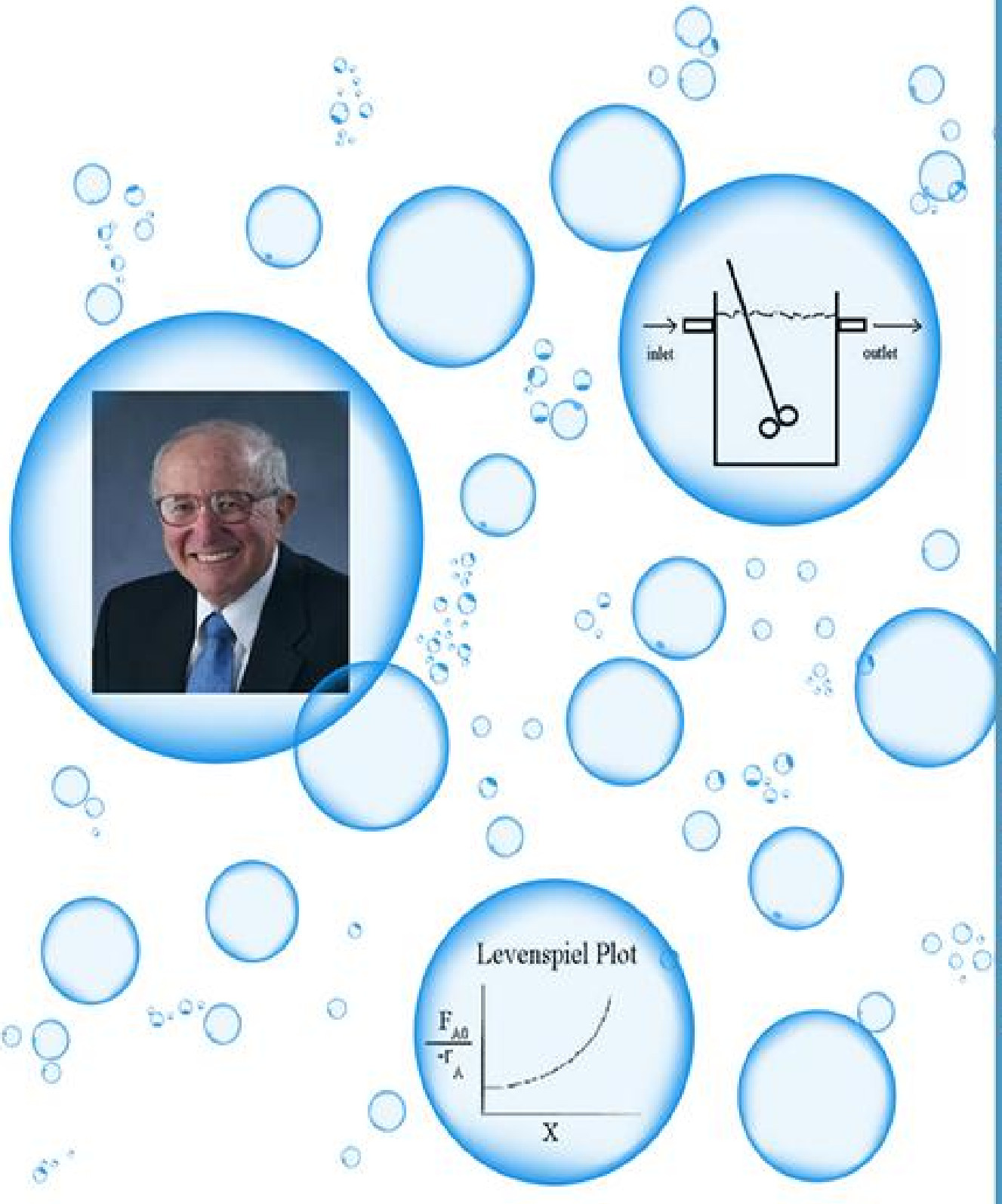
VOLUME 05 ISSUE 04

CHEMUNIQUE

FROM THE IICHE STUDENT CHAPTER



A TRIBUTE TO OCTAVE LEVENSPIEL

Message from the Associate Dean

Dear All,

It gives me immense pleasure in releasing *'ChemUnique Volume 05 Issue 04'*. The Department of Chemical Engineering at 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.

