

**SYNTHESIS OF BIOPETROL FROM RUBBER SEED OIL USING ZEOLITE
CATALYST USING CRACKING PROCESS: EFFECT OF MASS CATALYST IN
CRACKING PROCESS**

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ABSTRACT

The rubber seeds oil are readily available, cheap and help to improve the socioeconomic issues it is also easy to obtain because Malaysia is a biggest country that produce natural rubber. The rubber seed oil is extracted using the Soxhlet Extraction method. The cleaned, shelled and milled rubber seeds are placed into a thimble in the main chamber of the extractor. The solvent in the receiving flask is left to boil until it vaporizes and condensed, filling up the main chamber, extracting the RSO from the rubber seeds. The catalytic cracking of the mixture of 25mL of RSO, using variable mass of zeolite catalyst that is 1 grams, 2.5 grams , 5 grams and 10 grams of catalyst first been weighed after and before the cracking. At 300⁰C the furnace has been set up to 15 minutes using zeolite catalyst is to boost up the rate of reaction so that more successful reactions between the reactant particles can occur. The presence of Isooctane in a sample detected using Gas Chromatogram indicating that bio-petrol can be produced. Standards of different ratio mixtures of hexane and Isooctane were used to obtain chromatograms for Isooctane until a calibration curve is plotted from which the Isooctane produced can be determined. The results show that the actual concentration of Isooctane is very big. This could be explained using the cause of interlayer spacing of catalyst structure, larger surface area for reactions to occur, various types of fatty acid mixture present in rubber seed oil, the incorrect chromatogram modifications and the contamination in rubber seed oil. The mass of catalyst, volume or dilution factor of rubber seed oil, temperature of the cracking process used will affect the percentage of concentration of Isooctane in samples. As a conclusion, Bio-petrol can be produced from rubber seed oil using zeolite catalyst in the catalytic cracking process. And if the mass of catalyst increase it will increase the concentration of isooctane produced.

ABSTRAK

Minyak benih getah sedia ada, murah dan membantu untuk memperbaiki isu-isu sosio-ekonomi, ia juga mudah untuk abtain kerana Malaysia adalah sebuah negara terbesar yang menghasilkan getah asli. Minyak benih getah diekstrak menggunakan kaedah Pengekstrakan Soxhlet. Yang dibersihkan, dibuang kulit dan gilingan benih getah yang diletakkan ke bidal dalam ruang utama daripada pemerah. Pelarut dalam kelalang menerima dibiarkan mendidih sehingga ia vaporizes dan pekat, mengisi ruang utama, mengekstrak RSO daripada benih getah. Keretakan sebagai pemangkin campuran 25mL-RSO, dengan menggunakan jisim ubah pemangkin zeolit yang 1 gram, 2.5 gram, 5 gram dan 10 gram pemangkin terlebih dahulu ditimbang selepas dan sebelum keretakan. Pada 3000C relau telah ditetapkan sehingga 15 minit dengan menggunakan pemangkin zeolit adalah untuk meningkatkan kadar tindak balas supaya lebih berjaya tindak balas antara zarah reactant boleh berlaku. Kehadiran Isooctane dalam sampel dikesan menggunakan Kromatogram Gas menunjukkan bahawa bio-petrol boleh dihasilkan. Standard campuran nisbah yang berbeza heksana dan Isooctane telah digunakan untuk mendapatkan kromatogram untuk Isooctane sehingga keluk penentukuran diplot dari Isooctane yang dihasilkan dapat ditentukan. Keputusan menunjukkan bahawa kepekatan sebenar Isooctane sangat besar. Ini boleh diterangkan dengan menggunakan punca jarak interlayer struktur pemangkin, kawasan permukaan yang lebih besar untuk tindak balas berlaku, pelbagai jenis campuran asid lemak yang hadir dalam minyak biji getah, pengubahsuaian Kromatogram tidak betul dan pencemaran di dalam minyak biji getah. Jisim faktor pemangkin, isipadu atau pencairan minyak biji getah, suhu proses retak digunakan akan memberi kesan kepada peratusan kepekatan Isooctane dalam sampel. Sebagai kesimpulan, Bio-petrol boleh dihasilkan dari minyak biji getah menggunakan mangkin zeolit dalam proses keretakan sebagai pemangkin. Dan jika jisim peningkatan pemangkin ia akan meningkatkan kepekatan isooctane yang dihasilkan.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Biofuels in the solid form has been in use ever since man discovered fire. Wood was the first form of biofuel that was used even by the ancient people for cooking and heating. With the discovery of electricity, man discovered another way of utilizing the bio-fuel. Biofuel had been used since a very long time for the production of electricity. This form of fuel was discovered even before the discovery of the fossil fuels, but with the exploration of the fossil fuel like gas, coal, and oil the production and use of bio-fuel suffered a severe impact. With the advantages placed by the fossil fuels they gained a lot of popularity especially in the developed countries. Liquid bio-fuel have been used in the automotive industry since its inception. Research of bio-fuel and other alternative fuel source because of environmental pollution and the diminishing supply of the fossil fuel. It is important to develop a long term fuel supply for our future. Other than that the usage of fossil fuel causes many negative impacts to the environmental pollution such as climax change due to large release of carbon dioxide by the transportation that use fossil fuel.

