



Wealth from Waste: A Green Method to Produce Biodiesel from Waste Cooking Oil and Generation of Useful Products from Waste Further Generated “A Social Awareness Initiative”

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ABSTRACT

A large amount of waste, be it municipal solid waste (MSW), liquid sewage waste or industrial waste is generated due to human activities. This is expected to increase in the near future due to urbanization and economic development. Waste, if not treated properly, causes severe water, air and soil pollution. In order to reduce the amount of waste disposal increased recycling and waste minimizing initiatives should be taken. The most preferred solution is to reduce the waste at the source or utilize the waste by generating energy. Biodiesel obtained from waste cooking oil is used as a fuel in many countries but the process involves high temperature and pressure and in some cases microwave technology. Our method involves use of principles of Green Chemistry and is done at room temperature and thus saves energy. The oil has been collected from Gargi College canteen and street food vendors. The waste generated from the production of biodiesel is used to make hand wash. Through this project we want to create social awareness and enlighten the general public that cooking oil is not usable after three frying and are harmful to our health. We wish to emphasize that home cooked food is the best. This can be shown by the acid value of the oil after 1st, 2nd and 3rd frying respectively. The waste oil instead of being used as cooking medium can generate revenue if converted into biodiesel and glycerin.

Keywords: Undergraduate research, waste cooking oil, biodiesel, social awareness, Green Chemistry

INTRODUCTION

Gargi College is named after an eminent woman scholar featuring in the Upanishads. One of the biggest tributes which we could pay to this scholar is to encourage critical thinking and a questioning spirit among the young women.

Keeping the legacy of Gargi alive the college encourages holistic education which could inculcate independent thinking.

Gargi College has been encouraging undergraduate research since many years in the form of projects and instituted a “Pathfinder Award” which involves an innovative project having some social relevance. Under this scheme students work for one year and present their work to an expert committee. The present project was awarded the first prize in this competition in 2013-14.

With urbanization, industrialization and advances in science and technology, the quality of life has improved considerably in the last few decades. However most of the tools which are used for the improvement are using energy in one form or in another. This applies to running of household, industries, transport, communication, health care and hospitality. The energy requirement has a direct impact on our fossil fuels and this is being steadily depleted. The need of the hour is to sustain this by using alternative and renewable sources of energy. Some of these upcoming sources of energies are solar, wind, geothermal, hydro etc. All these have inherent advantages and disadvantages. Biodiesel is a good option as a source can be considered to be renewable. It can also be a source of revenue for farmers.

Disposal of waste oil causes aquatic pollution as oil and water are immiscible. Our grandmothers knew an effective method wherein they would mix it with sand or earth and then dispose it with solid waste. Most canteen owners, shops and hotels use the same oil again and again. Some large hotel chains are aware of the damage, but they sell the used oil at reduced rates to roadside vendors.

Linking science with society

A casual survey of street food sellers, school and college canteen workers revealed that they use the same oil over and again. The main reasons are

1 Lack of knowledge about the deteriorating quality of oil which had been used repeatedly.

2 Economic benefits as they have to sell their products at a low rate.

When they were educated and told that if somebody purchased the used oil then would they use fresh oil for every frying then they responded in a positive manner and were excited to know that the oil they used could perhaps run cars (two such responses have been attached at the end).

At present, employing waste and non-edible raw materials is mandatory to comply with the ecological and ethical requirements for biofuels. Biodiesel is a renewable fuel consisting of fatty acid methyl esters (FAME), currently produced from green sources such as vegetable oils, animal fat or waste cooking-oils.

The technical definition of bio-diesel is “the mono alkyl esters of long fatty acids derived from renewable lipid feedstock such as vegetable oils or animal fats for use in compression ignition engines. In simple terms, bio-diesel is a renewable fuel manufactured from alcohol (mostly from methanol or ethanol) and vegetable oil, animal fats and recycled cooking fats. It is often represented as pure fuel (B100).The number in the bracket along with B indicates the percentage of bio-diesel present i.e.100 %.

The most common method to produce bio-diesel is “trans-esterification” which involves altering the chemical properties of the oil using methanol (2, 4). Trans-esterification of oils with methanol is a relatively simple process that yields high conversions with only glycerin as a byproduct. It is manufactured from plant oils (soybean oil, cotton seed oil, canola oil) recycled cooking oils or greases (e.g., yellow grease), or animal fats (beef tallow, pork lard). Because plants produce oils from

sunlight and air, and can do so year after year on cropland, these oils are renewable. Animal fats are produced when the animal consumes plants or animals, and these too are renewable. Used cooking oils are mostly plant based, but may also contain animal fats; they are both recyclable and renewable. Figure 1 provides a simplified diagram of the transesterification process. Roughly speaking, 100 pounds of oil or fat are reacted with 10 pounds of a short-chain alcohol (usually methanol) in the presence of a catalyst (usually sodium hydroxide [NaOH] or potassium hydroxide [KOH]) to form 100 pounds of biodiesel and 10 pounds of glycerin, a coproduct. Many countries have started to make bio diesel from waste cooking oil but they use temperature upto 80°C and/ or pressure. In our process we would be using the principles of Green Chemistry for the synthesis of biodiesel.

The twelve principles of Green Chemistry are:

1. **Prevention:** It is better to prevent waste than to treat or clean up waste afterwards.
2. **Atom Economy:** Design synthetic methods to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Syntheses:** Design synthetic methods to use and generate substances that minimize toxicity to human health and the environment.
4. **Designing Safer Chemicals:** Design chemical products to affect their desired function while minimizing their toxicity.
5. **Safer Solvents and Auxiliaries:** Minimize the use of auxiliary substances wherever possible make them innocuous when used.
6. **Design for Energy Efficiency:** Minimize the energy requirements of chemical processes and conduct synthetic methods at ambient temperature and pressure if possible.
7. **Use of Renewable Feedstocks:** Use renewable raw material or feedstock rather whenever practicable.
8. **Reduce Derivatives:** Minimize or avoid unnecessary derivatization if possible, which requires additional reagents and generate waste.
9. **Catalysis:** Catalytic reagents are superior to stoichiometric reagents.
10. **Design for Degradation:** Design chemical products so they break down into innocuous products that do not persist in the environment.
11. **Real-time Analysis for Pollution Prevention:** Develop analytical methodologies needed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention:** Choose substances and the form of a substance used in a chemical process to minimize the potential for chemical accidents, including releases, explosions, and fires.

