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Chemical Induced Enhanced Oil Recovery

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In order to meet the demand and supply chain of the crude oil, the production rate needs to be increased. The crude oil production mechanisms in reservoirs are generally carried out in three phases. Initial oil production by natural pressure inherent in the reservoir (primary recovery) accounts only 20 to 30% of the original oil in place (OOIP). The natural reservoir energy gets depleted with time and hence injecting of external fluid (water/gas) is introduced in the reservoir to maintain the pressure (secondary flooding). Two-thirds of the OOIP is still remained in the complex region (heterogeneous reservoir) which can only be recovered by applying tertiary or enhanced oil recovery (EOR) technique(s).

Recovery of higher amount of original oil is place (OOIP) from reservoir is a challenging task. Enhanced oil recovery (EOR) technique recovers the residual oil those are trapped in the pores of the reservoir and cannot be recovered by secondary water flooding. EOR can be performed in various physical and chemical forms such as thermal oil recovery, gas injection, microbial injection and chemical flooding (Figure 1a). Thermal injection is the process of injecting steam, hot water and in-situ combustion inside the reservoir which reduces the viscosity of oil and results in higher oil production. Gas injection based EOR is the process of injecting miscible gas inside the reservoir which reduces the interfacial tension (IFT), reduces viscosity and improves oil displacement efficiency. Microbial injection is the process of injecting micro-organism which grows in the reservoir condition eating oil and producing bio-surfactants which reduces the IFT and swelling of oil reduces its viscosity. Chemical injection is the process of injecting exotic chemicals in the reservoir. The interaction of foreign fluid/chemicals with reservoir (fluid and rock) is often complex and facilitates diverse consequences towards higher residual oil recovery such as; interfacial tension (IFT) reduction, emulsification of crude oil, lowering capillary forces, maintaining favourable mobility ratio, enhancing sweep efficiency and alteration of wettability (Figure 1b). However, the success of an EOR scheme depends on petroleum reservoir factors such as the nature of crude oil, the compositions of reservoir formation water, temperature and pressure of the reservoir, and the surface charge nature of the reservoir rock, depth, porosity, permeability, etc. Mobilization of trapped residual oil depends on the ratio of viscous to capillary forces.

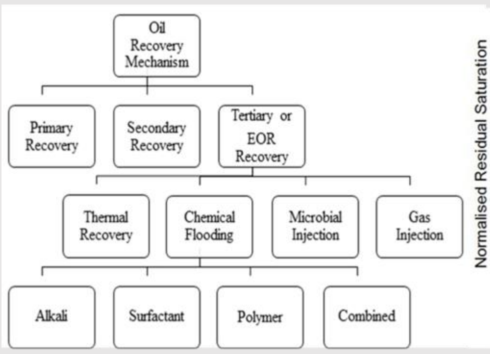

Figure 1a: Oil recovery mechanisms

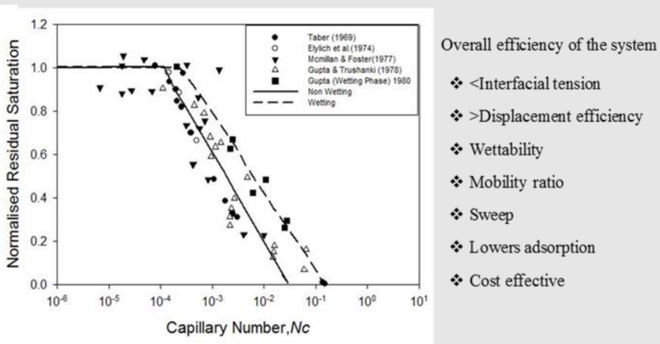

Figure 1b: Capillary Desaturation curves for sandstone Cores

Capillary number ($NC = \frac{\upsilon\mu}{\sigma}$) expresses the forces acting on an entrapped oil blob within a porous media. Where, v is the velocity of aqueous phase, μ is viscosity of displacing fluid and σ is interfacial tension (IFT) between displaced and displacing fluid. Figure 1b shows the reduction in oil saturation with increase in capillary number. At low capillary number the residual saturation (S_{or}) is almost constant; the phenomena

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indicates that large capillary number is beneficial to have high displacement efficiency as residual oil saturation becomes smaller.

Mobility ratio ($\boldsymbol{M} = \frac{\textbf{Mobilitywater}}{\textbf{Mobilityoil}} = \frac{\lambda_w}{\lambda_o} = \frac{k_{rw}/\mu_w}{k_{ro}/\mu_o} = \frac{k_{rw}\mu_o}{k_{ro}\mu_w}$) is the ratio of the mobility of the displacing fluid (i.e. water) to the mobility of the displaced fluid (i.e. oil). If the ratio M is >1, the invading fluid tends to bypass the displaced fluid which is unfavourable (viscous fingering). For maximum displacement efficiency (microscopic and macroscopic), M should be less than or equal to 1 and in such case the viscosity of the displacing fluid should be increased and/or the viscosity of the displaced fluid (i.e oil) decreased.

Displacement efficiency in reservoir oil field for residual oil recovery is of two forms; microscopic and macroscopic. Microscopic displacement efficiency measures the effectiveness of the displacing fluid in moving the oil at the pore scale. Macroscopic or volumetric sweep efficiency indicates the effectiveness with which the displacing fluid sweeps out the volume of displaced oil, both areally and vertically towards the production well. Overall sweep efficiency is the product of displacement efficiency and volumetric efficiency.

Wettability alteration is the process of changing the wettability (ability of one fluid to adhere or spread on the solid surface in the presence of another immiscible fluid) of reservoirs from oil-wet or intermediate wet to preferable water-wet, which helps in releasing the trapped oil from the pores of the rock. Wettability alteration is a function of crude oil composition, chemical formulation, rock mineralogy and initial water saturation.

