Chemical Engineering Department Faculty Research Focus Areas

Department of Chemical Engineering
College of Engineering
King Khalid University
Al Fara, Kingdom of Saudi Arabia

Chemical Reaction Engineering

Interested Research area

- Renewable Energy
- Biofuel Production
- H_2 Production
- All Solid- State Batteries
- Heterogeneous Catalysis

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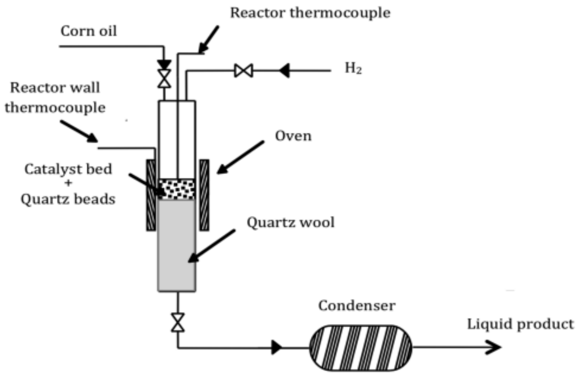
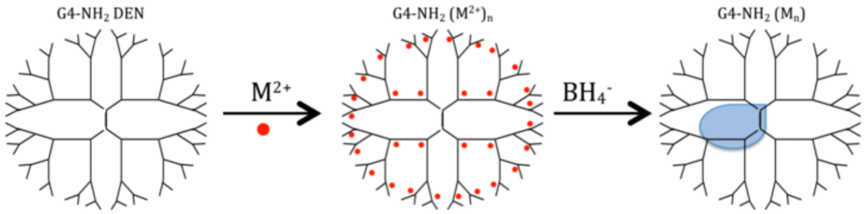
Green diesel production

The hydrocracking of distillers dried grains with soluble (DDGS) corn oil over bimetallic carbide catalysts was used for green diesel production. A catalyst composed of nickel−tungsten (Ni−W) carbide supported on Al-SBA-15 was designed based on the ability of nickel to adsorb and activate hydrogen and the potential of tungsten for hydrogenation reactions.



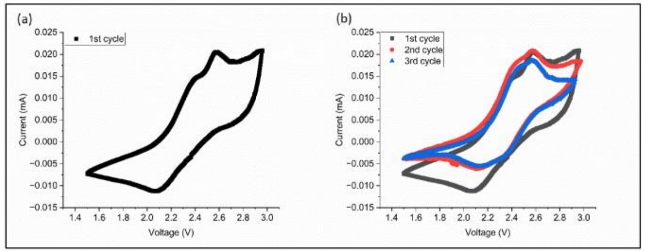
Synthesis of dendrimer-encapsulated nanoparticles

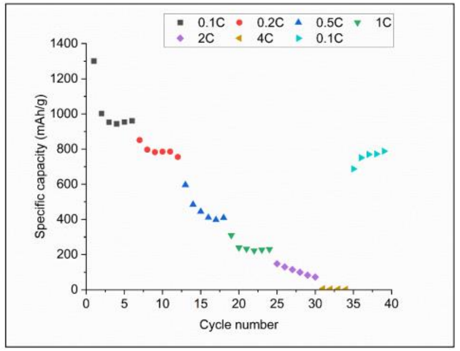
A dendrimer-encapsulated nanoparticle (DENP) method was employed to minimize alloy formation and increase the metal dispersion on the support. The catalysts prepared by the DENP method showed activity greater than that of the catalyst prepared by the impregnation method for the hydrocracking of DDGS corn oil.



All solid-state Li-S batteries

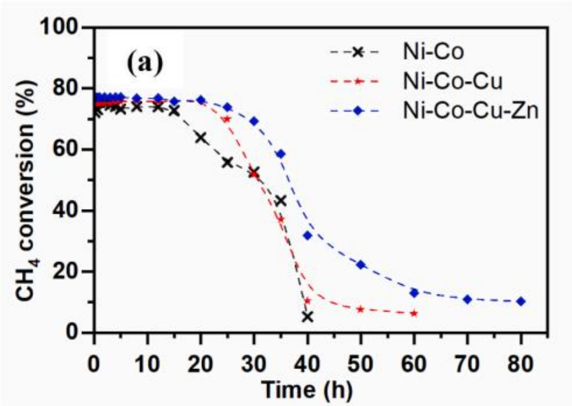
A novel composite solid-state electrolyte, which is nickel-tungsten carbides (NiWC) over mesoporous silica (SBA-15) filled polyethylene oxide (PEO), was developed and investigated for Li-S batteries.

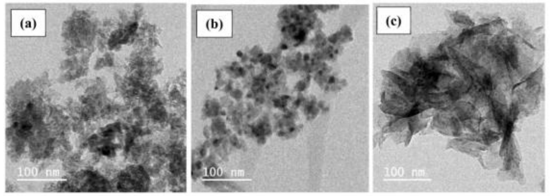




Methane decomposition for the production of COx free hydrogen

COx-free hydrogen production via methane decomposition was studied over bimetallic and trimetallic catalysts.





Main target are as follows:

- ❖ Synthesizing of solid electrolyte for Li-S and Na-S batteries
- ❖ Improving the ionic conductivity and stability of the solid electrolyte
- ❖ Developing metallic catalysts for methane cracking reaction
- ❖ Improving the activity and durability of the catalysts

Catalysis, Reaction Engineering & Hydrogen Generation

Interested Research area

- Catalysis and catalytic processes
- Environmental Protection-Carbon capture and storage
- Extraction Process
- Renewable energy
- Computational fluid dynamics

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Synthesis and optimization of suitable catalyst for enhanced methane decomposition to hydrogen

Mathematical formulations for H_2 production and CH_4 conversion vs. time curve

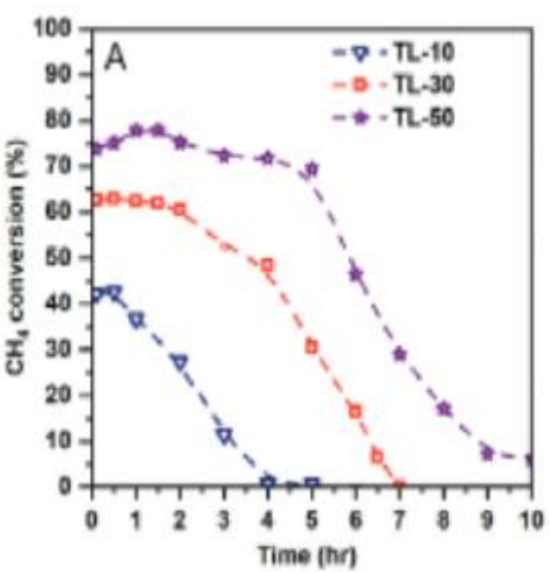
$$CH_4 = C(s) + 2H_2(g) \quad \Delta H^0_{298K} = 75.6 \text{ kJ mol}^{-1}$$

$$X_{CH_4}(\%) = \frac{\left(F_{CH_4 in} - F_{CH_4 out}\right)}{F_{CH_4 in}} \times 100$$

Hydrogen Productivity (HP, ml/g_{cat} h)

$$= \frac{\text{Hydrogen produced}\left(\frac{ml}{h}\right)}{\text{Wieght of catalyst}\,(g_{cat})}$$

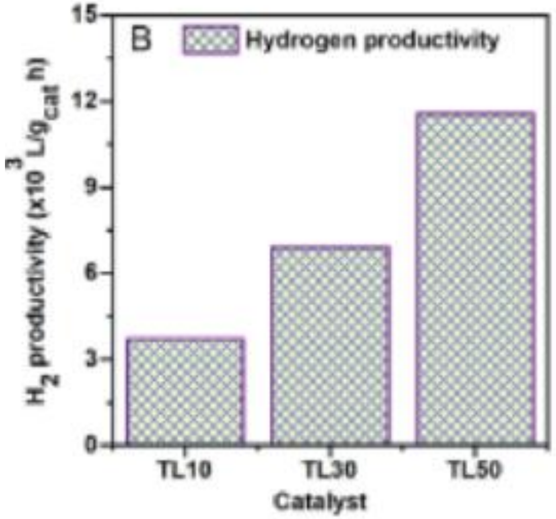
$$\text{Total carbon yield} = \frac{g_c}{g_{cat}} \times 100$$

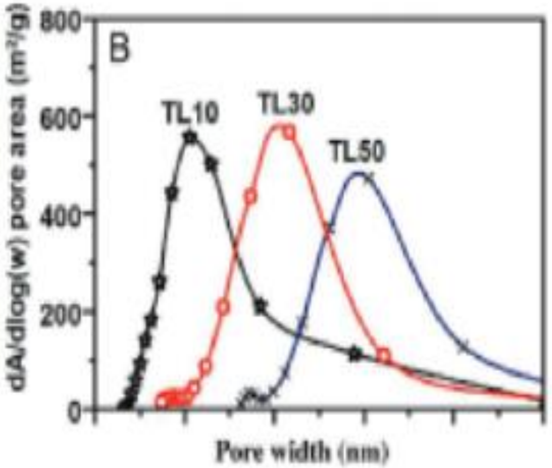


Hydrogen productivity and pore size distribution

Reported hydrogen productivity at 600 °C with 1 bar pressure and CH_4 : Ar = 1:1

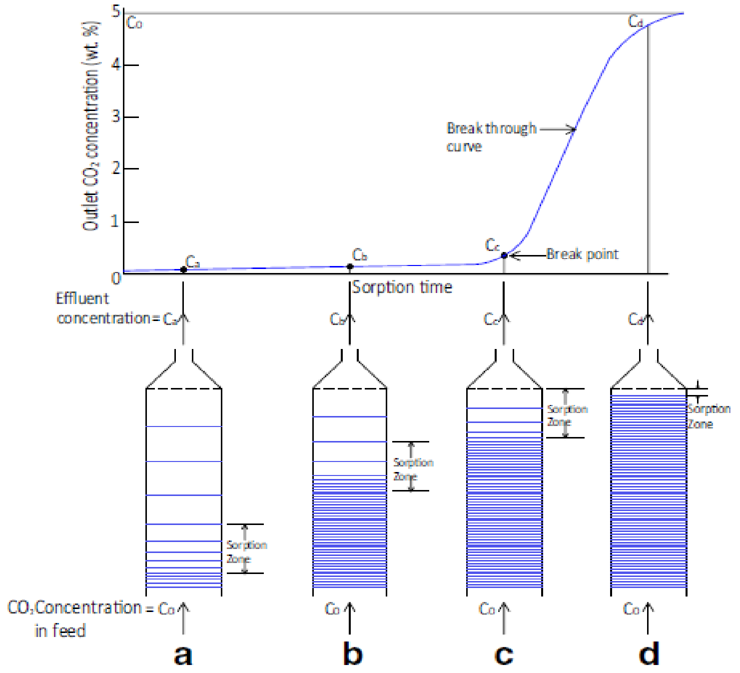
Pore size distribution for Co-based catalyst used for methane decomposition





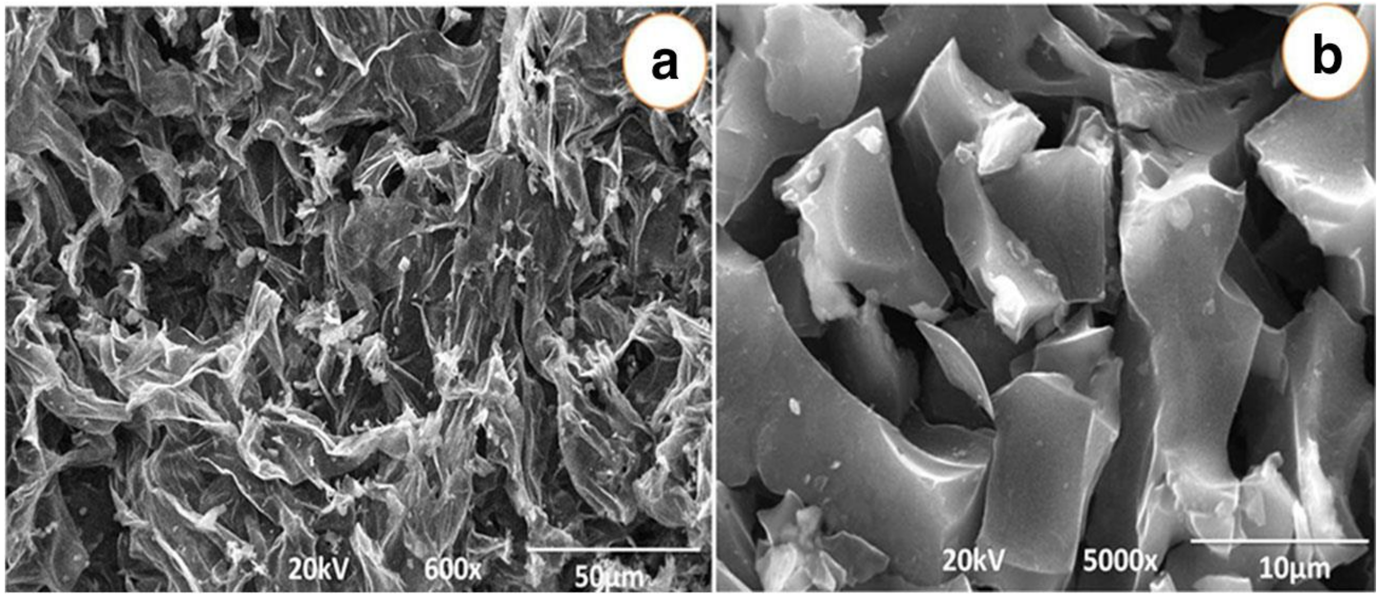
Mass transfer zone

The breakthrough profiles and movement of mass transfer zone during CO_2 capture process to reduce carbon emissions.



