The University of Iowa

EDITOR: CORINNE ANDRESEN

AIChE Spring 2016/Fall 2016/

Advisor's Corner

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

Greetings to Hawkeye Chemical Engineers!! This combined Spring 2016/Fall 2016 issue of our AIChE Student Chapter Newsletter includes student work from Professor Jessop's Process Calculations course and my Chemical Process Safety course. This includes 3 students papers about applications of Chemical Engineering from the Process Calculations course and 4 student papers from the Chemical Process Safety course, 2 of which are opinion papers about the best chemical regulation approach for the United States and 2 of which are opinion papers about the best approach to Chemical Plant Security in the United States. This newsletter also contains articles about the Spring 2016 AIChE Regional Student Conference, Invention Convention judging, plant trips to Emerson-Fisher and DuPont-Genencor, and Chemical Engineering Funnies.

University of Iowa American Institute of Chemical Engineers

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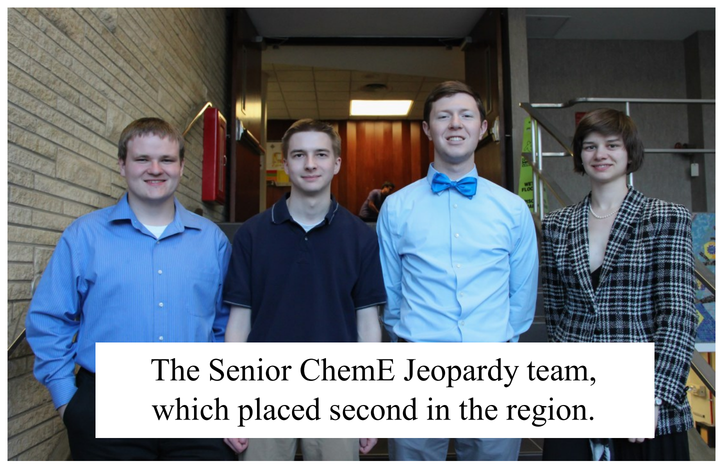
Spring 2016 AIChE Regional Student Conference

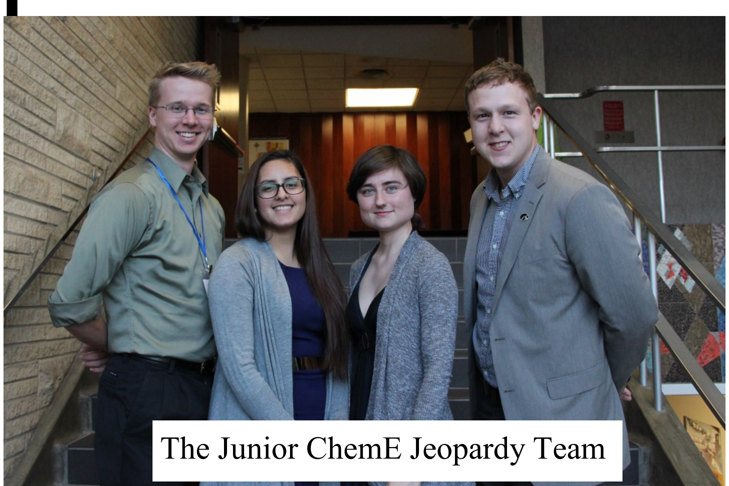
By: Corinne Andresen

Eleven Students and their faculty advisor attended the Mid-America Regional AICHE Student Conference at Kansas State University in Manhattan Kansas on April 1-2, 2016. Events included a student mixer, a research poster session and career recruitment fair. Although the University of Iowa was unable to enter the ChemE Car competition, we were able to send two teams ChemE Jeopardy teams to the competition, one team consisting of juniors, and the other, of seniors. Fittingly for the subject matter, the teams were named Team Laminar Flow and Team Fully Developed Turbulent Flow, respectively. Team Fully developed turbulent flow placed second. Three students, Lu Liu, Shiqin He, and Matthew Johnson entered the paper contest in which the participants gave oral presentations about their research projects. Lu Liu place first in the paper contest and represented the Mid-America Region at the 2016 National Competition that was held in San Francisco on November 12th.

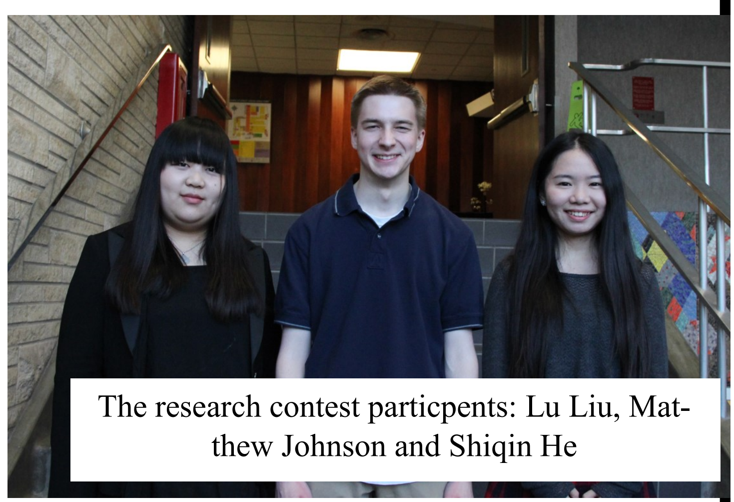
The AICHE Conference Attendees from the University of Iowa



The Senior ChemE Jeopardy team, which placed second in the region.



