VOL 05| ISSUE 03

# CHEMUNIQUE

From the IIChE Student Chapter

## Inside this issue

Chemical GPS,

Microfluidics,

Catalysis,

Chemistry of crime,

And much more!

# Message from the Associate Dean

Dear All,

It gives me immense pleasure in releasing *'ChemUnique Volume 05 Issue 03'*. The Chemical Engineering department of SASTRA University has been growing tremendously for the past 20 years. It has boosted its outreach to a commendable position in all dimensions. The department has reoriented its syllabus according to current industrial practices. Courses like ASPEN Plus have been included to nurture the significance of process engineering among undergraduates. The number of companies approaching SASTRA in search of Process Engineers has increased manifold. Advancement of research facilities in the department of Chemical Engineering has been helpful in inculcating an essence of research and development. The compilation of books in the department library has been progressing exponentially. My advice to you would be to make the best possible use of the facilities provided here to update yourself and stay ahead in the game. Nevertheless, we are striving to develop new strategies across the department and each of which involves renewed engagement and collaboration with our largest and most diverse assets: our students and faculties.

Thanking you,

R. Kumaresan,
Associate Dean,
School of Chemical and Biotechnology,
SASTRA University

# From the Editor's Desk

*"The noblest pleasure is the joy of understanding"*

*-Leonardo da Vinci*

ChemUnique magazine at the Department of Chemical Engineering has a unique mandate of initiating beyond-the-book learning. In a discipline such as Chemical Engineering, which reaches far and wide into every realm of science and technology, the magazine's function becomes immediately clear – no course structure can truly help us realise the immenseness of our discipline's applications. And true to its function, it has been prodding students to explore concepts and applications of Chemical Engineering where none are apparent.

In releasing ChemUnique Volume 05 Issue 03, we thank the support of our Associate Dean, faculty members and the IIChE Student Chapter. We hope that this issue kindles your passion for Chemical Engineering and learning alike.

Read on and relish!

**Team ChemUnique**

Akash Raman, Editor-in-chief

Athul Seshadri R., Editor

Porvajja N., Editor

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# Tiny tubes

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One of my professors asked in class one day, “What is the most common equipment in the chemical industry?” The class came up with several answers but we had missed one critical and yet much overlooked part of any process plant – pipes. Pipes are ubiquitous in our field of work.

Scale-up is a word that one often hears in process engineering circles. Scaling up, as the name suggests, is the process of increasing the dimensions of an equipment or increasing the capacity of a process while simultaneously accounting for new disturbances or non-idealities that arise due to the increase.

Scaling up makes makes a lot of sense to a chemical engineer – after all, increasing production and maximising profit is one of our key roles in the industry. But surprisingly, scaling down seems to be a major research focus these days! Microfluidics is the buzzword in labs around the world, as scientists and engineers develop devices that represent a paradigm shift in the way we look at a variety of existing technological solutions.

Microfluidics refers to flow of fluids through devices with channels whose diameters are in the range of micrometers. We know that the nature of flow of a fluid is dictated by the Reynold's number and when we reduce the hydraulic diameter of a pipe, the Reynold's number drops. In fact, in most microfluidic devices, the Reynold's number lies below 100. This means that flow is very highly laminar.

It turns out that scaling down can help us scale up – paradoxical and yet profound. If we consider two fundamental equations of heat transfer: and keep in mind that for microchannel devices, the value of d is very low while the area per unit volume of equipment is high, we can see that heat transfer is very high. Stacked printed microchannel devices offer two prodigious advantages: the volume occupied is small and the fabrication is much less complex compared to conventional equipment.

In the pharmaceutical sector, microreactors have been successfully employed in commercial applications. A Dutch company, DSM has been using stacked microreactors in the production of naproxcinod. Other major companies have concurred that microreactors can be used to produce high-quality products safely, economically and with minimal environmental impact. It has been estimated that the microfluidics market will be a 9 billion dollar industry by 2021.

Another product of the microfluidics industry is 'lab-on-a-chip'. Lab-on-a-chip refers to any chip that performs chemical or biological analyses. Such analyses often require test tubes, pipettes other glassware or specialised equipment. However, a lab-on-a-chip system does the same job in a more efficient, rapid and accurate manner. Chips have been designed to replace thermal cyclers for the Polymerase Chain Reaction, to conduct RNA and DNA sequencing, a multitude of biochemical assays and protein crystallisation.

Several questions and challenges remain inadequately addressed in microfluidics at present. However, it is evident that this emerging field is going to revolutionize established methods in both the process industry and research laboratories.

# Chemical GPS

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Its New Year 2k17 and many of us will be travelling to malls, beaches and temples with family and friends. Some may even embark on a "Journey to The Mysterious Island" or set off in search of a lost ark. It is very possible that one may eventually get lost along the way. This is where GPS comes into picture.

Many of us use that facility through our phones and one may even think like 007 and try to embed a nanochip which has ability to transmit waves using radio frequencies normally allocated to GSM cellular networks or implant microchip which is a RFID transponder. Anyway, the purpose is to just find the location.

Most of us know that GPS stands for Global Positioning System which is a series of navigation satellites launched by the USA to determine the precise position of the receiver. Hence to identify locations, we can rely on a map like a treasure hunter or a compass like the Captain Jack Sparrow or a GPS with a robotic, misanthropic, monotonic & sullen voice to tell us where to go as discussed earlier.

