The University of Iowa

EDITOR: Kenzie Curran

AIChE Spring 2020

Advisor's Corner

By: Prof. David Murhammer, Professor and AIChE Student Chapter Advisor

Greetings to Hawkeye Chemical Engineers!! The COVID -19 pandemic caused the Spring 2020 semester to go completely online following spring break. This pandemic also resulted in the cancellation of the AIChE Mid-America Regional Conference that was scheduled to take place at the University of Nebraska in April. Tentatively, the ChemE Car and ChemE Jeopardy regional competitions will be held in October at Iowa State University. Hopefully, we will be able to qualify to compete at the AIChE Annual student conference that is still scheduled to be held in San Francisco in November.

This Spring 2020 issue of our AIChE Student Chapter Newsletter begins with an article about the Tinker Process Safety Prize Competition that is generously supported by alumnus Sharon Tinker. This issue also contains articles about our department's newest elective focus area and our peer mentoring program in which junior and senior students serve as mentors for freshmen and sophomores. Furthermore, there are seven articles about student activities: (i) Winterim India Program, (ii) Geological Systems Research, (iii) musings about going online ("While at Zoom University"), (iv) Theta Tau professional engineering fraternity, (v) Grand Challenge Program, (vi) Co-op with Dupont, and (vii) research about the Environmental Consequences of Dichloroacetamide Safener. This issue concludes with a report about hygrometers written by a student for Professor Rundlett's Thermodynamics/Transport Laboratory course.

The faculty and students had to adapt on the fly to the online learning environment. We all hope that we will be able to have in class courses again in the fall. I certainly miss seeing the students in person and interacting with them. It was no fun recording lectures in an empty room! In the place of our usual senior banquet we had a Zoom event to honor the graduating seniors. This event went well, but it is certainly preferable to see the students in person and have a banquet with food.

Any comments about the newsletter content can be sent to me at davidmurhammer@uiowa.edu.

University of Iowa American Institute of Chemical Engineers

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The Tinker Process Safety Prize Competition– Katelyn Murhammer

For the second year, students in Dr. Murhammer's Chemical Process Safety class were given the opportunity to compete in the Tinker Process Safety Prize competition. This competition was developed by alumnus Sharon Tinker who spent much of her career working in process safety at Exxon Mobil. Tinker's reasoning for developing the competition stemmed from her interest in chemical process safety. Tinker said, "Process safety has been an important part of my career while working in refineries and chemical plants, and I was looking for a way to emphasize the importance of process safety for all chemical engineers." Working with Dr. Murhammer and Dr. Guymon, she was able to implement the competition for students to build upon the knowledge that students gain in the current safety course. Awards were given to all participants with the first place student receiving $1000, along with two runners-up who each received $500. Additionally, all other participants received a smaller monetary prize and an honorable mention.

The competition was composed of three aspects, including the student's final grade in the Chemical Process Safety course, a written report of a Chemical Safety and Hazard Investigation Board (CSB) investigation of a given incident, and a poster presentation of their chosen incident. Half of the competition's scoring was based on the student's final grade, and the other half was based upon a set of judge's scores of the paper and poster presentations. The papers were due on Monday, February 3rd, and the poster competition took place on Friday, February 21st. Tinker and other judges awarded Katelyn Murhammer with the 1st prize for the competition for her investigation on the Formosa Plastics Vinyl Chloride Explosion. This incident took place on April 23, 2004, when an explosion and fire occurred at the Formosa plant facility in Illiopolis, Illinois, after an operator accidentally opened a valve of a pressurized reactor. This incident ultimately killed five workers and severely injured three others.

The process at the Formosa plant involved the production of polyvinyl chloride (PVC) resins from vinyl chloride monomer (VCM) among other raw materials. The manufacturing process involved two operators who transferred VCM and other raw materials to a reactor where it was reacted under heat and pressure before being transferred to a stripper and then to a drying building. The two operators were separated by different level panels which were connected by a staircase and were responsible for different steps of the process. The incident occurred when the operator on the top panel went down the stairs to open the bottom and drain valves of the reactor to drain cleaning water, but the operator turned into the wrong set of reactors. The wrong reactor was in the midst of a heated and pressured process, and the operator bypassed a safety interlock that was restricting the valves from opening to allow an air supply to open the valves. This caused the toxic and flammable contents of the reactor to rapidly empty out onto the floor which ignited and exploded moments later and was followed by two to three smaller explosions.

