# Session 1

**Abstract** (#19275)

**Title**: Development of PEG-modified Poly(ether-b-amide) Membranes for Sour Gas Separation.

**Authors**:  John Yang, Daniel J. Harrigan, Milind M. Vaidya, Michele L. Ostraat

**Aramco Services Company**

Automotive manufacturers are continually endeavoring to improve the performance and efficiency of internal combustion (IC) engines and more importantly reduce fuel consumption and emissions. The push to achieve these targets has shifted the environment in IC engines to harsher conditions by gasoline direction injection (GDI), exhaust gas recirculation, turbocharging, etc. Improvements in IC engines cannot achieve better fuel economy and durability without a concerted effort to develop improved lubricants. The lubricant oil and additive technology have seen limited improvements in recent decades.  Although formulations have improved, their underlying chemistry has remained largely the same, and conventional lubricants were not designed according to newly adopted coatings as well more extreme conditions in modern IC engines. The major components of any engine lubricant are mostly base oil and around 5% chemical additives. Base oils are long chain hydrocarbons, typically 18-40 carbons. Chemical additives are tailored by considering solvency, friction reduction, anti-wear, anti-corrosion, anti-oxidant, detergency, and dispersion. Nonetheless, the main functionalities of lubricant additives, friction modifier, viscosity modifier, detergents, and anti-oxidants should be redesigned to meet current challenges and modifications in modern IC engines. The aim of this early stage research is to demonstrate how the multiple functions of additives could be integrated into just one macromolecule to obtain greater performance than the conventional lubricants do as well as the underlying tribochemical reaction mechanism to allow us for the rational design of polymeric multifunctional lubricant.

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**Abstract** (#19344)

**Title**: Employing Supramolecular Chemistry to Engineer New Macrocyclic Based Materials

**Authors**:  Basem Moosa , Niveen Khashab

**KAUST**

Macrocycle-based supramolecular organic framework (M-SOF) materials attracted attentions due to their wide types of applications and is considered to be an important approach to fabricate microporous material with an intrinsic pores. Cyclodextrin, Pillararenes and Cucubirtules are known macrocycles that have been used for different application such as separation and sensing, based on the physical and chemical nature of the cavity of the macrocycles.  Trianglamines, are new type of macrocycles with permanent intrinsic porosity and high affinity to CO2. The capability of tuning the pore aperture

dimensions is also demonstrated by molecular guest encapsulation to afford excellent CO2/CH4 separation for natural gas upgrading, with a facile separation and purification process. We present herein our efforts in developing a versatile toolbox employing supramolecular chemistry that is capable of precisely nano-structuring materials through self-assembly processes

**Abstract** (#19456)

**Title**: Self-Healing Supramolecular Block Copolymers via Non-covalent Complementary Interaction

**Authors**: Saibal Bhaumik, Nikos Hadjichristidis

**KAUST**

Living organisms like, Plants and animals has ability to self-heal by their own which is a key feature to increase their survivability and lifetime. On the other hand, synthetic materials generally fails to heal the injury. Therefore, it is important to design materials with self-healing capability for their long term uses. Self-healing materials with shape persistence properties can be obtained by microphase separation, cluster formation, partial covalent crosslinking, etc.  Microphase separation in block copolymers is one of the promising strategy to generate mechanically robust materials that contains a soft phase with low glass-transition temperature (Tg) and a hard phase with high Tg. Supramolecular block copolymers with self-healing property is an interesting and attractive strategy which can improve the performance and scope of applications for this important class of polymers. In this work, supramolecular diblock copolymers (PS-DAT-sb-PI-Thy) were prepared via noncovalent hydrogen bonding (H-bonding) between well-defined thymine (Thy) end functionalized polyisoprene-Thy (PI-Thy) and diaminotriazine (DAT) end functionalized polystyrene-DAT (PS-DAT), which were successfully synthesized with the help of anionic polymerization followed by end functionalization with the help of suitable organic reactions. We have varied the molecular weight of corresponding homo polymers and make different sets of supramolecular block copolymers to see the effect in self-healing properties and micro phase separation. The strong complementary DAT/Thy interaction resulted in micro phase separation and self-healing property of supramolecular block copolymer system.

