



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Hyokyung An | Project Number S0601 |
| Project Title Building a Multilayered Hydrogel Microsphere Crosslinked by Genipin for Controlled Dissolution in Drug Release | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Recently, microspheres have been receiving a lot of attention for their significance in the local release of drugs. This experiment sought to create a multilayered, biocompatible hydrogel microsphere by using natural ingredients including gelatin, olive oil, and genipin which is extracted from the plant <i>Gardenia jasminoides</i> Ellis. The hypothesis for this experiment is: if genipin is used as a crosslinking agent, then a multilayered microsphere, where the rate of dissolution is controlled, can be efficiently created.</p> <p>Methods/Materials Microspheres were built by using a new water-in-oil emulsion technique using olive oil as a base and ABILEM 90, cyclopentasiloxane, as a surfactant. Different food colorings were used to distinguish the different layers of each microsphere. The small particle was then stabilized every time a new layer was added by crosslinking with genipin. Degrees of crosslinking were determined by the incubation time inside the genipin solution. Release rates were studied using a microscope and the dispersion of each colored layer was timed. The various rates of crosslinking ranged from 5% to 60%. Each level of crosslinking had six trials.</p> <p>Results When the microspheres were tested, it showed that different layers would be released at different times. When timing the complete dissolution of the microspheres, there was a clear link between the percentage of crosslinking and the time the microsphere took to completely dissolve. The success rate for creating a genipin microsphere was 100%, while the success of creating a distinct second layer was 90.02%, and the success of creating a third layer was 86.65%.</p> <p>Conclusions/Discussion In conclusion, this experiment supported the hypothesis through the production of biocompatible multilayer hydrogel microspheres cross linked with genipin. With a multilayered microsphere created, this improves the medical field vastly by allowing patients to receive better care with more innovative medical practices. This experiment also proved that a water-in-oil emulsion technique is applicable when creating a hydrogel microsphere.</p> | |
| Summary Statement I created a process for creating a multilayered gelatin-oil hydrogel microsphere by using genipin as a crosslinker by using a water-in-oil emulsion technique. | |
| Help Received I paid for a 3 month membership for TheLab to access the lab and its equipment. Melissa Draeger and Cory Tobin helped to place orders for chemicals and taught me how to use certain equipments safely. I independently sought this lab out and independently worked on the trials. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Sakina Bambot | Project Number S0602 |
| Project Title Understanding the Difference between Working and Dead Pixels on an OLED Display: Investigation Using TOF-SIMS | |
| Abstract Objectives/Goals The goal was to analyze working and dead pixels on an OLED (Organic light emitting diode) phone display to understand why the display region stopped working and if the damage done to the pixels was reversible. This was achieved using the Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) technique. Methods/Materials The phone screen display areas with working and dead pixels (blue and red for each) were analyzed. The cathode was removed and the OLED stack was analyzed with the TOF-SIMS instrument. The data from a 200 microns x 200 microns region was collected, showing which ions to track. An argon cluster gun sputtered a crater of 500 microns x 500 microns. The spectrum from the newly exposed surface was collected and the process was repeated until the anode was detected. OLED peaks were plotted as a depth profile. The procedure was repeated 3 times for each region. Results For both regions, the blue and red pixels showed similar layers, however, the intensities and depths of ions differed between the two pixels, indicating differing compositions. In contrast to that of the working region, the depth profiles from the pixels in the dead region (both blue and red) were either missing layers or the layers were present only at low levels. For example, the ion at mass 679 was present at a high intensity for the working pixel region but was barely above the detection limit for the dead pixel region Conclusions/Discussion A significant difference in the depth profiles of the pixels in the working region versus dead region was observed. I had not expected such a significant difference between the working and dead regions. This suggests that in the dead region, either the molecular species degraded or they migrated, resulting in the pixels going dead. This shows that the damage done to the pixels is irreversible. The insight gained from this experiment can be used to help design better performing OLED displays. | |
| Summary Statement Using the TOF-SIMS technique, I found significant differences between working and dead pixels in the organic layers of an OLED smartphone display, and this insight can be used in developing better working OLED displays. | |
| Help Received I used the TOF-SIMS instrument at EAG Laboratories under the supervision of Dr. Ginwalla, who taught me how to use the instrument and the accompanying software, and with this knowledge I carried out my experiment. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Taraneh Barjesteh | Project Number S0603 |
| Project Title Photo-induced Degradation of Porous Silicon via a Redox Active Etchant: A Potential Novel Drug Delivery System | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Porous silicon's (PSi) unique properties, including biocompatibility and biodegradability, contribute to its potential as a drug delivery agent. If chemotherapy drugs are enclosed as a payload within porous silicon nanoparticles (PSiNPs), along with a redox-active etchant, then the drug can be targeted to the tumor sites, minimizing harmful side effects, as well as enabling a higher dose of the therapeutic to be delivered to the tumor. Exposure to light at certain wavelengths can stimulate the electrons in the porous silicon to react with the etchant, hexamminecobalt (III) Chloride, (Co(NH₃)₆³⁺) (abv. HXC), reducing the HXC, causing it to release its ammonia groups, resulting in a degradation of the PSi shell. In the loaded nanoparticles, this degradation results in the release of the drug payload at the site of the tumor if concentrated light at a certain wavelength is also applied to that tumor region. This project sought to prove the above reaction empirically, as well as looking at the effects of different wavelengths and intensities of light, and finally, using calcein dye within the system to simulate a drug payload.</p> <p>Methods/Materials Porous silicon wafers were etched in 3:1 HF: EtOH solution and partially oxidized in a borate solution to produce photoluminescence (PL) from the quantum confinement effect. Several experiments were done on these wafers looking at empirical values for different components of the proposed redox reaction. These included pipetting a 10 mM solution of HXC on top of etched PSi wafers, exposing the chips to 365 nm light, and measuring the decrease in PL from the degradation of the chip surface, as compared to a control solution with no HXC. Experiments were also done looking at the effect of light in the reaction as well as the component of NH₃ production. Partially-oxidized PSi nanoparticles (PSiNPs) were also made and placed in solutions of different concentrations of HXC and exposed to 365 nm light, and absorbance of nanoparticles was measured over 30 minutes. Finally, PSiNPs were loaded with calcein dye (to simulate a drug) and HXC or a control solution, and exposed to the same light conditions for 10 minutes, before measuring the absorbance of dye released.</p> <p>Results The findings indicate that the reduction reaction of HXC causes the degradation of PSi matrix due to release of NH₃, and that the reaction is light and concentration dependent.</p> | |
| Summary Statement A potential novel drug delivery system, utilizing a photo-induced reduction reaction resulting in the degradation of a porous silicon shell surrounding a payload only when exposed to certain lights, was created to minimize side effects. | |
