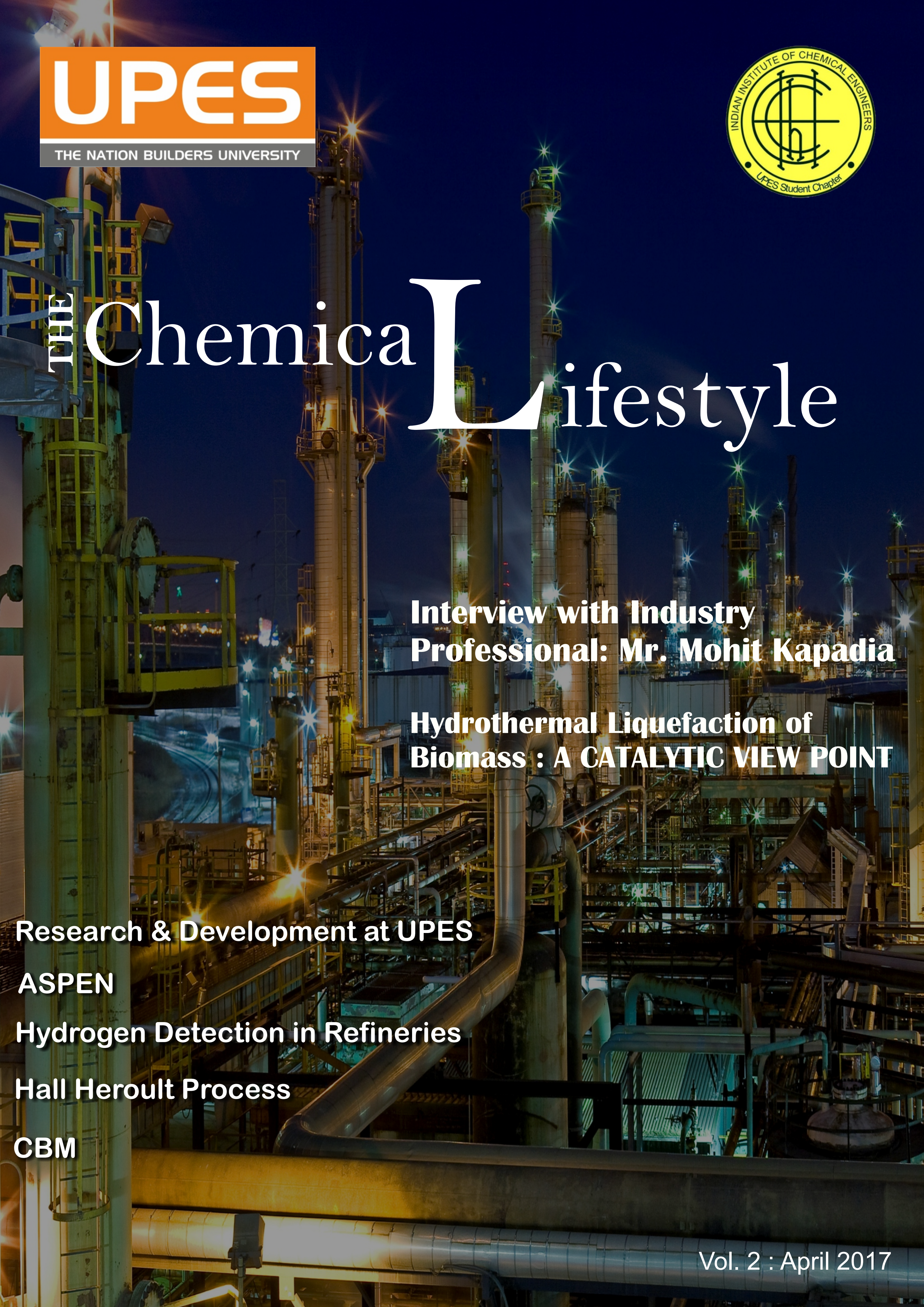
UPES
THE NATION BUILDERS UNIVERSITY

INDIAN INSTITUTE OF CHEMICAL ENGINEERS
UPES Student Chapter



THE Chemical Lifestyle

Interview with Industry Professional: Mr. Mohit Kapadia

Hydrothermal Liquefaction of Biomass : A CATALYTIC VIEW POINT

Research & Development at UPES

ASPEN

Hydrogen Detection in Refineries

Hall Heroult Process

CBM

Vol. 2 : April 2017

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ABOUT IIChE

Shri M. Hamid Ansari, Vice President of India being presented a memento at the 67th Annual Session of the Chemical Engineering Congress (by the Indian Institute of Chemical Engineers at Panjab University, in Chandigarh on December 27, 2014.
Image Courtesy : Shri M. Hamid Ansari (Website)

The Indian Institute of Chemical Engineers is a nationwide society for all personnel related to the Chemical Engineering domain, be it from academia, research or industry. Initiated in a small room at Jadavpur University, Kolkata by Dr. Hira Lal and a few other pioneers of the Chemical Engineering world in India, the society was formed when a need was felt to help simplify communication between the diverse personnel involved in this vast domain.

Within a span of nearly seven decades, IIChE has risen to numbers of over 15,000 members, 38 regional centers and over hundred student chapters and is now considered to be at the peak of professional bodies that bring together people of similar interests toward the chemical engineering world.

Headquartered at Jadavpur University, the activities of the Institute are spread across the country through its 33 regional centers and student chapters.

The regional centers promote and complement the activities and objectives of the Institute within their respective territorial limits, by organizing meetings, conferences and seminars; arranging workshops, refresher courses and counseling sessions; promoting research; guiding Chemical Engineering students in career planning; and initiating any other activities which are of social, technical and professional relevance to their members.

They serve as open fora for their members who regularly gather for informal get togethers and exchange of notes. The Regional Centers also confer awards, prizes and scholarships.

ABOUT IIChE UPES SC

In the year 2012, as a result of a common need felt by the students and the faculty, IIChE UPES Student Chapter was instituted in the University with the aim of facilitating the student and faculty interaction with the industry professionals.

The IIChE UPES Student Chapter is a student run body, headed by Dr. Adarsh Arya and Mr. Amit Kr. Thakur, the Faculty Advisors who work to ensure that all the hopefuls of the Chemical Engineering domain stay well acquainted with the ever changing dynamics of the Chemical Engineering world and to give them an added advantage in the professional sphere, after they finish their education in the University.

As a part and parcel of the initiatives undertaken by the Chapter, numerous competitions, seminars, workshops and distinguished lectures have also been organized. Some of the noted speakers include Bharat Ratna Dr. C.N.R. Rao; Dr. M.M. Sharma FRS; Dr. M.S. Ananth FNAE; Dr. K.S. Gandhi FNAE FASc; Prof. V.K. Ratan, Panjab University; Mr. D.M. Katre, Plant Head, RIL; Mr. Arvind Kaushik (R & D Hydrocarbons) ; Mr. Rohit Sinha (L & T), Mr. Pankaj Kumar (GM, ONGC).

Under the banner of the Chapter, students have participated in National and International level competitions involving Engineering Design Concepts and profound knowledge of the chemical engineering domain including CHEMCON, Student-CHEMCON, OYCE and many more.

Editor's Note

Dear Readers,

Welcome to yet another edition of The Chemical Lifestyle. We are starting afresh this year galvanized with your constant support and encouragement. The Chemical Lifestyle is all set to take a leap with better than ever advanced technologies flourishing in. There has been a paradigm shift in the academic guild, with focus shifting to newer subjects like catalysis,reaction engineering,transport process,nano-technology etc. You will find numerous such wordly affairs that took place in ChE domain in the news segment.

IIChE's role has been pivotal in providing the Chemical Engineering fraternity with a platform for critical interaction and networking. The Student Chapter of IIChE at UPES has done tremendous job over the years in shouldering this responsibility. Through this magazine,we want to do our bit in restructuring the conventional roles as a camaraderie and venturing into newfangled horizon. We have always strived to open up a portal to a world of opportunities and ideas for our young readers.

We hope that The Chemical Lifestyle follows up to your expectations once again, and shall be a resourceful companion in your quest of knowledge.

Signing off with some food for the thought for budding Chemical Engineers" Keep dreaming and be persistent".

Aditya Raj

Head-Editorial Committee 2016-2017

IIChE UPES SC

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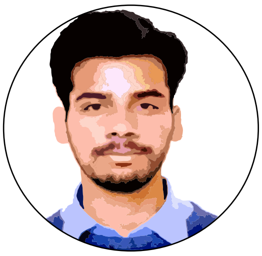

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chapter ARCHIVES

Educational Activities: Distinguished Lecture Programs

DISTINGUISHED LECTURE 1

On March 31, 2016, IIChE UPES Student Chapter had the extraordinary opportunity to organize a distinguished guest lecture by yet another erudite from the Chemical Engineering guild. Dr. A. B. Pandit (FNA, FASc, FNASc, FNAE) from ICT-UDCT, Mumbai is both a gifted lecturer and a leading researcher. Dr. Pandit commenced the session by designating the audience of being a part of the "Chemical Engineering fraternity" and encouraging the budding minds to "give back to the society" with their knowledge and skills. He then focused on how even a simple piece of research worked upon with the aim of bettering the society could be as valuable as a high-end research. After giving an igniting pep-talk, he then introduced the audience to the topic of his session, "Chemical Engineering Forays into Rural India" wherein he discussed the installation of a new pump in rural village in which the process of cavitation aided the removal of microbes from the water, thus purifying it. He also discussed an innovative design of "House Chula" and the resourceful application of solid fuel in rural villages. The lecture turned out to be an ever-amusing affair for both the teachers and the students wherein a healthy discussion and question answer session followed.

DISTINGUISHED LECTURE 2

Mr. Pankaj Kumar, General Manager at ONGC India Ltd., visited the campus on 3rd of September, 2016, and shared his views on the Advancements in Oil and Gas Exploration and Exploitation. Concluding on a happy note, the ceremony was followed up by an annual prize.distribution ceremony. A quiz was held based on the topics discussed in the lecture for which Mohd. Ozair Ansari of B. Tech-Chemical Engineering (2015-19) was awarded first prize.

CHEM-CONUNDRUM

A weekly quiz conducted online during the month of August. Aayush Belwal of B. Tech-Chemical Engineering (2015-19) bagged the top slot with a near perfect score of 39 out of 40.

FREEDOM SHOT

Photography is the best way to contain emotions and memories for a span of time. Freedom shot which was conducted in-order to celebrate India's 70th Independence Day. Harsh Prateek, B. Tech-Chemical Engineering (2014-18), for his brilliance with words and photography was awarded first prize.

WEBINAR

Alumni connect has been one of the major targets for the Chapter in this session. The founding stones were laid on 12th of September, 2016 when Ms. Sonal Bhadauriya, alumni of UPES from 2011-15 batch was put on a live conference straight from Ohio, U.S. The event was a grand level success with a healthy interest from masses. Ms. Sonal gave an insight in the research world and gave her experiences regarding the choices she had to make on her own part.

GATE GUIDANCE

IIChE UPES Student Chapter along with UPES CSI Student Chapter put forth Gate Guidance under the mentorship of Prof. Amit K. Thakur (AIR 64) and Prof. Rahul Kumar (AIR 38). A total of 6 tests were conducted over a span of 3 months under the supervision of our mentors. A formal introduction to the latest patterns and tips was given as a seminar centre-staged by Mr. Rahul Kumar, Mr. Amit K. Thakur, supported by Dr. P. Vijay and Dr. Adarsh Arya from the department of Chemical Engineering.

LOGO TREK

Logo trek was another event with summiting success, with registration and participation of over a hundred teams. The event was held on 21st of October, 2016. The three round event was concluded with Avirukh Roy and Jamaeelya Akula of B. Des bagging the winners spot followed up by Lakshay Singh and Shashank Pandey of APE-Upstream.

CHEMERGENCE

Chemergence was a grand show containing three events, namely, Sympedia, Case Study Challenge and Chem-e-Battle.

1. Sympedia: An event crafted to extract the confident speaker in oneself, Sympedia was a two round event with an extempore as the preliminary round and a panel discussion as the final round. Mohd. Ozair Ansari again bagged the top spot beating all the other contestants.

2. Case Study Challenge: Organized on 3rd of February, 2017, a case study on the topic “Compression, Transport and Re-Gasification of Liquid Natural Gas” was conducted. Out of all the abstracts submitted, only the shortlisted participants were given a chance of presenting their presentations before the judging panel.Aditi Bahuguna, Arvind Kapoor and Ashutosh Gaonkar (B. Tech-Chemical Engineering 2015-19) were the winners and Ashwin (B. Tech-APE Upstream 2016-20) was the first runner-up.

3. Chem-E-Battle: A two round event based on one's knowledge in the domain of chemical engineering, Chem-E-Battle was also a two round event with aptitude in the first round. The handpicked teams were promoted to the second round where the questions were based on one's grip in the realm of chemical engineering. Satyam Garg and Saurabh Jaiswal from Chemical Engineering 2015-19 emerges as winners.

M.E.L.A.

Abbreviated form of Music, Entertainment, Literature and Art, this one of a kind saga of various art-forms combined was the highlight of the entire session. A quiz was conducted facilitating a direct entry into the finals of all the events of M.E.L.A. Nikita Goel from B. Tech-Chemical Engineering 2015-19 was the one who bagged the opportunity to be the wild card finalist.

Word Play: The passion to read is hobby to many. Aimed at contemplating the knowledge of literature, while learning more of it. The first round “Contemporary Quiz” and the follow up was “Complete the Phase”. Winners of the event were Someshwar Gaur and Yuvika Sehgal from B. Tech- Chemical Engineering 2015-19.

Sketch-A-Story: Sketch-a-Story was organized on January 17, 2017 under the Art section of MELA. The event focused on how participants were able to interpret a story on a plain drawing sheet. The participants displayed some dazzling portrayals out of which, Kavitha Venugopalan from B. Des 3rd year was the winner.

Stick game: An event that tickled the creativity of the students while testing their managing skills. It was conducted on 20th of January, 2017 under MELA. Dakshita and Manav from B. Des 2nd year stood first, succeeded by Poorvakshi and Vipasha of B. Tech-Chemical Engineering 2nd year.

