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Research Internships in Science and Engineering

Research Interns in Science and Engineering (RISE)
Summer 2000 - Student Projects

Student Major/School	Mentor	Faculty Sponsor	Department	Student Project
Meghan Brown Chemical Engineering UCSB	----	Joseph Zasadzinski	Chemical Engineeirng	Morphology of lipids found in natual lunch surfactants
Helen Chang Biochemistry Cell biology UC Riverside	Heather Evans	Cyrus Safinya	Materials	Using fluorescence microscopy to understand behavior of cationic lipid/DNA complexes for gene delivery
Scott Crosier Geography UCSB	-----	Mike Goodchild	Geography	Metadata for computer models
Andrew Fisher Chemistry Dartmouth College	Jan Sumerel	Dan Morse	Biology	Structural control of polysiloxanes synthesized by silicatien
Alexander Gagnon Chemisry Berkley	Jennifer Martinez	Alison Butler	Chemistry	Amphiphilic properties of a physiological mixture of marine sederophores
Will Gans Mechanical Engineering Berkley	Vladimir Tolpygo	David Clarke	Materials	Development of a method for producing defined surface roughness of an Fe-Cr-Al-Y substrate
Matthew Garten Mechanical Engineering UCSB	-----	Kimberly Turner	Mechanical Engineering	MEMS SCREAM processing
George Deepak Microbiology UCSB	-----	Leslie Wilson	Microbiology	Structural study of tubulin using the Saccharomyces cerevisiae system model
George				

Roshni Biochemistry UC San Diego	Ayesha Ahmad	Cyrus Safinya	Materials	Effect of various concentrations of helper lipids in DNA transfection efficiency
Sara Graves Chemistry UCSB	Matt Robinson	Guillermo Bazan	Chemistry	Organic polymer LED's
Sherri Gwizdala Chemistry Alma College	-----	Galen Stucky	Chemistry	Characterization of Si:BaGaGe as a thermoelectric material
Alan Harvey Biochemistry UCSB	Tim Bullock	John Perona	Chemistry	Mechanism of RNA-dependent kinase PKR
Robert Klein Chemical Engineering UCSB	Maarten Biesheuvel Ben Yu	Fred Lange	Materials	Synthesizing the lotus effect using ceramic materials
Edward Letts Physics UCSB	Yewhee Chye	Pierre Petroff	Materials	Characterization of Fe thin films on GaAs
Michael Mackel Chemical Engineering UCSB	Bret Coldren	Joseph Zasadzinski	Chemical Engineering	Phase behavior and mechanical properties of catanionic surfactants
Jody Major Biochemistry UCSB	Chol Steven Yun	Geoff Strouse	Chemistry	Using nanocrystals for spectroscopy of protein folding
Abraham Mara Physics UCSB	-----	Deborah Fygenson	Physics	Structural characterization of tubulin
Arnaldo Marrero Chemistry Universidad Metropolitana, P.R.	-----	Nicola Hill & Roy Smith	Materials & Electrical & Computer Engineering	Computer modeling of PbSe/PbTe nanocrystals structure
Juan Martinez-Alvez Mechanical Engineering University of P.R.	-----	Nicola Hill & Roy Smith	Materials & Electrical & Computer Engineering	Shape and size dependance of optical properties in PbSe system

Aric Monts-Homkey Archaeology UCSB	Anabel Ford	Mike Goodchild	Geography	GIS applications in Archaeology
Malini Ranganathan Chemistry Bard College	Jianjun Cheng	Timothy Deming	Materials	Characterization and synthesis of beta-polypeptides
Jovan Rivera Montes Computer Science Universidad Metropolitana, P.R.	-----	Ming Li	Mechanical Engineering	Web-based interface for porgram plagerism detection
Marc Soares Materials MIT	-----	Samir Mitragotri	Chemistry	Characterization of chemical enhancers for transdermal drug delivery
Aundrea Tavakkoly Physics UCSB	Brian Gergen	Eric McFarland	Chemical Engineering	Growth and characterization of thin film Schottky diode sensors
Jeannie Wisch Chemistry UCSB	Christof Brandli Tom Jaramillo	Eric McFarland	Chemical Engineering	Combinatorial approach to photosynthetic hydrogent fuel production

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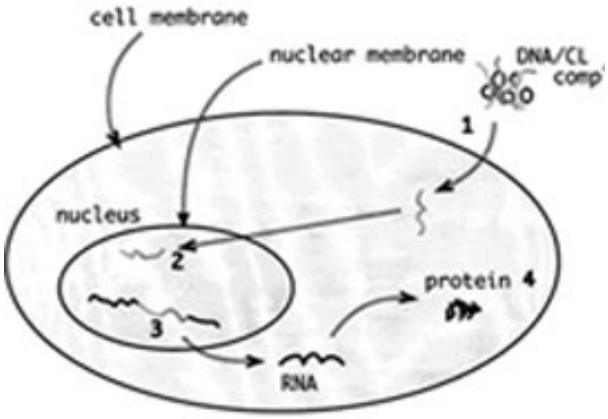
Helen's Project Page - RISE summer 2000

Intern: Helen Chang, Biochemistry/Cell Biology, UC, San Diego
Mentor: Heather Miles
Faculty Supervisor: Cyrus Safinya
Department: Materials

Using flourescence microscopy to understand the behavior of cationic lipid/DNA complexes for gene delivery.

Gene therapy enables the successful transfer of foreign DNA into a cell to correct defective or add missing genes. This phenomenon is currently studied vicariously in science and is being examined with multiple parameters. There are many factors that contribute to the successful transfer of foreign DNA into mammalian cells, but presently the methods of viral gene delivery is far more prevalent than its counterpart, nonviral gene delivery. There are clear differences between the two methods of gene delivery systems, but the most significant difference is that viral gene delivery is currently more efficient. Since nonviral gene delivery can take in large pieces of foreign DNA into a cell and does not trigger the human immune system immediately, being able to increase the efficiency of nonviral gene delivery will be a remarkable breakthrough in this vast field. The phrase, ænonviral gene delivery,Æ refers to the fact that nonviral vectors, or nonviral carriers, are used to aid the transfer of foreign DNA fragments into a cell. Just in the past few years, the development of synthetic nonviral vectors has become a popular study with the main intention of trying to increase the efficiency of nonviral gene delivery. Dr. Cyrus SafinyaÆs group at the University of California, Santa Barbara is primarily concentrated on the use of Cationic Lipids (CL) as a nonviral vector in gene delivery. In using fluorescence microscopy (inverted and confocal microscopy), my first objective for my summer project was to understand the methods of introducing foreign DNA into a cell, or in other words, the process of transfection. My second main objective was to understand the methods and techniques used to master the confocal and inverted microscopes in order to visualize the structures and images of the individual cationic liposomes and DNA, or the complexes themselves, from the multiple transfection experiments that were performed.

