Fellowship Application Information

Type: UNDERGRAD

Project Title: The Integration of NIR Active Azo-Dyes into an Elastomeric Polymer System through use of Thiol-Yne Click Chemistry

Abstract: Photomechanical polymers have blossomed into an exciting field of innovation due to their potential for wireless actuation. It has been demonstrated that photochromic monomers can be integrated into many polymer systems and convert light energy into mechanical work. Most current photoresponsive polymers are only functional in the ultraviolet to blue range, creating challenges like absorbance competition, photodegradation, and incompatibility with mammalian tissue. These drawbacks make it desirable to shift the active absorbance range to the near-infrared (NIR). This can be done by integrating a NIR absorbing azo-dye derivative into polymer systems. Our proposed approach is to use a thiol-yne click chemistry reaction that allows for the integration of an alkyne functionalized BF2-coordinated NIR-absorbing azo-dye into an elastomeric material system. Once synthesis is accomplished and the material is optimized for photomechanical response, future work will include integration of similar azo-dyes into other polymer systems.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Investigation of the Solar Nebula's Magnetic Field Strength from the Allende Meteorite Chondrules

Abstract: Remanent magnetizations recorded in CV-type carbonaceous chondrite meteorites can reveal the strength of magnetic fields in the ancient solar nebula and thus provide important constraints on the models of early solar system evolution. Magnetic record in the ~4.57 billion years old Allende meteorite and other CV-type meteorites will be investigated in order to obtain reliable estimates of the magnetic field strength (paleointensity) in the early solar system. Magnetic properties of individual chondrules will be measured using a comprehensive suite of rock magnetic and microscopy methods to identify specimens most suitable for paleointensity experiments. Paleointensity will be determined with the Thellier method using a novel experimental approach based on CO2 laser heatings. An additional non-heating method will be utilized to test the consistency of the paleointensity data. The obtained results will contribute to Objective 1.5 of the NASA Strategic Plan and may lead to the development of a larger proposal.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Characterization of Strontium-Doped Hydroxyapatite Nanoparticles with an Iron Oxide Core

Abstract: Strontium slows the rate of bone degradation, making it a prominent topic of research for osteoporosis treatment. Sr-doped hydroxyapatite nanoparticles (Sr-nHAps) with an iron oxide core and bisphosphonate surface modifications offer a stable method of targeting bones for direct Sr release. Due to the iron oxide core, these nanoparticles would be MR active, allowing for in-vivo tracking. I will study the rate of Sr leaching from the hydroxyapatite lattice into simulated bodily fluids to determine the effect of a biological environment on Sr leaching. I will characterize any morphological changes of Sr-nHAps through SEM, EDS, and P-XRD. ICP-OES will be used to determine the amount of strontium released over time. I will synthesize Sr-nHAps with iron oxide cores and characterize their MR capabilities. The development of iron-oxide core Sr-nHAps will further the current treatment options for osteoporosis as well as the reduction of bone density during long-term space flights.

Fellowship Application Information

Type: UNDERGRAD

Project Title: In Pursuit of High-Energy Molecules: Why Do Some First-Row Transition Metals Transfer Carbene to Isocyanide While Others Do Not?

Abstract: Ketenimines are a useful synthetic starting point for making heterocycles in materials and pharmaceutical applications because they are high-energy species. The sustainable synthesis of high-energy species presents a chemical challenge if the reaction is to be done in an atom economical fashion (i.e. most reactant atoms end up in the products). Recent work has shown that the first isolable high-valent cobalt carbene (J. Am. Chem. Soc., 2016, 138, 5531-5534) can transfer its carbene moiety to isocyanide and form ketenimines. Unfortunately, the reaction only happens once and not in the desired catalytic (repeatable) fashion. This project seeks to better
understand this transformation and improve its design to become catalytic through computational modeling. The project addresses NASA's Strategic Goal 2, Objective 2.2 because it advances
knowledge of Earth to meet the challenges of environmental change and improve life through the rational design of high-energy molecules in a sustainable way.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Using remote sensing to study ecological changes associated with hydrologic fluctuations in an interdunal wetland

Abstract: Interdunal wetlands within Lake Michigan’s coastal dunes are an imperiled ecosystem. The wetlands fluctuate between periods of inundation and dryness as their water levels are tied to those of the Great Lakes, rising and falling with the 30-year quasi-periodicity of these lake levels. This causes significant shifts in the wetlands’ ecology as they can dry completely during low lake levels and they are inundated during high lake levels. I will use remote sensing images to map the current vegetation in an interdunal wetland at Saugatuck Harbor Natural Area and will perform vegetation quadrat sampling to groundtruth that mapping. I will also use these results to interpret historic remote sensing images to map how past water level fluctuations have affected the wetland’s vegetation and ecology. This will provide important information for monitoring and conserving these areas in the future.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Rare-earth Complexes as Upconverting and Downconverting Antennae in Solar Cells