In her report, Murhammer analyzed the cause of the incident and discussed several factors including overlooked safety deficiencies, poor building design, no management of change, and a lack of emergency procedures. The CSB also recommended that the Formosa Plastics company review the current design of their manufacturing processes and implement new policies and procedures for those processes. Murhammer also included her suggestion to implement a communication system between the operators on the top and bottom panels along with an indicator system to display what step the reactor was in during the reaction process. Murhammer said that she "has learned a lot about how small flaws in a chemical process can lead to detrimental effects which emphasize the importance of process safety in an industrial setting."

The Tinker Process Safety Prize Competition– Katelyn Murhammer

Furthermore, the two runners-up of the competition were Yuejia Gu and Hank Gerst, respectively. Gu investigated an incident in which a metal dust explosion occurred at the AL Solutions, Inc. facility in New Cumberland, West Virginia, on December 9th, 2010. The accident killed three people, including two operators and a contractor. The facility recycled scrap titanium and zirconium metal from various customers by milling the pieces down to fine particles and packing them into small discs for sale. The accident was caused by the ignition of zirconium metal dust in the blender, which set off a large explosion and subsequent fire that consumed the entire building. The CSB investigation found that the blender blade had been experiencing issues with striking the walls of the blender, creating hotspots that most likely started the fire. Although maintenance was aware of the issue, their solution was to increase blade clearance from the wall and replace it with an old part. The lax safety standards, such as storing barrels of metal particles in the same areas as metal processing, a lack of an engineering dust control system, and water-based firefighting measures all contributed to the severity of the incident. This incident was just one of many dust explosions that have occurred over the past several decades. However, there is still no comprehensive Dust Control Standard from OSHA to enforce safety regulations. Gu said that she "gained a better understanding of how accidents occur as a result of a weak safety culture and lack of engineering safety controls."

Gerst investigated a runaway reaction that happened at the Morton International Dye Production Facility in Patterson, New Jersey. The overreaction of the chemicals within the batch reactor was due to a series of management related issues about changes in design specifications, including lack of sufficient management of change procedures as well as inadequate process safety management procedures. Due to a series of design errors, like the inadequate cooling system design and pressure relief system design, an elevated reactor system ultimately triggered a second decomposition reaction at high temperatures which ruptured the reactor. Gerst said that he "got a better understanding about how many warning signs there are prior to these types of disasters" which allowed him to learn about the identification process of safety hazards.

Ultimately, the participants of this competition had the opportunity to further their knowledge in process safety and have gained valuable experience in this important topic. Tinker believes that the completion would "give the student an opportunity to demonstrate initiative and grow their understanding of process safety by digging deeper into the impacts of process safety in industry and see the evolution of an incident." The competition will be offered again next year, and all students taking the Chemical Process Safety course are highly encouraged to participate.

The State Journal-Register (SJR). "Remembering the Formosa Plastics plant explosion, April 2004." *USA Today Network, Gannett Co., Inc., April 2004,* https://www.sj-r.com/photogallery/LS/20140402/NEWS/402009998/PH/1

Winterim India Program: The Kerala Experience - Mason Lyons

I'm a junior chemical engineering student who studied abroad in India during this last winter break. Usually engineers taking an India Winterim class decide to do the water poverty case study class with Professor Bradley. However, the Sustainable Developments program counts for the sustainability certificate and offered me a break from technical coursework. This class is taught every other winter break and focuses on architecture and construction techniques employed in India that use less carbon intensive materials and lower the operating cost of the building. The difficult part of using less carbon intensive materials such as local, renewable resources like bamboo, mud (mortar), and brick is overcoming the social stigma of these 'low class' building materials. Although these structures would not work back home due to drastically different environmental conditions, it taught me about the structures of indigenous people who had been living here for centuries before the invention of concrete and steel.

Connecting with diverse groups of people is an important aspect of formulating the most effective solution to a problem. Being immersed into Indian culture and meeting people from foreign walks of life opened my eyes to this effectiveness. My perspectives on lifestyle choices, wants, and needs drastically changed after seeing how people live in India.