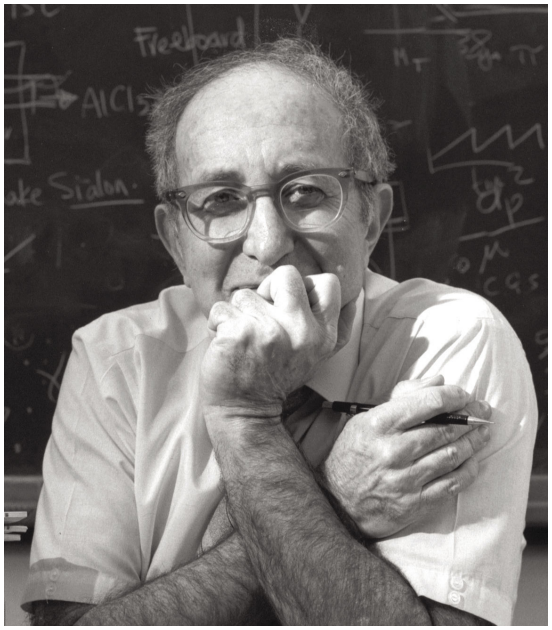
Thanking you

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

From the Editor's Desk

"Science and the application of science are worthwhile activities on which to spend a lifetime"

-Octave Levenspiel



On the 5th of March, 2017 one of the most influential chemical engineers, Dr. Octave Levenspiel, passed away. The ChemUnique team dedicates this issue of the magazine to Dr. Levenspiel in honour of his memories and his values.

In releasing ChemUnique Volume 05 Issue 04, 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.

Team ChemUnique

Akash Raman, Editor-in-chief

Athul Seshadri R., Editor

Porvajja N., Editor

Sudarsun V., Design Head

Mail us your feedback to chemuniquefeedback@gmail.com

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This magazine was compiled using Free and Open Source Software.

Levenspiel: Dinosaurs to Big Bang

Akash Raman, III Year, B. Tech. Chemical Engineering
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One simply does not become a chemical engineer without having read Levenspiel. Yes, Levenspiel – the author of the most widely prescribed textbook in chemical reaction engineering. But isn't there more to this person?

Mice, elephants, aerodynamics, dinosaurs, pressure and oceans. Could you relate all these? Didn't think so. But Levenspiel could and he did.

The 'mouse-to-elephant curve' is a popular theory in anatomy and physiology that relates the metabolic rate of an animal to its body mass. It is roughly similar to the scaling up we do in process development. As the body mass increases, the theory postulates that the metabolic rate of the organism also increases.

When the first dinosaur fossils with wing-like features were unearthed, aerodynamicists were quick to point out that flying creatures of such huge size could never fly given their metabolic requirements. They further showed that such creatures could only fly if the atmospheric pressure was 3 to 5 bars.

What did this mean for the history of the earth? The dinosaurs had wings and must have certainly flown 100 million years ago. That means the atmospheric pressure was indeed a crushing 5 bar. If so, how did it decrease to the mild and enjoyable present day 1 atm? Levenspiel proposed a theory. His answer was CO_2.

He noted that the Earth's initial atmosphere was almost entirely comprised of CO_2 and CO. Citing other publications that 50 – 70 bar of CO_2 now exists in a mineral solid form as carbonates in the Earth's crust, he showed that CO_2 must have dissolved into the oceans using Henry's law and that it must have reacted with the expunged calcium and magnesium oxides in the earth's crust.

He further extrapolated that the higher concentration of CO_2, which is a greenhouse gas, was the reason why the Earth didn't freeze over and life began.

In short, he used chemical engineering to explain evolutionary and geological questions!

This probably embodies one of Levenspiel's most inspiring trait. I believe that he never saw himself as a chemical engineer alone. Of course, it is noteworthy that he initially set out to be an astronomer but had to choose chemical engineering after having failed to garner a sufficient score in his freshman-year math course!

Levenspiel viewed problems as just problems and didn't bother to classify them into different disciplines. He would see a problem that needed solving and he would use all available tools and information to solve it. This is not the same as inter-disciplinary work, it is non-disciplinary! In fact, at

Oregon State University, where Levenspiel taught for a bulk of his career, he used to teach a variety of courses – game theory, statistics alongside thermodynamics.

Levenspiel has also authored the book, *Rambling Through Science and Technology*, which is a collation of all his musings about general science. In this book, Levenspiel takes the reader on a journey through the entire history of science right from Galileo's experiements to the Big Bang Theory. Astoundingly, the book bears no signs of his chemical engineering background – something that one would normally expect from a pioneer of the field. This is probably because Levenspiel himself never restricted himself as just a chemical engineer. The book is a product of his genuine and unfettered fascination with science – his love for knowledge in it's most unadulterated form.

