Project ID: 311

Senior Division

Engineering: Energy, Materials, and Transport

Hector Coronel-Villarreal
Central Union High School
Gr. 12

Properties of Different Bioplastics

AWARDS:

US Air Force Award Winner

This project was on the properties of different bioplastics. Three different bioplastic categories were made using corn starch or wheat starch as a polymer base. The bioplastics made either used glycerol, sorbitol, or boiled linseed oil. Each type was made in a pot while being heated and poured into metal trays, where then roughly equal-sized bioplastic films, the prototypes, were cut out and left to dry. After being dried, bioplastic films were divided into being subject to one of three tests: permeability, elasticity, or biodegradability. Because of time constraints, the best-performing bioplastic could not be improved. After running through each test there was no significant difference found between any of the categories of bioplastic in terms of their permeability. The prototype was made of wheat starch and boiled linseed oil degraded significantly faster than most other prototype categories. The data surrounding elasticity across categories varied too greatly to do a statistical analysis on it. However, through observing the data that was recorded, the bioplastic prototypes made using corn starch and sorbitol generally had the greatest elastic strength. Additionally, since sorbitol was tied as the cheapest plasticizer to use to make these bioplastics, it could be said that overall the best prototype for bioplastic was made using corn starch and sorbitol. Thinner films were also found to have a greater elastic strength than thicker films.

Project ID: 312

Senior Division

Engineering: Energy, Materials, and Transport

Demetrios Dresios
Carlsbad High School
Gr. 11

Vassilios Dresios
Carlsbad High School
Gr. 11

Developing a Novel Flexible UV Resin for Use in Scalable Micro-Photolithography Manufacturing of Biomimetic Adhesives

AWARDS:

Professional Engineers in California Government (PECG) Award Senior Division
Student Leadership Board Award Senior Division
San Diego Chapter - American Society of Materials International - Honorable Mention
Yale Science and Engineering Winner
CSEF Qualified

Biomimetic technologies leverage billions of years of evolutionary selection to develop effective solutions to complex issues by imitating mechanisms found in nature. The applications of such solutions range from novel medical products development to mechanical engineering and materials science innovations. However, the realization of the full potential of biomimetic solutions has been hindered by challenges in their large scale production. This is exemplified in the case of a Stanford lab's fabrication of innovative dry adhesives inspired by gecko toe pads; despite their immense potential for robotic and biomedical applications, they proved to be time-consuming and expensive to produce. Our project aims to tackle the scalability issue of biomimetic materials, thereby reducing their cost and enabling their large-scale and widespread use by integrating novel flexible UV resin chemistries with additive micro-photolithography. The proposed approach is distinguished from existing solutions as it enables more accurate replication of the cell-scale structures essential to biomimicry, and capitalizes on the scalability of photolithography to bring those solutions to massive scales, given that this technique is already used in producing the most manufactured item in human history, the transistor. This project aims to produce a proof-of-concept for scalable biomimicry manufacturing by fabricating gecko-inspired dry adhesives. It involves the synthesis of a novel flexible resin, development of an inexpensive photolithography device, and their integration to fabricate a scalable gecko-inspired adhesive. By applying production-scalable techniques to biomimetic solutions, this project represents a breakthrough in materializing the full potential of biomimetic materials.

Project ID: 313

Senior Division

Engineering: Energy, Materials, and Transport

William Gao

Canyon Crest Academy

Gr. 10

Transformer-Based Generative Models Enable Smart Polymer Design for Carbon Capture

AWARDS:

American Academy of Pediatrics Climate Change and Health Committee – SR Div Honorable Mention

CSEF Qualified

Climate change is a growing problem in today's world, and will only continue to worsen as time goes on. To reduce climate change by removing carbon dioxide from the air, my project focuses on homopolymers, polymers with only one repeating unit that can effectively separate carbon dioxide from other gases. My goal was to find new homopolymers with a high carbon permeability. I created a transformer model, like the one used in large models like ChatGPT, to generate novel homopolymers. Then, I fine-tuned the model on a smaller dataset of homopolymers with a high carbon permeability. Next, I trained a regression model on a dataset of sequences with known permeability and used it to determine the permeability of molecules that the transformer model generated. My original model generated many invalid sequences, as it was a basic model with no hyperparameter tuning. After tweaking the model to train with more data, it was able to generate valid homopolymers at a rate of 73%. Inputting a sample of 53 homopolymers through my regression model, the best carbon permeability was found to be 1.9414, as opposed to the maximum permeability in the original dataset, which was 4.6966. Although this may seem like a large difference, this was equivalent to the 50th best known homopolymer out of over 1000 and and this result was from only 53 homopolymers. The result of my project was a partial success, with homopolymers with a relatively high permeability being found.

