Community Awareness of Air Pollutants and Site Comparison of Nitrogen Oxide, Ozone, Sulfur Dioxide, and Particulate Concentrations in the Town of Davidson by Cindy DeForest Hauser (Assistant Professor, Department of Chemistry) and Nina Mace (Davidson College '10)

Introduction

Goals

1. To provide a meaningful internship experience for a rising sophomore, that combines her interest in environmental chemistry with her passion for service.
2. To measure the concentration of priority gas phase pollutants and particle concentrations at different sites in the Town of Davidson.
3. To evaluate the contribution by school-specific vehicle traffic to pollutant levels on a residential street.
4. To provide information to Davidson residents regarding local air quality.

Justification

Davidson College is located in Davidson, NC, an area of rapid development and high commuter traffic twenty miles north of Charlotte. The recent death due to lung cancer of a non-smoking college staff member, who had also been a beloved crossing guard at the elementary school, brought air quality concerns to the forefront for local residents. The elementary school is located at the end of a street with no outlet and, therefore, buses are forced to travel in and out using the same route. Bus emissions are compounded with emissions from personal vehicles waiting to drop off and pick up children. This combination leads to localized pollution potential in an area containing many small children, a population with increased susceptibility to lung damage. An individual resident approached members of the Davidson College science departments asking about local air quality. At the time of the inquiry, priority air pollutants were not being monitored locally. Since then, three students, receiving course credit towards their chemistry minor, have worked to establish a monitoring protocol and collect preliminary data on priority gas phase pollutants.

Gas vehicle emissions lead to increased concentrations of nitrogen oxides (NO_x), photochemical smog and tropospheric ozone (O_3).[1] In the stratosphere, ozone protects the Earth's surface from harmful UV radiation. In the troposphere, however, ozone's strong oxidant properties damage materials and harm plants and animals.[2] In addition to nitrogen oxides and ozone production, diesel fuels contribute to sulfur dioxide (SO_2) and substantially higher levels of air-borne particulates than gasoline-burning engines.[3] While studies have indicated pollutant gases are not harmful below a certain threshold, studies do not show any such indication for particulates. Even a small amount of fine particles in the air increases health risks.[4] NO_x, O_3,

[1] Baird C. and Cann, M (2005). Environmental Chemistry (New York: WH Freeman).
[2] US Environmental Protection Agency. (1999) Ozone and Your Health. EPA-452/F-99-003. Washington, DC
[3] US Environmental Protection Agency. (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/600/8-90/057F.
[4] Ruzer, L.S. and Harley, N.H. ed, (2005) Aerosols Handbook: Measurement, Dosimetry, and Health Effects (Florida: CRC Press).

SO_2 and particle pollutants irritate the eyes, nose, and throat, aggravate asthma and heart disease, and can cause respiratory illness.[5]

Preliminary data indicates that the elementary school campus has higher levels of these gas phase pollutants in comparison to a remote sampling site. Critical elements, however, are missing including concentrations for the end of the academic year, when ozone levels are expected to peak due to maximum levels of sunlight; baseline values, when school is not in session; and particulate matter concentrations. Obtaining this data has been problematic due to the absence of stipend support for a summer intern. Nina, a rising sophomore, approached me in the fall semester about the possibility of a summer internship. This internship is ideal for Nina. She is intelligent, motivated, meticulous in the laboratory, has an interest in environmental issues and a passion for service to others. With the understanding that Nina has not yet taken the analytical courses, this internship will provide her with invaluable "in the trenches" experience in experimental design, solution preparation, instrument calibration, sample analysis and data interpretation, while working on a project whose outcome is integrally important to the community. There could not be a better time to bring in a summer intern on this project and Nina is a perfect match.

Project Description

Sampling sites for this internship are selected based on traffic volume. Three sampling sites have been established; the elementary school campus, the intersection of Main Street and Concord Road (the busiest intersection in the Town of Davidson), and Erwin Lodge (a forested campus respite away from traffic sources). During this internship, we will expand this study to include a residential area remote from Main Street to evaluate the impact of school traffic and the proximity of Main Street on the concentrations measured. Traffic will be observed and recorded at all four sites at various times.

Gas phase species, NO_2, NO_x, SO_2 and O_3, will be monitored in duplicate at each site using OGAWA passive samplers loaded with precoated filters specific to each gas. After exposure, the filters are extracted and analyzed using ultraviolet visible spectroscopy or ion chromatography. The sample concentrations, combined with meteorological data and established proportionality constants, are used to determine the atmospheric concentration of the pollutants. New to this study will be particulate monitoring. Nina will develop a protocol for particle collection using a cascade impactor, which separates particles by size, and a personal air sampling pump. After collection, the particle filters will be weighed. Because traffic volume at the elementary school campus is tied to the academic year, collection periods will be varied to evaluate week day versus weekend levels and levels when school is in session versus summer break. Additionally, by establishing the collection period from January to December, we will evaluate seasonal effects such as temperature, actinic flux, and relative humidity and will analyze the impact of precipitation events. We anticipate that the concentrations of these gas phase pollutants exhibit spatial, temporal and seasonal variability.[6] Correlations among the pollutants and possible local, natural and anthropogenic inputs are additionally important. By gathering and