Mini Militia Tournament: On 20th of January, 2017, IIChE UPES Student Chapter organized Mini Militia Tournament under entertainment section of MELA. The grand level participation from all over the University was eye-catching. Sayan Mondal of B. Tech-CSE IT Infra 2nd year held the top spot followed by Kunal Chetwani of B. Tech-ADE 2nd year.

Music Maestro: Of all the elements of the world, Music can never be forgotten even on the saddest of days. Music Maestro was conducted in the Vivekanand Auditorium. It was a two round event and the top five teams from the first round were called upon to compete for the ultimate position which was joyfully bagged by Ritwik Mukharjee and Latika Sharma of B. Tech-Chemical Engineering 2nd year.

TURN COAT

As an initiative by the Petroleum and Chemical Department of UPES, all the Student Chapters governing the petroleum sector were called upon to collaborate in order to conduct events for conveying awareness on road safety and health. IIChE UPES SC under health week conducted Turn Coat. The event was an extempore round with a slight twist. Shradha Sood from B. Tech APE Upstream 2nd year was victorious.

DISTINGUISHED LECTURE 3

On the 31st of March, 2017, IIChE UPES SC organised a distinguished lecture by one of the eminent personalities of the Chemical Engineering domain, Dr. Uday Agarwal, FNAE, who is currently working as the President, R&D Management at Grasim Industries Ltd. Mumbai. He has a series of prestigious awards to his name which decorate his successful career. The interactive session revolved around the current scenario of the industries and the need of the hour: Innovation. Dr. Agarwal presented his views on the different products that have changed the world, indicating towards the creativity behind them. Emphasising on the fact that the different companies demand a wave of new ideas, Dr. Agarwal motivated the students of UPES, Dehradun. An overwhelming response from the crowd was a proof of agreement of thoughts.

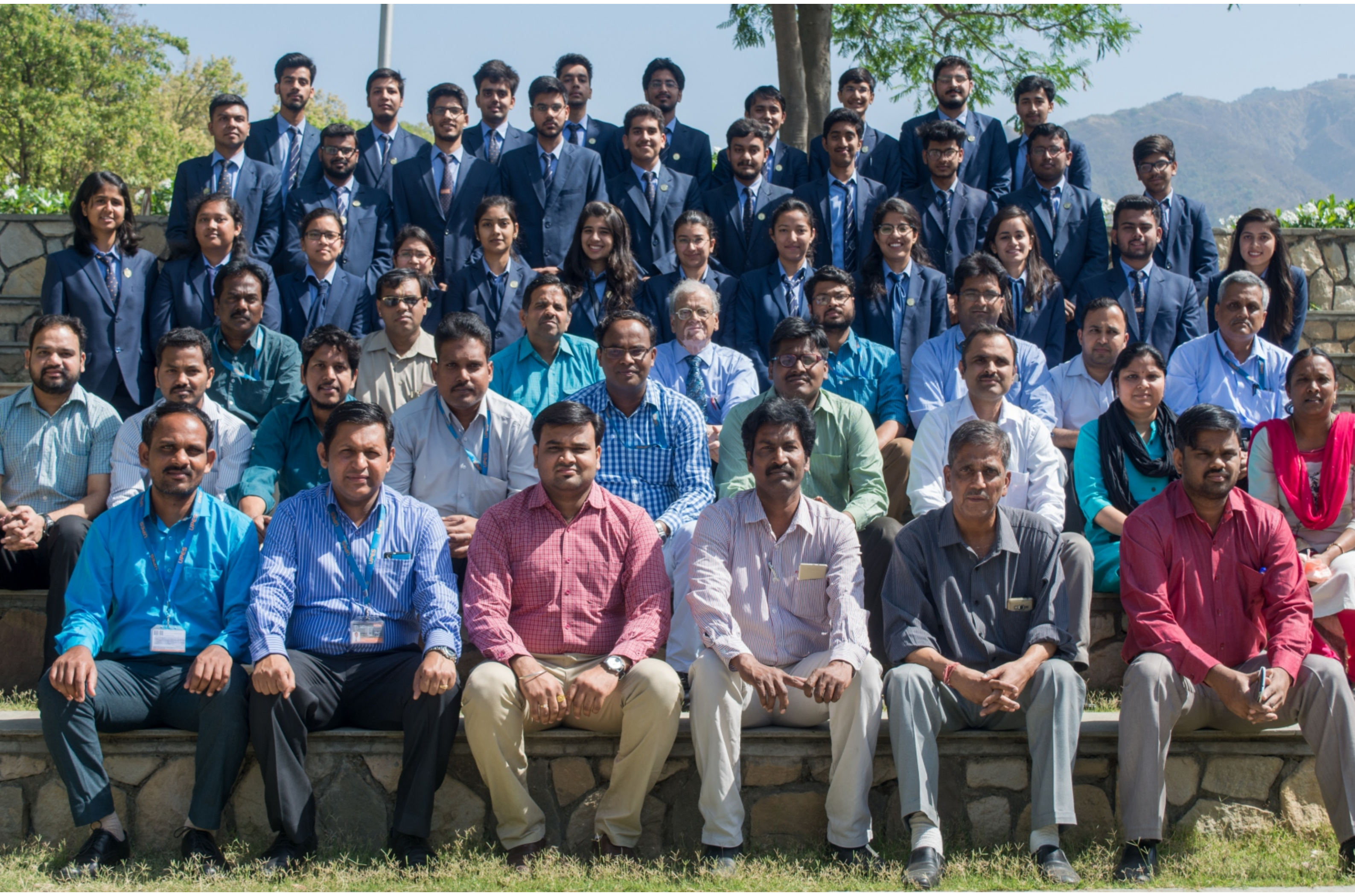
IGNITE 2017

Under the frame of Ignite-2017, IIChE UPES Student Chapter conducted three events, namely, Industrial Design Problem, Chem-e-Car and Prezento.

Industrial Design Problem: IDP was a case study which was conducted during the days of ignite. A participation of a team of not more than three members was entertained. The event was a two phase event which included an abstract submission which was followed by a presentation in front of the judges.

Chem-E-Car: A dazzling event dealing with the construction of a model car running on power source involving a chemical reaction. A craft between mechanical and chemical engineering, the event saw a great turn up and was the highlight of IIChE UPES Student Chapter's campaign under the banner of Ignite 2017.

Prezento: Prezento was a technical paper presentation competition with respect to the Chemical Engineering domain. The event was, again, a dual round event with abstract submission in the first round, followed by presentation in front of judges. It certainly was a platform for the aspiring engineers to showcase their talents in research and innovation.



Hydrothermal Liquefaction of Biomass:

A catalytic view point

Dr. G Gopalakrishnan

University of petroleum
and energy studies

Abstract

Hydrothermal liquefaction is an advantageous option among the thermochemical conversions of biomass into oil meeting the requirements of auto fuels in presence of hot compressed water which act as solvent, reactant and catalyst. The process involves the hydrolysis of complex molecules into simple sugars, amino acid, fatty acids which is catalysed by the hot compressed water itself, followed by deoxygenation to simple hydrocarbons, which needs presence of catalysts. Basic catalysts like K_2CO_3, KOH, Na_2CO_3 and others like Pt/Al_2O_3, $Co\text{-}Mo/Al_2O_3$, FeS, Pd/C, Pt/C, Zeolites, mixed $TiO_2\text{-}ZrO_2$ have been reported as catalysts yielding higher amount of oil. With the objective of developing a better deoxygenation catalyst to bring down the oxygen content in the oil, lFe-MCM-41 was synthesized and its kinetics was studied. From the XRD, surface area and SEM studies, it was found that nucleation of Fe-MCM-41 starts around 20 hours and maximum crystallization was achieved 24 hours and thereafter metastable MCM-41 was progressively converted into lamellar Fe-MCM-50.

Introduction

Increasing population, industrialization and improved living conditions resulted in huge consumption of conventional sources of energy like coal, oil & natural gas, leading to forecasted energy and environmental crisis. According to international energy outlook 2013 published by US energy information administration (US energy information administration, Washington, 2013), world energy consumption will rise from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040, an increase of 56%. This resulted in the worldwide energy-related carbon di-oxide emission of about 31 billion metric tons in 2010 which is projected to rise to 36 billion metric tons in 2020 and then to 45 billion metric tons in 2040, a 46-percent increase, expected to cause a long-term global average temperature increase of 3.6 °C. (World energy outlook 2013)

As the projected energy requirement is very huge coupled with the limited availability of fossil fuel like coal, oil and natural gas and to mitigate the problem of global warming, the bio-mass and fuels derived from it, became an attractive alternative source of fossil fuel, as biomass is carbon neutral from life cycle view point. There are different methods to convert biomass to fuels such as pyrolysis, hydro pyrolysis and hydrous pyrolysis or hydrothermal liquefaction (HTL) of which HTL has advantages over others like it can handle wet biomass which means elimination of the energy intensive drying step and can easily break down the thermally resistant biomass components like lignin at a temperature 200 °C less than required by other methods.

HTL is a thermochemical process for the conversion of biomass by the hydrolysis of the natural bio-polymers present in the biomass like lignocellulose, hemicellulose, fats, proteins etc. by hot compressed water, playing the role of solvent, reactant and catalyst, and the deoxygenation of hydrolysed products into bio-oil meeting the requirement of auto fuels in petrol and diesel range.

Hot compressed liquid water near its thermodynamic critical point ($T_c = 373.95\,^{\circ}C$, $P_c = 22.064$ MPa) behaves very differently from liquid water at room temperature. As water is heated along its liquid-vapor saturation curve, its dielectric constant decreases due to the hydrogen bonds between water molecules becoming fewer and less persistent and thus increases its solvating properties for biomass. Then the ionic product of water increases with temperature up to about 280 °C which leads to higher levels of hydronium ions in hot compressed water and thus accelerates the rates of acid-catalysed hydrolysis of biopolymers present in the biomass.

Role of water in the formation of petroleum was known as early as 1922 by Gavin who concluded water vapour was retarding agent for the formation of petroleum whereas for the first time in 1964 Jurg etal concluded water assisted the formation of petroleum. In 1979 Lewan carried out the hydrous pyrolysis of Woodford shale and compared the composition of hydrous pyrolysate with the natural Woodford crude oil and from the similarities of composition he concluded that hydrous pyrolysis approaches the duplication of natural process of petroleum formation (Lewan et al 1979).

Thus the development of catalysts for HTL which can result in bio-oil containing less oxygenates is an important area of research in the field of biofuels. More importantly catalytic hydrous pyrolysis can be a potential alternative to biological treatment of ever increasing domestic and industrial liquid organic wastes which is inherently slow and thus making waste management a serious problem in huge cities and hence successful development of HTL can help to convert the liquid waste into valuable liquid fuels quickly.

Catalytic View Point

In 1970 Appell et al studied the HTL of cellulosic biomass in the presence of hydrogen and carbon monoxide as process gas with and without sodium carbonate as catalyst and concluded that highest conversion of 90% with the highest oil yield of 30 to 40% in the presence of carbon monoxide with sodium carbonate as catalyst in the temperature range 250 to 400 °C and at the pressure of 4000 psig (Appell et al 1970).

Karagoz et al carried out hydrothermal liquefaction of pine wood biomass in the absence and presence of catalysts (NaOH, Na_2CO_3, KOH, K_2CO_3, RbOH and CsOH) at 280°C for 15 minutes. All these base catalysts increased the biomass conversion and oil yield and they can be arranged in the decreasing order of their catalytic activity as $K_2CO_3 > KOH > RbOH > Na_2CO_3 > NaOH > CsOH$, the highest conversion of 96% and oil yield of 33.7% for K_2CO_3 (Karagoz et al 2004 & 2005).

As hydrolysis of cellulosic biomass to monomer like glucose occurs in hot compressed water quickly without the catalyst and the key issue to be unlocked is deoxygenating the glucose to hydrocarbon, in 2006, Watanabe et al conducted HTL of glucose at 300 °C for 30 to 60 minutes with $KHCO_3$ and Co_3O_4 as catalysts in the presence and absence of HCO_2H as hydrogenating agent. Addition of Co_3O_4 enhanced the oil yield, but since half of the catalysts got dissolved after the reaction, they suggested its modification with the metals like Bi, Cd, Ga, Ir, K, Mo, Ta or W to improve the physical strength and stability the catalyst. (watanabe et al 2006)

In 2010 Ross et al investigated liquefaction of two types of algae Chlorella and Spirulina at 300 and 350 °C in presence of catalysts like potassium hydroxide, sodium carbonate, acetic acid and formic acid for 60 minutes. They concluded that the oil yield was higher but the heating values of oil were less in the presence of organic acids when compared to alkali catalysts. (Ross et al 2010)

In 2010 Chareonlimkun et al evaluated the HTL of sugarcane bagasse, corn hub and rice husk with TiO_2, ZrO_2 and mixed TiO_2-ZrO_2 as catalysts at a temperature range 200 - 400 °C. They observed that among these catalysts TiO_2-ZrO_2 was found to be the most active yielding maximum furfural and 5-hydroxymethylfurfural from corncob at 300 °C as it promotes hydrolysis, isomerization and dehydration reactions faster (Chareonlimkun et al 2010)

In 2011 Duan et al carried out the HTL of "Nannochloropsis" microalgae at 350 °C in the presence of six different catalysts (Pd/C, Pt/C, Ru/C, Ni/SiO_2-Al_2O_3, Co-Mo/ϒ-Al_2O_3 and Zeolites) in the presence of He and H_2. With He and H_2, the oil yield is 35% and 48% respectively in the absence of catalyst whereas in the presence of various catalysts, Pd/C gave maximum oil yield of 58% in the presence of He while Pt/C gave the maximum oil yield of 52% in the presence of H_2 with highest heating value of 40.1 MJ/Kg. (Duan et al 2011)

In 2011 Biller et al carried out the HTL of algae in the absence and presence of Co-Mo/Al_2O_3, Pt/ Al_2O_3 and Ni/ Al_2O_3 catalysts and found that catalytic HTL yielded oil with higher heating values owing to higher deoxygenation. (Biller et al 2011)

In 2011, Zhang et al conducted the co-liquefaction of secondary pulp mill sludge and waste newspaper in hot compressed water with a total solid concentration of 11.3 wt% at temperatures 250-380 °C for 20 minutes in the presence and absence of catalysts like FeS, HCO_2H and KOH of 5 wt% of the total solids (on dry basis). Addition of catalysts increased the oil yield by 8% and there is a synergistic effect between the feed stocks compared to liquefaction of either of them alone in terms of biomass conversion and oil yield. (Zhang et al 2011)

In 2015, Nazari conducted the hydrothermal liquefaction of birch wood sawdust with and without catalysts at 300 °C for 30 minutes. The catalysts evaluated were KOH, $FeSO_4$, K_2CO_3, MgO, synthetic hydrotalcite (HT) and ground colemanite of which $FeSO_4$ and MgO yielded less oil but having higher heating value, the oil obtained with $FeSO_4$ was 31 MJ/Kg which was the highest while KOH and other alkaline catalysts have given higher oil yield with lower heating value. (Nazari et al 2015)

Thus it can be concluded that the catalyst increases the yield and quality of oil in terms of heating value by bringing higher degree of deoxygenation during HTL. Hence the objective of this research is to develop a catalyst that can support the water gas shift reaction in the presence of carbon monoxide as a process gas resulting in hydrogen radical in situ which along with CO can bring deoxygenation more effectively to bring down the oxygen content in the oil, meeting the requirement of auto fuels. Since Fe and Co are well known catalysts for water gas shift reaction, Fe and Co substituted MCM-41 are prepared and the studies on the kinetics of Fe-MCM-41 is reported in this paper which has not been reported before, to the best of our knowledge.

