Production of Biofuel using Nano catalyst

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Abstract: Biofuels are an important factor as a substitute for fossil fuels. Their production is increasing around the world. Catalytic processes are used to produce biofuel. The availability and wide diversity of biomass resources have made them an attractive and promising source of energy. Nanocatalysts are used to improve product quality and achieve optimal operating conditions. Nanocatalysts due to its high catalytic activity and high specific surface area, can overcome the problems associated with heterogeneous catalysts such as mass transfer resistance, high time consumption, fast deactivation and inefficiency. In the present review importance of biofuel, overview of nanocatalyst in the preparation of biofuel have been reported. Also effect of various parameters such as alcohol to oil ratio, effect of reaction time and temperature , effect of catalyst loading on the biofuel production have been discussed. Overall it can be said that the biofuel production using nano catalyst is a promising approach.

IndexTerms: Biofuel, Nano catalyst, catalyst loading, Reaction time.

I. INTRODUCTION

The importance of fossil fuel energy source has been increased because of growing energy disaster caused by depletion of fossil fuels such as coal, oil and natural gas. Therefore it has become essential to look for alternative eco-friendly renewable energy resources. Biofuel is considered as an alternative source of energy as it is cheap,less toxic, renewable, biodegradable and environmental benign because it generates less amount of sulphur and does not increases carbon dioxide emission in the atmosphere. Biomass is gaseous or liquid fuel consists of a long chain of fatty acid alkyl esters acquired from renewable and natural lipid feedstock. An economy of biofuel production mainly depends on production methodology, catalyst and types of raw material. oil selection mostly depends upon its features such as cold flow property, stability, and price. Edible oils such as rapeseed, palm, sunflower, soyabean and coconut oils are frequently used feedstock for biofuel production . The usage of edible oil is quite expensive therefore Non – edible oils such as jatropha, Mesua ferrea oil, neem oil and castor oils has gained more attention as it contains free fatty acids used for biodiesel production. Animal feedstock waste includes Chicken fat, Waste cooking oil, Tallow, brown grease, Microalgal, and yellow grease are the waste produced during cooking and processing of meat . All these waste are been used in large amount for biofuel production due to its environment and economic benefits.

In the production of biofuel catalyst plays a vital role in increasing the rate of reaction of transesterification process and helps in producing a high yield of biofuels.The world demand for nanomaterials has continued to take an upward trend due to its unique chemical and physical characteristics. A nonocatalyst is a material composed with catalytic properties that have a large surface to volume ratio which increases performance of catalyst since more surface area is available to react with the reactants. Nanocatalyst can be classified mainly into two groups, homogeneous and heterogeneous catalyst In the production of biofuel catalyst plays a vital role in increasing the rate of reaction of transesterification process and helps in producing a high yield of biofuels.

Some technologies successfully use homogeneous catalysis to increase conversion rates and selectivity, minimizing by-products and side reactions and to speed up reaction rates. The main disadvantages related to homogeneous catalyst are they cannot be recycled and recovered, generates a huge amount of unwanted waste chemicals that need to be removed and are highly corrosive in nature. These restrictions of a homogeneous catalyst can be controlled by using heterogeneous catalysts. Heterogeneous catalysts are environmental friendly, non-toxic, noncorrosive, recovered and recycled without great loss of solid catalyst activity, long shelf life and give high yield as compared to the homogeneous catalyst. Different types of heterogeneous catalysis are alkaline and alkali earth metal oxides, mixed metal oxides metallic salts,hydrotalcites, transition metal oxides , carbon based catalyst, ion exchange resins and waste based material catalyst.

II.OVERVIEW OF NANO CATALYST IN BIOFUEL PRODUCTION

The trend of using nanosized particles is widely increasing. Many researchers have studied the preparation of nanosized heterogeneous catalysts to enhance the activity of the catalyst in the production of biofuel. Nanocatalyst exhibits different characteristics such as high catalytic activity and surface area, reusable, reduces biofuel production cost and global warming. The main parameters for catalytic performance mostly depend on porosity, metal(s) content, acid properties, and base properties. Nanocatalyst may be homogeneous or heterogeneous relying on whether it exists as a substrate or in the same phase. Heterogeneous catalyst may be further classified into acid/base heterogeneous such as Ion exchange catalyst, metal-based catalyst, carbon-based, metal oxide based catalyst, boron-based catalyst and waste material catalyst. Sidra et.al (2016) observed Biodiesel Production by using CaO-Al2O3 Nano Catalyst in which Jatropha oil is used as feedstock for biofuel production through transesterification process. The biofuel showed the maximum yield of 82.3% at 5:1 methanol to oil molar ratio. B Vijya et .al (2016)studied Magnetized-Nano Catalyst KF/CaO-Fe3O4for Biodiesel Production from Beef Tallow wherein transesterification of feedstock beef tallow and KF/CaO-Fe3O4 as nanomagnetic catalyst were used to produce biofuel. The biofuel showed the highest yield of 94% at optimized 10:1 molar ratio of methanol to oil, reaction time 1h and temperature 55 °C. Manash Borah et al. (2018) investigated Synthesis and application of Co-doped ZnO as heterogeneous nanocatalyst for biodiesel production from non-edible oil. CO doped ZnO nanocatalyst from feedstock Mesua ferrea oil were used for biofuel production. The maximum yield of 98.03% of biofuel was obtained at optimized 1:9 oil to methanol molar ratio, reaction time 3h, catalyst loading 2.5 wt% and reaction temperature 14 °C. Biodiesel synthesis by the TiO2-ZnO mixed oxide nanocatalyst palm oil transesterification process was studied by Madhuvilakku R and Shakkthivel Piraman (2015). they obtained a yield of 98% by using TiO2– ZnO mixed metal oxide nanocatalyst for palm oil transesterification after 5h at reaction temperature 60 °C with 6:1 molar ratio of methanol to oil and 200 mg of catalyst loading. Baskar G and S. Soumiya reported Production of biodiesel from castor oil using iron (II) doped zinc oxide nanocatalyst. They reached a yield of 91% (w/w) from feedstock castor oil using ferromagnetic zinc oxide as heterogeneous nanaocatalyst for transesterification reaction obtained in 50 min at 55°C with catalyst dosage of 14 wt% and 12:1 methanol to oil molar ratio which was confirmed by GC with MS. A novel heterogeneous nanocatalyst MgFe2O4@CaO coated with CaO was synthesized by Liu Y et al. (2016). Optimized conditions for obtaining a 98.3 % biofuel yield was a 12:1methanol/soyabean oil molar ratio, 1.0 wt.% of catalyst loading, a reaction temperature of 70°C and time of 3h. Rintu Varghese et al. (2017) studied Ultrasonication Assisted Production of Biodiesel from Sunflower Oil by Using CuO: Mg Heterogeneous Nanocatalyst. At optimal conditions such as methanol/oil molar ratio 6:1, catalyst dosage 0.25 %, reaction temperature 60°C and reaction time 30 min biofuel yield of 71.78% was obtained.

