

# **INVESTIGATION ON ENGINE PERFORMANCE OF MALALECUCA CAJUPUTI OIL AND MICRO ALGAE WITH VARIOUS COMPRESSION RATIO**

Submitted in partial fulfillment of the requirements for the award of Bachelor of  
Engineering degree in Mechanical Engineering

By

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**DEPARTMENT OF MECHANICAL ENGINEERING  
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## **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with grade "A" by NAAC**

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**APRIL 2023**



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**DEPARTMENT OF MECHANICAL ENGINEERING**

**BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the Bonafide work of VARADALA KARTHIK (Reg. No. 39150128), LAKKA BHUVANESWAR REDDY (Reg. No. 39150070), who have done the Project entitled **"INVESTIGATION ON ENGINE PERFORMANCE OF MALALECUCA CAJUPUTI OIL AND MICRO ALGAE WITH VARIOUS COMPRESSION RATIO "** Under our supervision from December 2022 to April 2023.

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**Submitted for Viva voce Examination held on 26-04-2023**

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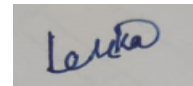
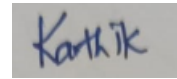
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## DECLARATION

I VARADALA KARTHIK (Reg.No.. 39150128) and LAKKA BHUVANESWAR REDDY (Reg.No.. 39150070) hereby declare that the Project Report entitled **“INVESTIGATION ON ENGINE PERFORMANCE OF MALALECUCA CAJUPUTI OIL AND MICRO ALGAE WITH VARIOUS COMPRESSION RATIO”** done by me under the guidance of Dr. S. GANESAN is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering in Mechanical Engineering.

**DATE:** 26-04-2023

**PLACE:** CHENNAI



**SIGNATURE OF THE CANDIDATES**

## **ACKNOWLEDGEMENT**

**We are pleased to acknowledge my sincere thanks to Board of Management of SATHYABAMA for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.**

**We convey our sincere thanks to Dr. S. PRAKASH, M.E., Ph.D., Dean, School of Mechanical Engineering and Dr. G. ArunKumar M.E., Ph.D., Head of the Department, Department of Mechanical Engineering for providing me necessary support and details at the right time during the progressive reviews.**

**We would like to express my sincere and deep sense of gratitude to my guide Dr. S. GANESAN M.E., Ph.D., for their valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.**

**We also express our thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering who were helpful in many ways for the completion of the project work.**

## **ABSTRACT**

This experimental work investigates the emission and performance of Melaleuca cajuputi oil with the addition of Micro algae with various compression ratio in engine. The free fatty acid content of the oil was determined and transesterification reaction with various compressive ratio of 14,15,16 and 17.5 was followed to convert Melaleuca Cajuputi oil and Micro Algae into biodiesel.

Biodiesel releases more amount of gases such as CO, HC, NOX which are harmful for the environment. In this project the biodiesel is extracted from a specific source such that the efficiency of the Biodiesel increases and the emission of the harmful gases decreases. Four specific source samples are prepared and mixed with diesel in different proportion. This project shall investigate the property, efficiency and emission of the biodiesel mixture.

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## LIST OF SYMBOLS AND ABBEREVIATIONS

|      |                            |
|------|----------------------------|
| VCR  | Variable Compression Ratio |
| SVO  | Straight Vegetable oils    |
| MCO  | Melaleuca Cajuputi oil     |
| FFA  | Free Fatty Acid            |
| FAME | Fatty Acid Methyl Ester    |



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# CHAPTER-1

## INTRODUCTION

A Biofuel is a fuel made from living organisms, most frequently plants or components obtained from plants. Plants use photosynthesis to fix atmospheric CO<sub>2</sub> and create polysaccharides like cellulose and hemicellulose. Carbon neutrality refers to the idea that when biofuels are utilized (combusted), CO<sub>2</sub> does not rise because they are made from plant-derived polysaccharides. Therefore, using biofuels to reduce CO<sub>2</sub> emissions is an efficient strategy to fight against the effects of global warming. Non-food based biomass, such as rice straw, corn stover, and residues from forest thinning, are viable sources for biofuel generation because their use does not compete with food production for land.

The development of biofuels from non-food biomass faces two technical challenges: 1.Modern conversion technique of pentose to biofuel. 2.Reduction of fermentation inhibition by organic substances (aromatics, organic acids, and furans) obtained from non-food biomass.

