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Chemistry & Biochemistry Newsletter

Chemistry & Biochemistry

Winter 2013

Chemistry & Biochemistry Newsletter

Department of Chemistry & Biochemistry, South Dakota State University

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The Avera Health and Science Center became the home of the SDSU's Department of Chemistry and Biochemistry on September 9, 2010.

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South Dakota State University

Chemistry & Biochemistry

Winter 2013



Greetings from the Department!

As this issue will tell, we've had a very busy fall, so busy that we've had to push this newsletter back to a winter edition!

We've received approval for a second Ph.D. program in biochemistry (p. 2) that will formalize the biochemistry track that had existed for some years in the chemistry Ph.D. program. The program is a partnership with Sanford Research and Avera Research Institute so has a unique public/private partnership component to it. Our department already has the largest Ph.D. program in the state, and the largest graduate program in a single department; but we are now the only department in the state with two Ph.D. programs. It is a statement of the faculty's belief that research is key to not only meeting national and regional knowledge needs but a strong undergraduate education. We have started admitting students and have eight already enrolled with a full cohort expected for the fall 2014 semester.

Our department is one of the first to sign onto the American Chemical Society's "Green Chemistry Challenge" whose goals are to reduce the use of hazardous substances in the instruction of chemistry and utilize chemical research to minimize their use in industrial processes. Dr. Doug Raynie led this initiative and it's described on p. 4.

Our medical laboratory science program and one of its students, Donald Richards, are featured in a national documentary prepared by the Institute of Higher Education Policy to highlight the need for novel approaches to quality higher education (p. 6). The documentary debuted December 3, 2013 at a national summit in Washington D.C.

The fall 2013 semester welcomed Dr. BreeAnn Brandhagen, Dr. Nicole Grove, and Dr. Michael Dianovsky to our faculty. We also welcome Sarah Purcell who joined the office staff this past fall. Eleven new graduate students joined our program, and we had one of the largest undergraduate classes in recent years. You can read more about them on p. 6.

This newsletter also highlights some of the other many accomplishments of the department's faculty, research staff and graduate students. They are a talented group of scientists whose recognitions reflect the commitment that the department's faculty have to graduate AND undergraduate education, and the commitment of the department's staff to supporting those endeavors.

You can support these activities with your gifts to Department, and on behalf of all of us in the department, I would like to thank all of you who chose to do so. Your support is a critical part of our ability to continue to meet the needs of students, the state and the nation.

You will be receiving this in 2014 so on behalf of everyone here in the Department I wish you a Happy New Year. Stay in touch!

Jim Rice

Ph.D. in Biochemistry Approved for SDSU

The South Dakota Board of Regents recently approved South Dakota State University's request to offer a Ph.D. degree in biochemistry. Since 2005, the university has offered a biochemistry track within its doctoral program in chemistry, but officials say it has been more difficult to recruit students to a chemistry program, who want a biochemistry degree. The new Ph.D. degree should solve that problem and make it easier to recruit both students and faculty.

South Dakota's job growth in the biosciences is outpacing the nation. The state's economic development officials have identified biosciences as a targeted sector for job development and the growing biosciences industry offers a range of new opportunities for graduates.

In South Dakota, the number of bioscience employers has grown 55 percent between 2001 and 2009, with an employment growth rate of 42 percent and the creation of more than 1,000 new jobs. By 2018, a 12 percent increase in new jobs is projected in the South Dakota biosciences industry, with 10 percent of those requiring a doctoral degree.

The new degree program is effective immediately. Since a majority of the biochemistry curriculum is already in place at SDSU, only a few new courses needed to be added. There were eight Ph.D. students in the biochemistry track last spring. University officials expect to attract 11 students, either new to SDSU or from other university programs, into the new degree program in its first year.



Dean Dennis Papini

"The impacts of the new Ph.D. program in biochemistry will be substantial not only to the state, but also to the chemistry and biochemistry department and SDSU," Arts and Sciences dean Dennis Papini said. "As the biochemistry Ph.D. program is advertised, highly qualified graduate students will be recruited into the department, leading to an expansion of research output. Postdoctoral fellows and research scientists with interests in biochemistry will come here for advanced training in bioscience. In the future, new faculty positions may be created to support the expected growth in the department thanks to the new Ph.D. program, which in turn will expand the department's ability to engage undergraduate biochemistry students. Taken together, these impacts of the new Ph.D. program will affect persons from all educational and business sectors within the state, the region and the nation."

