Abstract: Science and Engineering Fair of Houston

3143

Complex Coacervate: Novel Methodology to Crystallize Hydrophobic Drugs

Anvesha Subramanian

Fort Bend ISD /Ridge Point High School

Category:

Chemical Engineering & Materials Science

Unexpected polymorphic transitions in numerous pharmaceutical drugs have proved that polymorphs can drastically destabilize the proper function of drugs. This reveals a broader pharmaceutical vulnerability, namely, that hydrophobic drugs (like anticancer, HIV, and immunosuppressant drugs) are at a constant risk of being ingested by patients while in the incorrect polymorph and, therefore, inhibiting therapeutic performance with adverse effects including death. And so, this study investigates associative liquid-liquid phase separation (LLPS) specifically utilizing oppositely charged polyelectrolytes PAA and PDDA as a method to crystallize hydrophobic drugs (Mefanamic Acid (MFA)) in a specific polymorph. Mefenamic acid is an anti-inflammatory drug with low solubility in water (<0.02mg/mL) making it prone to slow dissolution and poor bioavailability but complex coacervation compartmentalizes the drug, controls supersaturation point, and permits crystallization to occur at the coacervate interface into the DMF phase. As PDADMA-PA is prepared in various DMF/water ratios, coacervate viscosity increases with higher DMF content. Using XRD, PDADMA-PA shows a broad peak around 2 θ ≈ 20 degrees and FTIR over time shows that water is released from the coacervate phase into the MFA solution. Pores on the coacervate surface act as a source of MFA and DMF solution can penetrate the PDADMA-PA coacervate. Future studies could investigate the crystallization of a hydrophilic drug or utilizing a solvent other than DMF.

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Abstract: Science and Engineering Fair of Houston

3144

From Waste to Wonder

Averi Pigg, Solana Muehr

Conroe ISD /ASHP: Academy for Science and Health Prof

Category:

Chemical Engineering & Materials Science

Microplastics are polluting the ocean and intoxicating many resources, with plastic bags being the leading cause. The problem is plastic bags are remaining in the environment and break up into microplastics. With 500 trillion plastic bags being used every year, at least 10% end up in the ocean. The aim of this study was to develop a biodegradable plastic bag made from waste products such as corn stalks as an alternative to conventional grocery bags. In a test using weights, tensile strength was recorded for the HEB, bio-resin and old prototype bags. After completing the research, it was found that the HEB high-density polythene and the Bio-resin bags did not have a statistical difference between the tensile strength. While manufacturing companies may be hesitant to switch to Bio-Resin bags, these bags can be directly transferred into the already set up manufacturing process through the use of nurdles. By using biodegradable and eco-friendly bags the percentage will decrease in the amount of plastic that ends up in the Earth's waters by at least 7%, which is equivalent to 350 billion plastic bags. They offer a practical solution to reduce microplastic pollution and environmental damage without changing the preexisting manufacturing process.

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Abstract: Science and Engineering Fair of Houston

3145

From Fog to Drink: Nature's Blueprint for a Self-Refilling Water Bottle

Kritika Bharadwaj

Conroe ISD /AST: Academy of Science and Technology

Category:

Chemical Engineering & Materials Science

Drought is a major problem in coastal deserts such as the Atacama Desert, where high humidity indicates abundant atmospheric moisture, yet many people lack access to clean water. One common solution to this issue is the use of fog nets, which can efficiently collect large amounts of water from fog but are often impractical due to their remote placement, high initial cost, and lack of portability. This project addresses this gap by designing a portable, low-cost, biomimetic water bottle inspired by the Namib Desert beetle. The design includes a cylindrical body with "beetle bumps" covering three-quarters of the surface (to capture fog droplets), a funnel skirt below the bumps to collect water, and internal straws that direct the water into the bottle, created using CAD software and 3D printed with PETG. Hydrophilic coatings were applied to the tops of the bumps, while hydrophobic coatings were applied to the surrounding areas to encourage droplet movement. Across three trials, the coated bottle collected an average of 51 mL of water, while the uncoated control collected only 2 mL, a statistically significant difference. For durability testing, the bottle was tested for four hours, scrubbed under running water for 30 seconds, and retested. After scrubbing, average water collection dropped to 4 mL, showing a significant decrease in performance. Overall, this project demonstrates that biomimetic fog collection on a portable surface is effective, but improvements in coating durability are needed before commercial use, possibly by lasering treatment for the hydrophobic and hydrophilic regions.

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Abstract: Science and Engineering Fair of Houston

3146

A Material To Tomorrow : A Sustainable Alternative For The Exterior Of Vehicles

Ken Sugita

Conroe ISD /AST: Academy of Science and Technology

Category:

Chemical Engineering & Materials Science

Abstract Currently, excessive carbon dioxide emissions and sustainability are among the many challenges for many researchers, where attempts are made to create performance-level alternatives, (Nagarajan et al, 2019). The problem of carbon dioxide emissions is prominent in the automobile manufacturing industry, where the vast majority of the composition and procedures to create vehicles are heavily dependent on petroleum, (Patel & Singh,2024). Due to the overwhelming demand for an alternative to petroleum based materials, I experimented and engineered with 5 distinct procedures and materials involving PVA matrix, pine resin, fabric press, starch and vinegar, and finally woodflour and chalk to create a bioplastic more sustainable and performance level than petroleum. In order to evaluate their beneficiality, each method was evaluated by aspects of flexibility and durability based on the ISO 178 guidelines, as well as water resistance using a mathematical formula. The 2-sample t-tests concluded that pine resin and the fabric press processes performed the best in both terms of flexibility and durability. They also did well in the water resistance category, having the smallest deviation compared to conventional plastics. The experiment partially supported the hypothesis of creating a performance grade material with limited material, confirming that non-petroleum materials may be modified to achieve performance level beneficiality. However, the proportions and procedures may differ when used in large-scale mass production, therefore, may require extensive research and resources. With this technology, industries could adapt the process of using more sustainable resources instead of non-renewable one, finding alternatives to create sustainable consumer products to the larger world.

