Project Leader
Dr. Umer Rashid

Project Title
Feasibility Study for Production of Biodiesel from Industrial Organic Based Carbonaceous Catalysts

Executive Summary
Continuously growing energy demand, depleting fossil fuel resources and environmental pollution are the major concerns to develop or find alternative resources of energy. Developing an environmental benign process for biodiesel production using a heterogeneous catalyst has become a global need. The consumption of edible oils for biodiesel production has led to the food versus fuel problem. As the demand for vegetable oils for food and oleo-chemicals has increased in the recent years, the contribution of low cost and non-edible feedstocks will have to play a role for alternative fuel production. Currently, most of the biodiesel productions are made from soybean, rapeseed and palm oil, through base catalyzed transesterification reaction. However, palm fatty acid distillate (PFAD), waste vegetable oils (WVO), and bio-based waste materials for catalysts synthesis which might be explored for biodiesel production. The sustainable use of resources will lead to the reuse and recycle of wastes into useful products. The objective of the present project is to assess the synthesis feasibility of series of catalysts from wastes materials *i.e.* empty fruit bunch (EFB), palm kernel shell (PKS), and kenaf using pyrolysis and hydrothermal process, furthermore the use of these catalysts for biodiesel production from low coast waste materials *i.e.* PFAD and WVO. Bio-based heterogeneous catalysts will be developed for both esterification/transesterification production steps. The catalysts will be functionalized using different sulfonating agents to produce sulfonated derived acid catalyst. The carbon-based wastes catalysts will be characterized using state of the art analytical techniques. These catalysts will be good for reducing the high amount of free fatty acids and also will be cheap, easy-to-prepare, environment friendly and readily available. The reaction process variables such as oil/methanol molar ratio, catalyst concentration, reaction time and reaction temperature will be optimized for both esterification and transesterification steps to develop a comprehensive protocol for obtaining high biodiesel yield with better quality. The quality attributes of the produced biodiesel will be evaluated and compared with specified standards. Furthermore, an economic performance for lab scale biodiesel process will be simulated in comparison with bio-based acid catalyzed process produced via pyrolysis and hydrothermal methods.

Project Leader
Dr. Umer Rashid

Project Title
Synthesis of Mesoporous Catalysts via Microwave-Hydrothermal Technique for Transesterification Reaction

Executive Summary
Biodiesel is an alternative diesel fuel consisting of alkyl monoesters of fatty acids derived from vegetable oils or animal fats. Currently, most of the biodiesel is made from soybean, palm and rapeseed oils through transesterification reaction using methanol and an alkaline catalyst.

However, there are a number of other potential waste resources such as discarded/deep-fried oils/fats from frying industry, palm fatty acid distillate the by-product of palm oil refinery which might be explored for biodiesel production. Recently, solid catalysts heterogeneous have been attracting more interest to produce biodiesel due to being non-corrosion, easy preparation, lower cost and environmental friendly nature. Various researches have been conducted on a wide range of solid acids and mixed metal oxides to produce novel catalysts with high activity and selectivity. Mesostructure catalysts have newly appeared as a novel biodiesel catalyst due to the combination of the harmonized surface characteristic, large surface area and flexibility in the pore. Absorbent surface properties of mesostructure catalyst can make them capable to absorb long chain of organic molecules such as free fatty acids. The objective of the present project is to focus on the synthesis of synthesis and modification mesoporous materials to enhance catalyst activity and catalyst acidity for biodiesel production and to modify the reaction environment of the acid catalyst site within mesoporous structure. In this project an alternative energy stimulant microwave-hydrothermal technique will be exerted to produce optimized biodiesel. Efforts will be made to fabricate the hollow microspheres catalyst by using sugar sources (glucose, cellulose, sucrose) as a template by microwave-hydrothermal technique. Also the effects of experimental variables on calcination reaction time and temperature in order to optimize the process using response surface methodology will be developed. The synthesized catalyst will be characterized using state-of-the-art analytical techniques *i.e.* SEM, TEM, TGA, XRD, XRF, BET and elemental analysis to check its efficacy and stability. The transesterification process variables such as microwave power, oil/methanol molar ratio, free fatty acid concentration, catalyst concentration, reaction time and temperature and stirring intensity will be evaluated to develop a comprehensive protocol for obtaining high biodiesel yield with better quality. Furthermore, the quality attributes and performance of the biodiesel produced will be evaluated and compared with specified standards and petroleum diesel. The prepared acid solid catalyst will be environment friendly and also improve the reactivity of mass transfer due to higher pore size.

Project Leader
Dr. Umer Rashid

Project Title
Mesoporous Carbon Based Solid Acid Catalysts for Biodiesel Production

Executive Summary
Mesoporous carbon-based acid catalysts have proven to be the future of catalysis in biodiesel production field. In the present project carbon based catalysts from biomass waste sources (seed cakes), such as the seeds of kenaf, palm and durian will be synthesized. The calcination on the raw materials before the sulfonation with different sulfonic agents will be performed to optimize the best sulfonic process for carbon based materials. Characterization of the catalysts will be achieved by carrying out various analyses such as NH_3-TPD, XRD, FTIR, SEM, BET and Raman spectroscopy. The efforts will aslo be made to analyze the catalytic activity of experimental variables *i.e.* alcohol to oil molar ratio, catalyst concentration, reaction time and temperature in order to optimize the process for higher biodiesel yield. Also the analysis for reusabilty and leaching of the catalysts will be done. Furthermore, the produced methyl esters/biodiesel will also be evaluated for fuel properties and compare with the International standards. Consequently, the

mesoporous carbon catalysts could be considered as a viable alternative to H_2SO_4 owing to their low material cost and high catalytic activity.

Project Leader
Dr. Umer Rashid

Project Title
Biodiesel Synthesis via Heterogeneous (Solid) Acid Catalyst by using Palm Fatty Acid Distillate as Feedstock

Executive Summary
Biodiesel will be produced from palm fatty acid distillate (PFAD) using carbohydrate derived solid catalyst via esterification in batch reflux and scaled up in oscillatory baffled reactor system. The operating conditions namely temperature, time, methanol to oil ratio and catalyst load will be optimized for higher biodiesel yield and the kinetic study of the esterification in batch reactor to determine the order of reaction and effect of temperature in Arrhenius equation will also be carried out. Carbohydrate derived solid acid catalyst has proven to be the future of catalysis in biodiesel production field. In the present project, sulfonated d-glucose will be synthesized to convert PFAD into biodiesel. Characterization of the catalyst will be achieved by carrying out various analyses such as NH_3-TPD, XRD, FTIR, SEM, BET, TGA and Raman spectroscopy. Also, the analysis for reusability and leaching of the catalysts in batch reflux will be done. Furthermore, the produced methyl esters/biodiesel will also be evaluated for fuel properties and compare with the International standards. Consequently, the carbohydrate derived solid acid catalyst could be considered as a viable alternative to H_2SO_4 which can only esterify and reduce cost of undertaking two-step process of producing biodiesel. The oscillatory baffled reactor system will help to reduce longer reaction time that occurs when using homogeneous acid catalyst in transesterification.