I love learning experiences and that is exactly what this class provided me with. One of my favorite stories from the trip happened when my roommate and I were walking to get biriyani at a local restaurant one day. On our way we passed a group of old men playing a game looking like a cross between shuffleboard and pool. After walking by a second time they invited us to sit down and play. Not a word was understood by either party because neither of us could speak each other's language, but we still learned to play the game. They invited us back the next day, which happened to be during a state-wide strike. When we showed up to play there were at least 15 men there and they were delighted to teach the rest of the students how to play their game, carrom. A news reporter passed by and wrote a story telling of the crossroads between worlds found at the carrom board.

If you are a person who loves to study more than equations, I would highly suggest an India Winterim class or any study abroad program! You will never regret getting out into the world and experiencing something unique.

Machine Learning; The Newest Elective Focus Area for Students –Jonah Marks & Kenzie Curran

In today's continually advancing world, engineers are constantly improving existing systems and designing more efficient devices. One major area of innovation is in material design, with new materials are being discovered using computational modeling every day. Machine learning can understand chemical structure-function relationships from data and be used to discover material design principles for a variety of engineering applications. At University of Iowa Professor Gomes and Jonah Marks are using machine learning as a tool to screen chemical space for new photovoltaic chemicals. The application of computational methods to engineering problems is a rapidly growing field with many career opportunities.

The beginners course for this EFA offered at IOWA is called 'Intro to AI & Machine Learning', Kenzie Curran took this course this Spring of 2020 and loved it. I am not the best coder, its easy to see how numerous opportunities can come of this technology with the way it serves as a skeleton for us to fill with research. Dr. Gomes has been extremely available to all students taking an interest in this topic, I would suggest the course if not the entire EFA to all my peers.

An Editor's Note –Kenzie Curran

As the AIChE Newsletter Editor, I would like to introduce Liz Occhi as our AIChE president. Liz has been an extremely effective leader and taken a lot of initiative with the organization. It is unfortunate she was not able to show this off at any spring conferences this year but the fall is going to be extremely successful with her around. We would all like to thank her for her time, effort, and attention to detail. Congratulations Liz on the presidency!

Geological Systems Research –Elizabeth Occhi

Hello! My name is Elizabeth Occhi and I'm a junior in chemical engineering here at the University of Iowa. I have been involved with research on campus through the environmental science department since the Summer of 2019. During that summer, I was involved with the sampling of multilevel well systems at a contaminated groundwater site. Not only that, but I was involved with a drilling project. This drilling project involved the recording of the physical properties and collecting of samples of the rock. The sampling was conducted to study the composition and location of the contaminants in the geological system. The final project that was conducted involved the usage of a FLUTe liner, a piece of technology that is used to identify the location of contaminants in a system via staining. It is also used to limit the level of cross contamination within a borehole.

The current project that I am working on involves the study of the behavior of contaminants within three cross contaminated boreholes. Since the borehole was cross contaminated at a specific time, there is a unique possibility to study how these contaminants attenuate over time if we can identify the regions of the borehole that were cross contaminated. Eventually, I will be applying analytical models to these data sets to attempt to make a prediction on the future behavior of the contaminants within the boreholes due to different mass transfer processes.

After starting this project, I have learned how chemical engineering impacts other fields. I have noticed how separations, chemical reaction engineering, heat and mass transfer, and even biochemical engineering are applicable to my current research. Therefore, while this research is not directly related to chemical engineering, I still find myself applying important principles that I have spent the last three years learning in a variety of chemical engineering courses. Throughout this research experience, I have learned how to communicate with a variety of people with different backgrounds, an experience that I am eternally grateful for. Not only that, but it has helped further define my future career path.

While At Zoom University—Kenzie Curran

The year is 2020 but instead of flying cars, we've been graced with the coronavirus; a much less exciting film to later be made. The initial orders to social distance and go out less seemed like a rather convenient scapegoat for taking some much needed alone time. However, this feeling was quickly replaced with unsettling questions of how intense isolation would become, then how long the intense isolation was to last.

Portraying this time of quarantine with online courses for Iowa's chemical engineers is not an easy task and not only because focusing has become nearly impossible. It's difficult because even though we (the junior class to be specific) are as close as can be, no one was to know how the next person could be dealing with such a predicament. I'm sure we all thought that the threshold of our emotional distress had been tapped out, but there was something to be said about the mental backflips one endures when told to nearly sit still for weeks. Rather than attempt to sum up lock down for everyone, I've kept a semi-daily journal. Here I've included excerpts from this daily journal that I believe best grasp the tone of these last two months of my life. Welcome to my quarantine headspace.