| Help Received Dr. Michael Sailor and Geoff Hollett from UCSD helped mentor me throughout this project in addition to allowing me to use UCSD lab facilities and materials. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Robert E. Bilodeau | Project Number S0604 |
| Project Title Comparison of Oxidizers in the Removal of NDMA in the UV Advanced Oxidation Process of Treating Drinking Water | |
| Abstract Objectives/Goals This project determines which oxidant is the most effective at removing N-nitrosodimethylamine (NDMA) when added to the ultra violet advanced oxidative process (UV-AOP) during the treatment of drinking water. The two oxidants looked at in this project are hydrogen peroxide (H ₂ O ₂) and chlorine (Cl ₂). My hypothesis is that H ₂ O ₂ added during the stage of the UV-AOP will be more effective than free Cl ₂ in removing NDMA present in drinking water. Methods/Materials The Orange County Water District provided the laboratory support for running this experiment. During each experiment water which had previously treated with both reverse osmosis and microfiltration was siphoned off into a test pilot. This water was then subjected to ultra violet light along with the addition of a specific oxidizer. Levels of NDMA were tested before and after each pilot run using a liquid chromatograph. After each sample was analyzed the percent of NDMA removed was calculated, and the contamination level differences were subsequently graphed. Results Hydrogen peroxide (H ₂ O ₂) saw the largest percent reduction of NDMA of any oxidant with an average of 99% removal. Most of the water with added hydrogen peroxide removed all NDMA present to ND. Chlorine (Cl ₂) saw the next largest reduction of NDMA with an average total removal of 74%. When chlorine is added at 0.99 mg/L, it effectively removed NDMA at 74% more reliably. During the UV process with no oxidants, NDMA was significantly removed from the water. The dark control, no UV, yielded an overall increase in NDMA levels. Conclusions/Discussion The hypothesis for this project proved to be correct; hydrogen peroxide (H ₂ O ₂) was the most effective oxidant at removing NDMA during the UV-AOP. Although photolysis itself is the largest remover of NDMA the added oxidants helped to lower the NDMA concentrations to levels that could not be achieved through photolysis alone. This is extremely important as the Environmental Protection Agency has determined NDMA is toxic at levels as low as 0.7 ng/L and the California State Drinking Water standard is set at 10 ng/L. It was also determined that although less effective than H ₂ O ₂ , the addition of free chlorine did remove a significant amount of NDMA and since it is a much cheaper oxidant it could be implemented in smaller and rural water districts which have monetary restraints. | |
| Summary Statement I analyzed which oxidizer, hydrogen peroxide or chlorine, was more effective in the removal of NDMA in the UV advanced oxidative process of treating drinking water. | |
| Help Received The Orange County Water District provided the laboratory support for running this experiment, specifically Dr. Shannon Roback. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Sarah L. Byrd | Project Number S0605 |
| Project Title The Efficacy of Curcumin on Chelating Alzheimer's-Associated Free Zinc Ions | |
| Abstract Objectives/Goals The purpose of the experiment was to test at what molar ratios curcumin, a turmeric derivative, would best remove the heavy metal ion $Zn^{(2+)}$ from an ethanol solution. Methods/Materials Extracted curcumin in solution by filtering a turmeric-ethanol tincture. Created zinc-curcumin complex (precipitate) by adding zinc acetate dihydrate and heating. Massed filters both before and after filtering out precipitate. Results Mass and mole data was used to calculate both amount and percent of zinc ions chelated. Percent chelation increased as the zinc ion to curcumin ratio increased. Little variation was seen among trial values from the same ratio set. High percentage results indicate curcumin chelated zinc ions as planned. Conclusions/Discussion Lack of data displaying a limiting reagent's presence suggests a necessary assumption used for experimental calculations was wrong. However, high zinc ion chelation percentages still confirmed curcumin's ability to remove heavy metal ions from the solution. | |
| Summary Statement Curcumin's ability to remove free zinc ions associated with Alzheimer's disease was evaluated using percent $Zn^{(2+)}$ ion chelation values across various zinc ion to curcumin ratios. | |
| Help Received None. I designed and performed the experiment myself after researching how to extract curcumin from turmeric. | |



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| Name(s) Sheridan Chavira; Preston Holliday; Samuel Simons | Project Number S0606 |
| Project Title How Can We Protect Homes from Wildfires? | |
| Abstract Objectives/Goals To measure and declare the rate of burning between initial and final times between different household substances. Methods/Materials Our materials include: Baking soda (sodium bicarbonate), Ash, Chalk (calcium carbonate), Borax (sodium tetraborate decahydrate), Agar Agar (our gelatin), Xanthan gum (our thickener), a hand mixer, Distilled water, 3 inc pieces of pine wood (untreated and sanded), Blowtorch, and assorted beakers. WE started by making the foam by mixing agar agar with boiling water, then let simmer until completely dissolved. As it starts to cool use a hand mixer to froth the mixture creating a foam while also mixing in Xanthan gum to thicken it. After that we mixed 2.5%, 5%, 7.5%, 10%, and 12.5% of each household material in with 20 mL of foam in beakers. Then hand spread it onto 5 blocks of wood. Then using a blowtorch to find the initial ignition time and the final ignition time Results The results that came to be is that 12.5% of Borax was the most effective due to Borax being a hydrate, it releases water when heated so therefore it was the most effective. Conclusions/Discussion The final result ties were correct to our assumption. Borax being a decahydrate, or containing ten water molecules, was the most effective option because the more water in the substance the longer it will take to ignite. | |
| Summary Statement A cost effective and eco- friendly alternative foam to help protect houses and prevent the spread of wildfires. | |
| Help Received We used lab equipment from Rio Mesa High School under the supervision of Dr. Rano Sidhu. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
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| Name(s) Ian S. Chen | Project Number S0607 |
| Project Title The Efficacy of a Silver-Zinc Oxide Nanocomposite under Varying Light Wavelengths in Photocatalytic Degradation | |
| Abstract Objectives/Goals This project is based on the preparation of a silver-zinc oxide nanocomposite and the determination of its efficiency of photocatalytically degrading various contaminants under various wavelengths of light. By using a urea-based precipitation method, the nanocomposite was prepared and was allowed to break down to sample contaminants, methyl violet and trichloromethane, under red, blue, and green light. My hypothesis was that light with smaller wavelengths will result in higher percentages and rates of degradation, due to the inverse relationship between energy and wavelength. Methods/Materials Zinc acetate and silver nitrate were the chemicals used as sources of zinc oxide and silver, the precipitation method catalyzed by urea and sodium hydroxide. The compounds were dissolved in water and heated for 15-30 minutes. Any leftover insoluble material was filtered and the filtrate was prepared for photocatalytic degradation. This, in itself, shows the success of a relatively simple, and readily accessible preparation of nanoparticles, and more broadly, nanotechnology. The preparation was followed with trials in which to determine its photocatalytic abilities. Fixed amounts of methyl violet and trichloromethane were added to a fixed volume of nanocomposite suspension under a particular wavelength of light and allowed to react for 1 hour. Results The methyl violet trials had an average degradation percentage of 80%, 70%, and 70% for red, blue and green light, respectively, while the trichloromethane had an average degradation percentage of 21%, 21%, and 22%. The graphs also exhibit no change of efficiency when varying wavelengths of light are used, as the graphed lines shown had little to no deviation from each other. This signifies a broad range of wavelengths that the nanocomposite is effective with. Conclusions/Discussion This project contributed to two main benefits: first, the success of a simple method in the preparation of silver-zinc oxide nanocomposites as well as the determination that the ability of the nanocomposite to degrade various contaminants is relatively efficient as well as robust. Instead of one wavelength of light being significantly more effective than the others, the nanocomposite was able to utilize each wavelength of light equally in the degradation. | |