One of the bio-fuel is bio-petrol. Bio-petrol is a renewable source and friendly type of fuel to the environment. Bio-petrol derived from natural bio based or biomass production such as plants and agriculture waste. Demand for transportation fuels is the fastest growing portion of the demand equation for fossil fuel, and on average will account for 78% of the global demand for fossil fuel to 2011, according to the International Energy Agency.

Because of that now day bio-petrol have attract attention of people in different countries all over the world and it is considered as relevant technologies by both the developing and industrialized countries. In addition, the bio-petrol offers a number of advantages over the fossil fuels in terms of energy security, reduced environmental pollution, foreign exchange savings, and socioeconomic issues related to rural sector.

Usually, the main component fatty acid used to produce bio-petrol that is present in the rubber seeds will be broken using catalyst cracking to breaks up the large and heavy oil molecule into smaller and lighter chain molecule of which will increase the reaction rate between the solid catalyst and the liquid fatty acid.

In this case study, the solid catalyst used will be the zeolite. Zeolite is chosen to be used as an acid catalyst due to its well known quality of adsorbent and it is cheaper than other catalyst such as the zeolite. Zeolite have advantages such as less or no corrosion, no waste or disposal problems, high thermostability and easy set up of continuous processes other than other catalyst.

1.2 Objective

- a) To synthesize isooctane from rubber seed oil by zeolite catalyst:
- b) To analyze effect of catalyst amount in cracking process of fatty acid.

1.3 Problem Statement

Every year the petrol price is increasing drastically. In 1 May 2004 the petrol price is only RM 1.37 per liter and for diesel only RM 0.78 but now the price is increase to RM 1.85 for RON 95, meanwhile RON 97 now retails for RM2.10 and diesel is now RM1.75. Other products affected by a price increase includes liquified petroleum gas which now sold for RM1.85 per kg as well as white refined coarse granulated sugar that is now sold for RM1.70 per kg. With the increasing prices of the fossil fuels, everything will be more expensive due to increasing of the petrol or fossil fuel. The manufacturing and

transportation company will take this advantage to increase the costs. For example the price of public transport ticket will increase because the increasing of fuel cost. Also for all of the product that used for transportation will increase the price because the same reason. Unfortunately for the lower rank of people who have lower income because of the increasing of the fuel price will not increase their income. So the bio petrol is the solution for this situation. It because the biopetrol and other derived from biomass such as natural plants, vegetable crops like palm oil and rubber seeds as well as the agricultural or forestry waste. The process to produce bio-petrol is not as expensive as the fossil fuels. Therefore, it is believed that the bio-petrol will helps to fulfill the demand of the world in the future.

Furthermore, in its strictest sense, all fossil fuels could be regarded as such. However fossil fuels take millions of years, and extreme pressure and heat from the earth, to be formed. Bio-fuels are manufactured from organic materials and produce fuels such as bio-diesel and ethanol. Both these processes produce energy, which is the bit that makes the car, truck or plane go. The problem with crude oil is that it takes millions of years to form, when the crude oil is finish so it cannot be renewable. Bio-fuels on the other hand, are made from by-products of farming.

Other than that, the technical definition of fossil fuels is "formed from incompletely oxidized and decayed animal and vegetable materials, specifically coal, peat, lignite, petroleum and natural gas". In transportation in certain condition the fuel that will burns incompletely and releases carbon monoxide gas as the product which is known to be deleterious to human health. Inhaled carbon monoxide it readily combines with hemoglobin in the blood during respiration thus hindering the body's ability to take up oxygen. It is thought therefore to aggravate respiratory and heart disease.

Carbon monoxide also contributes to global warming to a small degree. This gas produced indirectly after first taking part in chemical reactions within the atmosphere. One such reaction would be with oxygen, forming carbon dioxide and thus contributing to the enhanced greenhouse effect. The technical definition of fuel is "material that can be burned or otherwise consumed to produce heat". In the modern world, fossil fuels provide vast

luxurious importance. His retrieved that these fossil fuels extracted from the ground and under the sea and they had been converted into electricity. Approximately 90% of the world's electricity demand is generated from the use of fossil fuels.(UK National Air Quality Archive).

Combustion of these fossil fuels is considered to be the largest contributing factor of releasing carbon monoxide into the atmosphere. This gas is not harmful to human and environment, but it causes greenhouse effect. Greenhouse gas emission is leading to the increase of the Earth's atmospheric, land and sea temperatures. During the 20th century the global average surface temperature (the average of the nearest surface point air temperature over land and sea surface temperature) increases by 0.6 (± 0.2) °C. This temperature is predicted to increase by 1.4 - 5.8°C by 2100 (1990 baseline). Based on palaeo-climate data, the projected rate of warming is very likely to be without precedent during at least the last 10,000 years. The proportional rises in sea levels and resulting climatic change will be of great significance to all patterns of life on Earth.(Petrol News.co.uk). In fact it is believed that energy providers are the largest source of atmospheric pollution today. There are many types of harmful outcomes which result from the process of converting fossil fuels to energy. Some of these include air pollution, water pollution, accumulation of solid waste, without mentioning the land degradation and human illness. So, in order to overcome this negative effect by the fossil fuel, can be used as alternate source.

1.4 Research Scope

In order to accomplish the objectives, the scope of this research is focusing on the criteria that are stated as below:-

- i. The extraction of rubber seed oil from rubber seeds using Soxhlet Extraction
- ii. The application of catalytic cracking process to crack the fatty acid complex into smaller hydrocarbon molecule using zeolite catalyst.
- iii. The determination of the concentration of Isooctane through an analysis using the Gas Chromatography method.

