CONNECTICUT SCIENCE & ENGINEERING FAIR

www.ctsciencefair.org

Top Winners in the
2018 Connecticut Science & Engineering Fair

(Student information as of April 2018)

Maya Geradi, Grade 12

Wilbur Cross High School, New Haven, CT

Synthesis and Separation Of a Chiral Compound In Preparation Of a Positron Emission Tomography (PET) Radiotracer

Connecticut Science & Engineering Fair Awards

* Lockheed Martin Physical Sciences Awards --- 1st Place - Physical Sciences Senior High Individual - $500 & Plaque, trip to compete at Intel ISEF
* Petit Family Foundation Women in Science & Engineering Awards --- High School Finalist - Medallion
* CASE • PepsiCo Urban School Challenge Awards with IBM --- 2nd Place High School - $400 and Plaque, Medallion
* H. Joseph Gerber Award of Excellence presented by the Connecticut Academy of Science and Engineering in partnership with CCAT --- Physical Sciences 1st HS $1,000, Solid Silver Medal of Excellence, Invite to CASE

Abstract

Positron emission tomography (PET) is a promising technology that utilizes radiotracers for producing detailed, 3D images of the body. The radiotracer studied in this project targets the SV2A receptor in the brain, which is a marker of synaptic density and hence can be used to study Alzheimer's disease and epilepsy.

This project aims to synthesize an enantiopure compound in preparation of a chiral PET radiotracer. The racemic compound was synthesized at -20C and purified using a silica gel column. Reaction progress was monitored by TLC and structure was confirmed utilizing NMR. Conditions required for separation using the HPLC system were optimized by testing varying combinations of organic solvents (0–100%), in conjunction with different chiral columns and flow rates (0.1 –2mL/min). Three chiral catalysts were tested under varying reaction conditions for synthesizing an enantiopure compound. The racemic compound was successfully synthesized and separated using the HPLC system. Full separation was achieved by using ethanol and hexane in a 25%/75% combination, 0.1% TEA, 1.0mL/min flow rate and the CHIRALCEL OJ-H column.

The quinidine catalyst successfully yielded a 90/10 enantiomeric ratio. The other 2 catalysts still produced a racemic compound. Currently, the quinidine catalyst is being tested under new conditions to further improve the enantiomeric ratio.

Optimizing synthesis of the enantiopure compound using chiral catalysts could increase yield of the PET radiotracer and lower the cost and reaction time of the synthesis. This increases the viability of this PET radiotracer for diagnostics and research of Alzheimer's disease, epilepsy and other neurodegenerative diseases.

Biography

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Top Winners in the
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(Student information as of April 2018)

Hiba Hussain, Grade 10

Greenwich High School, Greenwich, CT

Non-Invasive, Low Cost Diagnosis of Chronic Obstructive Pulmonary Disease (COPD) via Smartphone Breath Analysis

Connecticut Science & Engineering Fair Awards

* Pfizer Life Sciences Awards --- 2nd Place- Life Sciences Senior High- $300 & Plaque, Trip to compete at Intel ISEF
* Barnes Aerospace Applied Technology Awards --- Senior High Finalist - Medallion
* UTC Aerospace Systems Engineering Awards --- Finalist - Engineering High School - CSF Medallion

