COCONUT FOR CLEAN AIR

by

Rafael S. Diaz

Editor's Note: Coconut oil is gaining recognition as an excellent health food and medicine, but its benefits don't stop there. It can also be used to improve air quality by reducing air pollution caused by automobile exhaust. How? By using it as diesel fuel or as a diesel fuel additive.

Using vegetable oil as a diesel fuel may sound bizarre but it has been done for decades. In fact, some of the first diesel engines invented ran on vegetable oil. Although pure coconut oil can be used as diesel fuel, coconut oil esters or coco biodiesel shows the greatest potential as a suitable diesel fuel replacement or additive. Vegetable oils are currently being used as biodiesel additives in many countries to enhance engine performance and efficiency, but coco biodiesel is superior to them all. This is due to the medium chain saturated fatty acids in coconut oil, which gives the fuel unique characteristics not found with other biodiesel additives.

Diesel fuel blended with just 1% coco biodiesel reduces emissions significantly. Studies conducted in Japan and Korea show that emission of particulate matter is reduced by as much as 60% and nitrogen oxide (a major component of smog) by 20% and smoke is reduced by 70% with the addition of only 1% coco biodiesel. Adding 2% coco biodiesel lowers pollution even more with smoke emission decreasing by an incredible 90%!

Not only does coco biodiesel burn cleaner but it increases the efficiency of the fuel, increasing gas mileage, reducing wear on the engine, and extending engine life. Coco biodiesel increases lubricity of the fuel by 36% thus reducing wear and tear on the engine. It increases solvency of the fuel, which dissolves carbon deposits in the combustion chamber and declogs fuel nozzles, lines, and ports allowing for greater engine efficiency. It also enhanced cold starting efficiency of diesel fuel. All of which improve gas mileage and reduces toxic emissions.
What an amazing fuel additive. And it comes from a natural, renewable source—coconut oil. The following article by Rafael S. Diaz explains the miracle of coco biodiesel.

The book "Coconut Oil Miracle" written by Dr. Bruce Fife provides a wealth of information on the wonders of coconut oil as dietary food. He presents, in easily understandable terms, why coconut is the "tree of life". Dr. Mary Enig sums it all up as the "health food for mankind". But what is remarkable still is that coconut can provide the means for the attainment of a "healthy air for mankind"- - when used as "Coco Biodiesel".

Air is constantly being polluted by hundreds of different sources. The greatest contributor to air pollution is emission from internal combustion engine. Air pollutants are public health hazard causing respiratory ailments, cancer, and destruction to plants and the environment (i.e. acid rain). People living in cold climates are more exposed to air pollutants since cold air settles closer to the ground. Pollutants from internal combustion engines are:

PM (particulate matter) - these are partially burned hydrocarbon which appear as black smoke emission. It consists of carbon soot and sulfur particulates.

HC (hydrocarbon) – these are unburned hydrocarbon which appear as white smoke.

VOC (volatile organic fraction) – evaporative emissions from fuels which are non-combustion products.

NOx (nitrogen oxide) – a combustion by-product that causes acid rain (nitric acid). It also aid in the formation of ground level ozone that leads to smog. .

CO (carbon monoxide) – a poisonous gas resulting from imperfect combustion. High concentration of ingestion can cause death in minutes.

CO_2 (carbon dioxide) **–** although not harmful to health, it is a major concern on the issue of global warming. It is one of the greenhouse gases (GHG).

SO_2 (sulfur dioxide) - a combustion by-product that forms into sulfur trioxide (SO_3) then to acid rain.