If there is one underlying lesson that Levenspiel wishes to teach us through his life, it is that classification and overspecialisation are not of much avail. We can be better and more productive professionals if only we were more eager to solve problems and view all knowledge as tools.

References:

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2. ChemWorx, A. C. S., C. E. N. Archives, and A. C. S. Photonics. "In Honor of Octave Levenspiel." Ind. Eng. Chem. Res 42.12 (2003): 2423-2426.

Answer Your Way Out

Team ChemUnique

Ever since Levenspiel was a little boy, he was intrigued by puzzles and mysteries. Everyday, after having had his lunch, he'd sit with a newspaper in hand, searching for brain scramblers. Like any other afternoon, he was at his desk, slowly and gently turning each page to check if there's anything to tease his brain. As he turned to the fifth side of the newspaper, his eyes started to give out and he got sucked into a place he had never seen before. More like, a mystery world.

Everything around him was dark except for a huge bridge which paved way to a castle. He had never seen such a place before. He waited for sometime to check whether there was anyone around for help but he couldn't spot anyone, not with his naked eyes.

He said to himself, "You can't wait any longer, the castle is your only way out.".

Levenspiel then took slow, jittery steps towards the castle and spotted a sentinel at the starting of the bridge.

Levenspiel: What place is this? How do I get out?
Sentinel: This is Chemenia. Your only way out of this world is through the castle of reactors. But beware, the path to the castle of reactors is not an easy one.

Levenspiel: How so? What should I do?
Sentinel: The bridge consists of three doors. At each door stands a sentinal just like me, who would ask you a riddle. If you can answer the riddle correctly, you get to proceed. If in case you pass through all the three doors, you will find yet another door, the door which gives you entry to the castle. But.

Levenspiel: But?
Sentinel: The final door is a tricky one. A riddle will be inscribed on it and it's coded with a numeric lock. The answer to that riddle would be the digits which would unlock the door. Go forth and carve your own destiny.

Levenspiel took the advice of the sentinel and proceeded towards the first door.

Sentinel at the first door:
I determine the temperature dependency of reactions. If I'm very high for a reaction, the reaction is temperature sensitive and if I'm low, the reaction is temperature insensitive. Who am I?
Levenspiel: Of course! You are ……!

The guard stood aside and Levenspiel walked towards the second door.

Sentinel at the second door:
I only exist if a system's density changes; I disappear if not. Forget to account me in the rate equation and you shall get the wrong answers.
Levenspiel: Hmmm. You must be …….

With the second door unlocked, Levenspiel was quick to put the door and the guard behind him.

Sentinel at the third door:
I am the very base of CRE. Know me and you shall be given the power to compare various conditions and designs of a reactor. Half my name occurs in all of math and the other half can mean a play or a concert.
Levenspiel: Riddles, riddles, riddles. I love this riddle. Wouldn't you be …….? Haha! I was right!

As the sentinel pushed a lever, the door opened and Levenspiel walked gleefully towards the castle door. The door looked massive and imposing and on the left wall was an inscription bearing the words:

"At 63^{o}C it takes 80 min
At 74^{o}C it needs 15 s.
He who stands at the first gate,
What value does he assume?"

The right wall had a keypad that could obviously unlock the door. Levenspiel stood there thinking for a bit and with an amused smile on his face, he typed out the numbers …….. in the keypad and the doors flung open.

A booming voice from afar sounded, “Come in!”.

McCabe: Welcome to the castle of reactors. I am McCabe, the minister and this is my king, the king of Chemenia, George E. Davis. The king and I shall ask a question each. If you can answer them correctly, we will open a portal ensuring your safe return to home!

Levenspiel: Alright! Bring it on!

McCabe: His behaviour is best described as orderly – a streamlined flow of morals. My siblings add up to two, do you know who?
Levenspiel: Uhm… Just two more steps to home! It is the ……...

McCabe: Correct answer!

George: Very well Mr. Levenspiel, try this!
I am the chain, connecting mass transfer and kinetics. Forms, I have many and if the resistance is low, I tend to be mini. Hold me as the basis and become the master of catalysis.

Suddenly, a mysterious light began to fill the castle halls.