1.5 Rationale and Significance

The Rationale and Significance statements are as below:-

- a) Bio-petrol is a renewable energy source and is biodegradable of which can be used as a substitute for the fossil fuels
- b) Bio-petrol is environment friendly as it brings about the reduction of greenhouse gases emission, sulphur free and non-aromatic
- c) Bio-petrol has oxygen levels from 10% to 45% while petroleum has essentially none making the chemical properties of bio-petrol very much useful than the petroleum
- d) Isooctane or 2,2,4-trimethylpentane is used to prevent knocking in the engines as it helps to improve the efficiency of combustion and increase the engine's performance
- e) Easy availability of fatty acid in most of the natural plants especially in rubber seeds
- f) Rubber seeds are easily available in Malaysia as Malaysia is one of the leading producers of natural rubber in the world (Indonesia, Malaysia and Thailand together account for around 72% of all natural rubber production.)
- g) Use of non-edible feedstock such as rubber seeds in bio-petrol production would reduce the feedstock cost.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Mixture of volatile, flammable hydrocarbons derived from plant material or animal waste and used as fuel. Some long-exploited bio-fuels, such as wood, can be used directly as a raw material that is burned to produce heat. . The heat, in turn, can be used to run generators in a power plant to produce electricity [Paul Mann et al, 2009]. The heat in turn can be used to run generators in a power plant to produce electricity. Sugars and starches from sugarcane, corn, and high-cellulose plants (such as switch grass) can be converted into ethanol, which is used directly in internal-combustion engines or is mixed with gasoline (gasohol). Oils from plants such as the soybean or oil palm can be chemically processed and blended with petroleum diesel fuel to make biodiesel.

Liquid biofuels are of particular interest because of the vast infrastructure already in place to use them, especially for transportation. The liquid bio-fuel in greatest production is ethanol (ethyl alcohol), which is made by fermenting starch or sugar. Brazil and the United States are among the leading producers of bio-ethanol. In the United States, ethanol bio-fuel is made primarily from corn (maize) grain, and it is typically blended with gasoline to produce “gasohol,” a fuel that is 10 percent bio-ethanol. In Brazil, bio-ethanol is made primarily from sugar cane, and it is commonly used as a 100-percent bio-ethanol fuel or in 85 percent ethanol.(Encyclopedia Britanica). Metabolism can be defined as the “Transformation of energy by converting chemicals and energy into cellular components (anabolism) and decomposing organic matter (catabolism)”.Living things require energy to maintain internal organization (homeostasis) and to produce the other phenomena

associated with life. Additionally, humans employ various techniques to convert one form of energy into another, producing usable energy for purposes that go far beyond the energy needs of a human body. The application of energy released from fuels ranges from heating to cooking and from powering weapons to the generation of electricity.

All currently known fuels ultimately derive their energy from a small number of sources. Fossil fuels, for example, are thought to have been formed from the remains of living matter, which received its energy from the utilization of solar energy through photosynthesis. In addition, fossil fuels are fuels formed by natural resources such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years [Paul Mann et al, 2009]. Solar energy, in turn, is generated by the thermonuclear fusion process at the core of the sun. The radioactive isotopes used as fuel to power nuclear plants were formed in supernova explosions.

2.2 Fossil Fuel

Fossil fuel is a fuel that has been made by ancient plants and animal that died millions years ago. Fossil fuel is not renewable source like electricity, solar energy and other kinds of renewable sources. Once the fuel finish we cannot make it over. Oil and gas deposits form in areas where ancient marine organisms form layers of organic sediments that break down into fossils fuels. Oil comes from crude oil, which is a mixture of hydrocarbons with some oxygen, nitrogen, and sulfur impurities. It is usually recovered by drilling wells through the non-porous rock barrier that traps the oil. Natural gas is the gas component of coal and oil. Wells for natural gas are drilled in underground reservoirs of porous rock. When it is removed from a reservoir, natural gas can either be pumped to the processing station for removal of liquid hydrocarbons, sulfur, carbon dioxide, and other components, or stored in large caverns underground until it is needed. Coal is an abundant fossil resource that consists mostly of carbon and it forms on land from decomposing plant material. Coal is often found in swampy areas with high moisture that prevents the decomposition of ancient plant materials. Coal is recovered from the earth by surface

mining or deep mining. Surface mining (also known as strip mining) is less expensive and usually occurs on flat land [Energy Information Administration (EIA) 2008].

Although until now the consumption of fossil fuel is still goes on, there are several of fossil fuel continuous consumption:

- Pollution is a major disadvantage of fossil fuels. This is because they give off carbon dioxide when burned thereby causing a greenhouse effect.
- Coal also produces carbon dioxide when burned compared to burning oil or gas and it gives off sulphur dioxide, a kind of gas that creates acid rain.
- The mining of coal results in the destruction of wide areas of land. Mining this fossil fuel is also difficult and may endanger the lives of miners. Coal mining is considered one of the most dangerous jobs in the world.
- Power stations that utilize coal need large amounts of fuel. In other words, they not only need truckloads but trainloads of coal on a regular basis to continue operating and generating electricity. This only means that coal-fired power plants should have reserves of coal in a large area near the plant's location.
- Use of natural gas can cause unpleasant odors and some problems especially with transportation.
- Use of crude oil causes pollution and poses environmental hazards such as oil spills when oil tankers, for instance, experience leaks or drown deep under the sea. Crude oil contains toxic chemicals which cause air pollutants when combusted.