Since perfect combustion produces only Carbon Dioxide (CO2) and Water (H_2O), all other emissions are products of imperfect combustion. Therefore, the quest for clean emission (and clean air) can be effectively attained through efficient combustion. ***Coco-Biodiesel optimizes combustion when blended in diesel fuel even with just 1%.***

COCONUT OIL AND COCO BIODIESEL

When people hear the word Coco Biodiesel for the first time, it is often mistaken for coconut oil (or cooking oil.). This is understandable because it does come from coconut oil. The molecule of coconut oil consists of 1 unit glycerine and a number of fatty acid component.of medium carbon chain. The medium carbon chain is what makes coconut oil unique from other plant oils in the world. Plant oil consists of glycerine and fatty acids. The glycerine component of plant oil has a high boiling point which prevents the plant oil from volatilizing. This is what makes it excellent as cooking oil. However, in biofuel application, what is used is the fatty acid component of the plant oil that is converted to another element called ester. Esters volatilize just as petroleum fuels. Glycerine and fatty acids are separated from each other by a process known as esterification. The plant oil is reacted with an alcohol with the aid of a catalyst. If the plant oil is coconut and methanol is the alcohol reactant, the resulting element is Coco Methyl Ester. Coco Methyl Ester is the chemical name of Coco Biodiesel.

Plant Oil + Alcohol + Catalyst (reaction process) → Glycerine
Plant Oil + Alcohol + Catalyst (reaction process) → Fatty Acid converts to Ester

A methyl ester molecule is a straight-carbon chain structure similar to fossil diesel fuel except that it is less clustered and has presence of oxygen molecule at the end of the carbon chain. In petroleum application, the nomenclature of saturated and unsaturated fatty acid changes to its IUPAC name "alkane" which is saturated carbon chain with carbon-hydrogen relationship expressed as C_nH_{2n+2}. Monounsaturated fatty acid becomes "alkene" (also referred to as olefin) with carbon-hydrogen relationship expressed as $C_nH_{2\ n}$. Polyunsaturated fatty acid becomes "alkyne" with carbon-hydrogen relationship expressed as $C_nH_{2n\ -\ 2}$.

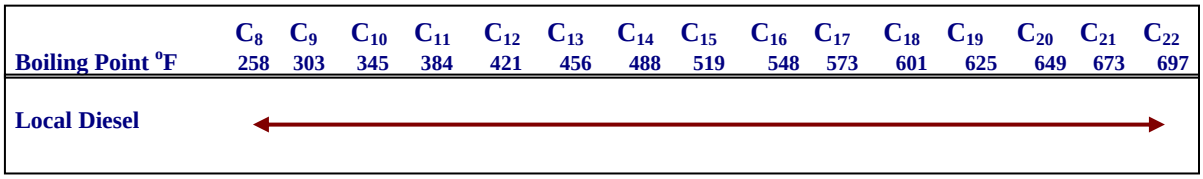
Example: Alkane C18 is saturated chain of 18 carbon and 38 hydrogen (C_nH_{2n+2}.)
Alkene C18 is monounsaturated chain of 18 carbon and 36 hydrogen ($C_nH_{2\ n)}$
Alkyne C18 is polyunsaturated chain of 18 carbon and 34 hydrogen ($C_nH_{2n\ -\ 2}$)

COCO BIODIESEL – A PREMIUM BIODIESEL

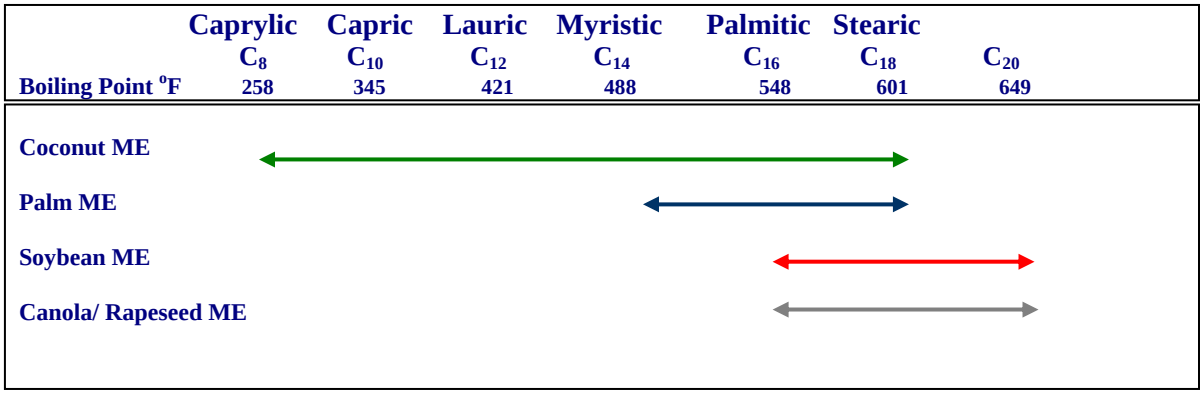
All biodiesels are excellent enhancers for diesel fuel proven to be effective in reducing emissions and in improving engine performance. But unlike biodiesel from rapeseed (Europe); soybean (U.S.); canola (Canada); and palm (Malaysia), Coco Biodiesel (Philippines) is unique due to its short and medium carbon chain making it a superb and versatile biodiesel. All Methyl Esters have ***high***

