Michigan Technological University

Chemical Engineering

Lorna and James Mack Professorship of Continuous Processing

Annual Report

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Teaching

From Fall 2015 through Fall 2019, I am the lead instructor for the chemical engineering senior level Unit Operations Lab (CM4110) and Chemical Plant Operations Lab (CM4120). We have had/do have the following numbers of students in these classes: 100 students in 2015-2016, 77 students in 2016-2017, 88 students in 2017-2018, 98 students in 2018-2019, and 95 students in 2019-2020 (I am responsible for 50 students in Fall 2019). Both of these classes involve continuous chemical engineering processes. For example, the Solvent Recovery Unit is a continuous pilot plant process that involves the separation of an ethanol/water system via a distillation column. CM4110 includes many continuous processes such as heat exchangers, cooling towers, pumps, fluid flow through various meters, air separation using membranes, water treatment, and continuous stirred tank and packed bed flow reactors. We are constantly striving to improve these laboratory experiences with our chemical engineering seniors. First, I will give an update on some improvement projects that started before Fall 2017. For the packed bed reactor that involves the sucrose goes to fructose and glucose reaction, in March 2016 we ordered a new digital polarimeter to use instead of the previously used manual polarimeter (used to monitor the reaction) and adjusted operating conditions to increase conversion from ~ 12 to 50%. In January 2017, we continued to improve this experiment by purchasing a small positive displacement pump that more reliably delivered low flow rates, and this increased the conversion to ~ 70%. This experiment was run again in Fall 2017 and Spring 2018 and these improvements continue to work well. In Fall 2015, a new experiment involving two continuously stirred tank reactors (CSTRs) in series was developed. In these reactors, ethyl acetate and sodium hydroxide form sodium acetate and ethanol. After the initial run, several modifications were made to the experiment. For example, the size of the first reactor was reduced by 50% so that the students would observe a significant difference in the conversion from the first and the second reactor. In February 2017 we continued to improve this experiment by purchasing new electrical conductivity meters (used to monitor the extent of reaction) so that the data could be continuously recorded on a laptop. In Fall 2017 and Spring 2018, these new conductivity meters were used and they worked well. As expected, the students enjoy improving an existing experiment, which is similar to tasks they will likely be given upon graduation.

Since Fall 2017, I have continued to improve the Unit Operations lab. I worked with Michigan Tech alumni who now work with Georgia Pacific to develop a required “Pump Troubleshooting Assignment”. In this problem, the students are given a scenario that involves a poorly performing pump and they have to determine what pump to replace it with. Georgia Pacific engineers also connected me with representatives from Gorman Rupp, who came to Michigan Tech in October

2017 and October 2018 with their glass faced pump. They operated this glass faced pump (water was the process fluid), explained how the pump worked, discussed cavitation, and troubleshooting techniques. The students enjoyed both of these 'real life' pumping experiences.

Feedback from students from the previous two years suggested we discuss the DeltaV process control system in more detail. Thus, I worked with Mr. Steve Wisniewski (Unit Operations Research Associate who has prior industrial experience in controls and instrumentation) to show the students how to create the DeltaV programs that provide Proportional Integral Derivative (PID) control of the water flow measurement experiment. Feedback from students indicated that they appreciated this experience.

In July 2017, Steve Wisniewski and Scott Wendt (Laboratory Supervisor) installed a new glass bubble cap distillation column. From Fall 2017 through Spring 2019, Unit Operations students ran this unit with the ethanol/water system. These students operated this equipment and explained the glass column and the Solvent Recovery Unit (SRU) pilot plant (uses same ethanol/water system) to all the Chemical Engineering sophomores (~100 students) taking the required separations class. In this manner, the sophomores were able to see on a small scale (glass column) and on the pilot plant (SRU) the distillation column problems they were solving in the classroom setting.

In Summer 2017, Georgia Pacific donated money and equipment to fabricate a new paper making experiment in Michigan Tech's Unit Operations lab. In Fall 2017 and Spring 2018, Unit Operations students worked with Steve Wisniewski and Scott Wendt and Georgia Pacific engineers to begin design and fabrication of this unit. In Fall 2018 and Spring 2019, we continued fabrication and began preparing standard operating procedures for this new experiment. Previously, we did not have any paper processing experiments.

