Personal Statement, Relevant Background, and Future Goals

Change can be overwhelming and sometimes difficult to adjust to, but for me it has been the link to self-motivation and a driving force to excel. As a young girl growing up in Cuba, I learned to appreciate the simplest things in life, like the wind moving the sugarcane fields in my backyard, sitting on the highest branch of an orange tree, my imagination escaping into the moving clouds, and living day to day on a 10-acre sugarcane farm.

When I was 3 years old, almost 18 years ago now, my dad left my mom, sister and me behind in Cuba, going in search of freedom and the American dream in the unknown location known as "La Yuma". La Yuma was the nebulous location in the United States everyone in my neighborhood whispered about, where one would be rich and prosperous. However, people also grumbled about and resented anyone who had the bravery to take that leap of faith. Sailing from Cuba in a wooden boat he had built with eleven of his friends on a humid August morning is one of the few childhood memories I have of my dad. Although not known to me then, he actually made it to the Floridian Coast three days after setting sail.

What none of us expected was that my dad would not be able to return for us for five interminable years, and therefore, at that point in my life, all I had to rely upon was my mom. She embraced the role of both mother and father in a country laden with poverty and seclusion. She cared for my younger sister and me while maintaining the farm. Her perseverance and fortitude taught me to be resilient, independent, and caring because family would always come first. I am grateful that my mom peddled me to school on the back of her bicycle across farm towns because she inculcated in us the importance of earning an education no matter what difficulties we encountered and enforced continuous learning.

As a small girl I grew passionate for school and my life revolved around the world of math. School was enjoyable and I developed a sense of self-belief, but just as this passion blossomed, my dad returned with the intent on moving us to La Yuma. After our relocation from Cuba, I learned my Dad had started his own machine shop business and saved his profits to reunite his family. As I have grown older, his fight for freedom and drive to make it on his own despite the strong language barrier has become an inspiration to me, driving me toward personal success even though at the time I did not appreciate the change.

I look back now and realize that this overwhelming change in my life transformed me and made me a stronger person. Learning the new language of English in a place of strange faces was difficult, but the willpower to excel pushed me to overcome every obstacle. In middle school I joined sports teams and science clubs, which opened the doors to what would become my 3rd language—science. During high-school, as I engaged in experiments and realized how my math and science skills led to even the smallest of discoveries, it became apparent that I had the potential of making a global impact to positively influence society.

The circumstances I lived through altered my way of thinking and enhanced my appreciation to the little things in life. While I still appreciate the simplest of things, I have acquired a deeper understanding of them. When I look at the wind now, I automatically think of the particles incremental velocities through the gaseous surface of the troposphere and as I climb trees, I evaluate the evaporation of the water molecules off the leaves' surface. When I peer at the clouds, I see shapes of infrastructures and other physical structures made possible through design. When I was no longer able to change my surroundings, I choose to change the way I looked and experienced them. This change only came about through the sacrifice of my parents and their years of struggle for a prosperous future.

Attending the University of Florida and enrolling in their Environmental Engineering program was the first step toward realizing my dream. Just as my father had known years ago, moving away from home and leaving everything behind to go to school was now a necessary step I had to take toward success. Coming from strong family ties, it was crucial for me to succeed since I was giving up so much. The first few months of college were tough, but I quickly became acclimated to the university environment, growing comfortable with the material while also discovering a passion for research.

Throughout my time as a student in UF's 5-year environmental engineering undergraduate program, I have become involved with several research tracks. Early on into my environmental engineering classes, I connected with Dr. David Mazyck and his research group. Dr. Mazyck's main research at UF included the synthesis of various sorbents for removing mercury from water and air. My initial forage into the lab started with repetitive methods to better acquaint me with the laboratory environment, statistical analyses, and safety practices. My primary research focused on determining the extent of a successful activated carbon from the pyrolysis and activation of agricultural byproducts including corn husks, soy hulls and coconut shells. Although this research field focusing on renewable resources is growing, my specific focus was on maximizing mesopore volume of these carbons to enhance their performance for removal of larger molecules (e.g., color) from water. After extended activations with the use of an activation furnace employing the use of steam, samples were characterized to determine specific surface area, pore size and pore volume. These initial laboratory investigations made me feel more comfortable with the research and experimental environment under the research group and urged me to continue pursuing opportunities like these.