Abstract: Lanthanide luminescence, the light-emitting property of rare earth metals, has garnered attention in applications from biosensors to LEDs. The unique electronic structure of these metals allows them to convert high energy ultra-violet (UV) light and low-energy infrared (IR) light into visible light; these processes are known as downconversion and upconversion, respectively. This is of great interest in photovoltaic technology as conventional silicon solar cells absorb most strongly in this visible region and cannot readily harvest energy from the UV or IR. Herein we propose the synthesis of a platform of lanthanides complexes with potential as converting antennae. In this system, the rare-earth metal can be exchanged for either downconversion (Tb3+, Eu3+) or upconversion (Yb3+, Er3+). Chemical characterization will be performed to confirm the strucutures of new molecules and their electronic and photophysical properties will be analyzed by fluorescence spectroscopy.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Classifying mass shooting incidents across the United States

Abstract: In recent years, the number of mass shootings across the United States has been on the rise and becoming more of a national concern as incidents have become increasingly tragic like the last Las Vegas shooting. Speculations on the motives and inevitable blaming of groups have begun to surface in recent years. With the aid of modern advancements of computing and statistical modeling, we can form algorithms in Unsupervised Learning to find relevancies in the events and identify key components which would be useful in classifying these shooting incidents. We plan to implement these classification algorithms on a database of United States mass shootings from 1982 to 2017. The advantages and disadvantages of these algorithms will be compared. This would help us discover commonalities in these events and identify factors which may help to reduce the likelihood of future catastrophes.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Assessing the Survivorship of Hurricane Maria by an Epiphyte Community in Puerto Rico

Abstract: Improving our understanding of how climate change is likely to affect various ecosystems is essential to mitigating its impacts on ecosystem services such as, but not limited to, water absorption and filtration, pest control, and production of food and timber. In the tropics, coastal and island ecosystems are likely to be reshaped by an increase in the frequency of severe hurricanes, affecting dependent human communities. We propose to survey an epiphyte (plants growing attached to trees) community in Puerto Rico during Summer 2018 to: (1) assess rates of survivorship of Hurricane Maria, (2) establish a baseline for future studies of epiphyte community recovery, and (3) identify traits (e.g., leaf size and shape, stem and root width) associated with vulnerability versus tolerance to extreme wind. The proposed project aligns with NASA's Strategic Goal 2: "Advance understanding of Earth and develop technologies to improve the quality of life on our home planet."

Fellowship Application Information

Type: UNDERGRAD

Project Title: Investigating groundwater springs and possible sapping valleys in western Ottawa County, Michigan, U.S.A.

Abstract: We propose to investigate the origin of groundwater springs and possible sapping valleys along Pigeon River in Ottawa County, Michigan. Sapping valleys are valleys eroded by springs and their streams. Erosion of steep slopes, and headward migration of springs has been well documented as a mechanism of valley erosion. The rate of valley erosion by spring sapping is determined by the capacity of springs to remove sediment. Hemlock Crossing County Park contains numerous springs where sapping erodes dune sediments forming small valleys with the signature amphitheater shape of previously documented sapping valleys. We propose to investigate controls on where springs occur, spring discharges, the rate of spring erosion, and the water quality of the springs. Our study will add to understanding groundwater springs and streams in western Michigan and further NASA goals of better understanding Earth Systems (in this case the hydrologic system).

Fellowship Application Information

Type: UNDERGRAD

Project Title: Evaluations of Microgravity on DNA Repair

Abstract: My research focus is to assess how the conditions of space affect DNA repair mechanisms in human cells. DNA repair processes are needed to correct the lesions formed by mutagens; otherwise, their accumulation can result in cancer, heart disease, and other genetic disorders. In space, the most prominent mutagen is UV radiation, which forms cross-links in genomic DNA. While there are repair pathways to this type of DNA damage in human cells, the consequences of low gravity environments on these mechanisms are not yet known. This research aims to identify not only the effect of UV radiation but also other sources of DNA damage on the human body. These outcomes will help define how the long-term impact of space travel.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Laser-Induced Phase Transformations in Nanodiamond Films

Abstract: Nanodiamonds have been found inside meteorites, speculated to be elsewhere in space, and can be synthesized in laboratories. It is believed that the formation of these nanodiamonds precedes the complete formation of our solar system. This formation process is an intense point of interest as nanodiamond is a unique form of carbon that is normally rare. It has been theorized that this nanodiamond transformation is caused by carbon-onion on carbon-onion collisions. We have found that laser irradiations on nanodiamonds can create a similar condition of local temperature and pressure and induce a phase transformation between nanodiamonds and carbon-onion (graphitic carbon). Therefore, we propose to perform high-resolution scanning transmission electron microscopy (TEM), Raman, and photon correlation spectroscopies to understand the mechanism of this phase transformation.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Evaluating Biodegradable Zinc Stent Materials