| Summary Statement The nanocomposite synthesized in this project was able to utilize a wide range of visible light in order to degrade aqueous chemical contaminants. | |
| Help Received I performed all the synthesis and experimentation by myself. My adviser did give me permission to work in the school fume hood to ensure absolute safety. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Jessica M. Cronin | Project Number S0608 |
| Project Title The Effectiveness of Homemade vs. Professionally Used Density Gradients | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The eventual objective of this project is to isolate a small strongyle egg using density gradient centrifugation. Five different density gradient solutions are being compared for effectiveness in completing this goal. They have also been tested using macroscopic objects.</p> <p>Methods/Materials First, homemade density and viscosity gradients were created using 7 liquids of different densities. These gradients were tentatively tested using a copper BB, a peppercorn, and a plastic BB (never centrifuged). Then, they were tested against three professionally used gradients (Percoll, Histodenz, OptiPrep) in two ways, using the same three macroscopic objects: spun with objects, and spun without (objects added after). There was also a control that was never put through the centrifuge. Currently, a way to use density gradient centrifugation to isolate small strongyle eggs is being devised.</p> <p>Results The initial homemade density gradient worked in that the liquids remained separate, and the objects settled according to density. The objects settled according to density in the initial viscosity gradient as well, but the liquids did not remain separated. The later homemade density and viscosity gradients controls reacted differently, all three objects settled in the same layer in both (Equifar vedlube). The same was true for the homemade density pre-spun. In the homemade viscosity pre-spun, all objects settled in the same layer somewhere in the middle, though the liquid they stopped in is unidentifiable. In both homemade gradients that were spun with the objects, all three objects were at the bottom of the tube. In all three professional gradients, in both tests and the control (excluding Histodenz pre-spun) the peppercorn floated to the top, but both other objects sunk to the very bottom.</p> <p>Conclusions/Discussion According to these limited results, neither my homemade gradients, nor the professionally used gradients are effective when testing with a peppercorn, a plastic BB, and a copper BB. However, these professional gradients are meant to be used with microscopic objects, and the objects I was using may have been too dense for them. I don't believe that I can have conclusive results until I begin testing with small strongyle eggs.</p> | |
| Summary Statement I compared the effectiveness of my homemade density and viscosity gradients against professionally used density gradient solutions. | |
| Help Received King Royal Industries purchased the professional gradient solutions, but excluding that financial support, I did this project all on my own. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
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| Name(s) Allyson Ee; Albert Tan | Project Number S0609 |
| Project Title Analyzing Electrochemical Effects of Ni Substitutions on Iron Silicate Compounds | |
| Abstract Objectives/Goals The objective of this study is to determine the effect of substituting Ni in iron silicate compounds used in cathodes on the battery performance. Methods/Materials A Li ion cathode compound was synthesized using weighed masses of lithium carbonate, silicon oxide, nickel(II) chloride, and iron(III) chloride. A Li ion battery was assembled inside an Argon glove box. The Li ion battery was cycled for two weeks and the current and voltage of the battery were recorded. Results The Li ion battery after Ni substitutions had a capacity of approximately 125 milliamp hours per gram and was shown to reversibly cycle against Li with voltage plateaus at roughly 3.8 V. This work presents the enhancements that come from substituting Ni into pristine iron silicate cathodes, which have capacities of around 75 milliamp hours per gram and voltage plateaus of 2 V. This shows that the Ni substitutions improved the battery performance. Conclusions/Discussion The gained battery efficiency from the nickel substitution demonstrates the feasibility of a promising new group of earth-abundant cathode materials implementing nickel, significantly contributing to the sustainability of depleting natural resources. | |
| Summary Statement This project studies whether introducing nickel to an iron silicate compound used as a cathode in Li-ion batteries would improve battery performance. | |
| Help Received The authors acknowledge the guidance of Nicholas Bashian and Brent C. Melot, as well as the support of Melot Research Group members. This work was done with financial support provided by the Dana and David Dornsife College of Letters, Arts and Sciences at the University of Southern California. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Nicholas S. Franks | Project Number S0610 |
| Project Title Optimizing of Electrolysis of Water through Variations in Electrolyte Concentration | |
| Abstract Objectives/Goals The purpose is to measure and describe the effects of electrolyte concentration on the rate of reaction of the electrolysis of water. The results obtained can help to develop new industrial methods for producing hydrogen gas, a form of alternative energy. Methods/Materials Various concentrations potassium hydroxide (KOH) were used as electrolyte solutions in an electrolytic cell. The cell - which was obtained from my school - consisted of a 6-volt current, inert graphite electrodes, and constant environmental factors. Hydrogen and oxygen gas production at the two electrodes was measured, and rate of reaction was calculated for each concentration. Results Increasing the concentration of the potassium hydroxide electrolyte increased rate of reaction in a strong, linear manner. Although predicted, rate of reaction did not reach some maximum value, indicating that this trend might continue for higher concentrations. Conclusions/Discussion In order to achieve the fastest rate of reaction for the production of hydrogen gas, the maximum amount of electrolyte should be used. This method would have to be applied to other types of electrolytes and a wider range of concentrations in order to gain a broader overview of electrolysis. Additionally, economic models would have to be considered to determine the feasibility of industrial electrolysis for hydrogen production. | |
| Summary Statement Through the manipulation of the electrolyte concentration of an alkaline electrolytic cell (i.e. potassium hydroxide concentration), I showed that electrolyte concentration and rate of reaction are directly, linearly proportional. | |
| Help Received My chemistry teacher provided assistance in obtaining materials and taught me the basics of electrolysis in class. All supplies were provided by my school's science department. All additional research and development was done independently. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Malika Gellman; Supriya Lall; Audrey Li | Project Number S0611 |
| Project Title Self-Sustainable Microbial Fuel Cell Driven High-Efficiency Nickel-Based Water Splitting System | |