From Fall 2017 through Spring 2019, I worked with Steve Wisniewski and Scott Wendt to introduce the students to lockout/tagout procedures and hazardous operations training. They will likely encounter this while working in industry. In addition, Steve Wisniewski and I continued to improve the standard operating procedures for the SRU.

Several improvements were made in Fall 2017 and Spring 2018 on the Polydimethylsiloxane (PDMS) pilot plant. PDMS is a silicone-based polymer that is used in many applications including antiperspirants, lotions, skin creams, shaving products, bath oils, and nail polishes. This plant includes a 30 gal reactor that produces PDMS product after an organic chemistry polymerization reaction of monomer, endblocker, and KOH catalyst at 140^{o}C. The goal of the process is to fabricate a specified viscosity product (related to polymer chain length). The polymerization reaction is stopped (neutralized) with CO_2 and the light ends are removed. The viscosity of the PDMS product is collected and tested during the reaction run day and at the end after the reaction is stopped and volatiles removed. Previously, a Cannon Fenske glass tube was used to measure PDMS product viscosity at 25^{o}C and also the PDMS product collected had to cool from ~ 120^{o}C to 25^{o}C prior to testing. In Fall 2017 and Spring 2018, we tested a new device (mini DIN) cup to quickly and accurately measure the viscosity of the PDMS product. This mini DIN cup needs 50 ml of product and consists of a 'cup' with a slit in the bottom. The operator submerges the mini DIN cup in a beaker of the PMDS product, raises the cup above the PDMS level, and measures the amount of time that there is a 'continuous' stream of PDMS product flowing out the bottom of

the cup. This time is related to PDMS product viscosity. This test is often used in the paint and ink industry to quickly measure viscosity. The students were all required to conduct a Minitab statistical software gage repeatability and reproducibility study on the data collected. Using Minitab, it was determined that the mini DIN cup does repeatability and reproducibility measure the PDMS product viscosity. In Fall 2017 and Spring 2018, Steve Wisniewski worked with Unit Operations students to design, implement, and test a new heat exchanger installed on the PDMS unit to cool product collected for this viscosity test from ~ 120^{o}C to ~ 25^{o}C. Both of these projects reduced the amount of time needed to get viscosity product information from 45 minutes to 10 minutes. Quicker, reliable viscosity product information is a 'real life' example the students may face after graduation. Once again, feedback from the students indicated they thoroughly enjoyed working on these projects.

In Fall 2018 and Spring 2019, the students, Steve Wisniewski, and Julie King continued to improve the PDMS unit. In one project, we implemented an improved sampling port to collect the light ends removed at the end of the PDMS run day. In another project, we added an improved sampling port to collect the PDMS from the product tank.

Journal Publications

Listed below are publications that have been published, are in press, have been submitted, or in preparation from 2015 to the present time.

J. M. Tomasi, A.S.Krieg, N. J. Jensen, I. Miskioblu, **J. A. King**, G. M. Odegard, "Accelerated Hydrothermal Aging of Talc/Cyloaliphatic Epoxy Composites", Polymer Composites, DOI 10.1002/pc.25131, pp. 2946-2953, Vol. 40. Issue 7, July 2019.

W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, K. Waters, R. Pandey, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", Polymer, Vol. 163, pp.96-105, January 2019.

J. M. Tomasi, W. A. Pisani, S. Chinkanjanarot**,** A.S. Krieg, E. J.Pineda, B.A. Bednarcyk, S. G. Miller, **J. A. King**, I. Miskoglu, G. M. Odegard, "Modeling-Driven Damage Tolerant Design of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composite Panels for Full-Scale Aerospace Structures", NASA/TM-2018-219988, Glenn Research Center, Cleveland, OH, September 2018.

S. Chinkanjanarot, J. M. Tomasi, **J. A. King**, and G. M. Odegard, "Thermal Conductivity of Graphene Nanoplatelet/Cycloaliphatic Epoxy Composites: Multiscale Modeling", Carbon, Vol. 140, pp. 653-663, September 24, 2018.

A. S. Krieg, **J. A. King**, D. C. Jaszczak, I. Miskioglu, O. P. Mills, and G. M. Odegard, "Tensile and Conductivity Properties of Epoxy Composites Containing Carbon Black and Graphene Nanoplatelets", Journal of Composite Materials, DOI: 10.1177/00021998318771460, Vol. 52, Issue 28, pp. 3909-3918, November 22, 2018.

