LONG TERM GRANT APPLICATION
Cover Sheet

Amount Requested: $ 3443.20

Project Information

Abourahma, Jehad	
Student Participant (Last, First)	
Zirconium Metal-Organic-Frameworks	
Project Title (10 words or less)	
Burnett, Brandon	brandonburnett@weber.edu
Faculty Mentor Name (last, first	Mail Code
College of science	Chemistry
College (Weber State is the University, NOT college)	Department

This project ___ DOES/_X_ DOES NOT require review by the WSU Institutional Review Board for Human Subjects or the WSU Animal Care and Use Committee.

Student Signature — Date: 11/1/15

Project Mentor Signature — Date Received by Mentor. Must be 10 business days before final deadline: 11/2/15

2503 Campus Mail — -6221 Phone Ext.

Undergraduate Research Committee Representative — Date Received by URC Rep. Must be 5 business days before final deadline: 11-5-15

Faculty Mentor Department Chair — Date: 5 Nov 2015

Please check if attended Research Proposal Workshop:

☑ Date Workshop attended September 16, 2015 at 2:00 pm
(Please fill in the date of attendance)

LONG TERM GRANT APPLICATION
Budget Worksheet

BUDGET ITEM	Department or College Funds	Outside Agency Funds	Personal Funds	Undergrad. Research Funds	GRAND TOTAL
Materials	Glassware, solvents, and other chemicals $350.00			Chemical $1,108.20 Consumables $750 (see appendix)	$2,208.20
Equipment	Infrared spectroscopy, NMR, GC ovens, and XRD			UV-lamp $285.00	$285.00
Research Scholarship (max request $2,500.00)			Hours previously Invested 153 hours @$10/hr. $1,530	$1, 300	$2,830
GRAND TOTAL	$350		$1,530	$3,443.20	$5323.2

NOTES:

- Maximum request not to exceed $3500 and may include a Research Scholarship.
- Equipment and left-over materials purchased with this grant will remain the property of WSU.
- You may not request money for gas purchases for travel. WSU reimburses travel expenses at a set mileage rate only.
- Grant money cannot be used retroactively on previously existing expenses. Requests for reimbursements will be denied. All purchases must be made after receiving funding and clearance from the OUR office.

Project Description

Since the late 1990's and early 2000's Metal-Organic-Frameworks (MOFs) have received a great amount of interest in the fields of material science, nanotechnology, and chemistry, because of their utility in gas storage, molecular sensing, catalysis, and drug delivery. Metal-Organic-Frameworks (MOFs) are unique, because they are a highly porous nano material that can be assembled in a two or three dimensional crystalline structure. MOFs have shown a promise in hydrogen fuel cells for their ability to increase the amount of hydrogen, and other gasses, stored safely within a vessel (Hupp, 2010). There has also been speculation of MOFs being used in the medical and pharmaceutical field to deliver drugs more effectively (Rosi, 2003).

MOFs consist of metal ions chemically bonded to an organic linker. Within this structure the organic linker acts like the wood beams on a house that have just been framed, while the metal ions are akin to the connecting joint where all the wooden beams meet in the house frame. There are many types of MOFs that have been created in the past two decades, all of which use a very similar method of synthesis called a "one pot" synthesis, where the metal ion and organic linker are introduced together in a solvent then heated to a certain temperature. For example MOF-5, one of the well-studied MOFs today, is synthesized in this manner (Yaghi, 1999). However, there is a group of MOFs that are incapable of being synthesized into crystals through the traditional "one pot" method. Providing an alternative synthesis will be our main focus.

The objective of this research is to devise a method that will provide an increase control over the crystallization of the MOF's, using zirconium MOFs as our flagship system. Zirconium MOFs traditionally have poor crystallinity when constructed through

the “one pot” method. (Yaghi, 1999) This will be done by breaking up the “one pot” method into two steps. First we will form “metal clusters”. These metal clusters consist of the organic linkers attached to a metal that does not form a crystalline structure. Once we confirm that we have made the coordination, then we will proceed on attempting to form a crystalline structure through other methods i.e. controlled cooling’s, evaporation, vapor diffusion, liquid/liquid diffusion and sublimation.

Dr. Brandon Burnett, the originator of this project, has studied MOFs throughout his time in the University of Nebraska-Lincoln. Dr. Burnett has also contributed to this body of knowledge through many discoveries and publications (Burnett, 2011). My role will be to take full control and responsibility over this project with the assistance of Dr. Burnett. My main focus will be in creating the synthetic conditions that optimize the connection of our Zirconium metal to a preferred organic linker, establish an appropriate crystallization method, and confirm conjectures through a variety of instrumentation and data collection. Dr. Burnet will be assisting by providing background information on MOFs, instrumentation and lab techniques, as well as the interpretation of data.