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Abstract: Science and Engineering Fair of Houston

3147

CADENCE: Evolutionary Fragment-Based Discovery of Novel BCR-ABL, HER1, and ERBB2 Competitive Inhibitors

Christopher Angell

Friendswood ISD /Friendswood High School

Category:

Chemical Engineering & Materials Science

Finding de novo candidates with high binding affinity remains a significant challenge in kinase inhibitor drug discovery. CADENCE, a compu- tational pipeline that integrates convolutional neural networks (CNNs) with evolutionary BRICS-based molecular fragmentation, generates novel candidate kinase inhibitors directly from kinase amino acid sequences. The pipeline comprises a binding affinity prediction model, a fragment-based generative algorithm for candidate synthesis, and a filtering stage that selects Candidates that closely follow Lipinski's Rule of Five, prioritizing drug-like compounds. Using 15 evolutionary generation cycles, the model produced candidates for ABL1, HER1, and ERBB2 with predicted binding affinities comparable to those of known kinase inhibitors. The affinity prediction model operates on amino acid sequence, and does not incorporate structural elements of kinase binding pockets, representing a limitation of the current approach. These results demonstrate the potential of sequence-driven computational methods for early-stage develop- ment of kinase inhibitors for cancer therapy.

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Abstract: Science and Engineering Fair of Houston

3148

Replicating Polytetrafluoroethylene Gaskets with 3D-Printed Materials

Ethan Ronnander, Andrew Moore

Conroe ISD /AST: Academy of Science and Technology

Category:

Chemical Engineering & Materials Science

Chemical plants use pipes connected with flanges to transport chemicals. A gasket is crushed between these flanges to create a seal, making sure no chemicals leak out. In the standard industrial setting, polytetrafluoroethylene (PTFE) is used to create these gaskets due to its exceptional properties. One problem using these gaskets is that when you have to replace them and don't have one readily in stock, the plant incurs loss of revenue from production delays. Using a 3D-printer and various filaments, we can attempt to recreate these gaskets on site for a cheaper cost and significantly reduced shipping time. We performed multiple tests to simulate conditions in a chemical plant to test the viability of different printable materials. Our 4 filaments include: thermoplastic polyurethane (TPU), styrene-ethylene-butylene-styrene (SEBS), acrylonitrile styrene acrylate (ASA), and polyethylene terephthalate glycol (PETG). Our tests include a UV/radiation test, a hydro test, a pH test, and finally a test to measure how easy it is to print these materials. All materials passed the successful print test, UV/weather tests and pH tests. TPU and PETG gaskets both crushed well and passed the hydrotest making them viable replacements for PTFE gaskets in chemical plants.

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Abstract: Science and Engineering Fair of Houston

3149

Fabrication and Characterization of Silk-Derived Actuators

Category:

Chemical Engineering & Materials Science

Anik Banerji

Private/ST. JOHN'S SCHOOL

Despite their increasing use in surgery and prosthetics, many robotic systems present safety concerns to medical patients due to their rigidity. This project explores the assembly and testing of tendon-driven, finger-like soft actuators made from regenerative silk fibroin (SF). Prior developments have focused on extracting and processing this protein, but this application goes further by demonstrating SF's uses as a material for the construction of soft and compliant actuators capable of safe and effective interaction with biological systems, specifically in niches that require soft mechanics, biocompatibility, modularity, and fluid motion. In this project, aqueous SF was extracted from silk cocoons and used to construct a soft continuum actuator. An aqueous solution of SF was prepared by boiling silk cocoons with sodium carbonate, dissolving the resulting fibers in lithium bromide, and removing excess salts via dialysis. Silk was shaped into computer-designed structures mimicking a human finger's mechanics via injection molding. Key mechanical properties of these structures, including the Young's modulus, yield strength, Poisson's ratio, and contact angle with water, were measured, demonstrating its suitability for biomedical applications requiring flexibility comparable to human tissue or high force output relative to mass.