Morphology of biomass derived activated carbon

The enhanced surface morphological images obtained for an adsorbent prepared by proper activation technique. An adsorbent with improved surface and morphological properties results in increased adsorption capacity of CO_2. The SEM images of adsorbent produced from biomass at varied magnification level are depicted in Figures a-b



Main target are as follows:

- Synthesis of catalyst and optimizing the condition for hydrogen production from methane.
- Determining hydrogen productivity and total carbon yield.
- Production of biomass derived high performance activated carbon CO_2 capture.
- Characterization of adsorbent using suitable characterizing techniques for carbon capture.

Catalysts : Synthesizing or Modification and Their Usage

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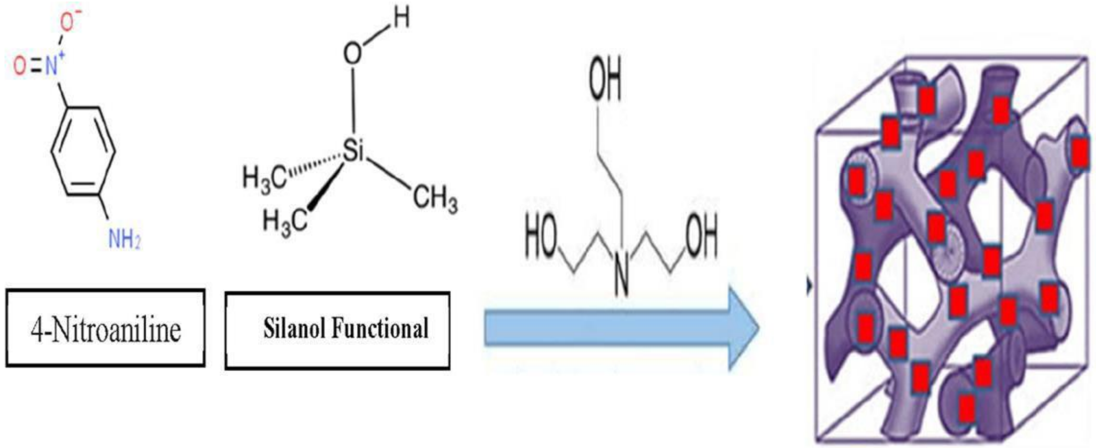
Interested Research area

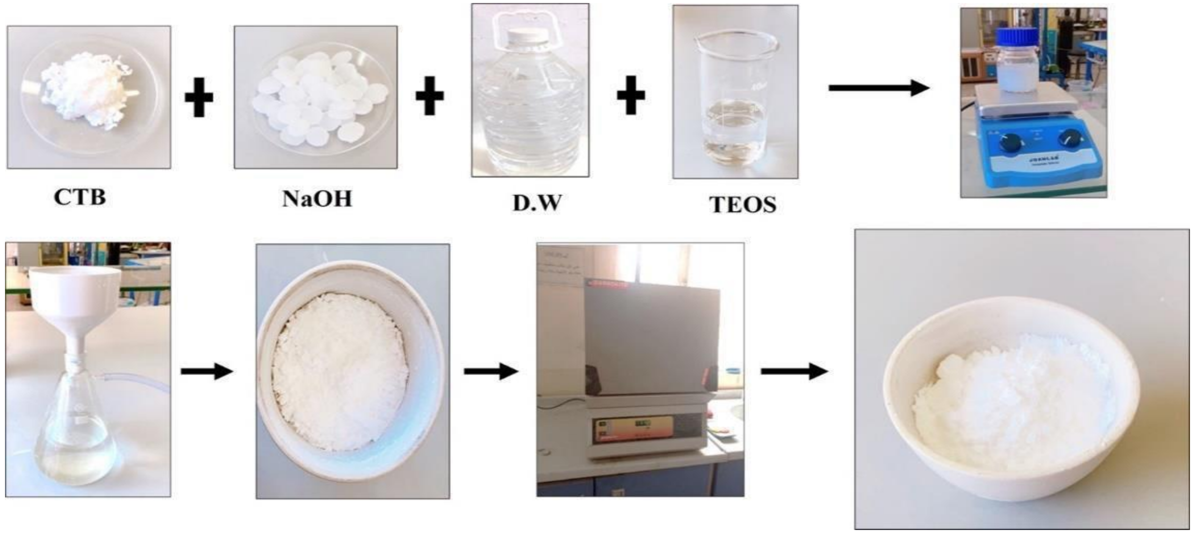
- Utilization of Loaded Cobalt onto MCM-48 Mesoporous Catalyst
- Applying MCM-48 mesoporous material
- Synthesizing and Characterizing a Mesoporous Silica Adsorbent.
- Using Polyelectrolyte and Palm

Applying MCM-48 mesoporous material

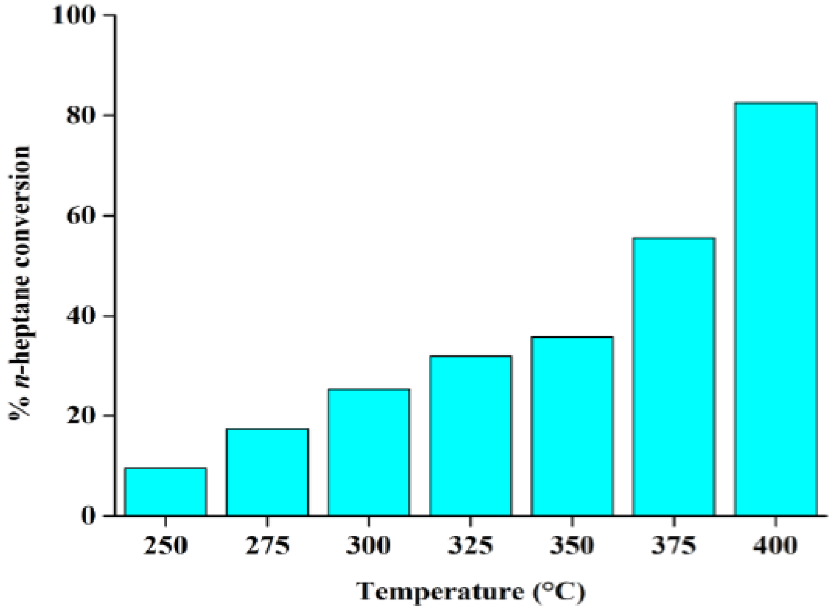
. The MCM-48 mesoporous material was prepared and characterized to apply it as an active adsorbent for the adsorption of 4-nitroaniline (4-Nitrobenzenamine) from wastewater.



Synthesizing Steps of Silica Adsorbent



Utilization of Cobalt onto MCM-48



Using Polyelectrolyte and Palm

Main target are as follows:

- - Utilization of Loaded Cobalt onto MCM-48 Mesoporous Catalyst to Produce Isomerization Product from n- Heptane
- -Applying MCM-48 mesoporous material for the effective adsorption of 4-nitroaniline from wastewater.
- -Synthesizing and Characterizing a Mesoporous Silica Adsorbent for Post-Combustion CO2 Capture.
- -Treatment of Fish-Processing Wastewater Using Polyelectrolyte and Palm Anguish

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Catalysis and Catalytic Processes Research Areas

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Interested Research area

- Catalysts Preparation
- Catalysts Characterization
- Catalytic Reaction Engineering
- Catalytic alkylation
- Catalytic oxidation , CO oxidation , ethane

Catalyst synthesis

Catalysts preparation includes

- precipitation,
- co-precipitation,
- impregnation ,
- mixing and
- sol-gel techniques

Catalysts Characterization

Xay- diffraction technique, BET, SEM, TEM

Mixed oxides catalysts and its application

Mixed oxide catalysts syntheis using traditional and new methdadology and its application

Catalysis for cleaner technology

convert the methane and ethane into higher hydrocarbon.

Main target are as follows:

- Catalyst synthesis
- Physco-chemical catalysts characterization
- Catalysis for cleaner technology
- Catalysts Testing in hydrogen peroxide decomposing

Name: Dr. Ihab M.T.A. Shigidi

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Research areas

- Separation Processes
- Water/ wastewater Treatment and Desalination.
- Membrane Technology
- Essential oils Extraction
- Computational fluid dynamics and fluid flow simulations

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Process Modeling optimization and control

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Interested Research area

- Machine learning for Advanced Process Control (APC)
- Model design and optimization for lube oil recycling
- Remediation of Heavy Metals from Aqueous Solutions
- Solar still modeling and optimization.

