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"Biodiesel Production From Custard Apple Seed"

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Abstract -

Now a day's increasing in price and depletion of fossil fuels creates a necessary to find out an alternative fuel from non-edible seed oil. Liquid fossil fuels are the main and most frequently used fuel for mobile machinery. This papers deals with the transformation of custard apple seed oil by mean of methanol in presence of potassium hydroxide catalyst at less than 65C. The viscosity of biodiesel produced from custard apple seed oil is nearer to that of the commercially available diesel. The custard apple seed oil is characterized by GC analysis and important properties of biodiesel of biodiesel such as density. Flash point, cloud point, pour point and kinematic viscosity. Ash content carbon residue are found out and compared with that of ASTM-biodiesel standards and commercially available diesel. The study encourage the production of biodiesel from custard apple seed oil and value addition of custard. The transesterification reaction formally requires a molar ratio of alcohol to oil of 3:1 but in practice molar ratio of 6:1 need to be applied for the reaction of proceed properly to high yield. The transesterification usually requires about 1 hour at normal pressure with the reaction temperature 60-65C. The extraction of oil from custard apple seed was done by using mechanical expeller and solvent extraction by soxhlet apparatus using methanol as solvent. By observing all result of biodiesel form custard apple seed oil, custard apple seed can be used as biodiesel feed stock. All the properties are in the range of ASTM biodiesel standards, this can be promising factor to used custard apple seed as one of biodiesel source.

***Key Words*:** optics, photonics, light, lasers, templates, journals

1. INTRODUCTION

1.1 General background

Energy consumption is constantly all over that world in spite of the rationalization measure that have been taken liquid fossil fuel are the main and most frequently used fuels for mobile machinery. Considering the fact that the entire development of mobile machinery is based on the use of liquid fossil fuel .it is difficult to except a shift from this trend to a mass development and use of new engine construction and that would meet the criteria regarding renewability, ecology and reliability of use. Fulfillment of the mentioned criteria is the basis for a successful fossil fuel replacement by some other type of fuel. During the last decade biodiesel has become the most common renewable liquid fuel due to its possibility to meet the set requirement of the previously mentioned criteria. Namely, the use of biodiesel dose not require any type of the engine modification and modification of fuel injection system. The exception are older engine construction which needs a replacement of sealant and fuel injection house.

Custard apple as shown I fig-1.1 belong to the family annonaceae with botanical name annona squamosl, is commonly found in deciduous forests, also cultivated in wild in various parts of India it is native of west indies now cultivated throughout India and other tropical countries.

Fig.1.1 Annona Squmosa Fruit

Annona squmosa processes medicinal property. It had also been known as sweetsop and sugar apple (English) seetaaphala and amritphala (Canada), Atoa and shariffa (Hindi) Biophysical limits: Altitude 0-2000m, mean annual squamosal tolerates a wide variety of soils, it grow loans. Its has been reported that annona squamosav seeds as Fig1.2 contain 26.8%.Residual agricultural product and food-processing by products or wastes are often remain without any application. The conversion of such material to valuavle resources can be a good contribution to a reduction in resudues. In these sense, residue valorization has become of great interest from an economical point of view. The transesterification reaction formally requires a molar ratio of alcohol to oil of 3:1 but in practice a molar ratio of 6:1 needs to be applied for the reaction to proceed properly to high yield. The transesterification usually requires about 1 hour at normal pressure with the reaction temperature 60-65^{0}C (for methanol).

Fig.1.2 Custard apple seeds

1.2 Use of Biodiesel

Biodiesel can be used in heating application such as a home heating or industrial application, transportation application if the vehicle has diesel engine, and on the form I machines like tractors. Today it is also very easy to purchase biodiesel blends in Connecticut. The information on this parts of this parts of the side addresses the consumer experience of using biodiesel and what application biodiesel can be used.