Synthesis and Characterisation of Fe-MCM-41

28.42g of sodium meta silicate was dissolved in 50 ml of distilled water taken in a Polypropylene bottle and stirred for 30 minutes. To this 0.202g of ferric nitrate, dissolved in 10ml of distilled water was added drop wise under stirring and aged for 1 hour. To this, 80 ml of 2N H_2SO_4 was added drop wise under stirring to bring the pH to around 10-11 and aged for 2 hours resulting in a gel. To the gel 6.728 g of Cetyl trimethyl ammonium bromide (surfactant) dissolved in 20 ml of distilled water was added drop wise under stirring and kept for 2 hours. Then the mixture was transferred into autoclave of 300 ml and kept in the air oven at 150 ºC. Autoclave was withdrawn after different crystallization time viz 12, 18, 20, 22, 24, 26, 28, 30, 36, 48, 60 and 72 hours by following the above procedure for each crystallization time. The autoclave was air cooled and the contents was filtered and washed with distilled water till the pH becomes 10. The samples were dried at 110 °C for 4 hours in hot air oven followed by calcination at 550 °C for 6 hours in electrical muffle furnace.

The XRD pattern of the samples were recorded in the 2ϴ range of 0.5-10º with Bruker D8 Advance diffractometer using nickel-filtered Cu Kα radiation (λ = 1.54 Å) and liquid nitrogen cooled germanium solid state detector. The SEM images were recorded with SEM-Zeiss EVO-40 EP with 30nm (HV SE) resolution, magnification up to 10,00,000 X and sample viewing at high vacuum, with conductive coating of Gold. The surface area, Pore volume and pore size distribution were measured by nitrogen sorption at -195.85 °C using Micromeritics ASAP-2020. The samples were degassed at 200 °C and 1.3 X 10-3 Pa for 8 hours prior to the adsorption. Pore size distribution was estimated using BJH algorithm available as built-in software from micrometrics. From the value of unit cell parameter 'a' calculated using XRD data and pore diameter values obtained using BJH algorithm, the wall thickness was calculated using the Equation 1;

$$\text{Pore Wall thickness (WTH)} = a - \text{Pore diameter} \quad (1)$$

Results and Discussion

X-ray diffractogramms of the calcined MCM-41 samples obtained at different crystallization time are shown in figure 1.

From the XRD results, it is found that no crystallization is observed up to 18 hours. The samples obtained at 20 and 22 hours have shown a peak at around 2ϴ of 2.5° which is the predominant peak shown by MCM-41 due to (1 0 0) diffraction lines. Sample obtained at the crystallization time of 24 hours besides the peak at 2.5º, shown three weak peaks at 3.9, 4.5 and 6.8º, characteristic higher order peaks corresponding to (1 1 0) , (2 0 0) and (2 1 0) planes respectively, indicating the formation of well-ordered hexagonal MCM-41 mesoporous materials (Malose et al 2009).With further increase in crystallization time , higher order peaks vanish and the intensity of predominant peak at 2.5° also decreases. This indicates that the MCM-41 is transformed into thermodynamically more stable lamellar structure known as MCM-50. This observation is further supported from the SEM images (Figure 2)wherein the sample obtained at 24 hours matches with SEM images of well-ordered MCM-41 reported in the literature whereas the SEM images of the samples obtained at longer crystallization times viz 36, 48 and 72 hours show irregular petals like structure. From adsorption isotherm of nitrogen (Figure 3), it is inferred that the sample follows type IV isotherm. From pore distribution of Fe-MCM-41 (Figure 4), it is clear that there is a narrow pore size distribution of 2.5 to 3.5 characteristic of mesoporous MCM-41. From the Table-1, the surface area and the pore volume are the highest for Fe-MCM-41 obtained, for the crystallization time of 24 hours and its wall thickness is 1.39 which is very close to the reported value of Fe-MCM-41 (Szegedi et al 2004), once again confirming the highest crystalline order. Therefore from XRD, SEM and surface area measurements, it is concluded that nucleation of Fe-MCM-41 starts around 20 hours and crystallization is achieved maximum at 24 hours and thereafter metastable MCM-41 is progressively converted into lamellar Fe-MCM-50.

Conclusion

Fe and Co, well known catalysts for Fisher-Tropsch synthesis and water-gas shift reaction, expected to generate hydrogen radicals in situ in the presence of CO as process gas and along with remaining CO can bring effective deoxygenation of oil to bring down its oxygen conten. By incorporating the same in silicon rich MCM-41 frame work will provide the required hydrothermal stability and hence Fe-MCM-41 was synthesized and its kinetics was studied. From the XRD, Surface area measurement and SEM analysis of Fe-MCM-41, it was found that 24 hours is the optimum crystallization time yielding highly crystalline samples.

Acknowledgements

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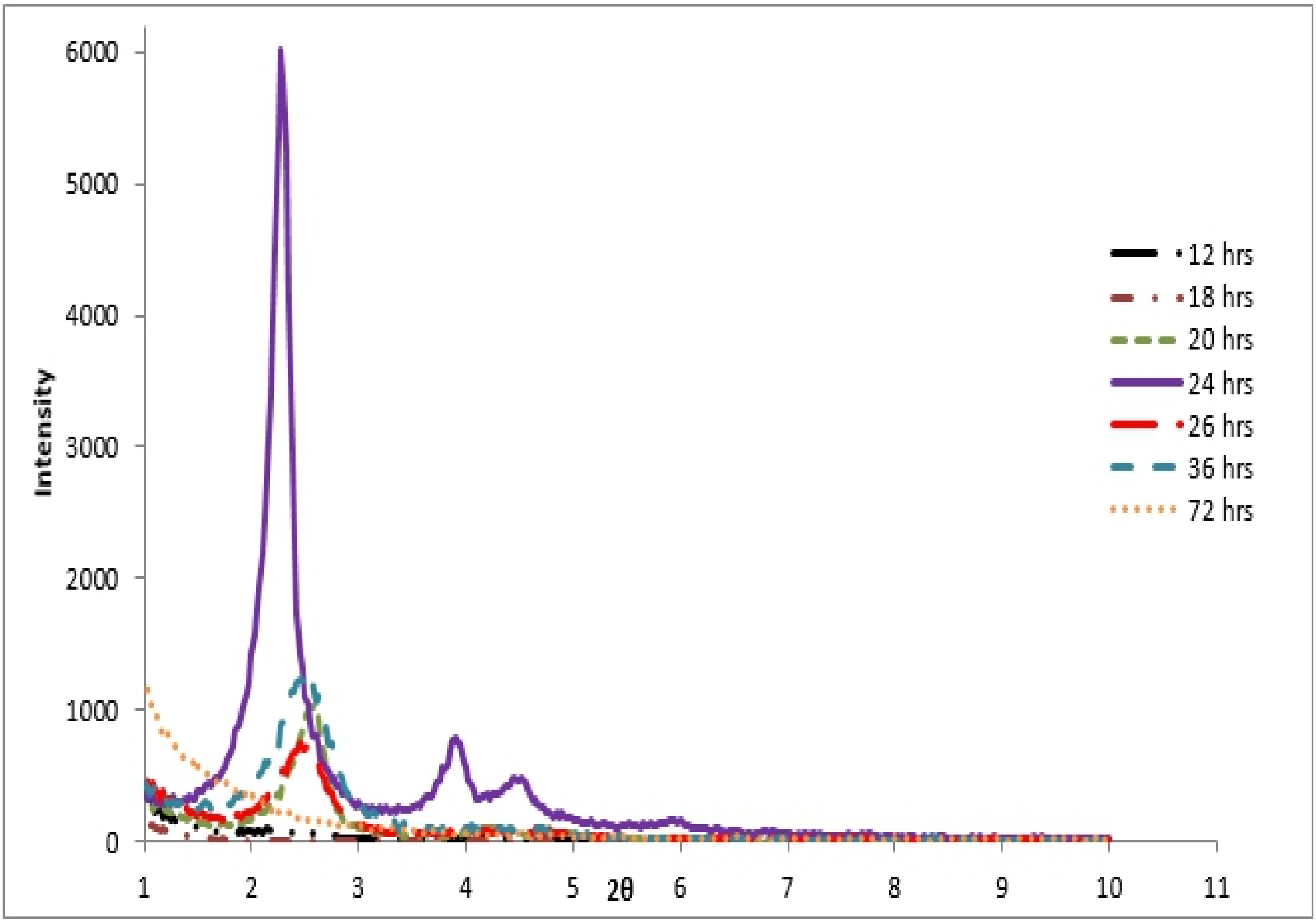

Figure1. XRD pattern of Fe-MCM-41 for different crystallisation time

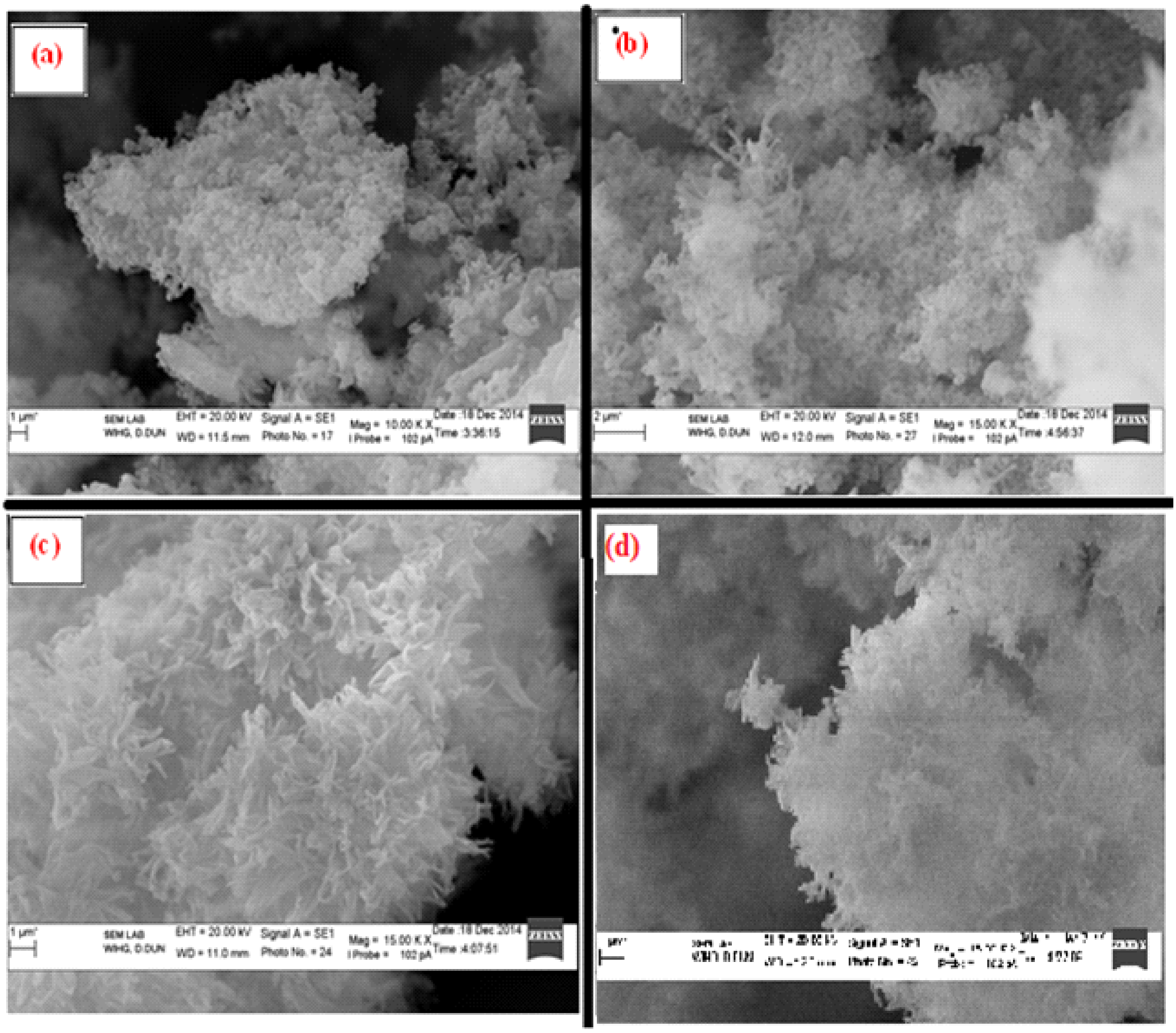

Figure 2. SEM images of Fe-MCM-41 obtained at (a) 24 hours, (b) 36 hours (c) 48 hours, (d) 72 hours