**Abstract** (#19595)

**Title**: Investigation of Green Synthesised Silver Nanoparticles in Dye-Sensitized Solar Cells

**Authors**: Khalil Ebrahim Jasim, Fatema Jaber Aljaboori, and Fryad Henari

**University of Bahrain**

Dye sensitized solar cells (DSSCs) is considered as one of the third generation solar cells. Incorporation of nanoparticles and quantum dots in DSSCs is promising light harvesting innovative materials. In this work natural dye extracts (NDEs) from various plant parts (such as Salvia, Cinnamon, Pomegranate, Saffron, and Gloves) were used in green synthesis of silver nanoparticles under different synthesis conditions. Both the extracted natural dyes and the grown silver nanoparticles were characterized using UV-visible spectroscopy. Transmission Electron Microscopy (TEM) was used to image and measure the size of the grown silver nanoparticles. Effects of dye extracts and silver solution concentration as well as preparation conditions have been investigated. The green synthesised silver nanoparticles and NDEs were used in fabrication of DSSCs. Operation principles, preparation, assembly and testing of the solar cells will be discuses. Electrical and optical characterization of the solar cells will be detailed. It is interesting to discover that cell electrical parameters such as photocurrent and power conversion efficiency of the solar cell get improved depending on the natural dye extract source.

# Session 2

**Abstract** (#19358)

**Title**: Design of Metal Nanostructures as High Performance Electrocatalysts for CO2 Conversion

**Authors**: Woong Choi and Hyunjoon Song

**KAIST**

For the long-term storage of renewable energy, electrochemical carbon dioxide reduction reaction (CO2RR) offers a promising option for converting electricity to permanent forms of chemical energy. Noble metals such as Au, Ag and Cu are widely employed catalysts for this purpose due to their optimum binding energy with *COOH, which is a core intermediate during CO2RR. Especially for nanostructured metal catalysts, their surface morphology is one of the most important factors for controlling binding energies with CO2RR intermediates and thus their electrocatalytic performance. In this work, Au nanostars, AuAg hollow nanocubes, and CuO branched nanoparticles were applied as electrocatalysts for the CO2RR to achieve high catalytic efficiency. In the first part, Au nanostars bounded exclusively with {321} facets are demonstrated which were fabricated from Au icosahedral seeds by a simple overgrowth method. These Au nanostars were applied as electrocatalysts in CO2RR, showing exceptionally high CO selectivity, mass activity, and specific activity due to their high energy surfaces. Secondly, porous AuAg alloy nanostructures were obtained by a simple galvanic replacement reaction from pristine Ag nanocubes. These AuAg hollow nanostructures not only reduce the amount of Au content in electrocatalysts to achieve affordable prices, but also meet higher electrocatalytic performances for converting CO2 to CO when compared with monometallic Ag and even Au nanocubes. In the last part, an oxide-derived Cu electrocatalyst with a scale of about 100 nm were prepared from the electrochemical reduction of branched CuO nanoparticles. This particle-based electrocatalyst showed extraordinary high ethylene selectivity of 70% in CO2RR without any side products except hydrogen gas. By precisely controlling the surface of metal nanoparticles and monitoring their electrocatalytic behavior during CO2RR conditions, we demonstrate the process of unravelling nanostructure- performance relationship and thus mechanistic insights for heterogeneous electrocatalysis.

**Abstract** (#19378)

**Title**: Development of a Liquid Crystal-Based Sensing Platform for Direct Detection of Heavy Metal Ions

**Authors**: Sulayman A. Oladepo

**KFUPM**

A simple sensing method based on liquid crystals (LCs) has been developed for the direct detection of metallic ions in water. The method consist of nematic 4-cyano-4’-hexylbiphenyl (6CB) LC. This LC is inherently photoluminescent, however, when mixed with a solution of metallic ions, the LC shows an anti-Stokes shift and an increase in photoluminescence intensity. Thus, a solution of 6CB in acetone was harnessed for the direct detection of several metallic ions, including Mg2+ and Ag+, without any chelating ligand or mediators. Various concentrations of the metal analytes were mixed with the LC solution, and the photoluminescence was measured. The photoluminescence intensity directly correlates with metallic ion concentrations. In addition, the concentration-dependent photoluminescence intensity graph becomes non-linear at specific concentration that is also metal ion-dependent. This LC-based detection method gives low limit of detection for tested metallic ions. For instance, the limit of detection determined for Mg2+ and Ag+ are 3.5 ppb and 140 ppb, respectively. The observed behaviour of the LC and its photoluminescence response to metallic ions are discussed in the context of disruption of the orientation of the LCs, which correlates well with concentration of the added metal ion.

