Optimization Study of Biodiesel Production from used Sunflower Oil

Manisha Mahatale¹, Sushil Kapoor², Dilip Patil³

¹Department of Chemistry, Janata College, Chandrapur 442402, India
²Department of Chemistry, Arts, Commerce and Science College TukumChandrapur, India
³Department of Chemistry, Institute of Science College, Nagpur, 440001, India

Abstract - This Study presents the effect of different parameters that effect the production of biodiesel from used sunflower oil and the optimum conditions using potassium hydroxide as a catalyst. Each biodiesel production (transesterification) run was repeated three times. The optimization parameters such as oil to methanol ratio (1:03 to 1:10), potassium hydroxide concentration (0.25 to 2.0 wt %), time duration (15 to 120 min), and temperature ranging from 35 to 70°C were determined. The optimum parameters were found to be 1 wt % of potassium hydroxide, 1:07 oil to methanol ratio, 60°C temperature, 90 minutes of the reaction time and highest yield of biodiesel obtained was 95 %

Keywords - Yield, biodiesel, used sunflower oil, transesterification, potassium hydroxide.

I. INTRODUCTION

The energy need is increasing continuously due to increase in industrialization and population. Most of the need are supplied through petroleum, coal, natural gases, hydroelectricity and nuclear energy[1]. Expect hydroelectricity and nuclear energy, all other sources will be consumed shortly. Hence it is necessary to seek alternative sources for petroleum.[2],[3] Used oil is the main source to make biodiesel. Transesterification of used oils form biodiesel and glycerin in presence of catalyst. Used oil reduces the cost of biodiesel production[4] and hence should be given priority over other sources[5]. Various catalyst[6] has been used to produce biodiesel from used oil. [11]-[13]

The effect of various parameters on the transesterification reaction for biodiesel production is important from the cost point of view. Several researcher has analyzed the effect of parameters on transesterification process[14]-[17]. They have used Taguchi method for the design of experiments.[18] Abdul Md.Wakil et-al [20] chosen cotton seed oil, musa oil and saeine oil as source for biodiesel production. The optimum condition recorded for the methanolysis of crude cotton seed oil were 3:1 molar ratio of methanol to oil and 1.00 % (w/w) catalyst. For musa oil the optimum condition were established to be 3.5:1M ratio of methanol to oil and 1.0% (w/w) catalyst. And for saeine oil the optimum conditions were recorded to be 3.5:1 M ratio of methanol to oil and 1.0%(w/w) catalyst.

Ali N.Eman and Tay Isis Cadence[21] used palm oil to produce biodiesel. To find out optimum yield, they selected reaction temperature 40, 50, 60°C, reaction time 40, 60, 80 min. and methanol to oil ratio 4:1, 6:1 and, 8:1. They found optimum yield of 88% temperature 60°C, reaction time 40 minutes and methanolto oil ratio 6:1. Similarly different worker had used different oils such as sunflower oil[22], palm oil[23], caster oil[24], [25] rubber seed oil[26] neem seed oil[27], campaca seedoil[28] and chicken fried oil.[29]

In present work potassium hydroxide catalyzed biodiesel production from used sunflower oil with methanol is carried out. The effect of various factors that affects the biodiesel production and optimum parameters has been investigated.

II. EXPERIMENTAL

2.1 Materials And Methods:

Materials: In present study used sunflower oil is collected from local restaurants. Larger particles such as pieces of fried batter and vegetables were removed by passing through a sieve. Then the sunflower oil was filtered with the help of a piece of cotton kept at the mouth of funnel and separated all food waste and suspended materials. Oil was passed again through cotton plug into a beaker to remove fine carbon particles. The chemical are methyl alcohol of 99.9 % purity was purchased from S.D. Fine chemicals Mumbai and potassium hydroxide pellets of 98.2% purity was used from S.D. Fine chemicals.

Biodiesel production from used sunflower oil was carried out in 250 cm³ three vertical neck round bottom flask equipped with reflux water condenser, thermometer and stirrer. The reaction procedure was as follow:

Potassium hydroxide 0.25 wt% was added to absolute methanol of required quantity to maintain the oil to methanol ratio 1:03 in 250 cm³ conical flask and tightly stopped with silver foil. It was swirled to complete dissolution. 100 g of used sunflower oil was measured into the three vertical neck round bottom flask. The oil was heated to 35°C while stirring at the same time. At maintained temperature of 35°C, the potassium hydroxide and methanol mixture was gradually added in the three vertical neck round
bottom flask and constant stirring was maintained at the same temperature. After the completion of reaction, the reaction mixture was allowed to settle overnight in separating funnel. The reacted mixture formed two separate layers. The upper layer contained biodiesel and impurity like excess catalyst and methanol. The lower layer contained glycerol. The crude biodiesel and glycerol were collected separately and their volume was measured. The crude biodiesel was purified by washing with hot distilled water and ensured the removal of residual catalyst and methanol. The experiment were carried out at different oil to methanol ratio (1:03 to 1:10), various potassium hydroxide concentrations (0.25 to 2.0 wt%), reaction temperature (35°C to 70°C), reaction time (15 to 120 min.) and the stirring was kept constant.