Papini said the number of students entering baccalaureate training in biochemistry has grown exponentially since a bachelor's degree in biochemistry started seven years ago.

"With the potential growth that a nationally recognized Ph.D. program in biochemistry will bring, the department will enhance recruitment and engagement of young scientists in training," Papini said. "The two programs will work synergistically to produce highly qualified, workforce ready scientists to support the university, the state and the nation."

Recent Faculty Publications

Jihong Cole-Dai

WAIS Divide Members, T. J. Fudge, E. J. Steig, B. R. Markle, S. W. Schoenemann, Q. Ding, K. C. Taylor, J. R. McConnell, E. J. Brook, T. Sowers, J. W. C. White, R. B. Alley, H. Cheng, G. D. Clow, J. Cole-Dai, H. Conway, K. M. Cuffey, J. S. Edwards, R. L. Edwards, R. Edwards, J. M. Fegyveresi, D. Ferris, J. J. Fitzpatrick, J. Johnson, G. Hargreaves, J. E. Lee, O. J. Maselli, W. Mason, K. C. McGwire, L. E. Mitchell, N. Mortensen, P. Neff, A. J. Orsi, T. J. Popp, A. J. Schauer, J. P. Severinghaus, M. Sigl, M. K. Spencer, B. H. Vaughn, D. E. Voigt, E. D. Waddington, X. Wang, and G. J. Wong (2013), "Onset of deglacial warming in West Antarctica driven by local orbital forcing," *Nature*, 500, 440-444, doi: 10.1038/nature12376.

Cole-Dai, Jihong, David G. Ferris, Alyson L. Lanciki, Joël Savarino, Mark H. Thiemens, and Joseph R. McConnell (2013), "Two likely stratospheric volcanic eruptions in the 1450s C.E. found in a bipolar, subannually dated 800 year ice core record," *Journal of Geophysical Research-Atmospheres*, 118, 7459-7466, doi: 10.1002/jgrd.50587.

Fathi Halaweish

Lucas, K., Salama, K. and Halaweish, F., "Synthesis of Novel Estrone Analogs by Incorporation of Thiophenols via Conjugate Addition to an Enone Side Chain," *Steroids*, 78, 1119-1125, 2013.

Salama, M. Ahmed and Halaweish, F., "Cucurbitacins: Potential Candidates Targeting Mitogen Activated Protein Kinase Pathway for Treatment of Melanoma," *Journal of Enzyme Inhibition and Medicinal Chemistry*, Early Online: 1-6 ISSN: 1475-6366 (print), 1475-6374 (electronic), 2013.

David Karkia, Karl D. Glover, Jeff Faheyb, Fathi T. Halaweishb & Amir M. H. Ibrahimc, A., "Variability and Heritability of Grain Extracts in Spring and Winter Wheat grown in South Dakota." *Journal of Crop Improvement*, 27(5), 547-560, 2013.

More Publications on page 8.

Research Aims to Bring Back Traditional Food

The next time travel plans are being made you might consider taking along some pemmican. What's pemmican you ask? Well, it's a food item invented by American Indians.

The recipe calls for minced dried meat from bison, moose, elk or deer. Fat is mixed in along with the most important ingredient of all: junoberries.

"It's very delicious — it tastes absolutely perfect," says chemistry and biochemistry professor Fathi Halaweish, who is researching the health benefits of pemmican, specifically the medicinal qualities of junoberries.

Pemmican was widely adopted as a high-energy food by Native Americans. It was also consumed by Europeans involved in the fur trade and later by Arctic and Antarctic explorers.

"Native Americans used it as a dry meal," explains Halaweish. "They'd mash up the berries, mix it up with fats and buffalo meat. They dried it in the sun and took it along as a source of food. White settlers used it, too, while crossing the country."