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**Abstract** (#19423)

**Title**: Electrochemical Synthesis of Ammonia with Proton-Conducting Solid Oxide and Operation of Direct Ammo.

**Authors**: Kangyong Lee, Seung Jin Jeong, WooChul Jung , Sai P. Katikaneni, Kunho Lee, Joongmyeon Bae

**KAIST**

Various studies have been conducted to find alternatives of hydrogen storage, such as ammonia, liquid organic hydrogen carrier, metal hydride, and so on. To resolve its low volumetric density, several materials based on liquid system have gotten interest. Among these, ammonia is considered as the most promising alternative for some reasons. First of all, it has 2.5 times higher volumetric density compared to compressed hydrogen since it can be easily liquefied at room temperature (10 bar, 25 ?). Furthermore, it doesn’t have any carbon component which can cause degradation of electrochemical device, and also CO2 emission.

However, it is hard to utilize ammonia as a fuel considering economy. Haber-Bosch process, the most conventional process of synthesizing ammonia, requires high temperature and pressure conditions, resulting in consumption 1-2% of produced energy worldwide to synthesize ammonia. Therefore, developing new methods to synthesize ammonia with lower energy consumption would be breakthrough to realize ammonia hydrogen carrier.

In this study, to demonstrate the feasibility of ammonia as a hydrogen carrier, two respective studies have been conducted. First, electrochemical synthesis of ammonia has been conducted to suggest an alternative process to synthesize ammonia. To do so, several metal electrodes were fabricated on both sides of La0.8Sr0.2Ga0.8Mg¬0.2O3-d pellets. Ammonia was successfully produced, and the formation rate is about 2 x 10-9 mol/cm2 s. Second, solid oxide fuel cells (SOFCs) has been operated with ammonia-fuel to see the feasibility of ammonia as a direct fuel of SOFCs. Two different types of SOFCs have been operated to find factors that affect performance of fuel cells, and the results obtained from ammonia-fed operation are comparable to that of hydrogen-fuel.

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**Abstract** (#19431)

**Title**: Reinforcing Polyethylene (LLDPE) with Polyethylene-Grafted Silica Nanoparticles

**Authors**: Reem D. Alghamdi, G. Zapsas, K. Ntetsikas, P. Bilalis, N. Hadjichristidis

**KAUST**

Nowadays, polymer/silica nanocomposites have a profound impact in academic and industrial field and have been employed in a variety of applications (tires industry). The addition of silica nanoparticles to polymers allows the modification of polymers' physical properties as well as the implementation of new features in the polymer matrix.

In this work, we synthesized novel polyethylene (PE)-grafted silica nanoparticles by following three different synthetic strategies: a) surface-initiated boron-catalyzed C1 polymerization (polyhomologation), b) surface-initiated anionic polymerization of 1,3-butadiene and subsequently hydrogenation of polybutadiene (PB) to transform the silica NPs-g-PB into silica NPs-g-PE and c) in-situ formation of silica NPs-g-PB by using anionically pre-synthesized PB chains terminated with tetraethoxysilane (TEOS) and modified Stöber process, followed by hydrogenation of PB to transform into silica NPs-g-PE (Scheme 1). The final PE-modified silica-NPs were characterized by size exclusion chromatography (SEC), Fourier transform infrared spectroscopy (FT-IR), solid state nuclear magnetic resonance spectroscopy (ssNMR) and transmission electron microscopy (TEM). Thermal properties were determined by differential scanning calorimetry (DSC) and thermal gravimetric analysis (TGA). Furthermore, we studied the ability of silica NPs-g-PE as reinforcing additives for linear low-density polyethylene (LLDPE) by tensile testing, in comparison with the conventional silica filler.