1.2.1 Biodiesel for transport

Biodiesel has become a valued commodity in powering auto vehicle. There are various economic and environmental advantages to utilizing this unique fuel. Detailed below are various strategic venues include private consumption in passenger care, school buses, and various

Using Biodiesel in school buses:

The below EPA and national biodiesel board websites discusses the current market for biodiesel in school buses as well as numerous example off school districts utilizing biodiesel in their school buses. The below links discusses how a group of student at the university of Connecticut developed and implemented a plan to operate some of the university bus fleets on biodiesel made from yellow grease from dining hall on campus. This national biodiesel board web page describes a series of example of using biodiesel successfully in school buses.

Below are some education instruction which use biodiesel to power their school buses:

1.2.2 Biodiesel for heat

Consumer today, some than at any other point time, have greater opportunity in Connecticut to purchase biodiesel than ever before. It is now possible to purchase biodiesel for use us transportation fuel and heating fuel. Price for biodiesel very by both location and manufacturer

In Connecticut biodiesel is now cheaper than regular diesel in some areas and more expensive than regular diesel in other.

Biodiesel used for heating buildings is now commonly referred to as"Bioheat". Below is a web site where it is possible to locate bio heat dealers in connecticut where bio heat can be purchased for business.

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Fig.1.3. Heating Biodiesel

1.2.3 It is use for alternative fuel

1.2.4 It is use for renewable sources

ADVANTAGES

- An excessive production of soybeans in the world makes it an economic way to utilize this surplus for manufacturing the biodiesel fuel.
- One of the main biodiesel fuel advantages is that it is less polluting than petroleum diesel.
- The lack of sulfur in 100% biodiesel extends the life of catalytic convertors
- Another of the advantages of biodiesel fuel is that it can also be blended with other energy resources and oil.
- Biodiesel fuel can also be used in existing oil heating systems and biodiesel engines without making any alternation.
- It can be also be distributed through existing diesel fuel pumps, which is another biodiesel fuel advantage over other alternatives fuels.
- The lubricating property of the biodiesel may lengthen the lifetime of engines.

DISADVANTAGES

- At present, biodiesel fuel is bout one and a half times more expensive than petroleum diesel fuel.
- Another biodiesel fuel disadvantage is that it can harm rubber houses in some engines
- As biodiesel cleans the dirt from the engine, this durt can the get collected in the fuel filter, thus clogging it. So, filters have to go changed Biodiesel fuel is a renewable energy source petroleum-based diesel.

2. Body of Paper

LITERATURE REVIEW

Biodiesel, a renewable source is able to cater the needs of people at the same time it helping towards clean and green environment. This has been possible by extensive investigations on renewable energy sources especially on the concept of biodiesel. Many researchers have carried out many investigations on usage of biodiesel in compression ignition engines. Problems encountered in usage of biodiesel were identified, many possible solution have been suggested and published on many journal papers. This proved to be valuable source for many researchers, laying path for further research. A thorough reading has been done on sources of biodiesel especially on nonedible sources, production method and usage of it as fuel in diesel engines.

Tran's esterification process and catalytic cracking methods are implemented based on the literature survey and the biodiesel thus obtained is tested in diesel engine and results are reported. Out of many journal papers that have been gone through, few

Journal papers are quoted. Ayhan Demarrias [1] in his paper detailed about biofuel, their sources, their effect on economy and future projections. With his briefing about biofuel and different product of biofuel presented their environmental effects and also socioeconomic issues related to rural areas. Due to inherent advantages of biofuel related to environmental issues, he expressed that it would occupy a major share of automotive market in next decade and by 2050 he estimated that modern biomass energy contributes nearly one-half of the total energy demand of developing countries. B.K. Barnwalet. A1 [2] expressed about necessity of alternative fuels. They proposed two methods for biodiesel production one was trans esterification and other one was super critical methanol trans esterification. Concluded that super critical methanol.

