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Extraction of Biodiesel from Turmeric Leaves

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ABSTRACT: The rapid depletion of fossil fuel on earth is resulting in the increase of fuel prices and also in other effects such as global warming, which is indirectly impacting on human health. Turmeric serves as a prime spice in our daily lives, having many beneficial characteristics and medicinal values. It is derived from the residue of turmeric leaves post rhizome removal. Due to less commercial importance, the chemistry of turmeric oil has not received much attention earlier. Thus, to solve the issue related to non-renewable source of fuel, present study highlights the process of soxhlet extraction, which is a traditional method to extract the oil. Here, the same method is used to extract oil using turmeric leaves which is further processed using transesterification. Turmeric leaf oil gives a lower emission value which is under the emission norms. Further, it will not only ensure a sustainable reduction in emissions but also provide multiple environmental as well as economic benefits. A long-term and sustainable approach to biofuel production can help India capture the market for sustainable transport biofuels.

KEYWORD: turmeric leaf, soxhlet extraction, biodiesel, transesterification, emission.

I. INTRODUCTION

Emerging energy source

The primary alternate to fossil fuels is biodiesel. The name 'Biodiesel' was popularized in the US in 1992 by the National Soy diesel Development Board which led the way to the commercialization of biodiesel. Biodiesel synthesis receives ample worldwide attention with the public, being one of the first alternative fuels with diesel- equivalent properties [1].

Biodiesel is a lucrative alternate energy source for numerous reasons:

(1) Being renewable, it can sustain a continuous supply chain; (2) The molecular structure is highly bio-degradable with minimal combustion toxicity; (3) Cultivation in rural and wastelands can result in considerable improvement of a country's economic potential and reduce the dependency on crude oil imports (4) Compared to diesel, it gives off negligible emissions of sulphates, aromatic hydrocarbons along with minute quantities of smoke containing carbon dioxide (CO₂), carbon monoxide (CO) and particulates; (5) it can be used as a substitute to diesel in boilers or internal combustion engines without major modifications; (6) it contains more oxygen which aids the complete combustion of the fuel, leading to decrease in emissions.

Production and usage

The overall biodiesel production around the world was an estimated 15 thousand barrels per day in 2000 which increased to 289 thousand barrels per day in 2008 [3]. Available statistics suggest that 85% of the global biodiesel production per year is sourced from the European Union [10]. Countries such as USA, Indonesia, Brazil, France and Germany are the top consumers of biodiesel. Biodiesel markets have recently started experiencing an enormous growth in the US and Asia, in particular India and China, where the government targets a 15% substitution of petro-diesel by 2020. However, the potential for its production and application is much more. Table 1 shows the list of the top biodiesel producing countries in 2016.

Table 1.1 : Top biodiesel producing countries in 2016.

USA	5.5
Brazil	3.8
Germany	3

Indonesia	3
Argentina	3
France	1.5
Thailand	1.4
Spain	1.1
Belgium	0.5
Colombia	0.5
Canada	0.4
China	0.3
India	0
Singapore	0

Global transportation sector Energy consumption scenario

After the industrial revolution, energy has emerged as a decisive factor for humanity’s economic growth and high standard of living. In terms of worldwide energy consumption, the transportation sector now requires 30% of the global energy supply is the second largest after industries. In the past few decades, the transportation sector has seen a steady growth owing to increase in both public and private transport vehicles [2]. Fig. 1 shows the global energy consumption (by sector) between 2005 and 2035, based on consumption trends, while Fig. 2 shows the overall global marketed energy from 1980 (data available) to speculated net energy production and its marketing up to 2030. The transport sector presently requires about 60% of world’s oil demand and is becoming the fastest rising energy demand sector.

Nearly all fossil fuel energy consumption in the transportation sector is from oil (97.6%), with a small amount from natural gas [3]. There is much speculation about the time span of peak oil production, with the 2005 French Ministry report having suggested it to be in 2013, whereas other models predicted the peak year to have been either 2010 or 2005, while some studies contemplate the peak extraction to be in 2020. From the predictions it can be speculated that oil resources will probably be depleted in fewer than 45 years if consumed at an increasing rate of 3% per annum.