Abstract

Chronic Obstructive Pulmonary disease (COPD) is expected to become the third largest killer worldwide by 2030. Current diagnosis mechanisms are time-consuming and costly, highlighting the need for a more accessible and rapid diagnosis so that the disease can be treated at its earliest stage. In this research, a rapid and simple smartphone-based detection of COPD was created. Single-walled carbon nanotubes (SWCNTs) were combined 2-hydroxy-1,1,1,3,3,3-hexafluoropropyl)-1-naphthol (HFIPN) in a 2:1 mass ratio, to create a COPD-breath gas specific PENCIL powder. When integrated into a Texas Instruments NFC Tag, and exposed to COPD breath gases isoprene, octadecane, hexanal, and undecane, conformational change in the PENCIL-HFPN selector was realized by an increase in the material's resistivity. Exposure of the PENCIL-on-NFC tag to 1ppb and 1 ppm COPD breath gases caused an increase in PENCIL resistance from 13-13.7kΩ and 12.7-27kΩ, respectively. Change in PENCIL-on-NFC tag resistivity produces changes in current usage drawn from a Smartphone, when read by the device, and acts as the basis for COPD detection. After 1 minute of exposure to typical 1ppb concentration of COPD breath gases for an afflicted patient, Smartphone read of the PENCIL-on-NFC tag drew only 1.5mA of current, which is 3.5mA less than current used under normal, ambient conditions. Increase in PENCIL resistance, and subsequent Smartphone current reduction was found to be COPD gas specific and was used to train a new Smartphone application to provide a 4-minute diagnosis for COPD, based on calibration of the circuit's current usage, and its effect on the phone's battery usage.

Biography

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Top Winners in the
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(Student information as of April 2018)

Raina Jain, Grade 10

Greenwich High School, Greenwich, CT

Magnetically-induced, Visual Detection of Trace Arsenic Contaminants in Water Using Fe3O4 Photonic Crystal Structures

Connecticut Science & Engineering Fair Awards

* Lockheed Martin Physical Sciences Awards --- 2nd Place- Physical Sciences Senior High Individual - $300 & Plaque, trip to compete at Intel ISEF
* Petit Family Foundation Women in Science & Engineering Awards --- High School Finalist - Medallion
* Environmental Sciences Awards with CACIWC --- 1st Place HS- $500, Plaque, CACIWC gifts
* UTC Aerospace Systems Engineering Awards --- Finalist - Engineering High School - CSF Medallion
* United Technologies Corporation Awards --- $500 in UTC Common Stock, Plaque, Backpack, and Annual Report
* GENIUS Olympiad --- GENIUS Olympiad Competition for 1st Place HS Environmental Project

Abstract

Arsenic, a highly toxic metal contaminant commonly found in our drinking water, is responsible for many accidental deaths. Currently, the only visual arsenic-in-water detection system is tedious, and can detect arsenic concentrations of 250ppb or more, well above the EPA 10ppb water-action-level. To combat arsenic drinking water contamination, a sensitive, inexpensive, portable, and easily-visualized detection system is needed, and has been developed in this research. To begin, superparamagnetic, SiO2-coated, polyacrylic acid-capped Fe3O4 colloidal nanocrystals (CNC's) were synthesized, and their photonic and physical properties characterized via SEM and UV-Visible spectroscopy. Application of 80-140G magnetic field from a portable, 3" magnet altered the refractive indices of the photonic structures, so that long-to-short wavelength, red-to-blue color change is easily visualized from the native brown CNC solution color. Addition of 1ml of 10ppb Arsenic, however, to 2ml of 8mg/ml CNCs causes alteration of the photonic characteristics, so that long-wavelength shift occurs with applied magnetic field (native brown to orange). This new color changing behavior is specific to arsenic contaminant, and attributed to As-O interactions at the surface of the SiO2-coated CNCs. Other typical metal contaminants did not share this same metal-oxide CNC-coating affinity. For the consumer friendly, rapid Arsenic-in-water assay, a color code was developed to detect/indicate as little as 10ppb As-contaminant, with color change at 10ppb increments. In the field, drops of suspect water are added to the CNC solution at 1:2 (v/v) in a small vial; Arsenic contamination is determined in seconds via color change through the application of a small magnet.