Figure 1 shows a simple schematic of gene therapy, where we take cationic lipids, used as the nonviral vector, to introduce the foreign DNA into a cell. Once the CL/DNA complex has passed through the cellular membrane, we hope that the DNA is broken free from the complex and released in the cell. The DNA will then pass through the nuclear membrane into the nucleus, which will eventually be transcribed into RNA and then expressed into protein. My part of the project was primarily focused on the process of transfection alone (points 1-2). Although I briefly learned the



1-2 = transfection time (6 hrs.)

3-4 = expression time (24 hrs.)

techniques to study the expression of DNA during the summer, I focused on studying the images taken from transfection. Another intern in the research group focused on how much protein was expressed from foreign DNA (points 3-4).

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Scott's Project Page - RISE summer 2000

Intern: Scott Crosier,Geography, UCSB
Faculty Supervisor: Mike Goodchild
Department: Geography

Metadata for computer models.

In 1989, Science Magazine had an article titled "Is it real or is it Crazy?" (Pool, 1989) in which they were introducing a whole new field of science referred to as computer experimentation. At that time only a handful of laboratories across the globe had the "super computers" large enough and /or powerful enough to operate computer models. Now, nearly 12 years later, computer models can be transferred "over the web" or "burned" onto a plastic disk, and downloaded into a palm-held computer. As technology continues, I'm sure that in the near future we'll look back at today's greatest technology as if were archaic. This sudden boom in technology has been paralleled by a sudden influx of computer models into the scientific community. Models are being used for research and understanding of everything from Hydrology to Yarn manufacturing, from gold deposits to survival rates in ICU's. With this sudden flux, comes a bit of confusion. The problem that arises is that, to date, there has been no standard method for one person to communicate with another about the model that they have, and with this breakdown in communication, there lies a breakdown in the ease of sharing knowledge and experience. For this cause, a Computer Model Metadata Standard has been needed. The driving force behind this effort to develop a computer model metadata standard, is the increasing number of digital libraries, registries, and clearinghouses, and the need (and desire) to be able to catalog computer models in these sources. It is through these sources that the knowledge and experience gained in model technology can be shared and distributed. The effort of creating a model metadata standard is taking place in the academic arena. The academic community has a vested interest in computer models. Not only are models used both in instruction and research, but also it is through said research that many models are developed. The academic circle will be able to develop standards that will be useful for academia, yet applicable and accepted to those both in government and industry.

What is Metadata?
Quite simply put, Metadata is Data about data. (Clarke, 1999) Metadata is the descriptors of a particular data set or object. I like to use the idea of a painting to describe metadata. Lets take for example the painting in figure 1. One of the first things we can tell about this painting is that it was painted by Picasso. (The Play-do head gives that one away). What else can be

said about this painting? Well, with a little research we can find out the title [(A portrait of E. M. Walter (Meme)] and that it was painted on October 21st, 1939. So we have three "elements" of the painting's "metadata." What else would someone care about?
A picture framer or a gallery would want to know the size. The size is 41cm X 33cm. An artist might be interested in how it was done. It was a pencil and oil done on canvas. An art critic or art history student might even be interested in how others interpret the painting. (By the way, they say that it reflects the love that he had for her?) All of these elements describe the picture. If I saw the picture in a gallery or museum and I had a pretty good understanding of Art History, I might be able to deduce all of this, but what if I couldn't see the painting, or I needed to catalog this painting? That is where the painting's metadata comes in helpful, if not necessary.

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Andrew's Project Page - RISE summer 2000

Intern: Andrew Fisher, Chemistry, Dartmouth College
Mentor: Jan Sumerel
Faculty Supervisor: Dan Morse
Department: Biology

Production of His-tagged silicatein a fused to green fluorescent protein and His-tagged red fluorescent protein.

The sponge, Thethya aurantia, produces large quantities of polymerized silica at ambient temperatures and pressures by biological mechanisms that are poorly understood. The siliceous spicules produced by this sponge contain a core axial protein filament that is layered with a highly repetitive silica structure. Three homologous protein subunits comprise the filament, and members of the laboratory named them silicateins (for silica proteins). They have dissociated these subunits to yield three similar subunits named, alpha, beta, and gamma. The most abundant of the subunits, silicatein alpha has been cloned and sequenced. Sequence analysis has revealed that this protein is highly similar to members of the Cathepsin L family of papain proteases. Using an in vitro assay at neutral pH, several members of Dr. Morse's lab have shown that silicateins catalyze the polymerization of silica and silsequioxanes from tetraethoxysilane and organically modified silicon triethoxides, respectively. It has been the goal of this work to engineer a chimera between silicatein-alpha and green fluorescent protein with a histidine tag in order to easily overproduce and purify fluorescent silicatein-alpha containing proteins in large quantities.

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Alexander's Project Page - RISE summer 2000

Intern: Alexander Gagnon, Chemistry, UC Berkley
Mentor: Jennifer Martinez
Faculty Supervisor: Alison Butler
Department: Chemistry

Amphiphilic properties of a physiological mixture of marine siderophores .