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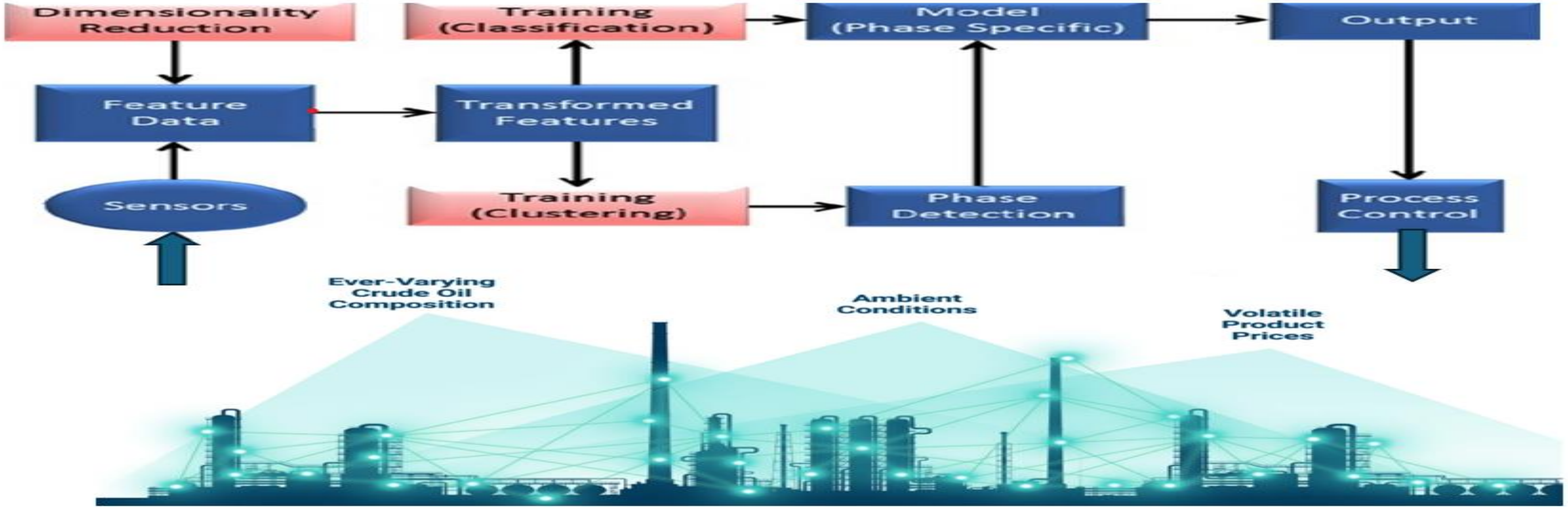
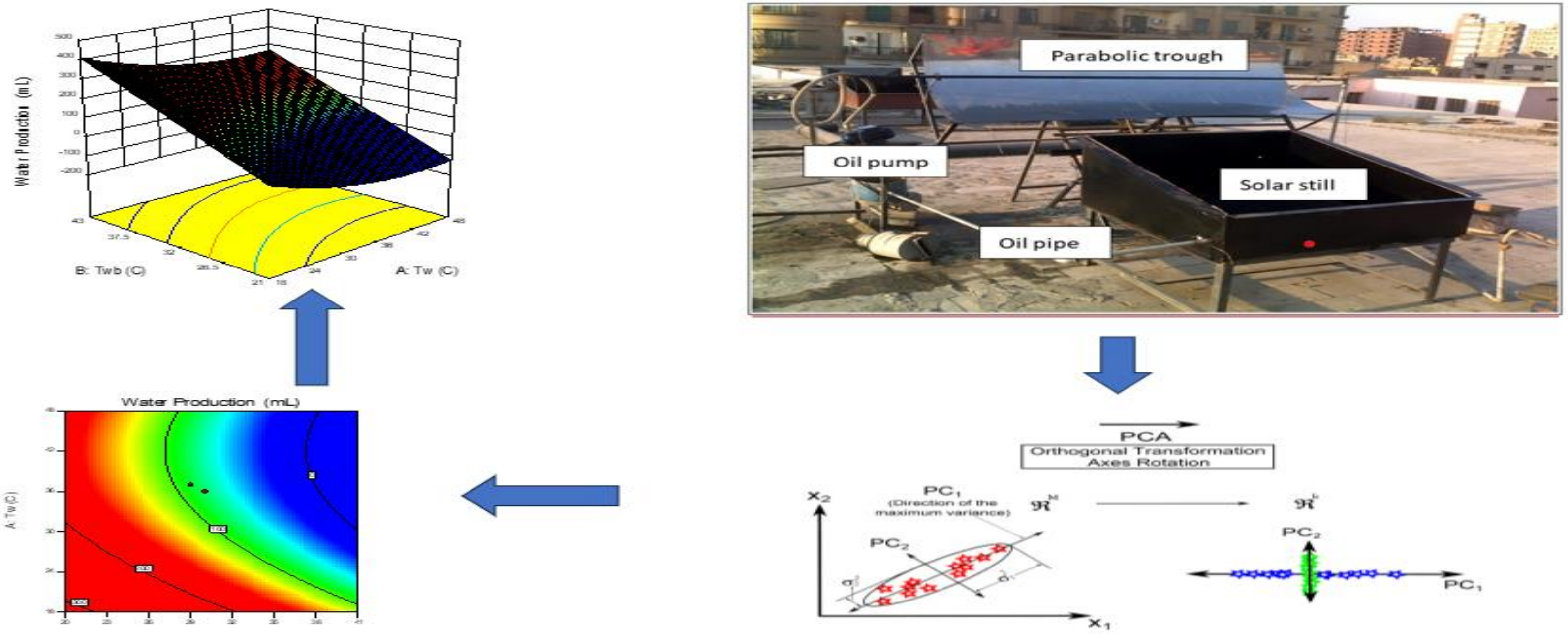
Machine Learning for Advance process control

APC sensing large number of sensors in order to predict and control the process efficiently, Deep learning can be use to improve model identification from historical data , to identify models from operating data in real-time, and to dynamically identify and manage changes in the process state (for example, due to a different feed or operating mode)



Solar still modeling and optimization

- Conventional single slope solar still integrated with a parabolic trough collector in addition to packaged glass ball layer was used in water desalination.
- Principal Component Analysis (PCA) reduced and categorized the number of effective parameters to three components.
- Effective System’s Performance parameters modeled to predictive optimum operation conditions



Main target are as follows:

- ❖ To Develop advanced process control using deep learning to improve control robustness, performance, precision ,and stability.
- ❖ Using advanced modeling techniques for model prediction and optimization various chemical processes

Transport phenomena : Numerical simulation

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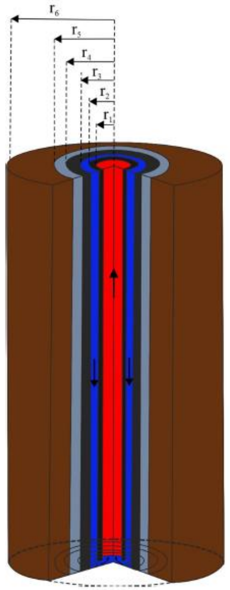
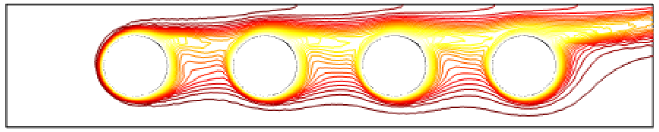
Interested Research area

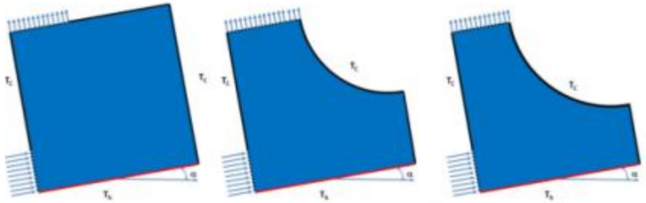
- Renewable energy
- Numerical simulation of coupled transport phenomena in continuous and porous media.
- Entropy production calculation
- Heat exchanger calculation
- Phytochemical characterization of essential oils

Renewable energy and heat transfer

Numerical simulation of hydrodynamic and heat transfer in a geothermal heat exchanger to obtain the optimal diameter of tubes with the lowest entropy using water and Al2O3/water nanofluid, also the study of coupled transport phenomena in continuous and porous media of nanoparticles or nar

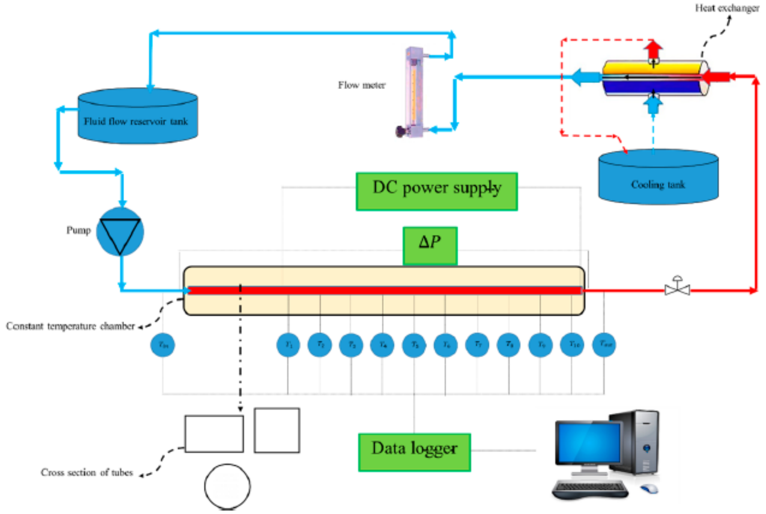






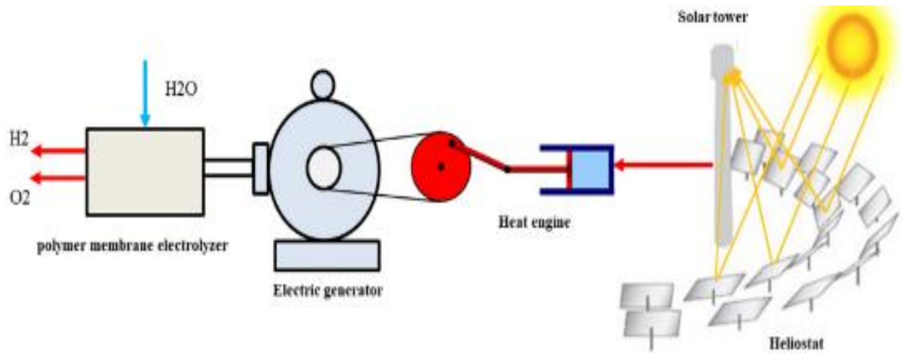
Entropy Generation

Sustainable Heat Transfer Management: Modeling of Entropy Generation Minimization and Nusselt Number Development in Internal Flows with Various Shapes of Cross-Sections Using Water and Al2O3/Water Nanofluid. Natural and mixed convection heat flow considered.



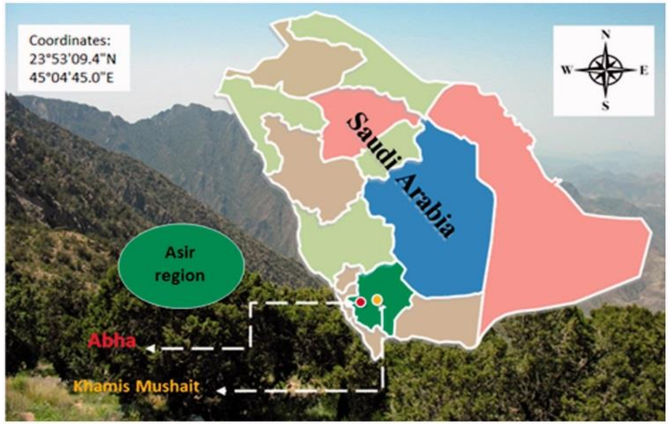
Thermodynamics investigation

Thermodynamics Investigation of Energy, Exergy, and Hydrogen Production from a Solar thermochemical Plant Using a Polymer Membrane Electrolyzer



characterization of essential oils

Phytochemical characterization, and antioxidant and antimicrobial activities of essential oil extracted by hydrodistillation of different parts of medicinal and aromatic plant from Abha, Saudi Arabia, and different cosmetics products produced.



Main target are as follows:

- ❖ Localization of the steam and isothermal lines for different various parameters and fluids through different enclosures geometries.
- ❖ Localization of the entropy production for different various parameters and fluids through different cavities or channel enclosures.
- ❖ Modeling and simulation of some prototypes, which, a thermodynamic irreversibility's under magnetic field should be done.
- ❖ Characterization of essential oils of different aromatics plants.

Reaction Engineering & Environmental Research

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Research Eexpertise and Interests

- Sorption and Transport Phenomena in Synthetic and Natural Porous Media
- Wastewater Treatment by physicochemical methods
- Treatment of liquid and gaseous effluents in chemical industries
- Valorisation of clay resources in the purification of water and air
- Research in environmental pollution

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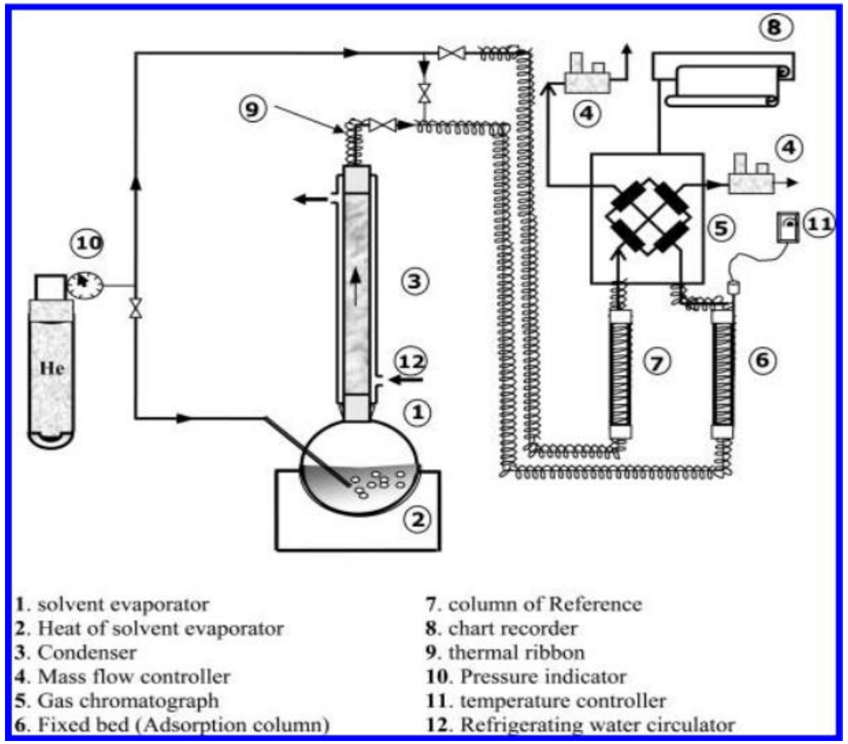
Adsorption of VOCs on Fixed Bed Reactor

Experimental setup used for the adsorption of VOCs on acid-activated bentonite in a fixed bed column.
A suitable adsorption model has been developed to simulate the measured data based on linear driving force approximation. The fourth-order Runge-Kutta method was used to integrate the partial differential equations, and the resulting functions were simultaneously solved to obtain the breakthrough profiles. Theoretical predictions from the model were compared with column adsorption data to ensure the validity of the model.



