The Center of Research Excellence in Nanotechnology (CENT) organized a seminar on “Selective oxidation of lower alkane” presented by Dr. Skrikant Gopal, a Lead Scientist at SABIC Technology Center, Riyadh on the 6th of December, 2017. The event was graced by CENT personnel, faculties, students, and members of staff of the University . . . (details on page 2).

Cover page of the current issue of ACS Applied Materials and Interfaces

A CENT-affiliated publication titled “Turning the Interplay between Selectivity and Permeability of ZIF-7 Mixed Matrix Membranes,” co-authored by Dr. Aasif and Dr. Yamani of CENT was selected to be highlighted on the cover page of the current issue (Volume 9, Number 39) of ACS Applied Materials and Interfaces.

http://pubs.acs.org/doi/10.1021/acsami.6b15803

Associate Editor for Frontiers in Energy Research Journal

CENT member Dr. Oki Muraza Muluk was recently assigned the role of Associate Editor for Frontiers in Energy Research Journal (https://www.frontiersin.org/journals/energy-research) and Review Editor for the Frontiers in Chemistry Journal (https://www.frontiersin.org/journals/chemistry). EPFL, Lausanne, Switzerland.

Assistant Subject Editor for International Journal of Hydrogen Energy

CENT member Dr. Ahsan UI-Haq has been appointed as an Associate Subject editor for the International Journal of Hydrogen Energy
The Center of Research Excellence in Nanotechnology (CENT) organized a seminar on “Selective oxidation of lower alkane” presented by Dr. Skrikant Gopal, a Lead Scientist at SABIC Technology Center, Riyadh on the 6th of December, 2017. The event was graced by CENT personnel, faculties, students, and staff members of the University. The speaker started his presentation with a brief introduction about SABIC as a company among the top three producers of chemicals such as glycol in the world, and with a huge patent portfolio, particularly with recent focus on realizing value from innovation. He gave a brief introduction on the topic of the day (selective oxidation of alkane) as one of his work areas in his earlier years at SABIC, and its benefit and how it fits into the chemical industry value chain.

He defined the selective oxidation of lower alkane theoretically as a simple reaction between alkane and oxygen in the presence of a catalyst to produce a decided product and carbon dioxide as the undecided by-product, and he highlighted the main challenge of the process as being to maximize the selectivity for the decided product and minimize the production of carbon dioxide.

He highlighted the major benefits of selective oxidation route as the use of lower cost feed cost, direct one step processing and environmental benefit due to reduction in carbon dioxide production.
He also mentioned selectivity and production work rate as the two key parameters for a successful selective oxidation route, highlighting that a catalyst that can provide high selectivity and high work rate will be very attractive in the industry. He also explained the global chemical industry feedstock dynamic to give an understanding of the economics of the industry, and talked briefly of the impact of the shale gas revolution in the chemical industry with future projection of the reduction in oil based feedstock and increase in gas-based feedstock such as ethane and propane. This projection makes the selective oxidation route more attractive.

He discussed the selective oxidation of alkane to acetic acid, propane to acrylic acid, and ammoxidation of propane to acrylonitrile. In the selective oxidation of alkane to acetic acid, he talked about the use of a multifunctional catalyst by SABIC which enables it to achieve high selectivity of acetic acid, enabling SABIC to commercialize the process and own the only plant running on the direct ethane to acetic acid oxidation route. He highlighted some of the challenges of the oxidative dehydrogenation process which include the low running temperature of catalyst, removal of impurities from the process, and the separation of the gases from the reactor outlet gas.

He concluded by emphasizing the high potential of selective oxidation reaction as a direct one step alternative to replace a current production route, however, they must demonstrate better economic scenarios than the existing route to attract industry to invest in this route. The patent data presented indicate a lot of industrial activity in some of the selective oxidation routes.
Dissertation title: COST EFFECTIVE CATALYST DERIVED FROM NATURAL ZEOLITE THROUGH BALL MILLING AND RECRYSTALLIZATION METHOD FOR HYDROCARBON CONVERSION

Dissertation Abstract

Natural zeolites are plentiful and inexpensive natural minerals, which have had wide applications in agriculture, aquaculture, soil adjustment, building materials, water purification, and wastewater treatment. However, the utilization of natural zeolites for catalysis purposes is limited due to low crystallinity and poor textural properties. In the present work, we investigate methods to synthesize catalysts from low-cost natural zeolites through facile methods, i.e. sequential milling-recrystallization, and sequential milling-recrystallization-dealumination. These catalysts were used in dimethyl ether to olefins conversion, and n-butane isomerization.