2.3 Bio-Fuel (Bio-Petrol)

Today the public show interest more in bio-fuel because of the increasing price of fossil fuel and the pollution caused by it. The use of bio-fuels decreases the external energy dependence, promotion of regional engineering, increases Research and Development (R&D) activities, decreases the negative impacts of electricity production and transformation, increases the level of services for the rural population, creation of

employment, etc [Miguez JL et al., 2006]. The advantages of the bio-fuels over the fossil fuels are:

- **Cost:** Once the technology is widely available, bio-fuels can be significantly less expensive than gasoline and other fossil fuels, particularly as worldwide demand for oil increases, therefore increasing oil and gasoline prices to unheard of levels.
- **Source Material:** Whereas oil is a limited resource that comes from specific materials, bio-fuels can be manufactured from a wide range of materials including crop waste, manure, and other byproducts, making it a efficient step in recycling.
- **Renewability:** It takes thousands of years for fossil fuels to be produced, but bio-fuels are much more easily renewable as new crops are grown and waste material is collected.
- **Security:** By reducing dependence on foreign fuel sources, countries can protect the integrity of their energy resources and make them safe from outside influences.
- **Economic Stimulation:** Because bio-fuels are produced locally, bio-fuel manufacturing plants can employ hundreds or thousands of workers, creating new jobs in rural areas. Bio-fuel production will also increase the demand for suitable bio-fuel crops, providing economic stimulation to the agriculture industry.
- **Biodegradability:** Bio-fuels are easily biodegradable and far safer to handle than current fossil fuels, making the fuel spills less hazardous and much easier and less expensive to clean up.
- **Lower Carbon Emissions:** When bio-fuels are burned or combusted, they produce significantly less carbon output and fewer toxins, making them a safer alternative to preserve atmospheric quality and lower air pollution.

Bio-fuel technology is relevant to both development and industrialized countries and it could be peaceful energy carriers for all countries. It is renewable and available throughout the world. In comparison to most of the other fuel types is that the energy within the biomass can be stored for an indefinite time period and without any dangerous. [Demirbas A et al., 2006]

2.3.1 Octane Number in Bio-petrol

One of the hydrocarbons that can use as a bio-petrol is octane. The octane number is the percentage by volume of the isooctane in the isooctane-heptane additive mixture that matches the fuel being tested in a standard test engine [Encyclopedia Britannica, August 2006]. Higher octane ratings correlate to higher activation energies. The activation energy is the total amount of energy necessary to start the chemical reactions.

A fuel with a higher octane rating can be run at a higher compression ratio without causing detonation. Compression is directly related to power and to thermodynamic efficiency, of which meaning that engines required higher octane fuel to generate more motive power and work more efficiently. Engine power is a function of the fuel, as well as the engine design, and is directly related to the octane rating. Burning fuel with a lower octane rating required by the engine will reduce the power output and efficiency. Isooctane or the 2,2,4-trimethylpentane, is an octane isomer which defines a 100 rating octane number. It is a highly branched compound that burns smoothly, with very little or negligible knock. In comparison, the heptane is a straight, unbranched molecule with an octane rating of 0 because of its bad knocking properties. Bio-petrol contains the isooctane as the main constituent which gives the best characteristic in the internal combustion of engines. The oxygen in the bio-petrol permits low temperature combustion as well as the reduction of greenhouse gasses emission such as the carbon dioxide, carbon monoxide, and nitrogen oxides [Balat M, 2008].

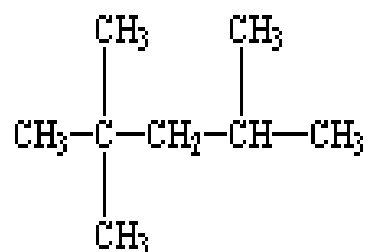


Figure 2.1: Chemical structure of 2, 2, 4-trimethylpentane or isooctane

Synonyms	Isobutyltrimethylpentane, 2,2,4-Trimethylpentane
Appearance	colorless liquid
Molecular formula	C_8H_{18} or $CH_3C(CH_3)_2CH_2CH(CH_3)CH_3$
Molecular weight	114.22 g/mol
Melting point $^{\circ}C$	$-107.38^{\circ}C$ (166K, $-161^{\circ}F$)
Boiling point $^{\circ}C$	$99.3^{\circ}C$ (372K, $211^{\circ}F$)
Density	688 kg/ m^3
Specific gravity	0.692
Solubility in water	Immiscible
Auto ignition temperature:	$396^{\circ}C$

Table 2.1: Physical and Chemical properties of Isooctane (Safety data for isooctane, 2005)

2.3.2 Bio-petrol from Fatty Acid in Rubber Seeds

The discovered rubber seed oil has many composition of fatty acid that can be converted to the isooctane by using the catalytic cracking. Recent analysis shows that rubber seed oil contains 17-20% of saturated fatty acids (myristic, palmitic, stearic, arachidic, and behenic) and 77-82% of unsaturated fatty acids (palmitoleic, oleic, linoleic and arachidoleic) [Hardjosuwito and Hoesnan, 1978; Njoku et al., 1996].

2.3.3 Fatty Acid

Fatty acid is a carboxylic acid with a long branched aliphatic tail (chain) found in fats, oils and lipids. It either be saturated or unsaturated. Fatty acids are produced by the hydrolysis of the ester linkages in a biological oil or fat. Fatty acids are aliphatic mono carboxylic acids derived from an animal, vegetable fat, oil or wax. Natural fatty acids commonly have a chain of four to 28 carbons which maybe unsaturated or saturated.