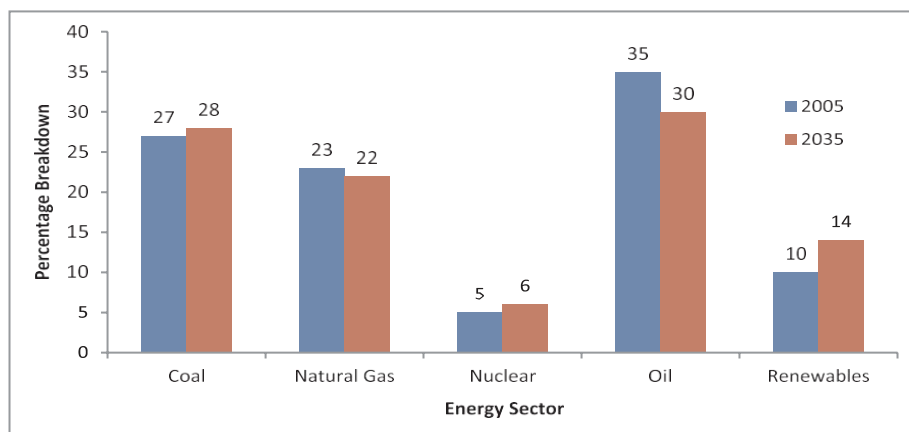


Fig 1.1 : Global energy consumption scenario (sector-wise).

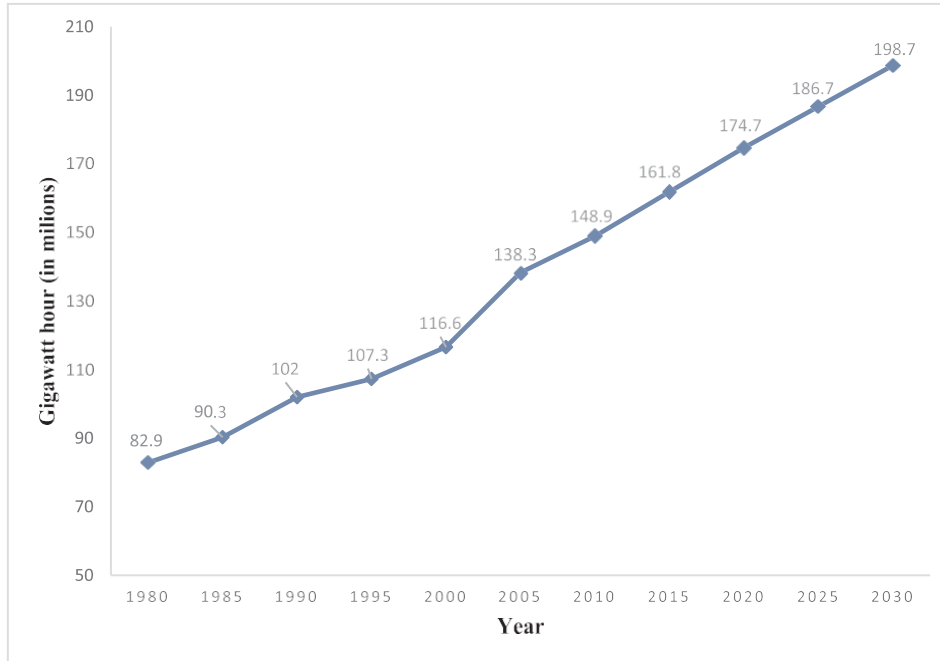


FIG 1.2 : Global marketed energy (overall).

Advantages of biodiesel

1. The combustion of biodiesel causes 80% less CO₂ emissions and no sulphur dioxide.
2. The proportion of un-burnt hydrocarbons is reduced by 90% of unburned.
3. It is totally non-toxic and biodegradable.
4. It has almost similar cetane number as that of diesel.
5. Also, it imparts relatively better lubricity.

Disadvantages of biodiesel

1. The biodiesel acts as an excellent solvent and thus the deposits at the filter section could get dissolved into it. This may cause severe degradation of engine parts.
2. The biodiesel can cause problems in winter as the cold point is relatively higher as compared to the diesel.