Iron containing proteins are essential for electron transport during respiration and photosynthesis as well as in nitrogen fixation among other important biological processes. Siderophores are low molecular weight organic iron coordinating compounds produced by certain bacteria and fungi. These compounds facilitate iron uptake in a variety of environments from terrestrial soils to the ocean surface. Iron acquisition in marine environments is especially challenging. The low solubility [pico to nanomolar (1)] of Fe(III) in neutral aqueous solutions leads to a limited iron supply. Low total iron levels in marine environments are significant enough to limit growth in certain areas of the world's oceans. Siderophores represent one important class of molecules that solublize iron in the marine environment. Understanding the coordination environment and uptake processes of the limiting nutrient is very important for understanding the effects on primary production and the global carbon cycle. The Butler group is currently studying Marinobactins; unique siderophores produced by a Marinobacter species. The distinguishing structural feature of these siderophores is an additional fatty acid "tail" attached to the common peptidic iron chelating head group. In general, amphiphilic compounds have both a polar and nonpolar region within one molecule. Opposing interactions between solvents and the separate domains of an amphiphilic molecule often force such molecules to self-assemble into ordered aggregates in solution. The molecules can form micelles, bilayers, or vesicles among other geometrical motifs depending upon the structure of the amphiphilic molecule and solution chemistry. Geometry and other aggregate properties also depend on the abundances of the individual amphiphilic species when heterogeneous aggregates are present. Recently, the Butler group has shown that the marinobactins exhibit unique amphiphilic properties (2). The marinobactins are produced in biological mixtures of varying fatty acid chain length and saturation (fig. 1). Marinobactin D showed a phase transition from micelles to vesicles upon addition of Fe(III). This novel and surprising transition from micelles to vesicles is effectively an iron switch.

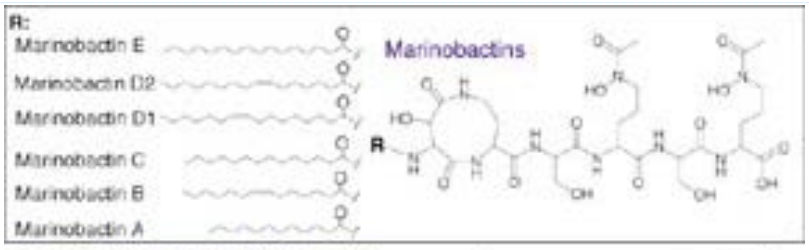

Figure 1: Marinobactin structures (2).

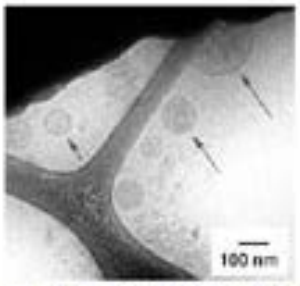

Figure 4: Fe(III)-Marinobactin D siderophore vesicles by cryoelectron microscopy (2).

Whether this so called "iron switch" is actually an important step for iron acquisition in this Marinobacter species is an interesting question. In the natural marine environment a physiological mixture of marinobactins of varying hydrophobicities is produced. The physiological mixture is of more interest than an isolated component when attempting to understand marinobactins actual behavior in the ocean. Using light scattering the so called "iron switch" was investigated for the physiological mixture of marinobactins. While the results from light scattering experiments can provide information about the existence and size of vesicles, it cannot provide information as to the composition of those vesicles. In an attempt to assess the degree to which each component of the physiological mixture participates in vesicle formation, High Performance Liquid Chromatography (HPLC) was used. The composition of the vesicles was assessed by comparing the relative ratios of the physiological mixture components in a complete "vesicle phase" preparation to a preparation of marinobactins in which the vesicles had been removed. In the experiment centrifuge filtration through a 0.22 µm filter was used as a new technique to remove vesicles from a solution.

1. M. Geldhill, C. M. G. van der Berg, Mar. Chem. 47, 41 (1994).
2. J. S. Martinez, G. P. Zhang, P. D. Holt, H.-T. Jung, C. J. Carrano, M. G. Haygood, A. Butler, Science 287, 1245 (2000)

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Will's Project Page - RISE summer 2000

Intern: Will Gans, Mechanical Engineering, UC Berkley
Mentor: Vladimir Tolpygo
Faculty Supervisor: David Clarke
Department: Materials

Development of a Method for Producing Defined Surface Roughness of an Fe-Cr-Al-Y Substrate.

Different methods for introducing a controlled surface roughness onto a Fe-Cr-Al-Y sample surface were explored. Roughness with a wavelength of l = 20-100 mm and up to 10 mm amplitude were sought. Ion milling and chemical etching were both used as means of material removal. Physically attached grids of different size and holographically-etched photoresist were used to selectively cover portions of the substrate surface during ion milling. Alternatively, niobium and silicon dioxide, deposited onto the substrate through a grid mask were used to protect the substrate during chemical etching. A maximum of 2-micron roughness was achieved using ion milling, while 4-micron roughness was achieved using chemical etching. Turbine Engines are an essential component of aircraft and power generation industries. The efficiency of the gas turbine is directly related to the temperature in the combustion chamber. Service temperatures for aircraft or power-generation turbine combustion chambers can reach up to 1500C. However, an increase in temperature of the metal components (in particular, the turbine blades) results in a degradation of their mechanical properties. In order to prolong the life and preserve the desired mechanical performance of the Ni-based superalloys, which comprise the functional part of the chamber, a Thermal Barrier Coating (TBC) is applied. Prior to TBC deposition, the superalloy surface is coated with aluminum-containing alloy, called a bond coat (BC) [1]. The bond coat increases adhesion of the TBC and corrosion (oxidation) resistance of the superalloy. During service, a thermally grown aluminum oxide (TGO) forms between the bond coat and the TBC. The properties and performance of this oxide layer largely determine the life of the whole component.

Fig 2. SEM photo of a rough bond coat surface

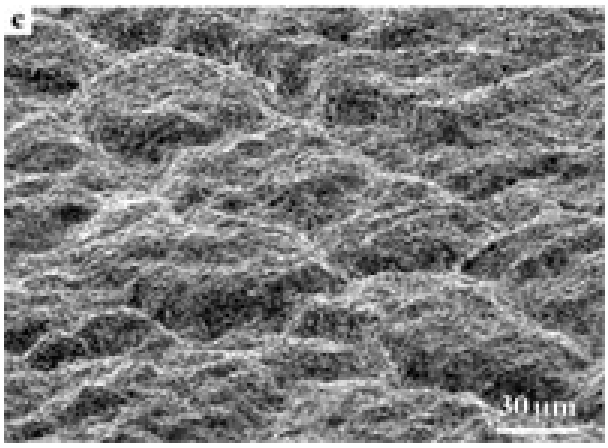

Figure 1 shows a simple schematic of gene therapy, where we take cationic lipids, used as the nonviral vector, to introduce the foreign DNA into a cell. Once the CL/DNA complex has passed through the cellular membrane, we hope that the DNA is broken free from the complex and released in the cell. The DNA will then pass through the nuclear membrane into the nucleus,

which will eventually be transcribed into RNA and then expressed into protein. My part of the project was primarily focused on the process of transfection alone (points 1-2). Although I briefly learned the techniques to study the expression of DNA during the summer, I focused on studying the images taken from transfection. Another intern in the research group focused on how much protein was expressed from foreign DNA (points 3-4).