But have you ever wondered how birds migrate? They fly thousands of miles, often to very specific locations for food – from the poles to more temperate lands and back. How do they know location? Is it based on wind direction or by the blooming state of *Calico aster*?

Actually, it's all about quantum mechanics and basic chemistry! We know about how electrons share shells when revolving around the nucleus. They have a magnetic moment satisfying the Pauli's Exclusion Principle – two electrons sharing same orbit must have opposite spins. We also know that earth acts as a giant bar magnet and generates a magnetic field.

Migrating birds have a chemical compounds like cryptochrome molecule with some magnetic elements in their retina which are connected to the optical nerve system. When light is incident on such entangled electrons of the atom inside these molecule, these electrons absorb those energy and get excited and thereby get separated. The earth's magnetic field tries to alter the spin of such excited electrons. So if the spin isn't varied due to magnetic field, they are still in entanglement and try to reunite by emitting the absorbed energy on reaching ground state. This emitted energy stimulates the nerve system in the bird's eye.

Hence birds are constantly getting stimulated signals through magnetic field lines. So they never ever get lost. Hence don't try to cage them, they are meant to fly by nature!

# A Chemical Glass on Forensics

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Crime investigation TV shows, more specifically CID shows, expose many unprecedented and gruesome crimes committed by not-so-stable people and try to make justice the sole winner at the end of the day. This is achieved by the work of a multitude of chemists, biologists, witnesses and cops using various technologies and science advancements.

Picture a crime scene. A murder in XYZs family. The suspects are the victim's own relatives. An angry mob is enveloping the house. The tension and anxiety in the air is palpable. Media and news reporters are eager to extract information. There are blood stains on the floor and gun powder residue tarnishing the hands of one of the suspects. How do we determine when and by whom the crime was committed? Can law and order banish the real culprits behind the bars?

And that's where the contribution of chemists makes a notable difference. Blood samples collected at the crime scene are subjected to a chromatography test. This test separates the blood sample into its constituents. The levels of these constituents are noted and possible assumptions are made to gauge the motives behind the suspect's actions. For example, if the blood contained a high level of alcohol, intoxication might have driven the way for murder.

Short Tandem Repeats (STR) analysis is employed by chemists to compare the suspect's DNA with the body cells, such as skin cells, hair, blood and semen found at the victim's place. If they match, the suspect will be convicted for the crime.

Forensic chemists can detect if an accelerant such as gasoline or kerosene was used during fire investigations. If they confirm its usage, it denotes that the fire was set intentionally. They can also narrow down the suspect list to people who would have had the access to the substance used in a crime. In explosive investigations, the identification of RDX or C-4 indicates a military connection as those substances are military grade explosives. Based on this, further investigations can be carried out to capture the actual wrongdoers.

Information regarding the type of firearm used and the amount of time surpassed since the firing of the bullet can also be found by performing a chemical analysis of the bullet. Infrared lights are used to look for gunpowder residue. If this residue matches that of the bullet found in the victim, there is evidence that the suspect recently fired the same type of firearm responsible for harming the victim.

Prospects for becoming a forensic chemist are high. If your suspicious and cautious nature has been criticized in the past, it is now your time to nurture it for the best by honing your smart detective skills and satisfying your passion towards chemistry!

# CRE in sustainable development

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"Ownership is a sine qua non of sustainable development."

As chemical engineers, it is one of our responsibilities to find new paths for sustainable development without impairing the lifestyle of future generations. We must adopt the most efficient and eco-friendly ways of using raw materials and energy for producing newer materials, chemicals and pharmaceuticals. Advancement in chemical reaction engineering is the key element required to uncover such eco-friendly and sustainable processes.

Current chemical processes depend heavily on fossil-based raw materials which are unsustainable on the long run. Our current focus must be on identifying new ways to employ renewable raw materials and minimising pollution at the source than at the tail and here's how chemical reaction engineering takes the lead.

Using environmentally benign raw materials has a huge impact on pollution control and thus enhancing sustainability. For a given process, atom and mass economies are a measure of how efficiently the raw materials are used, which is a deciding factor in the selection of raw materials. For example, the following are two reaction routes to produce maleic anhydride.

Benzene route: $2C_6H_6 + 9O_2 \rightarrow 2C_4H_2O_3 + H_2O + 4CO_2$ with $V_2O_5$ and $MoO_3$ as catalyst.

n-butane route: $C_4H_{10} + 3.5O_2 \rightarrow C_4H_2O_3 + 4H_2O$ with $(VO)_5P_2O_5$ as catalyst.

In the n-butane route, there are four carbon atoms in n-butane and four carbon atoms in maleic anhydride (the product) giving 100% atom efficiency. We need 1 mole of n-butane and 3.5 moles of oxygen to form one mole of maleic anhydride, thus the total mass of raw materials needed is 58+(3.5*32) = 170g. Therefore, the mass efficiency of the n-butane route is (98/170)*100 = 57.6%. Similarly, the atom efficiency and the mass efficiency of the benzene route are found to be 66.7% and 44.4% respectively.

Catalysts are being extensively used in chemical and process industries; hence selecting the right catalyst is necessary to ensure process and environmental safety. Catalysts which are chosen must be environmentally beneficial and economically viable. For example, acids such as $H_2SO_4$ and HF, which are used as catalysts in petrochemical industries, foist a significant environmental hazard due to their toxicity and corrosiveness. These catalysts are now being replaced by solid-acid catalysts.

