Research Experience for Undergraduates

Oral Research Presentations

Wednesday, July 26, 2023 8:30 am – Noon

Diercks Hall Auditorium at MSOE, 1025 N. Milwaukee St.

Refreshments served

STUDENTS, FACULTY, STAFF and GUESTS INVITED

Lap Shear Testing of Solvent-Welded Additively Manufactured Materials

Mathew Johnston, Junior – Mechanical Engineering, Bucknell University, Lewisburg, PA (Dr. Kevin Hart)

Previously AM ABS specimen with an embedded glass capillary filled with acetone was used to create a self-healing bio-inspired material. In this work, single lap shear specimens are used to evaluate how the type of solvent and solvent welding time affects the shear strength of ABS specimens additively manufactured on a Prusa i3MK3S using Fused Deposition Modeling in the horizontal orientation. Three candidate solvents were evaluated: acetone, dichloromethane, and ethyl phenylacetate. Solvation times varied from one minute to 48 hours. Following solvation, welded specimens' shear strengths were determined according to modified version of ASTM D3163 testing. Five specimens for each solvent and solvent welding time were tested. The results of each solvent were graphed and compared to find the ideal solvent and time combination. The results of this research will be used to improve the self-healing material previously created and optimize the healing process.

Studies on Diclofenac and its Metabolism

Abigail Sharath, Sophomore – Biology, Health and Society, University of Michigan, Ann Arbor, MI (Dr. Vipin Paliwal)

Drug induced liver injury/ hepatotoxicity, is a challenge to predict despite substantial preclinical and clinical testing. There are various nongenetic and genetic factors that impact the way in which the body responds to xenobiotics. This project studied the metabolic degradation of diclofenac, a nonsteroidal anti-inflammatory drug, in order to gain a better understanding of its hepatotoxicity and its metabolic clearance. The involvement of liver enzyme cytochrome P450 responsible for metabolic degradation of diclofenac was studied. Various concentrations of diclofenac were incubated with rat liver microsomes, a rich source of cytochrome P450 enzymes. Following incubation, the samples were evaporated to dryness in order to isolate the amount of diclofenac remaining in the incubation mixtures. The loss of the parent drug was observed to determine toxic concentrations of diclofenac and its metabolic clearance. Quantitation of diclofenac was done using Thin Layer Chromatography at various time points followed by UV-visible spectroscopy at 276 nm.

Green Synthesis of Gold-Palladium Nanoparticles Using Upland Cress: Synthesis and Characterization

Keagan Schmidt, Senior – Chemical and Biomolecular Engineering, MSOE, Milwaukee, WI, (Dr. Wujie Zhang)

Previously, the green synthesis of gold and silver nanoparticles using upland cress (*Barbarea verna*) has been achieved. This study explored the potential in synthesizing gold-palladium alloy nanoparticles. Upon successful synthesis and characterization using UV-vis spectroscopy, the analysis confirmed that the initial solution exhibited a peak at 438 nm for samples containing pure palladium, which is characteristic of the presence of Pd^{2+} ions; however, this peak diminished as synthesis progressed, indicating the formation of Pd-containing nanoparticles. For samples containing gold only, an absorbance peak between 500-600 nm can be seen increasing in prominence as time progressed, indicating production and growth of nanoparticles. Regarding the samples with both palladium and gold, the characteristic features of each pure palladium and gold absorbance values can be observed as a combination with skewing proportionate to the ratio of palladium and gold. The successful synthesis of gold, silver, palladium, and now gold-palladium alloy nanoparticles using upland cress demonstrates the versatility and potential of this green synthesis. By leveraging the unique properties of upland cress, researchers can continue to develop environmentally friendly and cost-effective approaches for metallic nanoparticle synthesis.

Synthesis and Testing of a Nanobead Sunscreen from *Kaempferia galanga* rhizomes, a Green Chemistry Approach

Amy Reyes, Senior – Biological Sciences, Chemistry, University of Wisconsin-Milwaukee (Dr. Vipin Paliwal)

Cinnamate derivatives are common sunscreen agents due to their ultraviolet radiation absorbing properties. This study involved extracting ethyl-p-methoxycinnamate, the most abundant cinnamate derivative from *K. galanga* rhizomes (via maceration, fractionation and drying) and encapsulating it within nanobeads (via flash nanoprecipitation) to form a sunscreen. The efficacy of this ethyl-p-methoxycinnamate embedded nanobead sunscreen was investigated using a UVB chamber and a radiometer. The results are expected to show a significant amount of UVB absorbed by the layer of ethyl-p-methoxycinnamate embedded nanobeads. This nanobead sunscreen has the potential to reduce the risk of skin damage and skin cancer while also demonstrating greater stability and a longer shelf life compared to commercial sunscreens.