Tran's esterification method gave good yield of quality biodiesel with very less conversion time. After economic feasibility study they expressed that biodiesel from non-edible oils are cheaper when compared to edible oils and that production of 12 biodiesel from vegetable oils will be economical and technically

Feasible only if cost of vegetable oils was less. S. Jaichandaret. A1[3]expressed their view that high viscosity and low volatility of vegetable oils are the problem to substitute diesel fuel. Biodiesel from vegetable oils can be product by Tran's esterification process there by reducing viscosity of vegetable oil they expressed their view that acceptable thermal efficiency of CI engines can be attained with reduced emissions and more investigation are to be done to get full potential of biodiesel engines. O. O. Agbebe [4] investigated extracted oil from three fruit seeds(mango, tangerine, African star) for their worthiness for production of biofuel. It was found that fuel properties were similar to those of common seed oils which were already being used as biodiesels. Their low acid value signifies its potential to be used as feed stock in producing biodiesel. Concluded with need for further investigation of other fuel properties. S Savariraj [5] Worked upon reducing viscosity and increasing calorific value extracted mango seed oils with 1, 4 biodiesel fuel additive. Tran's esterification of mango seed oil produced biodiesel that was mixed with additive in various proportions were tested. Optimal 10% additive added in biodiesel, fuel properties like viscosity reduced by 0.5% and slight improvement in calorific value. Further, little increment in brake thermal efficiency and reduction of 200 ppm in NO emissions. Silvia mironeasaet al. [6] studied physic-chemical, structural characteristics content and quality of grape seed oil. Concluded that higher oil concentration were obtained from the grapes that are grown in warmer climatic conditions. Oil content varies largely from 6.26 to 9.01% accordingly to grape variety and cultivation area. EI Diwaniet. A1[7] proved with results that ozonated vegetable oil (1%by weight) mixed biodiesels in comparison with biodiesel, contained more saturated carbon bonds in weight that that of unsaturated carbon bonds. When biodiesel was mixed with ozonated oil, oxygen content of biodiesel increases and helps in thorough reaction process there by reducing carbon residue . higher with ethanol in a heterogeneous catalytic reaction. Combustion efficiency , high 13heat of enthalpy and reduced emissions of partieulate matter was observed finally ozone treated biodiesel showed better thermal properties and oxidation stability. Murugu mohan kumar ET. A1 [8] on analysis eoneluded that a minimum drop of thermal efficiency, little higher specific fuel consumption was noticed to diesel fuel. This can be attributed to the low ealorifie value of sunflower oil ester. Nilaj. N. Deshmukhet. A1 [9] expressed that usage of biodiesel produced from grains may lead to hike in food grain prices. Essentiality for non-food based Biodiesel and their practicality to fuel diesel engines has been felt. Two different sources of bio-diesel one from food grain source and the other from non-food are combined together in different ratios. Further physical and chemical fuel properties of resulting bio-diesel blend were tested for its suitability to fuel diesel engine. On successful test run of engine with mixed biodiesel it was found that engine performance was nearer to neat diesel with higher exhaust temperatures. Ayhan Demarrias [10] detailed that alternate fuels are gaining significance toward their usage as fuel for diesel engines with decreasing petroleum reserves and also environmental coneem are making these renewable fuel more attractive and fuel of future.

Biodiesel was produced from Tran's esterification process from both edible and non-edible sources thus produced fuel was producing nearly same brake thermal efficiency and lower emissions compared to diesel fuel to run diesel engines. A. A. Refaatet A1. [11] intention were to look for the possibility of conversion of waste vegetable oils into biodiesel to cut down production costs of biodiesel and to curb pollution caused by waste vegetable oils. Trans esterification was done on three vegetable oils one with neat vegetable oil, second with domestic waste vegetable oil and third being restaurant vegetable oil. Yield percentage was more with neat vegetable oil, least with restaurant. Waste vegetable oil.