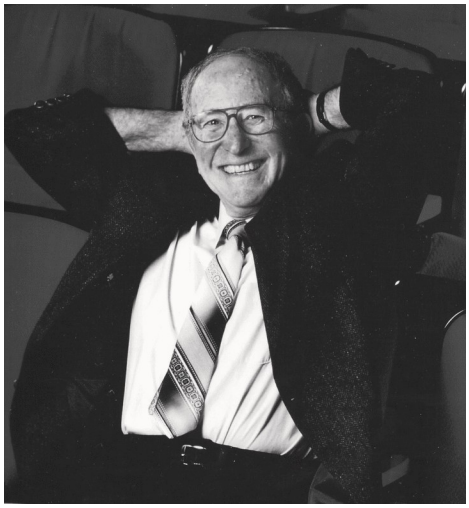
Levenspiel snapped back to reality and realized that all of it was nothing but a dream. A dream which evinced that wherever he might be, reaction engineering will always be an integral part of life.
(NOTE: If you cannot find the answers, just ask Levenspiel!)

The Man Named Levenspiel

Team ChemUnique

Here is what you didn’t know about this legend of chemical engineering!

- Levenspiel was born to a Polish father and a Russian mother in China and attended a German kindergarten, English school and a French University. Talk about an international life!
- When asked why he chose to write on reaction engineering, his reply was, “I flipped a coin versus thermo; chemical reaction engineering lost”. Of course, one could argue with merit that CRE actually won because it is impossible to imagine a CRE without his book now.



- He was a practical joker and often mused his students and colleagues. In one particularly famous story, he would claim to be the eighth (Octave) son in a family of thirteen children! His mastery over story telling gives all his books a certain allure and lucidity.
- Levenspiel aimed in everything. Sometimes this included rather unconventional pursuits – he once held his breath for a full five minutes and twenty five seconds!
- He was a master of playing chess. He played Chinese, Korean, Japanese and Manchurian Chess!
- He was the Eastern United States Boomerang Throwing Champion – he threw and caught a boomerang fifty seven times in succession!
- He often ventured into areas that were not strictly related to chemical engineering. He has published papers on varied topics such as orienting oneself in zero gravity, evolution of the earth, the least number of moves required to cross the board in Chinese checkers and many other eccentric topics!
- At the age of 35, he was diagnosed with terminal cancer but he far outlived the expectations of his doctors.
- He is know for his incredible ability to make quick back-of-the-envelope calculations! This inspired one of his students, John Eaton – one of the creators of the computational high level language GNU Octave (MATLAB alternative), to name the software after him!

Image source: http://levenspiel.com/wp-content/uploads/2016/02/Tavy-best-947x1024.jpeg

All of you say, “CHEEEESE!”

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“Yay! Finally I captured it. Look at all of you, those cheesy smiles on your faces”. That moment, as a kid, clicking-the-perfect-picture of your family and framing it to hang it on your wall gave you so much happiness.

Yes, Photographs. It’s the digital age; kids of present generation have no idea about photographs. Capturing the picture, framing it, and wrapping it up; all of it happens within a moment. This whole photography process puzzles me and makes me want to quench the thirst of chemistry behind the photographs.

To those grey cells that are yet producing theories to solve the uncertainty that has been provoked, any idea what gave birth to film cameras, photographs? The solution, that will never change be it million decades from now, is to create a long lasting image of a certain scene.

In the 19^{th} century, Louis Jacques Mandé Daguerre gave birth to photographs. Named after the inventor, they were called “Daguerretype” photographs. Each Daguerretype is a distinct, detailed, and personalized image on a silvered copper plate. This first ever process was arduous, one had to shed their sweat, and work their fingers to the bone to craft the photograph.

In the beginning, the copper plate had to be buffed and polished until it looked like a bright shiny object. Then, they were sensitized to light over iodine and bromine in light-proof boxes. Now, the plates were ready to play its role as a camera. They were exposed over a period of fifteen minutes. Finally, after the exposure, the plates were brought out over hot mercury, fixed by immersion in a solution of sodium thiosulphate and then washed with distilled water. The ultimate step was to tone the plate with gold chloride to give the photograph its grand, impressive, and glorious look.

This process made me jump out of my skin. Daguerre has indeed bequeathed his invention to the future generation.

Will this stop another member of the human race from advancement, improvement, and what not? Oh no! At a subsequent time, there arose a new method called Talbot’s method photographic process which again involved multitudinous chemicals and routes to succeed. The inclination to improve photography never hinted a “full-stop”.

From Talbot’s method, a myriad of photography processes were born. Few processes among them are classic processing, reversal processing, spectral sensitization, colour photography, instant photography, and digital photography.

Polaroid is the one that would strike any person when spoken to about instant photography. Those cute-tiny-pink-boxes every traveler has around his neck to capture the beauty of the indigenous places, and has it as a photograph before the ink is dry. Spectacular evolution, isn't it? The inventor devised a diffusion transfer process for achieving positive paper prints rapidly in the Polaroid cams.