We fabricated hierarchical mordenite nanoparticles from the low-cost natural mordenite through high-energy ball milling followed by hydrothermal recrystallization method. The as-received natural zeolites showed mordenite with impurity phases and low total surface area (ca. 133 m²/g) as indicated by X-ray diffraction study and nitrogen physisorption analysis, respectively. The as-received natural zeolites were milled by high-energy ball milling attritor to obtain nanoparticles within the size of 20-160 nm, which were confirmed by dynamic light scattering, field emission scanning electron microscopy, and transmission electron microscopy technique. The X-ray diffraction study revealed that crystallinity of the milled zeolites had decreased significantly. The crystallinity of mordenite nanoparticles was recovered after recrystallization of the milled sample in a hydrothermal basic silicate solution. The nitrogen physisorption study showed that the textural properties of recrystallized mordenite nanoparticles were improved with total surface area was ca. 240 m²/g and external surface area was ca. 150 m²/g, a 6-fold increase from the parent.

The hierarchical pore system was observed in the recrystallized mordenite as the mesopore volume increased to 0.36 mL/g from only 0.04 mL/g in the as-received natural zeolites.

A high conversion of dimethyl ether was obtained over the recrystallized mordenite (99.7%) and milled natural mordenite (54.1%) as compared to the parent (1.2%). Moreover, the milling only and the sequential milling-recrystallization processes improved selectivity toward olefins and prolonged catalyst lifetime. The reduced particles size, combined with the hierarchical porosity and acidity, effectively enhanced catalysts activity and selectivity to olefins. The samples were further tested for n-butane isomerization. The isobutane selectivity over nanoparticles mordenite fabricated by the sequential milling-recrystallization increased to 28% as compared to 11% on the parent mordenite. Moreover, the recrystallized mordenite nanoparticles showed better catalyst stability as compared to the microparticles parent sample. Finally, dealumination procedures were applied to the recrystallized mordenite nanoparticles. The total surface area of dealuminated nanoparticle sample increased to ca. 354 m²/g. The nanoparticles mordenite obtained by the sequential milling-recrystallization-dealumination exhibited the highest selectivity of ca. 58% to isobutane and less deactivation rate in the n-butane isomerization.
Combination of oil-water separation and water-soluble organic pollutants removal in a single unit operation is highly desirable for oily wastewater remediation (i.e. separation of water-insoluble oils and degradation of water-soluble pollutants). In this study, we fabricated textured surfaces with selective wettability and photocatalytic activity (i.e. multifunctional textured surfaces) for oily wastewater treatment in a single unit operation.

For developing of specific materials which are superhydrophobic (water contact angle > 150° and sliding angle < 10°) and superoleophilic (oil contact angle ~ 0°), a facile synthesis method for highly stable carbon nanoparticle (CNP) dispersion through the incomplete combustion of paraffin candle flame is also presented. The synthesized CNP dispersion is the mixture of graphitic and amorphous carbon nanoparticles, sized in 20-50 nm range and manifested by mesoporosity with an average pore size of 7 nm and a BET surface area of 366 m²·g⁻¹. As an application of this material, the carbon nanoparticle dispersion was spray coated (spray-based coating) on a glass surface to fabricate water jet resistance superhydrophobic surfaces.

Also, we developed a universal, scalable, solvent-free, one-step methodology based on thermal annealing of stainless steel meshes to create appropriate surface texture and simultaneously modify its surface energy (i.e. chemical composition, Fe₂O₃ and/or Fe₃O₄-based composites). These annealed stainless steel meshes are mechanically robust and exhibit under-water selective wettability of water over oil for gravity-driven oil-water separation and visible light responsive photocatalytic activity for water-soluble organic pollutants degradation under visible light irradiation. We believe that our approach will enable the fabrication of robust multifunction membranes for large-scale applications in oily wastewater treatment.

Furthermore, for the first time, a simple and facile spray coating method was successfully used to fabricate a novel Janus membrane that possesses superhydrophilic-superoleophobic surface on the feed side and photocatalytic surface on the permeate side. We developed a mathematical model that describes the photocatalytic degradation of organics upon UV illumination and showed that our model matches very well with the experimental result. Our Janus membrane exhibits high separation efficiency of free/emulsified oil-water mixtures and high in-situ photo-degradation efficiency of organic pollutants in the water-rich permeate upon UV light illumination. We believe that our Janus membrane has a great potential for large-scale treatment of oily wastewater.
PhD Dissertation of Mr. Shahid Ali of Chemistry Department

Dissertation Title: SYNTHESIS AND CHARACTERIZATION OF FUNCTIONALIZED SUPER-PARAMAGNETIC NANOMATERIALS AS IMAGING AGENTS FOR CRUDE OIL-BEARING FORMATION