Corrosion Inhibition and Renewable Energy Material

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Research Interests

- Corrosion Inhibition
- Adsorption and Adsorbents
- Environmental Remediation
- Waste to Energy and Renewable Materials

Recent Publications

- Synthesis, characterization, and anionic azo dye adsorption by polyaniline/clay nanocomposite from artificial wastewater – Submitted to Environmental Science and Pollution Research - *Currently under Review*
- Efficient adsorption of hexavalent chromium ions onto novel ferrochrome slag/polyaniline nanocomposite: ANN modeling, isotherms, kinetics, and thermodynamic studies – Published in *Environmental Science and Pollution Research*
- Conductive Polymers and Their Nanocomposites as Adsorbents in Environmental Applications – Published in *Polymers*

Remote Sensing: Investigation of Pollution through remote sensing

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Interested Research area

- Urban heat Island
- Air Pollution Monitoring
- Carbon sequestration Potential of mangrove forests
- Solid waste management
- Land surface temperature monitoring

Urban Heat Island (UHI)

Abd El-Hamid, H. T., **Arshad, M.,** & Eid, E. M. (2022). The effects of coastal development on the urban heat island in the mangrove ecosystem along the Jazan coast, KSA. *Journal of Coastal Conservation*, *26*(6), 70.

Arshad, M., Khedher, K. M., Eid, E. M., & Aina, Y. A. (2021). Evaluation of the urban heat island over Abha-Khamis Mushait tourist resort due to rapid urbanisation in Asir, Saudi Arabia. *Urban Climate*, *36*, 100772.

Solid Waste Management

Arshad, M., Hasan, M. A., Al Mesfer, M. K., Al Alwan, B. A., Qureshi, M. N., & Eldirderi, M. (2023). Sustainable landfill sites selection using geospatial information and AHP-GDM approach: A case study of Abha-Khamis in Saudi Arabia. *Heliyon*, *9*(6).

Ali, I. H., Siddeeg, S. M., Idris, A. M., Brima, E. I., Ibrahim, K. A., Ebraheem, S. A., & **Arshad, M.** (2021). Contamination and human health risk assessment of heavy metals in soil of a municipal solid waste dumpsite in Khamees-Mushait, Saudi Arabia. *Toxin reviews*, *40*(1), 102-115.

Carbon Sequestration Potential of Mangrove Forests

Arshad, M., Alrumman, S. A., & Eid, E. M. (2018). Evaluation of carbon sequestration in the sediment of polluted and non-polluted locations of mangroves. *Fundamental and Applied Limnology*, *192*(1), 53-64.

Eid, E. M., Khedher, K. M., Ayed, H., **Arshad, M.**, Moatamed, A., & Mouldi, A. (2020). Evaluation of carbon stock in the sediment of two mangrove species, Avicennia marina and Rhizophora mucronata, growing in the Farasan Islands, Saudi Arabia. *Oceanologia*, *62*(2), 200-213.

Mangrove health due to Impact of Jazan Economic City, Baish, Jazan

Arshad, M., Eid, E. M., & Hasan, M. (2020). Mangrove health along the hyper-arid southern Red Sea coast of Saudi Arabia. *Environmental monitoring and assessment*, *192*, 1-15.

Eid, E. M., Arshad, M., Shaltout, K. H., El-Sheikh, M. A., Alfarhan, A. H., Picó, Y., & Barcelo, D. (2019). Effect of the conversion of mangroves into shrimp farms on carbon stock in the sediment along the southern Red Sea coast, Saudi Arabia. *Environmental research*, *176*, 108536.

Main target are as follows:

- Investigating impact of industries on the surrounding eco-system.
- Siting sustainable Landfill disposal sites
- Impact of Land surface temperature on the industrial and commercial sites
- Carbon sequestration potential of Mangroves along the Red Sea coastal areas

Mass Transfer

Interested Research area

- Distillation
- Modeling and simulation
- Heat Transfer

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Modeling and Control of the Crude Atmospheric Unit in Khartoum Refinery

The work undertaken, lead to a mathematical model of the distillation column that can separate multicomponent systems in Khartoum refinery. Software was developed and might be used for research and development as well as at the stage of starting – up and shut down periods, A case study taking Distillation Column Units (DCU) of Khartoum Refinery was studied and investigated.

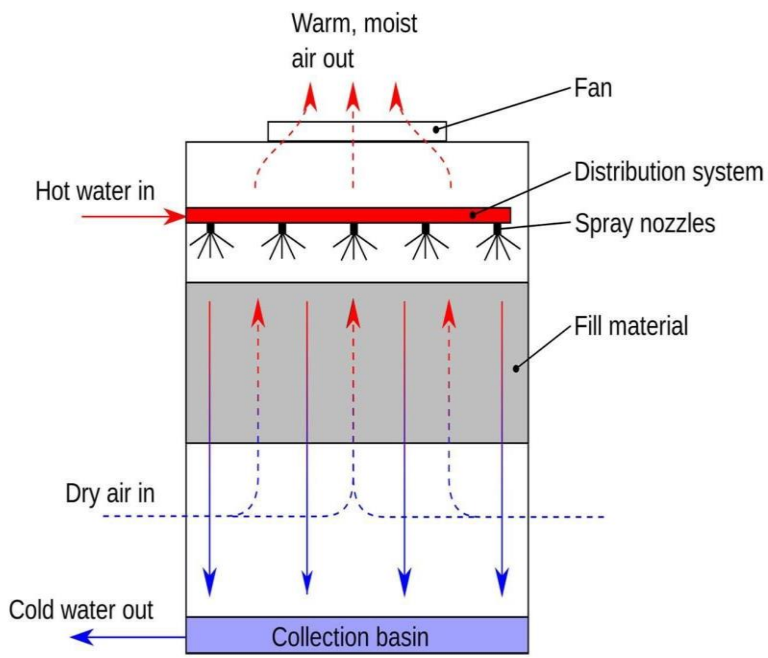
Gas Absorption

Absorption is a mass transfer process in which a vapor solute A in a gas mixture is absorbed by means of a liquid in which the solute more or less soluble. The gas mixture consists mainly of an inert gas and the soluble.

A typical example is absorption of the solute ammonia from an air-ammonia mixture by water.

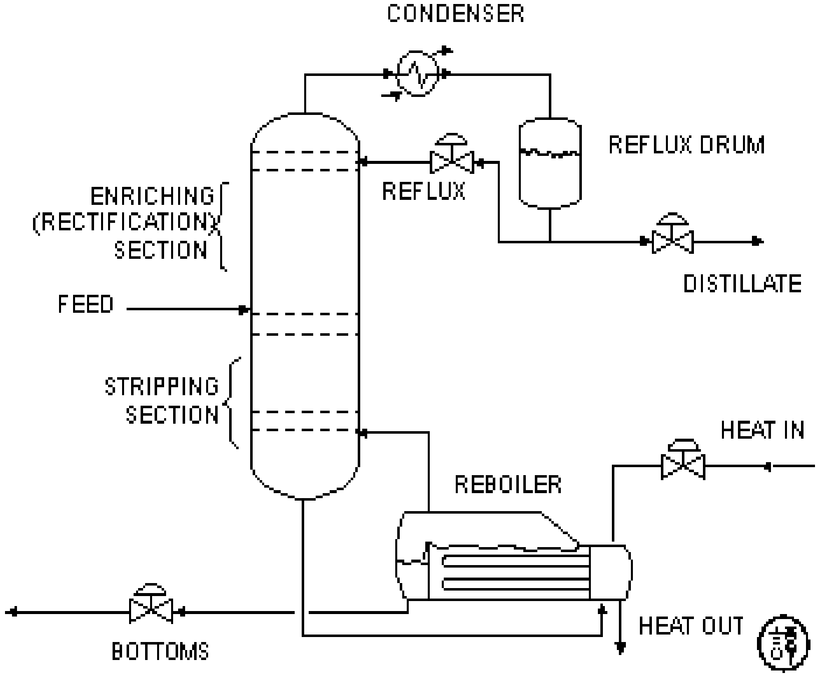
Cooling Tower

A cooling tower is a heat removal device that uses water to transfer process waste heat into the atmosphere. All cooling towers operate on the principle of removing heat from water by evaporating a small portion of water that is recirculated through the unit.



Distillation

Process in which the of components a substance or liquid mixture are separated by heating it to a certain temperature and condensing the resulting vapors. Some substances (such as crude oil) have components that vaporize at different temperature and thus can be separated by condensing their vapors in turn. Distillation is also used as a purification process in which non-volatile components are separated from volatile



Main target are as follows:

- ❖ Using software in designing of chemical engineering equipment
- ❖ Phase transition of mass transfer

Biomass, Renewable Energy and Advanced Material Processing

Interested Research area

- Advanced characterizations and materials processing
- Renewable energies; biomass and wind energies
- Conventional and microwave heat treatment
- X-ray computed tomography, 3D imaging analysis (ImageJ and simpleware softwares).
- Natural and synthetic polymers and composite materials
- water treatment and water desalination

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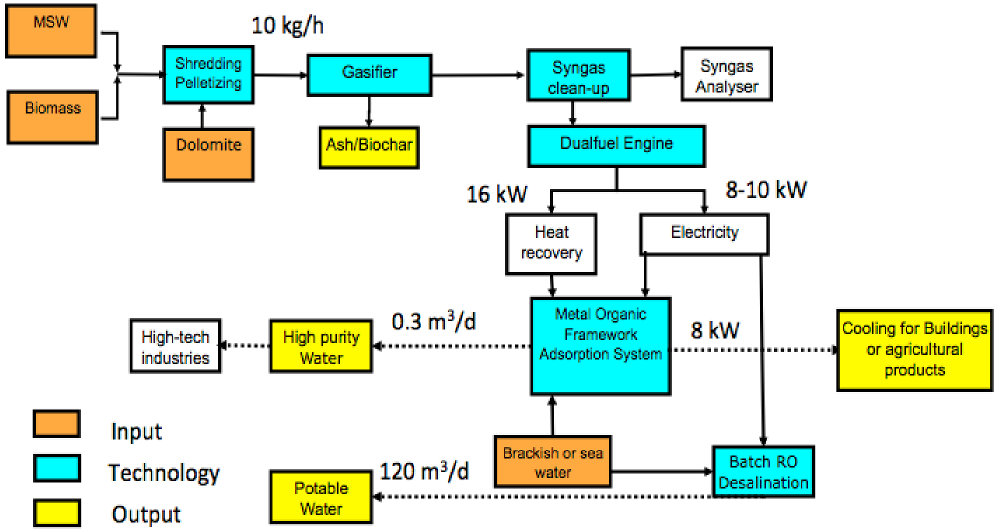
Integration of renewable (gasification and pyrolysis routes) energies with water desalination systems

- Renewable energy: using low to high-grade biomass for producing energy.
- Developing a novel and efficient approach to integrate waste management for energy conversion for electricity, water desalination, using gasification or pyrolysis