Last but not the least, the apple of everyone's eyes, DSLR pictures. Digital photography doesn't involve any film roll or copper plate, rather charged-coupled devices (CCDs) consisting of rectangular arrays of millions of minute light sensors. These CCDs can be reused an uncountable number of times.

Photography has taken its stand in today's world, from creating memories to spectrometry. It not only involves science, but it is also a form of art, expression, and emotion. The power of a picture is so sound that it can create an impact in promotion and communication of science.

It all converges to one famous cliché "A picture is worth a thousand words". A blog says, "human beings are very visual creatures". I say, aim your lenses, choose the frame, observe it, process and trip the shutter. Say cheese!

Origins of Au(rum)

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How many of us believe that some of the things that we wear, especially girls, bring us in contact with the universe in which we live in?

Yes, I am talking about the most sought out metal in this world , the metal for which not only humans but the governments of the world thrive for, the metal which is used for many auspicious occasions. Yes, I am talking about Au(rum), generally known as Gold. Yes! gold connects us to the universe.

This metal which I am talking about is not formed by any substance found on any planet. Yeah, you heard it right. It is formed by intergalactic dust formed during the formation of the star or during the death of a star .Traditionally, gold is thought to have been formed by the R-process in supernova nucleosynthesis, but a relatively recent paper suggests that gold and many other elements that are heavier than iron may have also been produced in quantity by the collision of neutron stars. This study is done by a process called satellite spectrometery.

First, let me explain about supernova nucleosynthesis. Supernova nucleosynthesis is a theory of the production of many different chemical elements in supernova explosions. The nucleosynthesis, or fusion of lighter elements into heavier ones, occurs during explosive, oxygen burning, and silicon

burning processes. This process produces heavier metals such as iron, copper etc. This is due to the fusion of hydrogen atoms at a very high temperature. Normally in stars, Hydrogen atoms fuse to form Helium but during nucleosynthesis, temperature released is a million times higher than the normal fusion reaction in normal stars. Elements heavier than nickel are created primarily by a rapid capture of neutrons in a process called the R-process.

R-process is a nucleosynthesis process that occurs in core-collapse supernovae and is responsible for the creation of approximately half the neutron-rich atomic nuclei heavier than iron. The process entails a succession of rapid neutron capture (r-process) by heavy seed nuclei, typically 56Fe or any other neutron-rich heavy isotope. The other predominant mechanism for the production of heavy elements in the universe and in the Solar System is the s-process, which is nucleosynthesis by means of slow capture of neutrons, primarily occurring in AGB (Asymptotic Giant Branch) stars.

A neutron star is the collapsed core of a large star. These gold nucleogenesis theories hold that the resulting explosions scattered metal-containing dusts including heavy elements such as gold into the region of space in which they later condensed into our solar system and the Earth. Because the Earth was molten when it was just formed, almost all of the gold present on Earth sank into the core. Most of the gold that is available today in the Earth's crust and mantle is thought to have been delivered to the Earth's crust later by asteroid impacts during the Late Heavy Bombardment. An example is the asteroid that formed Vredefort crater 2.020 billion years ago and is often credited with seeding the Witwatersrand basin in South Africa with the richest gold deposits on earth. From now, whenever we behold gold, it will be the time to reconnect ourselves to the outer world.

Sources:

1. https://en.wikipedia.org/wiki/Gold

2. https://en.wikipedia.org/wiki/R-process

3. https://en.wikipedia.org/wiki/Supernova_nucleosynthesis

Eco-friendly Leather

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Leather is one of the most archaic commodities in the present-day market. The art of leather making dates back to the stone age where people crafted leather from animal skin to keep themselves warm. The usage of leather has steadily progressed to a level that an individual now uses at least four leather commodities made out of leather, namely, belt, shoes, bags and watch straps.

The US holds the maximum share of the world leather market with a swaying 39% followed by Canada. India shares 3% of the global leather trade market with Tata International Ltd being the largest exporter of leather in India. The Indian leather footwear industry generates a revenue of 300 million USD per annum, producing 700 million pairs of leather shoes every year.

The preparation of leather goods involve 6 principle steps: curing, soaking, pickling, tanning, post-tanning and finishing, of which tanning is the most critical step. The greatest advancement in leather industry was undoubtedly the discovery of chrome process used for tanning. On the offset, chromium (III) which is used as a tanning agent in chrome tanning is a major environmental pollutant and is hazardous to human life. Although chromium (III) is an essential nutrient for a human being, exposure to high levels may have adverse effects like bronchitis and hyperemia.