| Objectives/Goals The project goal is to create a low-cost NiC(2)O(4) (nickel oxalate) catalyst for water electrolysis based on the hypothesis that porous structure leads to higher efficiency, and power this system using microbial fuel cells to generate hydrogen without releasing greenhouse gases and burdening power supply. Abstract Methods/Materials NiC(2)O(4) was grown on 2 pieces of nickel foam: the first piece in air (NiO) and the second one in nitrogen (N-treated) at 400°C for 40 minutes. Samples were analyzed with X-ray diffractometer and scanning electron microscope (SEM). Linear voltammetry evaluated their overpotentials, tafel slopes, and electrochemical surface areas. The electrochemical impedance (EIS) graph was obtained by applying a potential of -129 mV vs. RHE with amplitude of 5 mV from 100 kHz-1 Hz. Tryptic soy broth was made, sterilized in autoclave, and Shewanella Oneidensis MR-1 was cultivated in it. A microbial fuel cell (MFC) was constructed using anode and cathode chambers, cation exchange membrane, 2 end plates, 4 threaded rods, 4 rubber gaskets, bacteria in tryptic soy broth, and cathode electrolyte. 1 MFC was connected to multiple resistors and voltage outputs for each one were measured with multimeter. 5 MFCs were connected to water splitting device with N-treated samples. Results SEM shows N-treated sample more porous than air-treated one. X-ray diffraction patterns show that N-treated sample has Ni phase, and NiO one has Ni and NiO phases. For hydrogen evolution reaction (HER), overpotentials of NiO and the N-treated samples are 182 mV and 51 mV at 10 mA/cm ² and tafel slopes are 83 mV dec(-1) and 50 mV dec(-1). For oxygen evolution reaction (OER), overpotentials of NiO and N-treated samples are 310 mV and 337 mV at 10 mA/cm ² ; tafel slopes are 69 mV dec(-1), and 83 mV dec(-1). EIS Graph shows N-treated sample has lower charge transfer resistance and greater electrical conductivity than NiO sample. From electrochemical surface area graph, N-treated sample has slope of 40.16 mF/cm ² , and NiO one has a slope of 1.72 mF/cm ² . 1 MFC shows the most current at voltage of 0.15 V and has a maximum power of 1.524 mW at current of 1.73 mA. Conclusions/Discussion Results confirm hypothesis: porous structure leads to high water splitting efficiency. N-treated porous NiC(2)O(4) sample shows better HER and OER performance than other catalysts. | |
| Summary Statement We synthesized highly-efficient nickel-based electrocatalysts for water electrolysis, and powered this water-splitting system using microbial fuel cells in order to generate hydrogen in a self-sustainable way. | |
| Help Received Research conducted at UCSC under supervision of Tianyi Kou and Prof. Yat Li. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
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| Name(s) Blake E. Hermann | Project Number S0612 |
| Project Title The Effect of the Molality of Salts on Freezing Points of Water | |
| Abstract Objectives/Goals I try to find out how the affect of changing molality of salts, effects the freezing point of water. This is relevant in that, today America spends millions on deicing roadways, and in my experiment i try to find an easier, cheaper way to get the same result. Methods/Materials Materials: Plastic Test tubes and rack, Beakers (50 mL), A Scale (plus or minus 0.01 g), Lab Quest and Thermometer attachment (plus or minus 0.1 degree Celsius), Standard fresh water ice, A cooler, Salt (NaCl food grade), Salt NaCl lab grade, Salt MgCl ₂ lab grade , Stir stick For my Procedure I took the salts and measured out amounts out that followed as 0.2 molality change to 10g of water that I previously measured out. I did this three times, for both salts, varying molality from 0.5 to 1.9 mol/kg. For each I observed the solution until frozen and then I recorded the results. Results My end results showed me that, in the end the Sodium Chloride was out shown by the Magnesium Chloride, as the MgCl was more effective in all of the tests at lowering the freezing points of the solution. Conclusions/Discussion After reviewing my results I can determine that they yielded the same result as other tests with freezing points and salts. As the molality rose the freezing point of the solution traveled in a downward trend. Therefore, these results fall inline with what is already known and show no drastic differences or abnormalities than what was previously known in this specific area of chemistry. In general the Magnesium chloride out preformed the Sodium chloride but economically the sodium chloride proves still the more worth it. As all three trial graphs show, as the molality of the solutions increase there is a downwards trend (lower freezing point) for the solution. This is likely due to the higher amount of ions present in the water preventing the water molecules from freezing. There is also an obvious trend between Magnesium Chloride and Sodium Chloride, Magnesium Chloride clearly has lower freezing points at all molalities on all trials. | |
| Summary Statement In my project I vary amounts of salts and test to see their effect on the freezing point of water. | |
| Help Received Dr. Sidhu, teacher, provided the space for me to do the project, other than that i had no help. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
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| Name(s) Sahil Jog; David Kim; Ishan Modi | Project Number S0613 |
| Project Title Assessing the Electrochemical Performance of Mg(TFSI)₂ in Electrolyte Tetraglyme at Different Environmental Conditions | |
| Abstract Objectives/Goals The objective of this experiment is to fully understand the electric potential behind a Mg battery, along with the thorough analysis of its SEI layer, for the purpose of mass production of a new efficient battery. Methods/Materials Tube Furnace, Vacuum Seal, Argon Gas, Mg(TFSI) ₂ Sample produced dry sample of Mg(TSFI) ₂ under controlled environment. Wet sample was produced in normal conditions. Samples were hooked to a bob cell, in order to test their electric potential, measured with a computer program transmitting Cyclic Voltammetry. SEI Layer was measured with XPS, EDS, SEM, and XRD. Results After creating the electrolyte, the cell was tested through Cyclic Voltammetry and went through 50 cycles of reversible deposition/dissolution, which clearly show a noticeable difference in the current performance for the wet sample and the dry sample. The wet sample as shown, creating a mere fraction of mA/cm over voltage compared to the dry sample which were represented in whole numbers. Furthermore, steps were taken to analyze the surface of the anode, in order to understand the SEI layer. Using a SEM, clusters of Mg and other elements are visible on the surface. EDS mapping is done on the magnified clusters, for the purpose of determining the significant presence of Mg and oxygen over other elements. After finding which elements were in the clusters of Mg, XPS was used to find the binding energy of each compound such as MgO and MgS to confirm which elements that Mg is bonded to as it can create an SEI layer. Furthermore, XRD was used to also confirm the crystal structure in which one can find the matching peaks to further confirm that unwanted elements were present in the battery. Conclusions/Discussion As predicted, the hypothesis was correct as low water content would be dominant over the subject with higher water content. The benefits that come with this can be overwhelming, since this will give a general understanding where Mg batteries could be the most efficient, and could potentially replace Li-ion batteries, which are characterized as being more combusive, less abundant, and have a potential of forming dendrites that short circuit the battery. Using Mg would change this however, since it is the 4th most abundant metal on the planet, meaning low cost of production, has no dendrite formation during reversible plating/stripping, and have a higher volumetric capacity than of Li batteries. | |
| Summary Statement After using Cyclic Voltammetry for both dry and wet samples, we can clearly see that the dry sample produced much greater electric potential, implying that a Mg(TFSI) ₂ battery worked best in dry conditions. | |
| Help Received We built and tested the Mg battery by ourselves. Also, we got help in further understanding the electrochemical functions, and data interpretation from Prof. Guo in the Bourns Engineering Department at UCR. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Ananya Karthik | Project Number S0614 |