Dissertation Abstract

Information acquisition and analysis of oil reservoirs are the most challenging and scientifically demanding areas in the oil exploration industry. This research work has successfully demonstrated the potential of functionalized superparamagnetic iron oxide nanoparticles (SPIONs) as contrast agents for oil reservoir applications. In this seminar, Mr. Shahid presented the synthesis, characterization, and utility of functionalized SPIONs for two important issues faced by the petroleum industry: (i) overlapping of NMR signals produced from oil & water, (ii) imaging of fluid present within the reservoir rocks. For this purpose, relaxivity properties and NMR T₂-distribution measurements were performed for oil/water signal separation. The fluid phase (i.e., brine and oil) present within the rock cores was successfully identified by utilizing SPIONs as contrast agent via computed tomography (CT). The research work was carried out at lab scale using the sample packs (i.e., carbonate, sand packs) and reservoir cores that mimic the actual oil reservoir conditions. It will help to map the physiochemical properties and dynamics of the reservoir as well as will create the potential to develop next-generation technologies for oil reservoir applications.
Dissertation Title: DEVELOPMENT OF MESOPOROUS NANOSTRUCTURED CATALYSTS FOR HIGH EFFICIENCY H₂ PRODUCTION FROM WATER

Dissertation Abstract
One of the main impediments facing the large-scale production of hydrogen (H₂) via water electrolysis is the use of expensive platinum metal as an electrocatalyst. Early transition metal carbides and phosphides with platinum-like catalytic behavior have emerged as economic and earth-abundant alternatives to Pt. However, most of the synthetic procedures employed to produce these catalysts have led to bulky and low surface area products due to the agglomeration and coalescence of the metal during crystallization, which restrains their application for catalytic H₂ reaction. We, therefore, developed novel preparation protocols to improve the dispersion of the active sites on the carbon supports. We showed that highly porous frameworks of MIL-53, a metal organic framework, could be used as a template to guide the formation of highly dispersed molybdenum carbide (Mo₂C) embedded within the mesoporous carbon. The other strategy was based on the complexation method. Molybdenum was coordinated with an oxalate group using oxalic acid, which modified the self-assembling of molecular precursor and controlled the nucleation and growth of Mo₂C and molybdenum phosphide (MoP) on Carbon Nanotubes (CNTs).

In addition, we demonstrated the growth of interconnected hollow scaffold of cobalt phosphide (CoP) on CNTs. Hexamethylenetetramine, as used as a structure-directing agent. Plausible growth mechanisms were proposed. The methods are simple with the potential to scale-up. Compositions were characterized using standard techniques, such as transmission and high-resolution transmission electron microscope, field emission scanning electron microscope, powder X-ray diffraction, X-ray photoelectron spectroscopy (XPS), and so forth. The potential of as-prepared electrocatalysts was evaluated as low-cost electrodes for hydrogen evolution reaction (HER), both in acidic and basic electrolytes. It was demonstrated that smaller particle size with better dispersion, and hollow and interconnected artifacts, impart benign attributes, such as enhanced specific and electrochemically active surface area, low intrinsic charge transfer resistance, high interfacial charge transfer kinetics, and improved mass transport, to electrocatalysts. As a result, the electrode comprising as-synthesized compositions exhibited remarkable electrocatalytic performance, outperforming most of the electrocatalysts reported to date. The findings offer fresh impetus to engineer Pt-free electrode materials with high activity for large scale and sustainable H₂ production through electrolysis.
CONGRATULATIONS

Congratulations to the following CENT affiliated students on the successful presentation of their MS thesis

Mr. Omar Waqas Saadi
Mechanical Engineering

Thesis Title: Development and performance evaluation of CAU-1 metal-organic framework/polyetherimide mixed matrix membrane for gas separation

Mr. Hassan Ahmed Salih
Chemical Engineering

Thesis Title: Ethanol to olefins using modified SAPO-34 zeolite

Mr. Galal Atef Nasser
Chemical Engineering

Thesis Title: Synthesis and characterization of a novel chabazite (CHA) zeolite catalyst for the conversion of methanol to olefins (MTO) reaction

Mr. Abdul-Rashid Bawah
Chemical Engineering

Thesis Title: Development of transparent superhydrophobic and self-cleaning surfaces

Mr. Noman Naseeb
Mechanical Engineering

Thesis Title: Development and characterization of electrospun polyacrylonitrile-based nanocomposite membranes for oil-water separation

Mr. Mohammed Ameen Qasem
Chemical Engineering

Thesis Title: Preparation of metal oxide Nano particle-modified porous carbon electrode for oxygen evolution reaction

For comments, contact Mr. Mohammed Sanhoob +966 13 8607265, sanhoob@kfupm.edu.sa


