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Utilization of Bio-Glycerol to Synthesize Fuel Additive in Presence of Modified Mesoporous Heterogeneous Catalysts

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Abstract : The fast growth rate of energy consumption along with world population expected to demand 50% more energy by 2030 than nowadays. At present, the energy demand is mostly provided by limited fossil fuel sources such as oil, natural gas, and coal that are resulting in dramatic increase in CO2 emissions from combustion of fossil fuels. The growth of the biodiesel industry over the last decade has resulted in a price drop because glycerol is obtained as a by-product during transesterification of vegetable oil or animal fats, which accounts for one tenth of every gallon of biodiesel produced. The production of oxygenates from glycerol gains much importance due to the excellent diesel-blending property of the oxygenates that not only improve the quality of the fuel but also increases the overall yield of the biodiesel in helping to meet the target for energy production from renewable sources for transport in the energy utilization directives. The reaction of bio-glycerol with bio-acetone was carried out in a magnetically stirred two necked round bottom flaskS. Condensation of bio-glycerol with acetone in the presence of various modified forms of beta zeolite has been done for synthesizing solketal (AB-2 modified with nitric acid, AB-3 modified with oxalic acid). Among all modified forms of beta zeolite, AB-2 showed the best performance for maximum glycerol conversion 94.26 % with 94.21 % solketal selectivity and minimum acetal formation 0.05 %. The physiochemical properties of parent beta zeolite and all its modified forms were analyzed by XRD, SEM, TEM, BET, FTIR and TPD. It has been revealed that AB-2 catalysts with high pore volume and surface area gave high glycerol conversion with maximum solketal selectivity. Despite this, the crystallinity of AB-3 was lower than AB-2 which helps to provide the shorter path length for reactants and product but due high pore volume AB-2 was preferred which gave maximum bio-glycerol conversion. Temperature does matter the glycerol conversion and selectivity of solketal, as it increases from 40 ºC to 60 ºC the conversion of glycerol rises from 80.04 % to 94.26 % and selectivity of solketal from 80.0 % to 94.21 % but further increase in temperature to 100 ºC glycerol conversion reduced to 93.06 % and solketal selectivity to 92.08 %. AB-2 was found to be highly stable as up to 4 repeated experimental runs there was less than 10% decrease in its activity. This process offers an attractive route for converting bio-glycerol, the main by-product of biodiesel to solketal with bio-acetone; a value-added green product with potential industrial applications as a valuable green fuel additive or combustion promoter for gasoline/diesel engines.

Keywords : beta-zeolite, bio-glycerol, catalyst, solketal
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