We have utilized five of the twelve principles of Green Chemistry.

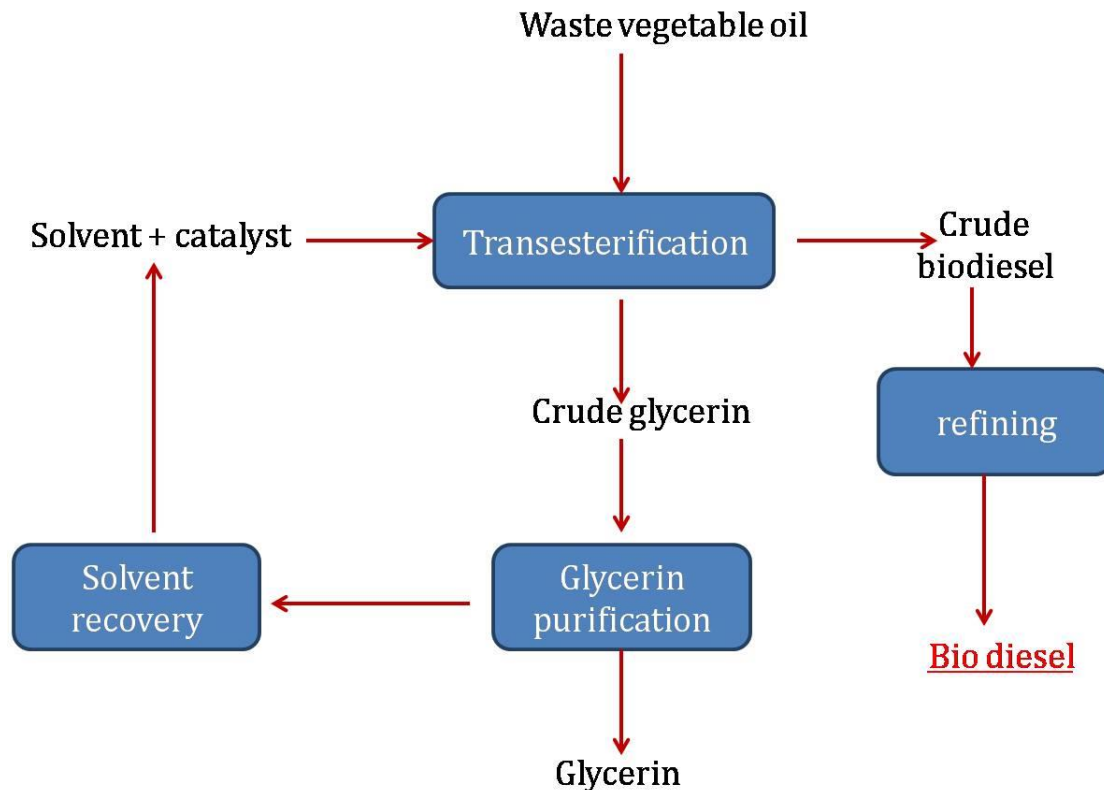


Figure 1: Flow diagram for the production of biodiesel

There are several significant advantages and limitations of using bio-diesel to replace petroleum based diesel.

ADVANTAGES:

1. Bio-diesel can be produced from renewable, domestic resources.
2. Bio-diesel is energy efficient.
3. Bio-diesel can be directly used in most diesel engine applications.
4. Bio-diesel can reduce global warming and tailpipe emissions.
5. Bio-diesel is non-toxic and biodegradable.
6. Bio-diesel is a good solvent and may clean out fuel line and tank sediments.
7. Bio-diesel also creates lower sulphur emissions when it is burnt, which helps to reduce acid rain.
8. Bio-diesel also breaks down more quickly in the environment, thus lessening the severity of accidental spill compared with crude oil.

LIMITATIONS:

1. Bio-diesel contains approximately 8% less energy per gallon.
2. Bio-diesel generally has higher cloud and pour point (will freeze at a higher temperature) than conventional diesel.
3. Bio-diesel is not compatible with some hose and gasket materials, which may cause them to soften, degrade and rupture.
4. Bio-diesel is not compatible with some metals and plastics.
5. Bio-diesel may increase nitrogen oxide emissions.

The most common method used to overcome the limitations of B100 (pure bio-diesel) is called “blending”. Blending biodiesel with diesel to produce B20 (20% bio-diesel), B5 (5% bio-diesel) and B1 (1% bio-diesel) retains many of the advantages of bio-diesel while overcoming some of its limitations.

METHODOLOGY

Aim of the project: Bio diesel is used as a fuel obtained from waste cooking oil in many countries and it became a big news a few years back when the governor of California drove his SUV which smelled like French fries. Through this project we want to create social awareness and enlighten the general public that cooking oil is not usable after three fryings and becomes harmful to our health. Specifically the project has the following objectives

- Preparation of bio diesel using principles of Green Chemistry from waste cooking oil collected from Gargi College canteen and road side vendors.
- To determine the acid number of the oil after repeated fryings
- To utilize the waste of the trans-esterification for the production of useful items
- To create social awareness to the general public and road side vendors.