It's 10 or 11 PM, I'm sure of it and again the clock says its 2AM, on…a Monday? No, Monday was ages ago. Wait, where is a calendar? Ok, so it's 2 AM on a Tuesday. Anyways, who cares? I will get up and be so incredibly productive tomorrow. I am bound to eventually find some sense of control over my life that was previously out of control but in a college way and is now literally out of my control in a world-wide pandemic, "the government is sort of leading this one I'll just wait here I guess" kind of way. Hold on, I have an ICON update. Ah, yes I still have homework. Oh no, is that due today??

So it's 6PM on a Thursday and I cannot paint more amateur portraits of people and fruit, I just can't.

It's noon and I just woke up and WALKED my roommate's dog IN THE SUN and looked at trees. Man, what a wonderful world. It is becoming so green out there. Like really green, ya now? I will count this as my workout for the day and get to taking notes.

My blissful bubble was finally popped three weeks in, when all the street words pointed towards lengthening the lock down. I made tea, journaled, played guitar, finally washed my hair, cleaned everything, at some point fell asleep...through my morning alarm and did it all again. And again.

Online classes are very weird and not what I signed up for, but pausing and fast-forwarding my professors gives me such a satisfying pleasure. My notes are at my pace, my desk is set up my way, and I refill my coffee as I please. These little wins are mine and today they are more than enough.

Although online classes overall have felt very challenging, there are aspects of this method we need to incorporate into our "normal" regimen as we move forward. Online classes have the ability to make inaccessible material available to everyone. I've never quite understood the hesitation when it comes to making all resources available online. These online lecture notes and recordings are merely resources to do with what we will. The difference is that with online resources, the playing field between overscheduled and unencumbered students is nearly leveled.

Chemical Engineering is challenging but it doesn't need to be limited to students who are fortunate enough to have coordinating schedules and a funded education. Professors are the pillars of the IOWA Chemical and Biochemical Engineering program, we as students know and appreciate this. We as students also want to take advantage of our professors as the resources they are. Rewatching a lecture seems like it should be an obvious inclusion in the expensive, painstaking bundle that is the college experience.

I have grown a new resentment and it weighs approximately 4 lbs of Microsoft Surface Pro technology. We used to be tight, best friends really but since I have been chained to it for emails, ICON updates, emails, reports, emails, excel, homework, emails, Netflix and emails; we have grown apart. Metaphorically because I am never physically more than 15ft away from it. However, there are only two weeks left so I am hanging in there. I need a squeaky-clean detox from my BeEp- bOp- BOoP buddies for a while (4 days) then I start online summer classes!

While At Zoom University—Kenzie Curran

Does college develop masochist-like tendencies for everyone, or is it just me? In other news, Google and I have broken up because it does not know what chemical engineering is and laughs at me every time I desperately type the word "Tutorial" after an academic search. It is clear we are no longer interested in the same things and will move forward as just friends. I would like to thank everyone in advance for their patience and condolences in this trying time.

I just hope the farmer's market comes back, otherwise the Iowa City summer could be a complete wash! Without the block party, jazz fest, arts fest, everything, the only good thing left is that there's finally parking. Parking is useless without a want to be downtown and downtown is useless without those rewarding experiences. On the other hand, I love a lot of these people (college kids) and I never thought I would have to choose between my friends and safety. This is stressful, I'm going to go play with my dog and pretend all my friends and family are safe as can be. Fingers crossed until it's over, and I'll see you in the fall!

Theta Tau—Kyle Wersinger

Theta Tau is a co-ed professional engineering fraternity here on campus. Founded over 115 years ago, it is the largest and oldest professional engineering fraternity. The Omicron chapter here at the University of Iowa has been bringing together our engineers since 1923! Theta Tau provides the infrastructure for both men and women from all engineering disciplines to further develop themselves professionally as an engineer. By establishing meaningful relationships with other fellow engineering students, members of Theta Tau are very well integrated into our engineering community. Active members have the opportunities and resources to further develop themselves from a social, educational, and professional perspective.

