MAHUA (MADHUCA INDICA): A Potential crop of Biodiesel, Extraction and Optimization of alkaline Transesterification process

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ABSTRACT

Amidst the several non-edible crops available in India, Mahua is identified as a potential source of biofuel production. In India, currently one million tons of tree –borne oil seeds are being collected. For developing and densely populated country like India, the consumption of edible oil is high as a source of food and henceforth biodiesel production from second generation feed stocks is a promising solution to substitute edible oils for extraction of biodiesel. This paper introduce Mahua as a source of alternative to diesel fuel, its production by base transesterification method and optimization of various process parameters of transesterification process. As a conclusion, itis been found that an optimum yield of biodiesel is obtained at 55^{o}C for methanol to oil ratio of

(0.3:1) by volume.

Keywords: *Biodiesel, Mahua, Optimization, Tree-brone oil, Transesterification*

1. INTRODUCTION

In developing countries like India, biofuels are given serious importance as a potential source of energy for the future. In sight of large gap in requirement and production of edible oils, the use of edible oils to extract biodiesel in India is not a practical solution [1]. This problem can cause ecological imbalance resulting in deforestation and damage to wildlife by cutting down forests for plantation purposes. Therefore the second generation fuels or non-edible vegetable oils is been widely used for the sustainable production of biodiesel. Some of the tree-bone oils seed crops are Jatropha curcas, Madhuca indica, Azadirachta indica etc. Madhuca Indica is an evergreen or semi-evergreen plant species mainly found in India belonging to Sapotaceae family which grows up to a height of 20m and adapted to arid environments[2]. Mahua is one of the forest based tree borne non edible oils with large production potential of about 60 million tons per annum, produces seeds after

10 years continues up to 60 years. The kernel constitutes about 70% of the seed and contains 50% oil [3, 4]. Depending upon the maturity and size of the tree, each tree yields about 20-40 kg of seed per annum and total yield per ha is 2.7 t per year. Its seed contains about 35-40% of oil [5]. Mahua trees are widely grown in Uttar Pradesh, Madya Pradesh, Gujarat, South India, three district of Karnataka (Mysore, Tumkur and Bidar) and Monsoon forest of western Ghats. Fresh mahua oil from properly stored seeds is yellow in color with an unpleasant taste.Medically the tree is very valuable. Flowers are prepared to relieve coughs, biliousness and heart- trouble while the fruit is given in cases of consumption and blood diseases. Mahua flowers show anti-bacterial activity against Esche-richia coli. The honey from flowers is edible and reported to be used for eye. The bark is used in treating of rheuma-tism, ulcers, itching, bleeding and spongy gums, tonsillitis leprosy, heal wound, and diabetes mellitus. The root base is applied to ulcers [6]. Mahua oil is also used in the manufacture of various products such as soap and glycerin [7].Crude Mahua oil extracted from seeds contains high percentage of free fatty acids and its conversion to biodiesel is very important [8]. Among the processes used to reduce the viscosity, alkaline transesterification is the method chosen for our study as it is very fast compared to acid catalyzed. The stoichiometricratio for transesterification requires one mole of triglyceride and three moles of alcohol to obtain one mole of glycerol and three moles of fatty acid alkyl esters [9].Raheman et al have reported that the biodiesel derived from Mahua oil (MO) can be used as sole fuel or blends with diesel in diesel engines, with considerable reduction in CO, UBHC and smoke emissions and slightly higher NOx emission [10]. In this study different properties of biodiesel and various parameters such as

alcohol to oil ratio, reaction time, reaction temperature and concentration of catalyst is varied to optimize the preparation of Mahua oil methyl ester.

2. MATERIALS AND METHODS

2.1 Transesterification

The Mahua oil extracted from seeds contained lower value of free fatty acids, hence base /alkali transesterification was carried out to obtain Mahua methyl ester. The Mahua oil is reacted chemically using optimized amount of methanol and base catalyst. The mixture is stirred continuously in a three necked round bottom flask and then allowed to settle in a separating funnel under gravity. It forms two separate layers, the upper layer is methyl ester and lower layer is glycerol which is a byproduct of the reaction. The fatty acid composition of Mahua methyl ester is determined using Gas Chromatography and tabulated in Table 1.