Modern methods for converting pentose to biofuel. Despite the fact that non-food biomass contains hexose sugars (glucose, mannose, and galactose) and pentose sugars (xylose and arabinose), microorganisms currently used in industrial bioprocess are unable to utilize pentose sugars, resulting in low production of biofuels. Thermochemical pretreatment of non-food biomass results in the production of inhibitory chemicals, although it is necessary for effective enzymatic saccharification of biomass. The productivity and yield of the bioprocess are low because of these inhibitory substances.

Due to their similarities to diesel fuel's qualities, straight vegetable oils (SVOs) are discovered to be the most appealing alternative biofuel. They are also biodegradable and renewable. Vegetable oils are non-toxic, do not include aromatic hydrocarbons, and do not contain sulphur. Absence of sulphur minimizes acid rain-causing emissions of sulphur dioxide into the atmosphere as well as the severity of corrosion in the engine crankcase brought on by the buildup of sulphuric acid.

## **1.1 BIO-DIESEL :-**

A type of diesel fuel called biodiesel is made of long-chain fatty acid esters and is obtained from either plants or animals. It is typically generated using the transesterification process, which involves chemically combining lipids, such as animal fat or another type of vegetable oil, with an alcohol to produce a methyl, ethyl, or propyl ester. Biodiesel is a drop-in biofuel, which means it is compatible with existing diesel engines and distribution infrastructure, in contrast to the vegetable and waste oils used to power converted diesel engines. However, as most engines cannot run on pure Biodiesel without modification, it is commonly blended with petroleum diesel (normally to less than 10%). Blends of biodiesel can be used as heating oil as well.

## **1.2 BLENDS OF BIO-DIESEL :-**

The most typical distribution for use in the retail diesel fuel market is blends of conventional hydrocarbon-based diesel and biodiesel. Most of the globe uses the "B" factor to indicate the percentage of biodiesel in any gasoline blend. B100 is the name given to 100% biodiesel. B20 is a designation for 20% biodiesel and 80% diesel. B7 is a designation for 7% biodiesel and 93% diesel. B5 is branded as 5% biodiesel and 95% diesel. B2 is categorised as 2% biodiesel and 98% diesel.

Diesel equipment can be utilized with blends of 20% biodiesel and lower with no changes or just minor ones, while some manufacturers do not extend warranty coverage if the equipment is harmed by these blends. The ASTM D7467 specification covers the B6 through B20 blends. In order to prevent maintenance and performance issues, biodiesel can also be utilized in its pure form (B100), however this may require certain engine modifications.

### 1.3 MELALEUCA CAJUPUTI OIL :-

Local tree species called *Melaleuca cajuputi* can be found in Papua New Guinea, Thailand, Indonesia, Malaysia, northern Australia, and Vietnam. Various names, including Kayu Putih (Indonesia) and Gelam, are employed in various nations to refer to the *Melaleuca cajuputi* tree (Malaysia). Possibly related to the tree's Indonesian name, the Cajuputi (also spelled cajuput or cajeput) is a word. The essential oil known as *Melaleuca Cajuputi* oil (MCO) is marketed for use as a home cure for colds, headaches, and stomachaches as well as for relieving itching brought on by insect or mosquito bites.



(a)



(b)

**Figure 1.1 Melaleuca cajuputi Tree and Leaves**

The projected yearly global production of MCO is about 600,000 kg, with more than half of the oil coming from Indonesia and Vietnam. Vietnam generates an average of 100,000 kg of oil per year, and Indonesia is thought to produce about 350,000 kg annually. The main method used to extract this oil from the leaves and twigs is water-steam distillation. This extraction technique is inexpensive, straightforward, and safe. Supercritical fluid extraction is an alternate method that is rarely utilised since it is more expensive than water- steam distillation.



**Figure 1.2 Melaleuca cajuputi Oil**

#### **1.4 MICRO ALGAE :-**

Microalgae, also known as microphytes, are tiny algae that are undetectable to the naked eye. They are a type of phytoplankton that can be found in freshwater and marine environments, coexisting in the water column and sediment. They are unicellular species that can dwell alone, in chains, or in groups. They can be as little as a few micrometres (m) or as large as a few hundred micrometres, depending on the species. Microalgae lack roots, stems, and leaves, in contrast to larger plants. They were created with a focus on environments with viscous forces. Microalgae that can perform photosynthesis are crucial for life on earth because they generate around half of the oxygen in the atmosphere and use carbon dioxide as a greenhouse gas to develop photoautotrophically. Microalgae, often known as phytoplankton together with cyanobacteria, are the primary producers of photosynthesis in the ocean. Together with bacteria, microalgae form the foundation of the food chain and supply energy to all trophic levels above them. Chlorophyll a concentrations are frequently used to gauge microalgae biomass and can serve as a good indicator of future output.

