2015 APS/CNM Users Meeting

ESRP POSTER ABSTRACTS

Exemplary Student Research Program

ESRP-1

Nanoscale Elemental Fingerprinting of Historic Ink

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Historic inks from a wide range of dates, from as far back as the 5th century, have shown signs of corrosion and degradation. Research into these inks can lead to progress in preserving important handwritten historical documents. We have utilized high-resolution x-ray fluorescence to analyze the elemental composition of a sample of mid-19th century ink. Additionally, the physical characteristics of the paper were analyzed by an optical light microscopy. Optically, torn fibers and vertical ink displacement were observed. Through nanoscale x-ray fluorescence concentrations of each element were identified and compared. The x-ray fluorescence maps indicated the presence of certain key elements in the ink but not paper: namely iron, calcium, nickel. Metallic atoms organized themselves into nanospheres and other organized distributions while metalloids such as Al, Si, and Mn are uniformly distributed. Notable variations include the decrease in chlorine in the sample with ink.

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ESRP-2

Sequestered Elements in Tissues of Water Willow and Freshwater Mussels as a Function of Sustainable Urban Stream Ecology

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The ecological health of urban streams has recently gained interest alongside the increased spread of suburban and urban communities. Urban streams commonly exhibit eutrophication as a result of increased nutrient load from point and nonpoint sources in the local communities. Point sources, such as wastewater treatment plants, contribute to high nutrient load and eventual cultural eutrophication of these ecosystems by releasing increased amounts of nitrates and phosphates. The Illinois EPA has determined the Spring Brook creek of Wheaton, IL to be impaired. This rating has resulted in a stream mitigation plan prepared by the DuPage Forest Preserve District's Urban Streams department. Spring Brook creek restoration plans by the DuPage Forest Preserve District include building a more natural streambed and the introduction of organisms that together will result in more sustainable stream ecology. The stability of the streambeds and development of sustainable microhabitats will be improved by the introduction of the plant American Water Willow (*Justicia americana (L.) Vahl.)*. It is not known if Water Willow is a bio-acculmulator. If Water Willow sequesters phosphorus and metals, this process would contribute to improvement of the stream ecology. The introduction of freshwater mussels, Giant Floater, *Pyganodon* (=*Anodonta*) *grandis* and White Heelsplitter, *Lasmigona complanata,* will occur in the second phase of the stream restoration. Freshwater mussels are part of and serve as an indicator of healthy streams. They provide microhabitats for various species, filter water, and sequester metals. Due to certain urban environmental stressors, it has been estimated that urban streams have lost a majority of our indigenous mussel species.

This research hopes to determine the possible contribution of Water Willow toward reducing stream water nutrient load by detection of plant tissue sequestration of phosphorus and metals. The measurement of phosphorus and metal

composition in Giant Floater and White Heelsplitter tissue will serve as baseline data regarding the possible mussel contribution toward maintenance of stream ecosystem stability.

ESRP-3

X-ray Crystallography of IF7 and Concanavalin-A

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The development of vascular supply is an essential source of the growth and metastasization of malignant tumors. Annexin 1, a potential anti-cancer drug involved in human anti-inflammatory processes, is capable of highly specific tumor vasculature recognition. Research has identified the carbohydrate ligand-mimicking 7-mer peptide, (IFLLWQR or IF7) as capable of targeting Annexin A1 in mouse tumors. IF7 has exhibited unprecedented tumor-targeting activity and has been detected in mouse tumors within a few minutes of intravenous injection of the peptide [PNAS, 108(49),19587-19592 (2011)]. IF7 has the potential to act as a vehicle for anticancer drugs delivering them to the location of the tumor. Concanavalin-A is a carbohydrate-binding lectin, originally extracted from Jack Bean *Canavalia ensiformis*.

It binds to various sugars, glycoproteins and glycolipids, by recognition of a Î±-D-mannosyl or a Î±-D-glucosyl group. In this experiment, crystals of Concanavalin-A were grown, cross-linked with glutaraldehyde, then soaked in solutions of IF7 and IF7CRR, to identify their biologically active conformation.

