RECENTTRENDS IN BIODIESEL PRODUCTION: CHALLENGES AND ADVANCES

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ABSTRACT

Biodiesel is synthesized in transesterification reaction that uses vegetable oil or animal fat and methanol or ethanol in presence of catalyststhat may be either homogeneous or heterogeneous catalysts This brief review covers recent trends in the biodiesel production, its challenges and future perspectives of this eco-green process. The major existing obstacles of biodiesel synthesis process, current innovations, search of sustainable feedstock oil, catalysts role in biodiesel synthesis, separation of product from byproduct, to refine the produced fuel,to enhance chemical and mechanical strategies for quality enhancement of biodiesel,has been concisely reviewed.

Key words: Biodiesel, Feedstock oil/fat, Catalysts, Recent Trends, Quality

1. INTRODUCTION

The depleting fossil fuels, population explosion, urbanization have increased demand of renewable energy and in this regard biofuel has appeared as best alternate in combustion engines.The rising ecological distresses and deteriorating fossil fuel have declared renewable energy as an remarkable and favorable basis for future substitutes of energy (Atabani *et al*., 2013). Renewable fuels have tendency to resolve most of the modern social and environmental glitches like distresses from effluence, climate change and sustainability issues (Gashaw and Lakachew, 2014). Biodiesel is the simply potential stand by to petro-diesel and favorablesubstitute resources for diesel engines (Farobie *et al*., 2015). Biodiesel, mono-alkyl esters of long chain fatty acids, is derived from

vegetable oils or animal fats and alcohol with or without a catalyst (Sadia *et al*., 2013).Comparing with regular diesel fuel biodiesel has several benefits such as renewable, green, less poisonous, portable, low CO exhaust emissions, high flash point, low sulphur content, inherent lubricity that extends the life of diesel engine. Major demerits of biodiesel includes low energy contents, engine compatibility, higher NOx emission, high price, high pour and cloud point, low power and engine speed, high engine wear, high viscosity and injector coking. Among biofuel sources, first, second and third generation feedstocks of biofuel include edible sources, vegetable and animal fat; second includes non-edible sources and cellulosic biomass; third generation biofuels include solid wastes, sludges and algae. Recently, edible plants are chief source for biodiesel production but they have competition with food supply and to avoid this economic imbalance and price hike due to edible feedstock, non-edible sources are preferred. Moreover, high FFA content is major challenge that reduces the biodiesel yield.Biodiesel is prepared mainly from four ways i.e. micro-emulsion, thermal cracking, direct use and blending and tans-esterification. Triglyceride in oil or fat reacts with three moles of methanol to form methyl ester of respective fatty acids and glycerol (Leung *et al*. 2010).

$$TRIGLYCERIDE + METHANOL \rightleftharpoons MIXTURE\ OF\ FATTY\ ESTERS + GLYCEROL$$

The basic biodiesel synthesis process is mentioned in flow sheet diagram(**Figure *1***)