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Abstract: Science and Engineering Fair of Houston

3150

Novel Photochemically-Activated Quantum Dot Conjugates for Modulation of Neurodegenerative Protein Aggregates

Vriti Mirchandani, Niketa Pati

Fort Bend ISD /Dulles High School

Category:

Chemical Engineering & Materials Science

Protein misfolding and aggregation are defining pathological features of neurodegenerative diseases such as Alzheimer's and Parkinson's disease, yet existing strategies lack spatiotemporal precision to selectively perturb pathological aggregates without disrupting native protein structure. Although nanoparticle based approaches have shown potential for modulating protein aggregation, controllable, light triggered disruption of pre formed aggregates has not been systematically established. In this study, we developed and characterized photochemically activated CdSe/ZnS quantum dot conjugates as a platform for optical control of protein aggregation state. Water soluble quantum dots with 570 nm emission were incubated with thermally aggregated egg albumin and exposed to 470 nm blue light. Light activated samples exhibited a 44% reduction in aggregate associated fluorescence compared to dark controls (2053 ± 45 RFU vs 3295 ± 28 RFU, $p < 0.001$, $n = 3$), indicating substantial aggregate disruption. Disaggregation scaled with quantum dot concentration and illumination time, approaching a kinetic plateau after approximately 10 minutes. Reactive oxygen species assays revealed a 2.5 fold increase in ROS generation upon light activation ($p < 0.001$), supporting a photochemical mechanism. Wavelength dependence studies demonstrated maximal activity at 470 nm, and native protein showed no significant change under identical conditions ($p = 0.69$), indicating selectivity for aggregated conformations. Together, these results establish a light addressable photochemical platform for controlled perturbation of protein aggregation dynamics, providing a foundation for future mechanistic and translational studies of aggregation driven neurodegeneration.

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Abstract: Science and Engineering Fair of Houston

3151

Category:

Chemical Engineering & Materials Science

Peels to Bioplastic: Development and Characterization of Pectin-Based Bioplastic Films from Organic Waste

Serene Huang, Mandy Cai

Conroe ISD /AST: Academy of Science and Technology

The prevailing issue of plastic pollution in the world has prompted many researchers to explore different methods of developing bioplastics. Pectin is a plant-based gel that shows a promising possibility to be a source for biodegradable plastic. However, pectin alone is too brittle and requires additives in order to perform like conventional plastic bags. Our project focuses on using cellulose and glycerol to improve the mechanical properties of the biofilm in order to make it sustainable and cost-effective. We first made a film with just pectin as our control. However, because pectin alone is too brittle, we incorporated additives like cellulose and glycerol to improve mechanical properties. After determining the optimal concentrations with a 2:1 ratio between pectin and cellulose and 2.5% glycerol, we then extracted pectin from watermelon rinds and repeated the same process. To test the mechanical properties, we used a spring scale and recorded the force at break and elongation to determine tensile strength and Young's modulus. With these tests, we found that our pectin films have a lower tensile strength than plastic, but were able to hold more weight due to it being around five times thicker. Through this project, we hope to not only shed light on the potential for pectin bioplastics but also reduce the amount of food waste, contributing to a circular economy.

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Abstract: Science and Engineering Fair of Houston

3152

Lunar Heat Shield; Thermal Testing of Regolith Stimulant Bricks

Lauren Jessel

Clear Creek ISD /Clear Springs High School

Category:

Chemical Engineering & Materials Science

With extreme thermal temperatures on the moon and limited space on the spaceship, this creates a challenge for the creation of future lunar colonies. This project is able to test the thermal insulations of a lunar regolith brick in order to see how successful it would be in a lunar habitat. From maintaining the oven heat temperature at 375°F for 35 minutes to cooling the bricks in a freezer for up to 2 hours. External temperatures were then taken, recording with the three different insulated bricks consisting of no insulation, aluminum foil- representing MLI sheets-, and cotton -representing fibrous insulation-. The data analysis shows that the insulation did, in fact, slow the temperature change compared to the non-insulated brick. Based on these finding, lunar regolith bricks could be a possible solution to have for safe and energy efficient lunar habitats. For future experiments there could be a change in the thickness of the brick along with other insulation being tested.

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Abstract: Science and Engineering Fair of Houston

3153

Category:

Chemical Engineering & Materials Science

Low-Cost Nanocrystalline Nickel Reinforcement of Additively Manufactured Thermoplastics for High-Stress, Aggressive Chemical Environments

Derek Jiu

Private/ST. JOHN'S SCHOOL

Additive manufacturing is often excluded from heavy industrial applications due to the inherent mechanical weaknesses and chemical vulnerabilities of common thermoplastics. This research develops a hierarchical metallic reinforcement methodology for additively manufactured polycarbonate to enable its use in high-stress and aggressive chemical environments. The process involves a dual-stage electrochemical deposition: first, an autocatalytic electroless nickel phosphorus (ENiP) tie layer is established to ensure uniform conductivity across complex geometries; second, a nanocrystalline nickel shell is synthesized using pulsed current electrodeposition. The study engineered the Hall-Petch effect by modulating pulsed current duty cycles to refine grain size to the nanoscale. Using a 3ms pulse duration and 30ms relaxation period, a surface hardness of 800 HV was achieved on the coated polycarbonate, representing a 40-fold increase over the base substrate. Mechanical characterization demonstrated that the metallic exoskeleton effectively enhances load-bearing capacity, yielding a significant increase in the ultimate tensile strength of the part. Thermal validation confirmed that the shell successfully disperses high heat loads, preventing the polymer core from reaching its glass transition temperature. Furthermore, the composite was evaluated as a hermetic barrier, successfully protecting the polymer from structural dissolution in aggressive chemical environments. The applicability of this methodology to complex industrial geometries was demonstrated through the structural design and additive manufacturing of multi-stage centrifugal impellers and ball valves. This approach bridges the gap between rapid prototyping and industrial performance, offering a high-strength, low-cost alternative to traditional metal additive manufacturing and superalloy machining.