Chemical Induced Enhanced Oil Recovery

Chemical flooding method enhances the residual oil recovery oil by injecting chemicals like alkali, surfactant and polymer in the reservoir. Typically, the chemical slug consists of either individual chemical (alkali (A)/surfactant (S)/polymer (P)) or their combination (A-S/ A-P, S-P/ A-S-P) formulations. The injected chemical slug offers favourable conditions required for mobilizing the residual oil towards production well. Chemical induced flooding reduces the interfacial tension (IFT), emulsify the crude oil, decreases the mobility of water phase and diverts the injected water into the unsweep volume thus enhances the overall (microscopic and macroscopic) sweep efficiency. As the number of components of chemical slug increases, the more complicated the screening procedure becomes. The chosen chemicals (optimum formulation of chemical slug) must also be able to tolerate the reservoir environment.

Alkali flooding mechanism: The main aim of alkali flooding is to reduce the interfacial tension (IFT) between oil-aqueous alkali phases and/or increase the capillary pressure for the trapped oil. Alkali flooding is effective in heavy oil reservoir which has high acid value. Alkali reacts with the acid content (naphthenic acid) of the crude oil to form in-situ surfactant at the oil-brine interface. Alkali-crude interaction is a complicated process; along with IFT reduction other mechanisms such as emulsification and entrainment, emulsification and entrapment, emulsification and coalescence, wettability reversal also contribute towards the success of recovering the trapped oil from the pore spaces of the reservoir. Alkali can react with reservoir rock depending upon the rock mineralogy by surface exchange and hydrolysis, congruent and incongruent dissolution rock, and formation of insoluble salt.

Surfactant flooding mechanism: Surfactant molecule shows dual nature (amphiphilic) due to hydrophilic (water loving) head and hydrophobic tail. This helps the surfactant to stay at the interface between aqueous and organic phases, and reduces the interfacial tension between the two fluids. Surfactant molecules in the solution disperse as monomer at very low concentration; monomers begin to associate to form micelles. Reduction of IFT is achieved until critical micelle concentration (CMC) value reached. Further increase in surfactant concentration increases the micelles concentration only. Surfactants are costly and its retention on the rock surface drastically affects the economy of the process. The selection of a surfactant for a particular reservoir is truly based on rock minerology and its charge nature. To avoid surfactant losses, initially alkali flooding is performed where alkali acts as a scarifying agent and adsorbs on the active sites of the reservoir rock.

Polymer flooding mechanism: The main role of polymer flooding is to maintain favourable mobility ratio between the displacing fluid and displaced fluid. Addition of polymer increases viscosity of injected water which reduces water permeability in porous media. Such condition increases the volumetric sweep efficiency. The success of polymer flooding depends on reservoir temperature and formation water. Polymer solution viscosity decreases with increase in temperature, polymer degradation and with increase in salinity of the reservoir water for anionic polymers. There exists an effective viscosity range within which oil recovery is maximum and beyond such range the recovery cannot be improved further. At high temperature or with high salinity, polymer may not be stable and polymer degradation may contribute towards decrease in its viscosity. Polymer may also adsorb/retain on the rock surface and can block excess water production. Polymer retention depends on various factors such as nature of the reservoir rock (sandstone, carbonate, minerals, or clays), surface area, permeability of the rock, salinity and hardness, molecular weight of the polymer and the volume of porosity that is not accessible by polymer solution.

Synergy of alkali-surfactant-polymer (ASP) flooding*:* Chemical slug consists of alkali-surfactant-polymer (AS/AP/SP/ASP) delivers the advantages of the individual chemical component by additional oil recovery with high swept efficiency. The major contributors towards enhanced oil recovery have been identified as neutralization and extent of soap formation and extent of emulsification. Surfactant along with alkali can achieve ultra-low IFT value due to synergic effect. Dilute amount of surfactant along with alkali forms oil in water (O/W) emulsion which mobilizes the viscous oil and entrains in the injected water. The emulsified oil forms an oil bank which leads to increase in pressure drop. The alkali consumption (to form in situ surfactant) in reservoir is overcome by adding surfactant. The in situ surfactant reduces the IFT and overcome the surfactant depletion due to adsorption. In surfactant-polymer process, surfactant effect causes the oil-water IFT to reduce to ultra-low IFT and promotes the mobilization of oil drops that are trapped in the pores and polymer helps the oil bank to propagate forward and increases the overall sweep efficiency. Surfactant might reduce or boost the viscosity of polymer as it reacts physically and chemically with polymer chain. Alkali may reduce the viscosity of polymer due to charge shielding mechanism or may increase the viscosity of polymer by hydrolyzing amide group in polymer chain. The size (injection rate) of the chemical slug (ASP) is detrimental for its effectiveness and technical/economic competitiveness. Optimum injection rate of chosen chemical slug should be employed to produce enough W/O emulsions to block the water channels effectively.

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Bombardier Beetle – Chemical Warfare in Nature

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The human admiration of nature is an incessant affair – from baffling conundrums to trite realizations; the beauty of nature manifests, between the humongous realm bordered by comprehension and inexplicability. The scientific community, rather the complete human race has since time immemorial sought refuge in nature, when it comes to answering questions and pushing the boundary of humanknowledge. One such fascinating instance is that of the Bombardier beetle, that the research community stumbled upon about two centuries back and has doted on it ever since, primarily owing to its self-defense mechanism – sensing threat, the beetle sprays a chemical solution, referred to as Explosive secretory discharge (ESD), to fend off predators in its vicinity. The chemical solution can have temperatures of 100 ^{0}C and above. This article aims at encapsulating the qualitative description of the working of the beetle's defense mechanism – the chemicals involved, underlying physical processes and reactions, and the innate congeniality of the milieu associated. Additionally, it touches upon the prospective technological usage that can be brought to the fore by mimicking this brilliant natural phenomenon.