Maximum yield percentage was obtained with methanol oil molar ratio of 6:1 in the presence of catalyst potassium hydroxide (1%) maintaining process temperature at 650C for a period of one hour. m 14 savarirajet. A1 . [12] conducted test on four-stroke single cylinder biodiesel engine with mahua biodiesel and also mahua biodiesel blended in different ratio's with diesel. Test result analysis show that brake thermal efficiency decrease sand specific fuel consumption increases at all loads as the mahua biodiesel proportion increases in diesel. Reduction in brake thermal efficiency was only 14.3% with B100at full load. With increase in quantity of mahua biodiesel in diesel, exhaust gas temperature decreases but smoke, NO and CO emissions increased at all loads. Morvarid Yousef ET. A1 [13] investigation for physici-chemical properties of two types of shahrodi grape seed oils (Lal and khalili) extracted by using soxhlet method and petroleum ether as solvent their responsible variable such as fatty acid, peroxide value, soapy number, acidity, etc. were considered. Linoleic acid fatty acid content was nearly equal to 65.39% of all
fatty acids which gives oxidation reaction resistance concluded that Lal variety was better than khalili for their oil content and for low peroxide value. Agarry, S.E ET. A1 [14] evaluated the citrus seed (orange grape, tangerine) oils for production of biodiesel. Transesterifieation process was carried out on the oils with ethanol and catalyst potassium hydroxide for producing fatty acid alkyl esters. Best yield of 90.6% was possible with grape seed oil compared to other two citrus seed oils. Fuel properties of all the three oils were evaluated. On analysis concluded that citrus seed oils can be used as biodiesel blended with petroleum diesel J.K. Heydrzaehet. A1 [15] describes an alternative energy for the replacement off fossil fuels has been developed biodiesel synthesis as a renewable energy was derived in a continuous packed column reactor. Free fatty acids (FFA)were esterified

3. MATERIAL AND METHODS

Component

* Custard apple seeds

* Methanol

* Potassium hydroxide catalyst

3.2 Extraction of oil

The extraction of oil from custard apple seeds was done by using mechanical expeller and solvent extraction by soxhlet apparatus using methanol as solvent. Soxhlet extraction(laboratory scale):To find out oil content of custard apple seeds.

1. 50 grams of fully ripened custard apple seeds crushed and taken in the testing set up
2. 150 grams methanol taken in the round bottom flask as solvent.
3. Kept reaction at 65^{0}C for number of cycles.
4. Methanol recovered by retaining oil roof bottom flask.
5. Oil in the flask transferred to measuring beaker and measure.
6. The quantity F oil obtained to 1 kg of seeds roughly.