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George's Project Page - RISE summer 2000

Intern: Goerge Roshni, Biochemistry, UC San Diego
Mentor: Ayesha Ahmad
Faculty Supervisor: Cyrus Safinya
Department: Materials

Effect of Various Concentrations of Helper Lipids in DNA Transfection Efficiency .

There are many illnesses caused by defective or mutated genes that are passed down from generation to generation. At present no effective cures for such diseases have been found. The best solution on a long term basis is to introduce functional genes in place of the defective ones. This process of replacing, adding or correcting defective genes by introducing a working gene is known as gene therapy. At the moment gene therapy is accomplished using various vectors (carriers) to carry the specific gene of interest into the cell. Certain viruses are used for this purpose. Though viruses are the most efficient carriers available at present, they, however, have certain disadvantages. One of these is the attack by the immune system of the host resulting in damage to the introduced gene. Other disadvantages include, the limited size of the gene that can be delivered, and the unexpected response of the viral gene as well. The other method is non-viral delivery which includes chemical as well as physical means of delivering the gene. Cationic liposomes provide a promising vector for use in gene therapy. There are many advantages to using liposomes. First of all, it does not limit the size of DNA that can be carried into the cell. Also, it is not prone to attack by the immune system, lipid toxicity is relatively low, and it can be produced rather easily. But as of now it is much lower in efficiency compared to the viral method possibly because the optimum conditions of DNA delivery and stability have not yet been fully worked out. The purpose of this lab's research is to find out optimal condition for delivery so as to increase the efficiency of the cationic liposome in delivering the gene into the cell. Introduction of genes into cells is achieved by a method called transfection. The cationic lipid currently used in the lab is, dioleoyl trimethylammonium propane (DOTAP). There are two main reasons for using DOTAP, which has a positively charged hydrophilic head. One is that, the positive charge of the liposome helps condense the negatively charged DNA and thus holds it in the structure. The second reason is that the negative charge of the plasma membrane and the positively charged liposome creates an electrostatic attraction that ensures the intake of DNA by the cell. DOTAP is combined with two neutral helper lipids dioleoylphosphatidylethanolamine (DOPE) and dioleoylphosphatidylcholine (DOPC). The helper lipids being neutral in charge help in stabilizing DOTAP and keep it from fast degradation. Two important differences can be seen in the structures of DOPE and DOPC. DOPE has a much smaller head compared to DOPC and this causes a difference in the structure of the complex as well as the efficiency.

From work done earlier in the lab the structures of the complexes have been studied through x-ray diffraction. There is the hexagonal structure where the liposomes form tubes that arrange itself into the hexagonal lattice, with the DNA forming a rod in the middle (Fig 2). The other structure is the lamellar which consists of the DNA sandwiched in between lipid bilayers (Fig 2). DOPC maintains a lamellar structure all the time. On the other hand, increasing the ratio of DOPE in the system causes a structural transformation from lamellar to hexagonal (Fig 2). Cationic lipid/DNA (CL-DNA) complexes contain the supercoiled DNA plasmid that carries the Luciferase gene (LUC, structure shown in Fig 3).

This gene was obtained from the N.American firefly. If the complex is taken up by the cells, the gene transcribed and the luciferase protein produced, then the protein, when mixed with a certain reagent produces a reaction that causes it to give off light. This intensity or amount of light can be measured using the luminometer where, based on the light given off, the amount of protein produced can be assayed. The efficiency of the transfection can therefore be found.

CL-DNA complexes are incubated with mouse cells for transfection. The steps involved in the transfection process is given in Fig 4. Data on transfection efficiency has been obtained from studies done earlier on the CL/DNA system (Fig 5). The blue lines indicate the DOTAP/DOPC system while the red lines indicate the DOTAP/DOPE system. Initially, the curves for both DOPC and DOPE are the same indicating that they have the same transfection efficiency. At this region DOPE and DOPC are both in the lamellar phase which accounts for them both having the same efficiency. At increasing amounts of Helper Lipid in the system, the curves start moving apart. While the curve for DOPC starts to decrease the efficiency curve for the DOPE system remains high. This indicates a functional change between the two systems. At higher ratios the DOPE exists in the purely hexagonal phase while the DOPC remains in the lamellar phase.

This summer my project involved experiments to find out whether the transfection efficiency can be further increased by having both DOPE and DOPC in the complex in the right amounts. For this purpose DOPE was added to DOPC in increasing ratios. Thus starting with just DOPC in the system, increasing amounts of DOPE were added and the results studied to determine the effect it had on the transfection efficiency.

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Sara's Project Page - RISE summer 2000

Intern: Sara Graves, Chamistry, UCSB
Mentor: Matt Robinson
Faculty Supervisor: Guillermo Bazan
Department:Chemistry

Amorphous Organic LED's .

Light-emitting diodes (LEDs) are the basis for many useful products including the screens on laptops computers and digital watches. Injecting electrons and holes into a compound allows for electrons and holes to combine. As the electron moves to its ground state, a photon of light is emitted (fig. 1). An ideal LED emits an equal amount of photons for every electron injected into the device.

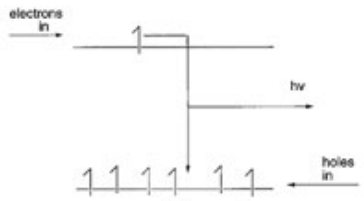

Figure 1

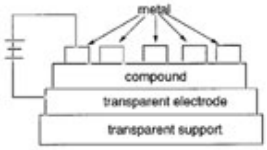

Figure 2

All LEDs that are currently in use are fabricated from inorganic compounds. We are attempting to synthesize an organic compound to be fabricated as an LED due to the advantages that they have over inorganic based LEDs. Firstly, they can be easily spin-caste into thin films, which offers a huge advantage over inorganic compounds. The compound can actually be spun-cast directly onto the substrate of the device (fig. 2). This allows for inexpensive an easy processing. Organic polymers are flexible. This allows for compounds that can be directly spun-cast onto a flexible plastic sheet that can then be illuminated. Another advantage is that these organic compound based devices can be fabricated by delivering the organic layer with an inkjet printer allowing for ultra high resolution and superior patterning. Finally, organic based LEDs have a much higher photoluminescence and quantum yield than inorganic based LEDs, potentially leading to a brighter more efficient device.