II. METHODOLOGY

Drying:

Before extraction of oil from turmeric leaves it should be dry properly. In this procedure weighted leaves containing moisture is placed on the trays of oven in such a way they are not placed on one another and temperature is maintained at 100°C. Drying is continued for one hour to remove all moisture from leaves.

Extraction of oil:

Soxhlet extraction has traditionally been used for a solid sample with limited solubility in a solvent in the presence of insoluble impurities. A porous thimble loaded with a solid sample is placed inside the main chamber of the Soxhlet extractor. By refluxing the solvent through the thimble using a condenser and a siphon side arm, the extraction cycle is typically repeated many times. Soxhlet extraction is a rugged, well-established technique and permits unattended extraction. However, it requires a long extraction time and the consumption of a large amount of solvent.

During the extraction, solvent vapour will flow up the distillation path, into the main chamber and up into the condenser where it will condense and drip down. The solvent will fill the main chamber, dissolving some of the desired compound from the solid sample. Once the chamber is almost full, it is emptied by the siphon, returning the solvent to

the round bottom flask to begin the process again. Each time the extraction is repeated, more of the desired compound is dissolved, leaving the insoluble impurities in the thimble. This is how a compound is removed from the sample. Unlike a traditional extraction method, a small amount of solvent is reused to perform an extraction many times. This means that much less solvent is used in a Soxhlet extraction, making it more time and cost effective. Also, the Soxhlet extractor can run continuously without any further operation, making it an excellent choice for extracting compounds over hours.



Fig 2.1 : Experimental Setup

Performing the Soxhlet extraction method for turmeric leaf oil

Plant material can be fresh (for example, a plant leaf) or dried. It needs to be crushed, using a pestle and mortar, to provide a greater surface area. The plant material should be sufficient to fill the porous cellulose thimble (in our experiments we use an average of 14 g of thyme in a 25 - x 80-mm thimble).

Following this, the solvent (250 ml of methanol) is added to a round bottom flask, which is attached to a Soxhlet extractor and condenser an iso-mantle(fig 3.1). The crushed plant material is loaded into the thimble, which is placed inside the Soxhlet extractor. The side arm is lagged with glass wool. The solvent is heated using the iso-mantle and will begin to evaporate, moving through the apparatus to the condenser. The condensate then drips into the reservoir containing the thimble. Once the level of solvent reaches the siphon it pours back into the flask and the cycle begins again. The process should run for a total of 4 hours.

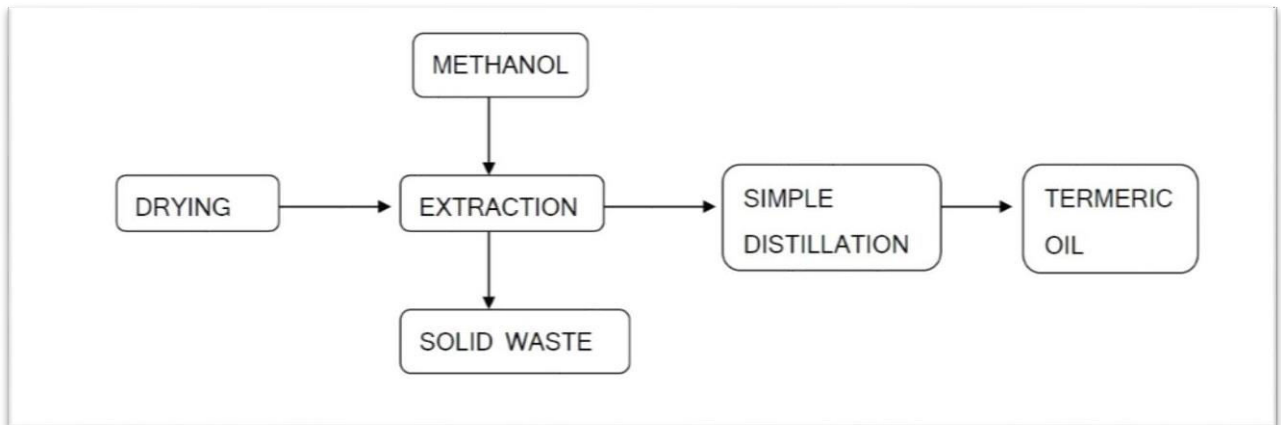
Simple Distillation

Once the process has finished, the methanol should be evaporated using a simple distillation, leaving a small yield of extracted plant material (about 2 to 3 ml) in the glass bottom flask. Simple distillation is carried out at a temperature of 67°C and we get methanol as a top product and methanol and bottom is turmeric oil.



