INTERNATIONAL PROGRAM FOR CCNY UNDERGRADUATE AND MASTER STUDENTS

CAREER: Molecularly Directed Assembly of "Patchy" Particles

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ABSTRACT: The establishing of an exchange program between the Royal Institute of Technology (KTH) in Stockholm, Sweden, and the City College of New York is described. The CCNY part of the exchange program has been in existence since 2005 and hosts 2-4 Swedish senior chemical engineering undergraduate or Master students from KTH every summer. The exchange program described in the following has enabled six CCNY undergraduate and Master students to perform research at KTH. Two of these students were funded by the Louis-Stokes Alliance for Minority Participation. The research topics ranged broadly from characterization of fiber materials and colloidal templating to solid oxide fuel cells and electrochemical characterization of metallic biomaterials. The students were placed in pairs into three laboratories.

INTRODUCTION (LIMIT: 1 PAGE)

In a world that is becoming more and more globalized, it is important that students receive their research training in an international and diverse environment. In an effort to provide such an environment, Dr. Kretzschmar requested IREE funding as a supplement to her NSF-CAREER award (#0644789) to establish an international research experience for undergraduate (IREU) exchange program between the Royal Institute of Technology in Stockholm (Sweden) and The City College of New York (USA).

The CAREER award in very general terms proposes a strategy for the synthesis of submicron " patchy" particles and the understanding of their molecular directed assembly. The research currently being performed shows that it is possible to generate gold patches with areas as small as 3.7% of the particle surface using glancing angle evaporation (GLAD).[1] A simple mathematical model allows us to correlate patch shape and size with particle size, angle of incidence and the particle monolayer angle. Excellent agreement between mathematically predicted patches and scanning electron images is observed. We have also shown that the gold surfaces on the polystyrene particle surface can be modified with bifunctional molecules such as

octane dithiol using fluorescent tagging of the unbond thiol functionality and confocal microscopy. Further, we have developed a procedure for the measurement of IR spectra for potential linker molecules yielding well defined IR spectra. More recently, two new classes of patchy particles with overlapping and non-overlapping patches have been fabricated.[2] Particles with non-overlapping patches present patchy particles with a branching anisotropy dimension, while particles with overlapping patches fall into the chemical ordering anisotropy dimension.[3] Further, we have shown that overlapping patches can be used to reduce the patch size achievable with GLAD from 3.7 to 1.7%. The simple mathematical model described above has been extended to include the additional patch and to calculate the patch overlap. As a result, the model can be applied to determine the accuracy of our PDMS stamping technique. In addition, in collaboration with O. Velev at NC State University, we have started to map the AC field assembly behavior of our patchy particles as a function of patch size and relative position on the particle surface.

The IREU candidates were selected based on their research experience, their academic standing and their personality. A flyer advertising the IREU program was posted visibly in the Chemical Engineering department and distributed through the mail server of the Louis Stokes Alliance for Minority Participation (LSAMP) program. The flyer requested interested students to submit a resume and a two-page assay explaining how such an experience would affect their life to the PI. All applications were reviewed and the top six candidates were selected and interviewed by Dr. Brathwaite and Dr. Kretzschmar for their suitability to participate in the exchange program. The two most important selection criteria were maturity of the student and possible impact of the IREU program on the student' s career. Four of the students were students with research experience in the group of the PI related to the CAREER award and two were students with research experiences relevant to the CAREER research, but in other research groups. The final candidates are summarized in **Table 1**.

Table 1. List of Participants

Name	Status	Departure Date	Return Date
Diana Castillo	Chemical Engineering Senior	06/03/08	08/15/08
Julius Edson	Chemical Engineering Sophomore	06/03/08	08/13/08
Amara Enemuo	Computer Engineering Junior	06/03/08	08/13/08
Ayanna Moses	Chemistry Master Student	06/03/08	08/13/08
Charlie Corredor*	Chemical Engineering Junior	06/17/08	08/13/08
Terrance Burks*	Biochemistry Master Student	06/08/08	08/17/08

*Supported by Louis-Stokes Alliance for Minority Participation

The benefits expected of the IREU program range from an interesting research experience for US undergraduate and Master researchers in a diverse international environment to an international materials science and interfacial phenomena network for the PI. The former is important in preparing students for the new job market and help them to quickly adapt to new circumstances

while still being productive. The latter is of importance for the dissemination of research results relevant to the CAREER award and the recruitment of students to CCNY. Further, the exchange with scientists from different countries helps to evaluate research practice and structure in the US.