Organic based LED devices do have some disadvantages, however. They are generally less stable. Each device must either be encapsulated to keep it from breaking down from contact with oxygen, or some other means of preservation to keep it operating properly. Small organic molecules tend to be crystalline, which reduces emission yields. The current research is geared towards working around these disadvantages, further encouraging the synthesis of the target compound -- tetrahedral fluorene.

The target compound is a relatively small molecule rather than a polymer. The advantage of synthesizing a small molecule instead of a polymer is that the molecular weight of the

compound will be known. The exact structure of the compound will be known, unlike the case with polymers, where they can vary in size, and the exact structure is impossible to know. The Bazan group previously discovered that conjugated molecules with tetrahedral geometry are resistant to crystallization, thus solving the problem that small molecules tend to be crystalline. By arranging the target compound in tetrahedral geometry, the Bazan groups' discovery will be used in the synthesis of the compound to optimize its LED characteristics.

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Alan's Project Page - RISE summer 2000

Intern: Alan Harvey,Biochemistry, UCSB
Mentor: Tim Bullock
Faculty Supervisor: John Perona
Department: Chemistry

Mechanism of RNA-dependent kinase PKR expression.

In a relentless attempt to meet the project's goals in their entirety, it is only a minor drawback that the challenging time frame did not suffice for the assignment's flawless completion.

The murine RNA-dependent protein kinase, which derives its significance from the fact that it is a key mediator in a cell's antiviral activity was the focus of our study. As a response to a viral attack, PKR autophosphorylates itself and then phosphorylates other proteins in a sequence of events that triggers the eventual "shut down" of the cell. Our research goal for the summer was to successfully isolate PKR from E.Coli cells and to determine several of its biophysical and biochemical characteristics, as well as its complexes formed with target substrate proteins and activating double-stranded RNAs. This investigation of its structure might help us to clear up many urgent questions considering the mechanistic properties of PKR. In order to do this, we were going to head towards the production of crystals in order to determine its exact structure via Xray crystallography. Eventually, the detailed structural analysis of PKR could lead to a variety of experiments to synthesize small-molecule ligands which are able to jeopardize TAR RNA and Tat protein functions (both HIV components) that disrupt the antiviral activity of PKR. Unfortunately, we had difficulties with the purification of PKR from E.Coli cells.

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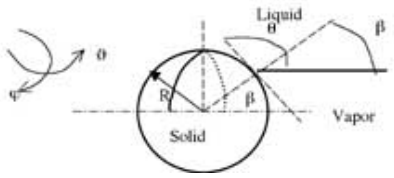
Robert's Project Page - RISE summer 2000

Intern: Robert Klein, Chemical Engineering, UCSB
Mentors: Maarten Biesheuvel and Ben Yu
Faculty Supervisor: Fred Lange
Department: Materials

Synthesizing the lotus leaf effect by adsorption of silica spheres on alumina surfaces .

When a liquid droplet is placed on a solid surface, the degree of wetting depends on the balance between the energy necessary for the enlargement of the surface (i.e., spreading of the droplet) and the gain of energy due to adsorption of the liquid on the surface [1]. The equilibrium wetting depends on two main factors: the set of surface tensions between the solid surface, liquid droplet, and the surrounding atmosphere; and the roughness of the surface. The contact angle of the liquid droplet on the solid surface indicates the degree of wetting. Flat alumina substrates were dip-coated in a dilute silica suspension and made hydrophobic by attaching fluorosilanes. These surfaces show very high hydrophobicity (internal contact angle for water up to 166). The surface coverage depends on the concentration of the silica suspension and influences contact angle significantly, in accordance with a model developed for a coating of silica spheres.



1] W Barthlott and C Neinhuis. Purity of the Sacred Lotus, or escape from contamination in biological surfaces. Ann. Botany, 79, (1997) 667.

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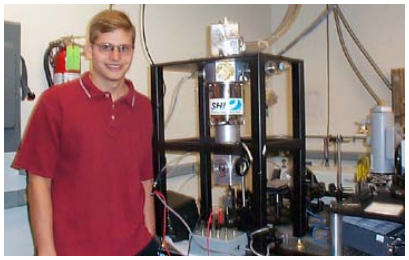

Intern: Intern: Edward Letts, Physics, UCSB
Mentor: Yewhee Chye
Faculty Supervisor: Pierre Petroff
Department: Materials

Characterization of iron thin films on GaAs for spin injector .

Thin Fe films and clusters can be grown on a GaAs substrate using molecular beam epitaxy (MBE). One of the possible devices that can be created from this combination of ferromagnetic material on a semiconductor is a spin injector, which might have important technological applications. So far there has been little success in building efficient spin injectors. A GaMnAs spin injector has been made, but it only operates at low temperatures, 4K. In order to build a spin injector we must first characterize the effects of the growth conditions of the Fe using an atomic force microscope (AFM), photoluminescence (PL), SQUID, and X-ray diffraction with the goal of making high quality Fe crystal lattices. I performed the measurements using the AFM and PL, while Yewhee performed SQUID and X-ray measurements. The primary properties that were studied with AFM and PL were the effects of Fe growth temperature and Fe film thickness on the topography of the sample and the electronic properties of a quantum well using AFM.

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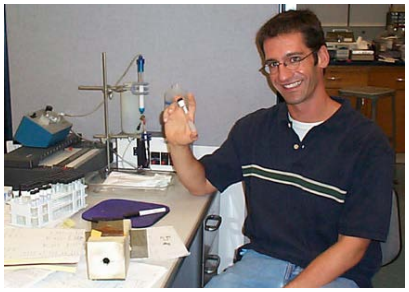
Michael's Project Page - RISE summer 2000



Intern: Intern: Michael Mackel, Chemical Engineering, UCSB
Mentor: Bret Coldren
Faculty Supervisor: Joseph Zasadzinski
Department: Chemical Engineering

Phase behavior and mechanical properties of catanionic surfactants.