Halaweish, whose training is on the medicinal use of plants, became involved in the research on an invitation from Kerry Hartmann, instructor and head of the science department at Fort Berthold Community College in North Dakota.

Hartmann, who has collaborated with Halaweish on previous projects, wanted to study the health benefits of junoberries because of what he was observing at the Fort Berthold Indian Reservation.

"He noticed the locals were using junoberries as a high source of food and mixing them up to make pemmican," relates Halaweish. "Many people pick the berries from bushes and some of the elders grow them in their backyard. They either mix them up with something or eat as fresh fruit."

Lots about junoberries

With a \$200,000 grant from the U.S. Department of Agriculture, they opened their research in summer 2012 and will conclude the project this summer.

To date, the scientists have learned plenty about junoberries, which are commonly referred to as saskatoons in certain parts of the country.

Similar in color to blueberries, junoberries are more closely related to cherries and plums. Research has shown that junoberries have a higher level of antioxidants compared to wild blueberries, strawberries and raspberries. In addition, they have discovered that junoberries have significantly higher levels of vitamins A and C, protein, calcium and fiber than blueberries.



Fathi Halaweish, professor of chemistry and biochemistry, is researching the medicinal qualities of junoberries and their use in pemmican, a food item invented by American Indians. Here, Halaweish conducts research on junoberries in his lab at SDSU. Research has shown that junoberries have a higher level of antioxidants compared to wild blueberries, strawberries and raspberries.

They also discovered that when junoberries are mixed with meat and fat, the antioxidant level increases even more — and in fact, the antioxidants serve as a meat preserver, which explains why pemmican hardly ever spoiled when used on long trips or stored away during winter.

"Of course, because it's a natural food," remarks Halaweish, "it can be a full meal or just a snack. You have the protein, the fat — the total antioxidant."

Students trained

Halaweish conducted a workshop for students last summer at Fort Berthold Community College that demonstrated how chemistry is used to show the activity of antioxidants in junoberries when used to make pemmican.

The students will continue their research at SDSU this summer. "We want to train them on the techniques that we use here."

The ultimate goal, according to Halaweish, is for the research to lead to something much bigger than lab work.

"If we can show the health benefit of this study, the alternative is huge," he says. "It means it will encourage the community to have healthy foods in their diet."

"It could also be a source of economic development because they could produce it themselves and market it."

SDSU Chemistry Department Goes Green

Chemistry and biochemistry students at SDSU will be trained to use techniques and make choices that are safer for the environment, thanks to a new department initiative.

SDSU is among the first 12 educational institutions in the nation to sign on to the Green Chemistry Commitment. Green chemistry encourages the design of products and processes that minimize the use and generation of hazardous substances, such as making plastics from plant sugars rather than petroleum.

“It’s about trying to find ways to do things that don’t have harmful impacts on the environment and people, that minimize the use of resources or use renewable, recyclable resources,” explained professor Jim Rice, the head of the chemistry and biochemistry department.

The Green Chemistry Commitment is a consortium of universities and industry partners that want to increase the number of green chemists and scientists in the country. It is sponsored by Beyond Benign, a nonprofit organization led by John Warner, who gave the department’s annual Lardy Lecture in February.

“Society is demanding safe materials,” Warner said, “and the next generation of students wants to learn how to make them.”

Warner has caused chemists to rethink how they do things, explained Rice, who gave credit to Doug Raynie, associate professor of chemistry and biochemistry, for spearheading the green chemistry effort at SDSU. “He recognized how our students can benefit and took the lead in getting it initiated.”

“This is the future, where developments in chemistry are headed,” said Raynie. The commitment to green chemistry will better prepare students to work in industry and research.

The faculty has been incorporating techniques into research and the classroom, but the department’s official commitment will result in a more coordinated effort, Raynie explained.

“Signing on to this commitment is an affirmation of what we’ve already been doing,” Rice said. “We can still do exciting, innovative chemistry that meets national and global needs, but we have to start thinking about how to do the research and teach our discipline in a different way to minimize the potentially negative sideeffects.”

Incorporating green chemistry up front is like building an energy-efficient house rather than trying to retrofit an old one, Rice explained. It’s easier and more cost-effective.