Fig 2.2 : Simple Distillation

Process Flowsheet I : For the formation of turmeric oil.



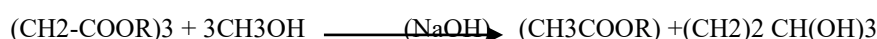
Transesterification

The use of biodiesel is an effective way of substituting diesel fuel in the long run. One important conclusion that can be drawn from the work done earlier is that the vegetable oils i.e. turmeric oil can't be used directly in the diesel engine. Several problems crop up if unmodified fuel is used and viscosity is the major factor. It has been found that transesterification is the most effective way to reduce the viscosity of vegetable oils. Also to make them fit for their use in the present diesel engines without any modification. Trans-esterification is the process by which biodiesel is produced. In this process an ester reacts with an alcohol to form another ester and another alcohol. The catalyst for this reaction is KOH or NaOH. Three moles methanol react with one mole of triglyceride which produces mixture of fatty esters and glycerine. The industrial-scale processes for transesterification of vegetable oils were initially developed in the early 1940s to improve the separation of glycerine during soap production. The primary input is assumed to be all that has previously been extracted from turmeric leaves. To accomplish the transesterification reaction described above, the oil, methanol, and catalyst are mixed together in a stirred resettle, 55-60°C temperatures will cause the reaction to reach equilibrium more rapidly; in most cases the temperature is kept below the normal boiling point of the methanol (67°C) so the reactor does not need to be pressurized. As shown in the reaction equation below, three moles of methanol react with one mole of triglyceride. In practice, most producers will use at least 100% excess in methanol (6:1 molar ratio) to force the reaction equilibrium, towards a complete conversion of the oil to biodiesel. The reaction is slowed by mass transfer limitations since at the start of the reaction the methanol is only slightly soluble in the oil and later on, the glycerine is not soluble in the methyl esters. Since the catalyst tends to concentrate in the glycerine, it can become

unavailable for the reaction without agitation.

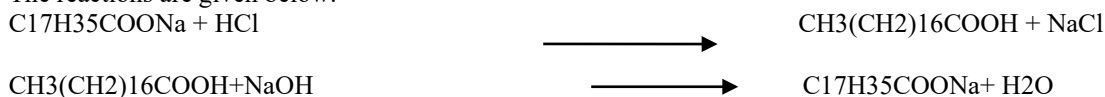
A common approach to overcome this issue is to conduct the transesterification in two stages

First, the oil is combined with 75% to 90% of the methanol and catalyst and this mixture is allowed to react to equilibrium. Then, the glycerine that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for a second reaction period. At the conclusion of this second reaction period, the remaining glycerines separated and the biodiesel is ready for further processing. The glycerine separation steps are usually accomplished by gravity settling or with a centrifuge. After the biodiesel is separated from the glycerol, it contains 3% to 6% methanol and usually some soap. If the soap level is low enough (300 to 500 ppm), the methanol can be removed by vaporization and this methanol will usually be dry enough to directly recycle back to the reaction. Methanol tends to act as a co-solvent for soap in the biodiesel, so at higher soap levels the soap will precipitate as a viscous sludge when the methanol is removed. The reaction is given below



Stronger inorganic acids, such as hydrochloric, sulfuric, or phosphoric, can be used to split the soap and this reduces the water requirement to 5% to 10% of the biodiesel flow because the salts are easier to remove than the soap. After washing, the biodiesel is frequently cloudy due to small water droplets suspended in the fuel. While these droplets will eventually settle out, it is much faster to use a flash evaporator to remove the residual water from the fuel. The glycerine that is separated from the biodiesel will contain a substantial amount of methanol, most of the catalyst, soaps that have been formed during the reaction and many of the polar contaminants that were originally present in the oil. These contaminants contribute to a dark brown or black colour for the glycerine spite of it being clear when present as a pure compound. The raw glycerine has very little value and must be upgrade to raise its purity before it can be sold. The usual practice is to add strong hydrochloric acid to the glycerine to neutralize the catalyst and split the soap.