Over 90% of global tanneries use chromium for tanning. During the process of tanning, only 70% of the chromium-containing chemicals is absorbed, leaving the rest unused. There are two ways of controlling heavy metals in the effluent: exhausting the chromium in the effluent or by increasing the amount of absorption of chromium.

Scientists at CSIR-CLRI have found a way to mitigate the effluent effects of chromium. To achieve an optimal absorption of chromium, scientists have devised a bio-based copolymer matrix which effectively fixes the chromium molecules on the active sites of the leather. As most of the chromium (III) would be absorbed by the leather, only a small residue of chromium would be retained by the effluent. The remaining residue can be reduced to a bare minimum using syntans along with additives such as aspartic acid. There are several other polymers and biopolymers that are in practice for effective removal of chromium from the leather effluent. Bacteria such as *Bacillus pumilus* is also used in the treatment of the effluent, which can bring down the amount of chromium drastically.

The copolymer matrix used is not only eco-friendly but also produces a finer quality of leather in terms of physical and thermal stability. By changing just one component of a process, the entire dynamics of the process can be changed.

Every chemical engineer must keep that in mind and work not just for money but also for the betterment of the society.

ChemE Snaps!

Team ChemUnique

ChemE Snaps is a new column where concepts hidden in images submitted to us are explored. Essentially, it is viewing the world through the lens of an engineer!

Hit me hard and I will glow for you!

Fascinating, isn't it? Who doesn't like to play with balls? The interesting fact lies in the engineering. The flexible, polymer made ball has all the force to be reckoned with. Look at its build, so strikingly awesome. The ball hits the ground, takes in the kinetic energy and the potential energy. Some of the energy is converted to light, resulting in this dazzling glowing bouncing ball!

Life flows through smoothly like a liquid, until a challenge enters and disrupts you, but it's all in how you deal with it to emerge out stronger, more exquisite, and as a winner. This crystallizes you out from the rest.

No. This is all not about the philosophy of life. Can't believe me? Ah. Engineer your thoughts, its crystallization.

Crystallization is a solid-liquid separation technique wherein the mass transfer of a solute from the liquid to a pure solid crystalline phase occurs. Crystallizer is the maker of our hero solid crystals.

Stay imperfect, stay beautiful.

What would have adorned the human race if we hadn't come up the idea of mixing of metals? Anything that's pure gets corroded without a hitch. Alloys walked in to our rescue. Phew! The origination of alloys solved multifarious problems. Alloys are a mixture of two or more metallic elements. It manifolds the characteristic properties of a metal exponentially. The properties like malleability, ductility, corrosion resistant, high-impact strength, and lightweight have been improved. This list hasn't ended; it will run for another two more pages.

No soul is pure enough. Imperfections make you strong enough to withstand even the biggest blows. Be an alloy!

Best served chilled.

Icing sugar, milk, rose milk powder, ice cubes; all put in a jar, well-blended, cold and served in a highball glass tumbler. Slurp. No soul can resist the sweet–mouth-watering summer drinks. Wait. In the joy of gulping down the drink, don't forget to apply the science that weaves together the beauty that surrounds you.

The beverages? So perfectly blended and lets you relish your creamy, delicious drink. They are nothing but colloids. Colloid is a microscopically small substance that is evenly spread in the dispersed medium. Colloidal solutions are also known as colloidal suspensions at times. The beverages we consume day-to-day are emulsions. The most commonly used colloids in food products are hypercolloids that are used to manipulate texture.

Pull yourself together, even under extreme tension. It's not just us who follow that phrase of inspirit, so do our molecules when put under extreme conditions.

The cohesive forces of the liquid molecules are responsible for the phenomenon of surface tension. In turn, it is responsible for the shape of the liquid droplets. Bubbles being small and spherical have a large surface area and this property is exploited in reaction engineering in bubbling reactors.

Image credits:

Rashmi P. Nayak B. E. Computer Science Engineering Sri Krishna College of Engineering and Technology nayakrashmi16@gmail.com Images 1, 2, 3, 5	Eniyan Shanmugavel III Year, B. Tech. Chemical Engineering eniyan1012@gmail.com Image 4

ChemUnity Speaks!

Disruption in vehicle technologies

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Automobile industry innovation has been stagnant over the past decade. Early in the 1900s, at the time of industrial revolution in England, the first massive disruption in the transportation sector occurred. Cars replaced till then used horse carriages. Internal combustion (IC) engine technologies became the center of attraction for innovators. Fast forward to the current scenario, the start of new disruption in vehicular technologies is evident.