Members participate in a variety of professional development, volunteer, and other philanthropic events throughout the semester. One example of these events is the professional development brunch that is put on every semester. During this, members share a meal and engage with engineers in their major who currently work in industry. It's a great way to learn about the real-world expectations and challenges that practicing engineers face. Members also have the opportunity to attend regional and national conferences where they can meet members from other chapters, spread ideas, and learn new ways to

Theta Tau Regional Conference 2020

Theta Tau (continued) –Kyle Wersinger

improve the fraternity.

Of course, there is a social aspect to Theta Tau as well. Our members are very close with one another and regularly participate in a variety of activities outside of class. From Smash Bros. tournaments to forming intramural teams, there are tons of opportunities to get to know everyone and form meaningful connections with your engineering colleagues. Apart from that, we often find ourselves studying together and helping each other out with classwork since many of us have taken the same courses or are currently TAs/Tutors. Many of our members are also a part of other organizations on campus which gives us even more opportunities to become integrated with the rest of the Hawkeye community. Being a member of Theta Tau for almost three years now, I can honestly say that this fraternity has significantly contributed to many of my successes during my engineering education.

Chemical Engineering & The Grand Challenge Program –Collin Sindt

The world is currently facing many challenges, most of which engineers are uniquely capable of innovating solutions for. The Grand Challenges program is focused on preparing students to address these challenges upon graduation, providing support for experiential learning opportunities which contribute to this goal during their degrees. My experience in the Grand Challenges program has allowed me to pursue research, study abroad, travel to our nation's capital, and expand my network to include other professionals and students in the program. This program has been a driving force in encouraging me to take bolder steps forward in my education, along with many other students all over the nation.

The Engineering Grand Challenges program at Iowa is one of many at universities all over the country. In collaboration with other national engineering associations around the world, fourteen "Grand Challenges" were identified as crucial for humanity to address in the coming years, spanning a wide range of disciplines from cyberspace to medicine to the environment. Grand Challenges programs at universities are meant to prepare students to tackle these challenges by focusing on five main experiential learning areas: Research, Entrepreneurship, Global Perspectives, Service, and Interdisciplinary Learning. Through a combination of these experiences applied to a grand challenge, the goal is to enable students to generate innovative solutions to these challenges in their future careers.

The role of a student in the program is to satisfy, to varying degrees, each of these 5 experiential learning areas before graduation. These can be fulfilled in a variety of ways, and how each student fulfills the various requirements of the program is subject to what they wish to accomplish through it. My selected grand challenge to focus on is developing carbon sequestration technologies, and so many of my experiences have tried to focus somehow on being applicable to that. A more detailed description of the program elements can be found online at the Iowa Grand Challenges web page. Upon application, students are asked what they have done or plan to do to address these components, and upon admission to the program, resources are provided to help them focus on those elements.

The main support the program provides is financial. A scholarship is given to scholars within the program, which can be applied to any academic costs like any other scholarship. In addition, $1000 of programmatic support is available for the student to use at their discretion in pursuit of their challenge. This can be used for research funding, travel expenses, program costs for study abroad, etc. In addition, the program provides access to the broader Grand Challenges community.

Chemical Engineering & The Grand Challenges –Collin Sindt

A national convention is held every year in Washington DC where scholars and advisors from programs all over the country come together to learn and network. I took part in this convention last November, using my programmatic support to cover all the expenses associated with the trip. The remainder of my programmatic funding then helped cover expenses for the India Winterim.

While the requirements can seem like a lot, my personal experience was that I was already completing several of the components between research and student org involvement, and the support of the program not only made these more feasible, but also pushed me to do more than I ever thought I would in college. The program and the support it's provided has given me opportunities I never thought I'd see, and I'd highly recommend it to any student.

Peer Mentoring –Katelyn Murhammer

Undergraduate students in the Department of Chemical and Biochemical Engineering have the unique opportunity to participate in a peer mentoring program between upper and lower classmen. This program was developed by the officers of Iowa's AIChE student chapter during the 2017-18 academic year and is administered by the vice-president of the AIChE student chapter. The mentor pairs are chosen primarily based on each student's respective elective focus area and professional goals. However, their gender and involvement in research or organizations on campus are also larger taken into consideration.

This semester fifty students participated in the peer mentoring program. It is expected that each pair communicates with one another and coordinates times to meet to discuss course work, their college experiences, professional goals, and anything about their personal life that they would like to share. New this semester, monthly events were offered to participants of the program to spend time with one another outside an academic setting. This semester two events were offered, including a jeopardy competition and board game night. At the jeopardy event, participants were able to enjoy a complimentary dinner with homemade desserts before playing a game of jeopardy with their classmates. The game night involved playing board games while enjoying some snacks and served as a great break from schoolwork.