Fatty acids are merely carboxylic acids with long hydrocarbon chains. The hydrocarbon chain length may vary from 10-30 carbons (most usual is 12-18). The non-

polar hydrocarbon alkane chain is an important counter balance to the polar acid functional group. In acids with only a few carbons, the acid functional group dominates and gives the whole molecule a polar character. However, in fatty acids, the non-polar hydrocarbon chain gives the molecule a non-polar character. The unsaturated fatty acid refers to the presence of one or more double bonds between carbons as in alkenes. The saturated fatty acid has all bonding position between carbons occupied by hydrogen. The melting point of fatty acid follows the boiling point principle. The melting point principle is when the molecular weight increases, the melting point increases.

The unsaturated fatty acids have lower melting points than the saturated fatty acids. It is occur because this phenomenon can be found by consideration of molecular geometries. The tetrahedral bond angles on carbon results in a molecular geometry for saturated fatty acids that is relatively linear although with zigzags. The term "saturated" refers to hydrogen, in that all carbons (apart from the carboxylic acid [-COOH] group) contain as many hydrogen atoms as possible. (redza).

The double bonds in the hydrocarbon chain in unsaturated fatty acids results in one or more "bends" in the molecule. The geometry of the double bond is almost always a cis configuration in natural fatty acids. The intermolecular interactions are much weaker than saturated molecules. The melting points are much lower for unsaturated fatty acids.

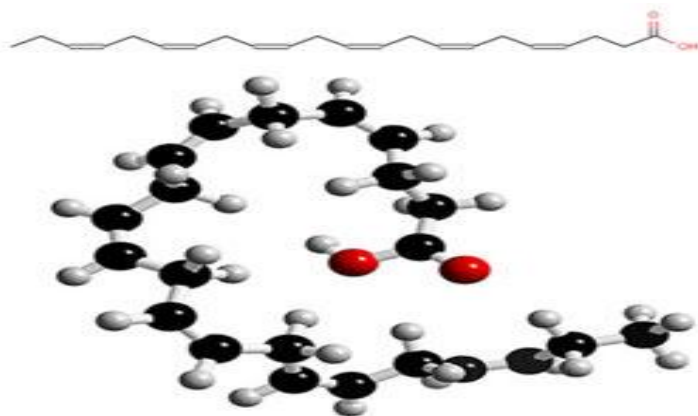


Figure 2.2: Geometry structure of fatty acid molecule

Triglycerides from various vegetable oils will produce through transesterification a mix of fatty acid esters. To describe precisely the structure of a fatty acid molecule, one must give the length of the carbon chain (number of carbon), the number of double bonds and also the exact position of these double bonds this will define the biological reactivity of the fatty acid molecule and even of the lipid containing the fatty acids studied.

The straight-chain fatty acids are the simplest are referred to as saturated of fatty acids. It is because they have no unsaturated linkages and cannot be altered by hydrogenation or halogenations. When double or triple bonds are present, fatty acids are classified as unsaturated.

The human body can produce all fatty acids but only two fatty acids are required which are linoleic acid (LA) and alpha-linolenic acid (LNA). These acids are widely distributed in plant oils. Hence linoleic acid and linolenic acid are essential fatty acids for humans. In the body, essential fatty acids are primarily used to produce hormone-like substances that regulate a wide range of functions, including blood pressure, blood clotting, blood lipid levels, the immune response, and the inflammation response to injury infection

2.3.4 Oleic acid

Oleic acid is known as mono-unsaturated omega-9 fatty acid found in various animal and vegetable sources. It has the formula $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$. The *trans*-isomer of oleic acid is called elaidic acid. The term oleic means related to, or derived from oil or olive. Oleic acid is also named as *cis*-9-octadecenoic acid ($\text{C}_{17}\text{H}_{33}\text{COOH}$). It is an unsaturated fatty acid and it includes also in group of carboxylic acids with one carbon-carbon double bond ($\text{C}=\text{C}$) between 9th and 10th carbon atoms.

2.3.6 Linoleic Acid

Linoleic acid (LA) is an unsaturated omega-6 fatty acid. The word linoleic comes from the Greek word linon (flax). Linoleic acid is a polyunsaturated fatty acid used in the biosynthesis of prostaglandins. It is found in the lipids of cell membranes. It is abundant in vegetable oils, especially safflower and sunflower oils. Fatty acids are a carboxylic acid with a long unbranched aliphatic tail (chain) which is either saturated or unsaturated. Fatty acids derived from natural fats and oils may be assumed to have at least 8 carbon atoms. Most of the natural fatty acids have an even number of carbon atoms because their biosynthesis involves acetyl-CoA, a coenzyme carrying two-carbon-atom group.

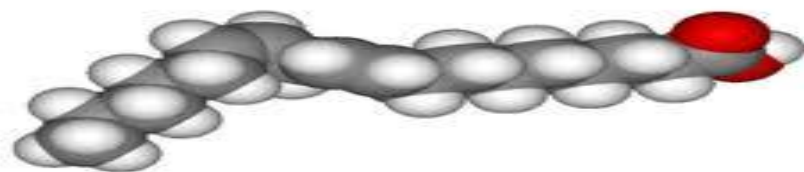


Figure 2.4: 3d structure of linoleic acid

2.3.7 Palmitic Acid

Palmitic acid is the commonest saturated fatty acid in plant and animal lipids. It usually forms less than 5% of the total fatty acids, sometimes as much as 10% in common vegetable oils (peanut, soybean, corn, coconut) and in marine-animal oils. Lard, tallow, cocoa butter palm oil contains 25 to 40% of this component.