A 2011 report from Navigant Research said that the development of safer, nontoxic chemicals and materials will save the industry more than \$65.5 billion by 2020.

The Twelve Principles of Green Chemistry*

Prevention It is better to prevent waste than to treat or clean up waste after it has been created.

Atom Economy Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

Less Hazardous Chemical Synthesis Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

Designing Safer Chemicals Chemical products should be designed to affect their desired function while minimizing their toxicity.

Safer Solvents and Auxiliaries The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

Design for Energy Efficiency Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

Use of Renewable Feedstocks A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

Reduce Derivatives Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

Catalysis Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

Design for Degradation Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

Real-time Analysis for Pollution Prevention Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

Inherently Safer Chemistry for Accident Prevention Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions and fires.

*Anastas, P. T.; Warner, J. C. *Green Chemistry: Theory and Practice*, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press.



New Graduate Students



Boamah

Bott

Jones

Mahnashi

Matthews

Nagel

Ochieng

Ideleye

Opoku-Kusi

Osa-Andrews

David Boamah

I received my undergraduate degree from Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, in 2005. I am currently working on designing a biochemical tool to monitor live cells. I chose SDSU because it has a great environment for graduate studies.

William Bott

I graduated from the University of Virginia's College at Wise in 2005 with a B.S. in chemistry and a minor in physics. In 2012 I received a master's in chemistry from Washington State University, studying the effects of high pressure and temperature on materials. I am a first-year graduate student here at SDSU pursuing a Ph.D. in chemical education.

Aubrey Jones

I am a first-year master's student here at SDSU. I received my undergraduate degree at the University of South Dakota where I majored in chemistry and minored in mathematics. I chose SDSU because it excelled in research areas. My main research interest is the further advancements in photovoltaic devices.

Mater Mahnashi

I am from Saudi Arabia and got my bachelor's degree there from the pharmacy school at King Khalid University, Abha, in 2009. Right now I am working on development of novel estrone analogs targeting hepatocellular carcinoma. I came to SDSU because I am interested in research focusing on drug discovery from natural products using techniques such as molecular modeling approaches for selection of drug candidates and in vitro and in vivo studies for drug discovery.

James Matthews

I was born and raised in Denver and attended Metropolitan State College there, graduating in 2011 with a Bachelor of Science in chemistry with a minor in mathematics. I decided to attend South Dakota State University for its chemistry education program.

Eric Nagel

I am originally from Bismarck, N.D., and graduated from the University of North Dakota in 2013 with a B.S. in chemistry. I came to SDSU to pursue a Ph.D. in chemistry while doing research that is more materials-science based. As such, I have joined Dr. Zhang's group and am working in the area.

Fredrick Ochieng

I am from Yala, Kenya, and hold B.S. degrees in chemistry and physics with a minor in math from Principia College, Elsah, Ill. My research interests are analytical chemistry and the chemistry of planets (astrophysics). I chose SDSU and Brookings because I believe it will serve my research interests, and I wanted to live in a peaceful city with cultural activities.

Oluwatobi (Tobi) Ideleye

While I am from Nigeria, I received both my B.S. and M.S. in chemistry at Eastern Michigan University in Ypsilanti. I am interested in student attitudes towards chemistry and the factors that could influence these attitudes. I chose SDSU because it's one of the few schools offering a Ph.D. in chemistry with a specialization in chemistry education and because I sensed that the whole department actually cared about the success of the students.

George Opoku-Kusi, Jr.

I'm from Ghana and attended Kwame Nkrumah University of Science and Technology in Ghana. My research interest is in macrophage colony stimulating factor receptor (MCSFR) signaling in cells. I was impressed with the research and academic standards as well as opportunities offered to international students in the department. I have found interesting research areas which overlap with my career ambitions. I now realize the SDSU has some of the finest faculty and facilities and can help my development into a competent scientist.

Bremansu Osa-Andrews

I am from Ghana and am married to Lydia and together we have two beautiful daughters. I have B.S. in biochemistry from Kwame Nkrumah University of Science and Technology, Ghana. I also have a master's in chemical pathology (clinic chemistry) from the University of Ghana. My research interests are lipid chemistry and cardiovascular research. An ex-college mate introduced me to SDSU and I thought it would be a great fit.