The students were hosted by three laboratories; (i) the Division of Corrosion Science headed by Professor Jinshan Pan, (ii) the Division of Functional Materials headed by Professor Mamoun Muhammed, and (iii) the Division for Wood Chemistry headed by Professor Monica Ek at KTH. The Division of Corrosion Science is working on improving the understanding of corrosion mechanisms, the influence of microstructure, passivity, and corrosion resistance. The Division of Functional Materials is housed at the Kista Campus and investigates energy, biomedical, and optoelectronic applications of nanomaterials. The Division of Wood Chemistry is pursuing pathways to convert wood components into valuable green chemicals and materials products.

RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE INTERNATIONAL COOPERATION

In the following, the six research projects of the students are briefly described together with their major accomplishments as well as their interaction with their research advisors. More detailed information is available upon request.

Research in the Division of Corrosion Science

Julius Edson. Title: Electrochemical Measurements of Metallic Biomaterials
The aim of this project was to gain an understanding of the electrochemical properties and the corrosion resistance of a titanium alloy and a super alloy composed of titanium and cobalt alloys. We find that titanium sintered with cobalt based alloy has a better corrosion resistance than titanium alone under phosphate-buffered saline (PBS) conditions. The addition of hydrogen peroxide to the PBS solution influenced the electrochemical behavior and the corrosion resistance of both alloys. For a complete understanding of the potentials of the sintered alloy TiMP35N further studies will be needed in multiple electrolyte solutions.

Ayana Moses. Title: Electrochemical Behavior of TiMP35N and MP35N Alloys for Surgical Implants
The electrochemical behavior and corrosion resistance of MP35N and TiMP35N, an alloy of Ti coated MP35N were measured in electrolyte of saline solution and of saline with hydrogen peroxide. The corrosion resistance of MP35N in just the pure saline of PBS was an order of magnitude less that when peroxide was added. However, when compared to TiMP35N it was less resistant by a factor greater than two. Results from the potentiodynamic polarization suggest that Ti present in the increased oxide layer help to increase the corrosion resistance of the alloy. Thus, TiMP35N would be a more favorable alloy for pacemaker application compared to MP35N alone. Further analysis will include subjecting plain titanium to the varying electrolyte solutions to support the conclusion and measuring the concentration of metal release during electrochemical testing.

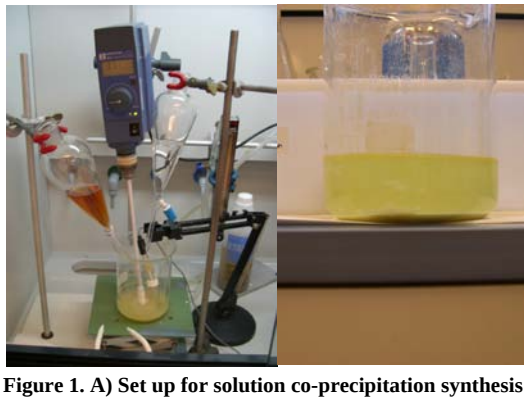

Figure 1. A) Set up for solution co-precipitation synthesis of BSCF material. B) BSCF material.

Research in the Division of Functional Materials

Charlie Corredor. Title: Synthesis and Characterization of Nanostructured BSCF Cathode Materials for Solid Oxide Fuel Cells

In this project, an innovative method to synthesize nanostructured BaSrCoFeO (BSCF) cathode materials for a solid oxide fuel cell has been developed (**Figure 1**). The method involves a neat, reliable and straight forward solution co-precipitation technique that can be use for large scale and mass production of these materials bringing fuel cells a step closer to becoming the next environmental friendly energy source for humankind. Analysis of the BSCF material with thermogravimetry (TGA) and X-ray diffraction confirmed the oxalate structure. Future research requires (i) measuring the conductivity of the BSCF material over a wide range of temperatures and its thermal expansion coefficient, (ii) performing DFT calculation of BSCF materials, and (iii) using Raman Spectroscopy to analyze the vibrational modes of the BSCF.

Terrance Burks. Title: Microporous Metallic Surfaces using Colloidal Templating Method for Heat Transfer Enhanced Surfaces

The main objective of this project is the preparation of colloidal layers for use in the preparation of porous surfaces. Electrophoretic deposition is used as a micro fabrication technique for the assembly of colloidal particles. The method uses a local electric field in a colloidal suspension which is generated by a microelectrode. A solution of dispersed SiO_2 (silica) microspheres (23 nm) is utilized along with Cu surfaces as substrate (**Figure 2**). A 0.10 mm Pt wire is used as the micro-counter electrode. A total of 8 trials have been conducted to find the best parameters that would fulfill our requirements for complete multilayer substrate coverage. Subsequently, the colloidal layers are analyzed with Thermo Gravimetric Analysis (TGA) to verify the weight percentage and scanning electron microscopy. Future experiments will involve the Cu deposition into the colloidal layer followed by removal of the silica templates with HF leading to a porous Cu substrate.