Materials synthesis , its characterization and its applications

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Interested Research area

- ✓ Polymer nanocomposite synthesis
- ✓ Characterization of polymeric composite materials
- ✓ Gas sensors
- ✓ Adsorption Techniques
- ✓ Waste water treatment

Electrochemistry : Fuel Cell Technology and Hydrogen Generation

Interested Research area

- Renewable: H_2-O_2 Fuel Cell
- Microbial fuel cell Water Treatment cogeneration of Hydrogen
- PEM H_2 Generation
- Electrochemical Reduction of CO_2
- Photo electrochemical for hydrogen generation, CO_2 reduction and water treatment

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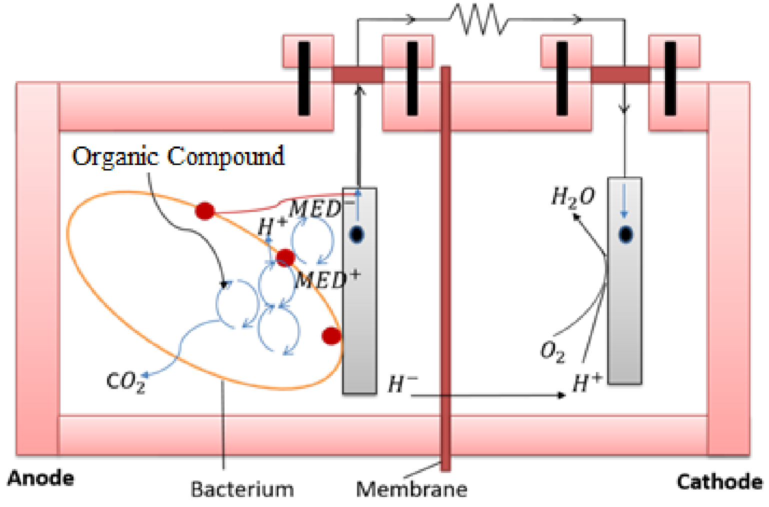
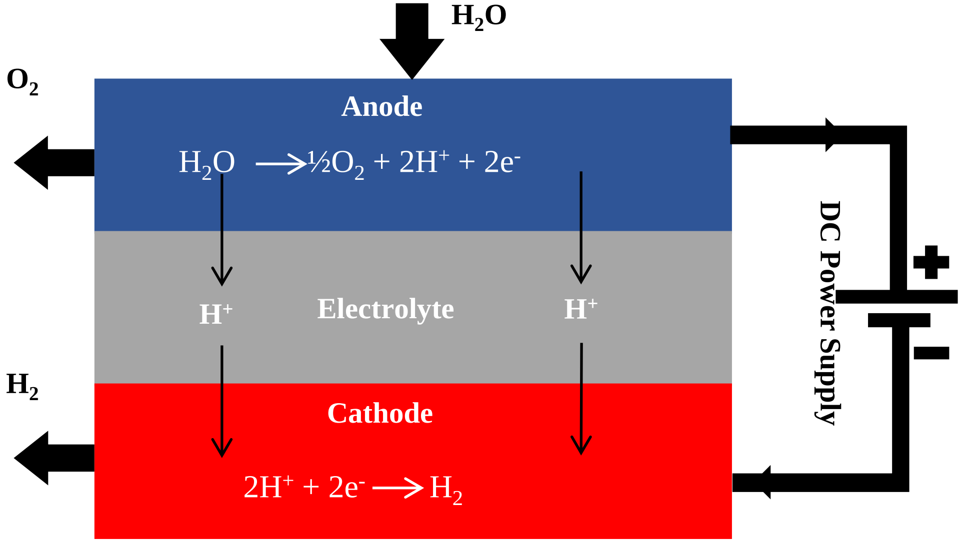
Water Treatment cogeneration of Hydrogen

A Microbial Fuel Cell (MFC) converts chemical energy, available in a bio-convertible substrate, directly into electricity. To do this, bacteria is used as a catalyst to convert substrate into electrons.



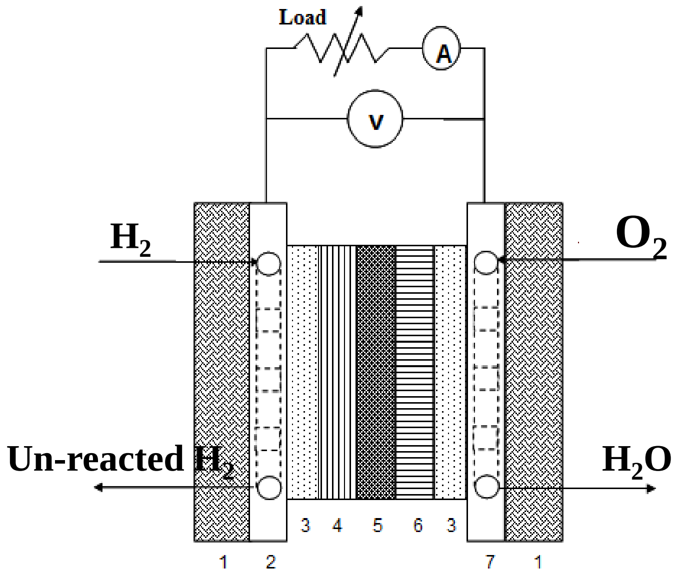
PEM H_2 Generation

Device used to split water electrochemically into pure hydrogen at the cathode and oxygen at the anode with the application of electrical energy.



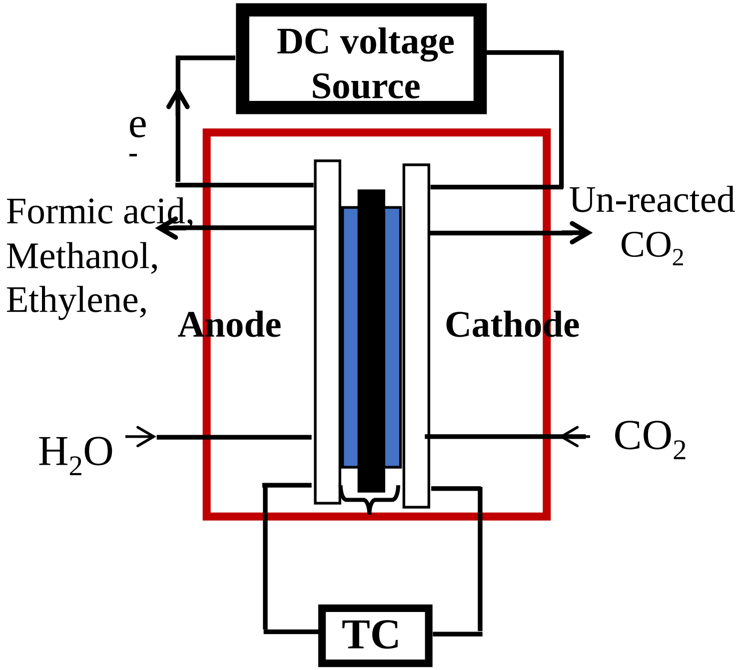
Renewable: H_2-O_2 Fuel Cell

Fuel Cell is a device converts chemical energy directly into electricity without causing any pollution to the atmosphere.



Electrochemical Reduction of CO_2

It's a device used to convert the CO_2 into higher hydrocarbon (say Formic acid, Methanol, Ethylene, etc.) with the help of power derived from the renewable energy sources (say solar, wind, tidal etc.,)



Main target are as follows:

- Electrocatalyst synthesis for the following reaction such as Oxygen Evolution, Oxygen Reduction, Carbon dioxide Reduction, Hydrogen Oxidation, Hydrogen Reduction
- Membrane and MEA fabrication
- Physical and Electrochemical Characterization of Electrocatalyst and Membrane
- Testing in respective electro cell

Renewable Energy and Separation Engineering

Research area

- **Pyrolysis:** Convert biomass/organic matters/plastic wastes into hydrocarbon rich oil
- **Adsorption:** CO_2 capture and liquid phase adsorption
- **Cavitation:** Cracking of crude oil and wastewater treatment
- **Catalysis:** Bio-oil upgradation
- **Energy Storage Materials:** Supercapacitors

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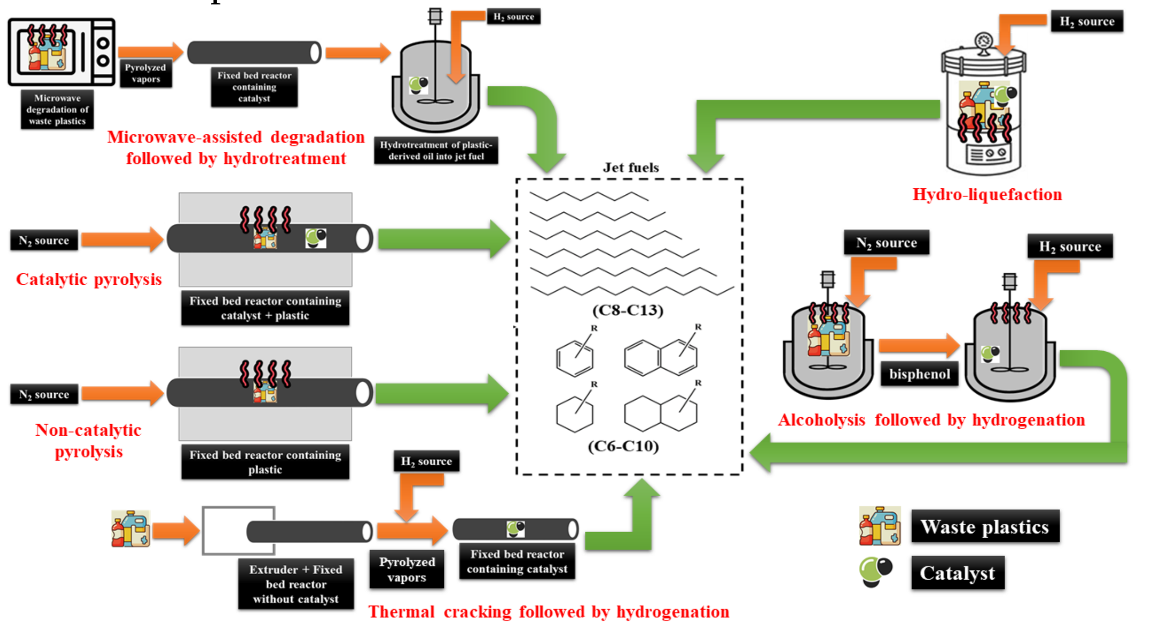
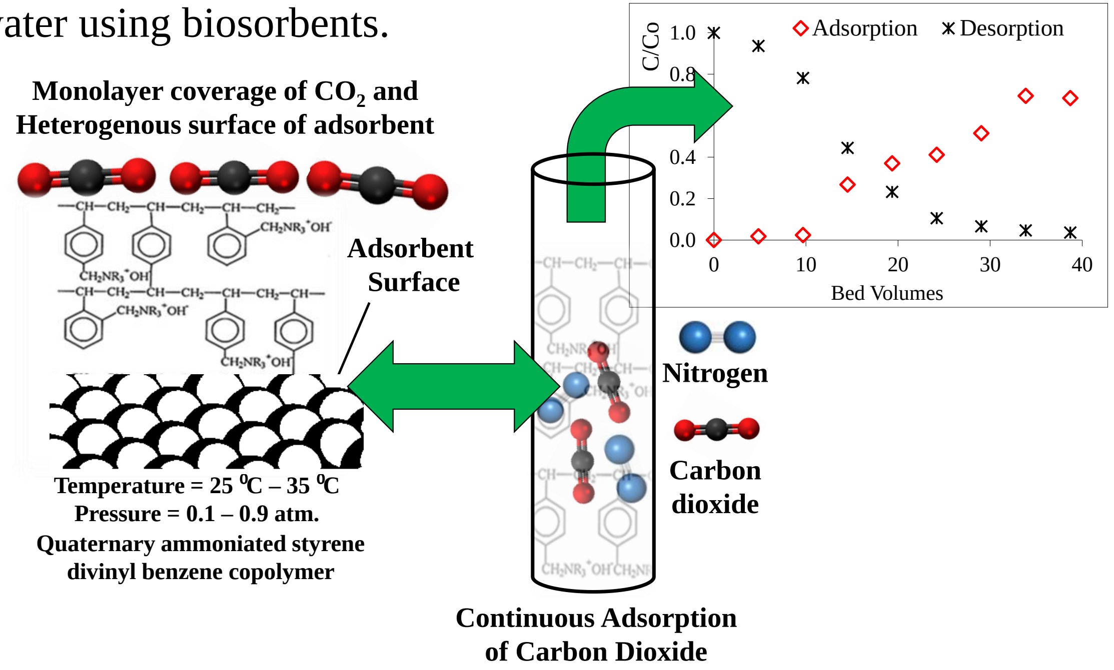
Pyrolysis and Thermochemical Conversions

Thermochemical conversion of biomass/organic wastes/plastics into gases, hydrocarbon rich oil, and, char in the absence of air at elevated temperatures.