MLS Part of IHEP Documentary

A student and professor in medical laboratory science have put this SDSU Department of Chemistry and Biochemistry program on the map. Donald Richards, a senior in MLS, and Pat Tille, who directs the program, are featured in a documentary created by the Institute of Higher Education Policy.

Richards and Tille were filmed on campus for the documentary that debuts during IHEP's National Summit on Dec. 3, 2013, at the National Press Club in Washington, D.C. Both are invited to attend the premier as the guests of IHEP.

"The experience of having a camera crew of five or six people following me around campus was unique," Richards said. "The IHEP chose me to represent the nontraditional students who are redefining access to higher education in the 21st century."

Richards was enrolled in the MLS program in 2010 when he was called up to serve as a civil affairs officer in the U.S. Army in Afghanistan. After two years in the military working with civilians on the battlefield, he returned to SDSU program.

"It is truly an honor for one of our seniors, our program and SDSU to be featured in this film. Don is one of a large group of students who are dedicated, work hard and continue to represent the MLS program and SDSU with the highest quality and commitment to laboratory science," Tille said.

During the conference, participants from institutions and students will be recognized for their contributions to higher education. In addition, Richards will be participating in a student question and answer session with policy makers, business professionals and representatives in higher education.

"This documentary gives national recognition of the quality of the MLS program and SDSU," said Jim Rice, head of the department of chemistry and biochemistry.

Richards, from Jackson, Minn., is in his final semester at SDSU and has been accepted to complete an internship at the Southwest Regional Mayo Health Laboratory. He is considering employment in the Army Medical Services Corps.

The MLS program is a professional allied-health program that prepares students for careers in medical laboratory science or related fields. SDSU is the only university-based program within South Dakota.

The Institute for Higher Education Policy (IHEP) is a nonpartisan, nonprofit organization committed to promoting access to and success in higher education for all students. Based in Washington, D.C., IHEP develops policy- and practice-oriented research to guide policymakers and education leaders, who develop policies that will address our nation's most pressing education challenges.



Dr. Pat Tille and Donald Richards were featured in a documentary film created by the Institute of Higher Education Policy.

MLS Student Sets New High on Board Exam

Medical laboratory science graduate Larissa Knutson recently achieved an overall score of 637 on the American Society for Clinical Pathology board exams. This is the highest score in medical laboratory science program history. Larissa's individual scores were: immunohematology 607, chemistry 575, hematology 727, immunology 624, laboratory operations 548, microbiology 635 and urinalysis 734.

Interested in keeping current on happenings in the department?



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New Faculty and Staff



BreeAnn Brandhagen

Originally from Rapid City, I completed my undergraduate studies at Northwestern College in Orange City, Iowa. I majored in both biology health professions and chemistry. After graduation I worked as the laboratory coordinator for both the biology and chemistry department at Northwestern. I then attend the University of South Dakota for graduate school, where I completed my doctorate in basic

biomedical studies. I have presented my research at multiple local and national conferences and have two articles in the journal "BMC Cancer." I am now an instructor in the medical laboratory science program teaching clinical chemistry. My academic interests include cancer biology, tumor markers, biochemistry and molecular diagnostics.



Michael Dianovsky

I am currently in my first year at SDSU as an assistant professor of chemistry and biochemistry. My research focus is in the area of chemistry education. I received a B.S. in chemical engineering from the University of Illinois at Urbana-Champaign. I earned an M.S. in chemistry from the University of Illinois at Chicago, followed by a Ph.D. in learning sciences.

After earning my Ph.D., I completed a two-year research/teaching postdoc at Rutgers University in the area of science education.

My research spans the area of chemical education, learning sciences and science education. One of my interests is the general issue of how to develop students' metacognitive skills with regards to problem solving and transferring knowledge across chemistry content. While it is important to understand students' metacognition during problem solving, it is also important to understand how high school and college teachers can promote it in their classrooms.



Nicole Grove

I'm a South Dakota gal, born and raised in Rapid City. I attended South Dakota School of Mines and Technology, where I obtained two B.S. degrees — interdisciplinary science and chemistry. From there, I headed to Indiana to study at Purdue University where I earned a Ph.D. in chemistry with an emphasis in chemical education.