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# Session 3

**Abstract** (#19469)

**Title**: From Oils to “Degradable Polyethylene”: A Fast and Living Organocatalytic Ring-Opening Polymerization

**Authors**: Viko Ladelta, Nikos Hadjichristidis

**KAUST**

Macrolactones (MLs) such as dodecanolactone (DDL), pentadecalactone (PDL), and hexadecalactone (HDL) are fragrances additives that originally extracted from plants and animals.1 With the recent development of synthetic chemistry, commercials MLs can now be synthesized from oils. MLs are known to undergo ring-opening polymerization (ROP) to yield polymacrolactones (PMLs) which have thermal and mechanical properties close to polyethylene (PE). Several catalysts such as enzymes and metal complexes have been reported capable of promoting ROP of MLs.1 However, enzymes exhibit low catalytic activity on the ROP of MLs, whereas metal complexes are difficult to be removed from the resulting PMLs and remain as impurities. In contrast, organic catalysts like phosphazene superbases (PSBs) offer a high catalytic activity and easy removal from the polymer. We report a fast and living ROP of MLs with primary alcohol as the initiator and strong PSBs t-BuP4 (pKa = 42.8) as the catalyst.2, 3 The ROP proceeds to high conversion in bulk and solution, even at dilute concentration. The microstructure of the PMLs were characterized by 1H, 13C NMR, and matrix-assisted laser desorption/ionization spectroscopies. The resulting PMLs have melting point (Tm) and degree of crystallinity (Xc ) up to 93 °C and 55%, almost similar to the Tm and Xc of PE. In order to test the degradability, a simple degradation experiment was performed. PMLs films (1 cm × 1 cm × 1 mm) were placed in aqueous sodium hydroxide solution at room temperature. The weights of PMLs films decreased ~10 % after six months, indicating that PMLs are potential degradable thermoplastics. Further study is needed to find a more suitable degradation agent, preferably with bio-enzyme under ambient conditions.

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**Abstract** (#19368)

**Title**: 2D Materials Hybrid Structure Effect On Rechargeable Lithium Battery At Elevated Temperature

**Authors**: Edreese Alsharaeh, Zahra Bayhan, Yasmin Mussa,Muhammad Arsalan

**Alfaisal University**

Over the past few decades, lithium-ion batteries (Li-ion) have revolutionized the energy storage market owing to their high energy and power density as well as their high lifetime when compared to other battery technologies. The demand for Li-ion batteries continues to increase rapidly, driven by the growth in hybrid and electric vehicle (EV) productions. However, as Li-ion batteries approach their theoretical

limits with high cost, there is a need for new battery chemistries that go beyond lithium-ion intercalation in response to the ever-growing energy demand.

Given the above, lithium-sulfur (Li-S) batteries based on a conversion mechanism hold great promise for next-generation batteries. The combination of metallic lithium with elemental sulfur enables a theoretical energy density of 2,500 Wh/kg, which is three times higher than Li-ion batteries. Moreover, the natural abundance and environmental friendliness of sulfur make Li-S batteries a green and low-cost alternative. However, a limitation of this technology is the rapid capacity fading resulting from the generation of long-chain lithium polysulfides (Li2Sx), a phenomenon called shuttle effect. Another problem is the insulating nature of sulfur.

In this work, a two-dimensional (2D) based on hexagonal Boron Nitride and Graphene Oxide Nanocomposites (h-BN/GO) is prepared via a simple, cost-effective route and investigated as a sulfur host to avoid shuttle effect. X-ray diffraction (XRD) reveals the effective utilization of sulfur in h-BN/GO. Moreover, band gap studies indicate that the incorporation of h-BN can tailor the electronic structure of GO. The high mechanical robustness (hardness: 0.072 GPa and modulus: 5.22 GPa) of the material can account for the volume expansion caused during the charge/discharge process. Electrochemical measurements showed that the h-BN/GO hybrids based Li-S batteries have an enhanced electrochemical property when compared to h-BN and GO revealing the synergistic effect between h-BN and GO. Moreover, this h-BN/GO hybrids also showed excellent performance at elevated temperatures from room temperature up to 100 °C which is attributed to the high thermal stability of the h-BN/GO Nanocomposites

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**Abstract** (#19409)

**Title**: Self-cleaning Superhydrophobic Epoxy Coating Based on Fibrous Silica-coated Iron Oxide Magnetic Nano

**Authors**: Haleema Alamri, Abdullah Al-Shahrani, Enrico Bovero, Turki Khaldi, Gasan Alabedi, Waleed ObaidI, hsan Al-Taie, and Aziz Fihri

**Saudi Aramco**

The superhydrophobicity properties found in nature, in entities such as lotus leaves have inspired scientists to explore a range of pathways for the fabrication of a variety of superhydrophobic structures that have varied functional systems, with the goal of developing the next generation of hybrid/functional materials [1,2]. Combining the properties of superhydrophobic structures and responsive materials such as iron oxide is currently of major interest in the materials science research community [3,4]. However, only few research has been devoted to the design of magnetic superhydrophobic nanocomposites with improved stability and durability [3,4]. The addition of an inert layer on the surfaces of the magnetite particles was found preventing their aggregation, thus enhancing their chemical reactivity and stability. The use of silica as an inert shell layer to the magnetite nanoparticles not only helps in enhancing the advantages of their high biocomptability, hydrophilicity, dielectric property and stability against degradation but also facilitates easy surface modification due to the availability of abundant silanol groups on the surface. In this communication, a new synthesis approach of fabricating superhydrophobic silica coated magnetite nanoparticles using a cost-effective process will be presented. In addition, the structural characterizations and performance of this new superhydrophobic silica coated magnetite nanoparticles under a variety of corrosive conditions will be also discussed.