Biography

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Top Winners in the
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(Student information as of April 2018)

Romano Orlando, Grade 12

Greenwich High School, Greenwich, CT

Design and Fabrication of a Smart, Medicated Gel Bandage to Deliver Antibiotics to a Draining Wound

Connecticut Science & Engineering Fair Awards

* UTC Aerospace Systems Engineering Awards --- Finalist - Engineering High School - CSF Medallion
* Alexion Biotechnology Awards --- Finalist - Biotechnology Senior High - CSF Medallion
* Society for In Vitro Biology --- Certificate and $25 Amazon gift card given by CSEF
* Connecticut Association for the Gifted --- Leonardo Davinci Award 9-12 Grade $50 Gift Certificate
* Connecticut Invention Convention "Next Step Inventors" --- Next Step Inventor Trophy & Invitation to compete at the 2018 Invention Convention, April 28

Abstract

For adhesives and wound dressings, consumer options are limited. Besides flexible Band-Aid strips, the only other inexpensive option for wound coverage is a liquid bandage. Although liquid bandages are better than their solid counterparts at covering an affected area, as their contact interface is more complete, they are still plagued by a common deficiency: the wound receives little to no assistance to fight initial-trauma bacterial infection, other than coverage from outside contamination. In this research, a Smart, medicated gel bandage was created that would release antibacterial agents into the wound while solidifying, then provide hardened protection, and subsequently release antibiotics only during additional periods of drainage, when it is needed most. To create the novel dressing, 65mg of tetracycline (Tc) was embedded into 210mg of HydroMed-D, an ether-based hydrophilic, biocompatible urethane, creating a gel-like formulation that is applied via a squeeze tube. When administered, the Smart bandage dries in 5 minutes, releasing Tc during that time of initial wound drainage. Once dry, it provides durable structural support for a cut/abrasion that is far improved relative to a stick-on cloth bandage. During the subsequent dry healing (scabbing), the Smart bandage retains significant Tc load, and can release it should drainage reoccur, further increasing the effective life and infection-fighting ability of the bandage. For a cut that is covered with a traditional Band-Aid, 210mg of the Smart bandage will deliver up to 42µg of tetracycline to the localized area as needed, as a function of (cut) bleeding, or drainage.

Biography

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Top Winners in the
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(Student information as of April 2018)

Shobhita Sundaram, Grade 12

Greenwich High School, Greenwich, CT

Detection of Early-Stage Alzheimer's Disease via Hierarchial Classification of Proteomic and Clinical Profiles

Connecticut Science & Engineering Fair Awards

* Petit Family Foundation Women in Science & Engineering Awards --- 2nd Place High School $250 / plaque
* Alexion Biotechnology Awards --- 1st Place- Biotechnology Senior High- Trip to compete at Intel ISEF, $1000 & plaque,

Abstract

Alzheimer's disease (AD) is a neurodegenerative, fatal brain disease characterized by impairments in memory, language, reasoning, and cognition. Identifying AD in its earliest stages of Mild Cognitive Impairment (MCI) allows patients access to the best possible treatments, and time to make crucial caregiving and financial decisions. Currently, no accurate diagnostic tests exist for early-stage AD; internationally just one in four patients are diagnosed. In this study, the development of a machine learning tool to accurately diagnose AD and identify high-risk MCI patients is proposed, using neuropsychological and blood proteomic profiles. A novel two-layer hierarchical framework was designed: The first layer diagnoses patients as healthy, MCI, or AD, and the second layer analyzes healthy/MCI patient profiles to predict future AD onset. A database of 560 patients was used to build the first model. A subset of 368 patients was used for the second model, using multiple observations per patient across a 12-month time-span. For each classification layer, a multi-pronged approach was developed to extract the most relevant biomarker data from patient profiles, integrating both univariate and multivariate methods. Upon evaluation, the first model diagnosed patients with a 90% overall accuracy, based on linear components extracted from proteomic profiles. The second model then predicted future AD onset for current MCI patients with a 92% ROC accuracy within a 6-48-month timeframe, using biomarkers selected from both proteomic and neuropsychological profiles. These results far outperform prior research and indicate that this tool will provide a low-cost, minimally invasive method of detecting early-onset AD.

Biography