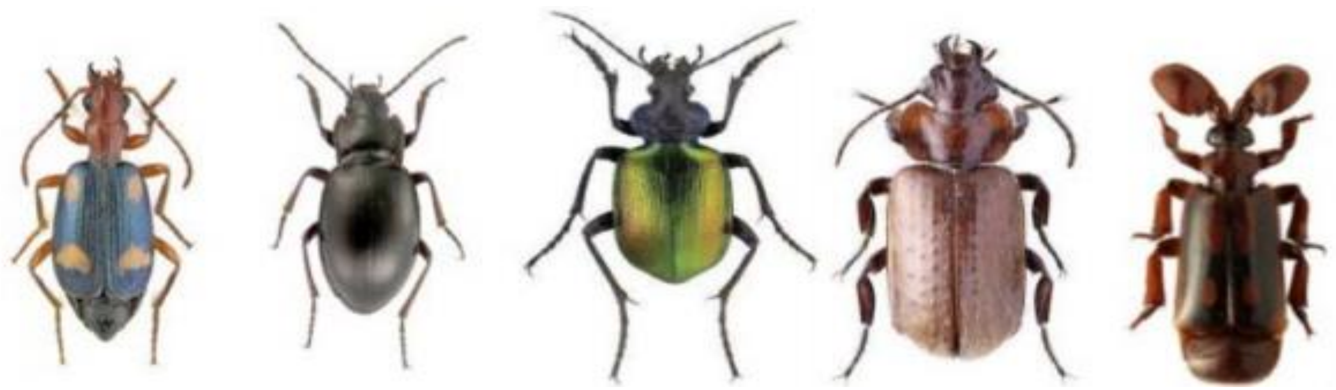

Figure 1. Bombardier tribes: Brachinnin, Martine, Mystropomini, Paussini and Ozaenini

The answers to many questions pertaining to the secretion of the aforementioned spray lie in the extremely fascinating anatomy of the Bombardier beetle. The beetle stores the reactants in a reservoir, which is connected to a reaction chamber via a non-return valve. Sensing threat, it contracts muscles to open the non-return valve, letting the reactants into the chamber where they undergo an exothermic reaction in the presence of enzymes. This causes a pressure rise in the chamber and eventually a relief valve on the chamber outlet opens ejecting the product solution. Studies of a wide array of species have revealed that the chemicals found in the secretions are similar but their compositions vary significantly. Another important point to be noticed is the temperature of ejection – the discharges depending on the species, can be ranging from cold i.e. approximately 30 degrees to hot temperatures exceeding 100 degrees. This can be attributed to the variation in valve sizes and closing/relieve pressures across species.

If the inlet size or closing pressure is very low, the flow entry is so sluggish that the oxygen generation is very less and the heat of reaction is completely absorbed by the chamber walls, which inhibits steam formation. This in essence means that there is no pressure build up in the reaction chamber. On, the other hand, if sufficient fuel enters the reaction chamber to cause pressure build-up, continuous cycles are witnessed. Continuous cycles give way to pulsed cycles if the flow rate becomes too low. Lastly, when the flow rates are sufficiently large, a steady state can be attained. In this state, the residence time of reactants is very low. The outlet comprises mostly of the reactants and is at a low temperature.

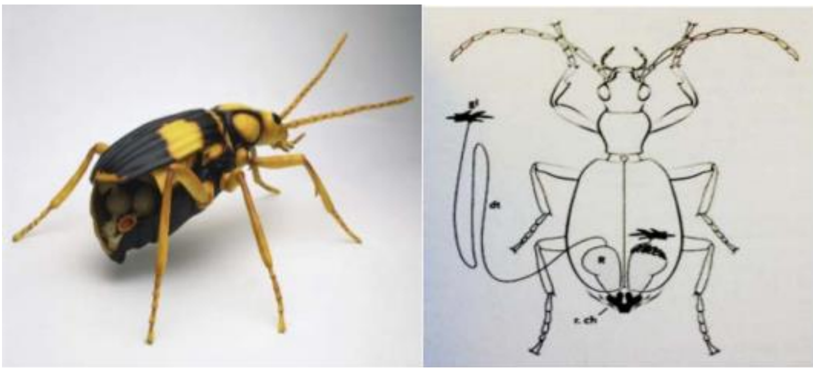

Figure 2. Bombardier Anatomy

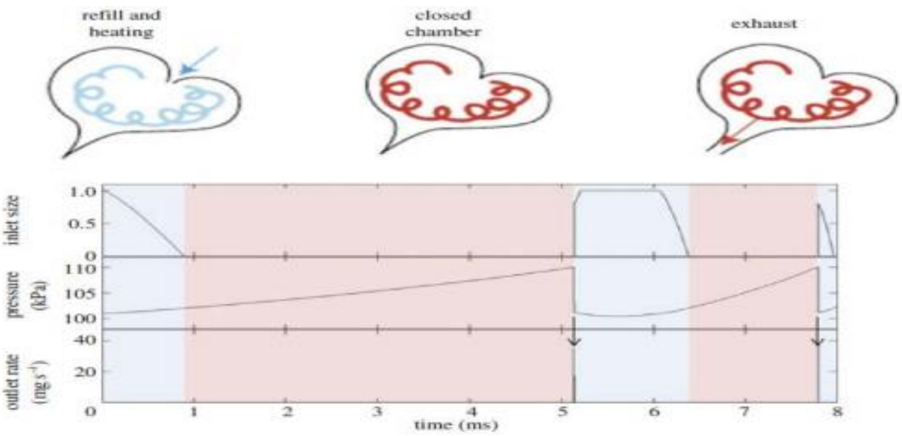

Figure 3. Stages of ESD [1]