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Abstract: Science and Engineering Fair of Houston

3154

Turning UV Losses Into Usable Light: COF-Based Luminescent Films for Improving Solar Cell Output

Alex Phan, Mia Repka

Conroe ISD /AST: Academy of Science and Technology

Category:

Chemical Engineering & Materials Science

Standard silicon solar cells struggle to convert ultraviolet (UV) light, which accounts for approximately 8.3% of solar energy. This "wasted" energy is often lost as heat or causes material degradation. The goal is to engineer a Covalent Organic Framework (COF) film solution capable of Luminescent Down-Shifting, absorbing high-energy UV light and re-emitting it as lower-energy, either red or green visible light to boost solar cell output. Researchers synthesized a Tp-PDA COF using 1,3,5-Triformylphloroglucinol and p-Phenylenediamine combined with an AIE luminogen and PMMA matrix. The solution was heated at 80°C, followed by exfoliation and filtration. Absorbance and fluorescence were measured using a Vis spectrometer. The film successfully captured light at a peak of 393.6 nm. It maintained an average transmittance of 72.1% in the visible range. A Stokes Shift of 16.5 nm was recorded, with peak fluorescence at 410.1 nm. The data support the hypothesis that COF films can perform LDS. While energy conversion was confirmed, the current emission is in the violet-blue region. Future research will focus on increasing the Stokes shift to reach the target green or red wavelengths.

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Abstract: Science and Engineering Fair of Houston

3155

Suited For Safety

Valencia Valdois

Clear Creek ISD /Clear Falls High School

Category:

Chemical Engineering & Materials Science

The purpose of this project was to test possible solutions for enhancing a standard school backpack to provide protection in a school shooting scenario involving an AR-15 5.56 sport rifle. It was hypothesized that a National Institute of Justice (NIJ) HG2 hard body armor plate combined with an outer layer of Ortho-Fabric would offer effective protection. Due to the federal government shutdown, there was a shortage of available Ortho-Fabric from NASA, which forced some modifications to the experiment. Testing was conducted using an AR-15 5.56 sport rifle with M193 ammunition fired from 15 yards. An initial setup of one HG2 hard plate followed by eight layers of Ortho-Fabric showed partial degradation of the projectile but insufficient protection, since the round penetrated the plate, fabric, and four wooden boards. A second setup, consisting of two HG2 hard plates, each backed by eight layers of Ortho-Fabric, produced significantly better results. The first hard plate deformed and fragmented the projectile, while the Ortho-Fabric absorbed and dissipated energy. The second hard plate successfully stopped the round, leaving only a shallow divot. The final Ortho-Fabric layers and wood block behind it showed minimal damage, indicating effective energy absorption and protection. In conclusion, while a single plate was insufficient, the combination of two HG2 hard plates with layered Ortho-Fabric provided significant protection against AR-15 5.56 M193 rounds. These findings suggest that backpacks can be engineered with layered armor to provide meaningful safety enhancements for students in high-risk scenarios.

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Abstract: Science and Engineering Fair of Houston

3156

Category:

Chemical Engineering & Materials Science

Paint-on Power: Photonic Crystal Sensitization of a Low-Cost Carbon Quantum Dot Photovoltaic Composite for Sustainable Energy Conversion

Maan Patel

Conroe ISD /AST: Academy of Science and Technology

Photovoltaic panels are confined to absolute planar geometries. The concept of solar paint unleashes the potential to transform any surface into a light harvesting interface as an alternative to traditional panels; however, solar paint has remained in an experimental phase for over a decade due to trade-offs in efficiency, eco-friendliness, and cost. A novel nanostructured solar paint comprising of an N-doped carbon quantum dot (CQD) sensitized TiO2 electron transport layer (ETL) was designed and manufactured through nanometer layer synthesis and assembly. After pre-sintering of the TiO2 ETL onto an FTO glass substrate, CQD biomass derived precursors were hydrothermally synthesized and loaded onto the ETL. During the CQD loading stage, select samples were embedded with nature-inspired Bragg reflectors (photonic crystals) for improved light trapping while remaining samples were loaded with deliberate CQD concentrations. The CQD load was dried, forming a TiO2-CQD heterojunction (n-p). A synthesized potassium ferri/ferro-cyanide electrolyte gel and spacer were deposited onto each sample's heterojunctions. After preparation of the experimental counter electrode, power conversion efficiencies were calculated from voltage-current test results. ANOVA revealed no significant difference between all fabrication batches (p □ 0.05), validating utilized methodology. Pairwise t-tests demonstrated statistically significant differences between each CQD loading condition, all outperforming the TiO2 control (p □ 0.00000001). Paint samples with the highest CQD loading concentration and photonic crystal impurity attribute maintained the highest efficiencies. The development of versatile photovoltaic paint paves a path towards bringing efficiency, eco-friendliness, and affordability to the rapidly growing industry of solar energy.