Isostatic Pressure Testing of Fused Deposition Modeling Materials

Gabriel Lewis, Junior – Mech. Engineering (Aerospace) / Physics, University of Wisconsin – Madison (Dr. Kevin Hart)

This work investigated the performance of AM materials made using novel filaments to those made using traditional filaments in high-pressure isobaric applications. To evaluate, thin AM plates were fabricated, sealed, and pressurized to failure where their burst pressure was then recorded. Thin plate material, printing orientation, and annealing conditions of AM plates were varied, and pressure testing results were compared against control samples made of injection molded ABS. Testing shows that samples fabricated with dual-material filaments, then annealed for 72 hours at 135C, have similar burst pressures of control injection molded sheets of ABS, while sample made of ABS alone and not annealed, failed at burst pressures of 10% the nominal injection molded value. Given the high burst pressure of annealed AM plates, it is projected these filaments may be used to fabricate pressurized tanks and vessels not normally fabricated using AM methods, such as: canteens, windshield wiper fluid reservoirs, oil reservoir plugs, and liquid/gas manifolds.

Design of Pectin-based Microspheres for Targeted Pulmonary Drug Delivery

Andy Chai, Junior – Chemistry and Chinese Studies, Rhodes College, Memphis, TN, (Dr. Wujie Zhang)

This research study aimed to develop an optimized electrospray process capable of consistently producing microspheres with a diameter of approximately 3 μm for effective pulmonary drug delivery. Additionally, the study explored the effectiveness of two promising coating materials in improving the stability of the microspheres under physiological conditions. The parameters investigated included the feed rate, height, voltage, and the ratio of pectin to PEO in the solution used. The selection of response variables was based on their ability to generate microspheres of appropriate size, minimize clogging issues, and determine the preferred spinning or spraying behavior. The Design-Expert software was used to optimize the process with the microsphere size and morphology. The optimized electrospray process involved a feed rate of 0.946 mL/hr, a voltage of 14.4 kV, and a solution consisting of 75% pectin and 25% PEO, with the addition of Pluronic® F-127 at a concentration equal to 2% of the solution's weight.

Investigation on the Effect of Photo-dose Parameters on Mechanical Properties of Photopolymer Resin

William Slater, Junior – Physics and Comp. Science, U of Southern California, Los Angeles, CA (Jordan Weston and Dr. Subha Kumpaty)

Digital Light Processing has become a popular method for additive manufacturing due to its ability to cure the product layer by layer, decreasing production times. The purpose of this research is to determine an optimal range of exposure time and light intensity that produces the optimal mechanical properties of a part, while still maintaining acceptable dimensional integrity. Tensile test specimen per ASTM D638 standard were printed in Z orientation and tensile properties and hardness were measured. Changing the ratio of exposure

time to light intensity while keeping the photo dose constant on a DLP 3D printer was shown to not have a significant impact on the tensile strength of products printed within the range of 2.5s to 4.5s for exposure time. Hardness was also unaffected by these parameter changes.

Challenges in Post-Processing of Fused-Deposition Modeled Parts

Rebecca Nokku, Sophomore – Health Sciences, Michigan State, Lansing, MI (Jordan Weston and Dr. Subha Kumpaty)

This work explored possible improvement in the post-processing of additively manufactured ABS parts from the Stratasys F370 Fused Deposition Modeling 3D Printer. The printed support material is dissolved in a Sodium Hydroxide solution at a pH14; previous research found that blisters were formed in ABS parts when placed in an ultrasonic tank. To eliminate or minimize the blisters, a flow method was employed using the same ultrasonic tank but leaving the frequency off and circulating the solution with a steel paddle attached to a synchronous motor with an RPM of 60-70. Five 1x1x1in blocks were printed and tested. Another set of experiments will look at ABS printed cups that have soluble support inside the hollowed-out area to determine the dissolving rate of support material by both ultrasonic method and the flow method.