Upon selection, the physical properties of catalysts have to be tailored to get optimum yield and selectivity. Properties like surface topology and adsorption can be studied using experimental methods like NMR spectroscopy and advanced microscopy. Also, simulation models of pore structure are used to study the transport behaviour of catalysts.

New technologies must be developed which prevent or minimise pollution. In order to develop such technologies, a quantitative understanding of reaction systems and transport properties is fundamental. The combination of chemical reaction engineering with the principles of green processing holds the key to a sustainable future.

# The Breakthrough Energy Coalition

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Let us pause for a brief moment and sit back to look at the fleeting world. Doesn't the rapid depletion of fossil fuel reserve shock you? Conventional energy resources are depleting in an exponential rate and we have done nothing about it. As chemical engineers, we have the moral obligation to make the world a better place to live in.

Your cerebrum must have shouted out 'sustainable development' when I posted the above question. Its high time to focus on the 'How' question rather than the 'What' question. Yes! We know that sustainable development is the key to a better future. But the million dollar question is how?

Bill Gates seems to have the answer to it. He has recently funded about one billion dollars for the cause of finding better energy techniques. The Breakthrough Energy Coalition is the brainchild of Bill Gates that seeks to eliminate our dependency on the carbon containing fossil fuels.

Experts posit that by the middle of this century, nations and corporations all over the world will use twice the amount we use today, most of which will be used by places which have no access to power today.

Growth is required, but not at the cost of our welfare of our next generation. Hence, the Breakthrough Energy Coalition proposes to substitute conventional methods of energy with environment friendly non-conventional sources of energy.

Some of the initiatives they have in hand are as follows,

- Next Generation Nuclear Fission: Nuclear Power is the key to the future. The pro-nuke nations are for it. It's up, working and already constitutes 10% of total energy production. With Breakthrough Energy Coalition, comes the opportunity to expand the nuclear power production.
- Enhanced Geothermal Systems: Carbon footprint can be considerably reduced if we resort to Geothermal energy. With the Enhanced Geothermal Systems of the Breakthrough Energy Coalition, we will be able to do that. With slight modification to overcome challenges like high deep drilling costs, forming and controlling complex fracture networks for water and heat flow, and efficiently converting low temperature heat into electricity.

- Ultra Low Cost Wind and Solar Power: The age old method will be altered to maximize the electricity harness rate from Wind and Solar power. The methods to be developed are expected to be of state of the art.
- $CO_2$ Capture: $CO_2$ capture is the process of removing carbon dioxide from the exhaust gases let out by the industries so that they can be converted into some useful products. This is done by a thermally generated amine based process. However, this process is very expensive and hence the Breakthrough Energy Coalition proposes to develop a much economically viable method for $CO_2$ capture.

On viewing from another vantage point, this has opened up plenty of entrepreneurship opportunities that promises profitable returns as well as betterment of the neighborhood. To sum up, energy is the need of the hour and The Breakthrough Energy Coalition is the key to the sustainable development in the future.

# Black eggs mushrooms one's life span

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Are you surprised? Intrigued? To be honest, so was I. Well, any nutritious grub in general keeps you healthy and fights against all the micro-level assassinators. But the question which immediately arises in every individual's head is, What are black eggs?".

Call it an interesting geographical piece of information. It's all about the region that lies nearby one of the greatest mountains in the world, Mt. Fuji. Earlier known as the Owakudani, it is now globally recognized as Great boiling valley or Great hell. These eggs are nothing different from the regular chicken eggs per se. The uniqueness that it holds is in the methodology of boiling these eggs. The egg boiling locale lies inside the crater of the volcanic mount Kamiyama. The eggs are boiled at a temperature of 80°C for almost an hour in spring water. Later, they are steamed at 100°C in baskets made of steel. Being in the volcanic circle, the water contains abundant sulphur and a little amount of iron.

Aren't you puzzled yet? What's unique in the methodology? This is a gigantesque data to digest and so I leaped into deciphering it.

Any clue what it could be? This might surprise you all again. The spring water is the secret behind its uniqueness. Water is the main constituent of Earth's composition. Groundwater that flows out of the earth's surface due to the natural pressure underneath transpires springs. It typically occurs along hillsides, or at the base of slopes. Spring water contains ample amount of health restoring minerals like lithium, calcium and magnesium.

Additionally, the spring contains a great deal of sulphur which has a therapeutic effect on skin diseases and infections like dermatitis and psoriasis. The sulphur hot springs are way too healthy.

Sulphur is a part of the chemical structure of three amino acids, namely cysteine, methionine and threonine. It works with vitamins to promote metabolism and communication between nerve cells. This mineral has great beneficial health effects. Primarily it is used to ease the itchy irritating skin diseases and is also shown to lower cholesterol and blood pressure. Secondly, sulphur water avouches to lessen digestive disorders like acid reflux and premenstrual issues. Furthermore, inhaling high mineral rich content water can treat respiratory problems like asthma, sinus and helps in clearing mucus from the lungs.

The surprising fact is that this spring water helps in balancing our skin tone. It is due to the pH of the mineral water which is close to that of our skin's pH. It helps in controlling the growth of acne-causing bacteria and prevents wrinkles and saggy skin, making us look young. This water can replace pricey skin-care and anti-acne products on a large scale. That's why it is called as "Nature's beauty mineral". Besides, it is very effective against insect bites, burns and poison ivy.