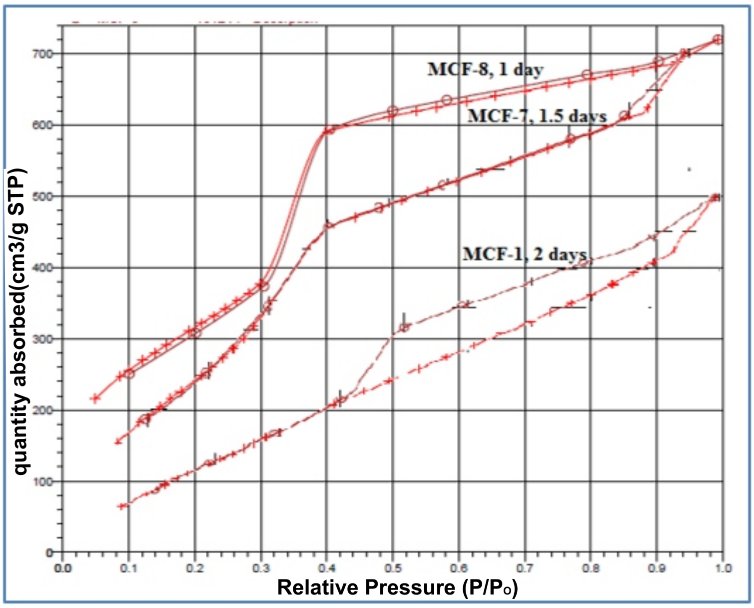

Figure 3. Nitrogen sorption of Fe-MCM-41

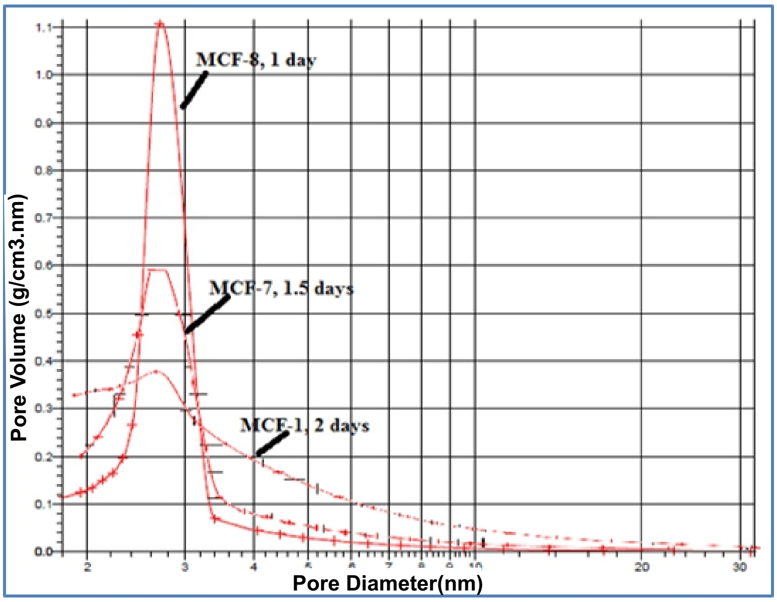

Figure 4.Pore size distribution of Fe-MCM-41

Sl.no	Sample code	Crystallization timing in Hrs	d (1,0,0) {nm}	a (1,0,0) {nm}	BET S.A. m^2/g	Pore Volume, BJH$_{ads}$, cm^3/g	Average Pore Diameter, BJH$_{ads}$, nm	Wall Thickness, nm
1	MCF-31	12	4.104	4.74	542	0.8254	5.741	-1.001
2	MCF-8	24	3.865	4.46	1211	1.1045	3.0677	1.3923
3	MCF-7	36	3.53	4.07	685	0.9724	3.4384	0.6376
4	MCF-1	48	4.04	4.66	637	0.7090	4.7660	-0.102
5	MCF-5	72	4.39	5.06	613	0.828	5.5406	-0.4716

Table1. XRD and nitrogen adsorption measurement results of Fe-MCM-41

- ***References***

- *International energy outlook 2013 with projections to 2040, US energy information administration, Washington, 2013*
- *International energy agency ,World energy outlook 2013*
- *M.D. Lewan, Winters J. C., and McDonald J. H. Generation of oil-like pyrolyzates from organic-rich shales. Science 203, 897-899, 1979.*
- *Appell, H.R., Y.C. Fu, S. Friedman, P.M. Yavorsky, and I. Wender. Converting Organic Wastes to Oil: A Replenishable Energy Source. Report of Investigations 7560. Washington, DC : U.S. Bureau of Mines, 1970.*
- *Selhan Karagoz, Thallada Bhaskar, Akinori Muto and Yusaku Sakata, Catalytic hydrothermal treatment of pine wood biomass: effect of RbOH and CsOH on product distribution, J Chem Technol Biotechnol 80:1097–1102, 2004.*
- *Selhan Karagoz, Thallada Bhaskar, Akinori Muto, Yusaku Sakata, Toshiyuki Oshiki and Tamiya Kishimoto, Low-temperature catalytic hydrothermal treatment of wood biomass: analysis of liquid products, Chemical Engineering Journal 108, 127–137, 2005.*
- *Masaru Watanabe, Florian Bayer and Andrea Kruse, Oil formation from glucose with formic acid and cobalt catalyst in hot-compressed water, Carbohydrate Research 341, 2891–2900, 2006*
- *A.B. Ross, P. Biller, M.L. Kubacki, H. Li, A. Lea-Langton and J.M. Jones, Hydrothermal processing of microalgae using alkali and organic acids, Fuel 89, 2234–2243, 2010.*
- *A. Chareonlimkun, V. Champreda, A. Shotipruk, N. Laosiripojana, Catalytic conversion of sugarcane bagasse, rice husk and corncob in the presence of TiO2, ZrO2 and mixed oxide TiO2–ZrO2 under hot compressed water (HCW) condition, Bio resource Technology 101 4179–4186, 2010*
- *Peigao Duan and Phillip E. Savage, Hydrothermal Liquefaction of a Microalga with Heterogeneous Catalysts, Ind. Eng. Chem. Res. 50, 52–61, 2011*
- *P. Biller, R. Riley, A.B. Ross. Catalytic Hydrothermal Processing Of Microalgae: Decomposition And Upgrading Of Lipids. Bioresource Technology 102, 4841–4848, 2011.*
- *Linghong Zhang, Pascale Champagne and Chunbao (Charles) Xu c, Bio-crude production from secondary pulp/paper-mill sludge and waste newspaper via co-liquefaction in hot-compressed water, Energy 36, 2142-2150, 2011*
- *Laleh Nazari, Zhongshun Yuan, Sadra Souzanchi, Madhumita B. Ray and Chunbao (Charles) Xu, Hydrothermal liquefaction of woody biomass in hot-compressed water: Catalyst screening and comprehensive characterization of bio-crude oils, Fuel 162, 74–83, 2015*
- *Szegedi, A.; Kónya, Z.; Méhn, D.; Solymár, E.; Pál-Borbély, G.; Horváth, Z.E.; Biró, L.P.; Kiricsi, I. Spherical Mesoporous MCM-41 Materials containing Transition Metals: Synthesis and Characterization. Appl. Catal. A: Gen. 272, 257–266, 2004.*

Carbon Capture and Storage in Indian Coal Seams - A Numerical Study


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Abstract: Combating climate change by mitigation of release of the anthropogenic greenhouse gases has attracted worldwide attention towards research and policy formulations. One such approach utilizes the geological sequestration of carbon dioxide into coal beds which is a value addition process, capable of enhancing the yield of coalbed methane (CBM) in producing reservoirs. CO_2 is preferentially adsorbed onto the microporous structure of coal seams and it displaces the methane molecule from the adsorption sites, thereby enhancing the production of the low carbon eco-friendly fuel. In this study, a finite difference based reservoir simulator, COMET3, has been utilized for construction of underground coal bed scenario for Indian seams.

Numerical modeling involves solving complex equations used to describe some physical process by iterative approximate solutions. Such simulation is worked out for underground coal of Lower Gondwana sequence in Jharkhand state in India. Laboratory tested parameters and some from published data were utilized for construction of the numerical model. The best fit model was developed for estimation of the volumes of gases involved in CO_2 enhanced coalbed methane recovery. It also gives a detailed analysis of distribution of gases with time and space.

The results obtained from the simulation are quite encouraging and ascertain that the process of CO_2 enhanced CBM recovery seems to be technically feasible for Indian scenario also. The simulation was executed for a period of 20 years to understand the space-time disposition of injected CO_2 and recovery of methane from the reservoirs. It is quantified in this study that for the chosen dimensions of coal block, a total of 15.1 bcf of CO_2 can be injected into the reservoir and approximately 5.0 bcf of methane can be recovered.

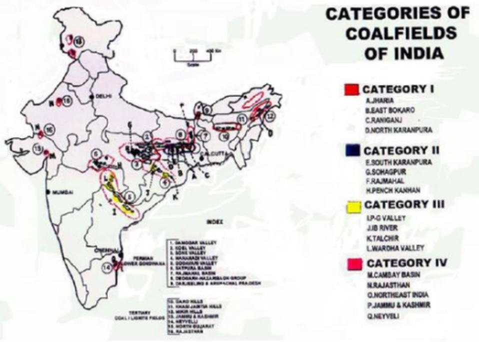
Keywords: Carbon capture and storage, CO_2, ECBM Recovery, Indian coal seams

Introduction: Carbon dioxide (CO_2) is the leading Green House Gas (GHG) mainly responsible for global warming. CO_2 emissions in the atmosphere have increased over the past 200 years from about 280 parts per million (ppm) to the current 380 ppm levels, a nearly 30% increase. One way to reduce CO_2 emission will be to replace fossil fuels by clean sources of energy. However, the established markets and availability of resources such as oil, natural gas and coal are bound to remain so in several years to come. Therefore, an achievable option is to reduce CO_2 emissions. IPCC report (2005) suggested the following options to meet this goal: to improve energy efficiency by reducing the fossil fuel consumption, switching from high carbon to low carbon fuels, increased use of low or near zero carbon fuels, sequester CO_2 through the enhancement of natural, biological sinks, carbon capture and storage (Gentzis, 2000, White et al, 2003). Geological sequestration means —the capture of CO_2 directly from anthropogenic sources and disposing it deep into the ground for geologically significant periods of time‖ (Bachu, 2002). These geological formations include deep saline aquifers, depleted oil and gas reservoir, CO_2 driven enhanced oil recovery, deep unmineable coal seams, CO_2 driven enhanced coal bed methane (ECBM) recovery, deep saline filled basaltic formation and other similar geologically sound formations. Coal is one of the most interesting sinks for the sequestration of CO_2 as it not only offers a high storage capacity of the greenhouse gas, but in turn may also release the less recoverable methane which is a low carbon, green fuel.

Carbon Storage in Indian Coals: Capture and storage of CO_2 in coals is mainly by the process of adsorption of the gas onto the porous microstructure of coals. Holloway et al. (2009) analysed the possibilities of CO_2 storage in the Indian subcontinent into deep saline aquifers, depleted oil and gas reservoirs, basalt formations and unmineable coal seams. The unminable coal seams have high potential for production of coal bed methane and are prime targets for CO_2 sequestration. The economics analysis states that the recovery of the partly offsets the cost of sequestration. In this process, CO_2 is injected into the coal seams and is used to extract methane. Injected CO_2 alters the partial pressure of methane and enhances its desorption from the matrix. CO_2 additionally is preferentially adsorbed onto the porous surface of the coal thereby displacing methane from adsorption sites (Arri et al., 1992, Greaves et al., 1993, Gunter et al., 1997, Gentzis, 2000, Mastalerz, 2004, Mazumder et al., 2006). The adsorption mechanism in coal offers a safe disposal of the GHG in these strata even if production of CBM is not economically feasible.

India has huge reserves of coal and among the top coal producers in the world. Coals not only produce maximum CO_2 per unit energy but also offer the major energy security to India. A preliminary investigation by Holloway et al. (2007) and IEAGHG (2008) suggests that huge CO_2 storage potential exists in the major coalfields in India and it could be of the order of 345 Mt i.e. approximately 6000 bcf of CO_2, while Mendhe et al. (2011) estimated a total CO_2 storage capacity of 4459 Mt (equal to 80.26 tcf) in the Indian coalfields. This is indeed a huge potential of the coalfields to capture the GHG, considering the large volumes of their emissions in India. This highlights the importance of working out the capacity of coals in the country for long term safe disposal of carbon dioxide.

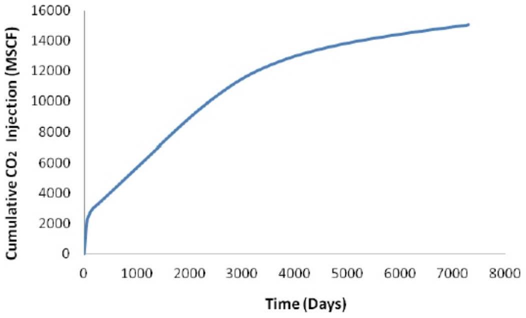
Coalbed Methane: An imminent Alternative Energy in India: Traditionally, methane has been identified as an evil companion of coal leading to major safety hazards in the past. Today, it is recognized as one of the prime energy sources across the globe which releases less waste gases per unit of energy. Methane forms in coal during the coalification process and remains trapped within the source itself. Coals in India are of two categories based on their period of formation, namely Gondwana coal and Tertiary Coal. Nearly 99% of the total coal reserves in India belong to Gondwana basins and are characteristically different from the rest of Tertiary coal. Based on coal rank, coal maturity, available area, chemical attributes of coal, CBM potential, depth of occurrence of coal and geological age, Peters et al. (2001) categorized the Indian coal basins into four types (Fig. 1). Category I coalfields include coals with high rank and maturity having think coal seams with huge reserves of methane gas and sorption capacity. These include mainly Jharia, Raniganj, Bokaro and North Karanpura basins of Gondwana Supergroup. Category II and Category III coalfields occur in the Damodar and Mahanadi valleys mainly and also belong to Gondwana basins, but they have lesser maturity, low rank and less gas content. The fourth category encompasses the Tertiary coals in India, namely in the Cambay basin, Bikaner-Nagaur basin, Cauvery basin, Assam-Arakan basin and coals of Pir Panjal. These are believed to contain less volume of methane gas in place, however, may prove to be prospective later with advancement in technology and improved understanding of the methane recovery process. Activities have started with success in most of the Category I basins. CBM is emerging as a challenging option to meet with the growing energy demands and also cutting down the emissions of per unit energy release.