S. Chinkanjanarot, M. Radue, S. Gowtham, J. M. Tomasi, D. R, Klimek-McDonald, **J. A. King**, and G. M. Odegard, "Multiscale Thermal Modeling of Cured Cycloaliphatic Epoxy/Carbon Fiber Composites", Journal of Applied Polymer Science, , DOI: 10.1002/APP.46371, March 30, 2018.

M. S. Radue, B. D. Jensen, S. Gowtham, D. R. Klimek-McDonald, **J. A. King**, G. M. Odegard, "Comparing the Mechanical Response of Di-, Tri, and Tetra-functional Resin Epoxies with Reactive Molecular Dynamics", Journal of Polymer Science, Part B: Polymer Physics, DOI: 10.1002/polb.24539, published online November 4, 2017, Issue No. 56, pp. 255-264, 2018 in print.

J. M. Tomasi, **J. A. King**, A. S. Krieg, I. Miskioglu, G. M. Odegard, "Thermal, Electrical, and Mechanical Properties of Talc and Glass Microsphere Reinforced Cycloaliphatic Epoxy Composites", Polymer Composites, DOI: 10.1002/pc.24513, published online July 23, 2017, Vol. 39, pp. E1581-1588 June 25, 2018.

J. Laureto, J. M. Tomasi, **J. A. King**, J. M. Pearce, "Thermal Properties of 3-D Printed Polylactic Acid-Metal Composites", Progress in Additive Manufacturing, DOI: 10.1007/s40964-017-0019-x, April 12, 2017.

J. A. King, J. M. Tomasi, D. R. Klimek- McDonald, Ibrahim Miskioglu, G. M. Odegard, T. R, King, J. W. Sutherland, "Effects of Carbon Fillers on the Conductivity and Tensile Properties of Polyetheretherketone (PEEK) Composites", Polymer Composites, DOI: 10.1002/pc.24250, 2016, in print May 2018 Vol. 39: E807-E816.

J. M. Tomasi, I. D. Helman, W. A. Pisani, D. R. Klimek-McDonald, S. Chinkanjanarot, I. Miskioblu, **J. A. King**, G. M. Odegard, "Accelerated Hydrothermal Aging of Cyloaliphatic Epoxy/Graphene Nanoparticle Composites", Polymer Degradation and Stability, Vol. 133, pp.131-135, August 2016.

D. R. Klimek-McDonald, **J. A. King**, Ibrahim Miskioglu, E. Pineda, G. M. Odegard, "Determination and Modeling of Mechanical Properties for Graphene Nanoplatelet/Epoxy Composites", Polymer Composites, DOI: 10. 1002/pc.24137, online July 2016, in print June 2018 Vol 39 p. 1845-1851.

C. L. Heldt, A. Bank, D. Turpeinen, and **J. A. King**, "Translating University Biosensor Research to a High School Laboratory Experience", Chemical Engineering Education, Vol. 50, pp. 70-75, 2016.

J. A. King, W. A. Pisani, D. R. Klimek-McDonald, W. F. Perger, G. M. Odegard, "Shielding Effectiveness of Carbon Filled Polycarbonate Composites", Journal of Applied Polymer Science, DOI: 10. 1002/app.42719, 2016.

J. A. King, W. A. Pisani, D. R. Klimek-McDonald, W. F. Perger, G. M. Odegard, D. G. Turpeinen, "Shielding Effectiveness of Carbon Filled Polypropylene Composites", Journal of Composite Materials, DOI: 10. 1177/0021998315602326, Vol. 50, No. 16, pp.2177-2189, July 2016.

C. M. Hadden, D. R. Klimek-McDonald, E.J. Pineda, **J. A. King**, A. M. Reichanadter, I. Miskioglu, S. Gowtham, G. M. Odegard, "Mechanical Properties of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composites: Multiscale Modeling and Experiments", Carbon, Vol. 95, pp. 100-112, 2015.

A. Kumar, S. Li, **J. A. King**, G. M. Odegard, S. Roy, "Fracture Properties of Nanographene Reinforced EPON 862 Thermoset Polymer System", Composites Science and Technology, Vol. 114, pp. 87-93, 2015.