The primary reactants involved in the reaction are Hydrogen peroxide and Hydroquinone, with a heat of reaction of 48.5 Kcal per mol Hydroquinone. The reactions involved are that of the decomposition of hydrogen peroxide (i) and the conversion of hydroquinone into benzoquinone (ii). The resultant hydrogen from (ii) reacts with oxygen from (i) to form water and assuming that hydrogen peroxide is more in amount than hydroquinone, (ii) and the formation of water can be clubbed together to give (iii).

$$H_2O_2 \rightarrow \frac{1}{2}O_2 + H_2O \quad \text{--- (i)}$$

$$C_6H_6O_2 \rightarrow H_2 + C_6H_4O_2 \quad \text{--- (ii)}$$

$$C_6H_6O_2 + \frac{1}{2}O_2 \rightarrow H_2O + C_6H_4O_2 \quad \text{--- (iii)}$$

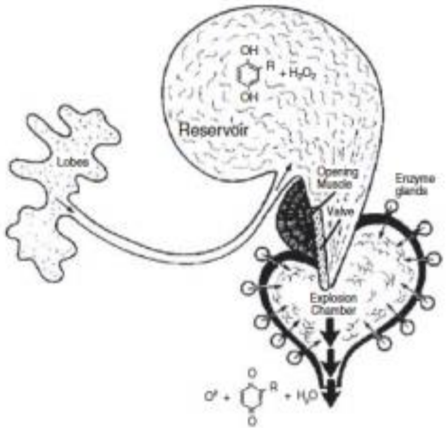

Figure 4. Bombardier: The chemistry inside

The fact that such complex thermodynamics manifests in a tiny chamber of the order of millimetres in a literal blink of the eye; is staggering to say the least. The most exciting elements of the bombardier beetle's anatomy involved in the ESD are the inlet and outlet valves. The outlet valve can be thought of as a relief valve in any industry, which has a certain popping and seating pressure. The inlet valve though is more like a flow control valve with the opening of the size varying. One could mimic the inlet valve by designing a feedback control system where the pressure difference could be used as the measured variable to manipulate the control valve opening. This very feedback loop in unison with the relief valve can be used for a wide array of small-scale industrial applications.

a) Firefighting systems: A common water header can be connected to a network of combustion chambers with the aforementioned valve system. This can be used for small range firefighting.

b) Fuel-injection systems: The efficiency of fuel-injection systems in vehicles can be improved by mimicking the bombardier beetle's ESD – a precise control over the fuel flow can be attained and operation can be achieved at optimal conditions.

c) Drug-delivery systems: Similar to fuel-injection systems, drug-delivery systems can be based on the bombardier beetle spray. Very small droplets carrying the drug can be sprayed into the host body.

d) Vaporiser systems for cryogenic storage tanks: Similar to the fire-fighting system, a network of small systems mimicking the bombardier beetle ESD without reaction, can be used as vaporiser systems for cryogenically stored gases at very high pressure – CO2 being an instance.

e) Power system for exoskeleton robotic applications: Wang et.al (2015) [2] have developed a prototype for a power system for decomposition of diluted H2O2 over manganese based catalyst. The system mimics the valve system of the Bombardier beetle.

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Effectiveness of Ionic Liquids as Solvents to extract Bio-Butanol from Aqueous Phase: A Molecular Dynamics Approach

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The reserves of hydrocarbon-based fossil fuels are available in a less number of countries, which are not sufficient to use for a longer period. The combustion of these fossil fuels emits greenhouse gases and threatens the balance of the ecosystem. It invariably becomes a challenge for governments, engineers, scientists and economists to overcome the gradual decrease of fossil fuel resources and ever-increasing environmental pollution. In this regard, alternative energy resource such as biomass has become an important area of research.

In the Acetone-Butanol-Ethanol (ABE) fermentation process, anaerobic fermentation of biomass produces Acetone, Butanol, and Ethanol with a proportion of 3:6:1 [1]. Butanol produced from ABE fermentation process is considered as a potential biofuel. The calorific value [2] of butanol (29.2 $\times 10^6$ kJ/m^3) is much higher as compared to Ethanol (19.6×10^6 kJ/m^3). Butanol also shows lesser flammability and hydrophilicity than Ethanol. Additionally, it is easily miscible with gasoline in any proportion. Butanol has several other industrial applications e.g., super absorbents, surface coatings, fibres, resins, plastics, hard-surface cleaners, electronics, paints, synthetic fruit flavouring product, pharmaceuticals and perfume manufacturing [3]. Solvent extraction can be a suitable operation to extract butanol especially with the solvents that possess high affinity for butanol and hydrophobicity simultaneously.

The selection criteria for a good solvent should be high selectivity, high capacity and non-toxicity to cells particularly when extraction is carried out inside a fermentation broth. Additionally it should have low viscosity and should be readily available commercially. Ionic liquids (ILs) can be a better alternative for the traditional volatile organic solvents for their properties such as non-volatility, non-flammability and thermally stability. ILs have been already studied experimentally for the extraction of bio-butanol from aqueous phase [4, 5].

In order to investigate the extraction process at a microscopic level for better understanding of the effectiveness of the ILs Molecular Dynamics (MD) can be considered as a promising approach. Classical MD requires optimized coordinates of the molecules of interest, their electrostatic charges and consistent force field parameters. There are several force fields available for liquid simulation e.g. OPLS, AMBER, CHARMM etc. Different software packages (NAMD, LAMMPS and GROMACS etc.) are available for running MD simulations.