The Junior ChemE Jeopardy Team



The research contest particpents: Lu Liu, Matthew Johnson and Shiqin He

A Trip to the Emerson-Fisher Plant in Marshalltown

By: Eastyn Fitzgibbon

On January 28, 2016 many Chemical Engineering students and the AIChE Student Chapter advisor from the University of Iowa visited Emerson Process Management's in Marshalltown, where Fisher Controls tests and manufactures control valves. The experience gave insight into both the research and manufacturing aspects involved in supplying control valves.

After a brief introduction, Fisher's engineers gave us a tour of their testing facilities. There, engineers can ensure that a particular control valve will fulfill a client's specific needs. They stressed that several factors go into choosing a control valve, including safety, reliability, performance, and cost. Since Fisher's clients use systems of all different sizes and complexities, Fisher utilizes a wide variety of testing methods. This includes flowing air or water through pipes at up to 60,000 gallons per minute and or at pressures up to 3500 psi. This part of the tour was interesting, because it combined many concepts from our fluid mechanics and thermodynamics courses with the practical challenges associated with implementing control valves into existing plants.

Next, we listened as a panel of Fisher engineers discussed their backgrounds and what they enjoyed about their roles at Fisher. It was extremely valuable to hear how the Iowa alums felt that their education prepared them for their careers in the industry.

Lastly, we travelled to another location, where Emerson fills orders for control valves based on what was determined to suit the client's needs. The environment felt much more fast-paced and chaotic, with dozens of different projects going on and people moving in every different direction. This plant starkly contrasted the quiet and methodical setting of the testing facility, and it allowed us to see another work environment for engineers. Overall, touring Emerson's facilities was a great experience that showed several different types of opportunities that exist for engineers today.

University of Iowa AIChE — Emerson Visit
Innovation Center for Fisher™ Technology — Marshalltown, Iowa
January 28, 2016

An Invention Convention

By: Kevin Tobin

On February 9, 2016 many chemical engineering students from the University of Iowa and Professor Murhammer judged the creative inventions of the Regina Elementary School's fifth grade students. The elementary school students either worked in pairs or alone on original inventions that would help make a task easier for society. These inventions varied from heated bicycle handle bars to hair bushes that would aid in applying conditioner on the go. The students gave a presentation of the inventing process which included a cost analysis, analysis of how the invention would help society, and even design specifications. Along with this they build actual working prototypes of their inventions!

It was very fun to see how innovative these young students were. Some of these students came up with inventions that, if they haven't already, should probably be mass produced because they would benefit many people. The best part of these presentations was being about to see how excited these kids were about their own inventions. It was amazing to see how passionate the children were in coming up with these ideas and following through to the final design.

A Trip to the DuPont-Genencor Plant in Cedar Rapids

By: Alex Bartlett

On March 25, 2016 Jake Crome (UI Chemical Engineering 2015 BSE graduate) led a group consisting of keen sophomores, weary juniors, and apathetic seniors through the DuPont/Genecor facility in Cedar Rapids. The tour took place at the highly-desirable time of 3:30 on a Friday afternoon to allow all those with difficult schedules to satisfy the Spring 2016 CBE Seminar plant tour requirement. Even with the good weather, the group had only one student that needed to wear a bunny suit, i.e., there was only one student who failed to comply with the long pants/closed-toed shoes requirement. We all donned stylish safety glasses.

Despite Jake's best efforts, it was difficult hearing the details when earplugs were required. However, I enjoyed the tour far more than I ever thought I would. Walking through the facility, I recognized equipment that I had been unable to identify on previous plant tours. A few seniors and I were classifying the valves as air-to-open or air-to-close as we walked through the plant. To ensure a safe plant, the Company utilized its label printer throughout the plant. We were frequently reminded to hold onto the handrail, which gave me flashbacks to first grade. Overall, the experience was interesting and provided some interaction among the grades.

Should Inherently Safer Design be Required?

By: Austin Tor

Inherently Safer Design is a philosophy adopted by agencies in order to minimize safety and health risks in operating chemical plants. The philosophy's methods intend to minimize, substitute, moderate, and simplify chemical processes in order to achieve inherent safety. The safety features are built into the process and are required for proper functioning of the plant processes. If the plant processes malfunction, the inherent safety of the system will minimize the resulting hazards. The concept has been expanded since 1978 with origins by Trevor Kletz. However, there has been recent debate on whether inherently safety should be required. Inherently safer design is not a solution to the safety of chemical plant operation because the current safety regulations already exist, facilities are already effectively reducing hazards, and the inherently safer design does not accommodate the needs of the chemical industry as a whole.

Implementing new safety regulations through inherent safety is unnecessary because safety regulations already exist. Rather, existing safety regulations should be followed more strictly. In April 2013, a fire occurred at a West, Texas facility due to mishandling ammonium nitrate. Many injuries and loss of infrastructure incurred. The incident could have been prevented if current regulations on ammonium nitrate handling were followed. A spokesman for the American Chemical Council (ACC) states, "A variety of existing federal programs already require facilities to make their operations as safe and secure as possible" (Hess, 2014, p. 5). Applying more regulations to an agency will only complicate the current safety regulations. Focusing on improving the current regulations and stricter management of these policies will create better results for safety. The American Chemical Council suggests that guidance should be provided "to help companies comply with existing regulations rather than impose new requirements" (Hess, 2015a, p. 33). If this is implemented, then companies that are lacking knowledge on existing regulations or on the actions needed to improve the safety of their system can improve safety regulations. The chemical industry has opposed the notion for inherent safety because they have been already considered, and mandatory adoption of the policy would be "counterproductive" (Hess, 2015a, p. 33). Implementing the inherent safety design will only create the same problem: the policies will not be completely and properly followed.