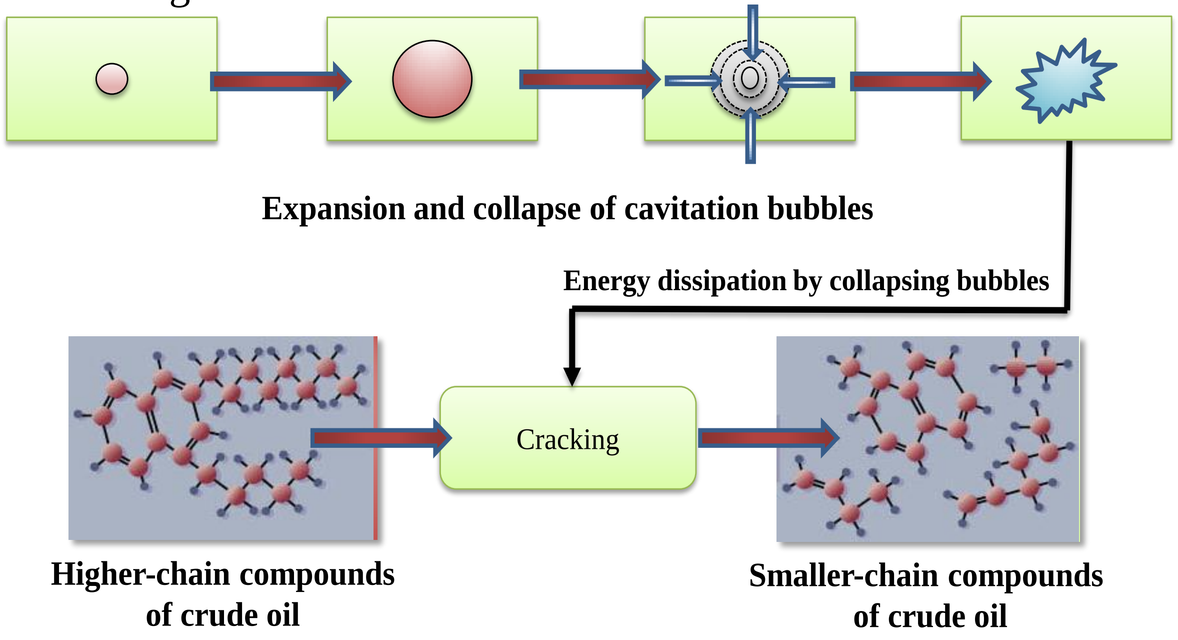
Adsorption

Separation of carbon dioxide from gaseous mixture using functional polymeric adsorbent. Separation of heavy metals from water using biosorbents.



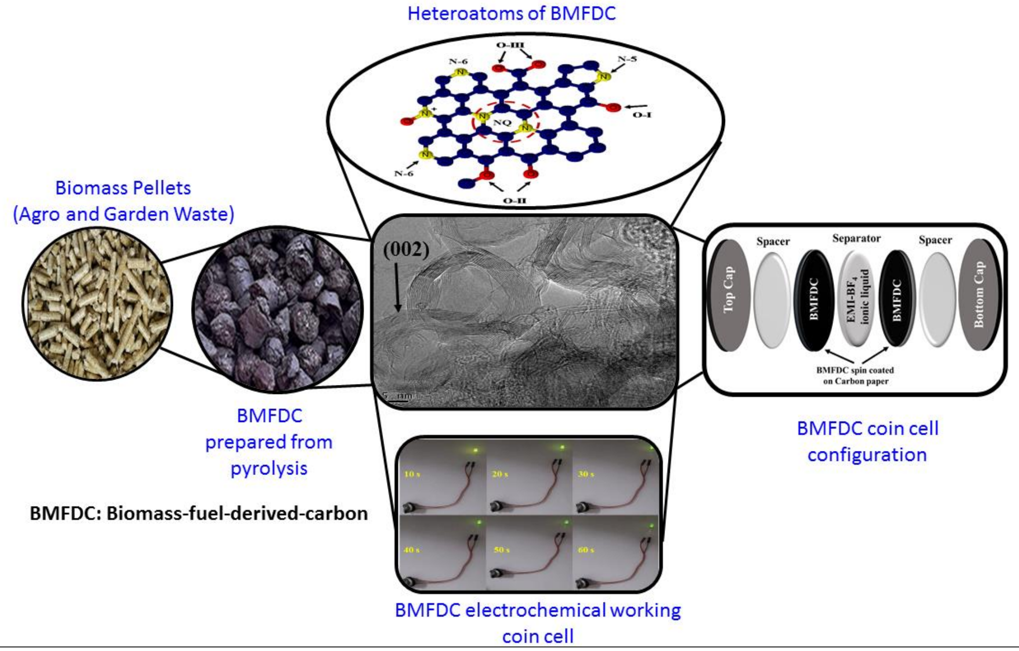
Cavitation

Cracking amongst crude oil compounds or dye compounds due to the formation and collapse of the cavities, generating localized temperature up to 1000 degree C.



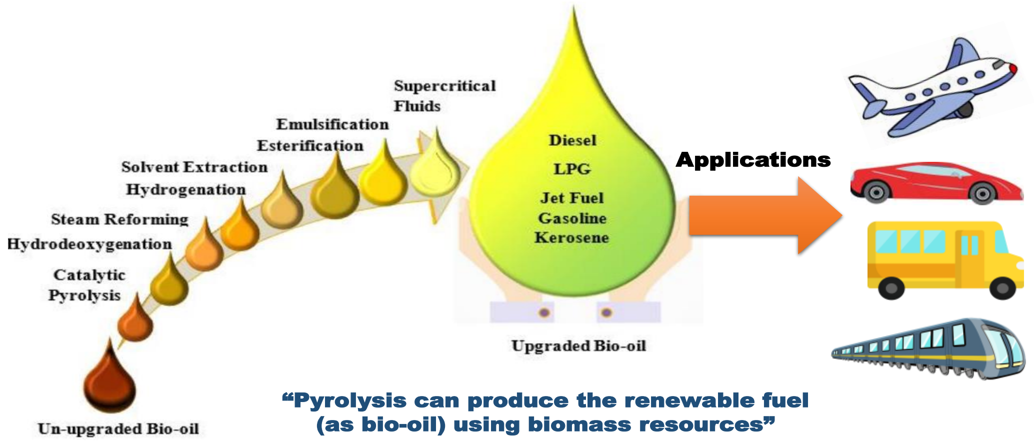
Energy Storage Materials

Necessity of energy storage had led to the development of new materials which can act like supercapacitor and provide immediately energy, especially in transportation.



Catalysis: Bio-oil upgradation

Pyrolysis derived oil is not suitable to be directly utilize in automobiles because of poor its fuel quality and hence it needs to be upgraded using a catalyst. Amongst various techniques, the catalytic upgradation of bio-oil is investigated.



Nano Catalysis: Energy and Environmental Applications

Interested Research area

- CO_2 utilization for chemical synthesis
- Design of Nanomaterials & industrial catalysts
- Photocatalysis and nanomaterial design for wastewater treatment
- Process Modelling and Simulation of chemical processes
- Life cycle assessment & sustainability analysis
- Biomass conversion processes
- Essential oil extraction and plant design

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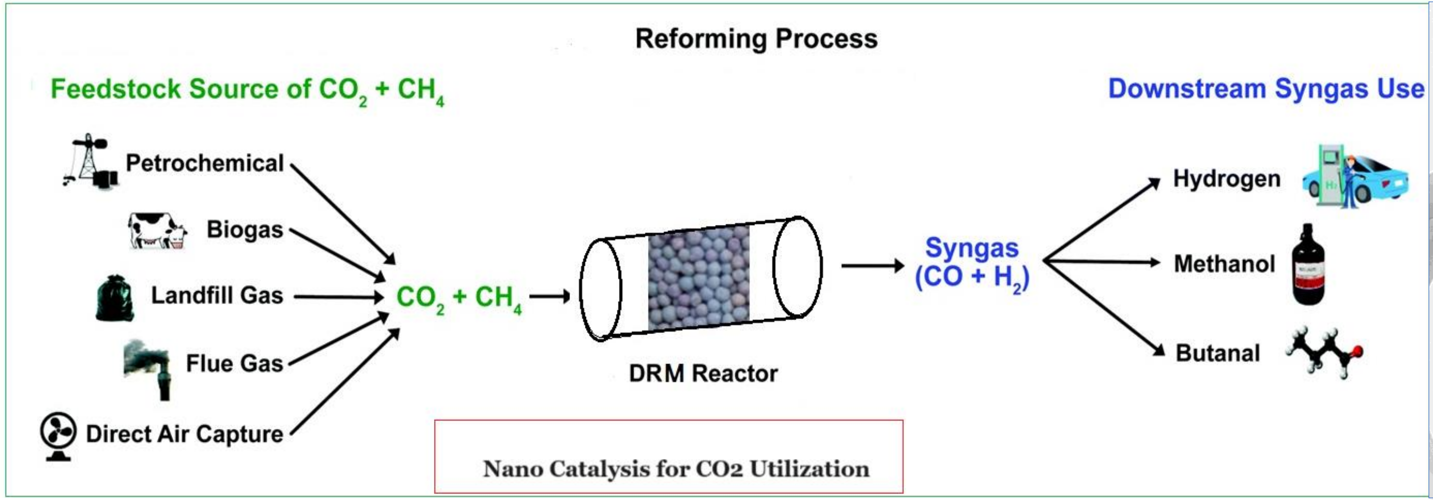
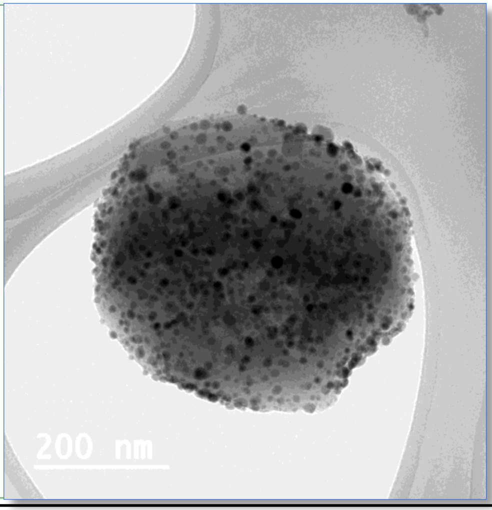
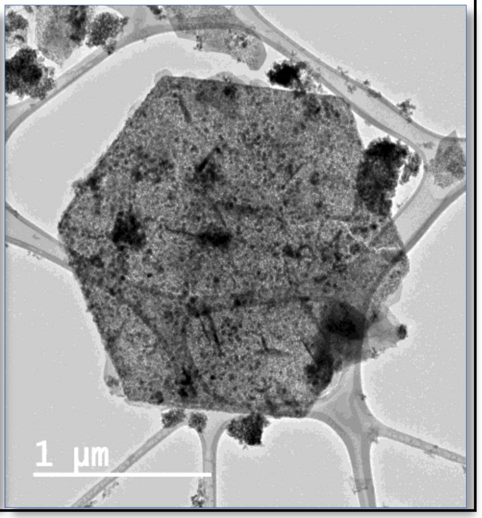
Catalyst and process design

CO_2 capture and its utilization for the synthesis of syngas and other chemicals

Captured CO_2 from various industries is used to reform the natural gas and biogas into synthesis gas which can further be upgraded to a large number of chemicals, New nano-structured catalysts, and processes are designed for sustainable syngas production.