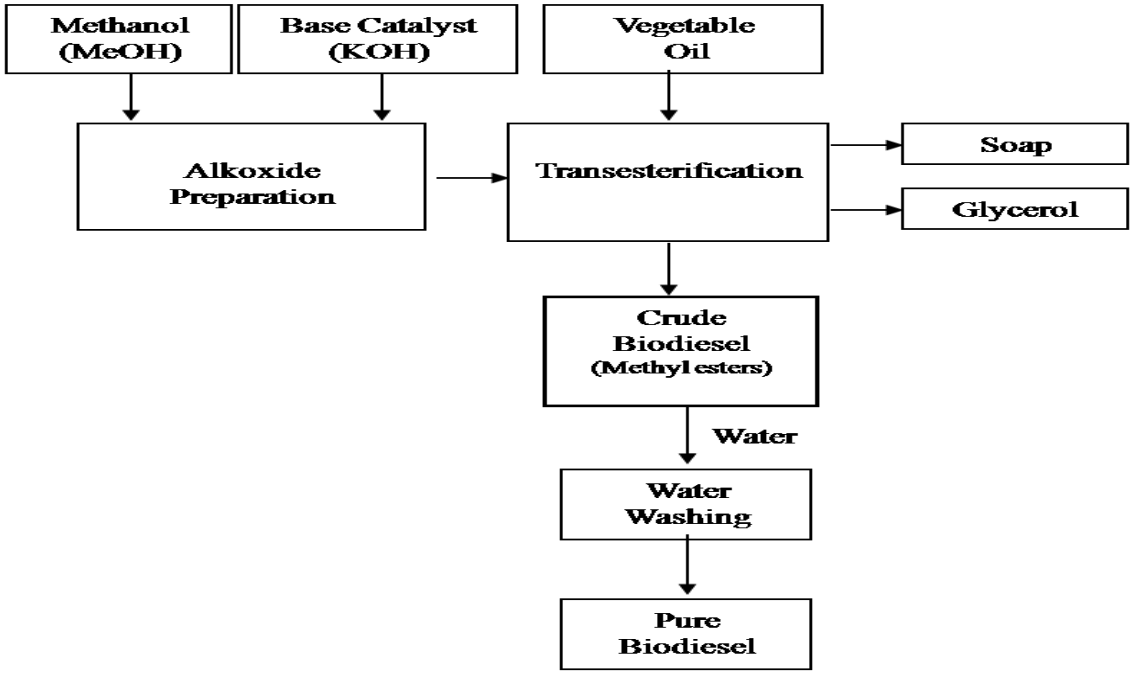

Figure 1 schematic diagram for biodiesel synthesis process

1. Trends in feedstock selection

More than 95% biodiesel is produced from edible sources because the characteristics are suitable for the alternate of petroleum based diesel fuel. Figure 2 shows world productivity of vegetable oil. The problemassociated with edible feedstock is its competition with food market hence increasing the fuel cost and leading to deforestation because these crops need specific fertile land to grow properly. In contrast, non-edible sources overcome such disadvantages because these are harmful for human consumptiondue to toxic compounds. Non-edible crops are grown at waste land and production cost is low however due to their high free fatty acid content they give high yield without specific care while growing at barren lands even. Animal fats with saturated fatty acids are solid at room temperature and their pretreatment enhances its production cost as compared to vegetable oils.

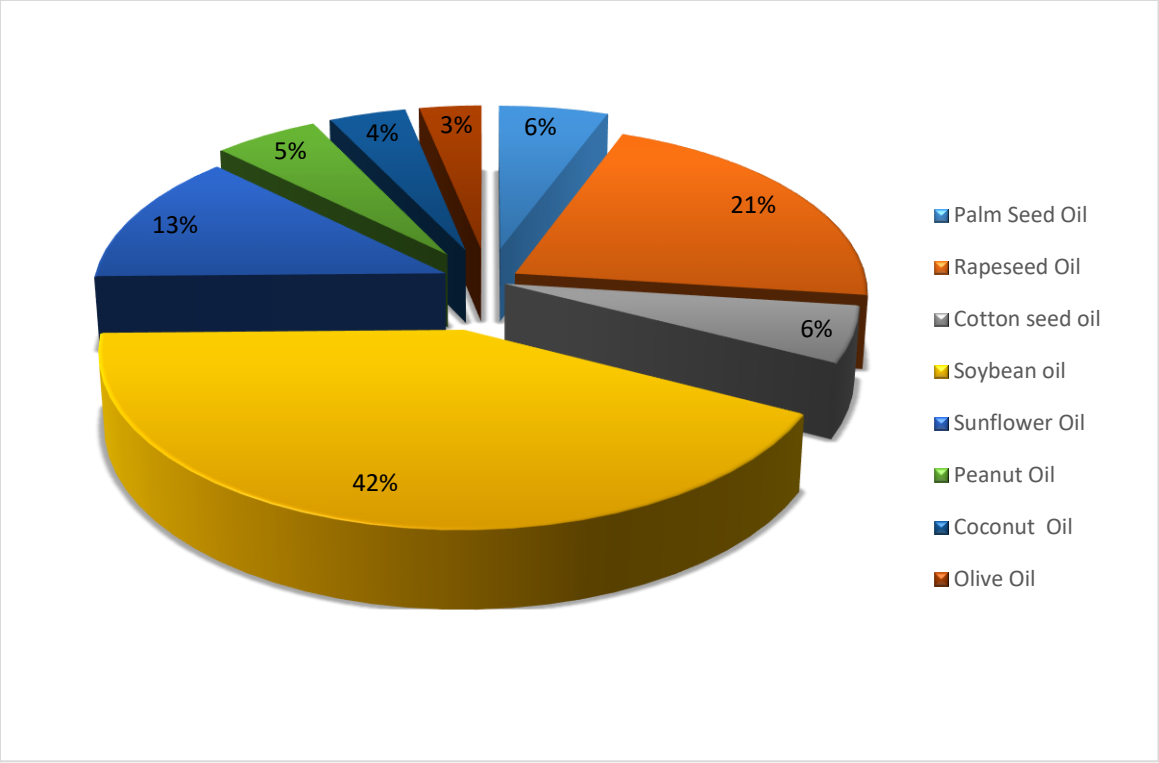

Figure 3 World productivity of vegetable oil

Microalgae is also best feedstock that helps to overcome food security issues as compared to edible non-edible feedstock. As microalgae are easily cultivated in short time round the year and give high yield of feedstock oil and productivity of algal biomass. Dewatering and harvesting algae is major bottleneck for algal biomass commercialization that is attributed to algal cell size and low conc. in culture medium therefore it is major obstacle in commercialization of algal biodiesel.

