oral presentation*.

"*Investigation of lanthanide and actinide metals with a multidentate carbamoylmethylphosphine oxide compound*" Katherine M. Coburn,* Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 9th, 2014; *poster*.

"*Selective control of aromatic placement on CMPO ligands for the fluorescence of lanthanide metals*" Alyssa Kulesza,* Erin Leach,* Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 9th, 2014; *poster*.

"*Characterization of a new CMPO ligand for the sensitization of lanthanide metal luminescence*" Justin Shady,* Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 9th, 2014; *poster*.

"*Developing a further understanding of heavy metal chelation for the improvement of radioactive waste remediation and magnetic resonance imaging*" Julie Stoscup,* Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 9th, 2014; *poster*.

"*Characterization of f-element bindentate phosphoryl complexes*" Paul Morse,* Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 9th, 2014; *poster*.

"*Lanthanide Luminescence with a new Carbamoylmethylphosphine oxide Ligand*" Justin R. Shady,* Adam C. Boyden,* Shannon M. Biros. 247th ACS National Meeting and Exposition, INOR, Dallas, TX. March 16-20, 2014; *poster*.

"*Investigation of Multidentate Carbamoylmethylphosphine oxide Compounds for Lanthanide and Actinide Chelation*" Julie A. Stoscup,* Shannon M. Biros. 247th ACS National Meeting and Exposition, INOR, Dallas, TX. March 16-20, 2014; *poster*.

"*Extraction of Lanthanide and Actinide Metals with Multidentate Carbamoylmethyl Phosphine Oxide Compounds*" Katherine M. Coburn,* Michael T. Peruzzi,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 16, 2013; *poster*.

"*Investigation of Multidentate Carbamoylmethylphosphine Oxide Compounds for Lanthanide and Actinide Chelation*", Julie A. Stoscup,* Shannon M. Biros, West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 16, 2013; *poster*.

"*Modified Bidentate Phosphoryl Compounds for f-Element Complexation*", Benjamin E. Nicholson,* Paul T. Morse,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 16, 2013; *poster*.

"*Synthesis of New Compounds For Sensitizing Lanthanide Luminescence*", Justin R. Shady,* Alyssa A. Kulesza,* Brooke Visser, Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI. Nov. 16, 2013; *poster*.

"*Extraction of Lanthanide and Actinide Metals with Multidentate Carbamoylmethyl Phosphine Oxide Compounds*", Katherine M. Coburn,* Shannon M. Biros. TIM 2013 End-of-Summer Research Meeting, NSF-REU (TIM Consortium), The University of San Diego, San Diego, CA. Jul. 27, 2013; *oral presentation*.

"*Investigation of Multidentate Carbamoylmethylphosphine Oxide Compounds for Lanthanide and Actinide Chelation*", Julie A. Stoscup,* Shannon M. Biros TIM 2013 End-of-Summer Research Meeting, NSF-REU (TIM Consortium), The University of San Diego, San Diego, CA. Jul. 27, 2013; *oral presentation*.

"Investigation of Multidentate Carbamoylmethylphosphine Oxide Compounds for Lanthanide and Actinide Chelation" Julie A. Stoscup,* Katherine M. Coburn,* and Shannon M. Biros. National Organic Symposium, American Chemical Society, University of Washington, Seattle, WA, June 26, 2013; *poster presentation*.

"Synthesis and Spectroscopic Properties of Carbamoylmethyl Phosphine Oxide Derivatives and Boron Difluoride Complexes", Adam C. Boyden,* Donald Klarr,* and Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI, April 10, 2013; *poster presentation*.

"Investigation of Multidentate Carbamoylmethyl Phosphine Oxide Compounds for Lanthanide and Actinide Chelation", Julie A. Stoscup,* Benjamin E. Nicholson,* Michael T. Peruzzi,* Eric J. Werner, Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI April 10, 2013; *poster presentation*.

"*Coordination Exploration, f-element Complexation, Extraction and Synthesis of Novel Multidentate Carbamoylmethylphosphine-Oxide Ligands: With Nuclear Waste Remediation Implications*", Hope T. Sartain,* Christopher Lawrence, Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI, April 10, 2013; *poster presentation.*

"Synthesis of Tripodal CMPO Compounds for Heavy Metal Chelation", Michael T. Peruzzi* and Shannon M. Biros. 245th ACS National Meeting and Exposition, American Chemical Society, CHED, New Orleans, LA, April 2013; *oral presentation*.