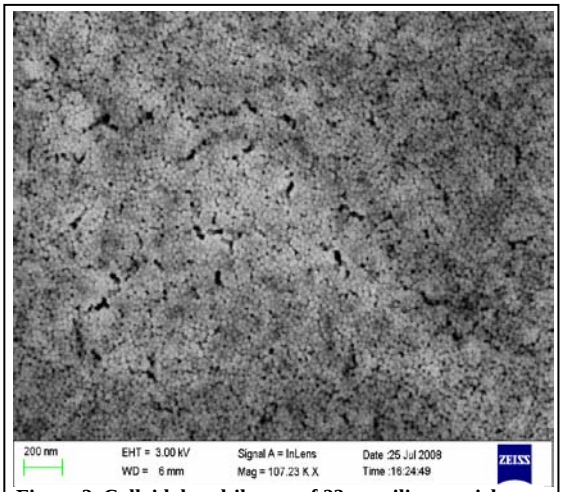

Figure 2. Colloidal multilayers of 23 nm silica particles on copper substrate assembled by dielectrophoretic method.

Research in the Division of Wood Chemistry

Diana Castillo. Title: Biointeractive Fibers with Antibacterial Properties

The main focuses of this project is the fabrication of new modified structures by building up polyelectrolyte multilayers onto their surfaces and finding possible methods to quantize their antimicrobial activity. Polyelectrolyte multilayers were built up using polyvinylamine C_6 (PVAm-C_6) as a polycationic polymer and polyacrylic acid (PAA) and microfibrilated cellulose (MFC) as polyanionic polymers. Quartz crystal microbalance and surface FTIR measurements were performed to confirm the formation of layers on the silicon wafers and glass substrates. In addition, techniques such as Contact Angle measurements prove an increase in hydrophobicity for surfaces treated with methanol, ethanol, and isopropanol. Although several analyses ensured the presence of multilayer built up it was not possible to determine a clear relation between the number of layers formed and amount of polymer absorbed.

Amara Enemuo. Title: Influence of monocomponent enendoglucanase on different fiber materials: Study of accessibility and reactivity

In this project, the main focus is on investigating the influence of several enzymatic pre-treatments on paper grade samples from hardwood (eucalypt, birch) and annual plant (sisal). This is achieved by evaluating the effect of hemicellulose content in cellulose reactivity and the influence of cold and hot alkaline extraction on cellulose reactivity of different paper-grade pulps. Evaluation of these parameters is done using Fock`s method and carbohydrate analysis. We find that cold alkaline extraction has a positive

effect on reactivity in contrast to hot alkaline extraction. From the gas chromatography outcome of sisal, eucalyptus and birch, these pulps exhibited very similar characteristics of dissolving pulp in terms of hemicellulose content. When endoglucanase, is added to the pulps, the degree of polymerization decreases, and thus leads to an increase in the reactivity of the hydroxyl groups.

Relation to current award

Five of the six projects are related in a broad sense to the CAREER project. The projects carried out by **Moses** and **Edson** taught the students about electrochemistry on metal surfaces and how to interpret the corrosion stability of these surfaces, which will be relevant to patch stability studies planned for later years. The two projects in the Division of Functional Materials are most closely related to the CAREER project in that they show (i) new pathways to materials formation (**Corredor**) and (ii) use of colloids for templating (**Burks**). One of the projects from the Division of Wood Chemistry is also related to the CAREER project in that is introduced students to the concept of layer-by-layer assembly (**Castillo**), which could be applied to the patch surface. The last project (Enemuo) is not related to the CAREER work but still provided a Computer Engineering student with a Biochemistry research experience. In a somewhat broader sense, this IREU program addresses the educational work of the CAREER project in that it provides an international research experience for undergraduate and Master students at CCNY.

Interactions with Host Laboratory.

As is evident from the experience reports (available upon request), all six students had quite different personal experiences in Sweden. However, overall all students were fully immersed and integrated in their research groups and accepted as fulltime members of the KTH Divisions. They interacted daily with their direct research supervisors who were usually PhD students in the laboratories the students were assigned to and at least weekly with the professors heading the divisions.