J. A. King, D. R. Klimek, I. Miskioglu, G. Odegard, "Mechanical Properties of Graphene Nanoplatelets/Epoxy Composites", Journal of Composite Materials, DOI: 10. 1177/0021998314522674, Vol. 49, pp. 659-668, 2015.

Conference Proceedings

J. Tomasi, **W. Pisani**, S. Chinkanjanarot**,** A. Krieg, D. Jaszczak, E. Pineda, B. Bednarcyk, S. Miller, J. King, I. Miskoglu, G. Odegard, "Modeling-Driven Damage Tolerant Design of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composite Panels for Full-Scale Aerospace Structures", AIAA Science Technology Forum and Exposition, San Diego, CA, Jan 7-11, 2019.
W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", American Society of Civil Engineers (ASCE) Earth and Space Conference, Cleveland, OH, April 9-12, 2018.

J. M. Tomasi, W. A. Pisani, S. Chinkanjanarot, A.S. Krieg, E. J. Pineda, B. A. Bednarcyk, S. G. Miller, **J. A. King**, I. Miskioglu, G. M. Odegard, "Modeling-Driven Damage Tolerant Design of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composite Panels for Full-Scale Aerospace Structures", American Institute of Aeronautics and Astronautics (AIAA) Science Technology Forum and Exposition, Kissimee, FL, Jan 8-12, 2018. Received outstanding paper award from Integrated Computational Materials Engineering (ICME).

J. M. Tomasi, **J. A. King**, D. R. Klimek-McDonald, N. D. Herline, A. S. Krieg, G. M. Odegard, I. Miskoglu, "Electrical, Thermal, and Tensile Properties of Cycloaliphatic Epoxy/Carbon Black and Cycloaliphatic Epoxy/Fumed Silica Nanocomposites, AIAA Science Technology Forum and Exposition, Kissimee, FL, Jan 8-12, 2018.

W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", Paper No. 114, American Society for Composites (ASC), W. Lafayette, IN, October 23-25, 2017.

J. M. Tomasi, I. D. Helman, W. A. Pisani, D. R. Klimek-McDonald S. Chinkanjanarot I. Miskioglu**, J. A. King**, G. M. Odegard, "Accelerated Hydrothermal Aging of Cycloaliphatic Epoxy/Graphene Nanoparticle Composites", American Society of Composites Conference, Williamsburg, VA, Sept 2016.

S. Chinkanjanaro, M. S. Radue, D. R. Klimek-McDonald, S. Gowtham, **J. A. King**, G. M. Odegard, "Predicting Thermal Conductivity of Graphene Nanoplatelet/Epoxy Nanocomposite using Non-Equilibrium Molecular Dynamics", American Society of Composites Conference, Williamsburg, VA, Sept 2016

W. A. Pisani, M. S. Radue, S. Chinkanjanaro, D. R. Klimek-McDonald, S. Gowtham, J. M. Tomasi, **J. A. King**, G. M. Odegard, "Predicting Thermo-Mechanical Properties of PEEK using Reactive Molecular Dynamics", American Society of Composites Conference, Williamsburg, VA, Sept 2016.

G. M. Odegard, C. M. Hadden, D. R. Klimek-McDonald, E. Pineda, **J. A. King**, A. M. Reichanadter, I. Miskioglu, S. Gowtham, "Mechanical Properties of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composites: Multiscale Modeling and Experiments", ICNN4-4th International Conference on Nanomechanics and Nanocomposites, Vicenza, Italy, September 14-17, 2016.

M. S. Radue, B. D. Jensen, G. Shankara, G. M. Odegard, D. R. Klimek-McDonald, **J. A. King**, "Applying Reactive Molecular Dynamics to Predict and Compare the Mechanical Response of Di-, Tri-, and Tetra-functional Resin Epoxies", American Society for Composites, 30th Technical Conference, East Lansing, MI, Sept 28-30, 2015.

C. M. Hadden, D. R. Klimek-McDonald, E. J. Pineda, **J. A. King**, A. M Reichanadter, I. Miskioglu, G. Shankara, G. M. Odegard, "Mechanical Properties of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composites: Multiscale Modeling and Experiments", American Society for Composites, 30th Technical Conference, East Lansing, MI, Sept 28-30, 2015.