An interesting fact for every nature lover is the alluring colour of the water. The explanation behind it is a chemical reaction between the water containing calcium carbonate and sulphur, which gives it the spectacular shade of blue.

Looking at the benefits of iron in the spring water, it builds up the quality of our blood, prevents stress and fatigue, and improves skin tone. Moreover, it builds resistance to disease and aids in muscle functioning.

Higher sulphur intake lowers the rate of heart diseases, obesity and increases longevity on the planet. Whoa! No wonder why these black eggs mushrooms one's life span.

Who would say no to prolong their lifespan on this mysterious and marvelling planet? Go to Great hell and quench the longevity thirst. So ironical, ain't it?

# Atlas of Education: VIII

Team ChemUnique

## University of Queensland

The University has over 50,000 students including 12,000 international students from across 141 nations. The University has produced some remarkable talents, noticeably, a Nobel laureate, two Fortune 500 company CEOs and an Academy Award winner. It was ranked 60 in the Times Higher Education World University Rankings and 55 in the Academic Ranking of World Universities.

**World Ranking:** 25 in Chemical Engineering

**Courses Offered:**

*M.Sc in Petroleum Engineering:* It is a one and a half year full time or a part time equivalent course which is offered by the University on collaboration with the Institute of Petroleum Engineering (IPE) at Heriot-Watt University. The program includes lectures and project work

with a wide range of petroleum engineering fundamentals relevant to the modern petroleum industry and Australia's gas industry.


*Master of Energy Studies (MES):* This course was introduced to equip students to overcome the challenges faced by the global energy sector and to develop alternate pathways for reliable and sustainable energy. It is a one and a half year full time course comprising of 24 credits.

*Master of Integrated Water Management (MIWM):* Being a one and half year full time course, this program aims to create future leaders who are well equipped to deal with planning, management and implementation of solutions to international water challenges.

*Master of Engineering Science (MEngSc):* It is a 3-semester full-time enrolment course. A one year course is offered to students who have a four-year degree in the same field. Students in this program are taught by internationally recognised faculty, who are leading experts in their fields, using state-of-the-art facilities.

*Master of Engineering Science (Management) (MEngSc(Man)):* It is a two year full time enrolment program comprising of 32 credits. It combines selected engineering disciplines with studies in selected areas of business.

**Entry Requirements:** To enrol for the above courses, the applicants must have an undergraduate degree relevant to their field of study. A minimum score of 6.5 in IELTS or its equivalent scores in TOEFL or PTE is necessary.

**Tuition Fees:** INR 17,37,000 per annum

**Estimated Living Expenses:** INR 8,64,500 to 12,88,000 per annum

**Scholarships:**

There are more than 10 and odd scholarships available to the students at the University of Queensland. Major scholarships include,

- Endeavour Scholarships and Fellowships, which are merit based scholarships bestowed by the Australian government to support students from Asia-Pacific, the Middle East, Europe and America.
- Zonta Advancement Grant is awarded for women to assist them with the costs of going to the university.

**Climate:** Queensland experiences hot summers and warm winters. It has an average daily temperature ranging from 20 to 28 degrees Celsius.

**Key Areas of Research:** With more than 60 full-time researchers in diverse fields of engineering, the University of Queensland has more than 930 publications since 2008. Their key centres for interdisciplinary researches include, Centre for Coal Steam Gas, Dow Centre for Sustainable Engineering Innovation, Rio Tinto Alumina Centre for Alumina Processing, The Baosteel-Australia Joint Research and Development Centre, Remondis Centre for Solid Waste Bioprocessing, Nanomaterials Centre.

## University of New South Wales

With over 50,000-plus students from over 128 countries, the University of New South Wales is one of Australia's most cosmopolitan universities. The main campus of UNSW is located on a sprawling 38 hectare area at Kensington, seven kilometres from the centre of Sydney. UNSW has a proud and versatile tradition of students, focusing on areas critical challenges for a sustainable future.

**World Ranking:** 33 in Chemical Engineering

**Courses Offered:**

*Master of Engineering Science (Chemical Process Engineering):* This is a two year full-time enrolment program with a total number of credits being 96. It has a total of 16 courses with 4 disciplinary courses, 5 advanced disciplinary courses, 3 research courses and 4 elective courses.

*Master of Engineering Science (Food Process Engineering):* The credit-wise structure of this program is same as any other M.Sc program in the University of New South Wales. This program is designed mainly for students who want to specialize in food process engineering.

*Master of Food Science:* This program aims to provide students with more science based perspective on food science. This program also has a total of 96 credits with 6 professional development courses, 5 specialization elective courses, 2 engineering and technical management courses, 1 design course and 2 research project courses.

**Entry Requirements:** Applicants must have an overall IELTS score of 6.5 with minimum score of 6.0 in each subset or its equivalent in other tests such as TOEFL and PTE.

**Tuition Fees:** INR 20,52,000 per annum

**Cost of Living:** INR 12,18,000 per academic year

**Scholarships:** There are a number of scholarships offered by the University of New South Wales for international students.