Those who participate in the peer mentoring program have benefited by connecting with their classmates, engaging in a unique professional development opportunity, and by better understanding the chemical engineering curriculum. Additionally, those who participated in the program had a unique opportunity to meet many students who are not in their graduating class which resulted in new connections. Going forward, the peer mentoring program will continue to be offered to the undergraduate students in the department.

Co-op with Dupont –Brittany Workman

Since May of 2019, I have been working in a Co-Op with DuPont in Fort Madison, Iowa. Many students are very familiar with DuPont Industrial Biosciences in Cedar Rapids. The plant I am working at is one of DuPont's Specialty Product plants. At this site, DuPont makes many inks and dyes for printers and fabrics. This site is also part of DuPont's Nomex® and Kevlar® chains. During the COVID-19 pandemic, this site even started to produce hand sanitizer which they sent to all national DuPont sites and to local businesses.

The Fort Madison site is very small which has given me the chance to see every aspect involved with operating the plant, instead of just a certain division. During my time at DuPont, I have worked on updating batch cards, standardizing the product labeling system, and writing standard operating procedures. I even created PowerPoints and time sheets used to help transition to a new process order for a new product in which this site is the pilot plant for. My main projects have been updating their records for their deionized water usage, which is used in production and as cooling water.

During both of these projects, I traced through the deionized water loops, or well water feeds, taking note of every process the materials were tied into. Then I went through all of the P&IDs and made a large number of updates so that they were consistent with the actual layout. I also made multiple spreadsheets which listed every process or tank that each water loop fed to. Now, when maintenance is needed, the plant only needs to shut down the processes that are affected instead of all of the plant's processes or taking the time to trace the lines.

While working on updating the cooling water records, I was also tasked with reducing the amount of unnecessary water usage. During planned down time, it was realized that the plant was running 70 gallons of water per minute even though nothing was running at the time. After discovering a network of piping that had not been used in years but was constantly running water, we were able to drop the water usage to 15 gallons of water per minute during down times. The remaining amount is believed to originate from faulty valves that are partially open. Overall, my Co-Op with DuPont allowed me to work closely with Chemical Engineers, Process Engineers, Chemists, CAD Personnel, and Management as well as on a variety of projects which exposed me to most of their product lines. To anyone considering an internship or Co-Op, I suggest that you don't overlook the smaller plants because you will gain a lot of exposure you may not experience at a larger plant. I have enjoyed every minute of it and I look forward to continuing my Co-Op this summer!

Environmental Consequences of Dichloroacetamide Safeners – Mayra Narvaez

For over a year, I have been working as an undergraduate research assistant for Professor David Cwiertny and Professor Gregor LeFevre within the Environmental Engineering department at the University of Iowa.

Under professional directions and supervision from a graduate student, the two of us worked to understand the environmental consequences of dichloroacetamide safeners. Dichloroacetamide safeners are a class of agrochemicals co-applied in large scale with chloroacetamide herbicides to protect crops from herbicide toxicity. All four dichloroacetamide species have been detected in Midwestern surface waters. Safeners are currently regulated as "inert" constituents under the U.S. Federal Insecticide, Fungicide, and Rodenticide Act and have received meager attention in the peer-reviewed literature. Recent studies suggest that some dichloroacetamide safeners are reactive in aquatic systems and can yield products with increased bioactivity which may pose risks to human and environmental health. To evaluate the date and transformation of dichloroacetamide safeners, we measured timescales (i.e., half-lives, sorption rates) for predicting safener per-

Environmental Consequences of Dichloroacetamide Safeners – Mayra Narvaez

sistence, determining the effects of water chemistry (i.e., pH, DOC) on the rate and extent of hydrolysis and sorption processes, and quantifying sorption parameters for active herbicide co-formulants and mixtures.

I have been exposed to numerous experiments; hydrolysis, photolysis, biotransformation among others, but the most relevant personal contribution to this research is sorption. For over 6 months, I have been assigned my individual project and have been perfecting this experiment. To obtain the desired data I operate a High-Performance Liquid Chromatography (HPLC).