Lately, Electric Vehicle (EV) technologies are replacing IC engines. Tony Seba, a leading entrepreneur, in a book "Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030" made a critical review of the scenario. According to his analysis, four major factors are influencing this disruption.

First is EV motors have more efficiency (90-95%) when compared to the current IC engines (17-21%) which make EV 5 times more efficient than IC. Second is the cheaper refueling cost. A gas type Jeep Liberty model costs $15000 in five years for refueling. On the other hand, an electric type of the same model costs 10x cheaper refueling costs. In economics, disruption in a service occurs when there is <10x difference. Smart grids/homes are complementary to EV sector. With the parallel technological development in both of these areas, consumers will enjoy free electricity along with zero marginal costs on fuel expenditure of vehicles. The maintenance cost comes next. A conventional IC car has 2000+ moving parts. However, on an average, EVs have only 18 moving parts. Thus, there is 10-100x less maintenance cost. For example, TESLA offers zero mile maintenance cost for the battery and driving parts for their EVs. At last for the performance, high-performing super cars are challenged by Tesla's P90D model at 1/2 or 1/10th their price points.

Every consumer's dream is acquiring a high-quality service at the lowest price. In the transportation sector, EVs are making this dream come true. Based on Tony Seba's cost curve, by 2018 affordable mid-range high-performance EVs will start to acquire the market. And the best example is the Chevy Volt, a high performing mid-range EV entering the market in late 2016. Consequently, the mid-range market will be completely dominated by EVs around the 2020s. Followed by this, the EVs will extend

their market to low-range vehicles because of the developing cheap Li-ion technologies. So, as of the final estimation, by 2025 all the global new vehicles produced will be electric.

Many digital companies like Uber, Apple, Google, Foxconn, and Xiaomi are investing in EVs. Their target areas are smart EVs, charging networks for EVs and developing Vehicle to Grid (V2G) technologies. To conclude, this disruption is now and real. Soon petrol industry will face a crisis because of EVs dominating transportation. When the disruption is complete along with significant development in renewable, the oil and gas demands will drop drastically leaving a huge unemployment in refinery industries. For now, there is no market competition for EVs at present (Or is it?).

Safety Puzzle

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Executive-Technical
SHV Energy Private Limited

Instructions

1. 15 words are hidden in the grid. Try and form as many words as possible!
2. Use connectors (lines) to form words.
3. Words can be formed horizontally, vertically and diagonally; forwards and backwards.
4.All words shall be related to Safety.

A	F	V	M	F	I	R	A	F	M	O	O	F	D	W
B	F	F	F	M	R	S	M	Y	R	U	J	N	I	Y
O	X	U	S	I	R	E	N	S	T	L	R	P	A	T
N	U	S	N	E	V	A	C	U	A	T	E	E	T	N
O	E	S	U	A	C	T	O	O	R	G	R	D	S	A
S	S	U	M	P	R	C	J	M	K	S	Y	I	R	R
I	N	O	I	T	A	G	I	T	S	E	V	N	I	D
O	E	X	P	L	O	S	I	O	N	K	M	A	F	Y
P	V	E	S	I	U	R	B	D	O	M	Y	Y	P	H
R	E	L	K	N	I	R	P	S	L	E	C	C	H	O
W	D	Y	U	F	U	Q	A	L	A	R	M	Q	N	N
I	E	L	H	O	S	E	R	E	E	L	I	I	P	S
S	S	I	M	R	A	E	N	W	W	Y	C	X	F	V
S	L	W	D	O	C	T	O	R	W	C	S	A	P	V
H	J	M	A	C	C	I	D	E	N	T	A	E	H	N

The Advent of Lithium Ion Batteries

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"If this sounds easy, then nothing could be further from the truth"

Yoshio Nishi

At the outset, I would like to pay my respects to the departed soul of Octave Levenspiel, the greatest chemical engineer who shaped the chemical engineering field as to what it is now. His work on Chemical Reaction Engineering is unparalleled.

Thinking about great chemical engineers who have done remarkable work, one cannot miss out on Yoshio Nishi, the man behind the astounding success of Lithium Ion Batteries.

Yoshio Nishi, 1941 born, is a Japanese Engineer who studied solid physical chemistry in the department of engineering at Keio University, Tokyo. Later, he joined Sony to work on semiconductor materials. However, he was commissioned to study about fuel cells. Around the same time, Sony started working on lithium batteries. They wanted to developed lithium based rechargeable batteries as an alternative to then existent Nickel-Cadmium batteries.