Table 1: Fatty acid profile of Mahua methyl ester

Sl.No	Fatty acids	Weight (%)
1.	Lauric Acid	0.77
2.	Mysristic Acid	0.60
3.	Palmitic Acid	20.52
4.	Stearic Acid	20.67

5.	Oleic Acid	41.90
6.	Linoleic Acid	13.58

2.2 Process Optimization

The objective of transesterification is to reduce the viscosity of raw Mahua oil by converting it into low molecular weight Mahua biodiesel. The different process parameters to be optimized for the transesterification process are:

- Methanol to oil ratio
- Concentration of base catalyst
- Reaction temperature
- Reaction time

For the purpose of optimization of process parameters a magnetic stirrer with heater set up is used as shown in Fig 1. The stirring speed is optimized to 400 rpm .The methanol to oil ratio (v/v) is varied such as 0.25:1, 0.3:1, 0.35:1. The concentration of catalyst is varied such as 0.5%, 1%, 1.5%. The reaction temperature is varied such as 50^{o}C, 55 ^{o}C,and 60 ^{o}C. The reaction time is also varied such as 60, 90, 120 minutes. Based on this result the optimized quantities is selected for mass production of biodiesel to conduct experimental trial for engine tests.

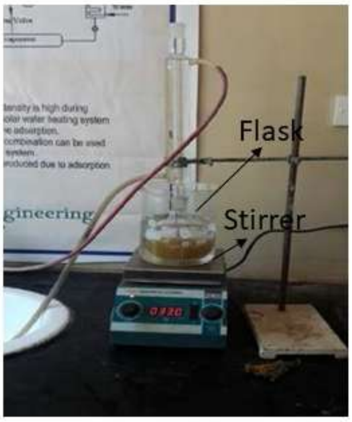

Fig.1: Photograph of transesterification experimental set up

3. RESULTS AND DISCUSSION

3.1 Effect of methanol to oil ratio

The molar ratio is one of the important parameter which affect the yield of biodiesel. Theoretically, transesterification reaction requires 3 moles of alcohol for each mole of oil. However, in practically molar ratio should be higher than stoichiometric ratio for completion of the reaction.The effect of methanol-to-oil ratio on biodiesel yield is shown in Fig 2. From the results, it is found that the yield reached maximum at the ratio 0.3:1.With further increase in methanol-to-oil ratio the biodiesel yield is reduced.

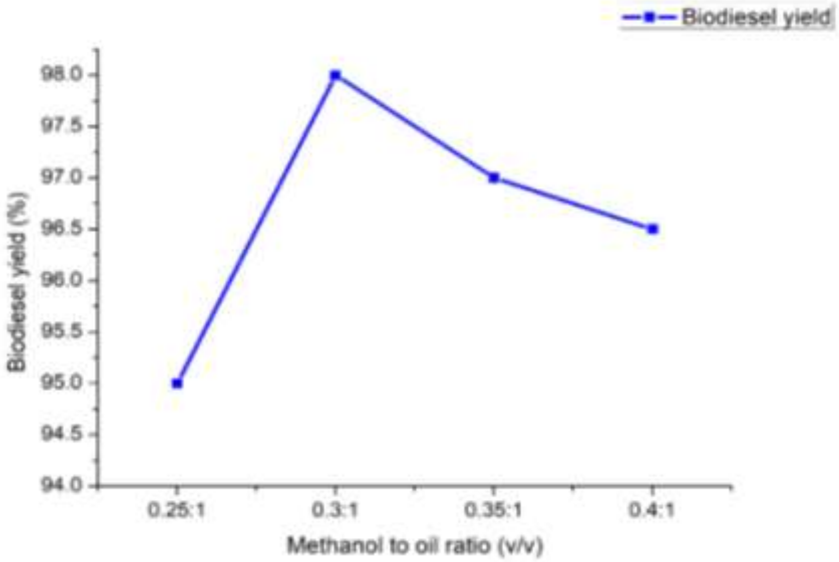

Fig.2: Effect of methanol to oil ratio on biodiesel yield

3.2 Effect of Catalyst concentration

The effect of catalyst concentration on yield of biodiesel is shown in Fig 3. The catalyst proportion is varied from 0.5% to 1.5 % KOH. It is observed from graph that the yield is increased slightly and reaches maximum at 1% KOH and decreases further with increase in catalyst concentration due to formation of emulsions (reverse reaction).