Experimental Work

The project has been divided into four parts

Part 1: Preparation of biodiesel from various waste cooking oils using principle of Green Chemistry

Chemical Concept: Biofuels, transesterification reaction, combustion

Green Chemistry Concept: renewable resources and sustainable energy systems

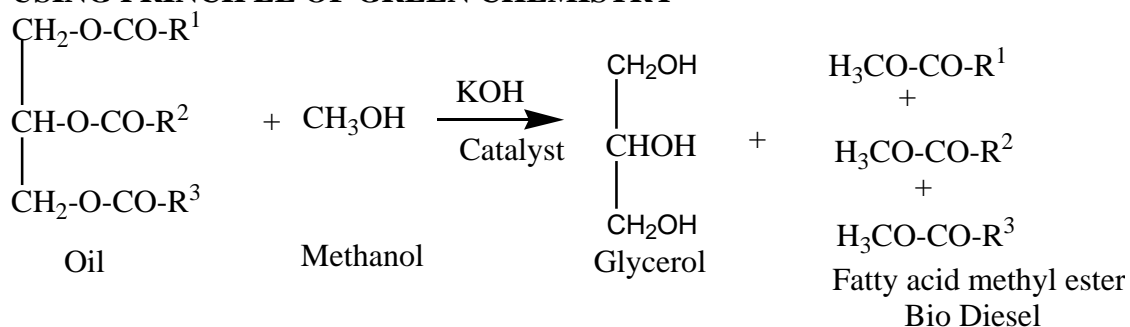
Green Chemistry Principles: Less hazardous chemical synthesis, design for energy efficiency, use of renewable feed stock, safer chemistry.

Part 2: Determination of acid value of cooking oil after repeated heating

Part 3: Production of useful product from the waste of the reaction

Part 4: Social implications of the project

Part 1: PREPARATION OF BIO-DIESEL FROM VARIOUS COOKING OIL USING PRINCIPLE OF GREEN CHEMISTRY



Chemical reaction for the conversion of oil into biodiesel

METHOD 1:

Chemicals and Equipment:

Vegetable oil

Methanol

10M KOH

Round bottom flask

Magnetic stirrer and stirring bar

Centrifuge machine

PROCEDURE: In a clean, dry round bottom flask 100 cm³ of waste oil (filtered through very fine sieve), 20 cm³ of methanol and 4 cm³ of 10M KOH was added. The contents of the round bottomed flask were stirred for about 20-25 minutes using magnetic stirrer. The reaction mixture was then transferred to a centrifuge tube and

centrifugation of this mixture was carried out for about 5 minutes. After centrifugation, two clearly separated layers were formed. The above layer was of bio-diesel which was carefully separated by using a dropper and the lower layer was of glycerol and KOH. Biodiesel was dried over Na_2SO_4 . The lower layer was kept for the conversion into useful by product (1)

YIELD

82 cm^3 of bio-diesel,

% yield= 82 % (volume by volume)

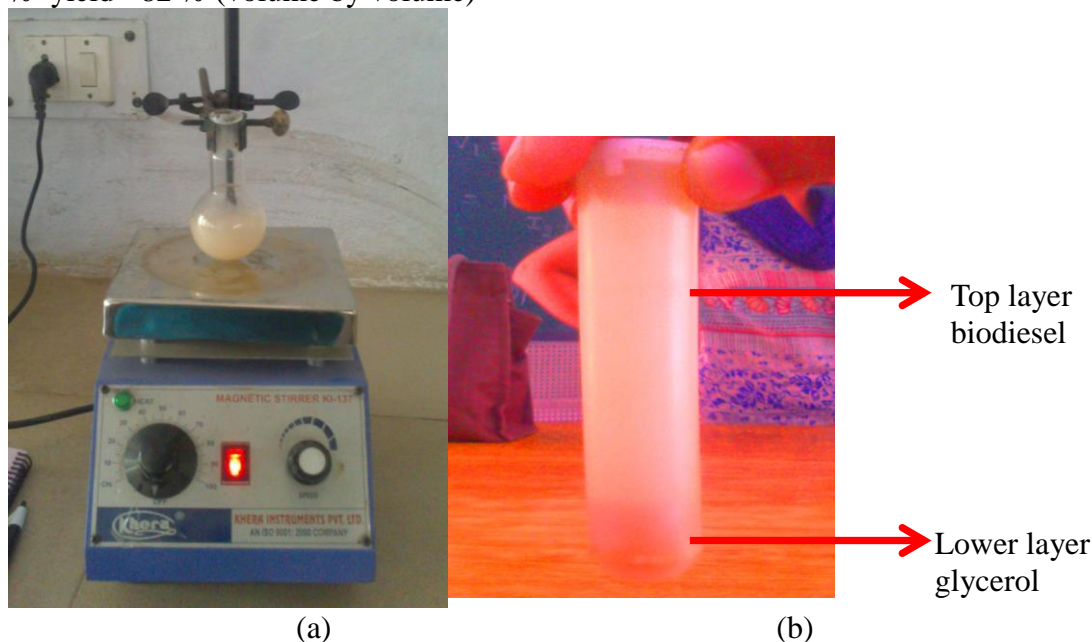


Figure 2: (a) Experimental set up for the preparation of biodiesel (b) two distinct layer after centrifugation



Figure 3: Separation of two distant layer of biodiesel and glycerol

Alternative method by using solid catalyst

50 cm^3 of fresh oil was taken in a round bottomed flask followed by addition of 10 cm^3 of methanol and 0.5 g of NaOH (solid). The contents were stirred using a magnetic stirrer for about 20-25 minutes after which they were allowed to settle down for few minutes. Two unclear layers were formed after sometime. The contents of the flask were then transferred to centrifuge tube and their centrifugation was carried out

for about 5 minutes. After centrifugation, two separate layers were formed but distinguishing them was difficult due to lack of clarity.

YIELD

50 cm³ of fresh oil gave 18 cm³ of bio-diesel,

% yield = 36 %

Colour of the product was pale yellow.

The first method gave a pure product and there were two distinct layers in many cases there was no need to purify the product. The alternative method was not used as the product was not pure. After standardization of the procedure for the production of biodiesel, following oils were chosen.