## CHAPTER-2

### LITERATURE SURVEY

**(Akubude, V., 2019)** This study examines the use of neat paradise tree oil as a combustion enhancer in a 4-stroke naturally aspirated direct injection compression ignition engine. Super-heated hydrogen (hydrogen in a gaseous state or above its saturation temperature) is used in conjunction with the study. Higher flame speed, calorific value, gaseous nature, and simpler molecular structure of hydrogen, among other greater features, enable to burn NPTO with higher performance and lower emission level. The performance of 15% H<sub>2</sub> + NPTO is superior to that of other hydrogen induction percentages. When compared to NPTO fuel operation, it produces 15% less BTE, 40% more NO<sub>x</sub>, 20% less smoke, 5% less CO, and 45% less HC than NPTO fuel operation.

**(Amer, L., 2011)** This study examines the Both solvent (hexane) and supercritical (carbon dioxide) extraction techniques were used to get *Melaleuca cajuputi* extracts. The goal of this research is to adopt supercritical CO<sub>2</sub> (SC-CO<sub>2</sub>) as a solvent in a batch procedure to extract leaves from *Melaleuca cajuputi*. Supercritical fluid (SFE) and solvent extraction (SE) produced the highest yields, 4.2% and 6.0%, respectively (SE).

**(Che Mat, S., 2017)** The hunt for alternative biofuel as a fossil fuel replacement has been spurred by the rising global energy demand and diminishing oil sources. This study suggests new combinations of a light biofuel based on refined palm oil and *Melaleuca cajuputi* oil (MCO) (RPO). This study proposes and analyses a new light biofuel blend made of *Melaleuca Cajuputi* oil (MCO) and refined palm oil (RPO). Accordingly, the calorific values (CV), density, and kinematic viscosity were evaluated. According to the findings, a binary blend of MCO and RPO creates a biofuel with less viscosity and density and more CV than RPO on its own.

**(Che Mat, S., 2019)** In this study, refined palm oil (RPO) and *Melaleuca cajuputi* oil (MCO) were offered as new possible biofuels that may be combined to create a new hybrid biofuel. Three phases were used to carry out the current study. The hybrid biofuel blend's physical and chemical

characteristics were examined in the first phase. The primary characteristics were also improved in compliance with ASTM D6751/EN14214 standards.

**(Che Mat, S., 2019)** Fuels' chemical and physical characteristics adhere to ASTM standards. When compared to D100 at 3.5 bar BMEP, the CO and HC emissions for D100SiO210 are 0.8% and 1.3% lower, respectively. SiO2 nano particles further lower CO and HC emissions for D100SiO220 than D100 by 1.4% and 1.6%, respectively. When using D100SiO210 and D100SiO220 as fuel, respectively, the tailpipe NOx emission was found to be 0.7% and 1.6% lower than that of D100. Due to its increased catalytic activity, SiO2 nano particle reduces the smoke emission emissions for D100SiO210 and D100SiO220 by 0.6% and 0.8%, respectively, when compared to D100.

**(Demirbas, A., 2019)** This study looked into algal energy conversions, production costs, and various algal production technologies, including open, closed, and hybrid systems. Algae are among the plants with the highest rate of growth, and nearly half of their weight is made up of oil. Microalgae grow far more quickly than terrestrial crops do. Oil from algae is thought to produce between 20,000 and 80,000 lper acre year, which is 7–31 times more oil per unit area than palm oil, the next best crop. Open ponds, photo bioreactors, and closed systems are industrial reactors used for algae culture.

**(Deshmukh, S., 2019)** A quantitative approach to scaling up and commercializing the processes for converting algae into biofuels was taken into account. The calculated production costs currently outweigh the selling price of oil from seed crops by a number of orders of magnitude. It has been established that each process needs to clear a number of obstacles and experience price drops before algae-based biofuels can compete economically with conventional fossil fuels or other oil crops.

**(Esteban, B., 2011)** The potential of creating algae biodiesel and better production methods are the focus of current work and commercial investment. Many businesses assert that they are at the cutting edge of technology and will be generating algae biodiesel profitably in the upcoming few years. However, few of these businesses have actually produced biodiesel from algae, and the majority of them lack the necessary technological know-how.