Dr. Mazyck is also the CEO of a start-up small business enterprise, Clear Carbon Innovations (CCI), and he offered me an opportunity to learn in this entrepreneurial environment. My responsibilities revolved around laboratory work while researching and implementing new methods to achieve a superior activated carbon product for mercury (Hg) capture from coal-fired power plants. At CCI I worked directly under their research and development director, Dr. Heather Byrne, who has years of experience developing new technology of activated carbon and other sorbents. She was also one of starting founders of the company. Under her, I led experiments and conducted lab work. I presented analyzed data and suggested paths forward when it was suitable. I was also tasked with troubleshooting different analyzers such as the Nova Surface Analyzer and the Atomic Absorption Spectrometer when they malfunctioned and worked closely with sales representatives to get the machines back in operation. I was also involved in designing new set ups for experimental test stands I built to compare the activated carbons I synthesized in respect to their abilities to capture Hg.

Just a few months ago during the summer, an exciting opportunity included applying the lessons learned in the lab to fieldwork at a coal-fired power plant conducting particulate and mercury sampling across the electrostatic precipitator and at the stack during activated carbon injections at a large coal-fired utility. This 10-day experience focused on testing innovative activated carbon injection lances designed to enhance particle dispersion and distribution in the flue duct. I was solely responsible for critical measurements that enabled the team to evaluate the difference between the four lances designed that week. Indeed, all of the lances showed improvements, with one particular lance improving Hg removal by about 20%, a very significant improvement. At the power plant, I was able to put various concepts into perspective when learning about the air pollution control devices and the efforts behind burning cleaner fuels. Knowing that the activated carbon we were injecting was going to reduce Hg exhaust

concentrations also spurred me to consider in more depth the lifecycle of the toxin along with more efficient methods of its removal.

Being involved in a startup company also provided me experience with other facets of the business realm including fund raising, budgets, accounting methods, and numerous other areas that make small business exciting yet demanding. This past summer I further engaged with the company by attending the Air Pollution Control and Air Quality Conferences. They exposed me to leaders of the activated carbon industry, equipment manufacturers, and utilities all around the country. Networking with researchers at these conferences and learning about the issues the power industry is facing with new regulations and monitoring concerns, motivated me to become more involved. At various technical sessions I learned about new methods the community has been using to treat various pollutants and the extent of the methods' success in the field. Hearing about the possibilities I grew extremely enthusiastic about this research and the strategy the industry is taking.

Simultaneously, I was heavily involved in the mentoring of other undergrads through the organization of the Cuban Association of Student Engineers. This organization is comprised of several students in the engineering field, mostly of Cuban decent, who feel truly passionate about our homeland. As a group we conducted research related to Cuban infrastructure and other challenges affecting the community back home. Our research was later submitted to design competitions and for publication in various conference proceedings including the Study of Cuban Economy. As a result of my involvement since early on in my sophomore year, I have grown with the organization. We have expanded the bounds of the research in which we are currently involved in and now mentor new team members on how to start their investigation and write their proposals for competitions. Last year, I personally advised one of the groups working on soil free agriculture with the use of nutrients from fish farms on the capabilities and possible integration of this system into one of the Cuban cities like Havana where I was raised. I presented to them the technical aspect of nutrient recycling through the system, while also familiarizing them with the possibilities of successful implementation due to my practical knowledge of the city and governmental statutes.

Over all my experiences have led me to a clear path focusing on the exploration of specific mechanisms responsible for the binding of Hg to carbon surfaces in the presence of other flue gas constituents. My doctoral work will serve as a catalyst to initiate my career as a professor where I plan to enthusiastically help other students realize their dreams. Naturally I am drawn to helping fellow Latino women, but I clearly understand the importance of mentoring students from all over the world because, for example, Hg is a global pollutant. Tenure and promotion will require great attention, and once attained, my new goal would be to start small business enterprises to create technical high paying jobs for others. At that stage of my career, I will have graduated at least one Ph.D. student who could potentially serve as the first member/employee. I trust that Dr. Mazyck will mentor me through this process and witnessing the opportunities he has created through his businesses, particularly for minorities and women, instills a passion in me to accomplish similar heights. Indeed, I considered pursuing a Ph.D. at other institutions, but the caliber of research at the University of Florida, its unique Entrepreneurship and Leadership Certificate program, and the mentoring of small business development available here makes it obvious that I have a superb foundation to build upon. I am driven and passionate about succeeding, and with an NSF Graduate Research Fellowship I will be armed to make the global difference I am confident I can make.