lubricity *and* ***oxygen content*** including coconut. However, the added features of ***high solvency, high cetane number, lower NOx emission, and excellent distillation range*** are specific only to Coco Biodiesel due to the presence of carbon 8, 10, 12, and 14 apart from carbon 16 and 18 which are the typical profile of most biodiesels. With five (5) fuel enhancing features versus only 2 or 3 features of other plant biodiesels, Coco Biodiesel is undoubtedly, a premium biodiesel!

Diesel Carbon Chain Profile



Methyl Ester (ME) Carbon Chain Profile



As seen in the foregoing chart, the distinction of plant hydrocarbon from fossil hydrocarbon is the absence of odd number carbon (i.e. carbon 9, 11, 13, 15, etc). Its molecule is less clustered and reacts better with oxygen in the combustion chamber.

BIODIESEL - FUEL FOR THE 21ST CENTURY

Petroleum analysts project that the world crude oil reserve shall reach its halfway mark between the year 2010 and 2015 and since demand growth is exponential, the world crude oil supply will be in critical level by 2040. The accuracy of this projection is not important. The message is simple - crude oil supply will run low within the first half of this century. Alternative fuels must be developed now and the most promising thus far are biofuels – ethanol for gasoline and methyl esters (or biodiesel) for diesel engines being renewable fuels.

Furthermore, the gloomy future of crude oil supply is exacerbated by disturbing important environmental issues concerning ozone depletion, global warming, and heavy air pollution. These have resulted in the legislation of stringent Clean Air Act in most countries. The development of Coco Biodiesel as well as Palm Biodiesels in Asia is timely since these tropical oils can address the problem of dwindling crude oil supply and the environmental issues for the Asian region.

As diesel fuel is produced from crude oil through fractional distillation, methyl ester (or biodiesel) is produced from plant oil through esterification. Plant oil such as soybean, rapeseed, canola, corn, sunflower, peanut, palm, coconut, mustard seed, jatropha, and many more will undoubtedly become the alternative fuel for the 21st century. Coco Biodiesel will play an important role in this new industry

Coco Biodiesel is an excellent emission cleansing fuel that can be blended with fossil fuel as well as with other biodiesels to address the quest for clean air. Perhaps the available supply of Coco

Biodiesel may be insignifacnt at the onset, but its development can be a very positive and promising direction. Developing supply of Coco Biodiesel only requires extensive replanting and fertilization of coconut trees. It is unlike the expensive exploration and drilling cost for crude oil which gives no assurance that crude oil can be found. Tropical countries have the proper climate, proper soil, and plenty of lands for planting.

ACTION OF COCO BIODIESEL
(Optimizing Combustion Efficiency to Produce Clean Emission)

There are thousands of studies and research data accumulated over the past 20 years from various universities and research institution in U.S., Europe, Canada, Japan, Australia and even Korea on Methyl Esters as biodiesel. All have dramatic and very favorable result. There are no negative report published on biodiesel except for the slight increase in NOx (in most plant oil) and potential effect of solvency on some rubber component at high treat rate. However, tests on Coco Biodiesel which includes those from Nihon University through the Japan Society for the Promotion of Science (JSPS) and the Technological University of the Philippines obtained excellent results in NOx and PM reduction:

1. NOx emission has decreased by as much as 20% (this is likely the effect of lower operating temperature due to the shorter carbon chain, wider distillation range, and high cetane number).

