Faculty Development Research Grant
for
Summer 2001

Request Submitted by: Michelle S. Applebee
Associate Professor of Chemistry

I. Project Summary.

Investigations leading to the determination of pesticides in natural waters have been driven by the need to monitor components with known or suspected health risks. The risk of these potential dangers is especially high in areas where field run-off water mixes with drinking water. Specifically, the determination of pesticides will be accomplished by the use of a thickness shear-mode resonator. The basic criteria for method development will be followed including: proof of concept, data collection, method validation with proven method and statistical analysis, as well as sampling procedures. Sensor development projects are useful research projects at the undergraduate level because they confirm many of the techniques and theories learned in the lecture setting.

Data collection will occur over the entire summer by a student working half-time with me. This will make up the majority of my time this summer but still allow me to devote 20% of my time to preparation for the upcoming academic year. Therefore funding is being split for faculty and student stipends.

II. Narrative.

Current Situation

The determination of environmental contaminants has been in the forefront of research for a number of years. Although numerous new methods have been developed for such applications, scientists are always striving for methods that are less costly, more sensitive and selective, and that hold the possibility of being utilized in the field. One environmental contaminant of interest is pesticides. The large quantity of pesticides used in agricultural areas has caused contamination in surface, ground and drinking waters. One new direction for an inexpensive, highly field-portable, pesticide sensor is the use of a thickness shear mode resonator.

Furthermore, it is important for new faculty, such as myself, to engage in the rigors of research early in one's career. Establishing a research program not only keeps me informed of the latest technical advances but also keeps me connected to my peers at other institutions. Students are also beginning to understand the importance of research programs to their futures, regardless of direction (graduate school or industry). To remain competitive in science, students involved in undergraduate research and/or internships have an advantage. Providing Elmhurst College students with the opportunity to participate in these experiences on this campus is a vital part of

keeping EC competitive with larger universities, yet still giving students the undivided attention associated with a small liberal arts college. Research necessarily develops a true mentoring experience between faculty and student and with it comes lifelong benefits for the student as well as a positive long term the student and the college.

Project Plan

Data will be collected over the summer by one student working half-time (approximately 20 hours/ week) and myself. As well as being an active participant in the collection of data, I will spend 20% (8 hours/week) of my time updating class materials and new class design for the upcoming academic year. This part of my work will be done on days the student does not work, so he/she gets as much mentoring time as possible. With most of the data being collected during the summer, the results will be written up for publication during the following school year.

Overall a new method for the determination of pesticides will be developed. To begin a polymer must be bound to the sensor surface as described below. This polymer must also be selective for pesticides. After the selective polymer is found, control analyses will be performed on numerous pesticides individually dissolved in distilled water. Similar studies will be carried out on mixtures of pesticides to prove the signals obtained from individual pesticides are additive. Finally, contaminated natural water samples will be analyzed and verified using accepted methods to prove the validity of the proposed sensor.

Specifically, the research conducted this summer will be an environmental project involving the determination of pesticides in water. To accomplish this task a thickness shear-mode resonator (TSM) will be used as a sensor. This device exploits the ability of quartz to express an electrical potential in response to a mechanical stress. The mechanical stress is exhibited as a frequency change that is directly related to the amount of analyte exposed to the sensor.

The sensing instrumentation is universal. That is, it can respond to many types of mechanical stresses including changes in temperature, matrix components and mass. Therefore special precautions must be taken before analysis can be performed. The first of these precautions is to obtain selectivity (isolate the desired analyte so that it is the substance monitored by the TSM sensor). To obtain this goal, various polymers will be studied to find one that sufficiently extracts the pesticides from the water matrix. Another requirement is that this polymer must remain on the sensor surface under aqueous conditions. This can be an inherent property of the polymer or can be achieved by chemically binding the polymer to the gold surface using a variety of methods. Determination of what polymer to continue analysis with will provide the student with his/her first challenge in assessing data and critical thinking.