| Project Title Developing Phase Change Nanoparticles for Focused Ultrasound Induced Targeted Neuromodulatory Drug Release | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The current, commonly-used technique of systemic drug delivery for modulating brain function lacks specificity, decreases efficiency, and threatens patient safety. An urgent need exists for a new approach towards noninvasive, targeted drug delivery to the brain. To address this need, this study embraces two unique elements: 1. Drug encapsulation in phase-change nanoparticles, and 2. Drug release via focused ultrasound (FUS).</p> <p>Methods/Materials Stage 1: The anesthetics propofol and dexmedetomidine were each encapsulated in phase-change nanoparticles with a biodegradable PEG-PLGA amphiphilic block copolymer matrix. Perfluoropentane (PFP), emulsified through sonication, formed the liquid core of the nanoparticles. Stage 2: Nanoparticle properties of size, polydispersity, and drug loading were quantified. Stage 3: In vitro drug release via FUS was performed in a water bath. The released drug was captured in a layer of solvent above the aggregate of nanoparticles, and this layer was then extracted for drug release measurement.</p> <p>Results The hydrodynamic diameters of both propofol-loaded nanoparticles and dexmedetomidine-loaded nanoparticles were less than 500 nm, essentially eliminating the risk of embolism in capillaries; the polydispersity indices were less than 0.1, lending constancy to the pharmacokinetics and biodistribution of the nanoparticles. The nanoparticles were effective in encapsulating propofol, but encapsulation of dexmedetomidine was more challenging, potentially due to precipitation of dexmedetomidine out of the micelle. The maximum drug release in vitro occurred at 1.7797 MPa (42.26% for propofol and 54.34% for dexmedetomidine).</p> <p>Conclusions/Discussion The results of this study indicate that phase-change nanoparticles can successfully encapsulate neuromodulatory drugs and respond effectively to focused ultrasound. This novel approach to neuromodulation establishes a platform for developing phase-change nanoparticles for all small-molecule lipophilic neuromodulatory drugs, and thus for any molecule that passively crosses the blood-brain barrier (BBB). FUS-induced drug release from phase-change nanoparticles improves safety (no BBB opening, clinically-approved particle components) and specificity (local drug release, high spatial and temporal resolution), with ideal attributes for clinical translation and important applications for treating cancer and neurodegenerative diseases.</p> | |
| Summary Statement My project establishes a novel platform for developing phase-change nanoparticles for all small-molecule lipophilic neuromodulatory drugs for focused-ultrasound induced targeted drug delivery to the brain. | |
| Help Received I acknowledge my family and teacher for their constant support, and Dr. Raag Airan and Qian Zhong from Stanford University for guidance and for giving me the opportunity to develop my project in their lab. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Juwon Lee | Project Number S0615 |
| Project Title Reflectance Spectroscopy Investigations of Clathrate Hydrates | |
| Abstract Objectives/Goals The objective of this study is to further study guest-host interactions in clathrate hydrates by analyzing isotopic clathrate hydrates - bromine clathrate hydrates formed from deuterated water. Methods/Materials Produced bromine clathrate hydrates from deuterated water by mixing liquid bromine and deuterated water. Formed clathrate hydrate crystals using an ice bath. Took spectroscopic measurements using fiber optic cables and CCD spectroscopy. Results Two different spectral lines (bromine vs bromine clathrate) were gathered from the spectroscopic measurements. The spectra showed that the enclathration of bromine in the form of clathrate hydrate increased pressure on the bromine, thus causing a blue-shift in bromine spectral profile. The blue-shift was observable through the color change from dark red bromine ice to yellowish orange Br ₂ -D ₂ O clathrate hydrate as well. Conclusions/Discussion A method to produce bromine-deuterated water clathrate hydrates was developed. The direct comparison of the two spectra (free bromine vs bromine clathrate hydrate) clearly demonstrated the dramatic change that bromine undergoes after enclathration. The observations made in this project can be extended to other guest molecules such as methane or natural gas when developing methods for optimal storage and transportation in a form of solid clathrate hydrate for oil/energy industry. | |
| Summary Statement I produced bromine clathrate hydrates from deuterated water, and studied the hydrates' guest-host interactions. | |
| Help Received Dr. John Kenney at Concordia University helped me set up my spectroscopy tests. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Tanya T. Matthew | Project Number S0616 |
| Project Title Synthesizing Inhibitors of Isocitrate Dehydrogenase 1 to Inhibit Glutamine-Dependent Reductive Carboxylation in Tumors | |
| Abstract Objectives/Goals Metabolic reprogramming is a hallmark of cancer, and tumor cells with defective mitochondria use alternative, efficient metabolic pathways to produce ATP energy when the electron transport chain is impaired. The purpose of this project is to synthesize a variety of small molecule inhibitors for the enzyme isocitrate dehydrogenase 1 (IDH1), in order to inhibit the alternative metabolic pathway glutamine-dependent reductive carboxylation in brain tumors. Methods/Materials Two classes of inhibitors were synthesized, one with a rhodanine ring core structure and the other with a thiazolidinedione ring core structure. The rhodanine inhibitor synthetic method was modified from the paper "Inhibition of Cancer-Associated Mutant Isocitrate Dehydrogenases by 2-Thiohydantoin Compounds" by Fangrui Wu, et al. I changed some of the intermediate reactants to use more cost effective chemicals. This meant my workup (filtration and washing) and analysis of my products varied greatly from the literature, due to products with different chemical properties. The thiazolidindione inhibitor synthetic method was taken directly from #Thiazolidinone€“Peptide Hybrids as Dengue Virus Protease Inhibitors with Antiviral Activity in Cell Culture" by Christoph Nitsche, et al. I simply changed one of the side chains to make the resulting compound slightly larger. Results Thin-layer chromatography (TLC) was performed using the starting materials and products of the various reactions to analyze whether a chemical reaction occurred or not. The TLC analysis was performed in a 1:1 ethyl acetate and hexane solvent because after testing multiple solvents, this was the one that produced the clearest results. My TLCs indicate that my two inhibitors were synthesized, and all reactions have occurred. Conclusions/Discussion Inhibitors with rhodanine and thiazolidinedione ring cores have been synthesized; further research includes performing R group substitutions and analyzing the activity and efficacy of the small molecule inhibitors using an Instant Isocitrate Dehydrogenase I ELISA Kit. This research delves into the possibility of treating cancer from the metabolic aspect; specifically, this research can indicate which structures and which core rings (rhodanine or thiazolidinedione) are effective inhibitors of IDH1. | |
| Summary Statement Two classes of small molecule inhibitors of the enzyme isocitrate dehydrogenase 1 were chemically synthesized; one class with a rhodanine ring core structure and the other with a thiazolidinedione ring core structure. | |
| Help Received My teacher, Mr. Darren Dressen, taught me useful lab techniques, like rotary evaporation and vacuum filtration. Dr. Steven Richards, BioElectron Corporation, helped me understand some chemical properties that must be considered when synthesizing inhibitors to treat human patients. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Rohan Mehrotra | Project Number S0617 |
| Project Title On-Demand Electrically Controlled Drug Release from Resorbable Nanocomposite Films | |