Project ID: 314

Senior Division

Engineering: Energy, Materials, and Transport

Collin Giometti
San Marcos High School
Gr. 11

A Physarum Simulation Approach to Macrogrid Topology Modeling

A proposed interregional macrogrid would allow easier, more affordable integration of renewable energy by connecting potential renewable energy development to various demand centers. Robust network performance would involve balancing cost, efficiency, and resilience. The slime mould Physarum polycephalum has received attention for its ability to form such networks to connect nutrient sources. The objective of this project was to exploit the slime mould's adaptability to develop robust conceptual macrogrid topologies. The initial agent-based physarum simulation utilized dual layers of particles and chemoattractants. The protoplasmic particles sense values from the trail layer to move and in turn deposit chemoattractants themselves. External nutrient stimuli were then projected onto the trail layer to model the slime mould's network adaptation. For the macrogrid application, nutrient placement was based on US maps of renewable resources and large population centers. The resulting simulation initially produced an inexpensive but non-resilient network solution. Simulation parameters were then adjusted to maximize the mould's foraging, developing more highly interconnected networks. The simulation's final network solution carried a 23% greater cost than its predecessor, yet compensated for it through cost-benefit tradeoff. The efficiency, represented by the average minimum distance between all pairs of nodes, was 19% less than that of the initial model. The network was also more fault tolerant, experiencing 56% less average decrease in efficiency for the removal of each individual edge than the NREL's proposed macrogrid network. This application also serves to demonstrate the versatility of decentralized network development at the urban scale.

Project ID: 315

Senior Division

Engineering: Energy, Materials, and Transport

Aryahi Gupta
Canyon Crest Academy
Gr. 12

Krishna Kuruvadi
Francis Parker School
Gr. 11

The Durability, Longevity, and Affordability of the Different 3D Printed Full Denture Materials

AWARDS:

San Diego Chapter - American Society of Materials International - niSeor Division 1st Place
San Diego County Dental Foundation - Winner

This project addresses the global challenges associated with the prohibitive cost, limited accessibility, and complexity of acquiring traditional full dentures, particularly for seniors who have lost all their teeth (edentulous). The number of edentulous individuals worldwide is estimated to be around 158 million as of January 2022.

Traditional methods involved a time-consuming process typically requiring 6-7 dental appointments at a considerable expense and time. We propose a novel approach utilizing 3D printing technology to streamline the fabrication process. Our solution involves three appointments: intraoral scanning, digital denture design, and 3D printing.

The purpose of this science fair project is to compare the durability (static axial compression strength), flexibility (static three-point bending) and longevity (dynamic axial compression) using universal testing machines (Instron and MTS). We also compared cost effectiveness and manufacturing process length of both conventional and 3D printed dentures.

Results indicate that 3D printed dentures demonstrate comparable or superior physical properties and significantly reduce overall cost and turnaround time.

We conclude that 3D printed denture technology can effectively replace conventional denture fabrication methods. This research not only has the potential to revolutionize the accessibility of dentures but also increases the affordability and efficacy in providing a practical and sustainable solution for those in need.

Project ID: 316

Senior Division

Engineering: Energy, Materials, and Transport

Hudson Kim
Westview High School
Gr. 11

A Novel 3 Stage Ionic Plasma Thruster for Interplanetary Travel and Spacecraft Propulsion

AWARDS:

CSEF Qualified

In recent years, ion thrusters have garnered significant attention for their high specific impulses, efficient design, and long thrusting periods. However, there still remains significant challenges with these thrusters, most notably the small amounts of thrust generated. This projects hopes to address the issue of thrust with a novel design consisting of 3 stages in a concaving nozzle geometry with aerofoil electrodes and tungsten ionizing wire.

The thruster was first designed in Solidworks and optimized with computational fluid dynamics simulations to find the optimal stage geometry and nozzle shape. The surrounding thruster structure was then 3d printed out of polylactic acid (PLA) while the inner metal rings were machined out of 1 mm 6061 aircraft-grade aluminium. Tungsten ionizing wire were then spot welded to the aluminium rings and laser cut delrin supporting beams were placed under the thruster. Additionally, aluminium aerofoils were inserted into each of the three thrusters and electrically connected with silicone wire.

The thruster was experimentally tested using a 30,000 volt power supply and underwent several iterations. For each test the input voltage, input current, and resulting gaseous flow were recorded. The final thruster ultimately achieved a propellant exit speed of 2.9 m/s meters per second at 35 watts.

Project ID: 317

Senior Division

Engineering: Energy, Materials, and Transport

Vivian Pruitt
Bonita Vista High School
Gr. 11

To What Extent Does Color Affect the Effectiveness of Solar Powered Energy

It is no secret that energy production and consumption is a problem that we are facing in the modern world. As someone who bakes and uses and oven daily and relies on this energy there was a sense of curiosity on figuring out how to make the most productive sustainable oven.

Purpose: To determine the effects of color on solar powered oven systems.

Engineering Design: My initial engineering design was quite simple. I used a 8 by 6 by 6 shoe box. The top flap that would close the box had a 2 inch margin cutting in the middle. The flap that I cut out was wrapped in tinfoil and was used as a reflector of the sun's light. The sides of the box itself were also covered in tin foils and the colored paper would be set on the bottom.

Testing: When tested I had very low temperatures averaging about 25 degrees celsius. And the food that was cooked (egg) was raw no matter what the color was. This resulted in all of my data being inconclusive.

Redesign: I choose to use a bigger box which was 12 by 12 by 6 inch. Instead of using tinfoil as a reflectors on the flaps I glued 3 inch mirrors on the flaps. To concentrate the heat more on the experiment I placed a magnifying lens.

Overall Results: The second design produced the most efficient results with conclusive data.