Results from experiment for 1-octyl-3-methylimidazolium bis (trifluoromethylsulfonyl) imide ([OMIM] [Tf_2N]) was successfully validated using MD simulation [6]. Clear phase separation between IL and water can be visualized from figure 1 [6]. Intermolecular interaction from Radial Distribution Function (RDF) indicates the role of cation and anion in extraction [6]. RDF and then running coordination number are the useful tools to interpret the system at molecular level. Higher values of distribution coefficient and selectivity have been noted with [OMIM][Tf_2N] [6] compared to previously performed experiments [4, 5] . For cations, higher the alkyl chain length, more the insolubility in water. Similarly, the anion bis (trifluoromethylsulfonyl) imide (Tf_2N) is also known for its immiscibility with water. Therefore, this typical property of both the ions has made the IL useful for butanol extraction. Further, in order to compare the ease of butanol separation with [RMIM][Tf_2N] (R= ethyl, butyl, hexyl, octyl) solvents , computational studies were performed by varying number of IL molecules and keeping the amount of water and butanol

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constant [7]. [EMIM][Tf_2N] with 100 molecules gives the least value for both distribution coefficient and selectivity [figures 2 & 3]. The highest for the same is observed with 200 molecules of [OMIM][Tf_2N]. Hence, it can be proved that with increase in number of carbon atoms in the alkyl chain of [RMIM] cation, separation efficiency enhances. Separation is also being better with increase in number of IL molecules. The longer alkyl chain of the cation [OMIM] makes the IL more hydrophobic. The same can be observed from microscopic results obtained from simulation. Running coordination number obtained from MD studies gives the information about the actual number of molecules or atoms present in the neighbourhood of a central atom. The higher concentration of [OMIM] cation than the other cations surrounding butanol molecules can be visualized from figure 4. [OMIM] has the highest coordination number within the first solvation shell compared to other three [RMIM] cations.

Molecular Dynamic simulation clearly explains the dependence of distribution coefficient and selectivity on alkyl chain length of [RMIM]. From running coordination number, microscopic structure of the extract phase can be deduced. From RDF and running coordination values, it can be concluded that the cation [RMIM] plays the major role in the extraction of butanol from water [6, 7].

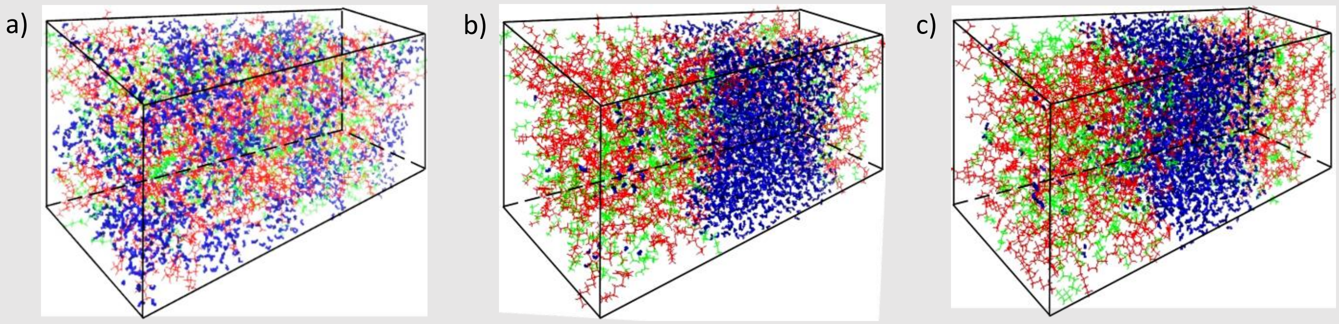
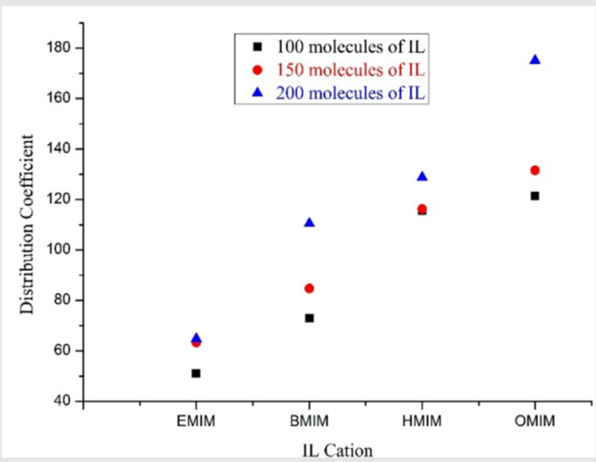


Fig. 1: Distribution of butanol in [OMIM][Tf_2N] and aqueous phases at (a) 0; (b) 20 and (c) 40 ns respectively (Red: IL molecules; Green: butanol molecules; Blue: water molecules[6]



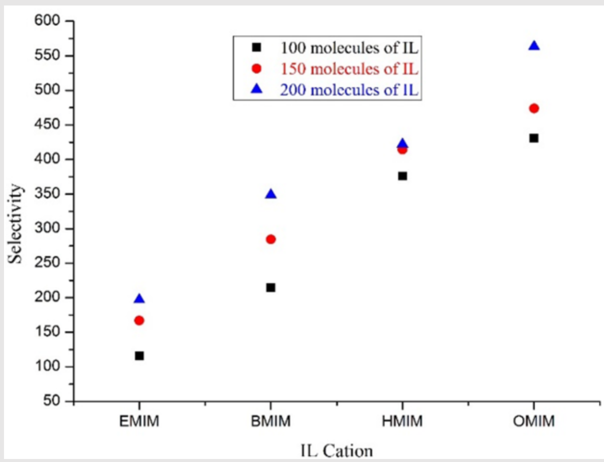


Fig. 2: Comparison of Distribution Coefficient among four different Ionic Liquids [7]

Fig. 3: Comparison of Solvent Selectivity among four different Ionic Liquids [7]