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Abstract: Science and Engineering Fair of Houston

3157

Geometric Properties of Obstructed Acoustic Insulators

Category:

Chemical Engineering & Materials Science

Kevin Yan, Nicolas Jan

Houston ISD/Bellaire HS

Acoustic metamaterials represent a promising platform for exploring topological phenomena in solid-state physics. By controlling the propagation of acoustic modes, these systems emulate electronic band structures and offer new methods to study topological states. One such system, the 2D Su-Schrieffer-Heeger (SSH) model, consists of coupled atomic dimers that give rise to topological phenomena such as fractionalized charge excitations dependent on lattice termination. In this work, we demonstrate that 2D SSH lattices can be effectively modeled using acoustic metamaterials, enabling rapid and accessible exploration of topological behavior. By analyzing the relationship between lattice geometry and eigenstate distribution, we show that the number of fractionalized states scales linearly with lattice size per side, the number of corner fractional states remains constant, and the bulk states scale with the number of internal cavities. However, extending the electronic-acoustic analogy reveals important limitations. Here we show, in an acoustic lattice, edge states do not emerge in the lowest energy band, indicating a breakdown in the electronic-acoustic analogy. This phenomenon may be associated with a Goldstone boson, which represents a breaking of continuous symmetry in our system. By comparing the lowest orbital to higher energy states across varying coupling strengths, we found that the ground state coupling decays much slower than the higher states. This observation is contrary to the expected behavior predicted by the tight-binding model. These results address a limitation in mapping electronic topological states to acoustic metamaterials which is important when using acoustic materials to rapidly prototype quantum systems.

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Abstract: Science and Engineering Fair of Houston

3158

Natura Antimicrobial Hydrogels for Wound Care

Category:

Chemical Engineering & Materials Science

Nidhi Patel

Clear Creek ISD /Clear Lake High School

Bacterial wound infections remain a major global health issue, especially with rising antibiotic resistance that makes conventional treatments less reliable. Because of this, there is increasing interest in natural, accessible antimicrobial alternatives that could support wound healing. This project examined the antibacterial effectiveness of three natural substances like aloe vera, honey and turmeric against E. coli bacteria which is a common bacteria found in infections. Each substance was tested individually, as well as in a combined formulation containing all three ingredients. Filter paper discs infused with each treatment were placed on a nutrient agar plate previously swabbed with E. coli. A control plate with no treatment was also included. All plates were incubated at 37° for 24 hours, and bacterial growth was measured with a digital caliper. This original swabbed surface measured 80mm in diameter, and smaller post treatment diameters indicated stronger antibacterial activity. The results showed that honey produced the greatest reduction in bacterial growth, with an average remaining diameter of 24.77mm. The combination treatment showed moderate success with a 54.33mm average, followed by turmeric at 35.91mm, and aloe vera with minimal inhibition at 68.15mm. The untreated control showed almost no change, averaging at 79.50mm. These findings suggest that honey is the most effective antimicrobial agent tested and could serve as a promising support treatment for wound care. Natural remedies like honey may help reduce bacterial presence un injuries while offering a safer, more accessible option where antibiotic resistance or limited resources pose challenges.

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Abstract: Science and Engineering Fair of Houston

3159

Self‐Sensing Mortar Composites for Structural Degradation Detection Using Graphene Nanoplatelet Conductive Networks

Chamika Udugamasooriya, Anurag Anandprasad, Vatsal Sharda

Katy ISD/Cinco Ranch - HS

Category:

Chemical Engineering & Materials Science

Cement-based materials such as mortar, cement, and concrete form the foundation of global infrastructure. However, structural aging often remains undetected until catastrophic failure occurs. Existing structural health monitoring methods are largely limited to manual surface-level observation or rely on highly expensive imaging technologies limiting their practicality for effective, continuous structural health monitoring. This study explores the use of graphene nanoplatelets (GNPs) as conductive additives in cementitious composites to enable low-cost, real-time damage sensing. Mortar specimens were fabricated with GNP concentrations of 0.3%, 0.62%, 1.8%, and 2.7% by weight of cement. GNPs were dispersed in water with a polycarboxylate ether (PCE) superplasticizer surfactant via a bath sonicator and mixed into mortar specimens. After curing, electrodes were attached to the specimens and mechanical loading was applied to induce strain and microstructural damage. Electrical resistivity was monitored using a double probe/surface point configuration to analyze changes in conductivity associated with structural damage. Ultimately, this project provides a scalable approach for internal damage assessment via embedded conductive networks, offering potential applications in real-time structural health monitoring.

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Abstract: Science and Engineering Fair of Houston

3160

Comparative Analysis of Gas Containment in Algae-Based Latex Balloons Using Air and Helium

Anabella Wilems

Clear Creek ISD /Clear Lake High School

Category:

Chemical Engineering & Materials Science

What is the effect of biodegradable balloon material on its ability to retain air and helium over time? Many commercially marketed “biodegradable” balloons still contain synthetic additives that are not environmentally safe and often permit rapid gas loss. This project represents step 3 in a 4-phase investigation aimed at developing a fully biodegradable balloon that performs comparably to commercial latex. It was hypothesized that balloon films produced from Saccharina latissima blended with natural latex would retain both air and helium more effectively than films produced from Palmaria palmata. To evaluate this hypothesis, two algae species (Saccharina latissima and Palmaria palmata) were blended with natural latex at two concentrations—50% and 33%—and balloon molds were dipped into the liquid mixtures to form consistent balloon films. Each balloon was inflated with air and helium, and gas retention was quantified by measuring changes in diameter using a digital caliper. A commercial latex party balloon served as the control. Results showed that S. latissima demonstrated the smallest decrease in diameter for both gases, while P. palmata exhibited the greatest loss. The commercial control balloon experienced significantly larger decreases than all biodegradable samples. It was hypothesized that Saccharina latissima would retain the most gas, and the data supported this prediction. The S. latissima films outperformed both the P. palmata films and the commercial latex balloon in air and helium retention, indicating lower material permeability. These findings suggest that algae–latex composite materials, particularly those derived from S. latissima, possess favorable barrier properties and may serve as strong candidates for the development of environmentally sustainable biodegradable balloons.