C. M. Hadden, D. R. Klimek-McDonald, E. J. Pineda, **J. A. King**, A. M Reichanadter, I. Miskioglu, G. Shankara, G. M. Odegard, "Mechanical Properties of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composites: Multiscale Modeling and Experiments", 20th International Conference on Composite Materials, Copenhagen, Denmark, July 19-24, 2015.

Presentations/ Posters:

J. A. King, A.S. Krieg, I. Miskioglu, G. M. Odegard, E. Zeira, A. Hart, G. Rollins, "Tensile and Flexural Properties of Carbon Nanotube (CNT)/ Polyetheretherketone (PEEK) and CNT/Carbon Fiber/ PEEK Composites", NASA Institute for Ultra Strong Composites by Computational Design (US COMP), Biannual Meeting, Salt Lake City, UT, May 7-9, 2019.

A. S. Krieg, **J. A. King**, L. K. Odegard, I. Miskioglu, and G. M. Odegard, "Flexural Properties of Epoxy Composites Containing Graphene Nanoplatelets", NASA Institute for Ultra Strong Composites by Computational Design (US COMP), Biannual Meeting, Salt Lake City, UT, May 7-9, 2019.

W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, K. Waters, R. Pandey, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", American Society of Mechanical Engineers (ASME), International Mechanical Engineering Congress and Exposition (IMECE), poster, Pittsburgh, PA, November 11-14, 2018.

A. S. Krieg, **J. A. King**, D. C. Jaszczak, I. Miskioglu, O. P. Mills, and G. M. Odegard, "Determination of Tensile, Electical, and Thermal Properties of Epoxy Composites Containing Carbon Black and Graphene Nanoplatelets", MTU Chemical Engineering Department, Houghton, MI, October 4, 2018.

J. M. Tomasi, W. A. Pisani, S. Chinkanjanarot, A.S. Krieg, E. J. Pineda (NASA Glenn), B. A. Bednarcyk (NASA Glenn), S. G. Miller (NASA Glenn), **J. A. King**, I. Miskioglu, G. M. Odegard, "Modeling- Driven Design of Spacecraft Hardware with Improved Shear Toughening Using Graphene Nanoplatelelet/Carbon Fiber/Epoxy Hybrid Composites", 1st International Conference on Mechanics of Advanced Materials and Structures (ICMAMS), June 17-20, 2018, Torino, Italy.

W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", American Society of Civil Engineers (ASCE) Earth and Space Conference, Cleveland, OH, April 9-12, 2018.

J. M. Tomasi, W. A. Pisani, S. Chinkanjanarot, A.S. Krieg, E. J. Pineda, B. A. Bednarcyk, S. G. Miller, **J. A. King**, I. Miskioglu, G. M. Odegard, "Modeling- Driven Damage Tolerant Design of Graphene Nanoplatelet/Carbon Fiber/Epoxy Hybrid Composite Panels for Full-Scale Aerospace Structures", American Institute of Aeronautics and Astronautics (AIAA) Science Technology Forum and Exposition, Kissimee, FL, Jan 8-12, 2018. Received outstanding paper award from Integrated Computational Materials Engineering (ICME).

J. M. Tomasi, **J. A. King**, D. R. Klimek-McDonald, N. D. Herline, A. S. Krieg, G. M. Odegard, I. Miskoglu, "Electrical, Thermal, and Tensile Properties of Cycloaliphatic Epoxy/Carbon Black and Cycloaliphatic Epoxy/Fumed Silica Nanocomposites, AIAA Science Technology Forum and Exposition, Kissimee, FL, Jan 8-12, 2018.

W. A. Pisani, M. S. Radu, S. Chinkanjanarot, B. A. Bednarcyk, E. J. Pineda, **J. A. King**, G. M. Odegard, "Multiscale Modeling of PEEK using Reactive Molecular Dynamics and Micromechanics", American Society for Composites (ASC), W. Lafayette, IN, October 23-25, 2017.

D. G. Turpeinen, S. M. King, C. L. Heldt, J. A. King, W. F. Perger, H. Fukushima, "Protein Detection Using Paper-Based Graphene Ink Biosensors from a Flexographic Proofer", National American Institute of Chemical Engineering Annual Meeting, Minneapolis, MN, October 30-November 3, 2017.

J. A. King, "Conductive Composites", Mechanical Engineering Seminar, University of Wyoming, Laramie, WY, October 5, 2017.