"*Synthesis, f-element complexation, Extraction and Computational Exploration of Multidentate Carbamoylmethylphosphine-Oxide Ligands: In Relation to Nuclear Reprocessing*", Hope T. Sartain,* Michael T. Peruzzi,* Christopher Lawrence, Eric J. Werner and Shannon M. Biros. 245th ACS National Meeting and Exposition, American Chemical Society, INOR, New Orleans, LA, April 2013; *poster presentation*. (Also accepted for SciMix)

"*Exploration of multidentate carbamoylmethylphosphine oxide ligands*", Hope T. Sartain,* Mallory Robinson, Shannon M. Biros, Eric J. Werner, Christopher Lawrence. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI, November 17, 2012; *poster presentation*.

"*Investigations Into a lovely world of multi-faceted chelating agents: Potential applications to medical imaging, nuclear remediation, and fluorescence*", LaNora Herrema,* Adam C. Boyden,* Michael T. Peruzzi,* Shannon M. Biros, Eric J. Werner. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI, November 17, 2012; *poster presentation*.

"*Synthesis of Tripodal CMPO Compounds for Heavy Metal Chelation*", Michael T. Peruzzi,* Shannon M. Biros. GVSU S3 Summer Showcase, Office of Undergraduate Research, GVSU, August 1, 2012; *oral presentation*.

"*Exploring the Multi-Faceted Ligand Carbamoylmethylphosphine Oxide, Tripodal Caps and Their Complexes with Lanthanides*", Hope T. Sartain,* Shannon M. Biros. 2012 End-of-Summer NSF-REU TIM Consortium Conference, Macalester College, St. Paul, MN, July 28, 2012; *oral presentation*.

"*Development of Carbamoylmethyl Phosphine Oxides as Chelating Agents*", LaNora Herrema,* Shannon M. Biros. 2012 End-of-Summer NSF-REU TIM Consortium Conference, Macalester College, St. Paul, MN, July 28, 2012; *oral presentation*.

"*Development of Carbamoylmethyl Phosphine Oxide Chelating Agents for Lanthanides and Actinides*", Hope T. Sartain,* Felix Boucher,* Charles F. DeLisle,* Michael T. Peruzzi,* Eric J.Werner, Shannon M. Biros. GVSU Student Scholars Day, GVSU OURS, Grand Valley State University, Allendale, MI, April 11, 2012; *poster presentation*.

"*Development of f-element binding agents using tripodal carbamoylmethyl phosphine oxides*", Michael T. Peruzzi,* Shannon M. Biros. 243rd ACS National Meeting and Exposition, American Chemical Society, CHED, San Diego, CA, March 26, 2012; *poster presentation*.

"*Development of Carbamoylmethyl Phosphine Oxide Chelating Agents for Lanthanides and Actinides*", Charles F. DeLisle,* Michael T. Peruzzi,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI, November 12, 2011; *poster presentation*.

"*Investigation of Carbamoylmethyl Phosphine Gadolinium Chelating Agents*," Michael T. Peruzzi,* Charles F. DeLisle,* Eric J. Werner, Shannon M. Biros. 21st Annual Argonne Symposium for Undergraduates, Argonne National Laboratory, Argonne, IL, October 14, 2011; *oral presentation.*

"*Development of Carbamoylmethyl Phosphine Oxide Chelating Agents for Use in Medical Resonance Imaging*," Charles F. DeLisle,* Michael T. Peruzzi,* Eric J. Werner, Shannon M. Biros. 21st Annual Argonne Symposium for Undergraduates, Argonne National Laboratory, Argonne, IL, October 14, 2011; *oral presentation.*

"*The Development of a Novel Gadolinium Chelating Agent for MRI Contrast Agents Employing Carbamoylmethyl-Phosphine Oxides (CMPOs)*", Kirsten Tissue,* Shannon M. Biros. GVSU S3 Summer Showcase, Office of Undergraduate Research, GVSU, August 4, 2011; *poster presentation*.