| Abstract Objectives/Goals Today, drugs are administered orally or intravenously. Such methods distribute drugs systemically, resulting in low drug efficacy and side effects. To solve this, scientists have been developing nanocarriers that can release drugs at targeted areas in response to stimuli. An exciting research area is nanocarriers that release drug in response to electric stimuli. Current electroresponsive drug release systems use dangerously high voltages (2-20V), are non-resorbable, or use non-FDA approved materials. My project goal was to develop a drug delivery system that uses safe voltages (<1.5V) to trigger drug release and is composed of materials that are FDA-approved and resorbable. I hypothesized that pH-responsive polymers could be used to achieve this goal, as electric stimuli generate pH changes that can be harnessed to trigger drug release. To test my hypothesis, I developed a nanocarrier composed of Eudragit S100 (EGT), a resorbable and FDA-approved polymer with pH-dependent dissolution. Methods/Materials I designed and synthesized nanometric films composed of EGT loaded with various drugs and coated them with a protective layer of chitosan. I tested the films' electroresponsive drug release abilities, and investigated my hypothesized drug release mechanism. Results Drug release experiments demonstrated that the nanofilm had electroresponsive release capabilities, as drug release was only observed upon voltage. Furthermore, excellent dosage control was observed, as drug release scaled linearly with the magnitude and number of applied stimuli. Finally, the versatility of the film was shown through the release of 4 drug molecules of varying hydrophobicity, pKa, and size. Conclusions/Discussion I envision that my nanofilm could be integrated with recently developed radio-powered implants that can wirelessly stimulate electroresponsive drug release inside the body. This drug delivery system would have several benefits for the treatment of chronic diseases, including increased drug efficacy and more precise drug regimens (due to control over the dose and timing of drug delivery). It would also be more convenient and safe, in part due to its resorbability (ability to disintegrate in the body). To the best of my knowledge, this is the first demonstration of an electroresponsive drug delivery system that is sensitive to low voltages and composed of completely FDA-approved, bioresorbable polymers. | |
| Summary Statement I designed a nanofilm composed of a resorbable polymer that can load drugs and release them on demand upon application of an electrical stimulus. This system would enable physicians to administer drugs in a more targeted, effective manner. | |
| Help Received I would like to thank Devleena Samanta and Katy Margulis, two scientists in Richard N. Zare's lab at Stanford, for mentoring me throughout the duration of this project. I would also like to thank the journal Nanoscale for publishing the paper that I co-first authored with my mentors about this work. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Dang Khoa Nguyen Ngoc | Project Number S0618 |
| Project Title Investigating the Effects of Various Energy Sources on Electrochemical Cells' Potentials | |
| Abstract Objectives/Goals As battery technology, specifically lithium-ion, reaches a physical limit, it is crucial to study the roots of electrochemistry to identify possible improvements so as to formulate a better model. In this project, the performance of a basic electrochemical cell setup is studied as different energy sources are introduced. Methods/Materials The "battery cell" is tested against thermal energy (temperature), chemical potential energy (electrolytic concentration and electrode mass), and for future studies: physical kinetic energy (ultrasonic waves) and even an atomic combination of chemical and physical (with 2D graphene). The cell in question is a galvanic zinc-copper setup, with either one (H ₂ SO ₄) or two (CuSO ₄ and ZnSO ₄) electrolytes, depending on the objective. Results As per intuition, the voltage level of any kind of electrochemical cell should increase if additional energy is introduced and properly exploited. The results reflect this hypothesis but varied for different types of setting. For example, temperature, despite being negative in the Nernst equation ($E_{cell} = E_{ocell} - (RT/nF) \ln Q_r$), turned out to have a positive effect of voltage in the experiment with a double-cell setup (around +200 mV for a 90oC difference on average) because of the increase in atomic kinetic energy, but has a negative effect when studying a single-cell due to local action and polarization. Also, the concentration of the electrolyte in the single-cell has a linear negative relationship with voltage (-250 mV for a 55% difference) but a positive one in a double-cell (+150 mV for 0.9M difference), which is also inconsistent with the Nernst Equation. Finally, the introduction of a sacrificial anode proved effective in limiting mass loss in the anode electrode over 24 hours with no significant effect on the voltaic output. Conclusions/Discussion In the big picture, these findings can be applied to advancing our battery models to optimize performance and lifespan by thoroughly utilizing the available energy sources surrounding and within materials. | |
| Summary Statement I tested the effects of different energy sources on the potentials of electrochemical cells. | |
| Help Received I carried out and analyzed my results for initial hypotheses and explanations, which are then revised by Dr. Grant, my adviser. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Laura Noronha | Project Number S0619 |
| Project Title TiO₂ Hollow Shell around Gold Nanoparticles: A More Efficient Photocatalyst | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Synthesize gold nanoparticles surrounded by a TiO₂ hollow shell to serve as a more efficient photocatalyst.</p> <p>Methods/Materials First, the gold nanoparticles were prepared by mixing the prepared gold precursor with trisodium citrate. Then, polyvinylpyrrolidone (PVP) was coated on the gold nanoparticles to prevent them from aggregating. The nanoparticles were then coated with a layer of silica. The titania was coated over the silica, and the silica was then etched, which created a hollow space around the gold nanoparticles. Hydrochloric acid (HCl) was added so that the TiO₂ surrounding shell would remain intact under high temperature conditions during calcination. Titania hollow shells without a gold core were synthesized as a control. The TiO₂ and the gold-nanoparticles with TiO₂ were then compared to see which of the two would be a more efficient photocatalyst in the degradation of the organic dye Rhodamine B (RhB). The 3 samples analyzed were: RhB blank sample, RhB with only TiO₂ hollow shell, and RhB with Au@TiO₂ catalyst. 1 mL of each sample was taken every 10 minutes for one hour. The UV-visible absorption spectrophotometer was used to compare breakdown rates of the RhB in each of the 3 samples.</p> <p>Results The RhB decomposed the slowest with no catalyst. When the TiO₂ shell was sonicated in the sample, the RhB degraded at a much faster rate. The reaction worked the best with the Au@TiO₂ photocatalyst, especially with the samples taken from thirty minutes to sixty minutes. At ten minutes, the TiO₂ had a slightly more efficient breakdown, but the gold and titania quickly surpassed the rate of the reaction using only titania.</p> <p>Conclusions/Discussion Using gold nanoparticles in a TiO₂ shell is a more efficient photocatalyst. This is due to the surface plasmon resonance property of gold nanoparticles which causes them to absorb and scatter light. This in turn optimizes the excitation of electrons in the titania hollow shell, leading to the formation of more electron hole pairs. Formation of electron hole pairs serves as the basis for the photocatalytic activity of titania. This can be used in many reactions such as decomposition of organic dyes and redox reactions including the splitting of water to produce hydrogen gas. It is a possible solution for a cleaner source of hydrogen gas.</p> | |
| Summary Statement Optimal photocatalytic activity was achieved by combining a gold nanoparticle inside a titania hollow shell. | |
| Help Received This project was completed at Dr. Yadong Yin's lab in the Department of Chemistry at the University of California Riverside. Graduate student Rashed Aleisa mentored me in this project. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Sasha L. Ronaghi | Project Number S0620 |