Coal behavior in CO_2 – ECBM Process: Coal seam gas (CSG) typically contains more than 95% methane other than fewer quantities of higher hydrocarbons or some CO_2. Seams with fairly good quantities of methane are targeted for production of gas on an economic scale.Understanding coal characteristics for working out production of CBM vis-à-vis storage of CO_2 is a vital step. Coal has dual porosity model represented by micropores and macropores. Gases in the micropores flow by diffusion, something like that described by Fick's Law while they follow a Darcian model during flow across the cleats. Coal seams are usually saturated with water and when a well is dug, dewatering starts and water continues to pump out from the seam. Excessive dewatering causes depressurization which leads to the release of methane from coal. Affinity of coal to adsorb CO_2 over CH_4 provides an extra advantage in storing CO_2 inside the coal seams which may lead to enhanced CBM recovery.

CO_2-ECBM Process in Indian Coals: This work relates to developing a numerical model for the general setting of coal reservoirs, belonging Gondwana Supergroup. A 3-D numerical model is developed using the simulator, COMET3, which is a multi-component, multi-phase, multi-porosity simulator capable of modeling coal bed reservoir environment. It encompasses the coal-cleat matrix represented by a well defined dual porosity system as described by Warren and Root (1963). The governing equations are those following the conservation equations for gas and water as discussed by Sawyer et al. (1990).

This model is applied for a 3000 ft x 2400 ft x 30 ft block of lower Gondwana coal at a depth of 1750 ft with two CBM production wells and one CO_2 injection well. The various rock parameters input in the model are reservoir temperature, initial matrix gas content, coal density, initial pore pressure, well bore dimensions, matrix porosity, permeability, sorption time for methane, fracture spacing, matrix compressibility, Langmuir's constants for both the components and relative permeability curves. History matching is done for the model without the case of CO_2 injection and then the same case is utilized for CO_2 sequestration and the results are discussed below. The injection of CO_2 is done in this block of coal using a central injection well and the cumulative gas injection for a period of 20 years is depicted in fig. 2. It can be observed that the rate of gas injection is high during the initial years of sequestration which is followed by a lower rate of injection upto a period of nearly 10 years. The rate of gas injection further decreases and remains almost constant till the end of this study. Towards the end period, the volume of CO_2 injected is further low. A close examination of the data generated as a consequence of this simulation indicates that the high sorption of injected CO_2 during the first year of injection decreases during which the gas takes some time for rearrangement. The peak CO_2 injection rate is attained within months of gas injection which gets modified in due course of time. The high CO_2 sorption capacity of coals enables injection of huge volumes of the GHG. Monitoring of injected gas depicts that the block of coal adsorbs nearly 3.5 bcf of CO_2 in mere one year, while at the end of 5 years, the total injected volume equals to 8.4 bcf of CO_2. Further monitoring the flow of CO_2 in the injected coal indicates that the coal adsorbs a total of 12.5 bcf, 14.1 bcf and 15.1 bcf of CO_2 at the end of 10, 15 and 20 years, respectively. Spatial monitoring the the distribution of gases indicates that the concentration of CO_2 expands on all sides and an entire range of high to low CO_2 zones is formed.

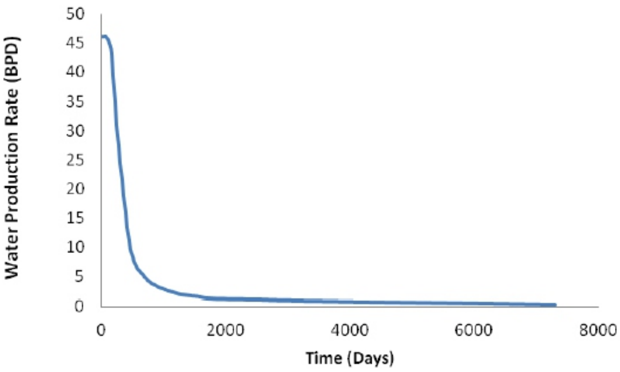


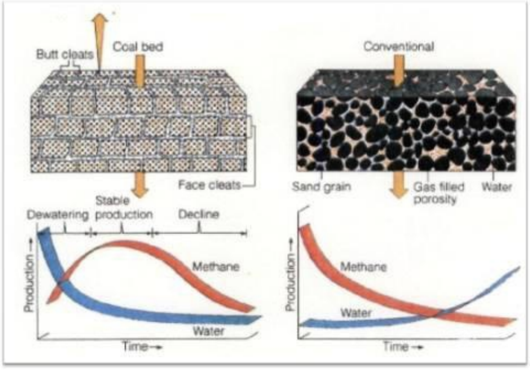
The maximum concentration zone is near to the injection well, however, it spreads as a large zone all around with time until attainment of equilibrium with the storage capacity of coal. This depicts that in due course of time; significant volumes of CO_2 may be injected into the unmineable coal seams of Gondwana Supergroup in Indian subcontinent. Injection of CO_2 in CBM reservoirs enhances the production of methane and the same was monitored in this case as the exercise is executed in the coals containing fairly good methane gas content. The initial production is marked by release of ample quantities of water which causes depressurization to induce the release of methane from the coal block. The breakthrough of methane takes place after four months of water release. At the end of first year, gas production takes place at a low rate. With further depressurization, volumes of CBM production increases. The injection of CO_2 in the coal block provides an extra drive mechanism for release of methane.

There is a sharp increase in the rate of CBM production after 2 years. The volume of CBM released at the end of 1 year and 5 years is 180 msf and 1.44 bcf respectively. A major volume of gas is produced in this decline, thereafter the CBM production increases and takes place at a more or less constant rate (fig. 3). The gas release at the end of 10, 15 and 20 years are 2.79 bcf, 3.83 bcf and 5.01 bcf, respectively.

The enhanced production of methane is primarily due to the injection of CO_2, otherwise the gas release would have declined due to reduction in formation pressure. Therefore, storage of the GHG in coal formations may be turned into a profit making business by release of green fuel, methane.

It is important to estimate the production of water from the coal seams, which depends on the characteristics and settings of the coal basin. Water management needs to be planned before the drilling of wells in the field to ensure safe and secure disposal and utility of the same in the nearby areas. The water decline curve indicates that water starts oozing out at a fairly high rate at the initiation of the process. The rate of water release from the two production wells begins at 46 b/D while it remains almost constant for nearly six months, following which it declines to a value of 30 b/D after seven months (fig. 4). At the end of first year, the water production is 19 b/D which continues to decline to 11 b/D and 6 b/D after further three months and six months, respectively.





Subsequently, water release fades away, reaching a minimum of 1 b/D after 5 years. The wells dry up towards the end of the period of study and hence, the release of gas is facilitated by the depleted pressure and the injection of CO_2.

Conclusions:

The huge reserve of coal in India offers a promising solution to combat global climate change alongside providing the clean source of energy, coalbed methane. Deep seated coals or those uneconomical for surface or underground mining are best suited for sequestration of anthropogenic CO_2. This may or may not be coupled with recovery of methane from the same, which is decided after detailed investigation of the reservoir parameters.

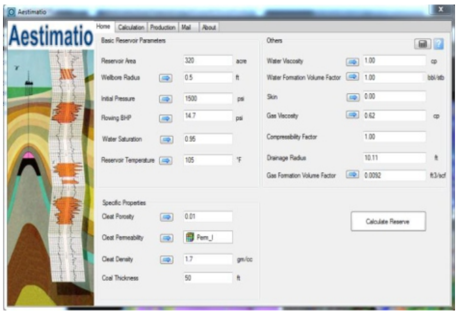
Compared to other locations for sinking of waste GHG, coal seems to be a prioritized option considering the huge gas storage capacity, mechanism ensuring safe disposal and the possibility of generation of methane. The study reveals that for the chosen dimensions of Gondwana coal block in India, a total of 15.1 bcf of CO2 may be injected for permanent storage alongside recovery of not less than 5 bcf of methane. This enhanced production of methane shall partly offset the costs of CO_2 capture, compression, transport and storage. The dual benefit approach of this mechanism of carbon capture shall not only help India meet in pace with the developing economy but also ensure its commitment towards securing a cleaner environment for future generations.

References:

- *Arri, L. E., Yee, D., Morgan, W. D. and Jeansonne, M. W. 1992. Mountain Regional Meeting, Casper Wyoming.*
- *Bachu, S. 2002. Sequestration of carbon dioxide in geological media in response to climate change road map for site Modelling coalbed methane production with binary gas sorption. SPE 24363, SPE Rocky*

- *selection using the transform of the geological space into the CO_2 phase space. Energy Conversion and Management 43 (1): 87-102.*
- *Gentzis, T. 2000. Subsurface sequestration of carbon dioxide – an overview from an Alberta (Canada) perspective. International Journal of Coal Geology 43: 287-305.*
- *Greaves, K.H., Owen, L.B. and McLennan, J.D. 1993. Multi-component gas adsorption-desorption behavior of coal. Proceedings of the 1993 International Coalbed CH4 Symposium, Tuscaloosa, AL 197—205.*
- *Gunter, W.D., Gentzis, T., Rottenfuser, B.A., Richardson, R.J.H., 1997. Deep coalbed methane in Alberta, Canada: a fossil resource with the potential of zero greenhouse gas emissions. Energy Conversion and Management 38: S217–S222.*
- *Holloway S., Garg A., Kapshe M., Deshpande A., Pracha A.S., Khan S.R., Mahmood, M., Singh, T.N., Kirk, K.L. and Gale, J. 2009. An assessment of the potential for CO_2 storage of the Indian subcontinent. Energy Procedia 1: 2607–2613.*
- *Holloway S., Pearce J.M., Hards V.L., Ohsumi T. and Gale J. 2007. Natural emissions of CO_2 from the geosphere and their bearing on the geological storage of carbon dioxide. Energy 32 (7): 1194–1201.*
- *IEAGHG, 2008. A regional assessment of the potential for CO_2 storage in the Indian subcontinent. IEAGHG R&D*
- *Programme Report, IEAGHG R&D Programme, Cheltenham.*
- *IPCC, 2005. IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by the Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C.de Conninck, M. Loos, and L.A. Meyer (eds.)]. Cambridge University Press, Cambridge, UK and New York , USA.*
- *IPCC, 2007. Climate Change 2007, The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin., M. Manning., Z. Chen., M.Marquis., K.B. Averyt., M. Tignor and H.L. miller (eds)]. Cambridge Univ. Press, Cambridge, UK and NY, N.Y. USA.*
- *Laubach, S.E., Marrett, R.A., Olson, J.E. and Scott, R.A. 1998. Characteristics and origins of cleat: a review. International Journal of Coal Geology 35: 175-207.*
- *Mastalerz, M., Gluskoter, H. and Rupp, J. 2004. Carbon dioxide and methane sorption in high volatile bituminous*
- *coals from Indiana, USA. International Journal of Coal Geology 60 (1): 43-55.*
- *Mazumder, S., van Hemert, P., Busch, A., Wolf, K. H. A. and Tejera-Cuesta, P. 2006. Flue gas and pure CO_2 sorption properties of coal: A comparative study. International Journal of Coal Geology 67: 267 – 279.*
- *Mendhe, V.A., Singh, H., Prashant and Sinha, A. 2011. Sorption Capacities for Enhanced Coalbed Methane Recovery through CO_2 Sequestration in Unmineable Coal Seams of India, In: International Conference on Unconventional Sources of Fossil Fuels and Carbon Management.*
- *Peters, J., Punjrath, N.K. and Singh, S.K. 2001. Development of Coal bed methane resources – challenges in the new millennium. Indian Geological Congress, KDMIPE, Dehradun, India.*
- *Sawyer W.K., Paul G.W. and Schraufnagel R.A. 1990. Development and application of a 3D coalbed simulator, in CIM/SPE International Technical Conference, Calgary.*

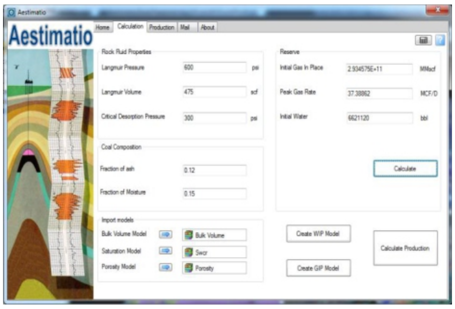
Application Interface:



Basic Reservoir Parameters
Reservoir Area 320 acre
Wellbore Radius 0.5 ft
Initial Pressure 1500 psi
Flowing BHP 14.7 psi
Water Saturation 0.95
Reservoir Temperature 105 °F

Specific Properties
Cleat Porosity 0.01
Cleat Permeability Perm_I
Cleat Density 1.7 gm/cc
Coal Thickness 50 ft

Others
Water Viscosity 1.00 cp
Water Formation Volume Factor 1.00 bbl/stb
Skin 0.00
Gas Viscosity 0.62 cp
Compressibility Factor 1.00
Drainage Radius 10.11 ft
Gas Formation Volume Factor 0.0092 ft3/scf

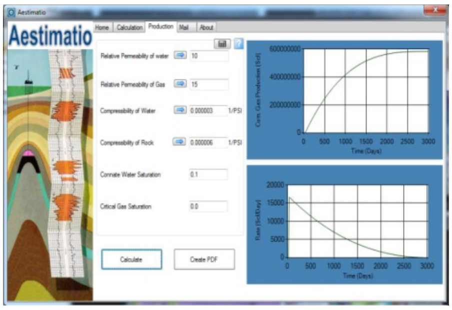


Rock Fluid Properties
Langmuir Pressure 600 psi
Langmuir Volume 475 scf
Critical Desorption Pressure 300 psi

Coal Composition
Fraction of ash 0.12
Fraction of Moisture 0.15

Import models
Bulk Volume Model Bulk Volume
Saturation Model Swcr
Porosity Model Porosity

Reserve
Initial Gas In Place 2.934575E+11 MMscf
Peak Gas Rate 37.38862 MCF/D
Initial Water 6621120 bbl



Relative Permeability of water 10
Relative Permeability of Gas 15
Compressibility of Water 0.000003 1/PSI
Compressibility of Rock 0.000006 1/PSI
Connate Water Saturation 0.1
Critical Gas Saturation 0.0

ASPEN

ASPEN PLUS is a simulation software that allow us to simulate almost any chemical engineering process. Firstly, we need understand what we mean by "Process Simulation".