Table 1: Comparison of bio-diesel produced from different types of oil

S. No	Oil Sample	Starting Amount cm ³	Biodiesel Produced cm ³
1	Fresh Oil	50.0	48
2	Oil left after 1st heating	50.0	46
3	Oil left after 2nd heating	50.0	46
4	Oil left after 3rd heating	50.0	46
5	Oil from local restaurant	50.0	40

Characterization of Bio diesel

1 **Thin layer Chromatography:** TLC of synthesized bio diesel showed single spot indicating complete conversion of oil into biodiesel.

Adsorbent: Alumina

Mobile phase: Acetone: Toluene: 5 M NH₄OH:: 8.5:5:1

Visualization agent: UV lamp

R_f = 0.6

2 **pH:** The pH was checked with pH paper and was found to be 7, which indicates that biodiesel is sufficiently pure.

3 **Solubility:** Clear solution was obtained on dissolving biodiesel in methanol.



Figure 4 Solution of biodiesel in methanol

4 **Visibility:** After work up the two layers of bio-diesel and glycerol were clearly distinct. This is shown in Fig 2b.

5 **Combustion Test:** 2 cm³ (approx 1.74 g) of sample was combusted by using cotton wick. It took 9 min for the complete combustion. Residual mass of the biodiesel was 2.097 g after combustion.

7 **Density:** The density of bio diesel was determined by taking mass of known volume of it. The observed density of bio diesel was found to be 0.8708 g/cm³ (5).

8 **Viscosity:** Absolute viscosity of bio diesel was determined by using Ostwald viscometer and was found to be 6.314 cp (6.314 x 10⁻² g/cm s) at 22°C. The kinematic viscosity was calculated by taking the ratio of absolute viscosity and density and was

found to be $7.25 \text{ mm}^2/\text{s}$. The literature value for kinematic viscosity at 20°C , 25°C and 40°C is 7.83, 6.85 and 5.21 respectively (6, 7).

9 **Freezing point:** Biodiesel is reported to be a gel at low temperature. The sample prepared was placed in a freezer and it was found to form gel within 15 min. This shows that the biodiesel prepared is not contaminated from any impurity of solvent.



Figure 5 (a)



(b)

(a) Gel formation at low temperature

(b) melting of biodiesel after removal from freezer.

9 **IR spectroscopy:** The triglyceride is converted by transesterification into the glycerol and diverse FAME. The IR spectrum (neat oil) of biodiesel was recorded in the range of 4000 to 600 cm^{-1} . Figure 6 displays the IR spectrum of the bio diesel obtained from the waste cooking oil. The ester carbonyl group stretching vibration at 1740 cm^{-1} is shown by strong bands, esteric $-\text{COC}$ vibration at 1171 and 1207 cm^{-1} reveals medium intensity bands, and the presence of the $(\text{CH}_2)_n$ group vibration band is seen at 724 cm^{-1} . The observed band at the $2500\text{-}3300 \text{ cm}^{-1}$ region is because of moisture and free acids in the oil. The peak at 1458 cm^{-1} is due to O-CH_3 group.