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**Abstract** (#19250)

**Title**: Synthesis and Characterization of Branched fcc/hcp Ruthenium Nanostructures and Their Catalytic Acti

**Authors**: Noktan M. AlYami, Shouwen Shen and Abdullah K. AlDakheel

**Saudi Aramco**

Fundamental properties of nanoparticles such as crystal structure is very useful for controlling their physical and chemical properties such as catalysis. Different crystal structures of the same single metal and/or bimetallic nanoparticles have a different catalytic response to the chemical reactions. Ruthenium (Ru) is a typically hexagonal close packed (hcp) nanomaterial, but recent reports have shown increased activity and stability for its counterpart crystal structure (face centered cubic, fcc) towards various catalytic reactions such as carbon monoxide oxidation and hydrogen oxidation reaction. In this talk, I will demonstrate a single and continuous synthesis for the formation of different morphologies of Ru nanoparticles with different concentrations of the fcc and hcp crystal structures. For example, highly branched ruthenium nanoparticles enclosed by high index surface planes grow from an fcc icosahedral seed and form sheet-like arms. Also, I will illustrate how the growth process, and hence final morphology of the Ru nanostructures is controlled by the selection of metal carbonyls present in the reaction media, where it was found that changing the metal carbonyls resulted in different Ru nanostructures and affected the crystal structure of the nanoparticles. Finally, I will share the catalytic activity of Ru nanoparticles towards the hydrolysis of ammonia borane (AB) which has been identified as one of the leading molecular candidates for hydrogen storage.

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# Session 4

**Abstract** (#19478)

**Title**: Improved Gas Transport Performance and Feed Stability Through Highly Tunable, Branched Nanoparticles.

**Authors**: Benjamin J. Sundell, Won Seok Chi, Ke Zhang, Daniel J. Harrigan, Steven C. Hayden, Zachary P. Smith

**Aramco Services Company**

Membranes improve the energy efficiency of desalination, gas upgrading and many other separation technologies, yet performance tradeoffs between permeability and separation efficiency limit industrial adoption. The use of precisely defined nanoparticles, such as metal-organic frameworks (MOFs), overcome these performance tradeoffs, though these nanoparticles often produce heterogeneous defective membranes. We synthesized two variations of the copper-based HKUST-1 MOF, one using conventional approaches that produced micron-sized particles, and one using a structural modulator that disrupted crystalline formation and produced highly branched nanoparticles. The use of a carboxylate modulator controlled the nucleation and growth kinetics of MOF formation and resulted in branched nanoparticles of greatly reduced size (100-300 nm) and aspect ratios of 5-20. DLS and SEM confirmed the size and shape differences between the two nanoparticles, while XRD confirmed the HKUST-1 structural identity. Afterwards, mixed-matrix membranes (MMM) loaded with 10, 20, and 30% of the bulk or branched nanoparticles were cast and characterized via FTIR, XRD, and FIB-SEM tomography. When loaded into a polyimide polymer matrix, these nanoparticles demonstrated greatly enhanced dispersion and homogeneity compared to analogous bulk MOFs. Bulk MOFs settled at the bottom of the polymer matrix and produced a heterogeneous two-phase membrane, while branched MOFs produced a percolated network, one homogenous phase and films of high optical transparency. In gas transport studies, the MMM produced with branched nanoparticles showed greatly improved gas permeability compared to the neat polyimide, and also showed a simultaneous increase in gas permeability and selectivity compared to MMM produced with the bulk HKUST-1 particles. High pressure testing up to 800 psi showed detrimental swelling and plasticization of the bulk MMM membranes beyond 150 psi, while the branched MMM notably showed no indication of plasticization up to 800 psi. The enhanced stability of the branched MMM in high pressure feeds likely stemmed from increased surface interactions between the polymer chains and branched nanoparticles.

**Abstract** (#19608)

**Title**: Therban HNBR and Extrusion Resistance in Packer Applications

**Authors**: Susanna Lieber, Christoph Gögelein, Marjan Hemstede, Andreas Kaiser, Victor Nasreddine

**Arlanxeo**

ARLANXEO is a world-leading synthetic rubber company with sales of around EUR 3.2 billion in 2017, about 3,900 employees and a presence at 20 production sites in nine countries.

Therban® HNBR is ARLANXEO's hydrogenated nitrile rubber within the HPE business unit. Therban is a specialty elastomer that shows excellent dynamical and mechanical properties as well as resistance to oil, heat, tear and abrasion. In order to meet the demanding performance requirements in the oil drilling industry, these properties are very important.