BROADER IMPACTS OF THE INTERNATIONAL COOPERATION

This IREE supplement to the CAREER award enabled the establishing of an International Research Experience for Undergraduate and Master Students at CCNY and increased the diversity at KTH. All six students who were selected for the IREU program are from underrepresented minority groups. Four are African-American and two are Hispanic and three of them are female. Sweden has a high number of Caucasian inhabitants and very few Hispanic and African-American immigrants. Stockholm as a city is a little more diverse, but still heavy on the Caucasian side with the exception of the Kista area, which has a higher percentage of immigrants. The IREU program brought diversity to the KTH campus and may in some cases even have opened the doors for participation of future immigrants and KTH undergraduates in KTH research. Traditionally, KTH undergraduate students are not involved in research on campus.

As part of the IREU program, Dr. Kretzschmar traveled to Stockholm in August 2008 for a poster session where the IREU students presented their research to the KTH faculty. During this poster session KTH faculty who apparently had never met were connected and found out about common research interests (**Figure 3**). In addition, Dr. Kretzschmar was able to meet with researchers from the Institute of Surface Chemistry and laid the foundation for future collaborations with Professor Mark Rutland. Currently research discussions are underway involving the use his Surface Forces Apparatus to measure stickiness of the patchy particles. As part of the IREU, Dr. Brathwaite (LSAMP coordinator) and Professor Raymond Tu also accompanied the PI to KTH. They connected with the international program coordinators and researchers in the School of Biochemistry.

Figure 3. IREU Students (front row 1-5 from left), KTH students, staff, and faculty after IREU poster session at KTH (Summer 2008).

Most importantly, the research exchange has lead also to a year-round agreement between KTH and CCNY for student exchange. Currently, 4 CCNY students are spending their spring 2009 semester at KTH and 2 KTH students at CCNY. Further, two participants (Julius Edson and Charlie Corredor) have been selected for a second international program in the summer 2009, which enables them to do research in Austria and France. One of the Master Students, Terrance Burks, has received funding to complete his PhD at KTH in the laboratory of Professor Mamoun Muhammed. Diana Castillo was able to secure a position at a big chemical company due to her international research experience.

The enhancement of the international perspective for the US researchers is best shown by citing from their experience reports:

Julius Edson. *"Amazing would be how I would describe the research opportunity. I never would have imagined that I would be given a chance to have a research experience abroad so early in my undergraduate career. The people in the Corrosion lab at the Royal Institute of Technology (KTH) were all amazing people. They were so insightful and extremely knowledgeable in the field, but at the same time accepted me warmly and taught me all that I needed to have a successful summer. Never once did I feel isolated, and though I was expecting it, there was not even a looming language barrier. They thought me a lot so I was glad to be able to help the lab anyway I could. During my time there, I was able to use some of my other skills with computers to setup a wireless networking in the lab. There were also times were we would explain certain meanings of English words to those in the lab that wanted it. There was an exchange of information of all sorts, and it truly felt like a small research family."*

Ayana Moses. *"We took the opportunity to do a mini EuroTrip while in Europe. Everyone wanted to visit the more popular cities but we had to settle for four destinations. We visited Oslo, Norway, where we visited Nobel Peace Prize center, took a tour on the bay, visited a few Viking museums, and the Vigiland sculpture garden. We also visited the new opera house and Diana encouraged us to take pictures as we jump up. Our next tour was to Berlin, Germany. This was very educational as we took a guided tour to sites around the then Berlin Wall. Helsinki, Finland was our next stop of which I wish I didn't waste my money to visit since the city wasn't very exciting. But the 16 hour cruise on the Viking line somewhat capped of that experience. The ship was huge and the buffet was too much to consume, wish I could have some of that food right now. Our final trip was to Paris, France and it was a nice end to our Eurotrip. The hotel was a little nook in the wall on a street somewhat similar to rowdy Harlem Manhattan with small streets. What amazed me more is the reservation of historical architecture. It felt like I was walking through history as I encountered the Louvre museum. We also visited the Eiffel tower twice and took some amazing pictures both times."*

Charlie Corredor. *"As a vivid example, I met a woman in my lab from Romania and for some reasons, which were inexplicable to me; she said that "Americans are destructible and arrogant people who want to take control over everything." However, after talking and spending time with her she realized that we, Americans, are not like what she imagined. I completely changed her perspective of Americans by showing her my manners and by telling her that 95% of the time we are nothing like what the media presents to the world."* and *"As a scientific aspect of my experience, I observed and practiced a new way of approaching science at the Division of Functional Materials at the Royal Institute of Technology. Productivity and deadlines are a big motivation in the research life style, showing me that working in the lab could be stressful as well. At the beginning, it was really hard to understand and fit into this work style because I thought that the only researchers who work under pressure are the people who work in industry, but with time and explanation of my mentor and advisor I became familiar with it. After having adapted to these work habits I decided to discuss them with my mentor at CCNY and the possibility of apply them in our lab. Also, it is part of my understanding that this new methodology will take time to be used by all of the members in our group but, I strongly believe that if all of them including myself start applying this work strategy, this will enhance our productivity and efficiency."*