Process Simulation is used to determine the size of equipment in a chemical plant, the overall yield, the amount of energy needed, and the magnitude of the waste streams.

The results of process simulation depend upon transport process, reaction engineering process, fluid and thermodynamics, therefore, the mathematical models are byzantine and would be time-consuming to solve. ASPEN can handle very complex processes, including chemical reactors ,multiple-column separation systems, distillation of chemically reactive compounds, azeotropes and even electrolyte solutions like sodium hydroxide solutions and mineral acids. Moreover, the dynamic simulation of such compounds can be done.

Aspen HYSYS is used more for refining application and oil and gas processing, process design and optimization.

Given a process design and an appropriate selection of thermodynamic models, ASPEN uses mathematical models to predict the performance of the process. This information can then be used in an iterative fashion to optimize the design.

However, in order to operate ASPEN, one requires a solid understanding of the principal chemical engineering principles to supply justifiable values of input parameters and to evaluate the suitability of the results obtained. Some preliminary or 'back of the envelope' calculations are largely recommended.

A variety of Aspen packages have been developed for different simulations. Below mentioned are the programs and capabilities:

Aspen Adsim	Fixed bed adsorption for pressure swing adsorption, etc.
Aspen Chromatography	Simulated moving bed chromatography, fixed bed adsorption. Runs independent of Aspen Plus.
Aspen Custom Mod	A utility to permit the creation of user unit operations.
Aspen Distil	Aspen's 'Conceptual Engineering Product' for planning for processing schemes. Runs independent of Aspen Plus.
Aspen Dynamics	Unsteady-state simulator.
Aspen Plus	Steady-state process simulator
Aspen Properties	Modeling of properties and phase equilibria. Incorporated into most other components, though it can be run as a stand-alone subset. All of the phase equilibria and mixture property methods discussed on this site are accessible in either Aspen Plus or Aspen Properties.
Aspen Polymers	Modeling of polymerization reactors and polymer thermodynamics. This package is available within Aspen

- ***References:***
- *http://www.chems.msu.edu/resources/tutorials/ASPEN*
- *Mahmud A, August 27,2015 Importance of Aspen Plus,Hysys,PROII,CHEMCAD in Chemical Engineering Retrieved from: https://www.linkedin.com/pulse/importance-aspen-plushysysproiicamcad-chemical-ashik-mahmud*
- *http://www.umich.edu/~elements/5e/software/aspen-creating.html*

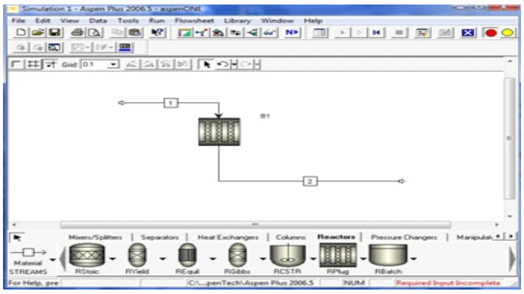
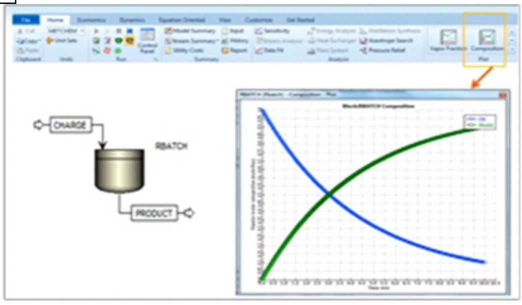


Figure: Creating a Reaction Engineering Process Model



Removal Of Toluene By Aspergillus Oryzae Using Nanoparticles Coated Membrane Reactor

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Aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylene are the representatives of volatile organic compounds (VOCs), which can produce harmful effect to human health and are suspected as possible carcinogens. With the aforesaid views, the present study attempts to develop a new biofiltration system involving a selective microbial strain isolated from aerated municipal sewage water attached with coir as packing material identification of the selected fungal isolate was made by analyzing the DNA sequences (16s rRNA) and constructed pylogenetic tree using BLASTn search procedure [1]. The environmental factors which affect the fungal growth and the degradation of toluene are tested in batch and continuous studies. Stability of the biofiltration was also tested by allowing the degradation process for 50 days. To predict the system behavior a plug flow kinetic model was developed by incorporating the Monod model [2]. Toluene degradation in batch reactors using the newly isolated Aspergillus oryzae strain showed a common optimized process parameters of pH 7.0, temperature 30°C and initial toluene concentration 1.5 (v/v)%. Under these optimum conditions the A. oryzae showed better toluene removal efficiency. Figure 1 shows that the continuous removal of gaseous toluene was performed in nanoparticles coated membrane reactor using isolated fungal species attached with coir as packing material. The effect of bed height, air flow rate and inlet toluene concentration on the performance of the reactor was studied. The maximum elimination capacity (286 g m-3h-1) was obtained with the packing height of 100 cm and the empty bed residence time 5 mintues. The biofilter performance was determined for the gas phase system by using macrokinetic approach using the plug flow model incorporated with growth model (Monod kinetics). The values of kinetic constants were evaluated by fitting the experimental data over a range of concentrations and predictions were made. Kinetic models have been developed for A. oryzae.

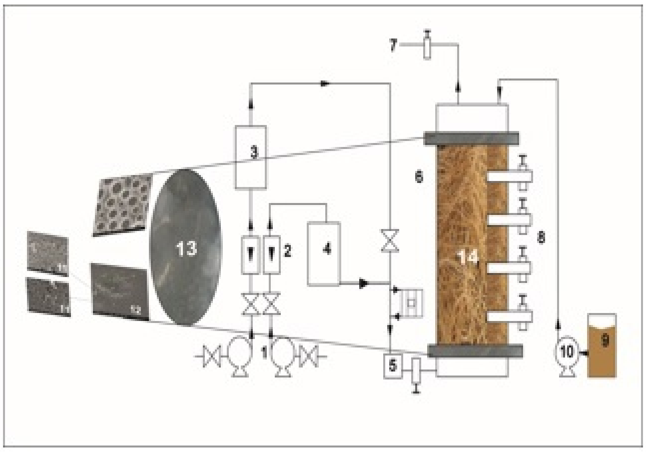


Figure 1: Schematic line diagram of Nanoparticles supported membrane reactor membrane reactor. (1) air compressor; (2) flow meter; (3) toluene; (4) humidification tank; (5) Entering point; (6) Biofilter; (7) treated gas outlet; (8) sample outlet with valve; (9) nutrient tank; (10) peristaltic pump; (11) SEM image of carbon nanoparticles; (12) SEM image of nanoparticles coated membrane; (13) Nanoparticles coated membrane

References:

[1] S. F. Altschul, T. L. Madden, A. A Schaffer, J. Zhang, Z. Zhang, W. Miller, D. J. Lipman, Nucleic Acids Res., 25 (1997) 3389.
[2] A. Aizpuru A, L. Malhautier, J. C. Roux, J. L. Fanlo, J. Air & Waste Manage. Assoc., 51 (2001) 1662.

INTERVIEW WITH MOHIT KAPADIA

1 How much has the industry transformed from the time you started working to now?

As a Chemical Engineer, one can get opportunities to work with quite a few segments within the Chemical Engineering domain itself. Be that as it may, the most popular sector is oil and gas because of various reasons- the most common one being financial remuneration.

I have been no exception to it. I wanted to be associated with the oil and gas division and hence, I shaped my career in that direction. I have witnessed many ups and downs in the oil and gas industry. I have seen other chemical industries evolving. Additionally, Industries like FMCG, pharmaceuticals are doing well from the time I graduated.

2 You have worked with many industry giants. How does the workplace and environment vary in different companies and segments of the industry?

Being Chemical Engineers, one can either choose to work with Operator Companies (E.g. Shell), Service Providers/Vendors (E.g. Schlumberger), EPC Contractors (E.g. Technip) or Simulation Companies (E.g. Honeywell). In my stint of 6 years, I have had the opportunity to work with an Operator (Reliance Industries), Service Providers (Jacobs Engineering and Dodsal Engineering) and with Simulation Company (Honeywell Automation) altogether. Working in different domains has its own differences.

Being an Operator like Reliance, the job profiles offered would be that of working on the field or in Technical Services or Projects team. The primary goal of the Operator Company is production without compromising the asset, personal or environmental safety. Working with EPC Contractors, you would be spending most of your time in the office working as a Process or Project Engineer. You might have to do field visits if required from the design point of view or during commissioning phase. A typical life cycle of a project could be around 2.5-3 years. One can be exposed to different kinds of projects thus could get a good understanding of different systems or unit operations in relatively short period of time. However, this job could get strenuous as documents need to be delivered on time. Working in a Simulation company like Honeywell will again expose you to different projects in a short period of time. You will be dealing with software like UNISIM Design. One project has typically three cycles which it goes through namely Model Acceptance Test(MAT), Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). This job would demand more traveling once you get the competency which usually happens within 1.5-2 years of joining the company.

3 How well does the college prepare you for the industry? Do you think the curriculum followed for teaching the undergraduates should be revamped/improved?

Well, I feel that the curriculum, undoubtedly, needs some tweak. I would personally appreciate if colleges would encourage the internship/co-op culture, like it happens abroad especially in the US.

Students are encouraged to take up internships/co-op after completion of the minimum coursework during their bachelor's degree decided by the University. The students can continue their co-op program along with their studies, thereafter. By the time they graduate, they have a solid 1.5 to 2 years of industrial exposure which makes them ready to face the industrial challenges right from day one of their graduation.

4 What do you wish you had more training in, before entering into the industry?

I believe that for a fresher, more than the trainings, if the students are given additional exposure to internships/co-op as addressed above, it would be of assistance to the students than any further certifications or trainings.

5 What do you think would be more suitable a degree in these times, MS in Chemical Engineering or MBA?

Well this is a very subjective question. My take on this would be if one wants to stick to Chemical Engineering and settle abroad then instead of Masters, I would say taking it one notch up by doing a PhD would be a better option. This would give you a better job stability and a better hold to settle abroad. The field of Safety and Environmental Studies too seems to be having a lot of opportunities. As an alternative, one could pursue Master's in Industrial Engineering which would be technical and also have applicability in various manufacturing industries thereby exposing students to more opportunities.

Talking about MBA, definitely, there are a lot of options after completion of an MBA degree due to the applicability in not only our industry but in any industry. Yet again, it depends in which field one wants to pursue an MBA. One needs to identify one's strength as to which would be a suitable stream to pursue an MBA in. Finance being the favorite of many but also these days supply chain and data analytics seem to be emerging fields.

Typically, one should try to get some work experience of, say, around one to two years before pursuing an MS degree. However, if one is sure about pursuing a PhD then it would be better to do that right after the bachelor's degree. If one is keen on doing an MBA in India, it would be ideal to have a work experience of around two to three years before pursuing an MBA. Moreover, if one is thinking about an MBA abroad, it is ideal to work for around five years to build a profile before pursuing an MBA degree.

If you are thinking about a MS or MBA, outside India, it is important to be aware about the government policies and other non-technical aspects which could influence your chances to find a job in those countries.

6 What opportunities did you get so far in your career for moving ahead in the industry?

To answer this question, I would say that since the time I have graduated with a Master's degree in Chemical Engineering from the University of Southern California in May 2010, there have been quite some ups and down in the oil and gas industry. I have got an opportunity to work in different segments within the oil and gas sector. I had to take up jobs and profiles which I would have given a second thought to pursue if the market would have been alright. The bright side of the downturn would be that, it has made me flexible and given me insights on different job profiles within the oil and gas sector in relatively short period of time.

7 Are there any professional courses or trainings that you would recommend to the young engineers as they enter the industry?

There are a lot of courses that one could go for at an entry level position. There are software trainings like HYSYS, ASPEN or courses on Process Engineering, Piping Engineering and many more. As far my experience goes, these courses will not give an individual a considerable edge that they might be looking for to join the industry. One needs to remember that, they need to have their fundamentals and basic concepts in place to secure a job. If the job requires any sort of training, it will be imparted to you on job.

8 How demanding is the job of a Process Engineer in terms of work and stress?

I would answer this question assuming we are talking about Process Engineers in EPC consultancies like Technip. The role of a Process Engineer becomes very critical in the EPC consultancies. A Process Engineer provides data through calculations or P&ID's (Piping and Instrumentation Diagram) or any other form which becomes the basis for other disciplines to begin their work with. Any discrepancy in the data provided by a Process Engineer could have a huge implications on the project in terms of cost or design in later stages of the project, if not identified at the right time. Secondly, when you work in an EPC consultancy, the projects are man-hour based, implying that the documents need to be delivered on time. Thus working as a Process Engineer could get demanding and challenging.

9 What are some of the safety risks related with the oil and gas industry? How does the industry cope with them?

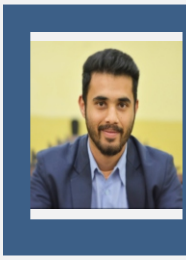
Well, safety is of utmost importance in any Chemical industry. Working in the oil and gas industry demands safety measures to be taken at all steps. There is no point where one can be complacent. Any ignorance at work could lead to a catastrophe from the asset, personal or environment point of view. A few of the risks are Fire and Explosion, Confined space entry, Leakage through high pressure lines and/or equipment, and Electrical hazards. However, it should be kept in mind at all times that, these safety risks are not just limited to the ones stated above.