Palmitic acid is a kind of carboxylic acid, with carboxyl (-COOH) molecule as functional group. The IUPAC name for palmitic acid is hexadecanoic acid with the molecular formula $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$.

Physical & Chemical Properties	
1. IUPAC Name	Hexadecanoic Acid
2. Molecular Formula	$C_{16}H_{32}O_2$
3. Molar Mass	256.42 g/mol
4. Density	0.853 g/cm ³ at 62 °C
5. Appearance	White crystals
6. Solubility	Insoluble in water
7. Specific Gravity	0.849 - 0.851
8. Boiling Point	350 -352 °C
9. Melting Point	59 - 64 °C
10. Stability	Stable under ordinary conditions

Table 2.3: Physical and Chemical properties of Palmitic acid

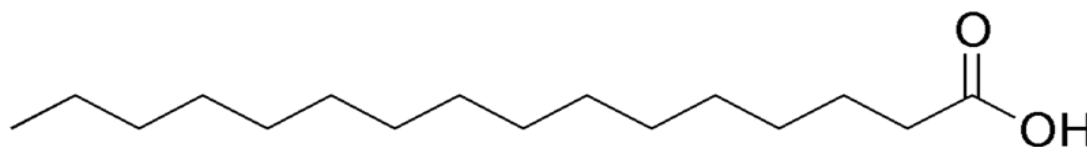


Figure 2.5: Skeleton Structure of Palmitic acid

Properties of rubber seed oil in comparison with the other oils

Property	Rubber seed oil	Sunflower oil	Rapeseed oil	Cotton seed oil	Soybean oil
Fatty acid composition (%)					
(i) Palmitic acid C _{16:0}	10.2	6.8	3.49	11.67	11.75
(ii) Stearic acid C _{18:0}	8.7	3.26	0.85	0.89	3.15
(iii) Oleic acid C _{18:1}	24.6	16.93	64.4	13.27	23.26
(iv) Linoleic acid C _{18:2}	39.6	73.73	22.3	57.51	55.53
(v) Linolenic acid C _{18:3}	16.3	0	8.23	0	6.31
Specific gravity	0.91	0.918	0.914	0.912	0.92
Viscosity (mm ² /s) at 40 °C	66.2	58	39.5	50	65
Flash point (°C)	198	220	280	210	230
Calorific value (MJ/kg)	37.5	39.5	37.6	39.6	39.6
Acid value	34	0.15	1.14	0.11	0.2

Table 2.4: Properties of rubber seed oil in comparison with the other oils

So rubber seed oil has higher composition of oil and fatty acid other than other seed. Cost for rubber seed also much cheaper than other seed. Rubber seed oil more potential to produce bio-petrol rather than other seed.

2.3.8 Isooctane

Isooctane is also known as 2, 2, 4-Trimethylpentane. It is an octane isomer which defines the 100 point on the octane rating scale. It is an important component of gasoline. Isooctane is produced a large quantity in the petroleum industry. The alkylation process alkylates isobutene using a strong acid catalyst. This process isobutylene is dimerized into isooctene and then hydrogenated to isooctane. Isooctane 100 is a mixture of C8 isoparaffins which contains virtually no aromatics or sulphur compounds. The enthalpy of combustion of -48 kJ/g or -33 kJ/cm³. It has a range of properties including low toxicity, lack of colour, high colour stability, low odor and rapid evaporation or drying which makes it an excellent solvent for a variety of surface applications.

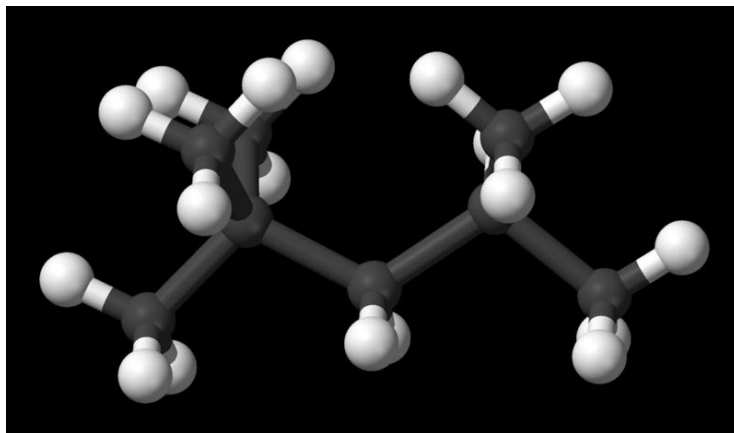


Figure 2.6: The Structure of Isooctane

Figure 2.9 shows the skeleton structure of isooctane and Table 2.2 shows the physical and chemical properties of isooctane.



Figure 2.7: Skeleton Structure of Isooctane

2.4 Catalyst in Catalytic Cracking

Modern cracking uses zeolites as the catalyst. These are complex aluminosilicates, and are large lattices of aluminium, silicon and oxygen atoms carrying a negative charge. They are, of course, associated with positive ions such as sodium ions. You may have come across a zeolite if you know about ion exchange resins used in water softeners. The alkane is brought into contact with the catalyst at a temperature of about 500°C and moderately low pressures.