Making algal biodiesel calls for extensive growth and harvesting systems, with the difficult task of lowering the cost per unit area.

**(Friso, D. 2014)** In comparison to traditional solvent extraction techniques, more oil was extracted using more current extraction techniques. The method and solvent employed have the biggest impact on oil yield. When microalgae biodiesel is used, especially at low blend ratios, performance and emission characteristics are reported to be satisfactory. However, more research is required to determine how to use Microalgae biodiesel in engines at higher blend ratios as well as in pure form. Other factors that affect this include the biomass to solvent ratio, temperature, and time used during extraction processes.

## **CHAPTER-3**

### **AIM AND SCOPE OF WORK**

#### **3.1 AIM :-**

The aim of conducting this experimental study is to find the performance for the diesel engine using Melaleuca Cajuputi oil mixture of diesel.

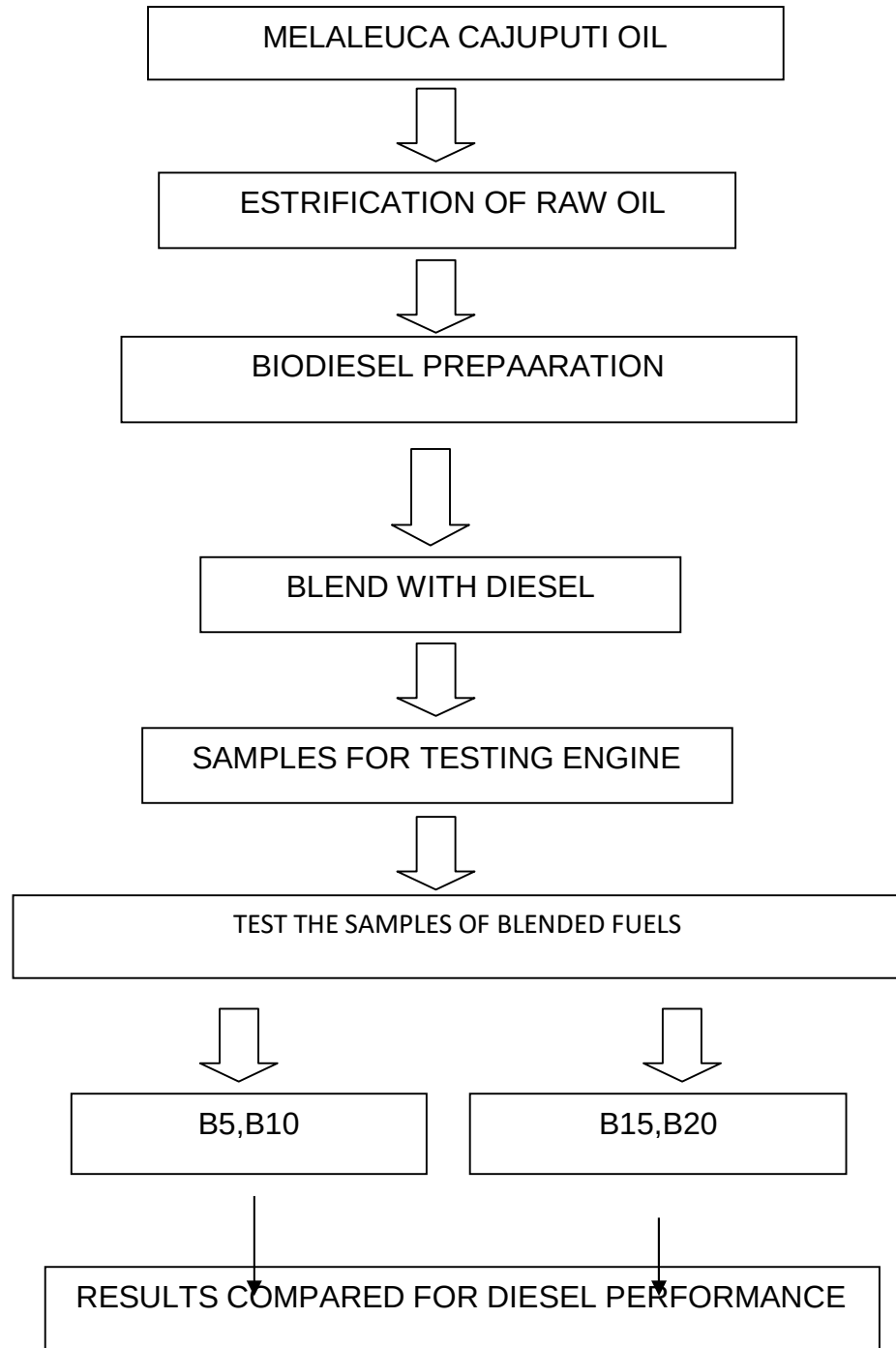
#### **3.2 SCOPE OF THE WORK :-**

The bio fuel is experimenting with different mixing proportions as well as the execution of a single chamber diesel engine. The test can be directed with a mixture of diesel and Melaleuca Cajuputi oil. The oil blends contain B10, B20, B25, and B30. The fills are used to reduce the need for diesel. Vegetable oils are widely available in the world and can be used in transportation and vehicles. The dwindling of petroleum derivatives, rising energy demands, and the development of ozone-harming substance discharges all have an impact on the importance of considering biodiesel. Normal diesel energizers are only available in certain parts of the world. All nations are pursuing easily accessible oils for biofuel energy. Biodiesel is created by combining liquor (typically methanol) with vegetable oil, animal fat, or recycled cooking oils. It is commonly used as an additive to reduce vehicle emissions (typically by 20%) or in its pure form as a sustainable alternative fuel for diesel engines. As global energy demands change and evolve, it is critical that all aspects of the bio energy production process are smoothed out and improved, from the design of more efficient bio treatment facilities to research into bio hydrogen as an energy transporter. To meet the guarantees of biomass for power age, current energy foundations should be adjusted and changed. Bio energies hosts a discussion for all bio energy partners. including audit articles, original research, analyses, news, innovative work spotlights, interviews with key assessment pioneers, and much more, with the end goal of establishing a global network of bio energy correspondence.