J. M. Tomasi, **J. A. King**, A. S. Krieg, G. M. Odegard, "Determination of Mechanical, Electrical, and Thermal Properties of Talc-, and Glass Microsphere-Reinforced Cycloaliphatic Epoxy Nanocomposoites", MTU Chemical Engineering Department, Houghton, MI, September 25, 2017.

J. M. Tomasi, S. Chinkanjanarot, W. A. Pisani, D. R. Klimek-McDonald **, J. A. King**, J. Hoffman, M. Kumosa, I Jasiuk, G. M. Odegard, "Physical and Chemical Aging of Polymer Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Denver, CO, May 16-17, 2017.

J. M. Tomasi, A. S. Krieg, **J. A. King**, "Determination of Mechanical, Electrical, and Thermal Properties of Talc and Glass Microsphere Reinforced Cycloaliphatic Epoxy Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Denver, CO, May 16-17, 2017.

J. M. Tomasi, S. Chinkanjanarot, W. A. Pisani, D. R. Klimek-McDonald **, J. A. King**, J. Hoffman, M. Kumosa, I Jasiuk, G. M. Odegard, "Physical and Chemical Aging of Polymer Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, October 18-19, 2016.

J. M. Tomasi, A. S. Krieg, **J. A. King**, "Determination of Mechanical, Electrical, and Thermal Properties of Talc in a Cycloaliphatic Epoxy with Anhydride Curing Agent", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, October 18-19, 2016.

J. A. King, J. M. Tomasi, D. R. Klimek-McDonald, G. M. Odegard, "Graphene Nanoplatelet/ Carbon Black/Carbon Fiber/Polyetheretherketone (PEEK) Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/ Temperatures Materials and Structures, Houghton, MI, October 18-19, 2016.

J. M. Tomasi, I. D. Helman, W. A. Pisani, D. R. Klimek-McDonald S. Chinkanjanarot, **J. A. King**, G. M. Odegard, "Accelerated Hydrothermal Aging of Cycloaliphatic Epoxy/Graphene Nanoparticle Composites", MTU Chemical Engineering Department, Houghton, MI, September 27-28, 2016.

J. A. King, "Composites Fabrication, Testing, and Modeling Capabilities at Michigan Technological University, NASA Glenn, Cleveland, OH, May 18, 2016.

D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, G. M. Odegard, "Determination of Mechanical, Electrical, and Thermal Properties of Carbon Black in a Cycloaliphatic Epoxy with Anhydride Curing Agent", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Urbana, IL, May 17-18, 2016.

D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, G. M. Odegard, N. D. Herline, A.S. Krieg, "Determination of Mechanical, Electrical, and Thermal Properties of Fumed Silica in a Cycloaliphatic Epoxy with Anhydride Curing Agent", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Urbana, IL, May 17-18, 2016.

D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, G. M. Odegard, "Graphene Nanoplatlet/Carbon Black/Carbon Fiber/Polyetheretherketone (PEEK) Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Urbana, IL, May 17-18, 2016.

S. Chinkanjanarot, D. R. Klimek-McDonald, **J. A. King**, G. M. Odegard, "Molecular Modeling: Thermal Conductivity of Graphene Nanoplatelet/Cycloaliphatic Epoxy System", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Urbana, IL, May 17-18, 2016.

D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, G. M. Odegard, J. Hoffman, M. Kumosa, I Jasiuk, W. A. Pisani, S. Chinkanjanarot, "Physical and Chemical Aging of Polymer Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Urbana, IL, May 17-18, 2016.

J. M. Tomasi, D. R. Klimek-McDonald, **J. A. King**, G. M. Odegard, "Mechanical Properties of Graphene Nanoplatelety/Epoxy Composites, Chemical Engineering Graduate Research Colloguium, Michigan Technological University, Houghton, MI, September 30, 2015.

D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, G. M. Odegard, "Determination of Mechanical, Electrical, and Thermal Properties of Carbon Black in a Cycloaliphatic Epoxy with Anhydride Curing Agent", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Denver, CO, October 20-21, 2015.

J. A. King, D. R. Klimek-McDonald, J. M. Tomasi, G. M. Odegard, "Graphene Nanoplatelet/Polyetheretherketone (PEEK) Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Denver, CO, October 20-21, 2015.