Table 1 Physicochemical properties of biodiesel from different edible sources

Edible fuel Sources	Edible oil	Density (g/cm^3)	Kinematic viscosity cSt. @40℃	Flash point ℃	Acid value mg KOH /g	Reference	Non-edible sources	Non-Edible oil	Density (g/cm^3)	Kinematic viscosity cSt. @40℃	Flash point ℃	Acid value mg KOH /g	Reference
	Soybean	0.91	32.9	254	0.2	(Niehaus, Goering, Savage, & Sorenson, 1986; Singh & Singh, 2010)		Jatropha	0.92	29.4	225	28	(Tiwari, Kumar, & Raheman, 2007)
	Rapeseed	0.91	35.1	246	2.92	(Winayanuwattikun et al., 2008)		Pongamia	0.91	27.8	205	5.06	(Sahoo & Das, 2009)

	Sunflower	0.92	32.6	274	-	(Winayanuwattikun et al., 2008)		Sea mango	0.92	29.6	-	0.24	(Kansedo, Lee, & Bhatia, 2009)
	Palm	0.92	39.6 @38℃mm^2 /sec	267	0.1	(Singh & Singh, 2010)		Polanga	0.90	72.0	221	44	(Sahoo & Das, 2009)
	Peanut	0.90	22.72	271	3	(Rao et al., 2009)		Tallow	0.92	-	-	-	(Goodrum, Geller, & Adams, 2003)
	Corn	0.91	34.9 @37℃mm^2 /sec	277	-	(Patil & Deng, 2009)		Nile tilapia	0.91	32.1@37℃ mm^2/sec	-	2.81	(Goodrum et al., 2003)
	Canola	0.91	38.2	-	0.4	(Issariyakul, Kulkarni,		Poultry	0.90	-	-	-	(Goodrum et al., 2003)

						Meher, Dalai, & Bakhshi, 2008)							

2. Trends in catalyst selection

Transesterification is reaction that uses vegetable oil or animal fat and methanol or ethanol in presence of catalyststhat may be either homogeneous or heterogeneous catalysts (Leung *et al*., 2010).Among above mentioned, efficient catalysts are nano-catalysts have been appeared as promising catalyst to give high yields. *Figure 4* shows fundamental distinction between efficiency between three basic types of catalysts. Homogeneous catalysts are more selective, active, less stable, modern reaction time, difficult to recover and moderate reaction time but heterogeneous catalysts are less active, so take more reaction time, recoverable and more stable as compared to homogeneous catalysts. Table 2 shows depicts the contrast of competency of homogeneous catalysts with heterogeneous catalysts in transesterification reaction.

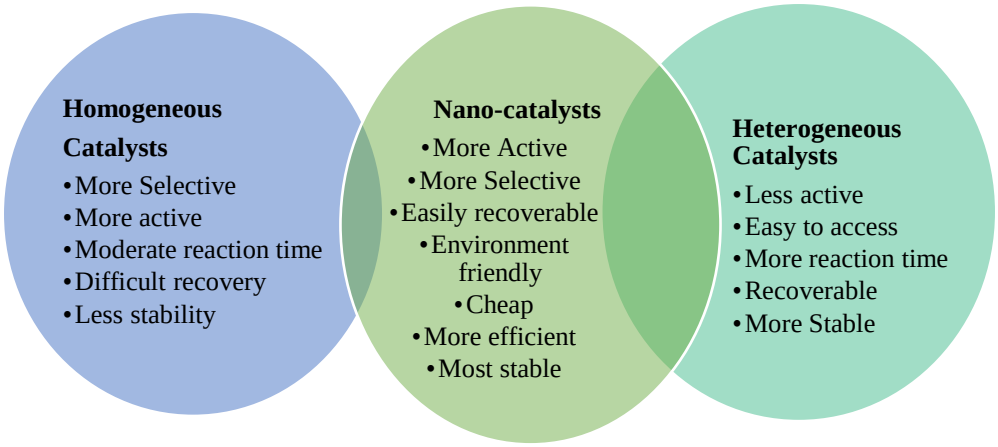

Figure 4. Difference in efficiency between three basic types of catalysts.