"*The Development of a Novel Gadolinium Chelating Agent for MRI Contrast Agents Employing Carbamoylmethyl-Phosphine Oxides (CMPOs)*" Kirsten Tissue,* Felix Boucher,* Charles F. DeLisle,* Biros, Shannon M. Student Scholarship Day, Office of Undergraduate Research, GVSU, April 13, 2011; *poster presentation*.

"*Development of a supramolecular chemistry and molecular recognition laboratory experiment for upper-level chemistry majors*," Lauren Thompson, Stephanie Schaertel, Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, Van Andel Institute, Grand Rapids, MI, October 30, 2010; *poster.*

"Development of MRI Contrast Agents" Felix Boucher,* Kirsten Tissue,* Shannon M. Biros. West Michigan Regional Undergraduate Science Research Conference, " Van Andel Institute, Grand Rapids, MI, October 30, 2010; *poster.*

"Development of Novel Chelating Agents used in MRI's," Felix Boucher* and Shannon M. Biros. Student Scholarship Day, Grand Valley State University, Allendale, MI, April 14, 2010; *poster*.

"Synthesis of Calix[4]furan Derivatives," Alvina Qureshi* and Shannon M. Biros. Student Scholarship Day, Grand Valley State University, Allendale, MI, April 14, 2010; *poster.*

"Synthesis of Calix[4]furan Derivatives," Alvina Qureshi* and Shannon M. Biros. Spring 2010 National Meeting & Exposition, CHED, American Chemical Society, San Francisco, CA, March 21, 2010; *poster.*

"Synthesis of Piperazine-Based α-Helix Peptidomimetics for the Disruption of the HIV-1 Rev-RRE RNA Interaction" Shannon E. Murphy,* Sarah J.Wood,* Shannon M. Biros, Kirk D. Wyatt,* Laurie A. Witucki. Student Scholarship Day 2009, Grand Valley State University, April 8, 2009; *poster*.

"Progress Toward the Synthesis of a Water Soluble Cavitand" Shannon E. Murphy,* Shannon M. Biros. Student Scholarship Day 2008, Grand Valley State University, April 9, 2008; *poster*.

Professional affiliations and service

1999 - present	Member, American Chemical Society (ACS) – Divisions of Organic and Inorganic Chemistry
2010 - present	Member, Council on Undergraduate Research (CUR)

Grant Activities — Internal

2017	Office of Undergraduate Research (GVSU) – OURS Project Supplies Grant "Synthesis of the Phosphine and Silane Derivatives of the TREN Molecular CMPOs for Improving Methods for the Recovery and Recycling of Lanthanide and Actinide Metals in Nuclear Fuel", Michael Hudson (student principal), Shannon M. Biros (faculty mentor). $500, (***funded**, Sep-Dec, 2017).*
2017	Office of Undergraduate Research (GVSU) – OURS Project Supplies Grant "Synthesis of quaternary organic ligands for nuclear waste remediation", Brandon Wackerle (student principal), Shannon M. Biros (faculty mentor). $500, (***funded**, Sep-Dec, 2017).*
2017	Office of Undergraduate Research (GVSU) — Modified Student Summer Scholars (MS3) Program "Development of a new method for the treatment of nuclear waste: Synthesis of compounds with soft donors", Shannon M. Biros (principal), Andrew LaDuca (student co-author). $3000, (***funded**, May-August, 2017*)
2014	Center for Creative and Scholarly Excellence (GVSU) – Research Grant-in-Aid "Development of Tripodal CMPO Ligands for Nuclear Waste Remediation", Shannon M. Biros (principal). $2840, (***funded**, April 2014-March 2015).*
2012	Office of Undergraduate Research (GVSU) — Student Summer Scholars (S3) Program "Synthesis of Tripodal CMPO Compounds for Heavy Metal Chelation", Shannon M. Biros (principal), Michael T. Peruzzi (student co-author). $6000, (***funded**, May-August, 2012*).