[5] "What are the Six Common Air Pollutants?" Environmental Protection Agency http://www.epa.gov/air/urbanair

[6] Leidi, A.; Grubb, H.J.; Howe, M.T. and Mugglestone, M.A. (2000) Local and Seasonal Variations in Atmospheric Nitrogen Dioxide Levels at Rothamsted, UK, and Relationships with Meteorological Conditions. *Atmospheric Environment*. 34: 843-853.

working through this data with me, Nina will gain a more complete understanding of both the specific laboratory and statistical techniques and the importance of clear and well-defined experimental design.

A critical component of the internship is the community aspect. In addition to the collection and analysis of gas phase species and particle concentrations, Nina will develop and distribute surveys to gauge residents' knowledge of these pollutants, as well as perceptions of their prevalence and relationship to health impacts. Utilizing information from the Davidson studies, the survey, and known data about the pollutants, we will then create and distribute an informational pamphlet, particularly to parents of students at Davidson Elementary, with the goal of educating the community and ultimately improving the health of community members.

Timetable

The internship will span eight weeks. Gases will be sampled weekly and analyzed during the following week. I will collect samples during the month of May and store them for Nina to analyze in her first week. This will allow her to become comfortable with the analysis methods. Nina will collect gas phase samples from all four sites during the first six weeks. This time period will provide two weeks of school in session and four weeks of baseline measurements. In addition to the gas phase collection and analysis, Nina will develop the particulate collection protocol in Weeks 3 to 5. Simultaneously in the first few weeks of the internship, Nina will develop and distribute the community surveys to be collected in Week 6. In Week 7, she will create the pamphlet. In the final week of the internship, Nina will distribute the pamphlet and develop a poster for display during the Fall Research Symposium.

Budget and Justification

Nina has applied for and received funds from the Stone Foundation for monitoring ($1199) and community education ($400) supplies and a housing supplement ($400). She will receive travel funds ($250) and part of her stipend ($1300) as a Merck/AAAS Scholar. In this proposal, we are requesting $1500 as the balance to Nina's stipend for the eight week internship.

Evaluation and Dissemination

One of the goals of this internship is the creation of a pamphlet targeting parents of elementary school children and senior citizens to educate them on the local air quality, air pollution and associated health risks. Results will be presented at an on-campus poster session, as well as at the Annual Southeastern Regional American Chemical Society Meeting (SERMACS) in the fall. The dissemination plans of the study also include submission of two manuscripts to peer review for publication. The first manuscript will report on the results from this study and be submitted to the Journal of Environmental Science and Technology. The second manuscript will outline this internship as a service-learning model to be submitted to the Journal of Chemical Education.

Personal Statement

Intern: Nina Mace, Davidson College '10

The presence of pollutants at Davidson Elementary is of particular interest to me because of my work tutoring students who go to this school at the Ada Jenkins After-School Program. I am

concerned about their health, and would like to be able to determine if pollution is present around the school, putting them at risk for illness. However, I do not only want to gather data on the issue, but I also want to share this information with the community. Additionally, I want to apply my knowledge of chemistry to environmental issues. In this internship, I will be taking what I've learned in my classes and using it to increase knowledge and awareness of harmful pollutants, with the ultimate goal of improving the health of community members. This internship is well-aligned with my current goal of a career in epidemiology or medicine.

Faculty Mentor: Cindy DeForest Hauser

I. Professional Experience and Education:

Department of Chemistry: Davidson College, Davidson, NC
Assistant Professor Aug 2002-present

Department of Chemistry: Oregon State University, Corvallis, OR
Instructor
Research Associate with Dr. Staci Simonich 2001-2002

Department of Chemistry: University of North Carolina at Chapel Hill, Chapel Hill, NC
EPA STAR Graduate Fellow
Graduate Student with Dr. Roger Miller
Development of Spectroscopic Methods for the Characterization of
Organic Aerosols Ph.D. December 2001

Applied Analytical Inc.: Wilmington, NC
Assistant Scientist I 1996

Department of Chemistry: University of North Carolina at Wilmington, Wilmington, NC
Graduate Student with Dr. Joan Willey
Gas Phase Hydrogen Peroxide in Coastal North Carolina M.S. May 1996

Analytical Technologies: Pensacola, FL
GC Analyst 1992 - 1993

Washington and Lee University: Lexington, VA
Major: Chemistry
Magna Cum Laude and ΦBK B.S. December 1991

II. Selected Academic Awards and Fellowships

Merck/AAAS Undergraduate Science Research Program
Co-PI Cindy DeForest Hauser and Karen Bernd $60,000 2007-2010

Associated Colleges of the South Science Reform Mini-Grant:

"Development and Implementation of Laboratory Modules to Accompany Introduction to Environmental Chemistry," $12,200. 2006-2007

Petroleum Research Fund Type G:
"Heterogeneous Chemistry of Gas-Phase Oxidants and Organic Aerosols," $35,000. 2005-2007

Faculty Study and Research Grants Davidson College, Davidson, NC:
"Heterogeneous Chemistry of Gas-Phase Oxidants and Organic Aerosols,"$3,200 Sum 2006

Faculty Study and Research Grants Davidson College, Davidson, NC:
"Validation and Characterization of Aerosol Flow Tube/FTIR Technique to study Aerosol Heterogeneous Chemistry," $3,200 Sum 2005

Faculty Study and Research Grant Davidson College
"Development of Spectroscopic Methods for Application to the Study of Aerosol Heterogeneous Chemistry," $3,200 Sum 2004

III. Selected Publications

A. Articles

DeForest, C.L.; Kieber, R.J.; Willey, J.D. Comparison of Stripping Coil and Condensate Techniques for the Collection of Gas-Phase Hydrogen Peroxide, with Applications of Condensate Collection in and off the Coast of North Carolina, *Environ. Sci. Technol*. **1997**, 31, 3068-3073.

Niedziela, R.F.; Norman, M.L.; **DeForest, C.L**.; Miller, R.E.; Worsnop, D.R. A Temperature- and Composition-Dependent Study of H_2SO_4 Aerosol Optical Constants Using Fourier Transform and Tunable Diode Laser Infrared Spectroscopy, *J. Phys. Chem*. **1999**, 103(40), 8030-8040.

Smith, G. D.; Woods, E., III; **DeForest, C. L**.; Baer, T.; Miller, R. E.; Reactive Uptake of Ozone by Oleic Acid Aerosol Particles: Application of Single-Particle Mass Spectrometry to Heterogeneous Reaction Kinetics**,** *J. Phys. Chem. A.* **2002**, 106*(35),* 8085-8095.

DeForest, C.L.; Qian, J.; Miller, R.E. Time-Resolved Studies of the Interactions between Pulsed Lasers and Aerosols, *App. Optics*, **2002**, 41(27), 5804-5813.

DeForest, C.L.; Qian, J.; Miller, R.E. Composition Determination of Multi-component Organic Aerosols By On-line FT-IR Spectroscopy. *App. Spec.,* **2002**, 56(11), 1429-1435.

Killin, R.K.; Simonich, S.L.; Jaffe, D.A.; **DeForest, C.L**.; Wilson, G.R. Transpacific and Regional Atmospheric Transport of Anthropogenic Semi-volatile Organic Compounds to Cheeka Peak Observatory during the Spring of 2002. *J. Geophys. Res.*, **2004**, 109, D23S15.

B. Abstracts/Posters/Presentations at Meetings
*denotes undergraduate co-author

DeForest Hauser, C.; Trappey, F.*; Williams, K.* Applications of FTIR Spectroscopy to the Study of Heterogeneous Chemistry, American Association for Aerosol Research National Conference, Atlanta, GA, **2004**.

Brown, D and DeForest Hauser, C. Incorporating Environmental and Green Chemistry into the Liberal Arts College Chemistry Curriculum, 2nd Int'l Conference on Green and Sustainable Chemistry, Washington DC, **2005**.

DeForest Hauser, C.; Barnett, S.*; Ockers, S.*; Tolson, S.* Spectroscopic Methods to Study the Heterogeneous Chemistry of Aerosols, International Conference on Energy, Environment and Disasters, Charlotte, NC, **2005**.

DeForest Hauser, C.; Tolson, S.*; Barnett, S.*; Ockers, S.* Characterization of an Aerosol Flow Tube/FTIR (AFT-FT) Technique to Study the Heterogeneous Chemistry of Aerosols, American Association for Aerosol Research National Conference, Houston, TX, **2005**.

DeForest Hauser, C.; Creighan, R.*; Hermes, C.* Aerosol Flow Tube/FT-IR (AFT-FT): A New Method to Study the Heterogeneous Chemistry of Aerosols, American Association for Aerosol Research International Conference, St. Paul, MN, **2006**.

DeForest Hauser, C and Cox, K.* Development and Implementation of Laboratory Modules to Accompany Introduction to Environmental Chemistry, ACS Science Reform Workshop, Birmingham, AL, **2006**.

DeForest Hauser, C. Aerosol Chemistry: Spraying Undergraduates, University of Georgia Analytical Seminar, Athens, GA, **2007**.

IV. Professional Memberships

American Association for Aerosol Research and American Chemical Society

V. Activities

Faculty Advisor: Davidson College Student Affiliates Chapter of the American Chemical Society
Premedical Advisory Committee
Director: Department of Chemistry Instructional Assistants Program
Mentor: Mooresville High School Senior Projects Fall 2003 and 2005
Volunteer: Carolinas Clean Air Coalition
Associated Colleges of the South Environmental Faculty Fellow Spring 2007