- UNSW Canberra PhD Scholarship for India is awarded to eligible PhD applicants, worth 10,000 AUD. 5000 AUD is given on the commencement of study and the rest is given after their PhD candidature is confirmed.
- International Postgraduate Research Scholarship is a 25,000 AUD tuition fee waiver. Applicants are also provided with stipend that matches the Australian Postgraduate Award rate.

**Climate:** New South Wales is a subtropical coastal region of Australia. Its eastern parts experience a temperate weather while central and southern parts are slightly cooler. It has well-defined seasons with hot summers and cold winters.

**Key Areas of Research:** As one of Australia's leading medical research centres, faculties in UNSW hold the big data in the field of medicine. The Centre for Big Data Research in Health (CBDRH) operates as the core of big data research across UNSW medicine. The city's future research centre at UNSW is the national leader in urban development. This research centre on collaboration with various academia's across Australia, works on urban planning, housing, health, design and social policies.

# In Focus

Team ChemUnique

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**1. What was your path after undergrad at SASTRA University?**
I worked for two years after which I joined a varsity in Finland, the Aalto University that specialises in renewable and nonrenewable resources. I pursued a research oriented Post Graduation that was almost free of cost. It had lesser theory based content and gave an international feel. I took a paid internship and landed myself in a job. Graduation holdups can extend your visa and helps you to get a job.

**2. How is life in Finland?**
The weather is a bit extreme and it takes some getting used to the fact that the sun never sets for half the year and never rises in the other half. The dark winters could get a bit depressing for people from tropical regions. Finns are very private people and you are often left in your own company. Eating out is not much of an option, I usually cooked my own meals. I learnt basic Finnish but most people understand and speak English, so communication is not a barrier. However, language could play a role in landing jobs there.

**3. Is it easy to find jobs there?**
Finding jobs is challenging everywhere. The usual way to land a job in Finland is to intern at a company and then it automatically leads to a job offer if your employers are satisfied. There is no 'recommendation' culture there but professors may help you out personally. There are career fairs held at the university where you can interact with representatives from various companies.
A Finnish visa can't be extended to search for a job there. Since the visa is valid till your MS ends, you can extend it by a few months in the premise of doing a project and you can use this extension to seek jobs.

**4. Which universities would you recommend for an MS abroad?**
KTH Royal Institute of Technology in Sweden is really good for a research-oriented PG. Germany is a great option but recent security crises there may force you to reconsider your

decision. Netherlands offers quality education but is more expensive than the rest. Personally, I feel expenses can be covered with a bit of frugality.
We must note that Indian students are often at a disadvantage because students abroad accrue much industrial experience even during their Bachelor's in the form of internships. Therefore, it is often desirable to work in a core company for two years before an MS.

**5. Would you recommend an M. Tech over an MS degree?**
It is a matter of personal preference and financial condition. Obviously an MS is more expensive but most programmes abroad are research-oriented. Often, there is very little theory content. The international experience is also a great plus.

**6. We heard your grades never dropped for four straight semesters. What's the secret?**
My fourth semester was absolutely disastrous. I was distraught with my performance. At that time I was afraid I would not even be able to get an IT job. It was Naren sir who motivated me to not study for marks but to study for learning's sake. I believe that was the key to getting better grades. Looking back now, I realise that grades weren't critical but yes, they are still important.

**7. Could you share your experience of working in a design company?**
I worked for Saipem India Projects Ltd, Nungambakkam, India. It was an off-campus interview. The wait for the results took donkey’s years. Ten other people joined the company along with me. I worked on a coal bed project for Reliance and other pipelining works. It helped me gain great insight into the software used in the industry.

**8. What pointers would you like to give to your juniors?**
Learning software like CAD and ASPEN put us ahead of the pack in the race. Even knowing just the basics might do. If you are aiming to work at a design company, keep your fluid mechanics at your fingertips. An updated LinkedIn profile is vital and plays a crucial role in connecting you with people in your domain. There are a good number of design consultancies these days so opportunities are very much available. When you apply for off-campus jobs, make sure that you not only e-mail but also call to inquire about your status.