Table 1 different types of Nano calalyst used along with biofuel yield

AUTHOR	NANOCATALYST	RAW MATERIAL	BIO-FUEL YEILD
Sidra Hashmi (2016)	CaO-Al2O3	Jatropha oil	82.3%
B Vijaya Kumar (2016)	nano-magnetic KF/CaO-Fe3O4	beef tallow	94 %
Manash Jyoti Borah (2018)	Co doped ZnO	Mesua ferrea oil	98.03%
Gurunathan B (2015)	CZO	neem oil	97.18%
Madhuvilakku R (2015)	TiO2-ZnO	palm oil	98%
Baskar G (2016)	iron (II) doped zinc oxide	castor oil	91%
Liu Y (2016)	$MgFe_2O_4$@CaO	Soybean oil	98.3%
Rintu Varghese (2017)	CuO: Mg	sunflower oil	71.78%

Various methods have been developed for nanocatalyst preparation for biofuel production. The common techniques are impregnation, chemical vapor deposition, vacuum deposition, chemical precipitation, a sol-gel method, and Electrochemical deposition. Below table (2) shows synthesis methods used for nanoparticles preparation and merits.

Table 2 : synthesis methods used for nanoparticles preparation and merits

Methods	Merits
Impregnation	• Simple to use • Low cost
Electrochemical deposition	• Economical • Particle size control • Less temperature required
sol-gel method	• Require lower temperature • Flexible • Less energy required for shaping and inserting
Chemical vapour deposition	• cost effective • proper deposition coatings
Gas condensation	• reduces kinetic energy

III. EFFECT OF VARIOUS PARAMETERS ON BIOFUEL PRODUCTION

3.1 Effect of alcohol to oil ratio

Production of biofuel increases as the molar ratio of alcohol/oil increases. when the molar ratio is increased beyond the level it causes biofuel conversion to decrease because the concentration of catalyst and oil decreases as the amount of methanol reactant is increased which causes detain in the reaction phase. Furthermore, the excess amount of methanol is a necessary reaction towards the product's phase because transesterification is a reversible reaction. when the molar ratio is higher transesterification reaction remains incomplete.

3.2 Effect of Reaction time

At lower time rate of reaction is low because the heterogeneous nanocatalyst is not fully activated therefore it gives less amount of yield. when reaction time is further increased biofuel conversion also increases. Beyond the optimum level, the biodiesel yield decreases because between FAME and glycerol backward transesterification takes place.

3.3 Effect of Reaction temperature

At higher temperature biofuel yield is maximum because sufficient amount of kinetic energy (K.E) is gained by reactants which increases the rate of mass transfer between catalyst oil methanol phases. When the reaction temperature is increased beyond optimum limits amount of methanol required for transesterification process in reaction mixture becomes unavailable therefore decrease in biodisel production was investigated. At this temperature interaction between reaction rate and catalyst reduces due to higher volatility of methyl alcohol. At lower temperature biofuel production is low.

3.4 Effect of catalyst loadings

The production of biodiesel increases as catalyst loading increases and gives maximum amount of yield. When catalyst dosage is increased beyond the optimized level , mixing problem occurs within solid catalyst, products and reactant also adsorption of biofuel products takes place into the catalyst due to which biofuel conversion decreases .

IV.CONCLUSION

The increasing demand for an alternative fossil fuel foster researchers to study more about biofuel, which is one of the most promising, environmental friendly, renewable energy source. In this review the literature survey on nanocatalysts used for biofuel production has been studied. Different parameters such as catalyst loading, reaction time, reaction temperature and alcohol/oil molar ratio is also reviewed. Nanoparticles has gained more attention due to its unique characteristics, Economy and pollution free nature.

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