What are Lithium Ion Batteries and Why then?

A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.

Moreover, these LIBs were not much of an environmental pollutant and yet had a much greater energy density than other batteries.

Principle of the Li- Ion Batteries:

Lithium ions carry the current by moving from the cathode to the anode during discharge. The process is reversed by applying an external charge of same polarity. The graphite anode allows lithium ions to embed themselves safely on the material, while the $LiCoO_2$ cathode binds and releases lithium via electrochemical reduction and oxidation. During charge and discharge, lithium ions simply shuttle back and forth between the cathode and anode and thus Sony named this system the "lithium ion battery".

Perfecting the Design:

Nishi and his team faced huge obstacles while developing and perfecting the design of the LIB prototype. One of them is the choice of electrode- the core component. Metallic lithium is liable to catch fire and to suffer from poor cyclic performance. To overcome these drawbacks, Nishi and his

team tried making anodes from materials which could store lithium, thus giving him the crucial lithium at the anode while keeping the risks to a manageable level, and achieving excellent cyclability. Graphite was a prime candidate – its layered structure allows atoms of another element to be inserted between the layers, a process known as intercalation. The intercalated anodes worked well, but turned out to be impractical for mass production. The third option was to use a pure carbon anode and replace a different component of the battery with a lithium compound (after all, the battery needed source of lithium ions). The team investigated lithium electrolytes but dismissed the idea because the battery could not practically hold enough electrolyte solution to store sufficient lithium ions. The cathode remained as the last practical solution. Indeed it turned out that a lithium cobalt oxide cathode would permit lithium ions to be inserted and extracted via simple electrochemical reduction and oxidation.

Future Scope:

Lithium Ion batteries have already started replacing nickel- cadmium in all possible fields. With the motto, 'Safety first, quality first', Nishi expects that in another twenty years, Lithium Ion Batteries will revolutionize this world. With the advent of the 'Breakthrough Energy' initiative, LIBs have all the more scope to serve as a viable battery alternative.

H_2O is better than CH_4

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For the past few months, Tamilnadu faced many topsy- turvy issues. The month of December covered news about Apollo, January was all about jallikattu. Now comes the hydrocarbon project. 31 places across the country are chosen for this project as per Central Government's Discovered Small Fields policy, launched in 2016. The main objective of this policy is to increase the gross revenue, to improve power issues, and to reduce import of oil and petroleum by the extraction of shale gas. Shales are a fine grained sedimentary rock which gets formed due to the accumulation of sedimentary particles at the earth's surface. So they should be broken for extracting shale gases like methane.

Methane forms the important component in natural gas which emits enormous heat upon burning and this gets converted to electrical energy. Statistics show that 14-25 million tonnes of methane gas escapes from the ground to the atmosphere every year. It contributes to 28% of global warming by absorption of heat and that is a serious threat.

The process generally used is hydraulic fracturing. Hydraulic fracturing (also fracking, fraccing, hydrofracturing or hydrofracking) is a well stimulation technique in which rock is fractured by a

pressurized liquid. This process involves the injection of high-pressured 'fracking fluid' (primarily water, containing sand or other components suspended with the aid of thickening agents) into a bore well to create cracks in the deep-rock formations through which natural gas, petroleum, and brine will flow more freely.

So obviously this process needs huge quantities of water and tons of sand. We also know that methane is a thousand times hazardous than CO_2 and the above process releases an enormous amount of methane which poses a threat to biological diversity. Apparently, hydraulic fracturing is under international scrutiny, restricted in some countries, and banned altogether in others. USA which runs more than 500 plants for methane, chooses methane fracking sites which are wastelands where there is less population and most importantly agriculture less lands.

So this raises a question, if there is any alternative way for producing methane in large quantities?

In India, solid waste management uses 2300 crores (around 10% of our tax). Around 1 lakh tonne waste is being disposed all over India on a daily basis. Through this around 40lakh kg of methane can be extracted. Using this, global warming can also be reduced as methane gets removed from wastes by recycling process.

Sweden which is considered as the green nation of the world imported 10 lakh tonnes of waste from neighboring nations for the generation of power through wastes, aiming to be one among the first fossil fuel-free welfare states of the world.

So let’s move to production of methane by biogas plant process and save the people who provide food for us.

Note: The article reflects the views and opinions of the author. ChemUnique magazine neither endorses not campaigns for the views.

Answers to Safety Puzzle

Investigation, siren, sprinkler, doctor, investigation, near miss, root cause, poison, first aid, injury, evacuate, explosion, hydrant, alarm, accident.