The zeolites used in catalytic cracking are chosen to give high percentages of hydrocarbons with between 5 and 10 carbon atoms - particularly useful for petrol

(gasoline). It also produces high proportions of branched alkanes and aromatic hydrocarbons like benzene.

The zeolite catalyst has sites which can remove a hydrogen from an alkane together with the two electrons which bound it to the carbon. That leaves the carbon atom with a positive charge. Ions like this are called carbonium ions (or carbocations). Reorganisation of these leads to the various products of the reaction.

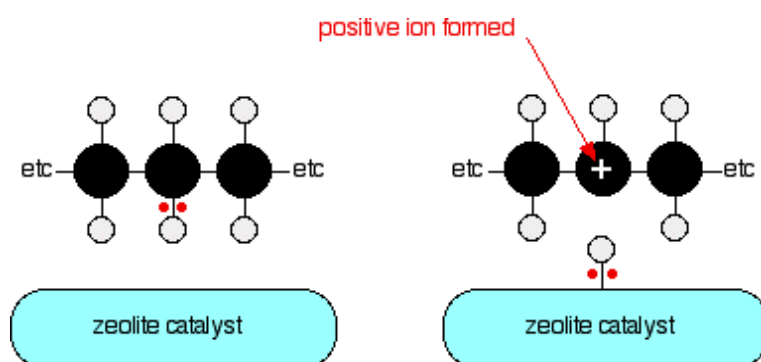


Figure 2.8 : Reaction of catalytic cracking using zeolite catalyst

2.5 Zeolite Catalyst

Zeolite is an inorganic porous material having a highly regular structure of pores and chambers that allows some molecules to pass through, and causes others to be either excluded, or broken down. It is in many ways, the inorganic equivalent of organic enzymes, many of which also have specific sized chambers that trap chemicals within our bodies, holding them where they either break down, or react with specific chemicals.

Compositionally, zeolites are similar to clay minerals. More specifically, both are alumino-silicates. They differ, however, in their crystalline structure. Many clays have a layered crystalline structure (similar to a deck of cards) and are subject to shrinking and swelling as water is absorbed and removed between the layers. In contrast, zeolites have a rigid, 3-dimensional crystalline structure (similar to a honeycomb) consisting of a network

of interconnected tunnels and cages. Water moves freely in and out of these pores but the zeolite framework remains rigid. Another special aspect of this structure is that the pore and channel sizes are nearly uniform, allowing the crystal to act as a molecular sieve. The porous zeolite is host to water molecules and ions of potassium and calcium, as well as a variety of other positively charged ions, but only those of appropriate molecular size to fit into the pores are admitted creating the "sieving" property.

One important property of zeolite is the ability to exchange cations. This is the trading of one charged ion for another on the crystal. One measure of this property is the cation exchange capacity (CEC). Zeolites have high CEC's, arising during the formation of the zeolite from the substitution of an aluminum ion for a silicon ion in a portion of the silicate framework (tetrahedral units that make up the zeolite crystal). A defining feature of zeolites is that their frameworks are made up of 4-connected networks of atoms. One way of thinking about this is in terms of tetrahedra, with a silicon atom in the middle and oxygen atoms at the corners. These tetrahedra can then link together by their corners (see illustration) to form a rich variety of beautiful structures. The framework structure may contain linked cages, cavities or channels, which are of the right size to allow small molecules to enter - i.e. the limiting pore sizes are roughly between 3 and 10 Å in diameter. In all, over 130 different framework structures are now known. In addition to having silicon or aluminium as the tetrahedral atom, other compositions have also been synthesized, including the growing category of microporous aluminophosphates

Various catalysts are reported for cracking of fatty acids. The choice of the catalyst plays an important role in the cracking of fatty acids. Since zeolites are extremely active, therefore it has been tested extensively for catalytic cracking, especially of vegetable oil by several researchers (Twaiq *et al.*, 1999; Yean-Sang *et al.*, 2004). Different catalysts will lead to different product distribution of catalytic cracking (Chew and Bhatia, 2008). Corma *et al.* (2007) studied catalytic cracking of glycerol and sorbitol, in the presence of 6 different catalysts, including a fresh FCC catalyst, an equilibrium FCC catalyst with metal impurities (ECat), a mesoporous Al₂O₃, a USY zeolite (Y), a ZSM5-based FCC additive (ZSM5), and an inert silicon carbide (SiC). The catalysts activity (in terms of total

conversion to gases, coke, and aromatics) for the conversion of glycerol increased in the order of SiC < ECat < ZSM5 < Al₂O₃ < FCC ~ USY (Corma *et al.*, 2007).

The combination of acidity, hydrothermal stability, and pore size made this zeolite as the main active component of cracking catalysts. In recent years, there have been several other studies on the production of hydrocarbons from palm oil mainly biogasoline/biopetrol (Twaiq *et al.*, 1999; Yean-Sang, 2004) which have been carried out using cracking catalysts in a micro-reactor. Zeolites have shown excellent performance as solid acid cracking catalysts due to their higher selectivity (Leng *et al.*, 1999). Catalytic cracking of vegetable oil for liquid hydrocarbon production was studied over various microporous catalysts (Sharma and Bakhshi, 1991; Katikaneni *et al.*, 1995; Twaiq *et al.*, 1999) as well as mesoporous catalysts (Twaiq *et al.*, 2003). In this direct catalytic conversion process, the choice of shape selective catalyst controls the type of fuel and its yield in the organic liquid product. The properties of catalysts are governed by acidity, pore shape and size (Bhatia, 1990).