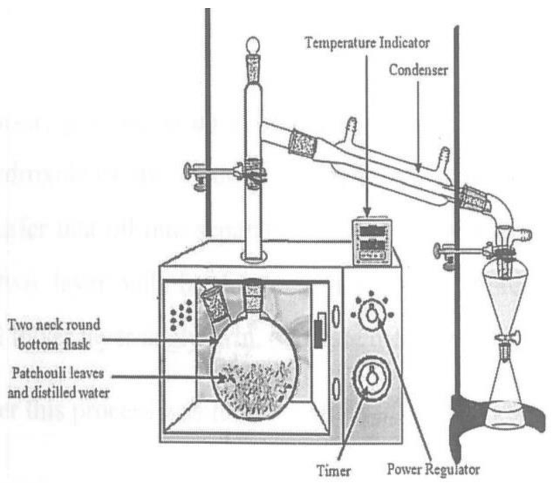


Fig.3.1 Experimental setup

3.3 Mechanical Expeller (production scale):

1. Seed are crushed using mechanical expeller to get oil. (mechanical expeller is of capacity 30kg /hr., 3passes).

2. For a batch 5kg of seeds are taken to crush, each of seeds 5 times to obtain complete oil.

3. Oil obtained was collected in glass reagent container by filtering it with filter

4. Filtered oil left for 10-12hrs for settling of minute dust particle.

5. After filter and settling, oil stored in a reagent glass bottles.

Fig.3.2 custard apple seeds

3.4 Trans esterification

Procedure: Take 1 lit of custard apple seeds oil in a three neck flask with reflux condenser, heat the oil up to 60^0C add 300ml of methanol and 10gms of potassium hydroxide catalyst. Run the process for about 90 minute as shown in fig-1 Transfer that oil into separating funnel, allow it to settle for about 7-8 hours then two layer will be forms as shown in fig -3.3 upper layer is biodiesel and lower layer is glycerin. Separate the glycerin and biodiesel.

The yield after this process was found to be 88-90% of biodiesel. (850-900ml)

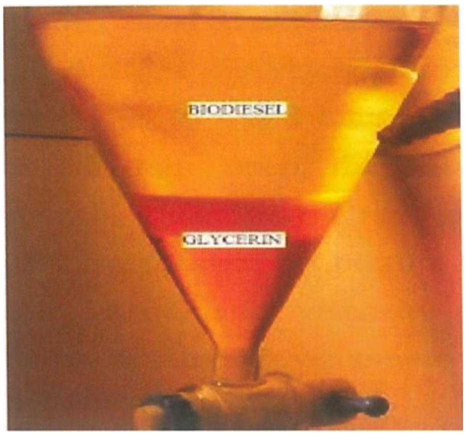
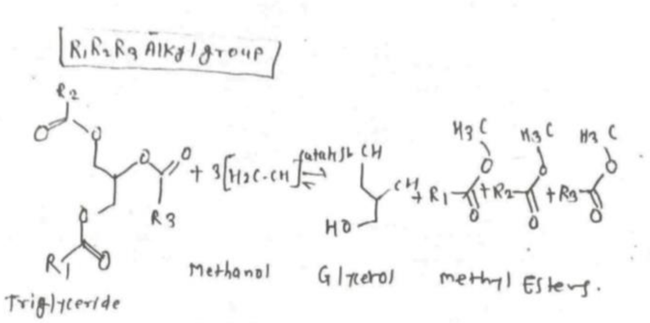


Fig.3.3 Separation of two layers



Reaction

3.5 Determination of physiochemical properties

3.5.1 Viscosity:

Kinematic viscosity is the resistance offered by one layer of fluid over another layer. The viscosity is important in determining optimum handling storage, and operational condition. Fuel must have suitable flow characteristics to ensure that an adequate supply reaches injection at different operating temperatures. High viscosity can cause fuel flow problems and lead to stall out.

Procedure: Fill the biodiesel n the canon fenske viscometer [tube no 100, direct type] bulb as shown in fig 3.4 insert the viscometer tube in the viscometer water bath apparatus. Heat the oil to 40^0C and maintain the temperature for a period of 20-30 min. after 30 min open the tube, suck the oil and simultaneously start the stopwatch when the oil reaches starting point mark. Stop the stopwatch once the oil flow reaches the bottom marks in centistokes (CST) (Number of second standard factor of the bulb viscometer used for testing)

Fig.3.4 Kinematic viscosity bath

3.5.2 Density:

A hydrometer is the instrument used to measure the specific gravity (relative density) of biodiesel. That is the ratio of density of water. The hydrometer is made up glass and consists of a cylindrical steam and bulb weighed with mercury or lead shot to make it float upright. The hydrometer contains a paper scale inside the steam, so that the specific gravity can be read directly.

Procedure: Measure 500ml of the biodiesel in a clean & dry measuring cylinder. allow the biodiesel to settle. Gently lower the hydrometer in to the biodiesel in the cylinder until its floats freely. Note the point at which the surface of the biodiesel touches the steam of the hydrometer. Reading will be specific
Gravity multiplied by thousand will give density.