J. M. Tomasi**,** S. Chinkanjanarot, W. A. Pisani, D. R. Klimek-McDonald, **J. A. King**, J. Hoffman, M. Kumosa, I. Jasiuk, G. M. Odegard, "Physical and Chemical Aging of Carbon/Epoxy Composites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Denver, CO, October 20-21, 2015.

M. Diehl, D. R. Klimek-McDonald, J. M. Tomasi, **J. A. King**, "Comparison of Mechanical Properties of Three Types of Graphene Nanoplatelets in Epoxy", MTU MICUP/MI-LSAMP, MTU Center for Diversity and Inclusion, Michigan Technological University, Houghton, MI, June 18, 2015

D. R. Klimek-McDonald, , **J. A. King**, G. M. Odegard, "Determination of Mechanical Properties of Two Different Graphene Nanoplatletes in EPON 862 with EPIKURE Curing Agent W", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, May 19, 2015.

D. R. Klimek-McDonald, , **J. A. King**, G. M. Odegard, "Determination of Mechanical Properties of Two Different Graphene Nanoplatletes in EPON 862 with EPIKURE Curing Agent W", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, May 19-20, 2015.

I. Jasiuk, G. M. Odegard, **J. A. King**, D. R. Klimkek-McDonald, W. A. Pisani, W. F. Perger, S. Kale, F. Sabet, P. Karimi, B. Raghavan, M. Bakir, M. Ostoja-Starzewksi, "Electrical Conductivity and Shielding Effectiveness of Polymer Nanocomposites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, May 19-20, 2015.

G. M. Odegard, **J. A. King**, D. R. Klimkek-McDonald, W. A. Pisani, S. Chinkanjanarot, J. Hoffman, M. Kumosa, "Physical and Chemical Aging of Carbon/Epoxy Comopsites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, May 19-20, 2015.

J. A. King, D. R. Klimkek-McDonald, G. M. Odegard, W. A. Pisani, W. F. Perger, "Shielding Effectiveness of Carbon Filled Polypropylene and Polycarbonate Composites", National Science Foundation Industry & University Cooperative Research Center, Novel High Voltage/Temperatures Materials and Structures, Houghton, MI, May 19-20, 2015.

A. M. Reichanadter**, J. A. King**, D. R. Klimkek-McDonald, I. Miskioglu, G. M. Odegard, "Comparison of Three Types of Graohene Nanoplatelets in Epoxy", MTU Undergraduate Research Expo, Houghton, MI, March 20, 2015.

P. Winters, J. Collins, S. Tuntithavornwat, A. R. Minerick, C. L. Heldt, **J. A. King**, "Graphene Paper Microdevice with Flow Across a PDMS Channel", MTU Undergraduate Research Expo, Houghton, MI, March 20, 2015.

Students

I have worked with the following graduate students concerning my research and teaching activities from Fall 2015 to September 2019.

- Julie Tomasi- Chemical Engineering Ph.D. candidate working with me on composite materials and as a teaching assistant for Unit Operations and Plant Operations (CM4110 and CM4120). Graduated Ph.D. Chemical Engineering August 2018.
- Rick Machiela- Chemical Engineering Ph.D. candidate working with me as a teaching assistant for Unit Operations and Plant Operations (CM4110 and CM4120). Graduated in December 2018.

- Dylan Turpeinen- Chemical Engineering Ph.D. candidate working with Dr. Caryn Heldt and I on graphene based biosensors.
- Aaron Krieg- Chemical Engineering M. S. candidate working with me on composite materials and as a teaching assistant for Unit Operations (CM4110 Fall 2017, CM4110 Fall 2018, and Spring 2019). Received M.S. in Chemical Engineering in August 2018. Starting in Fall 2018, working with me for Ph.D. in Chemical Engineering.

The following undergraduate students worked with me in my research area.