Throughout the time I have been spending in the lab, I have had the opportunity to work in close relation with a graduate student. I have learned from the graduate students about their programs, projects, and have constantly been exposed to different techniques and amazing teamwork. As a Chemical Engineering junior undergraduate student, I have also had the opportunity to put my academic knowledge into practice.

Working in the Environmental Engineering laboratory, confirmed my desire to apply my degree to an environmental cause. I have a better understanding of all the areas these different laboratory techniques can be applied to, as well as clarified my interest in green technologies. All the instruments I have been exposed to will be of great relevance for a future position in any laboratory. All the experience and the qualities that I have learned from my elder teammates will also perfect my academic progress. For my future work, I will be completing my contribution to this research and start another individual project involving aerosols.

Daily COVID-19 Update

Outstanding Thermo Dynamic Transport Lab Equipment Report and Infographic Poster Assignments:

Hygrometer Report –Luis Antezana

Hygrometers

What do Hygrometers Measure?

Hygrometers are a common piece of equipment in any lab and certainly any greenhouse or large-scale industrial process that uses air as a reactant. The difference between a hot, sunny desert and the overwhelming steamy heat of a rainforest, is the humidity. We can't see this physical property; however,

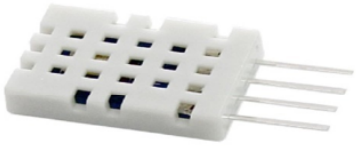

Figure 1- DHT10 Temperature and Capacitive Hygrometer Sensor (Banggood, 2020). Licensed Under CC

we are all aware of how it feels. Humidity is the amount of water vapor present in the atmosphere all around us, we measure this using Hygrometers. Before we can explore the intricacies and technicalities of how hygrometers work, we must understand what the hygrometer is going to measure precisely. Humidity is often expressed in most settings as relative humidity. This is defined as the amount of water vapor in the air (concentration which uses partial pressures of water in air) over the total maximum amount of possible water vapor in the atmosphere at that temperature. Another definition is, the ratio of partial pressure of water in air to the equilibrium vapor pressure of water at a given temperature (Perry, R.H. 2017)

Humidity plays an important role in every aspect of our life, from bacteria and fungi culture growth to the health our homes and even our own comfort. We are very sensitive to humidity changes, since the human body uses evaporation of water moisture in the skin as the main cooling mechanism. As relatively humidity increases the amount of water vapor that can further be dissolved in air decrease therefore evaporation of water moisture from human skin is blocked and thermal regulation not possible, which results in the known feeling of muggy, sticky and airless environment. (Rothfusz, P. L, 1990). Having a way to measure humidity is therefore vital in many situations and this is where hygrometers become important.

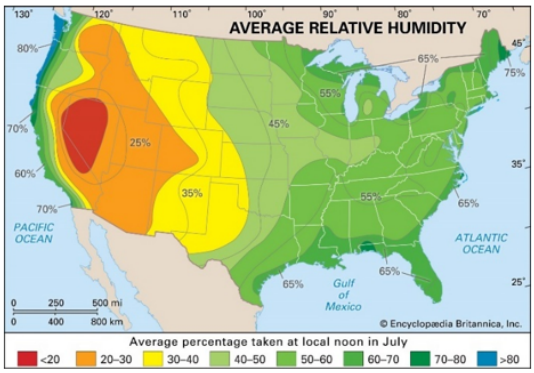

Figure 2- Average Relative Humidity in US 2007 (Editors of Encyclopaedia Britannica, 2013). Licensed Under CC

Humidity has been measured since the time of the Western Han dynasty in China (Hambly, R. 2010). Some early variations of hygrometers are called psychrometers. A psychrometer consists of two thermometers side to side. One thermometer is exposed to the outside air and measures the outside temperature. The other thermometer

Hygrometer Report –Luis Antezana (Continued)

is kept wet with a sock or wick (Gorse, C. 2012). The water on the "wet bulb" leads to evaporation of water and therefore a loss of heat from the wet bulb resulting in a lower temperature reading than the bulb exposed to the air. The water that can evaporate on the wet bulb depends on the water vapor already present in the atmosphere, as more water evaporates the temperature of the wet bulb decreases. By measuring the difference in temperature of the dry and wet thermometer we can measure the relative humidity (Woodford, C. 2020).

How does a Capacitive Hygrometer Work?