3.5.3 Flash point

The lowest at which the vapors of a combustible liquid can be made to ignite momentarily in the air is identified as flash point and correlates to ignitibility of fuel. Low flash point can indicate residual methanol remaining from the conversion process. The flash point is often used as a descriptive characteristics of liquid fuel and it is also used to characterize the hazards of liquid. ”flash point” refers to both flammable liquid and combustible liquid.

Procedure: Pour measured biodiesel up to the mark indicated in the flash point apparatus, heat the oil & stir the oil at regular interval. Introduce external firenear the opening provided in the apparatus at regular period till a flash is observed. Once the flash is observed note the temperature. The noted temperature at the time of flash is the flash point of biodiesel. The setup used for finding out flash point is as shown in fig 3.5

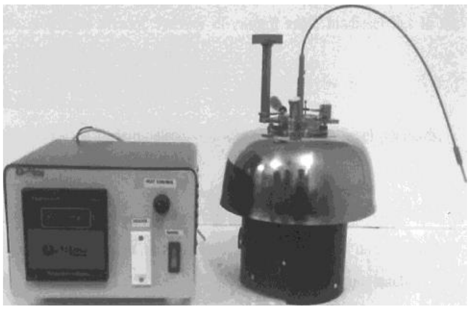


Fig.3.5 Penske martin flash point instrument

4. RESULT AND DISCUSSIONS

The percentage composition of free fatty acids present in custard apple seed oil was obtained by gas chromatographic analysis and is represented in table-2. In gas chromatography result table we can see that the oleic acid (39.72%) is the major constituents. The following physical properties listed of biodiesel produced were determined and compared with ASTM biodiesel standards values and commercially available diesel and the result are represented in table 4.1

4.1 Viscosity

Among the general parameter for biodiesel for the viscosity control the characteristics of the injection from the diesel. Viscosity value of custard apple biodiesel is in engine range of ASTM biodiesel standards.

4.2 Density

Higher densities of custard apple biodiesel as compared to commercially available diesel may be attributed to the higher molecular weight and triglyceride molecules present. Density of custard apple biodiesel lies in the range of ASTM biodiesel standards.

4.3 Flash point

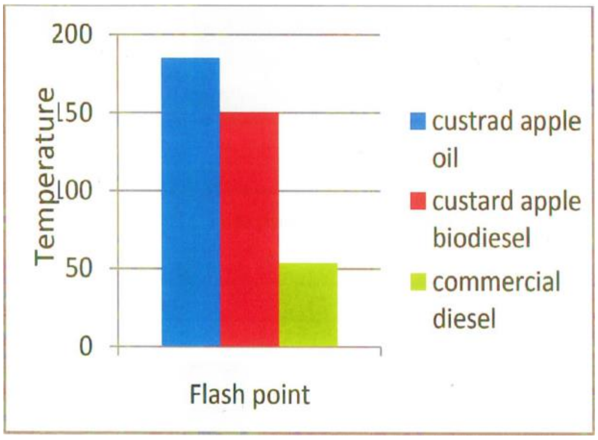
Flash point of custard apple biodiesel is nearer to ASTM biodiesel standards.

4.4 Calorific value

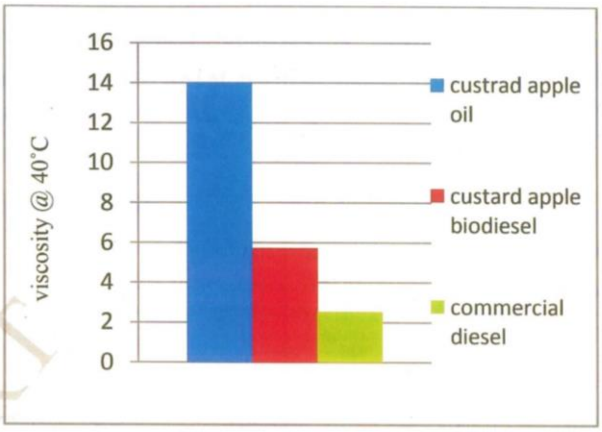
The calorific value is the energy released in the form of heat when a hydrocarbon undergoes complete combustion with oxygen under standards conditions. The chemical reaction is typically a hydrocarbon reaction with oxygen to form carbon dioxide, water and heat. The obtained calorific value is in range of ASTM biodiesel standards.