| Project Title Designing a Water Repellent and Breathable Material for Wound Dressings Using Nanotechnology | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Surgical dressings today are suboptimal because they trap moisture and do not prevent penetration of water causing bacteria to grow, leading to infection. An ideal surgical dressing would be hydrophobic, which would prevent outside moisture from reaching the wound and stimulating bacteria growth. Bacteria does not adhere to hydrophobic surfaces because it is not energetically favorable. Also, the dressing would be breathable to allow the wound to release excess moisture that causes bacteria growth. Lastly, the material must be biocompatible.</p> <p>Methods/Materials Using a Sputter Coater, gold is deposited on pre-stressed polystyrene sheets (PS). The sample is heated and the PS sheets shrink. Because gold cannot shrink, it wrinkles to fit the size of a PS sheets. The wrinkles are transferred onto polydimethylsiloxane (PDMS) in a cast and mold method. This study analyzed the surface roughness and contact angle of 0 nm Au, 5 nm Au, 10 nm Au, 15 nm Au, and Tegaderm samples. The material was punctured 25 times. The Upright Cup method was used to find breathability of PDMS punctured, PDMS non-punctured, Open tube, and Tegaderm.</p> <p>Results As the Au thickness increases, the surface roughness also increases. The exponential nature of the relationship suggests an increase in Au thickness will minimally affect the surface roughness beyond a certain limit. Furthermore, as the Au thickness increases, the contact angle increases linearly suggesting an increase in hydrophobicity. Compared to Tegaderm, the contact angle of the 15 nm Au (135°) is 52° higher. Next, the Perforated PDMS sample in this study was found to be 230% more breathable than Tegaderm and 220% more breathable than Non Perforated PDMS. Furthermore, the sample was 180% more breathable than 26 WWB (waterproof, windproof, and breathable) fabrics on the market.</p> <p>Conclusions/Discussion In this experiment, nanotechnology was utilized to increase the the hydrophobicity of PDMS, making it a more suitable material for surgical dressing. The final contact angle is 135° (close to superhydrophobic). Hydrophobicity decreases the likelihood of infection from outside moisture and is antibacterial. The breathability was also improved by adding micro-perforations to the material. The breathability allows the wound to release excess moisture and prevent growth of bacteria that could lead to infection. Furthermore, PDMS is a biocompatible material.</p> | |
| Summary Statement I created a material ideal for wound dressings because it is biocompatible, very hydrophobic, and 230% more breathable than the leading brand. | |
| Help Received I worked on my project at the research lab of Michelle Khine of Biomedical engineering at UCI. Graduate students Micheal Chu and Lancy Lin answered questions and taught me how to use the equipment. I designed, built, and performed the experiments myself. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Jaskirat Sandhu; Lydia Xu | Project Number S0621 |
| Project Title Fabrication of Nanoscale PDMS Wrinkles with Controlled Periodicity for Anti-Counterfeit Application | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals In recent years, the wrinkle fabrication of polydimethylsiloxane (PDMS) has attracted scientists' attention as it provides a cost-effective way of producing nanostructures. Those nanoscale wrinkle structures contain more randomized minutiae patterns than fingerprints and are not cloneable even when fabricated under the same conditions, making them an excellent candidate for anti-counterfeit material. An important question is how to control the periodicity of those random irreproducible wrinkles so they can have tunable security levels. The goal of this research is to develop an effective method to fabricate PDMS wrinkles with controlled periodicity for anti-counterfeit application.</p> <p>Methods/Materials The PDMS was made with a 10:1 silicone elastomer to silanizing agent ratio and cured at 65°C. We treated all PDMS in a plasma chamber at the same power for the same time duration. The plasma oxidation altered the chemical composition of the surface and induced a thin stiff skin. The strain mismatch between the stiff skin and the substrate produced nanoscale wrinkles. To control the wrinkle periodicity, we stretched the PDMS at different ratios, and at each stretch ratio, we experimented with different substrate thicknesses and observed the wrinkles under an optical microscope. A nanoimprint mold was then fabricated with optical adhesives cured under UV light.</p> <p>Results Varying the substrate thickness effectively changed the PDMS wrinkle periodicity, while varying the stretch ratio only slightly affected it. In the theoretical models for wrinkle periodicity, the substrate thickness is simplified to be semi-infinite and excluded from the equation, but the results of our experiment demonstrate that the substrate thickness has a significant effect on the wrinkle periodicity when the substrate thickness is finite.</p> <p>Conclusions/Discussion Changing the PDMS substrate thickness is an effective method to control the wrinkle periodicity, and it is a novel approach to tune the security level of this emerging anti-counterfeit material. More studies can be done to further enhance the security strength of the PDMS wrinkle patterns, and for our future research we plan to use gold nanoparticles to add complexity to the patterns.</p> | |
| Summary Statement We have developed a novel approach to fabricate nanoscale PDMS wrinkles with controlled periodicity for anti-counterfeit application. | |
| Help Received We used the lab equipment at the University of California Riverside under the supervision of Dr. Yadong Yin and graduate student Zhiwei Li. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Samira Sriram | Project Number S0622 |
| Project Title Exploring the Effect of Lanthanum Nitrate, La(NO₃)₃, with a Pyrrolidinium Ionic Liquid Electrolyte in a Li-S Battery | |
| Abstract Objectives/Goals In an increasingly unsustainable world, the demand for high-performing, rechargeable batteries is increasing. Lithium ion batteries, specifically, have been the subject of much research as their high energy density and long cycle life are suitable for a variety of applications. The main problem, however, is the decomposition reaction between the surface of the anode and the electrolyte, which creates insoluble polysulfides on the anode surface. This passivation layer, also known as the Solid-Electrolyte Interface (SEI), prevents the efficient intercalation of lithium ions into the anode and cathode structures, causing degradation of the battery system over long term cycling. The introduction of lanthanum nitrate into the electrolyte system will reduce this "polysulfide shuttle effect" by creating metal or alloy layers on the lithium anode surface. | |
| Methods/Materials A sulfur/carbon composite was synthesized to maximize lithium ion intercalation at the cathode surface. Nanoporous carbon with a hexagonally ordered mesostructure was synthesized via an SBA-15 hard plate. To first synthesize the silica template, Pluronic P123, TEOS, and HCl reacted to form a precipitate which was filtered and washed with ethanol. The resulting powder was soaked in mixtures of H ₂ SO ₄ and sucrose at varying concentrations. Pyrolysis was performed to solidify the carbon nanotubes within the shell. However, further research is necessary to determine how this cathode structure, and the subsequent increased battery efficiency, will work with in conjunction with lanthanum nitrate to optimize the SEI. In order to measure the effectiveness of lanthanum nitrate in this battery system, CR2032 coin cells will be used. A standard DME:DOL electrolyte will be used as a control, to measure against the pyrrolidinium based electrolyte. Lithium metal will be used on the anode surface, coin cell construction will be followed. Battery testing will go as follows: for SEI understanding, I will conduct XPS analysis, sputtering/ depth profiling to receive data on the SEI chemical makeup after long term cycling, and energy dispersive spectroscopy to determine the distribution of elemental lanthanum on the anode surface. Lastly, to test general battery efficiency, I will conduct Electrochemical Impedance Spectroscopy (EIS) with a 3-cell-geometry to measure the resistance of lithium ion charge transfer. | |
| Summary Statement I am building a more efficient lithium-sulfur battery by introducing a chemical species, lanthanum nitrate, into the electrolyte system to break down insoluble polysulfides on the battery surface that cause long term capacity fade. | |