The guidelines in place have already significantly reduced the need for more inherent safety regulations. One example is The Chemical Facility Anti-Terrorism Standards program (CFATS). This program has effectively reduced the use of inherent chemical hazards by allowing companies to make their own judgements on safety design. Glenn Hess states, "Chemical industry officials say the sharp decline in the number of regulated facilities shows that the security initiative (CFATS) is working as intended" (Hess, 2015b, p. 7). It is evident that facilities are taking initiate to reduce safety hazards. Therefore, they become less targetable to safety regulations. This further backs the point that additional regulations are unneeded, as the policies in place, such as the CFATS, are enough to drive companies to safer design standards.

By allowing companies to make their own safety design decisions and not require the inherent safety standards, the safety needs of the entire chemical industry can be better accommodated. The American Chemical Council argues that facilities know the best alternatives for safety for their processes and how it may affect other companies. The American Chemical Council says, "No single agency can fully appreciate the entirety of operational issues across industry sectors, and therefore no single agency should attempt to mandate a particular use of 'safe alternatives'" (Hess, 2015a, p. 33). The chemical industry is a complex web that depends on each industry involved.

Should Inherently Safer Design be Required (continued)

If the inherently safer design is required, then the changes made may create hazards elsewhere in the industry. Making wide-sweeping safety requirements like the inherent safety design may also put companies in the industry at economical risk. By using the inherent safety design, companies may need to install safety equipment or limit chemicals that they do not need. This not only makes companies have a higher maintenance cost, but can also limit their productivity. In turn, this affects other companies in the market that rely on the limited products.

One might argue that inherent safety requirements are the best alternative to safety procedures as they eliminate hazards before they happen. This is not true. While inherent safety may eliminate some, accidents are largely unpredictable in industry. It is nearly impossible to cover all safety precautions before they happen. There is no "one size fits all" safety design for a process. Furthermore, inherent safety creates an air of naivety. Installing inherent safety eliminates the need for innovation as one will think they have already accommodated for the safety in the chemical plant.

Inherently safer design is not necessary to improve the safety and eliminate hazards within a chemical plant. Current safety regulations are sufficient enough, but their adherence must be stricter. Secondly, facilities are making their own safety decisions without the inherent safety requirement. This has already shown improvement with respect to eliminating safety hazards. Lastly, by making their own decisions, companies are effectively reducing hazards by making choices that accommodate the industry as a whole. While chemical safety is a growing concern in today's society, the inherently safer design is not the right approach to increasing chemical plant safety.

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Inherently Safer Technology

By: Renae Kurpius

A popular topic of debate in recent years for the chemical industry is the idea of Inherently Safer Technology (IST) and whether it should be required by the Environmental Protection Agency (EPA). In 2013, President Obama issued an executive order requiring federal agencies to review safety rules at chemical facilities. This order came after an explosion occurred at a fertilizer storage facility in West, Texas (Moure-Eraso, 2014). It followed a series of chemical disasters, leading officials to question whether the current regulations should be adjusted in order to prevent future tragedies. I believe that the best approach for the United States would be to require companies to conduct an IST analysis to see if there are safer technologies or alternatives available to their current processes.

The current chemical regulation set by the Environmental Protection Agency is the Risk Management Plan (RMP) which is part of the 1990 Clean Air Act. According to the Environmental Protection Agency (2015), the Clean Air Act requires facilities that use extremely hazardous chemicals to develop a risk management plan which helps local fire, police and emergency response personnel prepare for and respond to chemical emergencies.

Inherently Safer Technology (continued)

The RMP must include a hazard assessment, prevention program and emergency response program and needs to be revised and resubmitted every 5 years. Under current RMP rules, flammable and toxic substances are covered, but explosive, reactive and other categories of chemicals capable of causing a significant chemical accident are not listed.

Inherently Safer Technology was a concept which was developed by Trevor Kletz, a chemical engineer. IST has four main goals: minimize the use of hazardous chemicals, substitute hazardous chemicals with safer ones, moderate or shift to less hazardous chemicals or processes at lower temperatures and pressures, and simplify processes and design plants to eliminate unnecessary complexity (Hess & Johnson, 2014, p. 12). This concept prompts chemical plants to analyze their current processes and take these actions when appropriate and feasible in order to reduce the risk of a chemical disaster. IST shifts away from depending solely on complicated safety systems, and focuses more on improving the safety of the process itself.

Although there is strong support for IST, there are many people who oppose making this a mandatory regulation. They believe that the focus should be on improving enforcement of the current RMP rules instead of imposing more restrictive regulations on chemical facilities (Hess, 2015, p. 32). Opponents claim that RMP has been sufficient in preventing incidents and that the accidents have occurred due to non-compliance with the regulation by certain companies. Other arguments against IST are that reducing inventory of chemicals on site would prevent companies from meeting customer needs according to Hess and Johnson (2015), and that mandating for safer approaches could force the elimination of chemicals that may be hazardous, but are still important for society.