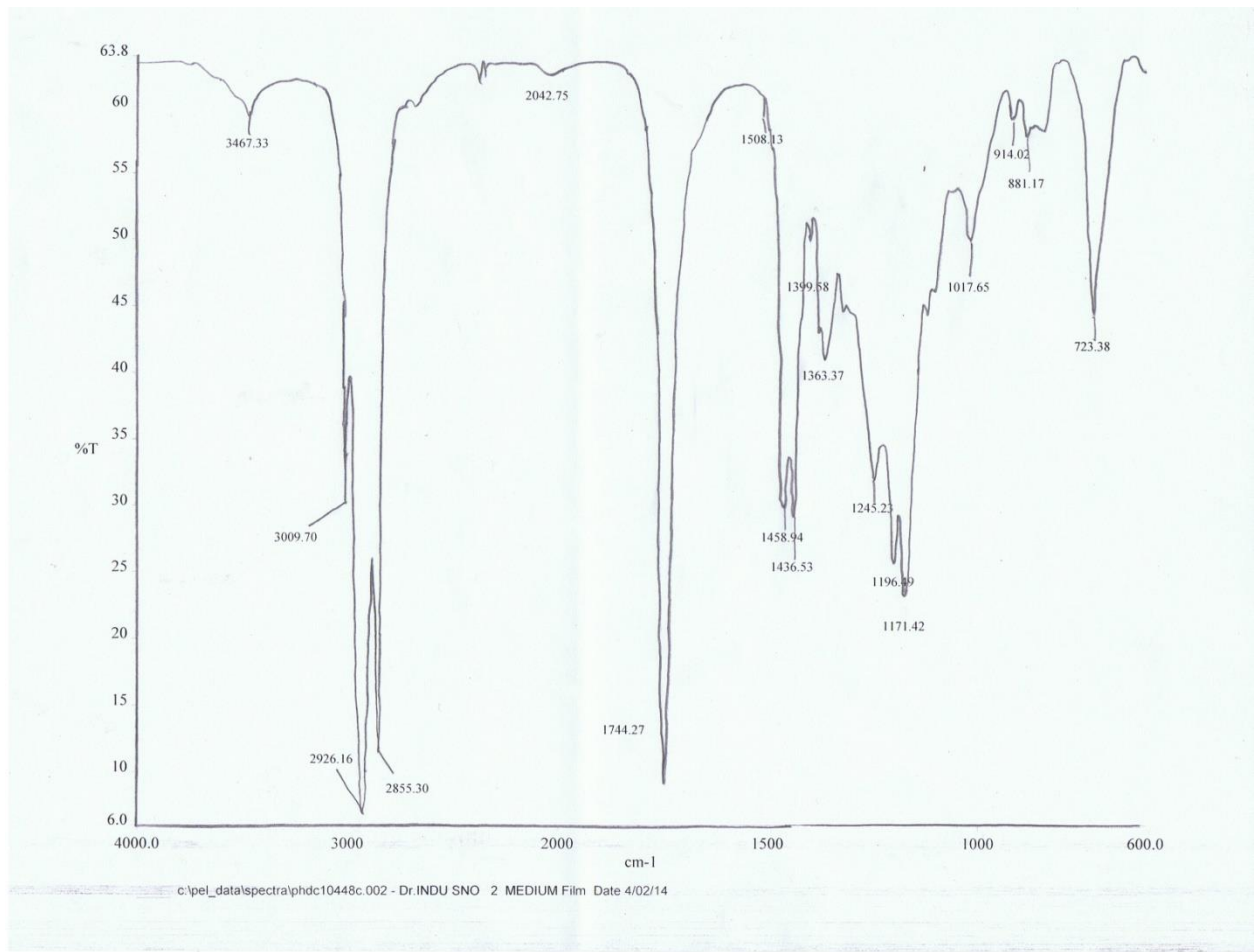


Figure 6: IR spectrum of Bio-diesel prepared by us

Disposal: After the reaction we stored the biodiesel in a glass bottle and the waste of the reaction has been stored in separate container.

Purification of waste generated glycerol

Technique Employed: Column chromatography

Adsorbent: Slurry of neutral alumina in hexane

Eluent: Methanol

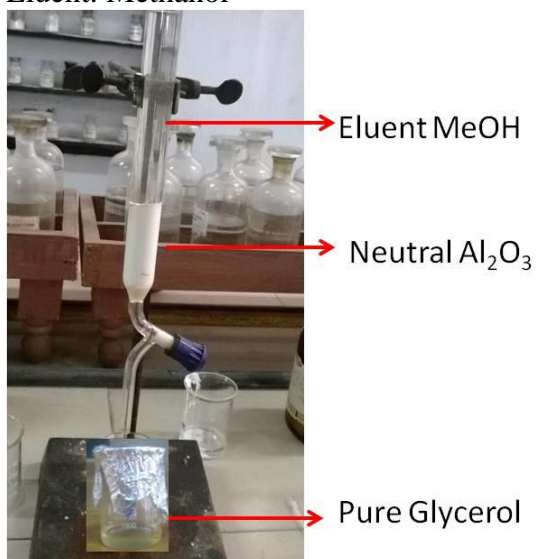


Figure 7: Column chromatography to purify glycerol

After purification, this glycerin was used to prepare a hand wash.

PART 2 DETERMINATION OF ACID VALUE OF USED COOKING OIL

Acid Value: Acid value (or neutralisation number or acid number or acidity) is the mass of potassium hydroxide (KOH) in milligrams that is required to neutralize one gram of oil, fat etc. It is a measure of amount of free acid present in a chemical compound, such as fatty acid, or in a mixture of compounds. As the glycerides in fat slowly decomposes, the acid value of oil increases. Therefore, acid value is a common parameter for the specification of oil. The maximum acid value of edible oil could be up to 1mg KOH/gm of oil.

Significance of Acid Value of Oil: The acid value which is an indirect measure of the amount of free acids present in fats and oils. The higher the amount of acid value, the greater is the deterioration or rancidity of the oils and fats. As the rancidity increases, the oil achieves a foul smell along with a sour taste. The cause for rancidity is the hydrolytic or oxidative cleavage of triglycerides causing the formation of free fatty acids in oils or fats. Acid value is an important indicator of vegetable oil quality. As oil become rancid, triglycerides are converted into fatty acids and glycerol, causing an increase in acid number.

CAUSES FOR THE ACCUMULATION OF ACIDS IN OIL:

- Oxidation processes
- When subjected to prolonged high temperature (ester thermolysis)
- Through exposure to acids or bases (acid /base ester hydrolysis)

Oil	Canola	Maize	Soya	Virgin Olive oil	Used Frying oil	Bee's wax
Acid Value	0.071	0.223	0.60	6.6	31	17-36

HARMFUL EFFECTS OF RANCID OIL:

- Damage animal cells
- Deteriorates nutritive value of food and cause health issues
- Impact on flavour, odour and appearance
- They are not metabolized so they are stored in low density lipids which lead to artery disease, heart attacks and strokes.

PRESERVATION OF OIL

- Add antioxidant (like α - and δ -tocopherol, citric acid, ascorbic acid and ascorbylpalmitate) they inhibit oxidation by reacting with free radicals thus blocking the formation of fatty acid radicals and terminating the chain reaction.
- Store oil at low temperature
- Deacidification of oil: using silica gel as an adsorbent by applying filtration and stirring methods.

DETERMINATION OF ACID VALUE OF VARIOUS OILS

MATERIALS AND METHODS

Materials

- vegetable oil (fortune soyabean oil)
 - (a) fresh oil
 - (b) used oil
- methanol
- potassium hydroxide (KOH)
- HCl
- Oxalic acid solution
- Phenolphthalein

- Alcoholic KOH
- Sodium hydroxide (NaOH)

Solution Used

0.5 N Oxalic acid

0.5 N NaOH

0.5 N HCl

0.5 N alc KOH

PRINCIPLE

To find the concentration of the fatty acids present in the waste cooking oil, oil was made to react with excess of alc. KOH. The acid present in the oil sample gets neutralized by alkali and the remaining KOH was titrated with standardized HCl. A blank titration was also done by taking the known volume of KOH and titrated with standardized HCl. The difference in volume is used to calculate the acid value of oil sample. To calculate the acid value of the used cooking oil, various titrations were carried out using following waste cooking oils:

- After 1st heating
- Cooling and heating 2nd time
- Cooling and heating 3rd time
- Gargi College canteen oil which had been used several times

PROCEDURE

0.5N standard oxalic acid was prepared by dissolving 3.1500 g of oxalic acid in 100 cm³ of water and this was used to standardize the NaOH solution which was further used to standardize the HCl solution.

0.5N alc. KOH was then prepared by dissolving 2.8000 g of solid KOH in 100 cm³ of alcohol. This KOH was titrated against HCl solution to determine the volume of HCl actually required to neutralizing 10 cm³ of alc. KOH.