# ChemToons

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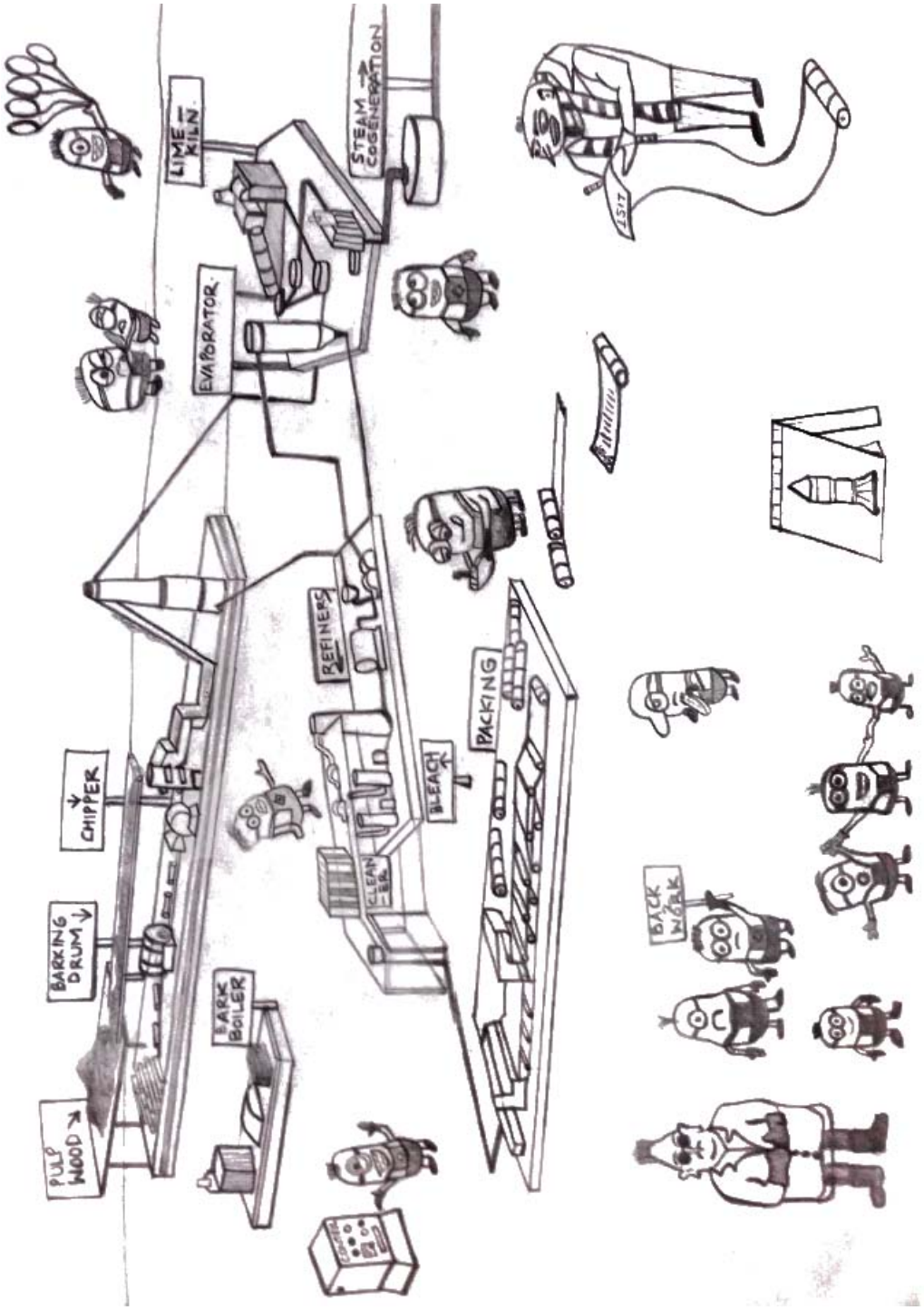

# ChemUnity Speaks

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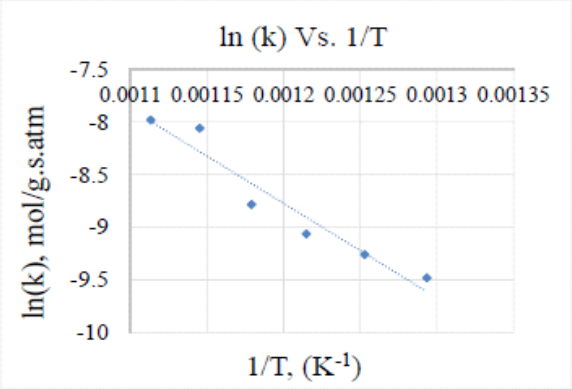
## Real-Life Illustration to Catalytic Gas-Solid Reaction

With an upsurge of modeling industrial processes in the chemical engineering community, gas-solid reactions are gaining enormous attraction towards capturing the thermodynamic and kinetic nature. In this context, dehydrogenation of gas streams in a petroleum refinery are critical, and one such interpretation is the propane dehydrogenation to propylene. With a huge demand for manufacturing of polymers, chemicals and fuels such as polypropylene, polyacrylonitrile, cumene etc., propylene is a major feedstock. Although various technologies for propane dehydrogenation have been commercialized, interest to gain higher propylene selectivity by satisfying the thermodynamic constraints makes it a topic of research.

Generally speaking, dehydrogenation reactions are highly endothermic and equilibrium limited which enhances in the presence of catalyst. Kinetic study of oxygen-free propane dehydrogenation over $Cr_2O_3/SiO_2$ – $Al_2O_3$/K/Zr catalyst was performed in a fixed bed Microactivity Testing reactor under atmospheric pressure. The reaction temperature was varied between 500 and 625 $^oC$ with WHSV (Weight Hourly Space Velocity) between 0.4 and 2 $h^{-1.}$ A plausible reaction mechanism for propane dehydrogenation was proposed.

$$r_S = \frac{k(P_{C_3H_8} - \frac{P_{C_3H_6}P_{H_2}}{K_{eq}})}{1 + P_{C_3H_6}K_{ad}} \quad (1)$$

Figure 1: Arrhenius plot




Different models based on Langmuir-Hinshelwood-Hougen-Watson reaction mechanisms were tested to correlate the kinetic data. Among these models, the one postulating that the surface dehydrogenation reaction of adsorbed propane is rate-limiting was successful in terms of physical likeness (kinetic parameters estimated by multi-variable least square regression technique). Convinced about the statistical goodness of fit, the activation energy and adsorption enthalpy were evaluated using the Arrhenius and vant-Ho relationships. A high correlation coefficient value of $R^2$ = 0.94 was obtained. The activation energy ($E_a$) and frequency factor ($k_o$) were calculated to be 74.6 kJ/mol and 0.0073 kmol/g.s.atm, which was superior to the literature reported activation energy of ~100 kJ/mol.