| Help Received My chemistry teacher helped me set up the CMK-3 reactions and work with dangerous materials like HF. E-mentors from UC Santa Cruz and San Jose State University answered preliminary questions on anode synthesis and SEI morphology. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Hari Subramanian | Project Number S0623 |
| Project Title Effect of Ultrasound Treatment on Tomato Pomace | |
| Abstract Objectives/Goals The objective of this study is to understand the effect of ultrasound assisted extraction (UAE) of tomato pomace to extract soluble solids. Methods/Materials Tomato pomace was collected from 2017 processing season from a tomato processing factory based in California. The sonication horn used was from Heat Systems Ultrasonics, 24KHz, 200W, and maximum amplitude of 120 microns. Soluble solids were measured using a refractometer (Brix meter) with the capability of measurement till the nearest hundredth. A thick walled glass jar was used as the reactor to hold the mixture during UAE treatment. Two solid-liquid ratios 1:4 and 1:5 were used for the treatment. UAE treatment was undertaken for 30 minutes, with soluble solids measured every 5 minutes. At the end of every 30 minute treatment, the mixture was taken to a pressing machine to separate the juice from the fiber and seed in the pomace. Soluble solids extracted from the combined steps was measured. Results UAE treatment increased the extraction rate and mass of soluble solids extracted. Rate of extraction increased with intensity (measured as amplitude) of UAE. 1:4 ratio of solids to liquid ratio was sufficient for the UAE to be effective. We were able to extract around 50% of the available soluble solids at the maximum amplitude of 60 microns which was 1.89g/100g of pomace. We observed that this was 62% increase when extraction was performed without UAE. The rate of extraction followed a logarithmic model. We estimate the value of the extracted soluble solids is equivalent to \$ 630,000 per million tons of tomatoes processed. Conclusions/Discussion Tomato pomace is currently considered as a by-product or waste from the tomato processing industry. This study shows that UAE can be used to significantly increase the rate and mass of soluble solids extraction present in tomato pomace. This study can be used as a base for industrial scale up. We estimate the value of the extracted soluble solids is equivalent to \$ 630,000 per million tons of tomatoes processed. | |
| Summary Statement Can ultrasound treatment act as a process intensification method for extracting soluble solids from tomato pomace? | |
| Help Received Dr. Leonard Fong helped me with the set up of the UAE treatment. My dad helped with the value estimation and creation of the presentation. | |



CALIFORNIA SCIENCE & ENGINEERING FAIR 2018 PROJECT SUMMARY

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| Name(s) Michael D. Wu | Project Number S0624 |
| Project Title Harnessing Photon Upconversion in a Microfluidic Reactor for Ultra-Efficient, Solar-Driven Photochemical Synthesis | |
| Abstract Objectives/Goals Achieving solar powered photochemical synthesis has long been the dream of scientists. Unfortunately, flaws with existing photochemical reactors and the solar spectrum's lack of high intensity, specified wavelengths of light necessary for organic syntheses have historically prevented large-scale applications of photochemistry. To address these challenges, this project continuously flows reagents through a novel reactor which harnesses upconversion. Upconversion concentrates only the required catalytic blue light from solar illumination without increasing thermal stain. Enabled by upconversion, this project presents a solar-powered reactor for the more efficient microfluidic synthesis of pharmaceuticals and other compounds. Methods/Materials The novelty and challenge of this experiment lies in effectively harnessing upconversion inside a microfluidic reactor. Tygon tubing was suspended in a specialized mold and surrounded with an upconverting polymer comprised of polyurethane and 9,10-DPA, PdOEP dyes. The efficiency of the reactor was tested by synthesizing ascaridole, a crucial anti-parasitic drug. A-terpinene, oxygen, and the photosensitizer ru(bpy) were flowed through the microchannel at varying flow rates and illuminated with 1.12 suns. Each flow rate was tested 3 times. Product analyzed using gas chromatography and NMR spectroscopy. The experiment was repeated to synthesize rose oxide, an important fragrance, to further display industrial applicability. Results After experimentation, the upconverting reactor improved ascaridole conversion by 400% compared to existing microfluidics technology. 66% of starting reactant was converted to rose oxide with the novel reactor, compared >1% from controls. Combined with the increased conversion, quicker flow rate and wider tubing diameter of the novel reactor, ascaridole production output was increased 35 times compared to the best microfluidics. The reactor was simulated using COMSOL Multiphysics and optimized for 100% product conversion. Conclusions/Discussion Harnessing upconversion in a microfluidic reactor represents a breakthrough in photochemical synthesis techniques. The solar-powered reactor has far-reaching applications: providing on-demand pharmaceutical relief for Syrian refugee camps to treat the Leishmaniasis outbreak, improving the medical infrastructure of developing nations, and more sustainable and cost-efficient industrial manufacturing. | |
| Summary Statement This project enhances microfluidic photochemical syntheses through photon upconversion and has extensive applications industrially, treating outbreaks in Syrian refugee camps, and improving the medical infrastructure of developing nations. | |
| Help Received Thank you to Dr. Rachel Steinhardt, Professor Aaron Esser-Kahn, and the Esser-Kahn group at the University of California, Irvine for providing me to the opportunity to conduct my research in their laboratory and for inspiring my scientific curiosities. | |



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY**

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| Name(s) Andre A. Yin | Project Number S0625 |
| Project Title A Novel Approach to Increasing the Permeability of Desalination Membranes | |
| Abstract Objectives/Goals High costs associated with the desalination process have been the bottleneck that hinders the prevalent usage of seawater for drinking, agriculture, and industry. The goal of my project was to reduce the cost of desalination through maximizing two factors that constitute efficiency: rejection ratio (the percentage of salt filtered out) and flux (the amount of water filtered per unit membrane surface area per unit time). Methods/Materials This project explored the addition of cellulose nanofibers (CN) into desalination membranes for seawater NaCl filtration at 800 psi (industrial operating conditions). Fabrication of membranes consisted of using a commercial substrate, integrating a middle CN scaffold using CN solution I created in the lab, and forming the top salt barrier layer via a polymerization reaction. Performance testing involved using the high pressure desalination machine. Characterization tests focused on microscopy. Results The results demonstrated that a membrane with CN produced a 26 percent higher flux than the same type of membrane without CN. In addition, the results highlighted that the two membranes achieved comparable rejection ratios, supporting the hypothesis that the addition of CN does not compromise the performance of the membrane barrier layer, which filters out salt from water. Conclusions/Discussion Microscopy characterization of membranes revealed that a membrane with a more uniform pattern of ridges tends to have a higher salt rejection ratio. Because CN-based membranes use naturally abundant cellulose derived from plants and have a higher flux with no degradation in rejection ratio, these membranes have great potential in low-cost, commercially viable desalination applications. | |
| Summary Statement In this project, I explored how to increase the efficiency of seawater purification by integrating cellulose nanofibers into desalination membranes. | |
| Help Received Conducted project in the Chemistry Department at Stony Brook University, New York, through the Simons Summer Research Program. I am very grateful to Professor Benjamin Hsiao, Dr. Hongyang Ma, and Ms. Qinyi Fu for providing lab equipment, clarifying concepts, and answering my questions. | |