Leveraging Machine Learning in the Design of Novel Ionic Liquids

Mitchell Johnstone, Senior – Computer Science & Computer Engineering, MSOE and Mays Neiroukh, Junior – Computer Science & Mathematics, Carleton College, Northfield, MN (Dr. Pawan Panwar and Dr. Subha Kumpaty)

Ionic Liquids (ILs) are recognized for their versatile applications across various domains. This study leverages machine learning to ensure desired chemical properties and novelty in generating unique ILs. Employing the Generative Chemical Transformer model for IL generation, which combines the proven Transformer and Conditional Variational Autoencoder architectures, this work generated 30000 data points for model testing by utilizing properties of 364 ILs at varied temperatures and atmospheric pressure (3204 data points) from the National Institute of Standards and Technology's database. Each data point was tailored to include the IL depicted as a standard SMILES string, alongside the recorded temperature, pressure, and IL properties such as density, viscosity, and electrical conductivity. Generated ILs were validated by predicting their set properties using hitherto developed artificial neural networks. By facilitating the creation of valid and innovative ILs with predefined attributes, our research streamlines and expedites generation of efficacious ILs.

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Anticipated Speaking Schedule

8:30 – 8:40 am	**Dr. Subha Kumpaty**	Welcome; Greetings from **Dr. Eric Baumgartner**, Executive VPA and **Mr. Sheku Kamara**, Dean of Applied Research
8:40 – 8:58 am	**Mathew Johnston**	Lap Shear Testing of Solvent-Welded Additively Manufactured Materials
8:58 – 9:17 am	**Abigail Sharath**	Studies on Diclofenac and its Metabolism
9:17 – 9:35 am	**Keagan Schmidt**	Green Synthesis of Gold-Palladium Nanoparticles Using Upland Cress: Synthesis and Characterization
9:35 – 9:50 am	*Break*	
9:50 –10:09 am	**Amy Reyes**	Synthesis and Testing of a Nanobead Sunscreen from *Kaempferia galanga* rhizomes, a Green Chemistry Approach
10:09 –10:27 am	**Gabriel Lewis**	Isostatic Pressure Testing of Fused Deposition Modeling Materials
10:27 –10:45 am	**Andy Chai**	Design of Pectin-based Microspheres for Targeted Pulmonary Drug Delivery
10:50 – 11:00 am	*Break*	
11:00 –11:18 am	**William Slater**	Investigation on the Effect of Photo-dose Parameters on Mechanical Properties of Photopolymer Resin
11:18 –11:35 am	**Rebecca Nokku**	Challenges in Post-processing of Fused Deposition Modeled Parts
11:35 –11:55 am	**Mitchell Johnstone & Mays Neiroukh**	Leveraging Machine Learning in the Design of Novel Ionic Liquids
11:55 –Noon	**Dr. Subha Kumpaty**	Closing Remarks (and Announcement of Poster Session on August 1st)

RESEARCH EXPERIENCE FOR UNDERGRADUATES

Research Experience for Undergraduates (REU) is an innovative, interdisciplinary program funded by the National Science Foundation and Milwaukee School of Engineering, providing hands-on experience to participants in applications of additive manufacturing and nano engineering at MSOE Research Centers in collaboration with industry.

Ten undergraduate students were recruited from all parts of the country with diverse experiences at small and large universities, skill levels, personal interests and science and engineering backgrounds. Their 10 weeks at MSOE are spent working closely with a faculty advisor with expertise in a particular research area. REU participants explore research topics through library and internet research, webinars, problem solving with advisors, teammates and other resources, poster sessions, group discussions, research documentation, learning new software, making presentations, building models, designing and completing experiments, and writing research papers.

MSOE was awarded its sixth REU grant in 2021 (EEC-2045738). Over 220 participants have passed through this REU program since 1997. REU programs are established at universities across the United States in all fields of science, mathematics, and engineering. MSOE is one of 110 universities sponsoring an REU program in engineering. The current REU site has K-12 outreach component as the participants engage in MSOE STEM Center programs. The current cohort also interact with prior MSOE REU alumni in various settings.

2023 Advisors

Dr. Subha Kumpaty	Professor − Mechanical Engineering, Program Director M.S. Engineering
Ms. Betty Albrecht	Assistant Dean of Students − Residence Life
Dr. Kevin Hart	Assistant Professor − Mechanical Engineering
Dr. Vipin Paliwal	Associate Professor – Physics, Chemistry and Math
Dr. Pawan Panwar	Research Associate – Fluid Power Institute
Mr. Jordan Weston	Additive Manufacturing Users Group (formerly Manager – Rapid Prototyping Center)
Dr. Wujie Zhang	Associate Professor – Physics, Chemistry and Math

For more information: Dr. Subha Kumpaty, REU Principal Investigator, kumpaty@msoe.edu; Ph. 414-277-7466