The term catanionic surfactants has been coined to refer to a mixture of anionic and cationic surfactants. For decades ionic surfactants have been used in industry, largely to reduce surface tension between immiscible phases. Surprisingly, mixtures of cationic and anionic surfactant have received little attention from researchers until recently. Earlier researched focused largely on equimolar mixtures of cationic and anionic surfactants, which tend to form precipitates and yield little interesting behavior.

When mixed at ratios other than their equimolar compositions, catanionic surfactants yield a rich phase behavior. Most importantly, the microstructures arise spontaneously and persist indefinitely. Thus, they are equilibrium phases. This is in sharp contrast to many non-equilibrium surfactant phases studied in other systems. Phospholipid vesicles, for example, are currently the focus of much research as a proposed means of pharmaceutical delivery. While structurally similar to catanionic vesicles, phospholipid vesicles must be formed through physical or chemical means such a sonication or extrusion. Phospholipid vesicles are stable for long periods of time, but eventually revert to a flat lamellar equilibrium phase. Such reversion to a lamellar phase does not occur with catanionic vesicles.

Catanionic surfactants have many potential uses. Already, they are used in detergents and to reduce the energy lost to turbulence when pumping fluids (such as crude oil) long distances. Catanionic vesicles have the potential to be used as microreactors, where chemical reactions may take place under highly controlled conditions. Since they closely resemble the phospholipid bilayers that form cell walls, catanionic bilayers may also be used to model membranes for biological systems. Since catanionic surfactant self-assemble with highly ordered microstructure, it is hoped they might be used as templates for novel materials. Already, hydrophobic polymer monomers have been introduced into catanionic vesicle systems. These monomers may then be cross-linked to form hollow polymer spheres on the scale of hundreds of microns in diameter. Similarly, it is hoped that surfactants might be used to form nanoporous materials and materials with novel magnetic properties. Finally, mixtures of amphiphilic polymers and surfactants can yield hydrogels. These hydrogels may be predominantly water, but still demonstrate extraordinarily high viscosities.

The focus of this research project is to understand how the structure of surfactant molecules and the mixing ratios of anionic and cationic surfactants determine the mechanical properties of catanionic surfactant bilayers. Three parameters are used to describe the mechanical properties of bilayers: the natural radius of curvature, the bending modulus, and the saddle-splay deformation modulus. The natural radius of curvature is simply the favored curvature of the bilayers. The bending modulus is proportional to the energy needed to bend the bilayer away from this natural radius of curvature. The saddle-spay deformation modulus is proportional to the energy needed to form a saddle-point in the bilayers.

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Jody's Project Page - RISE summer 2000

Intern: Jody Major, Biochemistry, UCSB
Mentor: Chol Steven Yun
Supervisor: Geoff Strouse
Department: Chemistry

Protein folding studies give insight into the mechanism and environmental conditions as to the most optimal environment for active proteins. Under physiological conditions, proteins typically exist in their non-active unfolded structure. Upon binding of a catalyst, folding into the proteins' active conformation is initiated followed by an unfolding event that occurs with the loss of the catalyst in the environment. To monitor the process of the folding event, a change in the optical properties of the proteins must occur for detection by spectroscopic means. Proteins, while exhibiting change of secondary and tertiary structure as seen through circular dichroism and UV absorption, can not be mechanistically studied with current technology. We can not confirm the exact confirmation changes that take place during binding.

The ability to detect binding events in biological materials has been limited mainly to the use of radioactive ligand labeling assayed by either autoradiography or through conjugation with biotin or other flourochromes. While both methods of analysis give accurate results, they are usually inconvenient to work with due to the radioactive elements and are time consuming due to exposure times of up to several weeks. Binding events as detected through optical spectroscopy are also limited with the use of conventional flourophores. Flourophores can typically only absorb light at a very specific wavelength making it difficult to excite the electrons in the system. The then emit light in a very broad range. In a system with two flourophores, it becomes difficult to distinguish between the two separate emissions due to cross-talking of the peaks.

A more efficient system would be one that exhibited the exact opposite of the common flourophores. This would be one that can absorb light at almost any wavelength and then only emits light at a very specific wavelength. This type of system could be accomplished with the use of nanocrystals. Particles in the range of 2nm in diameter up to almost 100 nm exhibit physical and optical properties that are not seen in bulk material. This is due to quantum confinement effects. At this size, quantum mechanics plays a large role in the optical properties of these materials. Semiconducting CdSe nanocrystals and metallic Au nanocrystals are the most commonly studied nanocrystals. Their ability to have a narrow, tunable, symmetric emission spectrum allow them to be in some cases superior to the existing flourophores.

To examine the use of nanocrystals in bio-material based sensors, it is first necessary to understand the binding properties that would be needed in such a system. In this report, we present a method of binding nanocrystals to specific sites on a peptide for controlled assembly through stoichiometric addition. Both CdSe and Au nanocrystals were studied due to their accessibility. For binding with biomaterials, the organically soluble nanocrystals must first be modified to be water soluble because the peptide is also water soluble. A methods for the ligand exchange of CdSe is also presented here to change the surface properties of the

nanocrystals.

Upon success of appending nanocrystals to a short peptide, electron and energy transfer studies can be done to determine the efficiency of this system. Further studies of larger proteins and more specific binding would also have to be done to eventually create a usable biosensor.

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Juan's Project Page - RISE summer 2000

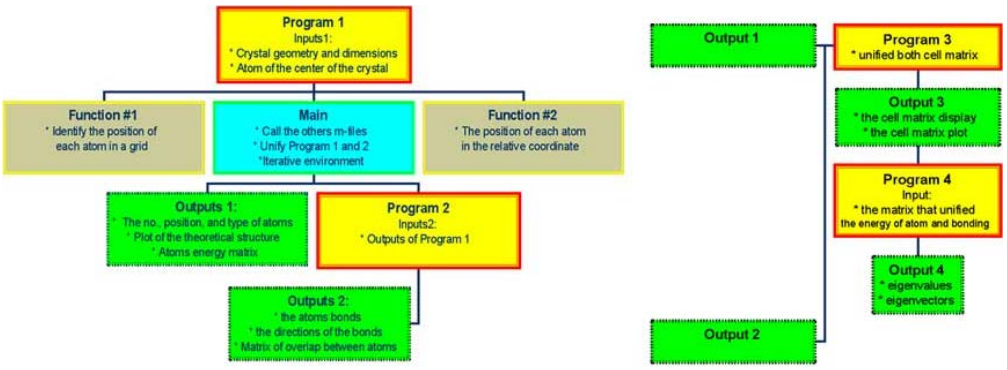
Juan Martinez-Alvez, Mechanical Engineering,
Universtiy of Puerto Rico
Faculty Supervisors: Nicola Hill and Roy Smith
Departments: Materials and Electrical & Computer Engineering

The shape and size dependence of optical properties in the PbSe material system.