## CHAPTER - 4

### EXPERIMENTAL METHODS

#### 4.1 METHODOLOGY :-



**Figure 4.1 : Methodology flow chart**

#### 4.1 TRANSESTERIFICATION PROCESS :-

Viscosity, free fatty acid content, density, water content, etc factors should be checked before using biofuel in the engine because if the water content is high then the engine will get corrosion and high viscosity will affect the injection system and combustion chamber because of gum formation. The high acidity of fuel also reduces the life of the engine. To avoid these failures several approaches should be used to produce biodiesel from Melaleuca cajuputi oil. Biodiesel of Melaleuca cajuputi oil will extract from used cajuputi leaves by the Transesterification Process to reduce the viscosity of Melaleuca cajuputi oil. In the transesterification process, Melaleuca cajuputi oil will react with ethanol alcohol. In this process, a catalyst should be used because it will improve the reaction rate and yield, as a catalyst Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH) is used to increase reaction speed, increase product weight and increase the yield of the final product. In this process, one mole of triglyceride reacts with three moles of alcohol to produce three moles of mono-alkyl ester and one mole of glycerol. Transesterification is the process by which fats or vegetable oils are transformed into FAME and glycerol at a specific temperature while being in the presence of a specific quantity of alcohol and catalyst. The process is also known as alcoholysis. Transesterification is commonly used to reduce the viscosity during the production of biodiesel. If this FFA value is less than or equal to 2, conduct the transesterification process directly. If not, we must take it into the Esterification process to reduce the FFA content (mg KOH/g) to a value less than or equal to 2. For the production of biodiesel, the transesterification reaction is used using fats or waste/vegetable oils. It is preferred to use a lot of alcohol to increase biodiesel production. The choice of catalysts is crucial since the reaction will result in greater soap formation if an appropriate catalyst with a defined amount is not employed. Different kinds of catalysts, including acid, base, enzyme, and nanocatalysts, can be utilized in this reaction. Alkali acid and base catalysts can be homogeneous or heterogeneous. The third generation of biodiesel includes MCO. Approximately 30% of the edible oil consumed by each person is wasted. The yield of biodiesel produced from transesterification reaction is highly

influenced by the reaction parameters in order of catalyst type >catalyst concentration >alcohol to oil molar ratio >reaction pressure and temperature >time of reaction. The physicochemical properties of MCO biodiesel are comparable with conventional diesel. The most effective technology for industrial-scale biodiesel synthesis with a high biodiesel output and low cost is two-step transesterification. The most effective technology for industrial-scale biodiesel synthesis with a high biodiesel output and low cost is two-step transesterification.

## CHAPTER - 5

### RESULTS AND DISCUSSIONS

The transesterification process has been completed by using Melaleuca cajuputi Oil, before processing into the transesterification process Free Fatty Acid content should be checked. The Free Fatty Acid procedure is to take 5gm of waste cooking oil, 25ml of Isopropyl alcohol, and 4 drops of 0.1 normality NaOH. It should be heated to 60 degrees temperature and allowed the room temperature.