2. Emission of Particulate Matter (PM) has reduced by as much as 60% from as little as 1% blend in low sulfur diesel.

3. One (1) liter of Coco Biodiesel combusted with diesel fuel reduces CO_2 emission by 3.2 kg.

To understand the actions of Coco Biodiesel in promoting efficient combustion, there must first be a good understanding of why poor combustion occurs. The elements of combustion are Fuel, Air, and Heat Source. Deficiency in any or a combination of these three elements will result in poor combustion. Deficiency, on the other hand, can also be caused by three conditions:

Defective Engine Condition: Poor compression (in diesel engine) due to worn out piston ring, broken piston ring; worn out fuel pump; worn out fuel injector units; worn out (enlarged) fuel nozzles; blow-by; etc.

Dirty Engine Condition: Plugged or partially clogged fuel injector nozzles; deposits in fuel lines and ports; heavy carbon accumulation in combustion chamber; blocked exhaust system (heavy carbon deposit in muffler); dirty air-filter; clogged fuel filter, etc

Poor Quality of Fuel: High distillation range (high T90); high sulfur content; low Cetane No.; low lubricity; other

There is nothing Coco-Biodiesel can do to correct a defective engine condition. This requires the skill of a mechanic. However, **Coco-Biodiesel can do wonders in addressing a dirty engine**

condition and poor quality of fuel due to its unique features not present in fossil diesel (and in other biodiesels).

Oxygen Content - presence of 11% oxygen is ***common in all biodiesel***. Fossil diesel fuel has no oxygen content and is therefore prone to oxygen starvation during combustion. Coco Biodiesel promotes clean burning.

Lubricity - high lubricity feature of plant esters is ***common in all biodiesels***. 1% blend of Coco biodiesel increases the lubricity of low sulfur diesel by 36% based on laboratory report from Southwest Research Institute in San Antonio, Texas, U.S.A. It enhances boundary lubrication of fuel pump and injector units to restore atomizing pressure efficiency.

High Solvency - this feature is ***specific only to coco biodiesel*** due to the short and medium carbon chain which provides such feature. Other biodiesels have low to mild solvency. This feature effectively declogs fuel injector nozzles, fuel lines, and fuel ports of accumulated deposits (i.e carbon soot, gum, varnish, ash residue, and other resinous elements) to restore fuel spray efficiency. It also cleanses the combustion chamber of accumulated carbon deposits. It provides diesel fuel with a self-cleaning feature even at 1% blend.

High Cetane Number – this feature is ***specific only to coco biodiesel*** due to the low level of unsaturated fatty acid of coconut oil. Iodine value measures the unsaturates in fatty acid and has direct correlation with cetane number. Low iodine value equates with high cetane number and vice versa. Coco Biodiesel has iodine value of 7 – 10 with cetane number of 68. Other biodiesels have iodine value of 45 and above and cetane number of less than 50. Coco Biodiesel promotes better acceleration response, clean emission and greater mileage.

Excellent Volatility Range – this feature is ***specific only to coco biodiesel*** since it is one of only two common plant oil that has an initial boiling point of 258 ^{o}F (C8) and final boiling point of 601 ^{o}F (C18). It is the only biodiesel that runs parallel with the distillation range of U.S. Diesel No.1. Other biodiesel have narrow distillation range. Coco Biodiesel enhances the rate of volatilization and cold-starting feature of diesel fuel.

Although biodiesel can be used as 100% diesel fuel substitute (or B100) without need of engine modification or alteration, its high cost however does not make it a feasible substitute to fossil diesel as yet. Due to its quality enhancing features not present (or has weak presence) in diesel fuel, Biodiesel is currently used only as enhancer for diesel fuel. Biodiesel from soybean, rapeseed, and canola is used in U.S. and Europe at 5% to 10% blend to meet their strict emission standards. In many parts of Europe, 5% biodiesel blend (B5) is mandated by government. As to Coco Biodiesel, a 1% to 2% blend is effective enough to substantially reduce smoke and harmful emissions. In time, Coco Biodiesel will be known as an excellent blending component for other biodiesels for its special features coming from the short & medium carbon chain components. Coco Biodiesel will further enhance the performance features of soybean, rapeseed, canola, and palm biodiesels.