Notations: $r_s$ - Rate of Surface Reaction, $P_i$ - Partial Pressure of component 'i', $K_{eq}$ - Thermodynamic Equilibrium Constant, $K_{ad}$ - Adsorption Equilibrium Constant, k - Kinetic Rate Constant, T - Temperature

# PoChéMoN

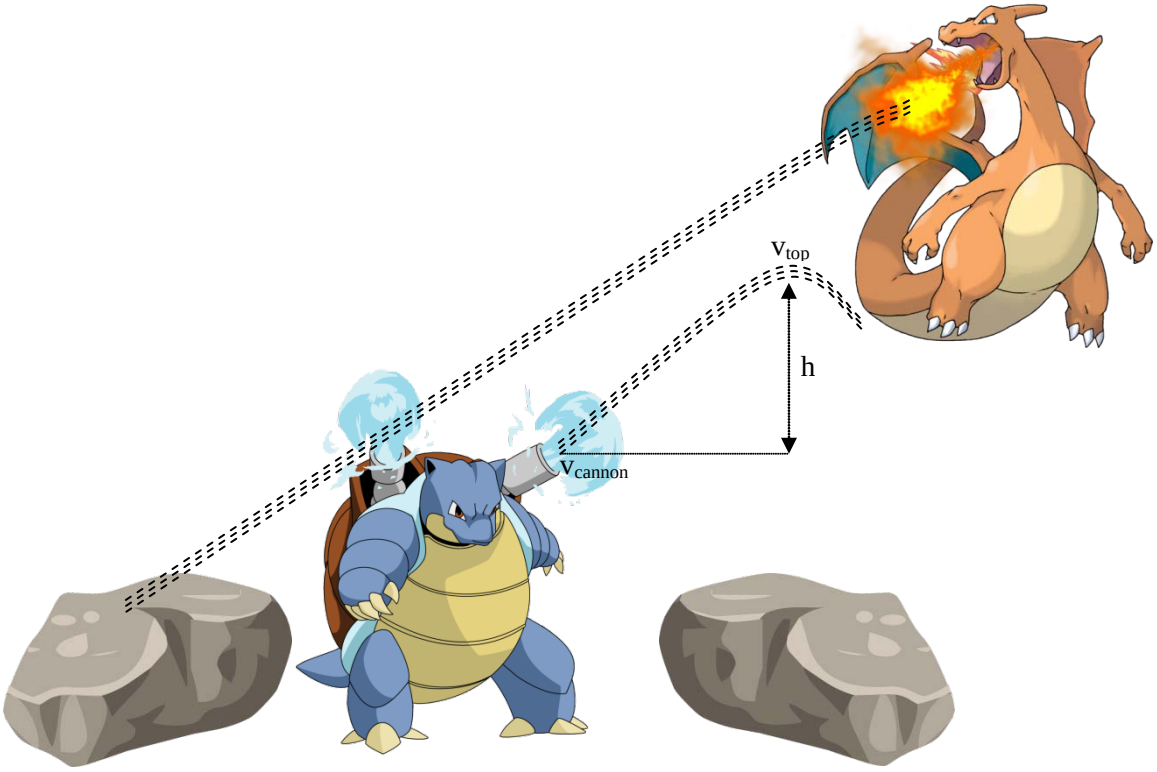
Kishor K., IV year Chemical Engineering

"Our hero, Ash is about to take on his long time rival, Gary in the middle of his six-on-six match on a rock field of the championship tournament at the Johto League Silver Conference. And now Ash down to one Pokémon, Gary still has 2 Pokémon in his arsenal (Scizor and an unrevealed Pokémon). What will Ash's last Pokémon be?"

**Pikachu:** Pika... Pi... Pikachu.
**Ash:** Hey Pikachu, what is it?
**Brock:** Ash, I think it's asking if it can battle.
**Ash:** I wish I could Pikachu. But I'm only allowed to use the Pokémon I registered before the match.
**Pikachu:** Pika?!
**Ash:** It's time Charizard, let's go!
**Gary:** Yeah, I'd figured this much earlier. Scizor, now use Steel Wing!
*(Scizor lunges toward Charizard with Steel Wing)*
**Ash:** Charizard, use Flamethrower!
**Gary:** Dodge it!!
*(Scizor jumps to avoid the attack)*
**Ash:** No way!
*(Charizard meets Scizor airborne and is knocked out by a super-effective Flamethrower to the face)*
**Gary:** What?
**Battle Referee:** That Flamethrower hits Scizor at a very close range. Scizor is unable to battle. Charizard wins!
**Misty:** Charizard! Awesome!!
**Brock:** Way to go Charizard!
**Ash:** How's that? Pretty powerful, huh?
**Gary:** You've gone this far Ash? Blastoise go!
**Misty:** Oh! It's final evolution of that Squirtle!
**Prof. Ivy:** And it's a water type Pokémon. So what Ash is gonna do?
**Brock:** I was wondering what you're doing afterward! *(gets dragged away by Misty)*
**Who's that Pokémon?**
This Pokémon's leaf-like growths around its neck have a healing aroma! Read till end for answers.
**Battle Referee:** Ladies and gentlemen the last battle is about to begin. Finally Gary reveals his Pokémon and Ash will be staying with Charizard. Based on type Blastoise has the advantage. But only time will tell.
**Ash:** Advantage? Who cares? We've made it this far and we are going all the way. Charizard, Flamethrower!
**Gary:** Blastoise! Rapid Spin, now!!
*(Charizard's opening Flamethrower is deflected by Rapid Spin)*
**Gary:** Blastoise, Hydro Pump!
*(Hydro Pump makes a direct hit on its face and this is a problem for Charizard)*
**Prof. Oak:** That was the most powerful Hydro Pump I've ever seen!
**Mrs. Ketchum:** *(holding a camera)* Oh no! Looks like I've missed another great shot.