Hess and Johnson (2015) quoted Paul Amyotte, president-elect of Engineers Canada who said that IST "does not mean that inherent safety is a cure for all ills or IST principles can be fully implemented in all scenarios," (p. 14). This is very important to remember when considering the opposition's concerns. Reducing hazardous chemicals stored on site or choosing safer processes for example, should only be implemented when the option is available, effective and economical for the company. Many times, there is more hazardous product stored on site than necessary. Doing something as simple as managing how much of the hazardous chemical is on site allows for a great reduction in the risk of a chemical incident. According to Moure-Eraso (2014), had IST been in place prior to the West, Texas incident, the outcome would have been a lot different. That fertilizer company would have used safer storage processes and fertilizer blends and would have kept less ammonium nitrate on site, thereby preventing the accident from occurring to begin with. RMP was inadequate for preventing this incident because ammonium nitrate is not covered by the RMP rules.

In order to create a safer environment for chemical facility workers and civilians nearby the facilities, it is important that Inherently Safer Technology analysis be required by the Environmental Protection Agency. By requiring chemical plants to perform analyses on their chemical processes, a wide range of concerns can be addressed and hazardous materials or conditions can be replaced with more favorable ones when available. This regulation will help to reduce the risk of chemical incidents, and therefore improve the safety of society.

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An Argument for Stronger Chemical Regulation in the United States

By: Katie Giles

The regulation of chemicals in the United States has been under the jurisdiction of the Environmental Protection Agency since the Toxic Substances Control Act (TSCA) was passed in 1976. Lawmakers, industry groups, and consumers eventually agreed that TSCA reform was needed, and bills were passed in both the Senate and the House of Representatives in 2015. However, some concerns exist about the TSCA updates. The current reform work is not as comprehensive as the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) legislation passed by the European Union in 2006. The new legislation also underutilizes recent breakthroughs in toxicity assessment technology that dramatically reduce the cost and time associated with safety testing. Legislators should consider the risk associated with low enforcement of hazardous chemical policies and place safety paramount by requiring more stringent chemical regulation in the United States.

The new legislation proposed in the United States would strengthen Environmental Protection Agency (EPA) control over hazardous chemicals, but Congress must resolve several key differences in their bills in order to pass a joint TSCA reform law. The Senate bill, S.697, was passed in December after months of bipartisan effort. Concerns with S.697 include the EPA's weakened ability to regulate imported chemicals, a large concern when considering the global chemical and manufacturing industries. The bill also limits state regulation over chemicals while the chemical is under EPA review at the federal level (Erickson, Congress Moves on Chemical Safety Reform, 2016).

The bill approved by the House of Representatives, H.R. 2576, has less restrictive provisions than the Senate bill; for example, companies would be allowed to keep chemical identities as trade secrets during the EPA review process under the House bill (Erickson, Chemical Control, 2016). Another difference between the bills is over evaluation of existing chemicals. The Senate bill allows the chemical industry to pick 30% of the chemicals to be reviewed, while the EPA decides on the other 70% to be reviewed (Erickson, Chemical Control, 2016). The chemical industry prefers the H.R. 2576 provision for evaluation of existing chemicals, where the manufacturers have complete control over which chemicals are to be reviewed; this greatly limits the EPA's control.

Although the TSCA reform will update regulation, other countries have stronger legislation in place for the chemical industry. Another approach to chemical regulation is the REACH legislation in the European Union. REACH provisions include registration of all chemicals made or imported into the European Union; the European Chemical Agency (ECHA) then decides if the chemical is safe for use in the EU. Chemicals that may be carcinogenic, toxic, or mutagenic are placed into the category of Substances of Very High Concern (SVHC) (Scott, 2016). These substances are reviewed and may be placed on the authorization list, where special authorization is required to use or manufacture these otherwise banned chemicals.

The REACH legislation offers stronger enforcement and reviewing power for the ECHA governing body than the TSCA reform bills offer the EPA. The candidate list for SVHCs is public, encouraging transparency for consumers who desire safer chemicals; this pressures chemical manufacturers to find substitutions for SVHCs and improves chemical safety. However, negative effects have been documented in the market over the cost associated with REACH registration and safety testing. Smaller companies in the EU struggle to comply with REACH provisions, complaining of limited innovation. Larger chemical companies such as BASF have stated they feel little restriction to innovation, due to their large presence in the market while paying similar costs as the smaller companies to comply with REACH. This inequality is a concern for allowing smaller compa-

An Argument for Stronger Chemical Regulation in the United States (continued)

nies to grow and compete with industry giants (Scott, 2016).

One of the largest barriers to chemical regulation has been the difficulty and cost associated with toxicity assessment. Progress over the last ten years by the National Center for Computational Toxicology under the EPA has produced technology capable of assessing chemical risk at a fraction of the time and cost (Partnership for Public Service, 2015). EPA scientist Robert Kavlock and his team created a new process to assess toxicity by watching for biological effects that may indicate toxicity in living cells exposed to chemicals. This replaced animal toxicity testing, drastically reducing the time and cost for chemical analysis. These advancements have improved the ability of the EPA to accurately and cost effectively test chemical safety, paving the way for more testing and enforcement in the regulation of the chemical industry.