The reactions are given below:



The soaps split into free fatty acids (FFAs) and salt, as shown in the equation. The FFAs are not soluble in the glycerine and can be separated with a centrifuge. The methanol can be the soaps split into free fatty acids (FFAs) and salt, as shown in the equation. The FFAs are not soluble in the glycerine and can be separated with a centrifuge. The methanol can be removed by vaporization leaving a crude glycerol that is 80% to 90% pure. Most of the impurities will be salts. Only a few of the biodiesel producers in the U.S. have invested in the equipment to refine this crude glycerine to the 99.5% purity required for pharmaceutical and cosmetic applications. The fatty acids are not soluble in the glycerine and can be separated with a centrifuge. These high free fatty acid oils present special challenges when used for biodiesel production. When an alkali catalyst is added to these feed stocks, the free fatty acid reacts with the catalyst to form soap and water as shown in the above reaction. This reaction makes the catalyst unavailable for catalysing the reaction and if enough soap is produced it can inhibit the separation of the methyl esters and glycerine.

When oils and fats with high free fatty acids are to be used for biodiesel production, an acid catalyst such as sulfuric acid can be used to esterify the free fatty acids to methyl esters as shown in the following reaction.



Then, the Methanol with the FFAs converted to methyl esters, a conventional alkali-catalysed process can be used to transesterify the triglycerides in the feedstock. While acids can be used to catalyse the transesterification reaction, the reaction is very slow at the 50° to 60°C reaction temperature the two-step approach of acid-catalysed esterification followed by base-catalysed transesterification gives a complete reaction at moderate temperatures. A problem with this approach is that the water produced by the esterification reaction should be removed before the base catalysed process begins so that soap formation is not excessive. This can be done by settling or centrifuging the methanol-water-acid layer that separates after the esterification has reached equilibrium. The additional equipment required for the acid-catalysed pre-treatment raises the processing cost, but this approach allows the use of feed stocks containing up to 100% Process Flowsheet II : For the formation of Biodiesel.



III. CONCLUSION

The turmeric leaves which is used as raw material for waste oil is first weighted and note the weight which is 150 gm then dry to temperature of 1050C, for an hour to remove moisture from leaves and again weigh dry leaves which is 75gm. Load the sample material containing the desired compound into the thimble Place the thimble into the main chamber of the Soxhlet extractor. Add 250ml methanol for extraction of oil After extracting oil from leaves is then distilled by using simple distillation process temperature is maintained at 670C which is boiling point of methanol. Oil obtained is about 2ml.

Similarly, there are 2 trial held for validate yield. Table 3.1 Result :

Sampl e no	Feed (with moisture) (gm)	Feed (without moisture) (gm)	Number of cycle	Time (hr)	Oil Obtained in ml	Oil Yield(%)
1.	150	75		32.5	2	2.66
2.	180	85		43.5	2.5	2.94
3.	45	19.5		54	0.5	2.564

IV. FUTURE WORK

Due to less turmeric leaf oli production we are not able to do transesterification process. In next time we can increase the feed of the extraction i.e., turmeric leaf which increase our quantity of oil for further process.

It is an innovative idea to produce secondary fuel from turmeric leaves. Turmeric leaf oil is extracted from turmeric leaves, these leaves are treated as waste product in farming and available vast value. This production will be effect in reduction of use of fossil fuels and reduction in global crisis. Currently, soxhlet extraction process is designed to yield the oil from turmeric leaves. More studies and efforts are need to be carried out to increase oil yield and explore its applications.

From this study we concluded that soxhlet extraction is more effective process for extraction of turmeric oil than other conventional methods. Turmeric leaves are the waste product that remains after removal of rhizomes. This experimental study is done using various methods of extraction from which " Soxhlet extraction" found. As per the studies, the yield of turmeric leaf oil obtained is ranges from 1.5 to 3 %.

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