10 What message would you like to give to the young readers of this magazine?

Oil and gas has always been a very lucrative field for Chemical Engineers to get into. But one should not ignore the other fields that Chemical Engineers could get into. Sectors like Specialty Chemicals, FMCG, and Pharmaceuticals are growing at a rapid scale. Being Chemical Engineers, we could find our applicability in these emerging fields as well. Not to forget the spur in the renewable sources of energy. My advice to you would be to keep an open mind and not restrict your thinking to just conventional fields like oil and gas. Correspondingly, try different job profiles in the beginning of your careers. That would inculcate qualities like flexibility and adaptability which would help you in your career at a later stage, once you decide the stream of your choice. This will also make sure that you do not get into a comfort zone in the beginning of your career and you would work hard with the right attitude to develop new skills with different job profiles. Basically, try to get maximum exposure in all domains during the beginning of your career.

Secondly, apart from professional career, also pay attention to investment planning the day you start working. This will make you more responsible and help you utilize your funds in the channelized direction. Last but not the least; try to talk to people in industries or professors if you have any idea that could be groomed into a start-up. There is no reward for work or work satisfaction you would get bigger than being an entrepreneur.

Hydrogen Detection in Refineries



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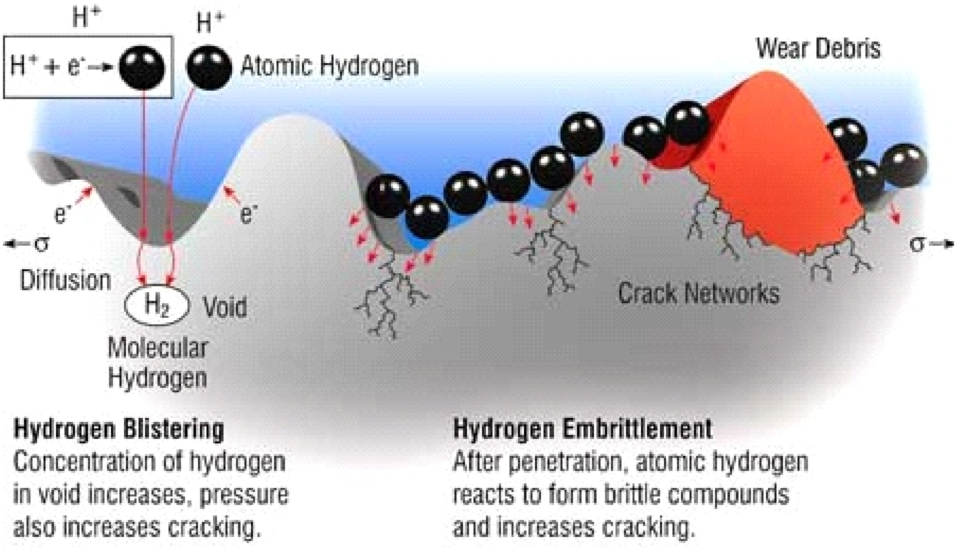
Hydrogen is a vital part of numerous refining operations, right from hydro cracking to reduction of heavy gas and gas oils to lower molecular weight component as well as treatment of gas steams, to catalytic reforming. Oil refineries have not only been the largest producers of hydrogen gas but the largest consumers as well. It also has a substantial role to play when it comes to prevention of carbon from reacting with the catalyst to extend the catalyst life and maintain the production if lighter hydrocarbons. As a result, refineries consume a handsome amount of hydrogen that is either produced on site or purchased from hydrogen production facilities.

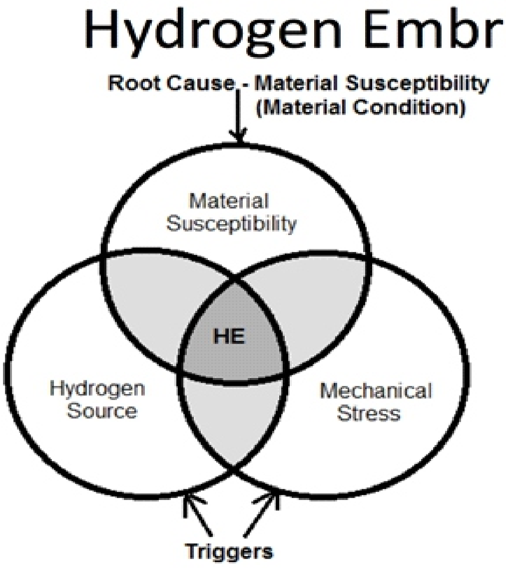
With changing environmental legislation, hydrogen gas has added to the improvement of grade of gasoline and diesel specifications. Contemporarily, the high crude prices have also promoted commercial prospects of heavier crudes, which require a more extensive hydrotreating and hydrocracking applications.

Working with hydrogen has never been easy knowing its unique properties which are challenging within the processing plants. The concerns that arise when working with hydrogen gas pivot around the fact that hydrogen gas is colorless as well as odourless and hence undetectable by human senses. Hydrogen gas detection is far away from infrared detection as well as accumulations. Hydrogen gas being lighter than air has no parameters bounding the molecular mobility at micro as well as macro levels. Hydrogen gas not only poses detection issues but safety issues as well.

Hydrogen gas causes respiratory ailments, component failure, ignition and burning. But before hydrogen could do any of this damage, its explosive mixture with air makes it highly flammable that ultimately leads to fire. With an ignition energy as low as 0.2mJ at atmospheric pressure, hydrogen is easily set afire. Apart from explosive nature, its corrosive nature is again an important aspect to look through. Hydrogen is likely to produce a mechanical failure of containing vessels, pipelines and other components. This happens due to a phenomenon called hydrogen embrittlement where long term hydrogen gas exposure causes the metals and plastics to lose ductility and strength. This results in cracking of material and eventually it's rupturing. At higher temperatures, hydrogen forms metal hydrides with the surfaces of containing metals which weakens the metal's lattice structure. This is an example of hydrogen embrittlement via chemical reaction.

The main cause of hydrogen leakage is defective seals or gaskets, valve misalignment or flanges or failures. Therefore the primary task in fire escalation and detonation is loss of contained hydrogen gas. Hydrogen has a high diffusion rate when released. If the leak occurs in open, the dispersion of hydrogen is affected by wind velocity as well as direction. Also, atmospheric turbulence and surrounding structures influence the cloud dispersion. This hydrogen gas when mixes with air can cause an explosion if an appropriate ignition source is available. Due to high dispersion rate of hydrogen, this mixture can form at any far distance making it hard to spot. processors or hydrogen separators. The fire related issues are dealt by hydrogen specific flame detectors, which protect the plants against fires.



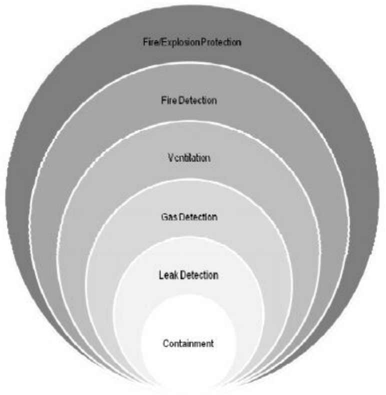


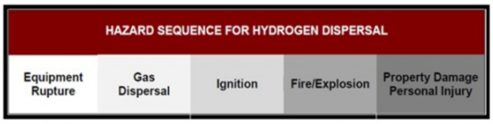
- Material Susceptibility is always the Root Cause of HE.
- Hydrogen Source and Mechanical/Tensile Load are Triggers

There needs to be a wide coverage because the hydrogen cloud diffuses rapidly and the fires may ignite at a far distance from the source of leakage.

Gas Leakage Detection Techniques

The havocs of gas leakage are done away by construction of various layers of protection to curb the hazardous propagation. The sequential layering of the containment has an effective check on the leakage hazards, with each layer acting as a safeguard. Each of the layers has a different detection technique that either adds to the scenario coverage or enhances the detection efficiency of a hazard. Such detectors are constituted of catalytic sensors, fire detectors and also ultrasonic gas leak monitors. The catalytic detector, which is a continuous hydrogen detection monitor, detects small leaks that may be due to failure of a vessel maintained at atmospheric pressure or a flange which is slowly deformed due to usage. The ultrasonic gas leak detectors respond to high pressure releases of hydrogen which are common in hydrocracking

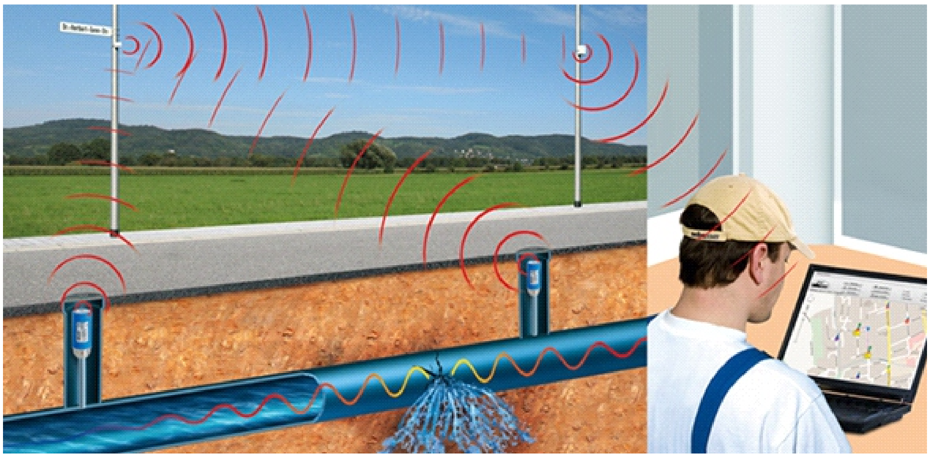




HAZARD SEQUENCE FOR HYDROGEN DISPERSAL				
Equipment Rupture	Gas Dispersal	Ignition	Fire/Explosion	Property Damage Personal Injury

Figure 1. Hazard sequence for hydrogen dispersal. Layers of protection separate each hazard state.

When the containment system fails, and hydrogen gas starts leaking from the orifice, ultrasonic monitors come into play. These monitors detect airborne ultrasound produced by turbulent flow which is above the predefined sound pressure level. The biggest advantage of this method is using ultrasound as a proxy for gas, as these don't require transport of gas to sensor element for detection of gas and are not affected by the leak orientation, plume concentration and wind directions.



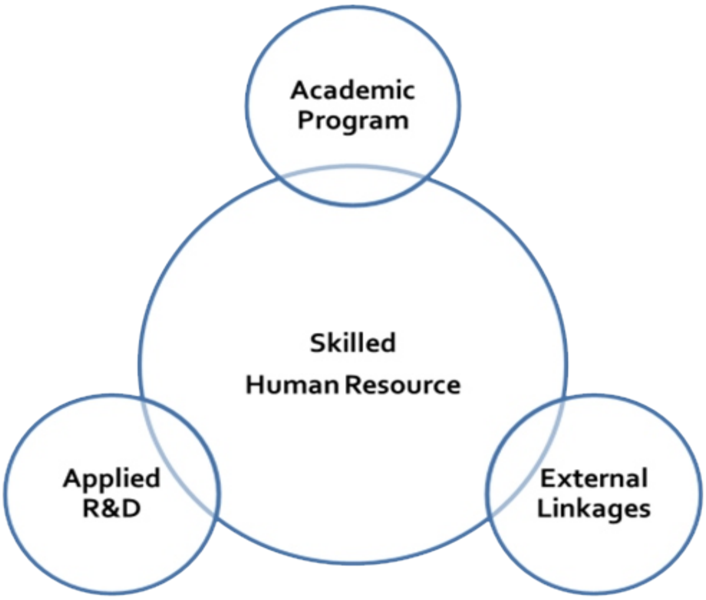
The second measure is direct gas detection by the help of a catalytic combustible gas detector. These consist of a pair of platinum wire embedded in a ceramic bead. The catalyst is coated on the active bead and the reference bead is encased in glass and is inert. When exposed to hydrogen gas, it begins to burn at the heated catalyst surface forming water molecules along with heat. This heat causes the wire's electrical resistance to change. This is linear across a wide range of temperature and proportional to concentration. When dealing with hydrogen specific catalytic detection, the reaction temperature and catalyst are designed to prevent combustion of hydrocarbons in the substrate. Where gas accumulation occurs, these detect hydrogen with a decent amount of accuracy and that too in a span of 5 to 10 seconds. As discussed earlier, infrared detection is not a viable option for hydrogen detection therefore catalytic detection is a reliable option.

The demand of a cleaner and higher grade fuel has lead to growth of hydrogen production. However, this rise in production must also be upheld with comprehensive measures for plant safety. The technologies used by hydrogen must be designed with safety parameters from potential hazards and the old ones must be regularly visited ensuring no mishap occurs. A combination of catalytic and ultrasonic gas leak monitors and fire detectors is effective knowing the fact that each one of them overcomes the shortcomings of the other and consequently, hazards have a fewer chances to propagate undetected.

References:
http://s7d9.scene7.com/is/content/minesafetyappliances/Hydrogen%20Gas%20Detection%20White%20Paper
http://en.wikipedia.org/wiki/Hydrogen_safety

Research & Development, UPES

A University's worth and long term sustainability is always judged by its value to the society. Since its inception in 2003, R&D is one of the key initiatives taken by UPES to reinforce the fine tradition of developing domain specific and industry ready graduates. UPES have come along with the creation of 12 virtual research centers (Alternate Energy, Energy economics, Energy Law, Supply Chain, Computing, Nanotechnology, Robotics, Environment, Infrastructure and Financing, Aerospace and Automotive) and winning several research projects from National and International Funding Organizations; both in the public and private sectors. At UPES our study and research programs build capability and skills which are required for building the infrastructure of a developing economy like India across. One of our greatest strengths is our highly qualified and dedicated team of researchers, this makes UPES an excellent centre for engaging in research and developmental work that's relevant to our societal needs. UPES R&D vision is to Develop and support a confident and successful academic research community, to become a research-intensive University recognized for its position at the forefront of setting and delivering the research agenda, nationally and internationally, across the range of disciplines in which we are active. UPES R&D encourage and helps to advance the community of learning by engaging in scientific research, humanistic scholarship, and innovative creation to prepare the next generations of skilled and ethical professionals by providing excellent graduate and professional education. Our main area of concern is for energy security and reduction of carbon footprint. The ranges of national and international collaborations that we have entered into indicate our desire to open up new frontiers of knowledge and scaling greater heights. To exceed with the ideas and the research UPES has an excellent sophisticated instruments facility such as Powder-XRD, AFM, Surface area analyzer, Thin film analyzer, Infrared spectrometer, UV-VIS spectrometer etc.