Then, 1g of waste cooking oil (Gargi College canteen oil) was allowed to react with 10 cm³ alc. KOH. The free fatty acids present in oil sample got converted into esters by the alc. KOH and the excess KOH solution was determined by titrating it with standardized HCl. The following four types of oils are used for determination of acid value.

- 1 Gargi College canteen oil
- 2 Sunflower oil
- 3 Soyabean oil
- 4 Oil collected from some local restaurant

1 Determination of acid value of Gargi College canteen oil

Titration Tables

Table 1.1. Titration of standard oxalic acid vs. NaOH

Indicator used – phenolphthalein

End point – colorless to pink

Volume of oxalic acid pipetted out = 10cm³

S.No.	Burette readings		Volume of NaOH used (cm ³)
	Initial	Final	
1.	20.0	28.0	8.0
2.	20.0	28.0	8.0
3.	20.0	28.0	8.0

Normality-volume relationship between oxalic acid and NaOH:

$$NV (\text{oxalic acid}) = NV (\text{NaOH})$$

$$0.5N \times 10 = N \times 8.0$$

$$N (\text{NaOH}) = 0.5 \times 10 / 8.0$$

$$N (\text{NaOH}) = 0.625 N$$

Table 1.2. Titration of NaOH vs. HCl

Indicator used – phenolphthalein

End point – pink to colorless

Volume of NaOH pipetted out = 10cm³

S.No.	Burette readings		Volume of HCl used (cm ³ .)
	Initial	Final	
1.	20.0	34.0	14.0
2.	20.0	34.0	14.0
3.	20.0	34.0	14.0

Normality-volume relationship between NaOH and HCl :

$$NV (\text{NaOH}) = NV (\text{HCl})$$

$$0.625N \times 10 = N (\text{HCl}) \times 14$$

$$N (\text{HCl}) = 0.625 \times 10/14$$

$$N (\text{HCl}) = 0.4460 N$$

Table 1.3. Titration of (1g oil + alc. KOH) vs. HCl

Indicator used – phenolphthalein

End point – pink to colorless

Volume of alc. KOH pipetted out = 10cm³

Sample	Initial Reading	Final Reading	Volume used (cm ³)
Blank	20.0	34.6	14.6
Oil sample	20.0	31.5	11.5

Volume of HCl used in blank titration = 14.6cm³

Volume of HCl used in oil sample titration = 11.5 cm³

Volume of KOH used up to neutralize the fatty acid present in Gargi College canteen oil = Volume of HCl consumed in blank titration – volume of HCl consumed in oil sample

$$= 14.6 - 11.5 = 3.1\text{cm}^3$$

$$\text{Acid value} = 0.446 \times 3.1 \times 56 = 77.42 \text{ mg KOH/g of oil}$$

2 Determination of acid value sunflower oil (Fresh and after repeated heating)

Table 2.1. Titration of oxalic acid vs. NaOH

Indicator used – phenolphthalein

End point – colorless to pink

Volume of oxalic acid pipetted out = 10cm³

S.No.	Burette readings		Volume of NaOH used (cm ³ .)
	Initial	Final	
1.	20.0	25.5	5.5
2.	20.0	25.5	5.5
3.	20.0	25.5	5.5

Normality-volume between oxalic acid and NaOH :

$$NV (\text{oxalic acid}) = NV (\text{NaOH})$$

$$\text{Normality of Standard oxalic acid} = 0.05 \text{ N}$$

$$0.05\text{N} \times 10 = \text{N} (\text{NaOH}) \times 5.5$$

$$\text{N} (\text{NaOH}) = 0.05 \times 10/5.5$$

$$\text{N} (\text{NaOH}) = 0.09 \text{ N}$$

Table 2.2. Titration of NaOH vs. HCl

Indicator used – phenolphthalein

End point – pink to colorless

Volume of NaOH pipetted out = 10cm³

S.No.	Burette readings		Volume of HCl used (cm ³)
	Initial	Final	
1.	20.0	28.5	8.5
2.	20.0	28.5	8.5
3.	20.0	28.5	8.5

Normality-volume relationship between NaOH and HCl :

$$NV (\text{NaOH}) = NV (\text{HCl})$$

$$0.09 \times 10 = \text{N} (\text{HCl}) \times 2.5$$

$$\text{N} (\text{HCl}) = 0.09 \times 10/2.5$$

$$\text{N} (\text{HCl}) = 0.36 \text{ N}$$

Table 2.3. Titration of (1g oil + alcoholic KOH) vs. HCl

Indicator used – Phenolphthalein

End point – pink to colorless

Volume of alc. KOH pipetted out = 10cm³.

	Burette readings		Volume of HCl used (cm ³ .)
	Initial	Final	
Blank	20.0	28.5	8.5
1 st usage	20.0	28.2	8.2
2 nd usage	20.0	27.8	7.8
3 rd usage	20.0	27.5	7.5

Volume of HCl actually required to neutralize 10cm³ of alc. KOH = 8.5cm³

1st usage oil :

Volume of HCl consumed = 8.2 cm³.

Volume of alc. KOH used up to neutralize the fatty acid present in the oil = 8.5 – 8.2 = 0.3 cm³

Acid value = 0.3 x 0.36 x 56 = 6.048 mg/ 0.5g of oil = 12 mg KOH/g of oil

2nd usage oil :

Volume of HCl consumed = 7.8 cm³.

volume of alc. KOH used up to neutralize the fatty acid present in the oil = 8.5 – 7.8 = 0.7 cm³.

Acid value = 0.7 x 0.36 x 56 = 14.11mg/ 0.5g of oil = 28.2 mg KOH/g of oil

3rd usage oil :

Volume of alc. KOH pipetted out = 10cm³.

Volume of HCl consumed = 7.5 cm³

volume of alc. KOH already used up to neutralize the fatty acid present in the oil = $8.5 - 7.5 = 1.0 \text{ cm}^3$.