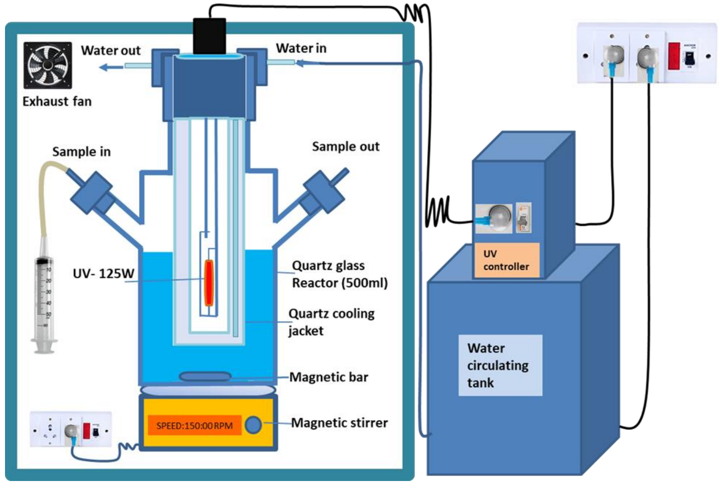






Wastewater treatment and photocatalysis

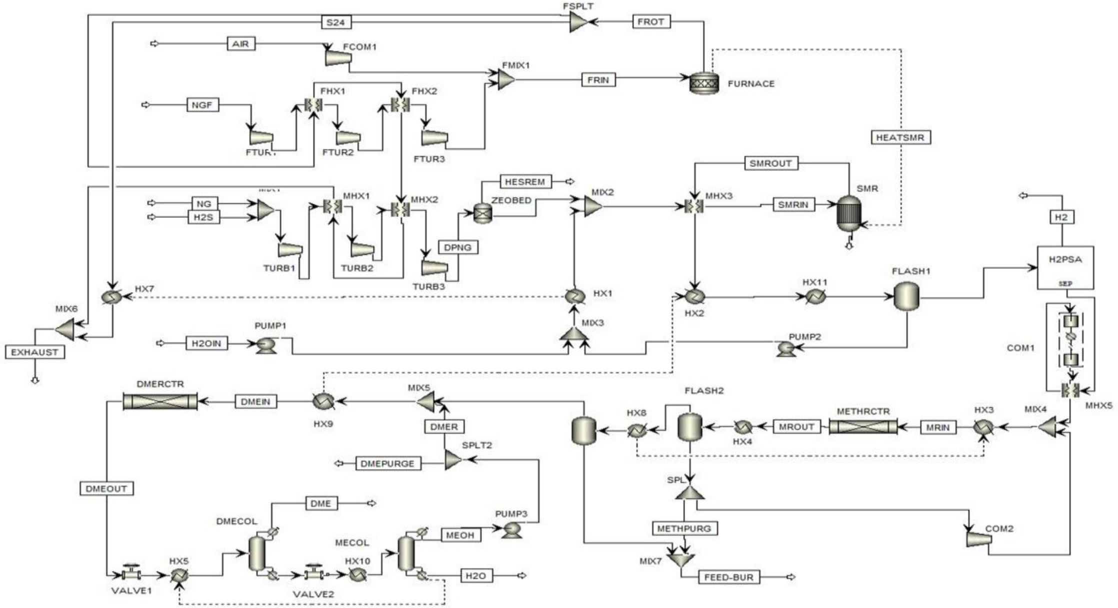
Adsorption of ionic contaminates from industrial wastewater and groundwater over biomass-based and metal oxide adsorbents is considered the greener water treatment method. The organic impurities can be treated using the photocatalytic methods.



Photocatalytic reactor

Modeling, Simulation, and LCA analysis

The flow sheeting using a commercial simulator like Aspen Plus is the first step in designing the New chemical processes. Sustainability and techno-economic analyses are critical in deciding on a greener chemical process.



Aspen Simulation of DME Production

The main targets are as follows:

- ❖ Design of green catalysts and processes for the production of methanol, and other higher alcohols.
- ❖ Development of green processes for industrial carbon capture.
- ❖ Process design for carbon-neutral cement, Iron & steel, and renewable energy generation processes.
- ❖ Design of industrial adsorbents for the sorption of waste gases and water contaminants.
- ❖ Green hydrogen production

Interested Research area

- Carbon capture and storage to reduce carbon emissions
- Hydrocarbon conversion & catalysis
- Material synthesis and characterization
- Reduction of carbon emission by adsorption
- Mathematical modeling and simulation

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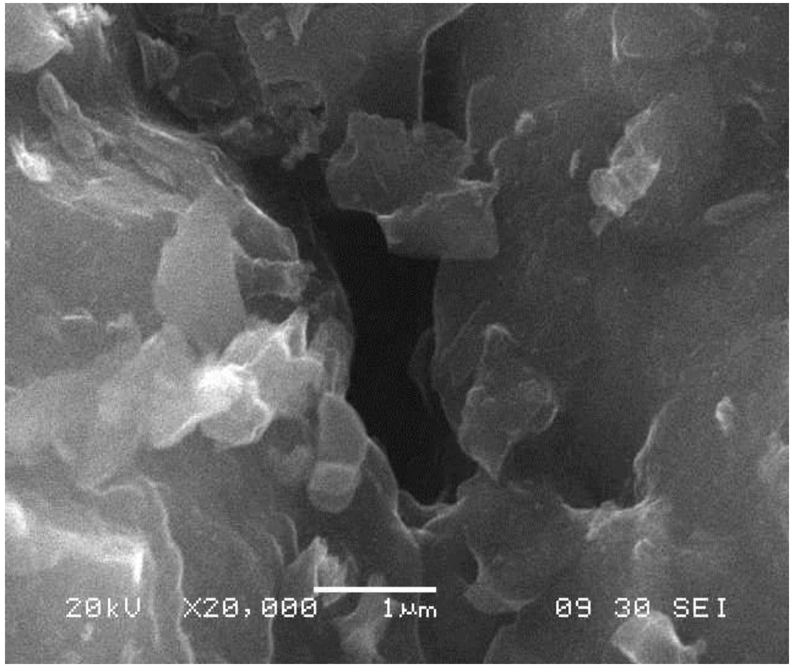
Date pits based biomass is converted to activated carbon using physical/activation technique

Activated carbon can be economically synthesised from vastly available date pits biomass.

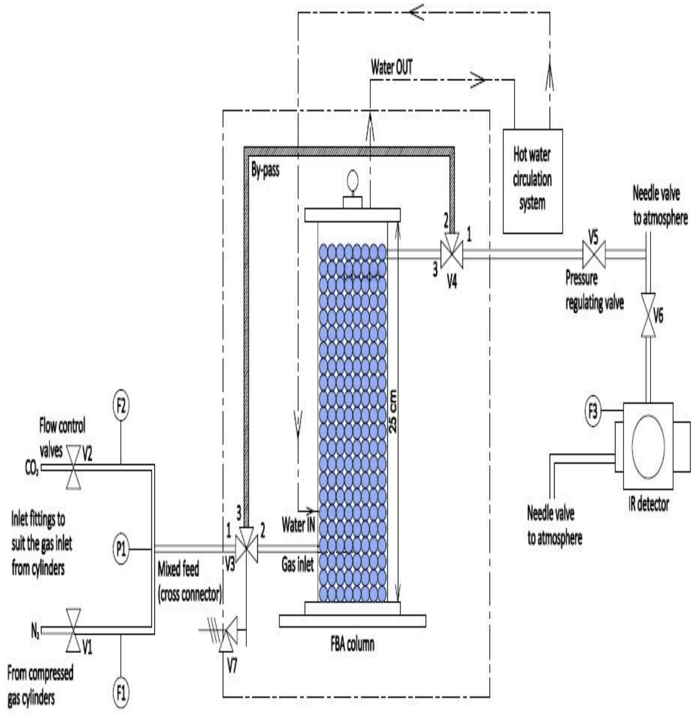
Surface morphology

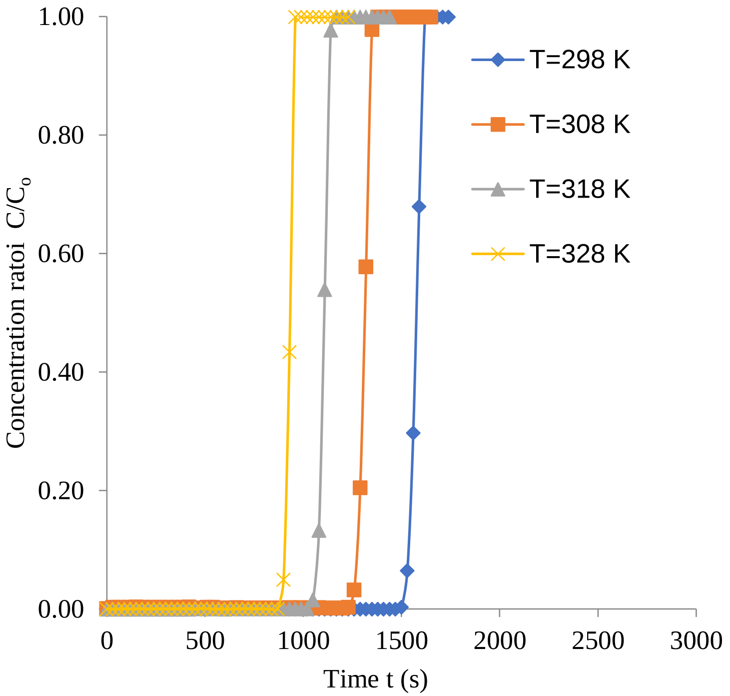
The produced activated carbon may be analyzed using SEM analyzer to study morphological characteristics.



CO_2 Capture unit & breakthrough profiles

The computer controlled CO_2 capture unit to study the carbon capture under varied conditions of temperature, feed rate, pressure and CO_2 mol%





Main target are as follows:

- Proper utilization of vastly available date pits based biomass by suitable activation technique.
- Investigation of CO_2 capture by adsorption using fixed bed continuous column.
- Estimating adsorption performances and characteristics of synthesized adsorbent.
- Fitting kinetics model and suitable adsorption isotherms.

Conceptual design, modelling and simulation

Interested Research Areas

- Modelling and Simulation of Petroleum Refining Processes
- Conceptual Design of Reactive Distillation system

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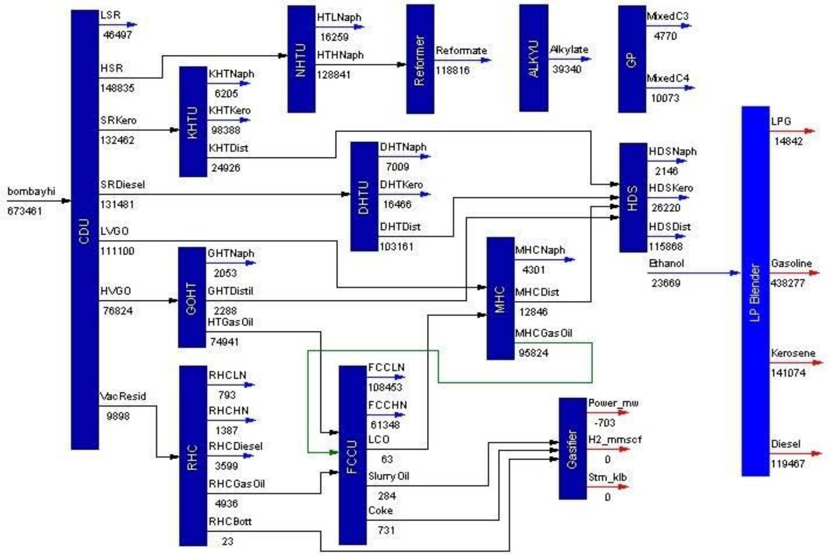
Modelling and Simulation of Petroleum Refining

- ✓ Efficiently planning grassroot refinery projects
- ✓ Decide profit margins for processing opportunity crude oils
- ✓ Determine operating variables and product specifications



Conceptual Design of Reactive Distillation Systems

- ✓ Combining reaction and distillation for economic and efficiency advantages
- ✓ Determining feasible conceptual design options for reactive distillation
- ✓ Analysing complex interactions of reaction and V-L equilibrium and azeotropes formation