Therban® can be used in a wide range of oil field applications, like packers, stators, blow-out preventers and seals. Compared to other elastomers, it could potentially extend the life time and replacement cycle of these parts.

In this presentation we will go into the properties of Therban® and our latest developments made to improve heat resistance and durability. Furthermore we will explore the effect of Therban® polymer properties on extrusion resistance, which is important for packer seals. We will also show results of compound formulation changes on how to balance extrusion resistance and other property requirements for packer seals.

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**Abstract** (#19701)

**Title**: Elevated Sour Gas Separation Performance by Controlling Crystallinity and Crosslinking in Poly(ethyl.

**Authors**: Daniel J. Harrigan, BenJamin J. Sundell, John A. Lawrence III

**Aramco Services**

Saudi Arabia faces significant challenges in natural gas processing due to high concentrations of H2S, an intractable and hazardous gas contaminant. Gas separation membranes offer an energy-efficient solution for removing contaminant gases, and this work describes novel crosslinked polyethylene glycol (PEG) membranes synthesized specifically for sour gas sweetening applications. Separation performance under high pressure mixed sour gas feeds was measured and compared to existing commercial alternatives to evaluate the effectiveness of the novel membranes. Oligomeric PEG of varying molecular weights was reacted with stoichiometric amounts of a trifunctional crosslinker to create highly crosslinked polymer gels, and the networks were characterized by FTIR, DSC, and XRD. Mixed gas permeation tests performed at 800 psi with simulated sour gas feeds containing H2S up to 20% by volume tested membrane stability.

Analyzing the effect of PEG content and crosslink density on membrane performance provided the basis for several intriguing property performance relationships. Thermal analysis confirmed the polymers synthesized from low molecular weight PEG (200-400 Da) as amorphous glasses at room temperature, the polymers synthesized from higher molecular weight PEG (600-2000 Da) as amorphous rubbers, and the polymers synthesized from PEG molecular weights greater than 2000 Da as semi-crystalline rubbers. Gas permeabilities increased with polymer Tg, but the selectivity trend exhibited a bell curve with the maximum ideal selectivity achieved by the PEG 600 network polymer. High pressure mixed gas feeds demonstrated improved plasticization resistance to H2S compared to commercial benchmarks, CA and Pebax®. The highest performing PEG membrane exhibited 3.0 times higher H2S permeability and 1.9 times higher H2S/CH4 selectivity than those of CA as well as 1.8 times higher CO2/CH4 selectivity and 1.2 times higher H2S/CH4 selectivity compared to commercially available Pebax.

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**Abstract** (#19573)

**Title**: Sustainable SABIC Solution for Insulation Foams in Building & Construction.

**Authors**: Milind Mhalgi, Bander Al-Farhood; Pal, Subodh; Ismail-Al, A. A.

**SABIC**

HBCD (Hexa bromocyclo dodecane) was commonly used as a as a flame retardant in Polystyrene foams. It has several health hazards and therfore brominated compounds that are REACH compliant are being used now-a–days as an alternative to HBCD. SABIC has successfully developed expanded polystyrene with Eco-friendly flame retardant by shortlisting many flame retardants in the initial phase and then selecting the best after the detailed experimentation. This is a sustainable non-halogenated flame retardant solution. The ojective was to retain the flame retardant property of a foam and provide a sustainable solution. The benchmarking of the samples foam samples from Europe with the foam samples with eco-friendly flame retardant developed in SABIC STC is completed and the perfomance is compared in terms of Oxygen Index. After successful When it is successful, it will be implemented on all EPS FF grades. This foam has an application in Building and construction where it improves the climate control of any house. Compared to HBCD, the is the promising solution in terms of sustainability retaining all the thermal insulation properties of the foam.

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# Session 5

**Abstract** (#19292)

**Title**: Capturing the Exhaust Pollutants – The Need to Develop Advanced Materials

**Authors**: Tamour Javed, Remi Mahfoez, Esam Z. Hamad

**Saudi Aramco**

Pollutant regulations for the automotive sector are expected to be further stringent in the future. Solid sorbent based adsorption has the potential to capture these pollutant species. Here, using a gasoline light-duty vehicle as an example, we first outline the pollutants that are present in the exhaust. Next, we propose the physio-chemical criteria for the sorbent selection to achieve meaningful onboard pollutant capture. Further, using the available sorbents, we estimate the sorbent volumes required for onboard pollutants capture. Finally, we will highlight the need to develop innovative materials for onboard pollutants capture.