4.5 Graphs

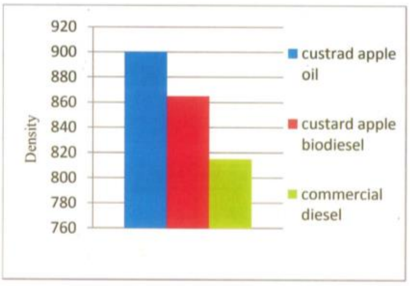
Below mentioned graphs, 1, 2 & 3 shows comparison of flash point viscosity and density for custard apple seed oil, custard apple biodiesel and commercial diesel.



Graph 4.1 flash Point Comparison



Graph 4.2 Comparison Of Viscosity @40^0C



Graph 4.3 Comparison Of Density

4.1 The physiochemical properties of custard apple biodiesel comparison with the ASTM biodiesel standards and commercially available diesel.

	PROPERTIES	UNITS	EXPERIMENTAL VALUES			
			BIODIESEL	BIODIESEL STANDARD VALUE(ASTM)	COMMERCIALLY AVAILABLE DIESEL	PROTOCALL
1	Kinematic Viscosity@40 C	Centistokes	5.712	1.9-6.0	2.54	ASTM D445
2	Density	Kg/m	865	870-900	820	ASTM D4052
3	Flash point	^{0}C	150	130	54	ASTM D93
4	Calorific point	KJ/kg k	37510.8	37000to 42500	43500	ASTM D240
5	Cloud point	^{0}C	2	-3 to 12	-28 to -7	ASTM D2500
6	Pour point	^{0}C	5	-15 to 10	5.6 to11.1	ASTM D97
7	Ash content	%w/w	0.02		0.02max	ASTM D482
8	Carbon residue	%w/w	Nil		0.05max	ASTM D524

4.2 The fatty acid composition of custard apple seed oil by gas chromatography

SR. NO	PARAMETER	RESULTS
1	Caproic acid	Nil
2	Caprillic acid	Nil
3	Capric acid	Nil
4	Lauric acid	0.08%
5	Myristic acid	Nil
6	Palmitic acid	17.79%
7	Stearic acid	4.29%

8	Oleic acid	39.72%
9	Linoleic acid	29.13%
10	Linolenic acid	1.37%
11	achidonic acid	1.06%
12	noceric acid	Nil

5. MATERIAL BALANCE

Material balance of the process wherein chemical reaction takes place are very important from the design point of view of chemical equipment. The material balance calculation gives information regarding material entering leaving accumulate or displeased during unit operation.

The basis of material balance calculation is the low conservation of mass it state that the total mass of various component involved remains constant during a unit operation and unit process.

For 50 grams seeds-13 ml of oil obtained for 30 cycles (for custard apple seeds, 1 cycle time =5 min 36 sec)

1000gram of seed =260ml oil. The percentage of oil obtained is 26%

Table-5.1 Comparison of oil extraction [Between mechanical and chemical]

Quantity	Type of extraction	
	Mechanical Expeller	Soxhlet extraction
1 kg of seeds	180-200 ml of oil	250-260 ml of oil