Material And Energy Balances

Physical Properties

Chemical Kinetics

Vapor-Liquid Equilibrium

Simulations

Waste Water Treatment

Interested Research area

- Water and waste water treatment.
- Waste oil treatment (recycling and reprocessing).
- Seeds oils extraction.
- Adsorption.
- Analytical Techniques (ICP – AAS -UV).
- Water quality Assessment

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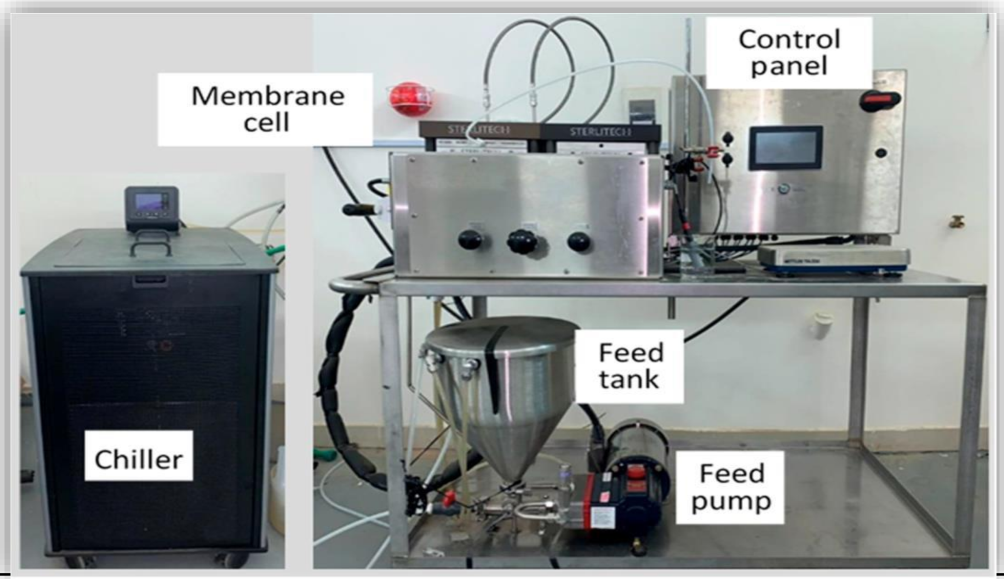
RO process lab scale setup



Waste Engine Oil Treatment Using Natural Adsorbents

Catalysis, Reaction Engineering and Process modelling

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Major Research Interest Areas

- Adsorbent & Adsorption Process
- Catalyst Synthesis and Catalytic Reaction
- Modelling and Simulation
- Computer Aided Design in Chemical Engineering

Modelling and Simulation

- **Multi-Scale Modeling**
- **Process Intensification**
- **Sustainable Process Design**
- **Bioprocess Modeling**
- **Digital Twins**

Adsorbent & Adsorption Process

- **Adsorbent Materials Development**
- **Kinetics, Isotherms & Thermodynamics**
- **Adsorption in Water Treatment**
- **Biological Adsorption**
- **Adsorption Process Optimization**

Catalyst Synthesis and Catalytic Reaction

- **Abundant material Heterogeneous Catalyst synthesis**
- **Catalyst Characterization**
- **Catalyst Optimization and Design**

Computer Aided Design in Chemical Engineering

- **Process Simulation and Modeling: Hysys, Aspen Plus, CHEMCAD, or COMSOL**
- **Process Optimization and Control: GAMS, MATLAB,**
- **Data Analysis and Machine Learning: Python, R**

KING KHALID UNIVERSITY

Nanotechnology : 3D Printing of CNCs Research Areas

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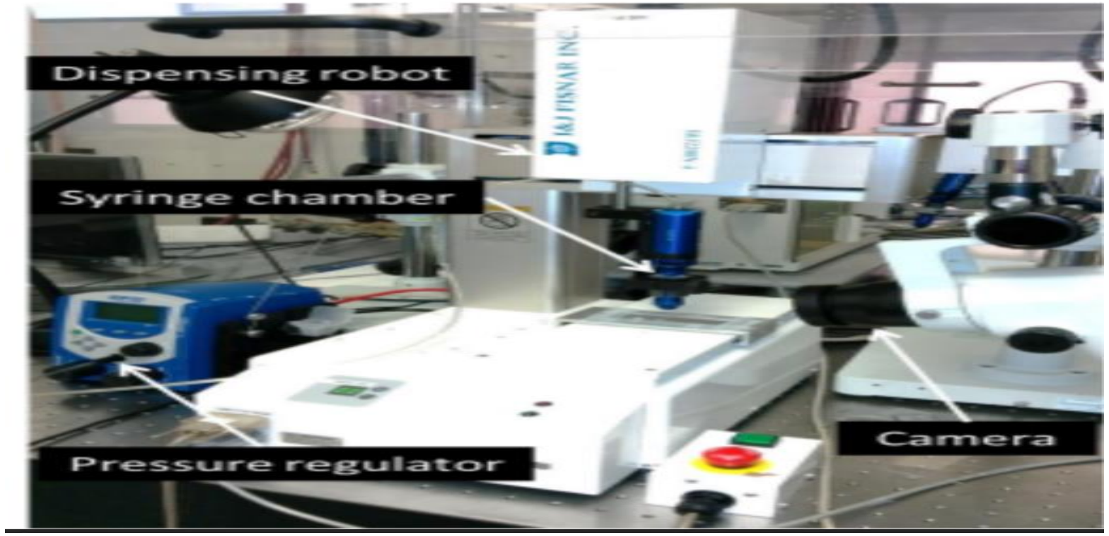
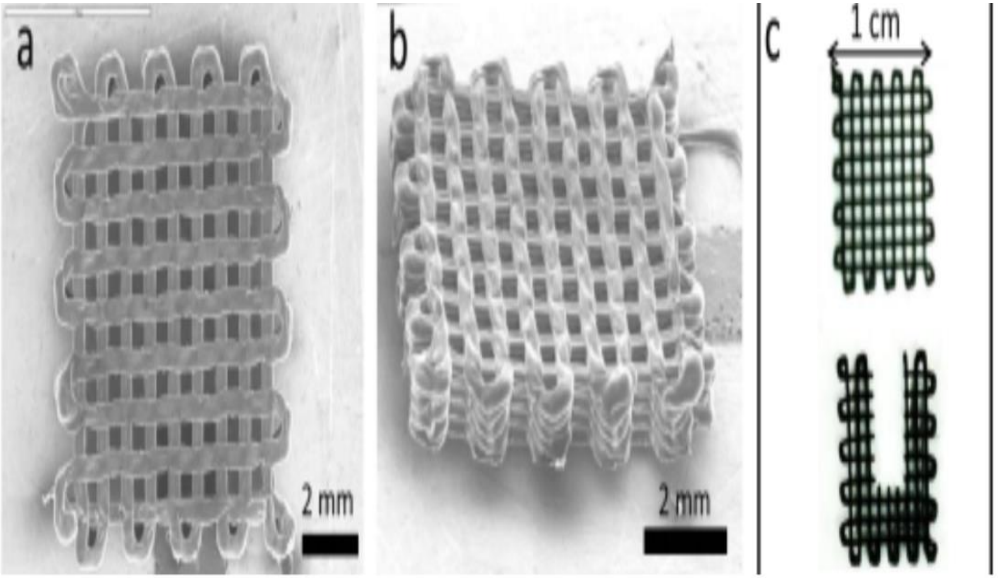
Interested Research area

- Fabrication liquid sensors using conductive nanocomposite.
- Energy Storage and electronics.
- Material characterization and polymer matrix.

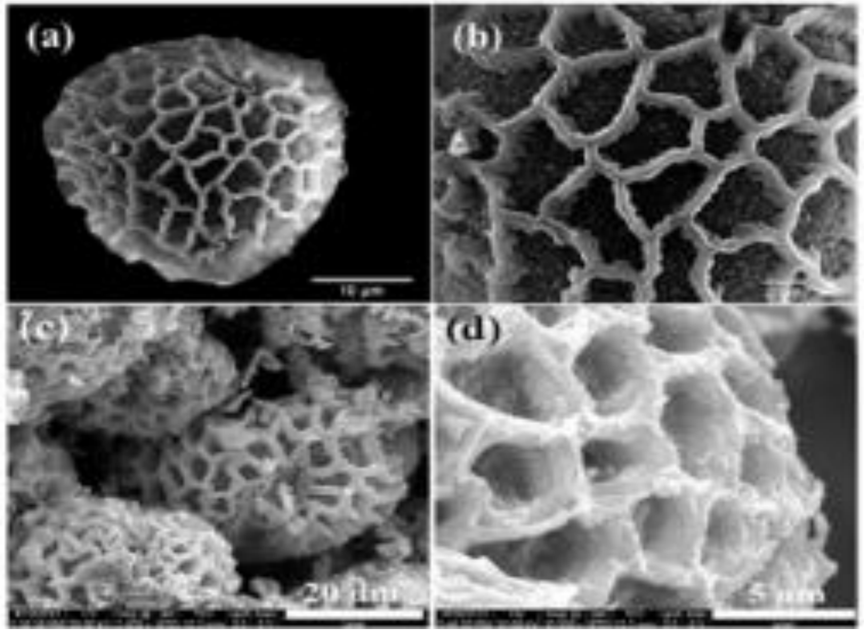
Fisnar Dispensing Robotic 3d Printing of Scaffold Microstructure



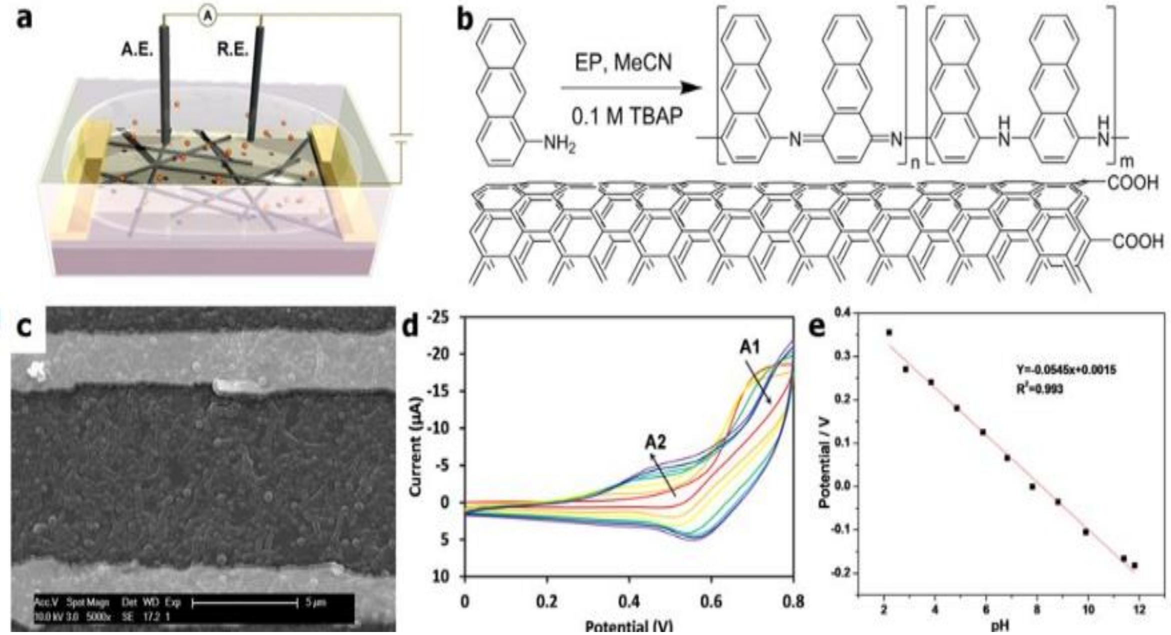
Scaffolds and Liquid Sensitivity Testing



Fabrication of Graphene Aerogels with Heavily loaded Metallic Nanoparticles



Carbon Nanotubes for pH Sensing



Main target are as follows:

- - CNCs as replacement for metals where lighter conductive materials are needed.
- -To detect leakage in fuel tanks and pipelines for improving the safety especially when the solvents are hazardous.
- - Beverage, water treatment, and food Manufacturing factories.
- - Synthesis and characterization of nanomaterials.