For over two years now I’ve had a great amount of experience in a material and chemical testing laboratory. In this laboratory I’ve learned many skills, such as the operation of analytical equipment, proper handling of chemicals, attention to detail, participation in research and development, as well as the collection of pertinent data and the interpretation of data. Throughout my time at Weber I have also completed many Chemistry classes which have given me insight to a variety of operations and chemistry disciplines. The experience I’ve acquired in laboratories together with my Chemistry courses, will promote my success in this project.

The final goal of this project will be to publish in an academic chemistry journal with the intent to contribute to the knowledge and synthesis of MOFs. When we make our crystals and collect our data we plan on presenting our findings to local science workshops, schools and Weber States Undergraduate Research Symposium.

Project Method and Timeline

Since July 2015, Dr. Burnett and I have been working on the Zirconium MOFs project and have accomplished much already that will furnish the success of this project. One of the accomplishments includes the coordination between the organic linker and metal node. In order to confirm our desired coordination, and proceed in our project, more chemicals and materials are needed. Once we acquire the appropriate chemicals we will abide by the following time line and goals:

1. January 2016
    - Duplicate our successful samples with new Zirconyl chloride (metal node) and Stilbenecarboxylic acid (organic linker) to verify reproducibility.
2. February 2016
    - Use bromostilbenecarboxylic acid, Stilbenecarboxylic acid, and styrenecarboxylic acid as the organic linkers while keeping the metal the same (zirconyl chloride). This will show us which organic linker is better.
    - Vary temperature, molar ratio, and solvent of synthesis to increase the overall product yield and control of synthesis.
3. March 2016

- Use bromostilbenecarboxylic acid, Stilbenecarboxylic acid, and styrenecarboxylic acid as the organic linkers while changing the metal (zirconium oxynitrate). This will show us which metal compound will work better.
- Vary temperature, molar ratio, and solvent of synthesis to increase the overall product yield and control of synthesis.

4. April 2016
    - Interpret data to see which metal and organic ligand would yield the most success towards the attempt to crystallization.
5. May 2016 -- July 2016
    - Crystalize samples and confirm with Powder X-Ray Diffraction (XRD). This will show the geometry of our crystals.
    - Confirm metal clusters by nuclear magnetic resonance (NMR) and inductively coupled plasma optical emission spectroscopy (ICP-OES)

Budget explanation

Since July 2015 the chemistry department has accommodated our project through the means of chemicals, materials, research space, and instruments; all of which holds a high monetary value. Without the departments providing's to our project we would not have an organized and furnished path to success. To complete the Zirconium MOFs project we are asking for the $3,443.20 from OUR, where $1,300 will go towards the scholar ship. In order to commit six to nine hours a week on this project, for 30 weeks at $10/hr., I had to drastically cut down on my working hours in another job. The $1300 that I am asking for will help me accommodate the reduced work schedule which is allowing me to provide more time to the project.

LONG TERM GRANT APPLICATION
Faculty Recommendation Form

Student Name (last, first): Abourahma, Jehad

Project Title: Zirconium Metal-Organic Frameworks

Mentor Directions: After carefully reviewing the proposal and assessing both the viability of this project and the qualifications of the student requesting funding, answer the questions found below. Please expand the sections as necessary (**do not attach separate letter**). If the project involves the use of human subjects or protected animals, be sure the student secures IRB or ACUC approval. If the project receives funding, it is your responsibility to work closely with the student, monitor the ongoing progress of the project and budget, and evaluate the project's results. Failure to do so will jeopardize funding for this project and any future projects.

1. How long and in what capacity have you known this student?

I have known Jehad since July 2015 when he began doing research with me. He is also a student of mine in my CHEM 3000 – Quantitative Analysis class this fall.

2. Briefly describe the proposed project. Is this part of a larger research project? Is this part of a course? If so, how is the project apart from the nature and scope of activities normally taken for the course (Please attach a copy of your course syllabus)?

Jehad will be working on making organometallic clusters based on zirconium metal ions attached to specialized organic linkers. The products from this project will be used in a future project to create highly crystalline porous materials which we are interested in for gas storage and catalysis applications. The clusters that Jehad will be making are novel and are have great potential over what is currently found in the literature. His research is independent and not part of any course.

3. Give an assessment of the project's significance to the student's discipline and of the project's educational and/or professional benefit to the student.