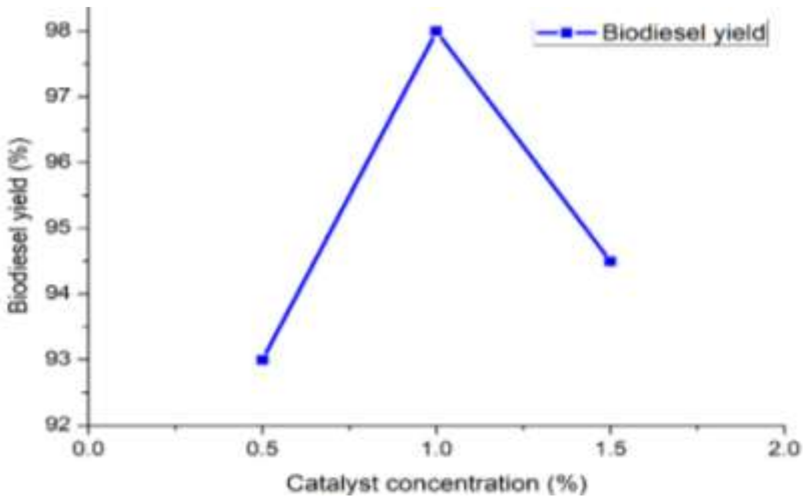

Fig.3: Effect of catalyst concentration on biodiesel yield

3.3 Effect of Reaction temperature

The reaction temperature has important role in alkaline-catalyst transesterification. The yield is increased with increase in reaction temperature. The effect of temperature variation on yield of biodiesel is shown in Fig 4. By varying temperature in different levels from 50˚C in steps of 5 ˚C, 55˚C gave maximum methyl ester yield. If reaction temperature is greater than 60˚C, there are chancesof loss of methanol.

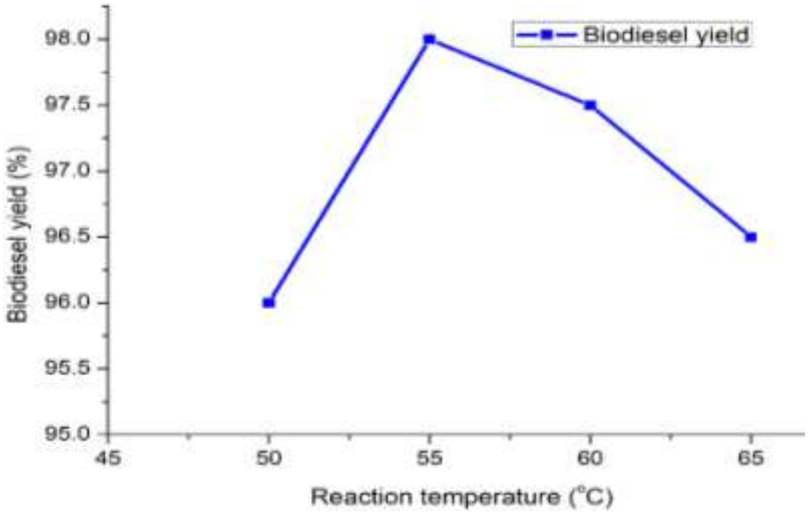

Fig.4: Effect of Reaction temperature on biodiesel yield

3.4 Effect of Reaction time

It is observed from the graph that with increase in reaction time the yield of methyl ester is increased. The variation of biodiesel yield against reaction time is shown in Fig 5.The maximum yield obtained is 98% for 90 minutes reaction. Withfurther increase in reaction time the yield of biodiesel decreases.

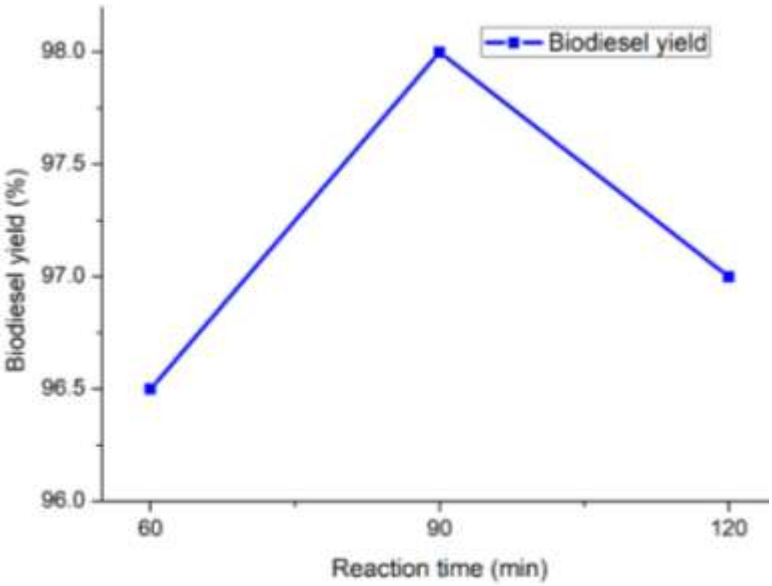

Fig.5: Effect of Reaction time on biodiesel yield

4. CONCLUSION

In this study, biodiesel production from Mahua oil using KOH as catalyst was carried out and it was found that KOH can be utilized as a catalyst for biodiesel production without any difficulty. The process parameters involved in biodiesel productionsuch as methanol to oil ratio (v/v), amount of catalyst, reaction temperature andreaction time was optimized. The combination of process parameters giving optimum biodiesel yield of 98% was found to be 0.3:1methanol to oil ratio, 1% KOH,55°C reaction temperature and 90 minutes reaction time.It was also found that excessive catalyst concentration results in formation of soap and can also cause emulsion formation during purification of biodiesel.

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