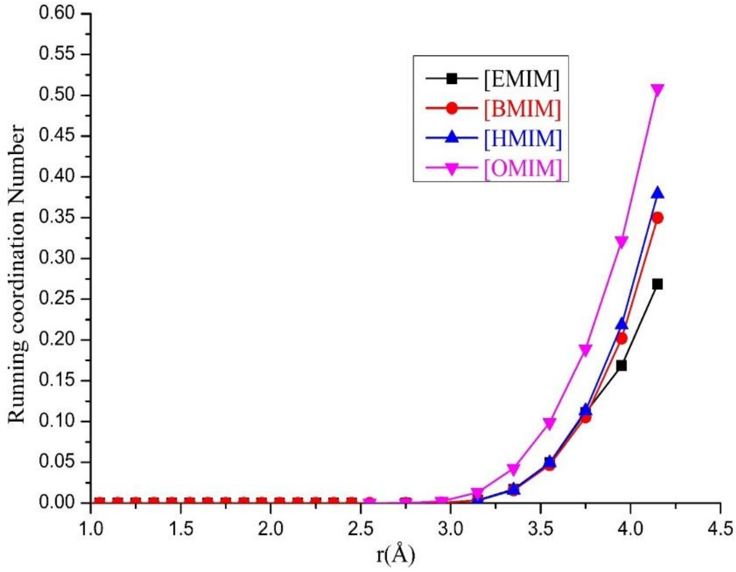


Fig. 4: Running coordination number between OH of butanol and carbon (attached to alkyl group) of [RMIM] [7]

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Margination and migration characteristics of suspension consists of rods and spheres in simple shear flow as well as pressure-driven flow

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Suspensions comprising of a mixture of spherical and non-spherical particles are common in many industrial and biological systems. For example blood consists of particles such as RBCs, WBCs, platelets etc. suspended in liquid medium (plasma). It has been well known that the geometry of the suspended particles, namely their shape and size have strong influence on the motion of such particles in a flowing suspension. An important phenomena associated with the transport of cells during transport of blood is thrombosis, and it has attracted significant attention in scientific research. The thrombosis is the formation of blood clot inside blood vessel. When any blood vessel is injured the body uses platelets and fibrin to form blood clot to prevent blood loss. The formation of blood clot requires platelet particles to move closer to the vessel wall. The motion of platelets in both lateral and axial directions is mainly influenced by the dynamics of red blood cells. The migration of RBCs towards the centre of the vessel induces the platelets to concentrate near the wall. This is known as famous Fahraeus-Lindquist effect. Many previous works reported that the concentration of RBCs and wall shear rate were important factors in margination of these particles.

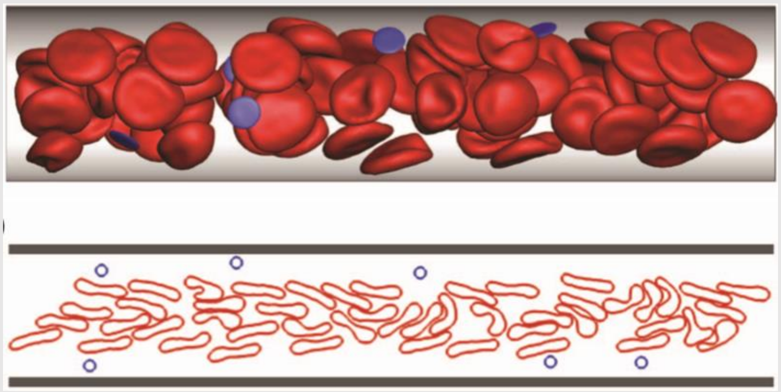

Figure.1 Margination of RBCs and suspended particles in micro channel flow in both 3D and 2D simulations (Muller *et al*. 2014).

My M.Tech project under Prof Anugrah Singh deals with investigating the margination and migration characteristics of rods and spheres similar to the RBCs and platelets suspension. We used the Stokesian dynamics methodology to simulate the particulate suspension in creeping flow regime (Brady & Bossis 1988). The previously developed code was restricted to the spherical particle suspension. The first challenge was to develop the code for the rod particles. In previous Stokesian dynamics simulations used the attractive forces between the spheres to model the fibre particles (Jayageeth *et al.* 2009). But this model was not accurate to simulate for the rod particles. We newly implemented the rod model based on principles of conservation of linear and angular momentum. For simulating the rod particles, we considered the rod consist of spherical particles such that their angular and linear momentum was conserved. Dynamics of rod particle was validated with ellipsoidal particles having equivalent aspect ratio (Jeffrey's orbit). To investigate the cross migration of particles, we placed the rod and sphere in close distances in simple shear flow. Aim of this experiment is to observe the lateral displacement of these particles after the interaction. It was observed that the sphere having higher cross migration compared

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to the rod particles. Some of the lubrication force experienced by the rod particles in the interaction used to rotate, whereas sphere displaces instead. In mixture of rods and spheres in simple shear flow, the spheres particles were migrating near the wall. This phenomena attributed to the tumbling motion of rod particles in simple shear flow. Fig.2 shows the particles configurations at different times for rods fraction of 0.75. We also analysed the viscosity of the mixture for different relative concentration of rod particles. The bulk viscosity of suspension increases with the relative concentration of rods in the suspension.