In this paper we present a theoretical study aimed of the effects of shape and size on the electronic properties of PbSe. We calculate the eigenvalues and eigenvectors of PbSe spheres and cubes over a range of size in the nanometer range. We analyze the eigenvalues and eigenvectors to determine the densities of electronics states and electron distribution in the various nanostructures.

For many years it has been possible to calculate the energy levels in very large crystal structures. Calculations are formed on a single "cell" of the structure that is repeated infinitely in each direction using periodic boundary conditions. This was good enough because the crystals were large and contained and enormous numbers of cells. Two things have happened: experimentalists have been able to grow smaller crystals which contain a much smaller number of cells; and computers have become fast enough to calculate all of the energy levels inside a small crystal.

In this work we use the Tight
hundreds to 1000 atoms. The Tight Binding method (described in section 2.2) allows us to represent the interactions between the atoms in a simple matrix form. The eigenvalues and eigenvectors of the matrix (which we calculate using the Matlab package) then tell us many of the theoretical electronics properties of the materials..



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Aric's Project Page - RISE summer 2000

Intern: Aric Monts-Homkey, Archeology, UCSB
Faculty Supervisor: Mike Goodchild
Department: Geography

GIS application in archeaology: UCSB Maya Forest GIS .

A Geographic Information System (GIS) is a tool that is becoming more and more widely accepted in many fields, both in academia and the business world. One reason for this is the GIS's ability to handle spatial data and to show relationships between objects that would have otherwise gone unnoticed. The field of MesoAmerican archaeology is one example where a GIS could improve our understanding of the past. For over one hundred years, archaeologists have been working in MesoAmerica, excavating ruins, and studying artifacts. A GIS has played limited roles in this area, mainly in the form of predictive models to aid in conservation and to efficiently plan future work. In this paper, we will go one step further, first creating a predictive model for settlement in a small part of MesoAmerica, and second, discussing the model in terms of artifact assemblages to form an understanding of the diversity of Maya settlement and its key to the environment.

The Central Maya Lowlands was once the heart of the Maya Civilization. Encompassing parts of western Belize and the Peten of Guatemala, its covers diverse terrain, various land resources, and rich jungle. Surviving for over 3000 years on such a unique environment, the Maya were agrarian, growing such crops as maize, beans, and squash. Over time they developed into a society with a complex hierarchical ruling party while practicing human sacrifice to appease their gods. In addition, the Maya were great astronomers, creating one of the most accurate calendars today. Overall, the Maya's greatness has much to do with their relation to their environment. To better understand the Maya, archaeological data collected by the Belize River Archaeological Settlement Survey (BRASS), directed by Dr. Anabel Ford, a Research Anthropologist at the University of California Santa Barbara campus, will be used.

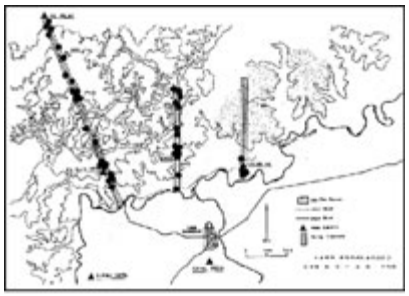

Figure 1: Location of the transect surveys on relation to the river

BRASS began work in 1983, a time when residential units were the focus of many surveys throughout the Maya area. By focusing on three transect surveys (one 10km and two 5 km) running from the river valley to the top of the ridge (see fig 1) the project best sampled the area, which has the most variation of soil types, slopes, and land resources. After the crew mapped all residential units found on the landscape, 348 sites were identified and drawn at a scale of 1:4000. The next phase of the survey began with test excavation and later full-scale excavation at 51 of the sites. The fieldwork was completed in 1993 with artifact analysis representing 2000 years of occupation (see Ford and Fedick 1992). With this complete data set, we can best understand life 1000 years ago.

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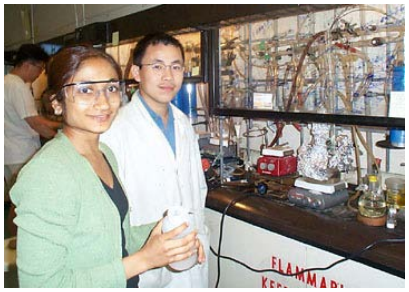
Malini's Project Page - RISE summer 2000



Malini Ranganathan, Chemistry, Bard College
Mentor: Jianjun Cheng
Faculty Supervisor: Tim Deming
Department: Materials

Synthesis of beta-polypeptides via ring-opening polymerization of beta-lactams

The natural world is replete with complex molecules classified in general as biopolymers, which are proteins that govern essential processes of life and that have physical properties that render them capable of forming fantastic materials like spider silk and collagen. Proteins achieve these functions by folding into compact, well-ordered formations known as tertiary or quaternary structures, which in turn depend on the nature of the polypeptide's stable secondary structure such as alpha-helix, turns, and beta-sheets. The nature of the protein's complex tertiary structure is vital in directing its specific biological function.

A nickel initiator that was developed by the Deming group for the polymerization of alpha- and beta-amino acid N-carboxyanhydride NCAs was attempted for the first time on beta-lactams yielding high molecular weight beta-polypeptides with quantitative conversion and in good purity. I report a brief summary of the work that was carried out in order to perform these polymerizations. I also provide some nuclear magnetic resonance (NMR) and infrared (IR) characterization data of beta-amino acids and beta-lactams synthesized and some preliminary conformational analysis data of the resulting beta-polypeptide, based on circular dichroism (CD) spectroscopy data.

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Jovan's Project Page - RISE summer 2000

Jovan Rivera-Montes, Computer Science, Universidad Metropolitana, P.R.
Faculty Supervisor: Ming Li
Department: Computer Science

Web based interface of plagerism detection program

Our goal for this project is to create an automatic program that determines the similarity of each file submitted and returns the result to the users via e-mail. It is more sophisticated than the system based on counting the frequency of certain words in the program text, since it actually examines the program structure. We have been inspired by the Moss program that compares different program languages. Our research attempts to determine the similarity between a submitted file and previously submitted work.