LEADERSHIP, ORGANIZATIONAL HIERARCHY AND PETER PRINCIPLE FOR OPERATIONAL EXCELLENCE IN THE MODERN E&P BUSINESS

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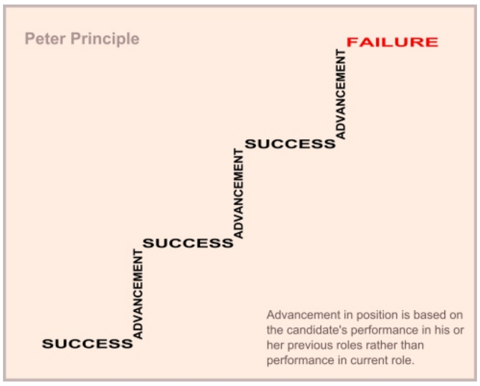
In a rapidly changing business, influenced by the realities of a cyclical commodity, career progression may seem a bit complex. Given the current downturn, most of the E&P professionals would be getting acclimatized to this in a tough manner. However, this could also serve as an opportunity to enhance skill sets, gain expertise and adapt. This article dwells on Peter Principle and its application in the modern E&P business in the current industry context.



Let us make an attempt to analyze the organizational hierarchy in the business with career transitions and promotions keeping an eye on the global industrial downturn. Developing a young leadership that is agile and competent, while evolving with each responsibility assigned, is a challenge that can be overcome through training and education to a certain extent. Employee growth and satisfaction goes in tandem with talent retention. The Peter Principle therefore becomes a key consideration that needs to be overcome for creation of a competent workforce. The Peter Principle believes that in an organizational hierarchy, an employee will move up the role ladder to his or her level of incompetence. This principle, coined by Dr. Laurence J. Peter, is based on the idea that an employee gets promoted till they are competent, but will get stuck at a certain job eventually because that role will have become too challenging for them. Based on this, over time, every position in the organization will be filled by someone who is incompetent to carry out his or her new duties. This is where the challenge is because an organization would never want such a situation hampering its growth. While referring to Operational Excellence, it must be kept in mind that a high performing workforce is a key factor affecting this aim.

The quote, “Cream rises until it sours”, is one harsh reality organizations are fighting each day. E&P professionals need to regulate their apprehension or despair, which overpowers their drive to succeed. Ensuring they are committed to the organization, continue to build their competence and focus their efforts for maximum impact, the young managers can survive the storm and defy Peter Principle. Achieving organizational targets by streamlining individual targets with them to ensure collaboration helps in smooth flow of work and ensures goals are met. Knowledge sharing, Learning academies, Group projects are some solutions organizations have come up with to deal with this. On an individual level, an employee needs to ensure they are an asset by continuing to grow. Learning need not stop beyond university boundaries.

Peter Principle is more than a management theory and its relevance to operational excellence needs to be understood with the aim to overcome it. Avoiding incompetence at mid-level positions through channels of skill development is certainly necessary to void the effects at a later stage.

NEWS - SECTION

1 "Indian Chemical industry to show heavy growth in the next two years"

According to the Tata Strategic Management Group, the current domestic market size of the industry is around $118 billion and it is about 3% of the global chemical market. The Indian Chemical Industry is likely to touch $190 billion by the financial year 2017-18 on account of increase in demand of chemicals from the industries of various sectors. The government, on the other hand said that the industry which accounts for 2.5%of overall GDP, is expected to grow at 15% per annum over the next few years.

A report released by the Fertilizer Minister, Ananth Kumar at the FICCI's 8th India Chem International Conference said, "It is highly diversified with more than 80,000 chemicals and currently accounts for 15 per cent of manufacturing GDP which makes it very crucial for the economic development of the country." According to the reports and the following announcements, it is clearly visible that current low per capita consumption across industries and segments and strong growth outlook for the key end use are the key growth drivers for this industry. Also, it is being said that the National Chemical Policy is being proposed for a long period which needs to be formulated to provide enabling environment infrastructure and duty structure for the Chemical industry in the country. It will place a framework for promoting safety & security and R&D in the sector.

This will help India's chemical industry to grow and become more competitive.

2 "BASF Catalyst open a new production facility in India"

The Baden Aniline and Soda Factory or BASF Catalyst division is one of the world's leading supplier of environmental and process catalysts. The division offers expertise in the development of technologies, produce fuel and a wide variety of chemicals, plastics and other products, including advanced battery materials.

Recently, BASF has inaugurated their new production house in Chennai, India. The new plant spans $47,000m^2$ and will replace the existing BASF plant in Chennai. BASF SE Asia-Pacific board of executive director's member Sanjeev Gandhi said: “Around the Asia-Pacific region, and especially here in India, mobility is ever more important."

The company said that its new production plant features latest manufacturing equipment with the ability to produce a complete range of catalyst products, including light-duty, heavy-duty and motorcycle emissions catalysts to serve the growing market demand and customer technology needs. The new site also produces BASF EMPRO emissions control solutions such as the three-way catalyst (TWC), diesel oxidation catalyst (DOC), catalysed soot filter (CSF) and selective catalytic reduction (SCR) catalyst.

3 "Jiangsu Sailboat Petrochemcials starts Honeywell UOP Methanol-to-Olefins unit"

Jiangsu Sailboat Petrochemical Company has started Honeywell's UOP Advanced Methanol-to-Olefins (MTO) unit during a ten-day test to confirm its successful operation. Once the complete unit goes on line, it will produce 833,000mt annually, making it the largest single-train MTO unit in the world.

Located in Lianyungang City in China's Jiangsu Province, the Sailboat facility will produce propylene for the production of acrylonitrile, which is used to make clothing and fabrics, and high-performance polymers used in automotive parts, hard hats and other hard plastic products. The plant also will produce ethylene for the production of ethylene vinyl acetate copolymers, which are used to make adhesives, foams, medical devices, photovoltaic cells, and other products, as well as C4 olefins for the production of butadiene, an ingredient in synthetic rubber.

Ethylene and propylene, the two most widely used components to make plastics in the world, have traditionally been derived from crude oil. For regions such as China that lack domestic sources of crude oil, the Advanced MTO Technology allows for the use of other more economical feed-stocks such as coal and natural gas.

4 "Chicago Academic Chemists win NSF Career Awards"

Justin Lorieau and Justin Mohr have recently received an annual prize money of $220,000 and $100,000 respectively via an NSF CAREER grant.

The five-year grants support early career-development activities of “those teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.

Lorieau will use his award to lead a project that investigates how the influenza virus infects cells at a molecular level and answer questions related to viral infections. Understanding how the fusion peptide functions could lead to new universal treatments for all flu serotypes, and it informs our understanding of related diseases, including HIV, Ebola, MERS and SARS viruses, Lorieau said.

Mohr's UIC-based research group specializes in synthetic organic chemistry with research focusing on reaction discovery, catalysis, and the synthesis of biologically active molecules.

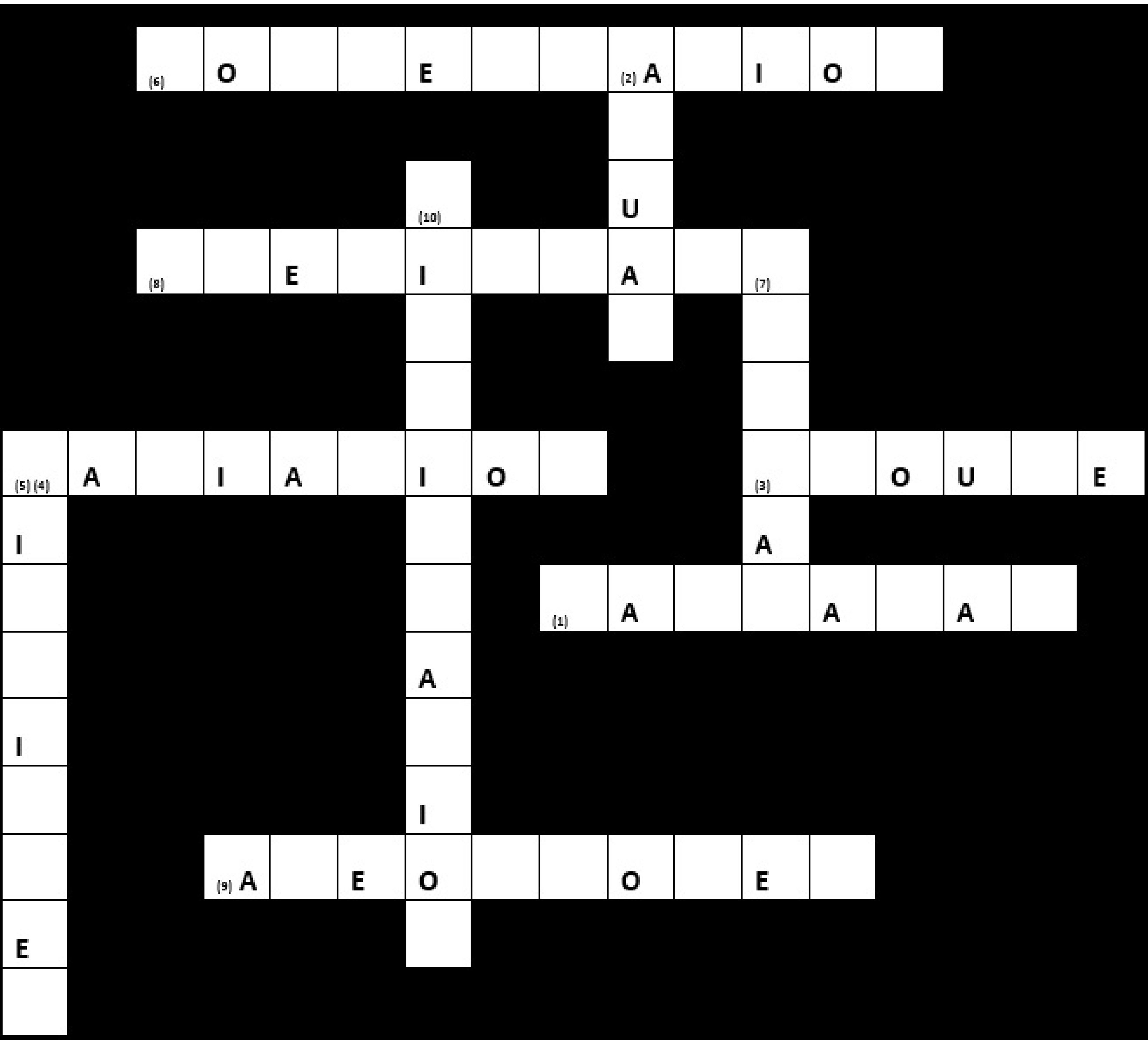
The NSF award will support Mohr's project to develop new catalysts useful for synthesizing complex molecules. He said the reactions will improve the overall efficiency of chemical synthesis and have potential applications in medicinal chemistry, agrochemicals, and materials science. His project also includes project also includes the development of new educational tools and activities to explain complex science topics to students from kindergarten through college.

Courtesy: University of Illinois at Chicago.

List of Winners

EVENTS	WINNERS	RUNNER-UPS
CHEM-CONUNDRUM	AAYUSH BELWAL (CHEMICAL)	-
FREEDOM SHOT	HARSH PRATEEK (CHEMICAL)	-
LOGO TREK	AVIRUKH ROY JAMAEELYA AKULA(B.DES)	LAKSHAY SINGH SHASHANK PANDEY (APE-UP)
SYMPEDIA	MOHD. OZAIR ANSARI (CHEMICAL)	-
CASE STUDY CHALLENGE	ARVIND KAPOOR ADITI BAHUGUNA ASHUTOSH (CHEMICAL)	ASHWIN (APE-UP)
CHEM-E-BATTLE	SATYAM GARG SAURABH JAISWAL (CHEMICAL)	-
WORD PLAY	SOMESHWAR GAUR YUVIKA SEHGAL (CHEMICAL)	-
SKETCH-A-STORY	KAVITHA VENUGOPALAN (B.DES)	-
STICK GAME	DAKSHITA MANAV (B.DES)	POORVAKSHI VIPASHA (CHEMICAL)
MINI MILITIA	SAYAN MONDAL (B.TECH CSE IT infra)	KUNAL CHETWANI (ADE)
MUSIC MAESTRO	RITWIK MUKHERJEE LATIKA SHARMA (CHEMICAL)	-
TURN COAT	SHRADHA SOOD (APE-UP)	-

The ULTIMATE CROSSWORD



across:

1. largest refining complex in India
3. it is a dimensionless number defined as the ratio of flow inertia to external field (gravity)
5. heat transfer through __________ does not require a material medium
6. ____________ is the type of polymerization through a condensation reaction where molecules join together losing small molecules, such as water.
8. ________ is also known as acrylic or acrylic glass, used as an alternate to silica based glass (hint: spectacle lenses)
9. constant boiling mixtures

down:

2. world's largest flexicoke, with processing capacity of about 64,000 bpd is located at ____________ refinery
4. empirical law of size reduction used when energy input per unit mass is not too high
7. $j^*=\sigma t^4$ is the mathematical expression for which law
10. process of separation of component substances from a liquid mixture by selective evaporation and condensation.

TEAM

Shrey Jain
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Batch 2014-18)

Vaibhav Jain
(B.Tech Chemical Engg.
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Tanya Kathuria
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Ritesh Kumar
(B.Tech Chemical Engg.
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Anmol Masand
(B.Tech Chemical Engg.
Batch 2015-19)

Someshwar Gaur
(B.Tech Chemical Engg.
Batch 2015-19)

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