2011 Office of Undergraduate Research (GVSU) — Student Summer Scholars (S3) Program
"Development of Novel MRI Contrast Agents", Shannon M. Biros (principal), Kirsten Tissue (student co-author). $6000, ***(funded**, May-August, 2011).*

2008 GVSU National Science Foundation ADVANCE program
"The Development of a Novel Supramolecular Capsule based on Calix[4]pyrroles", Shannon M. Biros. $9964, ***(funded**, Feb – Aug 2009).*

2008 Research and Development (GVSU) — Research Grant-in-aid and Faculty Summer Stipend
"The Development of a Metal-ligand Cluster based on Calix[4]pyrroles", Shannon M. Biros. $7500, ***(funded**, May-July 2009).*

Grant Activities — External

2017 National Science Foundation – Major Research Instrumentation (MRI) Program
"*MRI: Acquisition of a 400 MHz NMR Spectrometer for Research and Training at GVSU, GRCC and Aquinas College"*, Shannon M. Biros (principal), John E. Bender (co-principal), David A. Leonard (co-principal), Felix N. Ngassa (co-principal), Thomas Neils (co-principal), Jonathan Fritz (co-principal). $289,990 (***funded**, Sep 2017-Aug 2020*).

2016 Arnold and Mabel Beckman Foundation – Beckman Scholars Program
"*2017 Beckman Scholars Program - Grand Valley State University*", Khoo, S. K. (Principal), Mendoza, S. (co-Principal), Moore, J. A. (Supporting), Russell, A. (Supporting), Biros, S. (Supporting), Leonard, D. (Supporting), Lord, R. L. (Supporting), Powers, R. (Supporting), Wallar, B. (Supporting), Clifford Hart, D. (Supporting), Thompson, C. L. (Supporting), Biddanda, B. (Supporting), Strychar, K. B. (Supporting). $130,000 (***funded**, Jan 2017-Dec 2019*).

2016 Department of Energy — Basic Energy Sciences Program
"*Development of Multipodal Ligands for Selective f-Element Chelation*", Shannon M. Biros (principal), Eric J. Werner (co-principal), Rebecca J. Abergel (co-principal). $643,200 (not funded, *submitted*: Jan. 15, 2016).

2015 Michigan Space Grant Consortium – Undergraduate Fellowship Program
"*Recovery and Recycling of Spent Nuclear Fuel Pu-238 for Sustainment of Nuclear Reactors Using Extraction Techniques*", Michael Hudson (Principal, student), Shannon M. Biros (faculty sponsor). $2,500 (***funded**, submitted*: Nov. 16, 2015).

2015 National Science Foundation — Research Experience for Undergraduates (REU) Program
"*The TIM Consortium: A Dispersed REU Site in Theoretically Interesting Molecules*", K.C. Russell (Principal), Jeffrey L. Katz (co-principal), Christine Nolan (supporting), Shannon M. Biros (supporting), Peter Iovine (supporting). $350,000 (***funded**, submitted:* Aug. 26, 2015*).*

2015 Arnold and Mabel Beckman Foundation – Beckman Scholars Program
"*2016 Beckman Scholars Program - Grand Valley State University*", Khoo, S. K. (Principal), Moore, J. A. (Supporting), Russell, A. (Supporting), Biros, S. (Supporting), Cook, P. D. (Supporting), Leonard, D. (Supporting), Lord, R. L. (Supporting), Powers, R. (Supporting), Wallar, B. (Supporting), Christians, M. J. (Supporting), Clifford Hart, D. (Supporting), Thomas, D. (Supporting), Thompson, C. L. (Supporting), Biddanda, Bopaiah, B. (Supporting), Strychar, K. B. (Supporting). $130,000 (*not funded, submitted:* June 15, 2015).

2015 American Chemical Society Petroleum Research Fund – Undergraduate New Direction Program
"*Systematic investigations of lanthanide and actinide complexes with phosphoryl, thiophosphoryl, and selenophosphoryl ligands: X-Ray crystallography, NMR and computational calculations*", Shannon M. Biros (Principal). $75,000 (*not funded; submitted*: Mar. 11, 2015).

2014 National Science Foundation — Research Experience for Undergraduates (REU) Program
"*The TIM Consortium: A Dispersed REU Site in Theoretically Interesting Molecules*", K.C. Russell (Principal), Jeffrey L. Katz (co-principal), Christine Nolan (supporting), Shannon M. Biros (supporting), Peter Iovine (supporting). $330,000 (*not funded; submitted:* Aug. 26, 2014*).*

2013 National Science Foundation – Research at Undergraduate Institutions Program (RUI)
"Collaborative Research: RUI: Separation of Lanthanides and Actinides with Multidentate CMPO Ligands", Eric J. Werner (PI), Shannon M. Biros (Co-PI). $155,699, (*not funded, submitted*: Nov. 14, 2013).