Enhancement of Activated Carbon via Mixed Oxides and Oxygen Functional Groups for Enhanced Mercury Capture from Coal-Fired Power Plant Flue Gas

Key Words: activated carbon, surface chemistry, mercury

Background: With the signing at the Minamata Convention on Mercury by over 92 countries this past October, the environmental and health risks associated with anthropogenic mercury emissions became evident at a global stage. The United States through the Environmental Protection Agency's Mercury and Air Toxics Standards (MATS) will be removing about 90% of mercury from coal-fired power plant emissions by 2015. The technology most often employed is the injection of powdered activated carbon (PAC) impregnated with bromide/bromine (B-PAC), whereby bromide/bromine is added to enhance Hg oxidation and subsequent adsorption by the carbon (i.e., oxidized Hg is adsorbed much more readily than elemental Hg and both exist in flue gas depending on coal rank and coal halogen content). However, the Electric Power Research Institute (EPRI) recently presented at the Air Quality IX Conference (October 2013), and confirmed my working hypothesis, that the bromide/bromine within B-PAC can desorb and corrode essential power plant components (e.g., air heater). Furthermore, although PAC and/or B-PAC are likely the best available control technology, improvements in its synthesis and mechanisms responsible for Hg oxidation and adsorption are warranted to reduce costs for compliance. Reduced compliance costs are critical for developing nations so their global economic impact can be strengthened without over costly hindrance from environmental policies.

Hypothesis: Olson et al. (2003) proposed that activated carbon has both oxidation sites and adsorption (binding) sites, and more specifically, the oxidation site is an electron-accepting Lewis acid site while the binding site is an electron donating basic site [1]. The hypothesis is that activated carbon's surface can be engineered to enhance the presence of these sites through controlling the temperature and oxygen content of the process gas thus controlling the quantity and ideally the types of surface oxygen functional groups to enhance Hg capture without the addition of halogens (e.g., bromine). The improvements to the activated carbons may be hindered by the presence of flue gas constituents (e.g., HCl, SO_2, SO_3) because the basic carbene site may also react with these constituents [2]. To mitigate this potential, the final year of proposed research will incorporate mixed oxides to the carbon surface as additional adsorption sites for these constituents.

Research Objectives: The objectives of this research are to (1) confirm the hypothesis of Olson et al. 2003 [1] focusing on the role of oxygen functional groups typically prevalent on carbon's surface (e.g., lactonic, carboxylic, carbonyl, quinone, etc.), (2) manufacture activated carbons with varying concentrations of oxygen functional groups (particularly those identified through Objective 1, (3) coat the surface of activated carbon with mixed oxides to enhance Hg capture using an electrospray strategy, (4) characterize the carbons for physical and chemical attributes, and (5) test activated carbons in a simulated flue gas consisting of elemental Hg and varying the concentration of HCl and SO_x, and (6) disseminate the results in journals (e.g., Carbon), conferences, and possibly to the United Nations, for my advisor is one of 5 selected by the World Coal Association to assist the UN with the preparation of the Global Treaty for Hg and identification of best available control technologies.