Teaching is my passion, and I love helping and encouraging students to become the people they want to be. By teaching in a discipline that is usually frowned upon by most, I feel that I can be a positive influence on students' chemistry experience. I am also pleased to be a part of advising undergraduate students in chemistry and biochemistry. I believe a good teacher and a good advisor can really make or break a student's success in college, and student success is very important to me.



Sarah Purcell

My name is Sarah Purcell and I am the department's new secretary. I'm a mother of two and very excited to say I have another on the way! In my spare time I'm kept busy between my kids and my photography business. I'm very excited to have this opportunity to be a part of the chemistry and biochemistry department. It's been great getting to know everyone.

Where are you? What are you doing?

We gladly publish updates on our alums' careers and lives — if we receive them. It's a great way for all of us to keep in touch!

If you would like to share something send us a note and we will include it in the next issue. You can also Fax us at (605) 688-6364, or email us at James.Rice@sdstate.edu.

Recent Faculty Publications

Adam Hoppe

Sheng Z, Ran Z, Wang D, Hoppe AD, Simonson R, Chakravarty S, Hause BM, Li F, "Genomic and evolutionary characterization of a novel influenza-C-like virus from swine," *Arch Virol*. 2013 Aug 13. [Epub ahead of print]

Hoppe AD, Scott BL, Welliver TP, Straight SW, Swanson JA., "N-way FRET microscopy of multiple protein-protein interactions in live cells," *PLoS One*. 2013 Jun 6;8(6):e64760. doi: 10.1371/journal.pone.0064760. Print 2013.

Lin J, Hoppe AD, "Uniform total internal reflection fluorescence illumination enables live cell fluorescence resonance energy transfer microscopy," *Microsc Microanal*. 2013 Apr;19(2):350-9. doi: 10.1017/S1431927612014420. Epub 2013 Mar 11.

Hause BM, Ducatez M, Collin EA, Ran Z, Liu R, Sheng Z, Armién A, Kaplan B, Chakravarty S, Hoppe AD, Webby RJ, Simonson RR, Li F, "Isolation of a novel swine influenza virus from Oklahoma in 2011 which is distantly related to human influenza C viruses," *P LoS Pathog*. 2013 Feb;9(2):e1003176. doi: 10.1371/journal.ppat.1003176. Epub 2013 Feb 7.

Grants

Biochemical Spatiotemporal NeTwork Resource (BioSNTR) Center. Awarded \$11,809,150 on 8/23/13.

Brian Logue

Mitchell B.L., Bhandari R.K., Bebartá V.S., Rockwood G.A., Boss G.R., and Logue B.A. (2013), "Toxicokinetic profiles of α -ketoglutarate cyanohydrin, a cyanide detoxification product, following exposure to potassium cyanide," *Toxicology Letters*, 222(1), 83-89 (<http://dx.doi.org/10.1016/j.toxlet.2013.07.008>).

Mitchell B.L., Rockwood G.A., and Logue B.A. (2013), "Quantification of α -ketoglutarate cyanohydrin in swine plasma by ultra-high performance liquid chromatography tandem mass spectrometry," *Journal of Chromatography B*, 934, 60-65 (<http://dx.doi.org/10.1016/j.jchromb.2013.06.029>).

Mitchell B.L., Billingsley B.G., and Logue B.A. (2013), "Rapid quantification of dimethyl methylphosphonate from activated carbon particles by static headspace gas chromatography mass spectrometry," *Journal of Chromatography A*, 1293, 120-125 (<http://dx.doi.org/10.1016/j.chroma.2013.03.038>).

Grants

Option Year 01 Renewal: Rapid Field-Usable Cyanide Sensor Development for Blood and Saliva, proposal for DoD/NIH, PI, \$200,000 for a total of \$400,000 for the project over two years (September 2012-2014).

The analysis of 3-mercaptopyruvate for a sulfanegen pharmacokinetic study in rabbits, University of Minnesota Center for Drug Design Contract, PI, \$12,840 (September 2013-April 2014)

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