2013 National Science Foundation – Faculty Early Career Development Program (CAREER)
"CAREER: Tuning Lanthanide Luminescence with Carbamoylmethylphosphine Oxides", Shannon M. Biros (PI). $425,806, (*not funded, submitted*: Jul. 24, 2013).

2013 National Science Foundation – Major Research Instrumentation (MRI) Program
"MRI: Acquisition of a 500 MHz NMR Spectrometer by Grand Valley State University",
R. William Winchester (PI), Shannon M. Biros (Co-PI), Laurie A. Witucki (Co-PI), Felix N. Ngassa (Co-PI), Steven Matchett (Co-PI). $440,000 (*not funded, submitted*: Feb. 19, 2013).

2012 National Science Foundation — STEP Program
"*Grand Valley STEM Scholars Program*", Scott B. Grissom, (PI), Shannon M. Biros, (Co-PI), Shaily Menon, (Co-PI), Peter E. Riemersma, (Co-PI), Laurie A. Witucki, (Co-PI). $1,849,252, (*not funded, resubmitted*: Dec. 5, 2012).

2012 National Science Foundation — Research at Undergraduate Institutions Program (RUI)
"*RUI: Development of Novel CMPO-Ligands for Lanthanide and Actinide Chelation*", Shannon M. Biros (PI), Eric J. Werner (Co-PI). $309,837 (*not funded, submitted:* Oct. 31, 2012).

2012 National Science Foundation — WIDER:EAGER Program
"*GVSU Inventory of Instructional Practices*", Scott B. Grissom (PI, Shaily Menon (co-PI), Robert Talbert (co-PI), Shannon M. Biros (co-PI). $137,893 (***funded**, Sep. 15 2012 – Aug. 31, 2013*).

2011 National Science Foundation — STEP Program
"*Grand Valley STEM Scholars Program*", Scott B. Grissom (PI), Shannon M. Biros (co-PI), Shaily Menon (co-PI), Peter E. Riemersma (co-PI), Laurie A. Witucki (co-PI). $1,975,064 (*not funded).*

2010 National Science Foundation — Research Experience for Undergraduates (REU) Program
"*The TIM Consortium: A Dispersed REU Site in Theoretically Interesting Molecules*", K.C. Russell (Principal), Jeffrey L. Katz (co-principal), Ronald Brisbois (supporting), Shannon M. Biros (supporting), Peter Iovine (supporting), Nancy Mills (supporting). $330,000 *(**funded**, Jan. 1 2012 – Aug. 31 2014).*

2009 Research Corporation — Cottrell College Science Awards
"*Development of Supramolecular Capsules based on Calix[4]furans*", Shannon M. Biros. $45,000. (*not funded).*

2009 Shimadzu Corporation — Equipment Grants for Research
"*Equipment Grants for Research*", James Krikke (principal), Shannon M. Biros (co-principal). $54,500 (***funded** by Shimadzu, but not accepted by GVSU).*

2008 Research Corporation — Cottrell College Science Awards
"*The Development of a Metal-ligand, Self-assembled Capsule as an Artificial Cyclase*", Shannon M. Biros. $44,280 *(not funded).*

2008 American Chemical Society — Petroleum Research Fund
"*Self-Assembled Petroleum Sweetening Agents*", Shannon M. Biros. $50,000 *(not funded).*

Honors and Awards

2016	C&EN Molecule of the Year Award (with Aaron Odom's group at MSU)
2015	GVSU Distinguished Undergraduate Mentoring Award
2013	GVSU Distinguished Early Career Scholar Award
2012	GVSU Pew Teaching Excellence Award
2007	GVSU Department of Chemistry Alumna-in-residence
2004-2006	ARCS Foundation Graduate Fellowship (TSRI)
2002-2006	Skaggs Predoctoral Fellowship (TSRI)
2001	GVSU Outstanding Senior Chemistry Major Award
2000	NSF-REU Fellow, Columbia University, New York, NY (Advisor: Gerard Parkin)
2000	GVSU Outstanding Junior Chemistry Major Award
2000	Republic Bank Scholarship
1999	GVSU Analytical Chemistry Award
1996-2000	Gerber Fund Scholarship
1996	GVSU Award for Excellence