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**Abstract** (#19386)

**Title**: Design and Analysis of Spoolable Thermoplastic Reinforced Pipes (RTP) for On-shore Oil and Gas Applications

**Authors**: Ali Alghamdi, Abdul Rahim Arafath and Ratnesh Khandelwal

**SABIC**

Reinforced Thermoplastic Pipes (RTPs) are considered as prospective alternatives to traditional steel pipes in various onshore/offshore oil and gas applications due to their attractive properties such as better corrosion resistance, high stiffness and strength to weight ratios and low maintenance costs. They were initially developed in the early 1990s to replace medium-pressure steel pipes in response to the growing demand for noncorrosive application in the onshore oil and gas industry. Typical construction of RTP includes polymeric liner, a structural layer and an outer polymeric cover.

Currently, designs and qualifications of RTPs are governed mainly by industry standards and specifications such as API SPEC 15S. In this work, Finite Elements Analysis assisted approach for pipe design to meet API SPEC 15S requirements is presented. A studies of the mechanical behavior of RTPs composed of different composite structural layers, and subjected to pressure and bending loads are conducted using FEA. Mainly, the pressure resistance and spoolablity of an RTP is investigated as they are the primary concern in designing onshore pipes for water and hydrocarbon transportation.

**Abstract** (#19702)

**Title**: PA11 & PVDF : High Performance Polymers for Oil and Gas Applications

**Authors**: Cyrille Mathieu, Patrick DANG and Cyrille Mathieu

**ARKEMA**

In industrial piping applications, the main plastic materials used are High Density Polyethylene (HDPE), Polypropylene (PP), Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (C-PVC). But for applications other than potable water, waste water, land drainage, and low-pressure natural gas distribution, there are too many weaknesses to have a safe use. That's the reason why the industry is using technical polymers like polyamides (PA) or polyvinylidene difluoride (PVDF) for their higher thermomechanical properties, and better chemical and permeation resistance to liquid hydrocarbons and gases.

A special focus will be made on the use of PA11 as pressure sheath for high pressure flexible pipes used in offshore oil and gas production since the 1970's. The oil and gas industry has developed a lifetime model for the use of PA11 and PA12 in offshore flexible pipes which can also be applied to high pressure natural gas distribution piping systems.

Some differences between PA11 and PA12 will be highlighted, and a comparative in-situ creep study with PE-RT will show why it is important to be cautious when considering the use of materials designed for hot water applications in hot hydrocarbon transportation pipes.

For high end applications (temperature > 80°C, sour conditions), Kynar® PVDF is the solution proposed for Oil&Gas market. Arkema has designed a specific PVDF range for this application. We will show how our product portfolio is answering to the different customer requests ( Riser /Flowline, RTP , Liner)

**Abstract** (#19289)

**Title**: 3-Dimensional Nanoarchitectures for Energy Conversion.

**Authors**: Yeon Sik Jung

**KAIST**

This talk introduces our novel solvent-assisted nanotransfer printing (S-nTP) strategy that can controllably generate extremely fine (down to sub-10 nm) functional nanostructures with excellent transfer yield (~100%). As an example for energy conversion applications, we demonstrate that 3D Pt and Ir nanostructures can be used as highly active electrocatalysts for polymer electrolyte membrane fuel cell and water electrolysis cell, respectively, due to highly enhanced materials transport in the well-ordered 3D geometry. In addition, high-yield conversion from CO2 to carbon compounds is essential for sustainable production of fuel feedstock and for balancing nature's carbon cycle to resolve the greenhouse effects caused by CO2 emission. We show that S-nTP can produce novel 3D structure which can realize electro-reduction of CO2 to CO with high efficiency and selectivity at low overpotentials based on the control of local pH gradient. We expect that various 3D-ordered nanostructures formed using our S-nTP provides markedly enhanced functionality and robustness compared to random nanostructures.

# Session 6

**Abstract** (#19501)

**Title**: Optimizing Porous Catalytic Materials with Respect to Intra-particle Mass Transfer

**Authors**: G. Pirngruber

**IFP Energies nouvelles (IFPEN)**

Most catalysts for refining processes are shaped in the form of extrudates or spheres. In many reactions, in particular for the conversion of heavy oil fractions, the mass transfer within the shaped particle has a big impact on the effective catalyst activity. It is, therefore, extremely important to optimize the porosity of the catalyst particle with respect to mass transfer and to develop methods to characterize the pore network and its connectivity. The presentation will illustrate recent advances of IFPEN research in the field, covering methods like PFG NMR and inverse gas chromatography. Examples on hydrotreating and hydrocracking catalysts will be provided, which highlight the hierarchical nature of the pore systems and the relation to mass transfer.