Jehad is interested in continuing his education beyond a bachelor's degree and obtaining a doctorate degree in materials science. The research he will be performing aligns directly with his intended goals and will expose him to many different synthetic and analytical tools that will greatly benefit him in graduate school and beyond. Additionally, we plan on presenting and possibly publishing the results from this project. This will give him experience in scientific communication which is increasingly important to future educational and professional endeavors.

4. Comment on the qualifications of the student to successfully complete this project, both in terms of the project's scope and its time frame.

Jehad is an assiduous worker who is very bright. Indeed he is one of the leaders in my CHEM 3000 course. The topics involved for this project are covered in general chemistry (which he has completed), but need supplementation. This supplementation is received from advisement by me. Because of his work ethic, I am very confident that he will be able to complete all of the objectives within the timeframe indicated in his proposal.

5. Comment on the justification and appropriateness of the project budget, including the necessity of a Research Scholarship (if requesting one).

This research project heavily depends on having the correct chemicals and supplies for the reactions. As such, most of the budget is for specific chemicals for our syntheses and consumable lab equipment (like vials, test tubes, etc.). The research will not be able to continue without the purchase of these items. Additionally, $1,300 is requested for a research scholarship. Jehad has already put in hundreds of hours into the project and is planning on putting in many more hours. We have a set schedule for him to do research each week, but often I find him in the lab during off-hours, further working on the project. The amount requested will certainly not make up for all of these hours, but it will help offset costs from working less to do the research. While these funds are desired by me and Jehad, the research will continue regardless of scholarship. Thus, if the project is in trouble of not getting funded at all because of this scholarship, we would be willing to take a reduced scholarship in order to fund the other parts of the project.

6. Describe your role in the project.

I will be advising Jehad by helping him design experiments to create the organometallic clusters, isolate the products, and analyze his data. I will also be providing instruction on instrumentation and synthetic/analytical techniques, and provide him with pertinent background information for his project in the form of current literature and informal discussions.

7. Include anything else that you think will be helpful to the committee in evaluating this application.

I have never quite met a student who has such a thirst for learning and performing research like Jehad. He is a natural. Even if we are not awarded this money, he will still work on the project because he believes in it and is passionate about incorporating research into his undergraduate career. I would love to reward this behavior and character.

This project ____ DOES X DOES NOT require review by the WSU Institutional Review Board for Human Subjects or the WSU Animal Care and Use Committee.

Project Mentor Signature

11/4/15
Date

2503
Campus Mail Code

-6221
Phone Extension

Appendix

Stilbenecarboxylic acid (3 ea.)	$279.30
BromoStilbenecarbocylic acid (6 ea.)	$240.00
Styrene-4-carboxylic acid (1 ea.)	$281.00
Trans-cinnomic acid (1 ea.)	$37.10
Zirconylchloride (1 ea.)	$108.00
Cobalt Thioscyanate (1 ea.)	$39.30
Zirconiumoxynitrate (1 ea.)	$123.50
TLC Plates (2 ea.)	$160.35
Vials/Glassware	$478.83
Pipettes (2 pk.)	$110.82
UV-lamp (1 ea.)	$285.00
Scholarship	$1300
Total	$3,443.20

References

Burnett, B. J. (2011). Stepwise Synthesis of Metal–Organic Frameworks: Replacement of Structural Organic Linkers. *J.A.C.S*.

Hupp, J. T. (2010). Nature Chemistry . *Nature Chemistry* .

Rosi, N. L. (2003). Hydrogen Storage in Microporous Metal-Organic Frameworks. *science* .

Yaghi, O. M. (1999). Design and synthesis of an exceptionally stable and highly porous metal-organic framework. *Nature*.

LONG TERM GRANT APPLICATION
Additional Questions

1. What funding have you received from OUR in the past? Where has your previous project been disseminated?

   I haven't received any form of funding from OUR in the past.

2. Is this project part of a required course? If so, please indicate the support (monetary and in-kind) provided for this project by the academic department.

   This project is not a part of a required course.

3. What additional sources of funding have been solicited? Is your department willing/able to fund any equipment they will be retaining?

   The Chemistry department has contributed through this project through the means of chemicals, materials, and instrumentation. All of the major equipment that will be used in this project already exists within the college. Most of the equipment and materials that will be used are consumed then disposed of.

4. Where do you plan to disseminate the results of this project?

   Once we gather all of our data and results we plan on submitting a publication to one of many scientific journals, mainly a chemistry journal. As well as presenting the results in Weber States Undergraduates Research Symposium.

5. If you are requesting a Research Scholarship, please list all significant time commitments (5+ hours per week) that you expect to maintain over the duration of your project including, for example, class and work schedules.

   I will be maintaining a full time school Schedule as well as working a part-time job.