Having a wet and a dry thermometer would be too much work for any practical situation. Fortunately, most hygrometers today are electronic. The most common type of hygrometers are capacitive hygrometers. These sensors rely on the difference in relative permittivity of different materials to provide a change in voltage and therefore a proxy for relative humidity. Permittivity is the measure of how polarizable a material can become in the presence of an electric current. A material with high permittivity, polarizes more in an electric field and stores more energy in that electric field (Landau, 2009).

Capacitive hygrometers consist of two metal plates (the electrodes) separated by a dielectric material (usually aplastic polymer). The relative permittivity (permittivity of chosen material over permittivity of empty vacuum) for the dielectric material in most sensors ranges from 2 to 18. The relative permittivity for water vapor is around 80. Once the sensor is exposed to the atmosphere, it absorbs water vapor in the air, increasing the relative permittivity of the dielectric material, allowing it to store more energy and hence a spike in capacitance is recorded. Capacitance is simply a measure of how much potential energy a material can store (Lish, 2017).

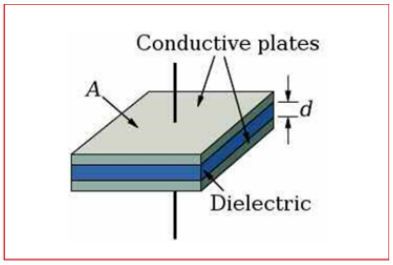

Figure 3- Capacitive Hygrometer (Rotronic, Technical Note). Licensed Under CC.

The amount of change in capacitance is proportional to the water vapor absorbed by the dielectric and this is proportional to the amount of water vapor available in the air at a set temperature. Capacitance hygrometers give relative humidity values since it uses the total change in capacitance generated over the total possible change in capacitance (Rotronic Technical Note).

Capacitance hygrometers are very accurate and sensitive. Another common electrical method to measure humidity are resistance hygrometers. These work in a similar way to capacitance hygrometers however they measure the resistance to electrical flow due to added water vapor in the air. Resistance sensors are typically less sensitive to humidity changes meaning they can work well for 90% and above relative humidity however they require considerable circuitry compared to capacitance hygrometers (Roveti, 2001).

Electrical hygrometers offer accurate and fast measurements, however other physical properties such as thermal conductivity (the ability of a material to conduct heat) can be measured to account for the change due to humidity as well gravimetric hygrometers (measure weight of air compared to weight of dry air) however these are often more expensive and bigger than electronic hygrometers.

Hygrometer Do's and Don'ts

What is common throughout any hygrometer is the mechanism. They all rely on a physical property (i.e. resistivity) that is both impacted directly by water vapor present in air, and that it is measurable. Hygrometer handling is different for each type however some good general practices include using the hygrometer inside the temperature or humidity range (as this might shift calibration), avoiding dust or exposure to condensation on the probe, being mindful of conditions (harsh chemicals, large changes in pressure), and allowing the probe or sensor to reach the system temperature before recording.
It is also important to watch out for temperature and pressure changes as this affect relative humidity measurements. (Bell, 2012).

Why does it matter?

Hygrometers are of relevance in the greenhouse industry where the indoor growth of plants depends on the controlled environment inside such as the temperature, and relative humidity. Additionally, processes that use a

Hygrometer Report –Luis Antezana (Continued)

furnace, such as steam reforming (methane is reacted with oxygen to obtain hydrogen for further hydrocarbon reactions) where air is used as a main source of O2. High humidity results in lower oxygen concentrations and therefore the furnace must intake more air to maintain production of syngas (Dincer, 2015).

Humidity plays a significant role in human health as previously mentioned in this article as water evaporation through the skin is the body's ways to regulate temperature. Humidity impacts the infectivity of influenza virus aerosols; at higher relative humidity the influenza virus can travel for longer distances however the added water vapor inactivates the virus making it not effective for virus transmission (Noti, 2013). Humidity affects many aspects of our daily life and is no wonder humans looked for ways to measure humidity since ancient times and have improved it over that course.

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Interested in speaking at professional seminar? If so, then contact our current AIChE Student Chapter Vice President Katelyn Murhammer at Katelyn-murhammer@uiowa.edu or Student Chapter Advisor Prof. David Murhammer at david-murhammer@uiowa.edu for details and availability!

4133 SEAMANS CENTER OF
ENGINEERING ARTS AND SCIENCES
IOWA CITY, IOWA 52242

THE UNIVERSITY OF IOWA