Coco Biodiesel surpasses the quality parameters for diesel fuel established in the "World Fuel Charter" by all automotive and engine manufacturers worldwide.

	International Spec.*		
Quality Parameters	**Diesel**	**Coco Biodiesel**	**Remarks**
Viscosity (cst @40^{o}F)	2 – 4	2.63	Meets Int'l Specification
Cetane Numer	53 min	68	Surpasses Int'l Specification

Flash Point, ^{o}C	55	104	Surpasses Int'l Specification
Sulfur Content,	0.030 max	Trace	Surpasses Int'l Specification
Distillation T90	340 ^{o}C	313 ^{o}C	Surpasses Int'l Specificatioon
Final Boiling Point (FBP)	365 ^{o}C	335 ^{o}C	Surpasses Int'l Specification

(Note * Specification published by the World Fuel Charter signed by all automotive and engine manufacturers. It allows blend of up to 5% Vegetable Derived Ester provided it is compliant with DIN VS 1606)

Coco Biodiesel is fast catching up in Asia. Tests conducted at Tokyo Metropolitan Research Institute in Japan and SK Corporation at Daeduk Institute in South Korea show favorable potential of Coco Biodiesel in addressing air quality standards. Industrialized countries in Asia like Japan and Korea are seriously looking at 5% blend of biodiesel to address the objective of the Kyoto protocol i.e. reduction of CO_2 emission and other greenhouse gases or GHG as well as Particulate Matter (PM). For Japan alone, a 5% biodiesel blend translates to 2 billion liters per year, far beyond what the Philippines can supply. Furthermore, the 2004 Biodiesel Guidelines published by U.S. NREL (New Renewable Energy Laboratories) show excellent potential of coco biodiesel as a blending component for other plant biodiesel to enhance their emission cleansing features.

Effects of Fatty Substance in Engine Performance *

	Saturated $C_{8:0}$; $C_{10:0}$; $C_{12:0}$; $C_{14:0}$; $C_{16:0}$; $C_{18:0}$; $C_{20:0}$	**Mono Unsaturated** $C_{16:1}$; $C_{18:1}$; $C_{20:1}$	**Poly Unsaturated** $C_{18:2}$; $C_{18:3}$; $C_{20:2}$; $C_{20:3}$
	(Coconut/ PKO)	***(Palm)***	***(Soybean, Canola)***
Cetane Number	**High**	**Medium**	**Low**
Cold Flow Plug Point	**High**	**Medium**	**Low**
Oxidation Stability	**High**	**Medium**	**Low**
NOx Emission	**Reduction**	**Slight Increase**	**Large Increase**

(Note * Data from U.S. NREL 2004 Biodiesel Handling Guidebook)

From the foregoing, it can be clearly seen that coco biodiesel will play a very important role in the development of New Renewable Energy (NRE) for land transport in the 21st century.

Coconut is indeed the "tree of life" not just for the *food* that we eat *but* also for the *air* that we breathe. If government policy is crafted well, coconut can also be a "tree of prosperity" due to its high volume potential export market just waiting to be tapped.

Everything begins with the development of the local market to promote interest in coconut planting and fertilization as well as plant investments.

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(The *Author:* *Rafael S. Diaz was formerly a Senior Marketing Executive of Petron Corporation and prior to that, he was Division Manager for Operation at PNOC-EDC concurrent as Gen. Manager of PNOC Alcogas Corporation. He took an early retirement from Petron Corp. in Nov. 1999 after 29 years in the petroleum industry and is currently the Managing Director of the Asian Institute of Petroleum Studies, Inc. (or AIPSI). He has undertaken extensive studies and research work on Bio-Petroleum specially on Coconut Methyl Ester and has been conducting Information and Education Campaign (IEC) on Coco Biodiesel. Todate, he has conducted more than 100 lectures and seminars in promoting CME as Biodiesel since he first co- presented the concept to UCAP and PCA sometime 2nd quarter of 2001. He also conducts seminars and special lectures on Fundamentals of Petroleum and Bio-petroleum, Combustive Emissions, and Tribology of Lubrication to oil company personnel and to graduating engineering students of various colleges and universities)*