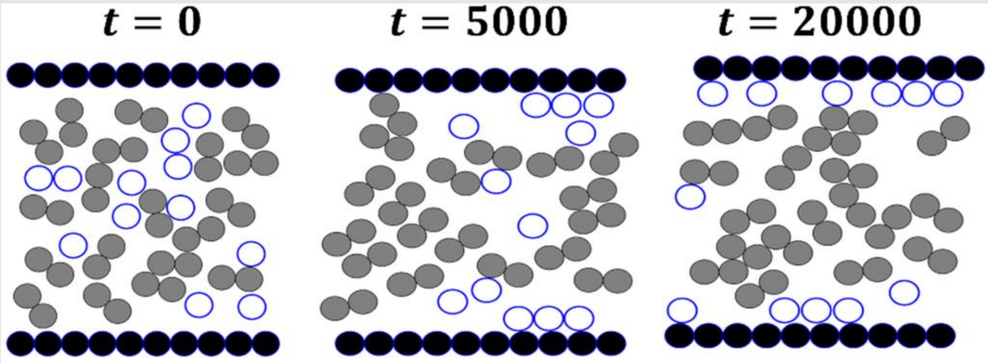

Figure.2 Mixture of rod and spheres in simple shear for different time steps

In pressure driven flow, the shear induced migration of particles also plays key role in the margination of particles. Shear induced migration is the migration of particles from higher shear rate region (near the wall) to the low shear rate region (centre of the channel). The shear-induced migration of particles depends on the size of the particles. It is directly proportional to the square of particles size. So the rod particles in the mixture having higher shear induced migration compared to the spheres. The rod particles leaves no space for the spheres in the centre of the channel results in the migration of spheres near to the wall. In pressure driven flow, the rod concentration profiles in the mixture qualitatively agreement with RBCs concentration profiles in blood particles suspension (see Fig.3). The margination of spheres near the wall increases with the concentration of rods in the mixture (see Fig.4).

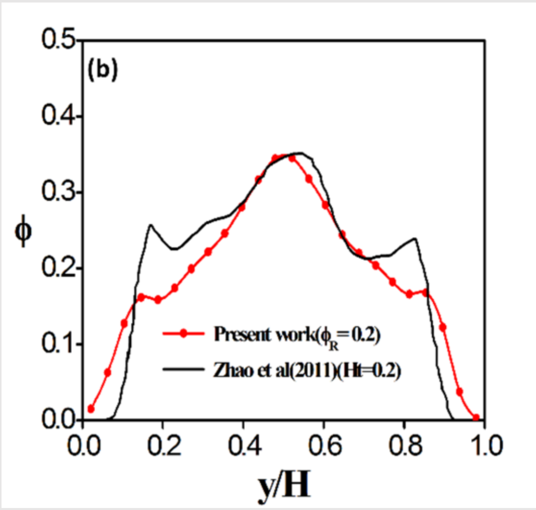

Figure.3 Concentration profiles of rod particles in mixture in pressure driven flow compared with RBCs concentration profile.

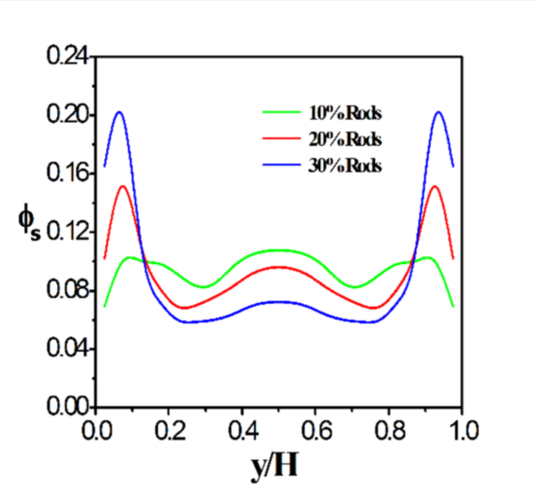

Figure.4. Concentration profiles of spheres in mixture consists of different concentrations of rods in pressure-driven flow

In future works, we are interested in including the friction forces between the rods and spherical particles. For higher concentrations, the friction force between the particles were more significant in determining the rheology of the mixture. We also interested in extending this method for aspect ratio of rods and different shapes of particles. This rod model also flexible to extend it for higher aspect of rod and different shape of particles.

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Guwahati Regional Centre Activities

Seminar series on *Nanoparticle - Antibody Conjugates as High Sensitive Reagents for Mass Cytometry*

Dr. Jothir Pichaandi, Scientist at Fluidigm Canada has delivered the talk on February 15, 2018.

Mass cytometry (MC) is a recently developed single cell analysis technique to identify several cellular biomarkers simultaneously. This technique combines the power of flow cytometric injection of cells with an inductively coupled mass spectrometer (ICP-MS) coupled with time of flight detection. MC employs metal isotopes to tag the antibodies (Abs) and these metal isotopes have a unique mass that can be detected and quantified by mass spectrometry. Flow cytometry, the most commonly used single cell analysis technique to study cellular biomarkers can measure only up to 8 to 10 cellular biomarkers simultaneously. Beyond the detection of 8 to 10 biomarkers, the technique is limited by the luminescence spectral overlap of the dyes and the quantum dots used to tag the Abs which identifies the specific biomarker on the surface or inside the cell. On the other hand, the number of biomarkers identified using MC depends only on the number of different metal isotopes that can be used to tag the Abs. As with all techniques, there is certain limitation to this technique as well. When compared to flow cytometry, this technique suffers from poor sensitivity due to the fact the current reagents, metal chelating polymers with 40 to 50 metal atoms per polymer chain, cannot generate enough signal to identify proteins which are present in very low copy numbersin cells. MC is a quantitative technique and the fact the signal intensity increases linearly with the number of metal atoms tagged to each Ab. His research is primarily involved in developing antibody conjugates with more metal tags per Ab. To achieve this goal, he is working on developing reagents based on nanoparticles to enhance the detection sensitivity of low copy markers by one or two orders of magnitude than current reagents. He explained the various criteria which have to be satisfied when employing NPs as high sensitive reagents. The synthesis, nucleation and growth kinetics of the various NPs was discussed in detail. Subsequently, he talked about two surface modification process to make the NPs biocompatible and their effect on the non-specific interaction of the NPs with various cells lines. The various conjugation chemistries to couple the NPs to Abs was explored and finally finished with examples of mass cytometry single cell measurements where the NPs exhibit higher signal for various biomarkers when compared to current metal chelating polymer reagents.

Emerging Wastewater Treatment Technologies

Dr. S. Kanmani, Professor & Director, Centre for Environmental Studies, Anna University has delivered the talk on February 22, 2018.