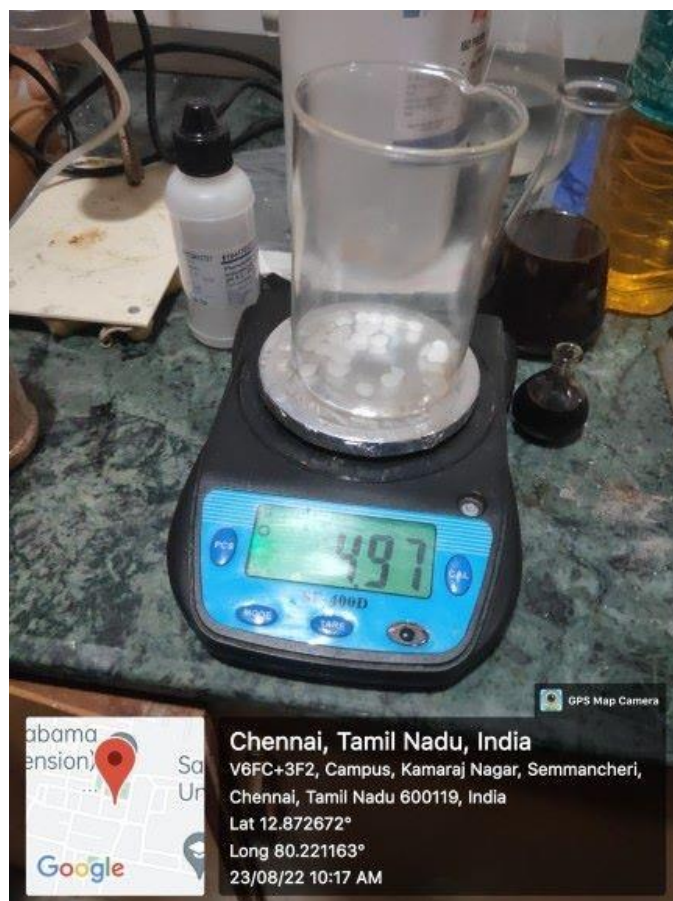
**Figure 5.1 Isopropyl alcohol for FFA**

After allowing it at room temperature add 2 drops of phenolphthalein indicator and keep stirring, pink color appearance will appear at the endpoint.



**Figure 5.2 Methanol**

Once Free Fatty Acid content reading shows 2% less then it is the Transesterification process. For the Transesterification process take 1lt of MCO heated at 60 deg temperature and add methoxide in the ratio of 1:3. 1lt of MCO, 182 ml of methanol, and 5gm of NaOH are the apparatus required for the Transesterification process.



**Figure 5.3 Checking the weight of NaOH**

1lt of oil will be placed on the hot plate with a stirrer magnetic palate will be placed inside the oil for the stirring process and the will also be placed to know the temperature of the oil. The temperature should be 60 degrees. The stirrer is used to circulate the temperature of the oil.



**Figure 5.4 Adding NaOH to Biofuel**

After the temperature reached 60 degrees add the catalyst. After adding the catalyst condenser equipment will be fixed to maintain the oil temperature stable at 60.



**Figure 5.5 Extraction of Biofuel**

When it reached 60 degrees temperature we added methoxide maintain it at 60 degrees and allow the time for 90 minutes. Transferring to the separating funnel 2 layers will form.



**Figure 5.6: Washing of Biofuel**

The top layer is crude biofuel and the bottom layer is crude glycerol. The Crude glycerol will be separated and it is the byproduct it can be used in many products such as toothpaste, mouthwashes, shaving cream, and soaps. The extraction of Biofuel from Waste cooking oil has been extracted with the transesterification process.

## **CHAPTER - 6**

### **SUMMARY AND CONCLUSIONS**

#### **6.1 SUMMARY**

The transesterification process is successfully completed.

#### **6.2 CONCLUSIONS**

Melaleuca Cajuputi oil was filtered to remove food residues and other suspended matters to complete the filtration process: Then it was heated at a high temperature to remove the soluble impurities and moisture. The acid number of the Melaleuca Cajuputi oil should be measured to get the Free Fatty Acid value We aimed to reduce the free fatty acid value of Melaleuca Cajuputi oil to a value of less than or equal to 2% The transesterification process has been completed and further processes are to be carried out like property check of the biofuel.

## CHAPTER – 7

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