6. COST ESTIMATION

Table no.6.1 Cost Estimation

SR.NO	COMPONENT	COST
1	Storage facilities	30360
2	Oil storage plant	1320
3	Biodiesel storage plant	3000
4	Lording /Unloading station	1320
5	Crude glycerol storage tank	26820
	subtotal	62820
II	Process Equipment	
1	Methanol storage tank	1440
2	Sodium met oxide	1500
3	Methanol mixer	420
4	Reactor preheater	540
5	Glycerol biodiesel separator	18900
6	Biodiesel wash tank	2100
7	Biodiesel was water separator	19680
8	Biodiesel final water removal heater	120
9	Biodiesel final water removal vacuum system	4500
10	Methanol distillation tower preheater	240
11	Methanol distillation tower	5700
12	Distillation re-boiler	300
13	Fatty acid storage tank	600
14	Glycerol distillation tank	960

5.PLANT LAYOUT

The layout means the arrangement of various machine work area transporting and process of manufacturing different parts in the best possible manner. It can be defined as locating different machine and plant service with in factory so that the greatest possible of quality.

At the lowest possible total cost could be obtained. The main aim of layout is a mentioned below:

1. The layout should be such that it should be give better quality product.
2. There should be maximum utilization of floor area so that internal trans sport cost can be reduced to minimum 0.
3. There should be proper lighting facility.
4. The layout should be such that there should be least chance of accident.

5. There should be least wastage.
6. It should have better working condition for worker and supervisory staff.
7. The neatness in layout bring down the per unit cost of production.
8. The speed of production can be achieved if the layout is proper.

PRINCIPLE OF PLANT LAYOUT :-

1. There should an overall iteration of main material machinery money and other supporting activity.
2. The distance between the various operating units should be minimum.
3. The best layout is one which arranges the work area for each operation in the same order that forms terms treats the material.
4. Layout should be such that it utilize in the best possible manner the space both vertical and horizontal.
5. The layout should be such that it takes there best eare of workers and makes their work pleasant.
6. The layout should be rearranged at the minimum cost and the least in comvince.

CONCLUSION

By observing all result of biodiesel from custard apple seed oil, custard apple seed can be used as biodiesel feed stock. All the properties are in the range of ASTM biodiesel standards, this can be promising factor to use custard apple seed as one of the biodiesel source.

The percentage yield of biodiesel is more in custard apple oil compared to karanja and mauhu oil. The flash point of each biodiesel is high, hence advantage for fuel transportation. The cloud point of custard apple biodiesel is less than biodiesels of karanja and mauha, hence it may cause less problems in start of engine in cold climates the kinematic viscosity, flash point and density of produ ced biodiesel is high compared to conventional diesel. Hence the biodiesel are blended with diesel in required proportions to reduce the fuel properties to conventional diesel range from the performance study (BTE, BSFC,EGT v/s BP), IT shows that custard apple biodiesel and its blends with diesel can achieve similar and close performance curves like diesel most of the exhaust emissions such as CO, CO_2 and HC are reduced with the use of custard apply biodiesel and its blend.

The above work involves the production of biodiesel from the seeds of the custard apple. The vegetable oil was extracted from the seed which wax processed for diesel extraction. The crude oil obtained was further purified using various techniques and the final product was analyzed. The pure diesel was analyzed for its viscosity, pour point, Specific gravity, flash point, ash content, and colour. All the properties were further compared with standard ASTM values and commercial diesel values. It was found that all these parameters were within the standard range and comparable to the commercial diesel. Thus this procedure can be followed with several other vegetable products to obtain the renewable diesel.

FUTURE SCOPE

In 2000, biodiesel become only alternative fuel in the country to have successfully completed the EPA-required Tier I and Tier II health effects testing under the clean air act. This independent test conclusively demonstrated biodiesel significant radiation of virtually all regulated emission, and showed biodiesel does not pose a threat to human health. Biodiesel contains virtually no sulfur or aromatics, and use of biodiesel in a conventional diesel engine result in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter. A.U.S. Department of energy study showed that the production and use of biodiesel, compared to petroleum diesel, resulted in a 78.5% reduction in carbon dioxide emission. Moreover, biodiesel has a positive energy balance. For every unit of energy needed to produce a gallon of biodiesel, at least 4.5 units of energy are gained.

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