Acid value = $1 \times 0.36 \times 56 = 20.16 \text{ mg} / 0.5 \text{ g of oil} = 40.2 \text{ mg KOH/g of oil}$

Table 3: Determination of acid value Soyabean oil and oil from local restaurant

Oil Sample	Initial	Final	Volume Used cm^3
Blank	20.0	29.4	9.4
Fresh oil	20.0	29.3	9.3
Ist Usage	20.0	29.1	9.1
2 nd usage	20.0	28.8	8.8
3 rd Usage	20.0	28.5	8.5
Local Restaurant	20.0	28.0	8.0

Using the same calculations

Acid value of fresh oil = $0.1 \times 56 \times 0.51 = 2.856 \text{ mg KOH/g of oil}$

Acid value of Ist Usage = $0.3 \times 56 \times 0.51 = 8.568 \text{ mg KOH/g of oil}$

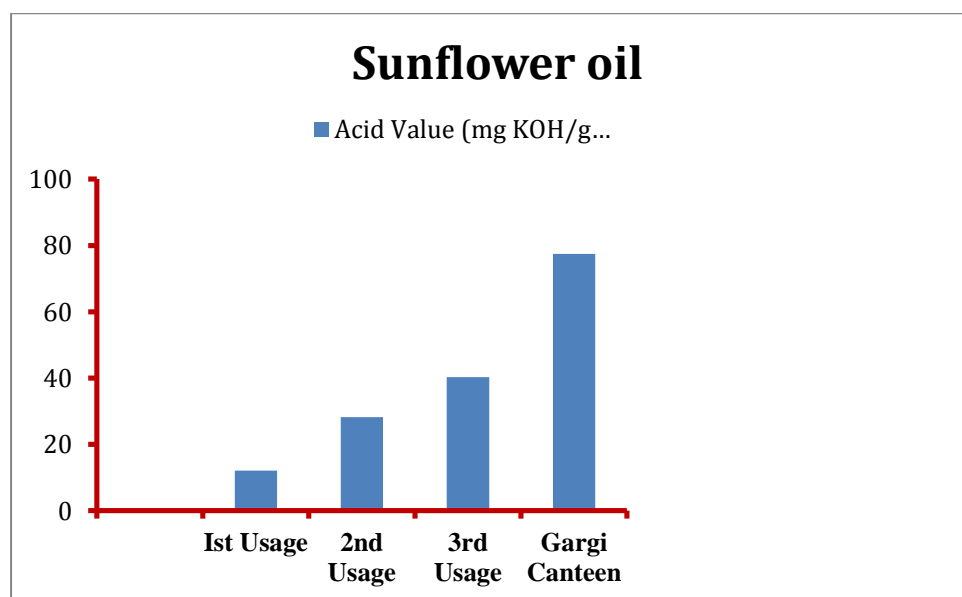
Acid Value of 2nd usage = $0.6 \times 56 \times 0.51 = 17.136 \text{ mg KOH/g of oil}$

Acid value of 3rd usage = $0.9 \times 56 \times 0.51 = 25.704 \text{ mg KOH/g of oil}$

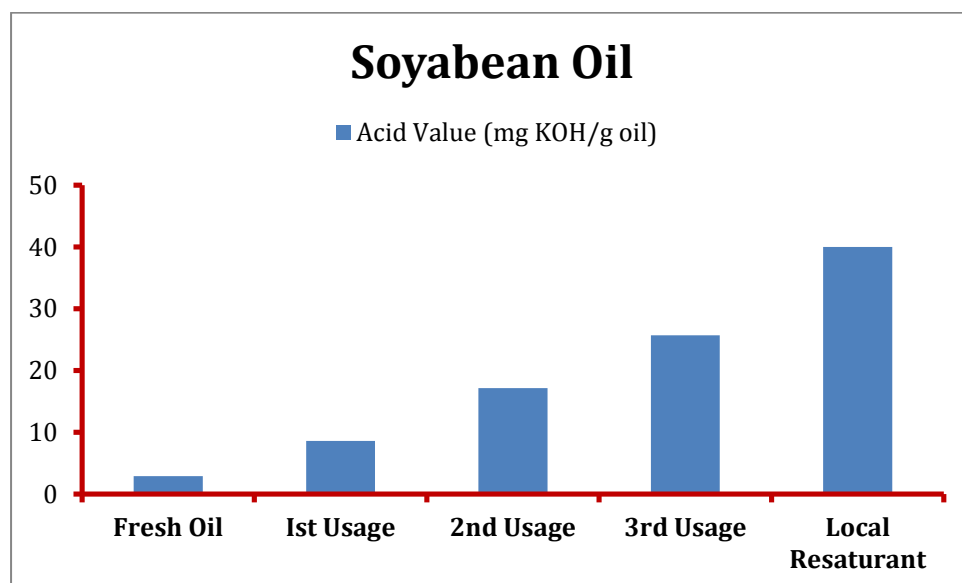
Acid value of Local Restaurant Oil = $1 \times 56 \times 0.51 = 39.984 \text{ mg KOH/g of oil}$

Graphical representation of acid values of different oils analyzed :

Graph 1 Sunflower Oil



Graph 2: Soyabean Oil



PART 3: PRODUCTION OF USEFUL PRODUCT FROM THE WASTE OF THE REACTION

METHOD OF PREPARATION OF HANDWASH

5 ml of purified glycerol was taken in a beaker. 7 ml of 40 % NaOH was added to it. The contents of the beaker were then heated for few minutes and then they were allowed to cool. After 48hours, a viscous liquid was obtained out which was used as a hand wash.