Terrance Burks. *"When I arrived in Sweden, I was taken aback by the genuine kindness of the Swedish people. I told myself after deboarding the plane to put your New York face on, which means do not talk or say anything too me. As I was being taken to meet our coordinator, the driver was teaching me how to*

speak Swedish. I think I had the best experience out of the other researchers, due to the fact; I had the privileged of living with a Swedish family. I experienced from them how they perceived Americans. The citizens are very in tuned with American politics. They might know more than we, Americans. What I learned from the people of Sweden was to treat people as Americans despite their ethnicity. This is an extremely difficult task to overcome, but; I will achieve it. Not one time did I hear anyone refer to me as African-American. I will always remember the conversation I had with a professor from Iraq. He told me that it breaks his heart when he hears Americans refer to other Americans based upon their ethnicity. He said that everyone is like a flower; we have a distinct color, fragrance, and texture' but; we are still a flower. If one does not speak, you are assumed to be Swedish until otherwise, which I found to be very liberating."

Diana Castillo. *"When I got to the Royal Institute of Technology in Sweden, what I considered obvious was not that obvious and I encountered many different uncomfortable situations due to the differences between the United States and the Swedish Systems. I do not think that either of them is wrong but they are very different. Probably, since this was the beginning of the program there were a couple of things that were not stated clearly and some of them needed to be worked out during the first round. However, for me this experience was full of great lessons. For the first time in my life I was alone in a lab and I had to decide on my own how to schedule my experiments and when and what type of analysis I could performed on them. Due to the freedom that I was given, I could experience something that I consider extremely important for my near future as researcher, the power to develop the confidence to do things on my own."*

Amara Enemuo. *"All work and no play make Jill a dull girl. I loved my working environment. It had a nearly 50/50 gender distribution, and comprised of two different specializations on the same floor. During lunch time, those who did not go out sat in the dinning area for lunch. There I met new people. It was a time to catch up with fellow co-workers. From our conversations, I learned many new things about Sweden and its customs. I also learned from other researchers from Spain, Brazil, Japan and Argentina. When it was very hot, we would have lunch outside - like a picnic. Sometimes we ate on the roof of our lab. During the week, usually once, twice or even more everyone would gather for "fika". This was a time for cake and coffee or tea accompanied by other types of desserts, usually made by fellow researchers. It was the social highlight of the week and everyone including me looked forward to it especially on busy days. It was a time to relax."*

DISCUSSION AND SUMMARY

This IREE supplement enabled the establishment of a true international research exchange program for undergraduate and Master Students between the Royal Institute of Technology and the City College of New York. It provided wonderful and educational research experience for six students from underrepresented groups and thereby increased the diversity at the host campus. The experience affected the lives of these six students positively in making them aware of international research practices, exposing them to European culture and habits, and by making them realize that they can succeed in any environment.

As recommendation for future operations of the IREE program, we think that it was extremely useful to have a group of undergraduate and master students travel together. In addition, we found that the mix of scientific and engineering backgrounds was also very supportive. The students were able to support each other in different ways due to their diverse backgrounds. We found that it was important to bring the students together prior to the trip, which was possible at the pre-travel conference in Washington. We noticed that the $5000 allowance given to the students was a little too small due to the weak dollar during the summer 2008. While the students felt that knowing Swedish would have enabled them to immerse deeper into Swedish culture, they also realized that English allowed them to interact with the Swedes.

ACKNOWLEDGEMENTS

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Materials), and Professor Monica Ek (Division for Wood Chemistry) for providing the research projects to the IREU program and for mentoring and advising our six exchange students.

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BRIEF BIOGRAPHIES OF RESEARCHERS

Ilona Kretzschmar Ilona Kretzschmar received her Diploma (1996) and PhD (1999) degrees in Chemistry from the Technical University of Berlin. From 2000 to 2002, she was a Feodor-Lynen postdoctoral fellow at Harvard University and from 2002 – 2004 a research associate in the Department of Electrical Engineering at Yale University. Currently, she holds an associate professor position with tenure at the City College of New York. Her research interests range from particle surface modification via nanomaterials to molecular directed assembly.

Anna Haraldsson received the MS in Chemical Engineering from the Royal Institute of Technology in 2006. Since 2007 she has served as the coordinator for the International Students at the School of Chemical Science and Engineering and the School of Biotechnology at KTH. Since 2008 she also works as instructor at the Chemical Engineering Undergraduate Laboratories.