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Abstract: Science and Engineering Fair of Houston

3161

Efficient Spray

jose galvan

Pasadena ISD/Pasadena Memorial High School

Category:

Chemical Engineering & Materials Science

I've discovered a way for when a vehicle looks bad and how to make your car look like it just came out the dealership. I came to a discover where if you use linseed oil, tire shine, and a good smelling stench this would be perfect. Some of the hazards i would have to point out is to not drink it, and make sure you have gloves on when applying. Its a really fast spray on i really got my research from reviews under armorall reviews. So i came up with the percentages usage on each chemical and how to maintain the balance with it being sticky and smelling good but also not to liquidy to where my product doesn't drip down on paint.

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Abstract: Science and Engineering Fair of Houston

3162

Engineering a Novel Cool-Coating Material to Lower Surface Temperatures in Urban Environments

Harrison Tran, Alex Lopez, Raymond Nguyen

Alief ISD/Alief Taylor HS

Category:

Chemical Engineering & Materials Science

Urban Heat Islands make cities hotter by storing solar energy in roofs and pavements, increasing cooling energy use and health risks. This project aims to create a coating better at mitigating urban heat islands more effectively and/or cheaper than current commercial options (ex. White paint). Key metrics are peak surface temperature, delta T relative to ambient, cooling rate after peak, and a relative thermal time constant from cooling curves. During Phase 1, five different treatments were screened. White paint performed the best with the lowest peak surface temperature (23.22 C), lowest peak temperature 2 cm off the surface (17.1 C), and highest mean albedo proxy of .364. The second best was mylar which was third in reflectivity (.273) but had peak surface and near-surface temps comparable to white paint. The custom coating came second in reflectivity (.279), and yet had the second-worst peak surface temperature of 36.11 C. We hypothesized that it was either the result of heat being trapped by the texture, or it has a high thermal diffusivity. Phase 2 created and optimized new variants of the custom coating material based on the results from Phase 1 and tested them with automated contact logging, replication, and durability tests which allowed for better data on the thermal behavior of each coating including thermal diffusivity. Phase 3 took the best coating compound from phase 2, improved it, and tested it rigorously for finalization and produced the final product metrics.

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Abstract: Science and Engineering Fair of Houston

3163

Assessing the scalability of biologics production via process modeling

Aaryateja Addala

Cypress Fairbanks ISD/Bridgeland - HS

Category:

Chemical Engineering & Materials Science

Processing expensive materials requires carefully engineered methods to minimize losses throughout production. Biologics used in healthcare, such as viral vectors for treating genetic disorders, are especially costly, with some therapies costing several million dollars per dose, which makes them inaccessible to much of the patient population. Improving manufacturing yield is therefore critical to reducing costs and expanding access to life-saving treatments. In this work, we present a first-principles process model that explains how material loss depends on key factors such as the starting amount, step-wise yields, and the distribution of losses across multiple processing steps. The model is evaluated under extreme process conditions to better understand the fundamental limits and weaknesses of current manufacturing approaches. This rational process engineering framework helps identify where new technologies and targeted investments are most needed to reduce losses of valuable materials. Although motivated by viral vector production, this approach is broadly applicable to other areas of materials science, including implant tribology, high-value hardware tools, semiconductor manufacturing, and food processing.

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Abstract: Science and Engineering Fair of Houston

3164

Designing Anisotropic Electrospun Fiber Mats for Medical Fluid Delivery

Ananya Gupta

Katy ISD/Seven Lakes - HS

Category:

Chemical Engineering & Materials Science

Electrospun fiber mats are increasingly investigated for medical, sanitary, and material design applications due to their controlled fluid transport that stems from a high surface area and tunable microstructure. Traditionally, these mats involve polymer based chemicals that are not biodegradable. By using water soluble polyvinyl alcohol, this project uses a biodegradable and environmentally safe alternative. Fluid transport and delivery for medical use is highly dependent on the anisotropy of the fibers, which determines how directional and aligned they are. Additionally, significant challenges persist in attempting to optimize electrospinning conditions and material architectures since multiple parameters interfere and are often explored through inefficient trial and error methods. Hence, a data guided experimental pipeline is developed to explore and optimize electrospun fiber mats with respect to directional moisture transport (anisotropy) and fiber quality. Together, this method is used to generate an improved electrospun fiber mat in the context of sustainable composition, medical application, and anisotropy.