Proof of concept data will then need to be collected by verifying that the effects associated with multiple components and matrix can be overcome. Validation of the sensor will be accomplished by analyzing control samples of pure matrix and real matrix by both the new method and a government approved method. This validation will be assessed using the typical statistical methods. Sample collecting and handling will be introduced to the student during this stage of the study.

This project is considered to be analytical chemistry in its nature (the quantitation of a specific analyte). However, analytical chemists are sometimes considered 'jacks-of-all-trades'. By this one means that although the final outcome is a specific measurement related to a specific analyte, there are many different areas of chemistry that are applied to reach this goal. Specifically for this project, basic concepts in surface and polymer chemistry will be undertaken. Therefore the theory learned in many classes can be applied in this situation.

Similarly, the development of sensors is an excellent area for undergraduate research because such research can teach undergraduates numerous fundamental skills. While developing a new technique, many basic concepts learned in lab classes are re-emphasized. Solution preparation, standard addition, and method verification with known techniques will all be used in the research of new sensors.

Finally, sensor analysis of pesticides is a good place to begin because this line of research should be straightforward and productive early on, because these sensors have direct application potential and because the environmental concerns are relevant and important to students. Environmental projects demonstrate the responsibility scientists have to survey and/or alter their impact on society and on the ecological system.

Faculty Expertise

My research in graduate school centered on the development and application of sensors. Work focused on the determination of both environmental and biological analytes. Also during my undergraduate studies I interned at a water quality laboratory where I learned the rules and requirements for examination of water and wastewater as dictated by the Environmental Protection Agency and other government organizations.

Plans for Evaluation and Dissemination

Results will be verified against methods currently accepted by the EPA in accordance with their regulations with equipment already available in the Department of Chemistry. Upon finding acceptable results a paper will be submitted to a refereed journal. This may also lead to a presentation at a national or regional chemical conference. Locally the results of this research will be presented on campus in two forms, first in Chemistry Seminar (Chm 498) and also at the Faculty Women's Caucus Research Symposium held in March of 2002.

III. Timeline.

Initial work has begun during the current spring term by an undergraduate student working for free. Further work will continue over the entire summer. The student shall work an average 20 hours a week over 10 weeks. My time will be split 80% research, 20% upgrading lecture and laboratory materials for the upcoming academic year. The results will be written up during the following school year and submitted to a peer-reviewed journal when applicable.

IV. Budget.

Student Stipend (20 hrs/week for 10 weeks at $7.50)	$1,500
Faculty Salary	$2,000
Total	$3,500

(The student stipend is approximately half that of typical summer stipends for undergraduates doing chemistry research funded by national outside agencies.)

The equipment required to initiate this project has been secured through start-up money from the Department of Chemistry and Office of the Dean of the College.

V. Current and Previous Grants.

None.

VI. Publications and Presentations.

Applebee, M.S.; Jaeger, R.J.; Pierce, D.T.; Geissler, J.D.; Schellinger, A.P. "Film Swelling Analysis of Waterborne Hydrocarbons by Thickness-Shear Mode Resonator Measurements.", **in preparation.**

Pierce, D.T.; Applebee, M.S.; Lacher, C.; Bessie, J. "Low Parts per Billion Determination of Sulfide by Coulometric Argentometry", *Environmental Science and Technology*, **1998**, *13*, 2713-2716.

Applebee, M.S.; Pierce, D.T.; Jaeger, R.J.; "Direct Determination of Petroleum Hydrocarbons in Water by Solid Phase Microextraction/Thickness Shear Mode Resonator", 32nd Great Lakes Regional Meeting of the American Chemical Society, Fargo, ND 2000.

Schellinger, A.P. "Direct Determination of Petroleum Hydrocarbons in Water by Solid Phase Microextraction/Quartz Crystal Microbalance", 51th Pittsburgh Conference, New Orleans 2000.

Pierce, D.T.; Jaeger, R.J.; Applebee, M.S.; Geissler, J.D. "Determination of Volatile Organic Hydrocarbons in Water by Quartz Crystal Microbalance", 50th Pittsburgh Conference, Orlando, FL 1999.