Abstract: Bare metal or drug eluting stents are commonly used to re-open arteries after stenosis. The permanent implantation of these materials commonly causes restenosis and therefore failure of the implant, which would lead to an invasive and costly vascular bypass surgery. A material that could be implanted in the artery long enough for it to heal, and then completely bioabsorb could eliminate the chronic inflammatory responses associated with the failure of permanent stents. Our lab has introduced new classes of zinc alloys for the purpose of developing biodegradable stents. This project will investigate key factors of the biocompatibility of these materials such as chronic and acute inflammation, neo-intimal hyperplasia, necrosis, and localized immune response in order to characterize the feasibility of these new zinc alloys serving as biodegradable coronary stents. Biodegradable materials could have many other practical medical applications other than just vascular stenting, such as implant screws, plates, or sutures.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Population synthesis with realistic magnetospheric emission geometry

Abstract: Significant advances have been made describing realistic magnetospheres of pulsars; force free electrodynamics or infinite conductivity within the light cylinder, requiring finite conductivity beyond the light cylinder (FIDO) and describing regions within the magnetosphere where electric fields parallel to the magnetic field are capable of accelerating charge to produce significant curvature radiation in gamma-ray wavelengths. These new FIDO models need to be incorporated into our population synthesis Monte Carlo codes to test them and their predictions of the statistical characteristics of gamma-ray pulsars. We incorporate the FIDO model of pulsar magnetospheres into our population synthesis model, in order to simulate radio and gamma-ray emission from pulsars using the FIDO sky maps; we use this simulation to compare the latest beam geometry model using realistic magnetosphere emission geometry. We also incorporate within our study the phase difference between gamma-ray and radio peaks observed by Fermi.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Development of Organic Flow Cell Electrolytes for Terrestrial and Space Based Large-Scale Energy Storage

Abstract: Flow cells are rechargeable battery systems that use two compatible redox electrolytes dissolved in solution which are pumped from external reservoirs to a primary reaction cell. These systems have potential use either for large-scale energy storage for space exploration and research platforms such as the international space stations (ISS) or for terrestrial intermittent renewable sources. The development of prototype flow cell systems using organic quinone-based electrolytes is proposed here. Various quinone derivatives will be synthesized as potential flow cell electrolytes, and their potentials and electrochemical characteristics will be measured. Charge/discharge cycles of these electrolytes will be collected using a flow cell prototype device, along with the electrolytes' energy efficiency, relative current density, and energy capacity. The work proposed here aligns with NASA's Strategic Goal of advancing innovative space technologies, and would potentially improve the energy storage capacity and lower the cost of electrical power for manned vehicles and space stations.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Using Remote Sensing Information from Drone Flights to Create Sensitivity to Mobilization Maps of Coastal Dune Systems

Abstract: Dune mobility can threaten human infrastructure but is essential to maintaining diverse ecological communities in coastal dunes. Only those patches on a dune with little or no vegetation will migrate. The size of these patches together with their shape, topographic position, and topographic orientation with respect to the direction of strong sand transporting winds affect the sensitivity of the dune surface to mobilization. Images acquired by drone flights over Saugatuck Harbor Natural Area will be used to analyze topography and extent of vegetation of the dune surfaces. The results will be used to create maps showing variations in the sensitivity to dune mobilization within the complex. The method will be tested by comparing drone images from successive years and by setting up systems of rods in test plots against which sand migration can be directly monitored. Monitoring will continue for at least two years.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Distinguishing Multiple Populations in Galactic Clusters

Abstract: Once thought to host a single stellar population, nearly all globular star clusters are now believed to harbor multiple stellar populations, distinguishable most often by multiple sequences on the red giant branch (RGB) of a color-magnitude diagram. The nature of these subgroups can provide insight into the formation history of globular clusters and how they have contributed to the growth of the Milky Way. Such distinct sequences of stars are not often visible to the eye on these diagrams, but with sufficiently precise photometry they can be distinguished statistically. We have developed a procedure to distinguish multiple populations using ground-based data from the Calvin-Rehoboth Observatory for the globular cluster Messier 13 and the evolved open cluster NGC 6791. Results for both clusters agree well with published observations, giving us confidence that we can obtain data of sufficient quality and implement a procedure of sufficient precision to distinguish these stellar populations.

Fellowship Application Information

Type: UNDERGRAD

Project Title: Mapping the form and areal coverage of small inland dunes in western Michigan using digital elevation models and satellite imagery.

Abstract: Inland dunes are small relict dunes that are found well inland from the Lake Michigan shoreline, in contrast with the larger coastal dunes found near the shoreline. Colgan et al. (2017) mapped inland dunes in Ottawa County, Michigan and determined that they were between 13,600 and 11,300 years old using optically stimulated luminescence methods. We propose to map inland dunes in the coastal counties of western Michigan where our preliminary observations indicate they are common on the former lake bed of Glacial Lake Chicago. We will use digital elevation models (DEMs) and satellite imagery to map inland dunes in Oceana, Muskegon, Newaygo, Allegan, and Van Buren Counties and determine their areal coverage and form to determine paleowind directions. This research will contribute to one of NASA's stated goals of better understanding the Earth Systems and past climates (in this case dune systems and the paleoclimates they formed in).