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Abstract: Science and Engineering Fair of Houston

3165

Engineering Shape-Memory Self-Healing Hydrogels For Soft Tissue Applications With Integration Into 4D Printing Techniques

Aaron Raj

Conroe ISD /AST: Academy of Science and Technology

Category:

Chemical Engineering & Materials Science

Current technology utilizes soft-tissue implants, such as stents, to restore blood flow and provide structural support; however, current implant materials lack self-healing capabilities and experience mechanical disintegration under constant physiological stress. This often leads to device failure and multiple tedious revision surgeries. Many existing hydrogels prioritize biocompatibility at the expense of their mechanical integrity. As a result, this limits hydrogel's long-term performance in dynamic biological environments. This project specifically focused on the chemical engineering-based design and computational testing and evaluation of a self-healing bio-synthetic hybrid hydrogel composed of a glycol chitosan polyethylene glycol (GC-PEG) polymer network while remaining biocompatible and suitable for 4D printing. Using computational material modeling, GC-PEG networks were constructed using varied crosslink densities in order to analyze their given properties. These properties included mechanical strength, elasticity, swelling behavior, stress-strain, and network stability. Reversible interactions, like hydrogen bonding, dynamic covalent bonding, and chain entanglement, were incorporated to enable bond breakage and reformation after mechanical damage. Simulations were performed under physiologically relevant conditions (Temp = 25°C - 37 °C and pH level = 6.8 - 7.4) to assess material performance in soft‐tissue applications. Results show that a self-healing bio-synthetic hybrid hydrogel composed of GC‐PEG chitosan achieves a favorable synergy of mechanical durability, flexibility, self‐healing efficiency, and biocompatibility while remaining suitable for 4D printing by 91%. A comparative analysis indicates improved performance over conventional hydrogels, synthetic polymers, and traditional stent materials. This work demonstrates the high potential of chemically engineered polymer networks to address key material limitations in current soft‐tissue implants.

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Abstract: Science and Engineering Fair of Houston

3166

Catastrophic Chlorine

Category:

Chemical Engineering & Materials Science

Johanna Zechariah

Fort Bend ISD /Hightower High School

Many people who work and practice in chlorine water experience problems with chlorine due to the problems that occur later on. This can include dry hair, frizz, brittle hair, and so many more problems which can break the hair and cause unhealthy hair to occur. This is a constant problem with people who use chlorine water and unhealthy hair is very hard to manage as well as bad, therefore, through my research, I found 2 ways to help restore healthy hair and prevent lots of damages. Even if you do not use chlorine water, damaged hair can occur for everyone and these solutions can work to help heal the hair. During my procedure I used 2 dolls to observe the texture change of the hair and I used a hydrating shampoo and moisturizing conditioner to help repair and heal the hair. Noticeable changes such as rough texture occurred and through the repair products, the hair began to heal and feel softer. The ending results showed that using repair products can help restore the hair from dry and rough to soft and healthy since they focus on helping the hair. My project supports my hypothesis since the texture of the dolls changed and then healed through the use of the repair products showing that using these for damaged human hair can help heal it and bring it back to being healthy. Healthy hair is achievable therefore start healing your damaged hair!

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Abstract: Science and Engineering Fair of Houston

3167

Category:

Chemical Engineering & Materials Science

Sustainable Edible Coating/Active Food Packaging Production from Kombucha Fermentation and Food Industrial By-products: A Low-Cost Preservation Approach

Lizbeth Er

Conroe ISD /AST: Academy of Science and Technology

Due to the increasing awareness of the risks associated with plastic usage, consumers have started to shift towards sustainable, inexpensive, and environmentally-conscious mediums for food packaging. One such alternative is edible coatings and films. These materials have been shown to protect food products from microbial contamination, mechanical damage, and light exposure while increasing shelf life and reducing lipid oxidation and moisture loss. To date, there have been limited studies focused on the creation of a low-cost and sustainable edible coating for fruit preservation utilizing food production by-products. The aim of this study was to investigate if edible coatings/food packagings developed from kombucha fermentation and food industry by-products are effective at improving the shelf life and preserving the quality of commercial fruits. The results of this study showed that films fabricated from pectin, kombucha tea, and 40% w/v bacterial cellulose are effective in reducing weight loss and preserving the firmness of green table grapes. However, edible coatings appear to show an opposite effect. These findings are supported by visual assessments which reveal greater deterioration in unpackaged and coated grapes when compared with edible film-packaged grapes. This study presents a sustainable alternative to plastic packaging with the ability to extend shelf life and preserve food firmness.

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Abstract: Science and Engineering Fair of Houston

3168

Category:

Chemical Engineering & Materials Science

Enhancing Crop Longevity: A pH-Responsive MOF-Based Delivery System for Reversible alpha-Amylase Inhibition to Combat Post-Harvest Starch Degradation

Clare McKenna

Conroe ISD /TWHS: The Woodlands High School

Post-harvest food loss accounts for nearly one-third of global agricultural production, with enzymatic degradation during storage and transport contributing substantially to economic and nutritional losses worldwide. A primary driver of this deterioration is alpha-amylase, which converts stored starch into simple sugars, accelerating softening, microbial growth, and spoilage in harvested crops. Many existing preservation strategies rely on passive wax coatings or carcinogenic chemical preservatives that provide limited biochemical control and do not directly regulate enzyme activity. This study investigates an enzyme-targeted approach to post-harvest preservation based on reversible inhibition of alpha-amylase and controlled delivery using a pH-responsive, metal-organic framework (MOF) enabled edible coating designed to respond to spoilage-associated acidic conditions. The study consisted of: (1) high-throughput screening of over 800,000 natural and food-safe compounds to identify effective reversible inhibitors of alpha-amylase; (2) characterization of inhibition mechanisms using glucose-based enzymatic assays; and (3) incorporation of the most effective inhibitor into crop-specific edible coatings evaluated across multiple crop types using starch retention, glucose production, mass loss, browning, and spoilage metrics. The optimized coating system reduced preservation costs by up to 96% and more than doubled crop shelf life relative to existing methods under tested conditions. These results suggest that targeted enzyme regulation offers a promising and scalable strategy for improving post-harvest preservation and reducing food waste.