The presence of thousands of contaminants in wastewaters and their impending threats has drawn a significant attention of the scientific community in recent years. The major sources of pollution include domestic wastewater, industrial wastewater and agricultural discharges. Indiscriminate disposal of domestic and industrial wastewater to surface water causes degradation of the environment and degenerative effects on both public health and ecosystem. Conventional suspended biomass reactors (ASP) are widely used for sewage treatment despite their specific drawbacks, such as requirement of large reactor volumes, large-sized sedimentation tanks and high excess bio-sludge production, while Sequential Batch Reactor (SBR) has lesser footprint but still it has the problem of excess sludge production and high sludge volume index. As a solution to these problems, carrier elements can be added to the aeration tank or SBR. This led to the development of Sequential Batch Biofilm Reactor (SBBR), which improves the quality of bio sludge of the system resulting in improvement of the effluent quality and system efficiency.

The other challenge is the treatment of industrial wastewaters containing recalcitrant organic compounds. The wide range of non-biodegradable organics in waste streams includes textile dyes, pesticides, pharmaceutically active compounds, phenols, tannery and distillery compounds. Most of these effluents are highly coloured in addition to the presence of a high organic load. Advanced Oxidation Processes (AOPs) have gained more attention in the past decades and are seemed as a viable option for complete degradation of non-biodegradable organics. Various AOPs that find application in the treatment of industrial wastewaters are Photocatalysis, UV/H_2O_2, $UV/O_3/H_2O_2$, Fenton's process, Wet Air Oxidation, Sonolysis, Electrochemical Oxidation, Super-Critical Water Oxidation, Non-thermal Plasma, Gamma rays, Electron beam etc. All the AOPs depend on the generation of highly reactive hydroxyl radical ($^{\circ}OH$) which are non-selective oxidant and react with almost all the organic compounds. In addition, AOPs can also be used in the removal of Persistent Organic Pollutants (POPs), Emerging contaminants and other micropollutants. The cost of the AOPs could be high as they yield almost complete degradation of target pollutants without giving rise to hazardous sludge. Nevertheless, the treatment cost can be reduced by combining the AOPs with biological treatment as the AOP pre-treatment would make any recalcitrant water amenable for biological treatment.

Upcoming Events

Research Conclave - 2018

Research Conclave is organized under the banner of Students' Academic Board (SAB) of Indian Institute of Technology Guwahati (IITG) during March 8-11, 2018.

It is a staunch platform to nurture the young minds towards research, innovation and entrepreneurship, which intends to bring the integrity integrity of the students towards both industries and academia to redress the academic research challenges, concerns of the entire student community and upcoming entrepreneurs around the globe. It is a forum to harness innovative mind to level-up the economic strata of current society from research to industries. The Research Conclave work as catalyst for building leaders through holistic, transformable and innovative ideas. It has started in 2015 with great rhythm and passion, and this year with the same enthusiasm we are conducting this event in a broader spectrum.

Additional details can be obtained from www.iitg.ac.in/researchconclave/

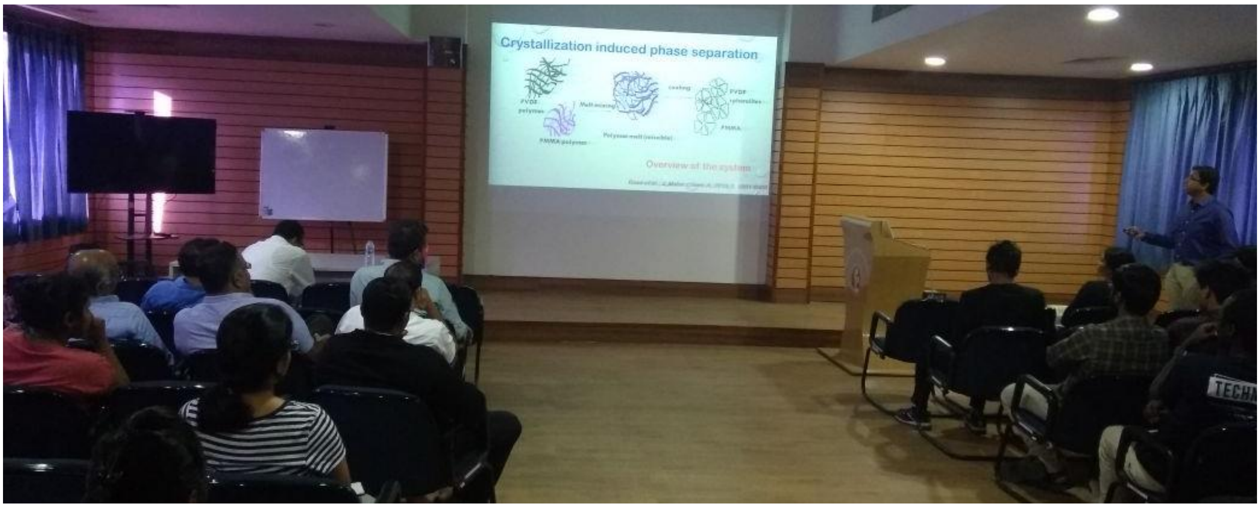
Reflux - 2018

Reflux, the annual Chemical Engineering Symposium of IIT Guwahati, is organized during March 16-18, 2018. It has been a pioneer in chemical industrial and entrepreneurial scene of the country.

The aim of Reflux is to provide an opportunity for budding Chemical Engineers to share scientific expertise and knowledge towards the development of new methods and strategies in different fields of Chemical Engineering. The event is planned to be highly interactive and an excellent learning experience for all the delegates.

Additional details can be obtained from http://www.reflux.in/

IIChE newsletter is available at http://www.iiche.org.in/pdfs/NLVol9.pdf



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