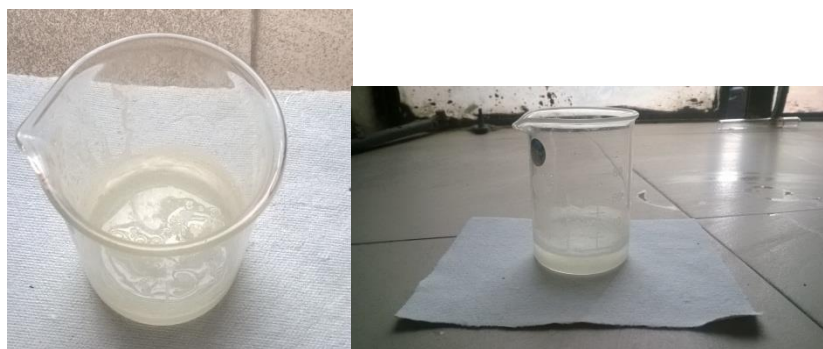


Figure 8: Preparation of hand wash from glycerin

PART 4: SOCIAL IMPLICATIONS OF THE PROJECT

The project was most satisfying for us. Apart from our efforts towards waste management and energy conservation we could create awareness among various sections of society. It touches upon the following main points.

- Fossil fuels are undergoing depletion so we tried to bridge the gap demand and supply by using alternative sources of energy that too from waste generated in the kitchen.
- The general public is made aware of adverse effect of repeatedly using the same oil for frying and a suggestion is given that this oil can be used for better purposes. It also reaffirms the statement that homemade food is the best.
- Disposal of oil causes serious environmental problems as oil cannot be separated from water. Our project not only takes care of this environmental problem but also tackles the energy problems.
- Street food vendors are educated about the harmful effects of repeatedly using the same oil. Their responses of reusing this oil to produce energy were very

encouraging. This will not only benefit them economically (as they will sell the used oil) but will encourage farmers to grow more seed crops. In the real sense this is an ideal case of “Wealth from Waste”.

RESULTS

There are several reports in the literature for the preparation of bio diesel and it is well known that the temperature, catalyst and amount of solvent are very critical for the conversion of oil into bio diesel (8, 9). Meng et al. (3) produced biodiesel from waste cooking oil with methanol and NaOH as catalyst. They investigated the effects of different operating parameters on conversion and quality of product. These parameters include molar ratio of methanol to oil (3:1, 5:1, 6:1, 7:1, and 8:1), the amount of catalyst (0.5, 0.7, 1, 1.1, 1.2 wt%), the reaction time (30, 50, 60, 70, 90, and 110 min), and the reaction temperature (30, 40, 45, 50, 60, and 70 °C). They reached 86% conversion at the optimum condition of 6:1 molar ratio, 0.7% catalyst weights, 90 min reaction time and 50 °C reaction temperatures. Sometime vegetable oil is heated at very high temperature before the trans-esterification process (10). All these process requires energy.

In this report we have utilized the principles of Green Chemistry in the preparation of bio diesel. All the reactions were carried out at room temperature and the yield obtained was excellent. Along with this the waste of the reaction is further utilized for the production of soap.

The biodiesel was characterized using various methodologies. The completion of conversion was checked using TLC, IR spectroscopy, density, kinematic viscosity etc. The observed values of all the physical parameters are matching well with the literature values.

Further the oils had been analyzed for their acid value. The relevant observations for calculation of acid values are shown in tables 1 and 2. The acid values of different oil (Sunflower oil and soyabean, fresh oil and oil obtained after repeated heating) have been determined and is shown in Graph 1 and 2. It was found that acid value of oil increases with repeated heating. The acid value of the canteen oil and the oil obtained from the local restaurant was exceptionally high. A survey has been carried out from the local restaurant owners (attached at the end) and they have been educated about the deteriorating quality of oil after repeated heating and it was suggested to them to sell the waste oil to any bio diesel production plant.

CONCLUSION

It is well known that repeated heating of cooking oil is injurious to health. Oil samples from various sources including college and canteen which had been used for frying were procured. Their acid values were determined which gave an indication regarding their further suitability. The samples which would otherwise be rejected were used to make biodiesel using green methods. The bio diesel so obtained was characterized. The waste generated during this reaction was also utilized to make hand wash. Vendors were educated to give their samples to bio diesel power plant and contribute to waste from wealth program.

QUESTIONNAIRE

1. What is your daily consumption of oil?

15 litres

2. After one use, do you separate the used oil or pour the fresh oil into this previously used oil?

The oil is used for 3-4 times, then a small amount of fresh oil is poured into that used oil

3. How many times do you do this?

5-6 times per day

4. Do you filter any of the particles which are separated after repeated frying?

Yes, the particles are filtered

5. Do you observe any change in the colour, taste and thickness of the oil after repeated usage?

Yes, the colour gets darker and the oil also gets thicker.

6. When and where do you finally throw the oil after usage?

Oil is thrown into dustbin.

7. Do you throw this oil or do you get it recycled in some way?

No, the oil is thrown.

8. Are you aware of the harmful effects of fried oil which is being used repeatedly? If any, please share.

No, not much

9. Do you buy sealed cooking oil or used cooking oil?

Sealed cooking oil

4

10. If someone is willing to purchase the oil (which is already being used by you thrice for frying) at a nominal rate, Will you agree to give that oil to the respective person honestly or use it further prior to selling?

No, we are not willing to sell the oil.

11. Are you aware that this oil is used for the production of bio-diesel?

No

Name: College Canteen

Shop Details (optional)

2

QUESTIONNAIRE

1. What is your daily consumption of oil?
12 litre
2. After one use, do you separate the used oil or pour the fresh oil into this previously used oil?
No
3. How many times do you do this?
3 times
4. Do you filter any of the particles which are separated after repeated frying?
Yes
5. Do you observe any change in the colour, taste and thickness of the oil after repeated usage?
Colour → Dark
Thickness more
6. When and where do you finally throw the oil after usage?
In the sand
7. Do you throw this oil or do you get it recycled in some way?
Throw
8. Are you aware of the harmful effects of fried oil which is being used repeatedly? If any, please share.
No
9. Do you buy sealed cooking oil or used cooking oil?
Sealed

10. If someone is willing to purchase the oil (which is already being used by you thrice for frying) at a nominal rate, Will you agree to give that oil to the respective person honestly or use it further prior to selling?

No, we will throw

11. Are you aware that this oil is used for the production of bio-diesel?

No

Name: Kuldeep
Shop Details (optional)

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