Co-crystals of the protein/peptide complexes were also grown, independently of the glutaraldehyde cross-linking process and crystals of the IF7 and IF7CRR peptides. Diffraction images were collected using Beamline 19 at Argonne National Laboratory and the results were analyzed to determine the macromolecular structure of the crystalline contents.

ESRP-4

The Effect of Increased Phosphorous on Metal Absorption in Lettuce

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Varying levels of phosphorus will be added to separate samples of lettuce plants. In addition to the phosphorus, a controlled amount of nickel, zinc and iron in solution will be added to all the samples. The metal concentrations and distribution in the leaves will be analyzed using the APS. Since phosphorus is linked to root growth, we expect that the phosphorus should increase the amount of metal found in the lettuce leaves. Some researchers have found that high levels of phosphorous prevent metal uptake. We expect that at a certain point, the effects of adding phosphorus in relation to metal absorption would reach a peak. After this point, increasing the levels of phosphorus would no longer have a positive correlation with the metal absorption. By finding the range of peak metal absorption, we may be able to determine the optimal amount of phosphorus. The results will give us more insight on the effects of adding certain aqueous solutions during the plant's growth on leaf growth and metal absorption. To find these results, we will need to read and accurately interpret the levels of metal absorption found within the varying phosphorus sampled plants.

ESRP-5

Understanding the Reduction Mechanisms and Structural Changes of a Lithium-rich Oxide Material Using *Operando* X-ray Absorption Spectroscopy

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Taking advantage of the element specificity and operando capability of x-ray absorption spectroscopy, we have studied the evolution of the local electronic and atomic structure of a lithium-rich oxide material, $0.1Li_2MnO_3$ $0.9LiCoO_2$, during electrochemical discharge in a half-cell. The study elucidates the mechanism of the reduction reaction of this complex material and sheds light on the nature of the reduced species generated during the lithiation reaction. The findings of this study help enhance our understanding of conversion and alloying reactions. Additionally, these studies are of relevance to the topic of performance degradation — initiated by a crosstalk between the positive and negative electrodes — in lithium-ion full cells.

ESRP-6

Determining the Suitability of Fly Ash Produced in Illinois for Use in Geopolymer Concrete

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This proposal hopes to determine the suitability of locally produced fly ash for use in construction-grade materials. Fly ash is a by-product of coal burning power plants, and 4.4 million tons of fly ash are produced annually in Illinois alone. Fly ash is known to contain many harmful elements, and disposal of fly ash has historically been problematic. One possible route to beneficiation of fly ash is to use it as a geopolymer concrete. However, the question remains as to whether or not this geopolymer concrete is environmentally safe. We hope to determine the answer to this question by using fly ash generated or used in Illinois and analyzing the sample for the presence of Cr(VI) and other harmful elements. By determining both the concentration of potentially hazardous elements and their spatial distribution in the sample, we hope to be able to reach some conclusion regarding the potential environmental impacts of the use of locally produced fly ash as a geopolymer concrete.

ESRP-7

Comparing Extant and Fossilized Spiders to Determine Evolutionary and Preservational Changes Using Synchrotron X-ray Tomography

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The goal of the experiment is to evaluate the differences between three extant and fossil spiders preserved in amber, using synchrotron x-ray tomography. The propagation phase contrast-based x-ray synchrotron imaging techniques provide detailed 3D images that will allow the group to virtually dissect the fossil species and determine if the changes in the modern samples are due to evolutionary changes in the genus, or alternatively to taphonomical (preservation related) factors. A comparison between the amber-preserved and extant samples will also be conducted to evaluate the effectiveness of amber as a preservation medium. The samples will be scanned using a medium resolution setup to study the general morphology of the specimens. Some areas of anatomical interest will then be scanned at a high

resolution (spinnerets and male palps). Each medium resolution scan takes from 40 to 90 minutes depending on the sample horizontal size, and each high resolution scan takes approximately 40 minutes. The use of the synchrotron device at the advanced photon source will show enhanced detail unable to be achieved through conventional methods.