The United States has made great progress in chemical regulation with the current TSCA reform legislation being debated in both the House of Representatives and the Senate. The reform law is expected to pass in 2016, bringing more power to the EPA and placing more restrictions on the chemical industry. Even with reform looming in the United States, the European Union REACH legislation offers more governmental control over chemical manufacturing and has been shown to encourage substitution of safer chemicals. With recent technology advances allowing for greater assessment of toxicity risk of chemicals at cheaper costs, the United States should consider increasing the EPA's regulating power to match the REACH provisions by requiring screening for all chemicals using the process pioneered by Kavlock's team. Unfortunately, with a third of the Senate and all 435 seats in the House up for reelection in 2016, little progress will be made this year as Congress heads home to campaign (Erickson, Chemical Control, 2016). The reform legislation of TSCA may be passed, but with less restriction on chemical safety and power granted to the EPA than the technology warrants and other countries' policies have contained for years.

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Chemical Regulation in the United States

By: Nicole Loch

Hazardous chemicals are used by many industries across the country. Currently, there is very little regulation regarding how companies handle these substances, which is alarming. In order to consider the United States to be a safe country, chemical safety must be a key concern, and stricter regulations must be put in place. The United States should refer to the European system but add aspects like flexibility and company protection. This is necessary to improve our country.

Currently, in the United States, chemical regulations are governed by the 1976 Toxic Substances Control Act, or TSCA, which has only led the EPA to ban five chemicals (Pearson, 2015). This number is shocking, seeing as there are far more than five potentially hazardous chemicals. The regulations need revisions, which are supported by both the U.S. House of Representatives and the Senate. Those bodies have both passed different versions of reforms of the TSCA as of June 2015 (Bettenhausen & Garcia, 2016). These reforms are widely supported in Congress, but disagreements between the House and Senate must be worked out before they can be put in place. However, the agreement that a reform is needed, especially in times when Congress seems to be at a standstill on most issues, shows that the current regulation system is severely outdated. This notion is reinforced when U.S. regulations are compared to the European Union's regulations. The European Union currently uses the Registration, Evaluation, Authorization, and Restriction of Chemicals, or REACH system, which allows the European Chemical Agency to determine the hazard level of chemicals, and whether or not they may be sold or used in the European Union (Scott, 2016). Currently, the European Chemical Agency has banned thirty-one different chemicals. The same chemicals are used in both Europe and the United States, therefore, the difference in how many chemicals are considered hazardous should be nonexistent. When compared to the REACH system, it is evident that the U.S. chemical regulations need to be reformed and tightened.

In creating a modernization of the TSCA, the REACH system should be referenced for guidance. The United States should adopt the registration system of having all companies submit information about what chemicals they use and/or import, and any hazard information that they have on those substances. This would create a database of chemicals and their hazards. With this, the EPA, or a new agency, can review all known hazard data when reviewing chemicals. Some companies may fear that this will expose trade secrets and classified information, however, if handled properly it shouldn't. Due to a difference of opinion, the current Senate reform proposal does not protect the identity of new substances, however protection needs to be available in order to receive industry support (Government Department, 2016). If a company is expected to be honest in reporting the substances they use, then the government should respect the privacy of their work. The chemicals each company uses should be classified information that is only available to the agency conducting the hazard assessment. If a chemical is reported that is not yet publically available, then the hazard review should remain confidential between the EPA and the company itself. This way, the EPA can help conduct hazard research, further benefiting both the agency in deciding the future of this chemical's use, and the company in knowing which safety regulations they should be aware of.

The methods for conducting chemical research also need an upgrade. The current method involves animal toxicology testing, and costs about one million dollars per chemical. These high costs have limited the EPA in their studies. In the last fifteen years, they have only been able to evaluate seventy of the eighty thousand chemicals in use (Partnership for Public Service, 2015). Instead of using this method, the EPA should make use of the ToxCast system at the National Center for Computational Toxicology. The ToxCast system is a da-

Chemical Regulation in the United States (continued)

tabase that generates data and predicts behavior of chemicals using a software program. The ToxCast system has the capability of screening over 2000 chemicals over a four year period, and only costs thirty thousand dollars per chemical (Partnership for Public Service, 2015). Including this technology in the reform is crucial. This system will allow the EPA to gather the maximum amount of hazard information for a substance, and allow them to evaluate substances at a faster pace. This is necessary because in order to avoid safety disasters, the EPA needs as much information as possible, and needs the ability to gather information and make decisions in a timely manner.

Once research is done, the EPA must make decisions regarding if it is reasonable to continue use of the chemical, and if so, the safety guidelines that must be followed to allow use. If a chemical is banned from use, then any companies using the substance would be notified, and given a set amount of time to phase out use. As with the REACH system, companies should be allowed to apply for an extended phase out period; however, in addition to that process, the companies should have to regularly show evidence that the phase out process is underway, or that research for a substitute chemical is taking place. This method should motivate companies to produce substitutes, since it has already done so in Europe (Scott, 2016).

The United States is in dire need of a reform of their chemical safety regulations. The European REACH system should be referenced for this reform. Companies should register their chemicals, but also be provided with protection on the information they supply to the EPA. The chemicals should then be reviewed using the newest technology available, ending with a final decision on whether the chemical can be used or not. Companies then will have the ability to apply for extended use of the chemical provided that they invest time into researching alternative substances to use. This system takes the layout of the REACH law, but adds more company protection, and flexibility during the phase-out process. This creates an optimal system that would improve chemical safety, while still promoting innovation and company support. This system ultimately would lead to a safer country.