Table 2. Comparison of efficiency of homogeneous catalysts with heterogeneous catalysts in biodiesel synthesis

Factors	**Homogeneous Catalyst**	**Heterogeneous Catalyst**
Processing Methodology	Continuous process faces limitations	Continuous fixed-bed Operation

Concentration	Low	high
Reaction Rate	Fast Conversion	Medium Conversion
Thermal stability	Low	high
Life time	Variable	Long

The main strategies to overcome the demerits of biodiesel include use of nanosized catalysts i.e. more active, more selective, easily recoverable, environment friendly, cheap, more efficientand most stable. Features and advantages of nanocatalysts are shown in Figure 5

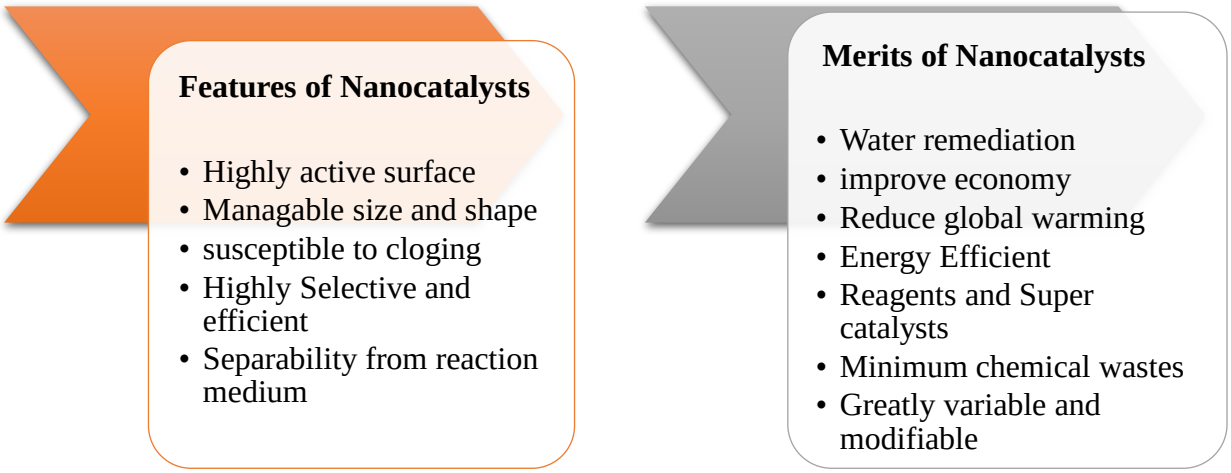

Figure 5 Features and Broad term merits of Nano-catalysts

3. Trends in biodiesel qualityenhancement

Purification and quality enhancement is major point of concern to be addressed as feedstock oil, byproduct, side reactions, high FFA content, reaction conditions have considerable effect. Chemical strategies involve cosolvent e.g. tetrahydrofuran, 1,4 dioxane, di-iospropyl ether and methyl tertiary butyl ether. Co-solvent usability is aimed for alcohol-oil single phase achievement. Separation of glycerol from biodiesel is slow and it is done by NaCl assisted gravitational settling 1g salt in 100ml glycerol reduced the glycerol settling time up to 100% without affecting the methyl ester yield (Shirazi *et al.*, 2013). Electrocoagulation is done for acceleration of decantation

rate of glycerol. The high FFA is dealt with esterification with an acid along with transesterification via twostep process. (Pisarello *et al.*, 2018)To meet international standards ASTM D6751 biodiesel purification is done either by wet washing or dry washing and MST i.e. membrance separation technology. Electrospun polystyrene membranes are more promising for industrial scale application due to their easy availability and low cost. To improve biodiesel properties oxygenated additives, cold flow improvers, combustion improvers, cetane no. improvers has been used for biodiesel quality enhancement (Mirzajanzadeh *et al*., 2015)

Conclusion

In spite of detailedstudyconductedon different aspects of biodiesel synthesis process for improvement of economic viability of exclusive sustainable energy carrier yet its future feasibility is uncertain. It is because of inadequate feedstock oil accessible to meet the rising demand of biodiesel, and at the same time controversial matter of fuel and food supply competition. Furthermore, maintenance of biodiesel's market price with fluctuation in oil cost competitive to petro-diesel would appear as a challenge. Along with this, integrated strategies are vital to enhance the economic aspects of process.

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