Fall 2015
Chris Blevins
Bryan Cammin
Nathan Herline
Jonathon Lamers
Justin Stefko
Pennie Winters
Alexander Wright

Spring 2016
Nathan Herline
Anna Hohnstadt
Lexie Keena
Aaron Krieg
Emily Peterson
Katie Rohls
Brandon Schmidt
Justin Stefko

Summer 2016
Charlie Biyong
Nick Jensen
Aaron Krieg
Evan Murphy

Fall 2016
Chase Chauvin
Anna Hohnstadt
Aaron Krieg
Jeannette Kussow
Jennifer Lenter
Emily Peterson
Karsyn VanLaanen

Spring 2017
Nate Baldwin
Nate Blaszak

Chase Chauvin
Aaron S. Krieg
Jennifer Lenter
Matt Pahl
Emily Peterson
Karsyn VanLaanen

Summer 2017
David Jaszczak
Evan Murphy
Carson Williams

Fall 2017
Nate Baldwin
Sarah Boyd
Anna Hohnstadt
Lexie Keena
Emilia Kuemin
Rebecca Phipps
Austin Weick

Spring 2018
Nate Baldwin
Charlie Biyoung
Sarah Boyd
Nick Olson
Holly Woloshik

Summer 2018
David Jaszczak
Leif Odegard

Fall 2018
Cally Meixner
Trevyn Payne
Brock Rudlaff

Summer 2018
Cally Meixner
Trevyn Payne
Brock Rudlaff

Fall 2018
Cally Meixner
Trevyn Payne
Brock Rudlaff

Spring 2019
Cally Meixner
Leif Odegard
Mia Pudas
Brock Rudlaff
Sommer Skeps
Ben Updike

Summer 2019
Leif Odegard

Fall 2019
Daniella Kyllonen
Cally Meixner
Leif Odegard
Brock Rudlaff

Research Funding

I am involved in a National Science Foundation Industry & University Cooperative Research Center named "Novel High Voltage/Temperatures Materials and Structures". This center is funded from September 2014 to February 2019. This center involves Denver University (Dr. Kumosa is the lead PI), Michigan Technological University (Drs. Odegard, King, and Sanders), and University of Illinois (Drs. Jasiuk and Ostoja Starzewski). This project has typically provided $20,000 per year to my research activities.

I am a co-PI on a new project "Institute for Ultra-Strong Composites by Computational Design" that is funded by the National Aeronautics and Space Administration (NASA) for five years (started Fall 2017 with $1,000,000 provided for the first year). Other Michigan Tech faculty involved are Dr. Greg Odegard (PI in Mechanical Engineering- Engineering Mechanics), Dr. Ravi Pandev (co- PI in Physics), and Dr. Trisha Sain (co-PI in Mechanical Engineering- Engineering Mechanics). Funding for Dr. King's research efforts are scheduled for years 3, 4, and 5. Year 3 funding for Dr. King is ~ $80,000 and began on June 15, 2019. Over the entire 5 year funding period, this project could provide $14,999,995.

As sole investigator, I received $46,000 (June 1, 2016 to December 30, 2016) and $12,562 (July 28, 2017 to October 1, 2017) and $101, 176 (February 13 to October 27, 2018) and $97,712 (June 20, 2019 to December 20, 2019) in funding from Boeing for continuous polymer processing work. I am also a co-PI on two bio-related funded projects that are listed below.

- Caryn L. Heldt (PI), **Julia A. King (Co-PI),** "IRES US-Denmark Collaboration to Create Next Generation Biosensors", National Science Foundation. $244,528.00: June 1, 2016 to May 31, 2019.

- Caryn L. Heldt (PI), **Julia A. King (Co-PI),** A. R. Minerick (Co- PI), W. F. Perger (Co-PI), "GOALI: Graphene Paper Sensor for Disease Detection", National Science Foundation. $349,250.00: May 1, 2015 to April 30, 2019.

Budget:

For fiscal year 2016 (ended June 30, 2016), this endowed chair did not generated any income from the Michigan Tech Fund that I can spend.

For the fiscal year 2017 (ended June 30, 2017), this endowed chair did generate $21,939.29 of income from the Michigan Tech Fund. These funds were used to pay Dr. Julie King 1 month of summer support in 2017 and to partially fund a graduate student.

For the fiscal year 2018 (ended June 30, 2018), this endowed chair did generate $38,754.45 of income from the Michigan Tech Fund. These funds were used to pay Dr. Julie King 1 month of summer support in 2018 and to partially fund two graduate students in Summer 2018.

For the fiscal year 2019 (ended June 30, 2019), this endowed chair did generate $31,744.45 of income from the Michigan Tech Fund. These funds were used to pay Dr. Julie King 1 month of summer support in 2019 and to fund one graduate student in Summer 2019.