My part of this research is to create the website to hold this program and make it user friendly and interactive to the all the people that want to use it. To use this web page program one has to have an account on our secure website. The web site will have all the personal accounts on data base computer so we could have our own processing in our local campus lab.

Background information:

What is Moss?
Moss (for a Measure Of Software Similarity) is an automatic system for determining the similarity of C, C++, Java, Pascal, Ada, ML, Lisp, or Scheme programs. To date, the main application of Moss has been in detecting plagiarism in programming classes. Since its development in 1994, Moss has been very effective in this role. The algorithm behind moss is a significant improvement over other cheating detection algorithms (at least, over those known to us).

An Internet Service
Moss is being provided as an Internet service. The service has been designed to be very easy to use--you supply a list of files to compare and Moss does the rest.
In response to a query the Moss server produces HTML pages listing pairs of programs with similar code. Moss also highlights individual passages in programs that appear the same, making it easy to quickly compare the files. Finally, Moss can automatically eliminate matches to code that one expects to be shared (e.g., libraries or instructor-supplied code), thereby eliminating false positives that arise from legitimate sharing of code.

Registering for Moss
Moss is being provided in the hope that it will benefit the educational community. Moss is fast, easy to use, and free. Access to Moss is restricted to instructors and staff of programming courses. To obtain a Moss account, send a request to moss-request@cs.berkeley.edu.
Processing requests for accounts may take up to a day; once you have an account queries are processed as soon as they are received.

How Does it Work?
While there is a big difference between a good cheating detection algorithm and a bad one, all such algorithms can be fooled if one knows how they work. It's best if we don't say too much

here about the ideas behind Moss. Suffice it to say that it is more sophisticated than systems based on counting the frequency of certain words in the program text (a widely used cheating-detection heuristic); Moss actually examines program structure.

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Marc's Project Page - RISE summer 2000

Marc Soares, Mechanical Engineering, MIT
Faculty Supervisor: Samir Mitragotri
Department: Materials

Using a combinatorial approach to improve transdermal drug delivery

At first glance, transdermal drug delivery offers a near-perfect solution to the sometimes complicated and cumbersome methods of drug administration. transdermal Drug Delivery (TDD) avoids invasive techniques, such as subcutaneous injection and intravenous deliver, and "first-pass" complications arising from detoxification processes of the liver. Additionally, the nature of TDD allows for a long term, controlled release administration of a drug, augmenting its therapeutic value. Despite these potential benefits that TDD offers, this route is not widely used because of the inherent barrier properties of the skin.

The skin is the largest organ in the body, with the specific function to provide an almost impenetrable barrier to the external environment. The most external layer of the skin, the stratum corneum, made of densely packed, highly ordered, keratinized tissue provides the bulk of protection.

Consequently, the major task in improving TDD involves making the stratum corneum more permeable. There have been a variety of methods employed, such as low-frequency ultrasound, electroporation, and iontophoresis to increase permeability. However, in this paper, we will focus specifically on using surfactant chemical enhancers to improve TDD. The chemical properties of surfactants have been widely studied, and have long been known to enhance TDD.

The current methods of testing chemical enhancers are many times unproductive, which is primarily due to the low number of tests performed per area of skin. Additionally, the price of testing on human cadaver skin proves can be quite expensive. Discovering and confirming the efficacy of an enhancer can prove to be a costly process. Since the exact chemical mechanisms of TDD are not understood, using serial chemistry approaches to screen for chemical enhancers are rather inefficient.

The main thrust of this project is to develop, design, and test a method to simultaneously, systematically, and economically study numerous chemical enhancers, using combinatorial methods.

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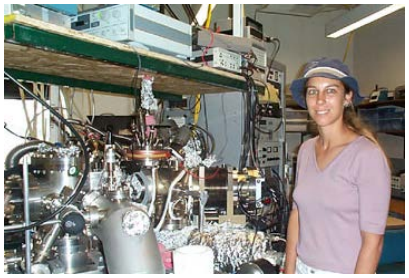
Aundrea's Project Page - RISE summer 2000



Aundrea Tavakkoly, Physics, UCSB
Mentor: Brian Gergen
Faculty Supervisor: Eric McFarland
Department: Chemical Engineering

Reaction Kinetics: Adsorption on Ultrathin Films

Using electroless and electrochemical deposition, deposition of copper, silver, and cobalt on n-type silicon wafers was achieved. By immersing samples in various baths containing the desired ions, ulra thin films on semiconductors have been identified. These solutions will be tested via combinatorial methods.

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Jeannine's Project Page - RISE summer 2000

Jeannine Wisch, Chemistry, UCSB
Mentors: Christof Brandli and Tom Jaramillo
Faculty Supervisor: Eric McFarland
Department: Chemical Engineering

A combinatorial approach to the synthesis of inorganic heterogeneous photocatalysis for hydrogen production

Using combinatorial methods, potential heterogeneous photocatalysts were synthesized. Al2O3, Fe2O3, TiO, and SiO2 beads were used as supports for TiO2 prepared by sol-gel methods. Then via split-pool synthesis, they were doped using 10 mM aqueous solutions of PdCl2, RuCl3, CoCl2, CuCl3, FeCl2, CrCl3, NiCl2, and SnCl2 in HCl (2M). 230 chemically different beads were synthesized, and 96 of these were screened for hydrogen production, via water splitting reaction and methanol reformation.

The continued use of non-renewable natural resources such as petroleum-based fuels is environmentally taxing. There are many areas of research, which focus on making hydrogen an affordable source of energy, including research for storage vessels, fuel cells, and catalytic materials to carry out reactions for the production of hydrogen. Hydrogen is a desirable energy source, because it can be used directly as a fuel for transportation and electricity, without the production of pollutants. Water splitting (Scheme. 1), is the reduction/oxidation reaction, through which only water is needed to produce H2 and O2. However, with out the use of a catalyst, and energy supplied by either heat or photons, the activation energies of the multiple step reaction are too high to overcome.

Scheme 1.
I. The Reaction
H_2O ¦ H_2 + 1/2O_2 DG=243 kJ/mol

II. The Half Reactions (Redox)
4H+ + 4e- ¦ 2H_2 E0 = 0V
2H_2O ¦ 4e- + O_2 + 4H + E0 = 2.46V

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