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Abstract: Science and Engineering Fair of Houston

3169

How Far Can Smoke Damage Travel During a House Fire?

Nash Townsend

Charter/SST - Champions College Prep - HS

Category:

Chemical Engineering & Materials Science

On Tuesday, August 12th, 2025, my family experienced a serious house fire. Since that traumatic event, I wanted to research it to provide both closure for myself and research to assist people in similar situations. I decided to research how far smoke damage can spread during a house fire, due to how smoke damage (especially soot) can carry harmful chemicals and pose danger to people inside the house, as well as property damage even after the fire is put out. I will assess smoke damage in my previous home by collecting surface samples in each room of the house, documenting other factors such as closed doors and distance from the fire source, and comparing the results.

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Abstract: Science and Engineering Fair of Houston

3170

Comparing Chemically Activated, Physically Activated, and Untreated Dead Leaves as Low-Cost Sorbents for Carbon Capture

Marcelo Rodriguez

Private/Strake Jesuit College Preparatory - HS

Category:

Chemical Engineering & Materials Science

Atmospheric carbon dioxide concentrations continue to escalate, driving global climate change which is having increasing catastrophic effects on our planet and humanity. Although carbon dioxide capture technologies exist, they often rely on costly materials and energy-intensive processes that limit scalability and accessibility. This project investigates low-cost leaf-derived carbon sorbents produced from an abundant, renewable, and widely available biomass resource. I will process dead leaves from the same tree type into high surface-area adsorption materials and measure their carbon dioxide adsorption capacity in millimoles of carbon dioxide per gram (mmol CO2/g) across the different activation methods: Chemical activation, physical activation, and untreated. My goal in this experiment is to compare low-cost sorbent materials for carbon dioxide capture under simple, accessible experimental conditions, identifying key performance drivers while prioritizing cost and feasibility. By combining bio-inspired design with practical materials experimentation, I will assess the potential of transforming natural waste materials into effective and affordable carbon dioxide capture sorbents, supporting long-term decarbonization efforts.

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Abstract: Science and Engineering Fair of Houston

3171

Fabrication of Novel ZIF-8@Alginate Hydrogel Beads as a Cost-Effective and Scalable Greywater Treatment Solution

Jairam Susarla

Fort Bend ISD /Elkins High School

Category:

Chemical Engineering & Materials Science

In the United States, 40% of fresh water is used for residential purposes. Greywater, which is lightly used water from residential uses such as showers, baths, washing machines, and sinks, can be reused for non-potable purposes like irrigation and toilet flushing, but current treatment mechanisms are costly and often inaccessible. In 2025, 2.7 billion people faced water shortages, and greywater reuse can reduce freshwater usage by 29–47%. This project presents a low-cost nanomaterial consisting of the metal-organic framework ZIF-8 encapsulated in an alginate matrix to filter graywater pollutants like dyes, surfactants, and organic contaminants. By leveraging the mechanical strength of alginate with the high adsorption capability of ZIF-8, this method offers a promising strategy to filter greywater for reuse. 0.2 g of ZIF-8 nanoparticles were encapsulated in 1.0 wt% sodium alginate and crosslinked in 0.1 wt% calcium chloride to form beads. Alginate-only and no-bead controls were included to isolate the effects of ZIF-8 and alginate on greywater adsorption. Batch adsorption experiments with DIH2O + methylene blue and greywater +/- methylene blue (5–15 mg/L) were monitored for dye removal, colorimetric change, and turbidity over 60 min using smartphone apps. One-way ANOVA ($p<0.00001$) and Tukey post-hoc tests showed ZIF-8@Alginate beads removed pollutants significantly better ($p<0.00001$) than controls while Alginate-only and no beads had statistically similar removal efficiencies ($p>0.0167$). Kinetic analysis indicated a pseudo-second-order mechanism for ZIF-8@Alginate bead adsorption. ZIF-8@Alginate beads achieved 84–97% removal, reduced surfactant volume 10–15x, and turbidity 2–4x, demonstrating a low-cost, scalable, and effective approach for improving greywater reuse.

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☐ Vertebrate animals ☐ microorganisms ☐ rDNA ☐ tissue

2. This abstract describes only procedures performed by me/us, reflects my/our own independent research, and represents one year's work only.

☒ yes ☐ no

3. I/We worked or used equipment in a regulated research institution or industrial setting.

☐ yes ☒ no

4. This project is a continuation of previous research.

☐ yes ☒ no

5. My display board includes non-published photographs/visual depictions of humans (other than myself):

☐ yes ☒ no

6. I/We hereby certify that the abstract and responses to the above statements are correct and properly reflect my/our own work.

☒ yes ☐ no