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Prospects and Obstacles in 3D Printing

By: Ted Paulsen

More broadly referred to as additive manufacturing, 3D printing has grown both in popularity and sophistication since its creation more than 30 years ago (Sethi). Additive manufacturing is a manufacturing process that constructs objects by printing them layer by layer (Green). There are now many different additive manufacturing techniques that can print a wide variety of materials for many different applications (D'Aveni). Due to its unlimited customization, 3D printing will continue to become more popular (D'Aveni). Previously, 3D printing was seen as a niche technology, but thanks to advancements in the field of chemical engineering, it has expanded into a legitimate manufacturing technique that can be used for large scale production and is an exciting prospect in the biomedical industry (D'Aveni). With further innovation in the field of chemical engineering, 3D printing will experience greater utilization in general manufacturing, especially the biomedical industry.

3D printing has many advantages. One of its greatest advantages over traditional manufacturing methods is its customizability – alterations and improvements can now be applied with the click of a mouse (D'Aveni). Traditionally, manufacturing machines were designed to produce a specific part and only that part, but now designs can be altered on the fly (D'Aveni). The possibilities 3D printing presents are endless; only limited by our current understanding of chemical engineering. With all of this, it may seem difficult to see why traditional methods still exist. One challenge facing 3D printing is scalability (Alton). 3D printing techniques print parts layer by layer. This takes a lot of time (Alton). Most products can take several hours – if not days – to print (Alton). Cost is another big obstacle preventing 3D printing's further expansion. Many of the production sized 3D printers cost upwards of $200,000 ("3D Printer Price"). This is one area in which chemical engineering could have a positive impact. Advances in chemical engineering could increase print speed, decrease cost of materials, and help make 3D printing a more feasible method of mass production (Green). When 3D printing is available to the masses, the general population would benefit by gaining the ability to have products custom fit to their exact specifications (D'Aveni). For example, shoes could be printed to fit an exact foot size and shape. This is just one among many exciting applications of 3D printing.

Because 3D printing allows for infinite customization, a major application of 3D printing lies in the biomedical field. Everyone's body is different; each person would require unique specifications for a prosthetic or a dental implant. For this reason, the field of biotechnology has turned to 3D printing as the best way to mass produce products on a customizable basis (Sethi). Biomedical applications range from producing dental implants more cheaply and quickly to printing whole organs using polymer scaffolds that will eventually be transplanted into humans (Sethi). Although the customizability of 3D printing suits biomedical applications, many of the chemicals used in traditional 3D printing do not (Green). When limited to biologically friendly materials, problems such as unfavorable end-properties, slow print speed and distortion appear (Green). This is a major area where advances in chemical engineering would allow for the further expanse of 3D printing. The future of customizable biomedical devices depends heavily on advancements in the field of chemical engineering and material science. These advances have the potential to allow a wider variety of 3D printed devices to be created.

Advances in chemical engineering could allow for better end properties, cheaper production costs, and faster print speeds (Green). This will allow for parts to be made more customizable and cheaper, therefore making 3D printing available to a wider audience. The biomedical industry is heavily involved in the growth of 3D printing due its wide variety of applications ranging from dental implants

Prospects and Obstacles in 3D Printing (continued)

to whole organs (Sethi). The manufacturing industry is also involved with this technology because it has the ability to cut manufacturing costs and increase the customizability of any product (D'Aveni). Although 3D printing cannot currently compete with traditional manufacturing in terms of production scale, it makes up ground with its alteration friendly nature and will continue to grow as a manufacturing method with the help of chemical engineers.

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Biotechnology in the Future and Beyond

By Ankur Parupally

Biotechnology is a field that has seen a recent emergence in the world of science and engineering. The ideal blend between the two fields, biotechnology has a bright future, with new advances being made every day. Biotechnology is, "…technology based on biology - biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet (Biotechnology Innovation Organization, n.d.). Biotechnology impacts different areas, however, the medical, petroleum, and agricultural industries are the most affected and have the best potential to utilize biotechnology in future inventions. Biotechnology will be very important for the future as we face increasingly difficult problems that cannot be solved by traditional methods. This allows biotechnological solutions to bridge the gap between science and technology. Chemical Engineers will prove vital as they will need to use both their technical skills and scientific knowledge to come up with practical everyday solutions.

The healthcare industry is a perfect place to implement biotechnology for the future. One key way manner in which it can be utilized is personalized patient treatments. Every patient is unique, so a therapy based specifically on your genetic makeup and health habits could be very beneficial. A subfield in medical biotechnology is pharmacogenomics. This area targets how a patient will react to various medications (Amgen, n.d.). It would be an important development to get an understanding of any detrimental effects or a patient's response without the patient actually having to go through the pain. Similarly, recognizing the impact of a certain dosage and its potential effects before a patient takes the medication could save many lives. To analyze how a patient will be impacted by different medications their genome must be traced which requires a large amount of time and money. An alternative approach, utilizing biotechnology, was found by chemical engineers at the University of Colorado. These researchers use electronic and optical fingerprints to determine the sequence of molecules (University of Colorado Boulder, 2015). This would be a

Biotechnology in the Future and Beyond (continued)

significantly cheaper option for most of the population in comparison to the old and tried method of sequencing.