III. RESULT AND DISCUSSION

3.1 Effect of reaction time:

The increase in biodiesel percentage yield observed when there is an increase in reaction time. The reaction is slow at the beginning and then proceeds fast. The maximum yield was achieved up to 90 minutes. Further increase in reaction time does not increase the biodiesel yield.

The increase in reaction time from 15 minutes to 90 minutes increases the biodiesel yield from 65% to 95%. Increase in reaction time from 90 minutes to 120 minutes decreases the biodiesel yield from 95% to 85% (Table.1 and Fig.1). The initial slow rate of biodiesel production is due to the mixing and dispersion of methanol and used sunflower oil. The decrease in percentage yield beyond 90 minutes is due to reversible reaction resulting in loss of biodiesel as well as soap formation.

TABLE I

<table>
<thead>
<tr>
<th>Expt No.</th>
<th>Reaction time/Min</th>
<th>Volume of Biodiesel/ml</th>
<th>Percentage of Biodiesel/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>83</td>
<td>83</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>90</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>7</td>
<td>105</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>120</td>
<td>85</td>
<td>85</td>
</tr>
</tbody>
</table>

The maximum temperature = 90 min

3.2 Effect of potassium hydroxide:

Biodiesel formation is affected by concentration of potassium hydroxide, which acts as a catalyst. The percentage yield of biodiesel increases with increasing the amount of potassium hydroxide. By increasing the amount of potassium hydroxide from 0.25 g to 1.0 g, the percentage yield of biodiesel increased correspondingly from 65% to 95%. Beyond 1.0 g potassium hydroxide (up to 2.0g), the percentage yield of biodiesel decreases from 95% to 78% (Table.2 and Fig.2). The increase in percentage yield of biodiesel with increase in potassium hydroxide is due to the availability of the more and more active sites of catalyst (potassium hydroxide) in the biodiesel production process. The decrease in biodiesel yield beyond 1.0g of potassium hydroxide is due to the excess basic character of potassium hydroxide which enhances the triglyceride involvement in the saponification and reduction in the biodiesel yield.

TABLE II

<table>
<thead>
<tr>
<th>Expt No.</th>
<th>Amount of Catalyst/g</th>
<th>Volume of Biodiesel/ml</th>
<th>Percentage of Biodiesel/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>0.75</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>5</td>
<td>1.25</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>1.50</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>7</td>
<td>1.75</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>8</td>
<td>2.00</td>
<td>78</td>
<td>78</td>
</tr>
</tbody>
</table>

The maximum amount of potassium hydroxide (catalyst) = 1.00 g
3.3 Effect of Temperature:

Reaction temperature is an important parameter that affects the yield of biodiesel production. Increasing the reaction temperature from 35 to 60, the percentage yield of biodiesel production increases from 37% to 95%. Beyond 60, the percentage yield of biodiesel decreases to 85% (Table 3 and Fig. 3).

The increase in temperature (35-60) increases the viscosity of the used sunflower oil, energy of the reacting molecules and, also improves the miscibility of methanol polar media in to a non-polar used sunflower oil phase, resulting in increase in biodiesel yield [30].

Increase in temperature beyond 60 (up to 70) leads to decrease in yield of biodiesel production. This is due to the increase in the saponification of the used sunflower oil [31].

3.4 Effect of oil to methanol ratio:

One of the most important parameter affecting the yield of biodiesel production is the oil to methanol ratio. In present study, the results shows that as the oil to methanol ratio increases from 1.03 to 1.07, the percentage yield of biodiesel production increases from 70% to 95%. Further increase in oil to methanol ratio from 1.07 to 1.10 decreases the percentage yield of biodiesel production up to 80% (Table 4 and Fig. 4).

The maximum oil to methanol ratio = 1:07

The maximum Temperature = 60º C

Fig. 2 Biodiesel production from used sunflower oil: optimization of potassium hydroxide (catalyst).

Fig. 3 Biodiesel production from used sunflower oil: optimization of temperature

Fig. 4 Biodiesel production from used sunflower oil: optimization of oil to methanol ratio

IV. CONCLUSION

Used sunflower oil is a good source of biodiesel production, because it is easily available source. As it is waste, reduces the total production cost. The optimum
parameters for biodiesel production from used sunflower oil are: The potassium hydroxide concentration (catalyst) employed are 0.25, 0.50, 0.75, 1.0, 1.25, 1.50, 1.75, and 2.0 wt% respectively. The optimum potassium hydroxide concentration is 1.0g( wt %). Thetemperature of the reaction under study are35, 40, 45, 50, 55, 60, 65 and 70 C respectively. The optimum temperature for biodiesel production is 60. The oil to methanolratio employed was 1:03, 1:04, 1:05, 1:06, 1:07, 1:08, 1:09 and 1:10 respectively. The optimum biodiesel is obtained at 1:07 ratio. Therefore used sunflower oil is a good source of biodiesel production.

ACKNOWLEDGEMENT

The authors are sincerely thankful to Director, Government Institute of Science, Nagpur for necessary facilities to carry the present work.

REFERENCES

[5]. Connemann, J. and Fiseher J., Biodiesel in Europe; Biodiesel processing technologies. Int. Liquid Biofuels congress, Brazil; (1998), 1-16.
[17]. Phodke M.S., quality Engineering using robust design, 1st Low price edition, pearson education; (2008)