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**Abstract** (#19285)

**Title**: Development and Testing of Novel Lubricants for Extreme Piston Ring Pack Environments.

**Authors**: Frank T. Hong, S. Mani Sarathy

**KAUST**

Styrene Butadiene Rubber is one of the first synthetic general purpose rubber to be produced in the world. However, in little over two decades time, there has been significant development in this polymer, which is mainly driven by regulations and government mandates like CAFÉ in US and Tire labelling requirements in EU. Add to this, there have been more stringent requirements coming from Electric Vehicle (EV) development, which requires tire to have significant improvement in rolling resistance to conserve battery life of vehicles and improve non-stop running of vehicles without recharging. Unlike the conventional IC engines, these vehicles have very high torque transmission from electric engines, which requires tire treads to have excellent traction properties. With almost silent engines these vehicles, the only noise is from the tire running which also has to be minimum.

Considering all the new regulatory and market requirements, SABIC produced licensed Solution SBR grades, namely SSBR3323H & SSBR3041H, which were evaluated for rolling resistance and traction properties against available competitor material. SABIC SSBRs exhibited excellent physical and mechanical properties. Relatively higher Styrene content, improved traction characteristic while higher vinyl content improved rolling resistance in high performance tire tread compounds evaluated in the study.

**Abstract** (#19446)

**Title**: Selectivity and Efficient Pb and Cd Ions Removal by Magnetic MFe2O4 (M=Co, Ni, Cu and Zn) Nanopartic

**Authors**: K. Al Yaqoob, M. Bououdina ,B. Al-Najar, M. S. Akhter , J. Judith Vijaya , W. Cai
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Spinel ferrite MFe2O4, (M = Co, Ni, Cu and Zn) nanoparticles (NPs) were prepared by microwave combustion method using metal nitrates as precursors, in addition to urea as fuel. Rietveld analysis of X-ray diffraction patterns indicates the formation of single phase for NiFe2O4 and ZnFe2O4, while (?-Fe2O3 and CuO) phases precipitate for CoFe2O4 and CuFe2O4, respectively. After annealing 800°C for 16 h, single cubic CuFe2O4 phase is obtained. SEM images show spherical/undefined shaped particles at the nanoscale with broad particle size distribution and high level of agglomeration. Magnetisation-field (M-H) curves reveal ferromagnetic behaviour for CoFe2O4, NiFe2O4 and CuFe2O4, and superparamagnetic behaviour for ZnFe2O4. Interestingly, after annealing CuFe2O4 shows a superparamagnetic behaviour due phase tetragonal-cubic phase transformation. Saturation magnetization, remanence and coercivity slightly change after annealing, except for CuFe2O4, due to phase transformation from tetragonal to cubic; Ms decreases abruptly from 25.97 to 1.685 emu/g. The as-obtained spinel ferrite nanopowders are tested for two toxic metal ions removal from aqueous solutions; Cadmium (Cd2+) and lead (Pb2+) with different concentration (5, 10, 20 and 30 mg) and pH (2, 12). The maximum adsorption capacities are found at the lowest concentration (5 mg) and at alkaline medium (pH 12). The as-prepared magnetic nanoparticles demonstrate enhanced efficiency for both Cd2+ and Pb2+, with maximum adsorption capacity of 69.4 and 47.1 mg/g, respectively. Interestingly, the nature of metal M has a direct influence on selectivity, CoFe2O4 toward Cd2+ while ZnFe2O4 toward Pb2+.

**Abstract** (#19302)

**Title**: Additives to Sustain Quality of Product During Storage and Transport Under Harsh Climatic Condition

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**SABIC**

Saudi Basic Industries Corporation (SABIC) offers high quality chemicals processed under stringent quality control for a wide range of applications. Customers' from world –wide demand very stringent specification of chemicals for their various downstream applications. Transporting of certain chemicals without affecting their quality is a challenge and it became more challenging under middle-east harsh weather condition. This presentation emphasis on transportation of certain chemicals, which require stricter monitoring and care during storage, supply and voyage until consumers end. The reason behind off specification of those chemicals quality lies within autoxidation/ self-polymerization of compound. Autoxidation is well known phenomenon. However, it did not get serious attention in certain field like long chain or branched chain alcohols. This presentation will focus on risk mitigation during transportation and safe handling of those material in presence of different additives or antioxidants.