One of the most talked about ideas when people hear the word biotechnology is the fuel/petroleum industry. It is common to see that more efficient methods are being used to conserve fossil fuels, or even combine biological factors to make them more efficient. However, why not look at an alternative fuel source for the future all together. The use of algae as a biofuel is quite promising. It has the potential of being used as renewable diesel, gasoline, and even jet fuel (United States Department of Energy, n.d.). Algae function similarly to plants in that both convert sunlight into a useable form of energy. The difference is that the many different types of algae present unique properties that can be harnessed to develop new biofuel technologies that can be used to produce billions of gallons of gasoline each year (United States Department of Energy, n.d.). Chemical engineers are currently looking to establish the best way to utilize the most useful parts of the algae for fuel. For example, they are concentrating dilute biomass and recovering lipids as well as many other products. New production techniques for culturing algae are also being devised where biological precursors are released instead of feedstock. (Cornell Engineering, n.d). Using their knowledge of the industry, chemical engineers may soon be able to sell algae as a hot commodity.

Another future biotechnological impact can be seen in the agricultural industry. One of the more intriguing topics is drought resistant plants. As the name suggests, drought resistant plants have the ability to remain alive at times of very little rainfall. Scientists at Purdue University are attempting to control the ability of plants or crops to open their pores, which are used to regulate water intake (Purdue University, 2016). Researchers are looking to see if they can modify the genes that control these pores, to make the plants use water more efficiently. Many of the previously conceived ideas relied on irrigation after a large drought, but the researches have found a way around that, especially since many people cannot afford the luxury of irrigation. Their idea stems from the fact that the plant pores can be rapidly opened and closed to limit water loss. Essentially, the plants are protecting themselves (Purdue University, 2016). If the use of drought resistant plants becomes more widespread in the future, it could save famers a considerable amount of money during dry spells without forcing them to use expensive technology such as irrigation to save their crops.

Biotechnology has the potential to impact a wide variety of disciplines. As both science and engineering continue to grow at such a rapid rate, biotechnology will grow alongside them. Chemical engineers play an extremely vital role in the future of the field, especially when considering their ability to work between a lab setting and the commercial industry. Today, chemical engineers are mainly contributing by performing extensive lab work to synthesize new chemicals or devise alternative methods to long standing processes. From, analyzing genomes to investigating alternative fuel sources to tracking water loss in plants, chemical engineers have the potential to impact the field to a great degree.

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Future of Lithium-Ion Batteries

By Lee Lounsbury

It would be hard to imagine today's world without the innovation of the lithium-ion battery. Everyday devices and emerging technologies, from sleek smartphones to long-range electric vehicles, could simply not exist. Since the lithium-ion battery's introduction to consumer goods in the early 1990s, their use has steadily increased to almost include every device not requiring a power outlet. As consumers demand more powerful devices in greater quantity than ever before, further advances in lithium-ion technology are both necessary and imminent. Scientists and chemical engineers have had a tremendous impact on the lithium-ion battery's development and will greatly influence future innovations.

In order to better understand the future of lithium technology, it is worth briefly looking into the battery's history. Although the concept of the lithium-ion battery was first devised by the physicist John Goodenough, it was Yoshio Nishi, a chemical engineer at Sony, that brought the idea to life. The development of the lithium-ion battery offered a solid replacement for the commonly used nickel cadmium battery, which suffered from low energy density and contained toxic materials. While at first only placed in small consumer electronics such as home cameras and cassette players, it only took a few years for the lithium-ion battery to catch on and be included in larger devices such as laptop computers.[1] While other advances would come along such as nickel-metal hydride batteries, the power density of the lithium-ion continues to be unsurpassed.

As mobile devices become increasingly popular, and the combustion engine goes the way of the horse, demand for lithium-ion batteries will continue to increase at an astonishing rate. Currently, electric vehicles (EV) make up less than one-tenth of one percent of vehicles sold, yet their sales skyrocketed 60% worldwide in 2015, similar to the growth figure of the Ford Model T in the early 1900s. Bloomberg expects electric vehicles to reach 35% of new vehicle sales as soon as 2040.[2] Challenges with lithium-ion batteries do still exist, but scientists and engineers are making exciting breakthroughs.

One of the largest challenges with the lithium-ion battery is the rate of charging. While slow charging batteries may frustrate mobile device users, they have a crippling effect on EV sales. For example, when taking a long road trip, it is not practical for EV owners to pull off every few hundred miles and charge their battery for over an hour. Currently, rapidly charging lithium-ion batteries lead to various problems, from the rapid decrease in battery capacity over time[3] to issues of user safety caused from overheating. However, Professor Xiaodong Chen and his group of researchers think they may have solved these problems by switching the anode, the positive side of a battery, to a gel containing titanium dioxide nanotubes, an ultra-strong and thus reliable substance. By ditching the weaker graphene anodes now used in batteries, which can expand and contract when quickly charging, the team was able to create a battery which could reach a 70% charge in only two minutes. Duration tests showed further benefits where the new stronger battery was able to hold performance over ten times the charge/discharge cycles of today's batteries. Chen is now attempting to license the technology and believes mass production possible within the next couple of years.[4]

Another challenge comes in supplying enough lithium for a rising demand in batteries without creating environmentally toxic waste. While the lithium used in most batteries is almost 100% recyclable, currently it is much cheaper to mine new lithium than re-use the old. Being dependent on mined lithium puts strain on the environment and places lithium prices at the mercy of the political stability of the few nations from which lithium is mined, such as Argentina and Bolivia. While partnerships are underway to secure lithium deposits in the foreseeable future, the long-term success of the lithium-ion battery demands recycling plans be set in place. Small-scale operations do currently exist, but high costs prevent large scale operations.[5] It will be up to scientists and engineers of the future to develop cheaper and more efficient methods of recycling lithium-ion batteries.