Methodology: My previous research responsibilities included the construction of a Hg test stand whereby modified activated carbons can be compared for the removal of Hg. Activated carbon synthesis will begin with lignite char (chosen because the resulting porosity is mesoporous and Hg capture is kinetically driven), activated with steam, and then thermally processed to create various oxygen functional groups. (The resulting surface area of these carbons is expected to be about 450-500 m^2/g and this variance is of little concern based on previous research.) While temperatures under 400°C result in the formation of C(O), temperatures over 400°C decompose acidic C(O) groups to CO_2 while basic groups decompose to CO. Anhydrides are removed at 550°C, phenols at 630°C, lactones at 670°C, and 810°C for carbonyls and quinone. The resulting carbon is basic due to Lewis base sites, primarily delocalized π electrons on the basal planes but also localized electron pairs at the edges of the graphene layers. Using H_2 rather than N_2, He, or another inert gas flow minimizes O_2 chemisorption after stripping by producing relatively stable edge carbons without unpaired electrons, thus maintaining a hydrophobic carbon surface. Carboxylic and lactonic functional groups will be generated through air treatment at about 370-400 °C. Carbon surfaces will be characterized via Boehm titration and FTIR. Mixed oxidizes of interest include aluminum hydroxide, magnesium hydroxide, and copper hydroxide, as preferential adsorption sites for HCl and/or SO_x. Varying application techniques include electrospraying, and during the first 3 years of research on surface oxygen functional groups other techniques for applying these mixed oxides will be researched and experimented with.

Intellectual Merit: Activated carbon surface chemistry is not well understood and less likely investigated as a plausible means to enhance carbon's removal of constituents (i.e., the activated carbon industry turned to halogens). This research will provide a clearer understanding of Hg oxidation and adsorption onto activated carbon. Furthermore, results would be equally beneficial to activated carbon and other sorbents that require engineering surface chemistry to enhance removal of toxins.

Broader Impacts: Hg is a global concern and most nations have yet to address its removal from coal-fired power plant flue gas. Coal is presently about 50% responsible for electricity production in the US and more so for other developing nations. Hg emissions can remain airborne for up to one year, and therefore, research understanding its removal is critical. Throughout this work, mentoring undergraduate students is essential to provide them the same opportunities I experienced. I am particularly interested in mentoring minorities and women and will mentor them through the process of publishing (including them as co-authors), conference presentations (e.g., Air Quality), and through the development of a 4 part lecture to be presented in Dr. Mazyck's Activated Carbon Environmental Design course. Assisting with the next steps of the UN Global Treaty regarding Hg control technologies was a significant factor in pursuing my doctoral degree at the University of Florida.

Literature Citations: 1) Olson, E.S. et al. The multiple site model for flue gas Mercury interactions on activated carbons: The Basic Site. Fuel Chemistry Division Preprints 2003. Vol. 48. 2) Olson, E.S. et al. Catalytic effects of carbon sorbents for mercury capture. Journal of Hazardous Materials, 2000. Vol.74, p 61-79.

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Very Good

Explanation to Applicant

Applicant is quite familiar with the research area she is working now, and she is planning to continue as graduate student. Her research plan is very detailed, and it is aligned with the research conducted by her academic adviser. Applicant will be able to conduct planned research, and be good member of the already established team.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

Explanation to Applicant

Applicant is heavily involved with Cuban Association of Student Engineers, which is providing her with opportunity to reach out and use her education to help in solving common, and less common problems in her homeland. Applicant has well planned her future

Summary Comments

Applicant has ability to conduct research; her proposed research plan is reasonable, and her current adviser will closely monitor her progress. She is involved in community outreach, and her chosen research topic has global importance.

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Very Good

Explanation to Applicant

The research plan has clear objectives and scope deomonstrating significant understanding of the complexity surrounding the Hg pollution and potential mitigating actions that can be deployed to elimiante the same. It is unclear if the research can be conducted as part of the Clean Carbon firm or as part of the University.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

Explanation to Applicant

The applicant has participated in conferences in the specific field of study and is starting to create a network crucial for future success as an independent researcher. She has strong mentors that can guide her through the plan. The success of the proposed plan would greatly aid in the recovery of the expelled Hg and the techniques can be deployed worldwide.

Summary Comments

This application demonstrates a comprehensive research proposal derived from societal needs, unique research/internship opportunities. The applicant demonstrates passion. The proposal could benefit from stronger statements about how previous experiences (academic, internships, research) inspired the very detailed and specific research plan. The applicant has demonstrated the drive needed to overcome adversity and has earned academic success.

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Good

Explanation to Applicant

Academic preparation is quite mixed. Good experience working with a faculty member in his start-up company. Proposal seems good though could be written to a bit broader audience.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

Explanation to Applicant

Possible role model as a hispanic woman in engineering. Mercury pollution is a worldwide issue with solutions having broad impact. Interested in mentoring undergrads.

Summary Comments