2.6 Soxhlet Extarctor

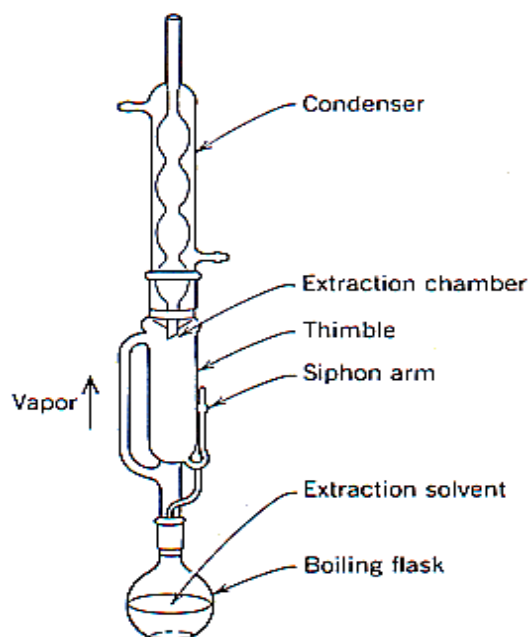


Figure 2.9: Soxhlet Extractor

A Soxhlet extractor is a piece of laboratory apparatus originally meant for the extraction of a lipid from a solid material. However, a Soxhlet extractor is not limited to the extraction of lipids. Typically, a Soxhlet extraction is required to extract substances with a low solubility in the extracting solvent, and the impurity is insoluble in that solvent. If the desired compound has a significant solubility in a solvent then a simple filtration can be used to separate the compound from the insoluble substance. The extraction process is carried out whereby; a solid material containing some of the desired compound (such as oil) is placed inside a thimble made from thick filter paper, which is loaded into the main chamber of the extractor. The Soxhlet extractor is connected onto a boiling flask containing the extraction solvent and a condenser is equipped above the extractor. The boiling flask should not be overfilled and the volume of solvent should be two to four times the volume of the Soxhlet chamber.

The solvent is heated or boiled to reflux. The standard extractor has a distillation arm where the solvent vapor travels up to, and floods into the chamber housing the thimble of solid. The solvent vapor then condenses as it is cooled by the help of a condenser, and drips back down into the chamber housing the solid material. The extractor chamber containing the thimble filled with solid material slowly fills with warm solvent. Some of the desired compound will then dissolve in the warm solvent. Once the solvent reaches the top of the siphon side arm, the chamber is automatically emptied with the solvent running back down to the distillation flask. The solvent is reheated; and the cycle may be allowed to repeat many times, over hours or days. During each cycle, there will be a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound is concentrated in the distillation flask. . Furthermore, after the extraction, the apparatus is allowed to cool down before the solvent is removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble, and is usually discarded.

The advantages of using this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled. This technique is particularly useful of which the Soxhlet Extractor enabling the isolation of the

desired compound where the compound has only a limited solubility in a solvent, and the impurity is insoluble in that solvent. In addition, the working principle of mechanism is so simple that one can obtain more desired compound without any difficulties.

2.7 Rotary Evaporator

A rotary evaporator (also known as “rotavap”) [Laurence M. Harwood and Christopher J. Moody] is a device used in chemical laboratories for gently and efficiently removal of solvents from reaction mixtures by evaporation. Use of a rotary evaporator allows liquid solvents to be removed without excessive heating of what are often complex and sensitive solvent-solute combinations. It is a very efficient way of rapidly removing large quantities of solvent.

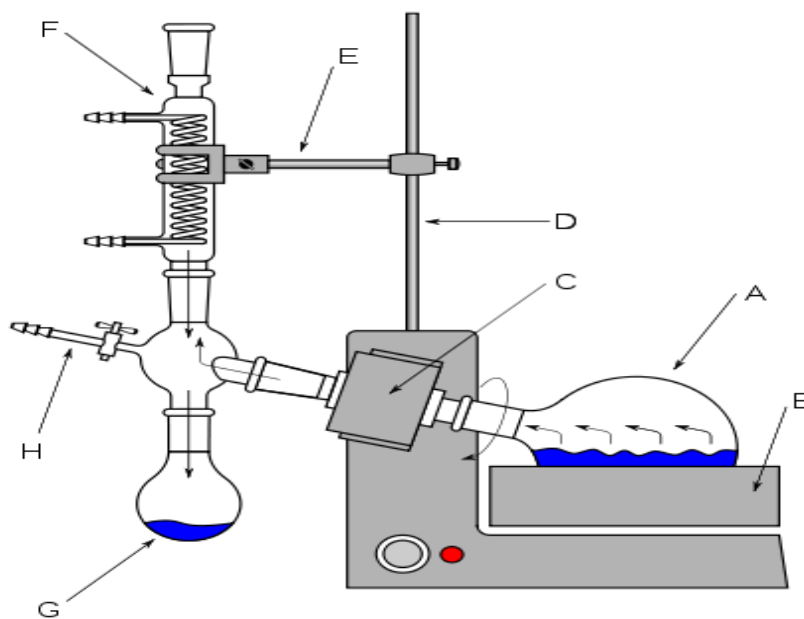


Figure 2.10: Rotary Evaporator