Future of Lithium-Ion Batteries (continued)

Even though lithium-ion batteries are currently unsurpassed in power density there is still room for innovation. Lithium-ion power density has certainly increased in recent times, doubling from 1995 to 2007,[6] a rate many are seeking to improve. For one team of chemical engineers at Cornell University led by Professor Lynden Archer, the answer to greater power density may lie in using lithium metal batteries instead of lithium-ion. Currently, this style of battery is feasible, but the operation must occur at 600-800 degrees Fahrenheit, an operating temperature unachievable in mobile electronics and vehicles. By using stronger materials, such as nanotechnology and polymers, it is possible to create a membrane that allows stable performance at room temperature. While this research requires further progress, it provides insight into how developments in the fields of chemical engineering will improve future battery capacity.[7]

By looking at the history of lithium technology, the challenges it faces, and how lithium-ion batteries will change in the years ahead, one can see the enormous impact scientists and chemical engineers have had and will have innovating battery technology. Since the lithium-ion battery's introduction in the 1990s, innovation has proceeded at an astonishing rate. With advances to debut soon, it will be exciting to see how the future of battery technology will change individual's lives for the better.

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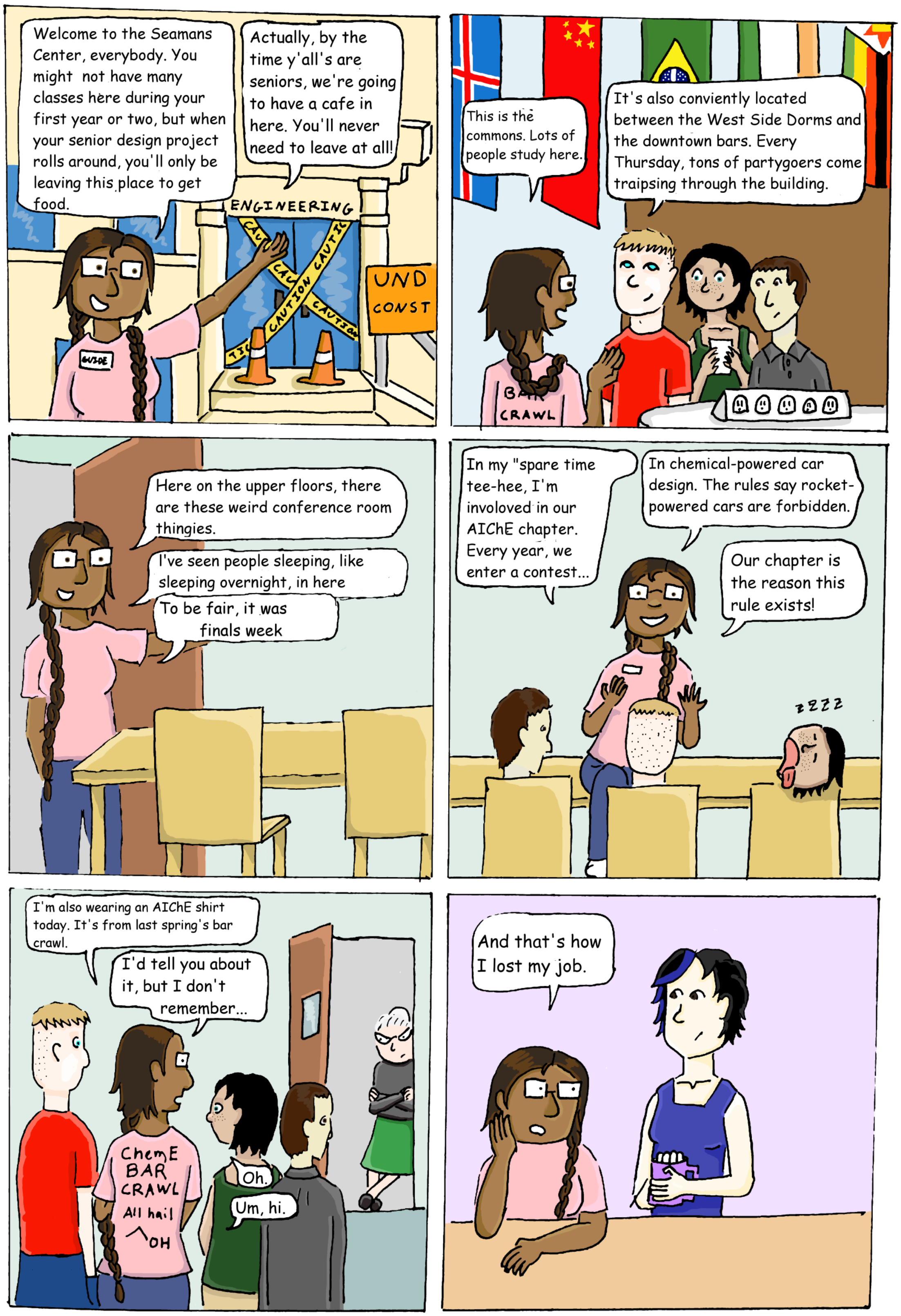
Chemical Engineering Funnies

By: Corinne Andresen



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Your help is much appreciated!

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

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