**Ash:** Alright Charizard, get behind Blastoise now!
**Gary:** Skull Bash, now!
*(Charizard's airborne attack is repelled by a Skull Bash and Charizard's Flamethrower attacks are pretty much worthless at this point)*

**Ash:** Charizard! Hang in there!!
**Gary:** C'mon Ash. Fire attacks aren't very effective against water types...
*(Ash desperately looks for some way. He suddenly notices that although Charizard's attacks have missed Blastoise the fire that has hit the rocks have been left red hot)*
**It's Question Time!**
Two free jets of water are being blasted under great pressure from Blastoise's Hydro Cannon with a speed of $v_{cannon}$ equal to 30 m/s. Can you deduce the speed of jet at top i.e., $v_{top}$ with which one of the jets would've stricken Charizard flying at a height of h equal to 20 m? Also Charizard's Flamethrower has hit one of the rocks and has turned into red hot. Can you guess which side of rock (top / side / bottom) will have higher heat transfer coefficient (h). It is to be noted in the battlefield, heat transfer to the ambient air is primarily by natural convection. Read till end for answers.




**Ash:** That's it! If we can't hit Blastoise we can hit everything else. Charizard, use Flamethrower and burn battlefield!!
**Gary:** *(puzzled by Ash's tactic)* What's Ash's idea this time?
**Misty:** I can't figure out what Ash is doing...
**Brock:** Hmm...
**Ash:** Way to go Charizard. Keep up the Flamethrower!
**Battle Referee:** What kind of crazy, I mean, what a novel and unique strategy. Charizard's Flamethrower attacks are melting the field leaving completely immobilized Blastoise with nowhere to run.
**Gary:** Use Hydro Pump to cool the field down.
*(Blastoise only succeeds in covering the field with a big layer of steam. As the steam clears, Blastoise and Charizard have locked up in close range hand-to-hand combat)*
**Gary:** Charizard is too close. Blastoise can't aim properly now.

**Ash:** Use Dragon Rage!
**Gary:** Dodge it! Quick!!
*(Blastoise ducks out a typical dragon type attack! Charizard lifts Blastoise up in the air)*
**Who's that Pokémon?**
*It's Bayleef!*
**Gary:** Bite attack, Blastoise! Go!
**Ash:** Ah! Charizard don't give up. Seismic Toss with everything you got.
*(Blastoise tries to escape by biting Charizard's arm but couldn't. The attack continues and once Charizard and Blastoise land on the ground, everyone begins to wonder who won. When the smoke clears Blastoise is able to get up but soon succumbs to the damage it took and faints)*
**It's Answer Time!**
For a projectile, K.E.+P.E. = constant
i.e., $0.5mv^2_{top} + mgh = 0.5mv^2_{cannon}$
Therefore $v_{top} \approx 22.5$ m/s (reduced)
Moreover hot surface of the rock facing up (top) will have higher heat transfer coefficient (h) when compared to other surfaces. Hot air becomes lighter & rises up, so colder air moves in which makes it easier for natural convection.
**Battle Referee:** It was a long and fierce battle and in the end the winning trainer is Ash from Pallet town!
**Ash:** I won?! and did I beat Gary?
**Pikachu:** Pika... Pi...
**Misty:** That was awesome!
**Prof. Ivy:** Incredible job!
**Ash:** Thank you Prof. Ivy. I wish I could train my Charizard like you trained your Gyarados.
**Brock:** I wish she train me!! *(gone virtually love sick crazy)*
**Ash:** Thanks a lot guys. I finally beat Gary! And I won the first match in a championship tournament!!
**Pikachu:** Pi... Pikachu!!!
**Gary:** Hmm... *(walks away)*

"The next morning, Ash begins his second Full Battle on a grass field against Harrison from Hoenn. Pikachu is very excited. But Harrison's Pokémon is one that Ash has never seen before. It's Blaziken, a really high level fire type Pokémon. Ash has saved Charizard for last. With two strong fire types in the arena, it's hard to predict the winner of this battle who will go on to the semi-finals..."

At present day... Howard plays card game with Willman as they would do in their dorm. Clara decorates Christmas tree. Anna and Amanda make delicious dinner with mincemeat puddings. Amanda joins the card game too. Clara shows her remarkable magic tricks to everyone and later turns on telly to watch her favorite show, Pochémon. Such a happy All Hallows' Eve isn't it? Things at present may look normal... however all is not as it seems until the show gets interrupted for a while for a disease outbreak in Toyama...!?

**THE END**

*H.A.G. bids farewell to all its players! Thanks for your support!!*

To know what has happened so far, visit
**https://sites.google.com/site/howardsadventuresgame**