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Potentials of palm oil as new feedstock oil for a global alternative fuel: A review

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ABSTRACT

Increasing in oil consumption and ridiculous prices has caused the urgency for the main global oil industry players to search new alternative fuels which is biofuels. Biodiesel is better option to replace the crude oil due to its similar characteristics and sustainable. This paper will review the biodiesel produced and implementation from palm oil in Malaysia and current engine research that related to palm oil. Precedency given to the palm oil as it is main raw stock for biodiesel produced in Malaysia. Among scopes of this paper are to discuss current issues related to the palm biodiesel production and specific use in diesel engines. Another issue that arisen for Malaysia is to promote the palm oil as the alternative fuel that meets the stringent regulations and standards in Europe and North America. This paper also briefly covers the continuous global biodiesel consumption trend including the constraints that faced by Malaysia for leading the global biodiesel market with the benefits and drawbacks of palm oil biodiesel as an alternate fuel compared to the other common biodiesel sources.

1. Introduction

Fossilized energy has contributed the most impact of the economic development in the world through the transportation sector and energy conversion sector. Middle East region has supplied about half of oil production in the world and the rest come from the central Asia region and America continent. However, the uncertain of oil prices have given the side effect to the world economic with the factors of instability political situation especially in the Middle East region and the decrease of crude oil production reserve. This scenario has started in early 1970 with the oil price increased to US Dollar 110 per barrel and another highest oil price recorded was in 2009 with over US Dollar 135 per barrel [1]. The erratic increase in oil prices was reflected due to Arab-Israel War and the Iran revolution that held between year 1965 and 1975. The economics of depending mostly on imported fuels have grown in recent years as oil prices have become unstable, doubling in less than two years the price of 2004 and reaching in 2006 oil prices [2]. This trend of events has shown that the oil prices will not be permanent and could be escalate again depending on world instability situation and increasing demand factor. Uncertain oil prices in the oil market have enhanced the growth of commercial viability of alternatives fuels that can replace the fossilized fuels without any modification to the engines. Moreover, in the environmental side, the use of fossilized energy especially in the transportation where at least 25% has contributed to the increasing of toxic gas and affected and greenhouse emission. With the growing awareness of energy-pollution and a climate change consequence, as well as complying to the Kyoto Protocol that targets the use of less energy pollution from emitting energy source which is a clear message to the global for a change towards more sustainable energy production and conservation [3–14]. In year 2030, transportation sector will be the most emitting factor for the world with the growth demand of vehicles on the road. Emission contents which released from the vehicles show the linear scale with the fuel consumption where today's vehicles are mostly running with fossilized fuels [9,12,13,15–25]. Following the trend, the increase of GHG also will be projected to 50% by 2030. The use of fossilized fuels has released the toxic gas including carbon monoxide (CO), nitrogen oxide (NOx), unburned hydrocarbon (UHC) and unseen particulate matters. This combination of harmful portion can cause unhealthy air that affects to the human respiratory system and thick fog that

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surround the area with low vision range. According to Vardoulakis et al., the higher contents of particulate can result cancer, respiratory diseases such as asthma, allergic and others that can affect the quality of health [26].

With those main conflicts that related with the fossilized oil, new technology discoveries have been promoted by researchers in order to overcome the dependent on fossilized fuels. There are astonishing efforts to promote the use of solar power, hybrid with less consumption of fuel, hydrogen fuel cell, biofuels and others to the people. Still not many people are ready to the complete changing where the cost is still expensive in terms of cost, not truly practical and lots more researches needed to improvise those methods. Nevertheless, the suitable replacement and quite similar to the fossilized fuels is the biodiesel fuels that extracted from the plants and animal fats in term of characteristics, properties and without any modification of the engine. In recent years, there are two main types of biofuels which refer to first of generation biofuels called bioethanol, which is derived from starch or sugar such as cane, corn and sugar beet, and second generation biofuels is biodiesel, derived from animal fats and vegetable oils, for example from palm oil, jathropa, soy bean, rapeseed oil, neem oil and others [27–32]. In this case, the European Union has shown the full commitment and support for the biofuels, with targeting the demand in biofuels for the transportation sector to 5.75% by 2010 and projected to 20% by 2020. The Biofuels Directive issued by the European Commission in 2003 set the target to implement the use of biofuels in EU countries and committed in achieving their targets and following the proposed EU policies in 2006 to cultivate the use of biofuels massively [33,34].

In this review, a brief outlook has been conducted on the potential of palm oil biodiesel to substitute the conventional diesel as a new fuel generation. The survey cover the current trend of production and implementation of palm oil in Malaysia, chemical compositions and physic-chemical properties of palm biodiesel, and current summary reviews on application in terms of engine performance and emission.

1.1. Advantages and disadvantages of biodiesel

Biodiesel is the generic terms for all types of fatty acid methyl ester (FAME) which considered other organic renewable alternative fuel that can be used directly in any mineral diesel engine with little or no modification [18,35–39]. They are transesterified-vegetable oils that have been adapted to the properties of fossilized diesel fuel and considered to be superior since they have a higher energetic yield been combusted in the diesel engine [12,16–18,20,40–44]. Current compression ignition (diesel) engines are able to operate upon a wide range of fuels due to its specific characteristic, which is internal combustion under a variety of operating conditions. In a world of resources, it seems prudence to focus upon fuels, which are potentially efficient and renewable, like bio-fuels.

Besides this advantage in fuel flexibility, compared to those of spark ignition (petrol) engines, diesel engines can offer better engine durability, higher thermal efficiency and more economical fuel consumption [45–47]. Through centuries, diesel engines were used in many sectors such as in transportation and industries. Diesel engines usually used in heavy industries, light heavy automotive, ships, locomotive transportation such as truck and buses, and farm machines such as lawnmowers and tractors [48]. The latter relates to fuel economy savings that can potentially produce less carbon dioxide (CO_2) emission. Diesel engines are therefore, part of a long-term solution to global warming.

Tables 1 and 2 present the advantages and disadvantages of the biodiesel summarized from the past literature review by the researchers.

Currently, diesel engines use fossilized fuel in its combustion process. However, it is estimated that the fossil fuel supply will decrease in the future. Petroleum demand around the world is projected to increase by 50% by 2030 [97]. This happens due to maximum production of the fuel, which causes fuel reserve decreases drastically to a minimum level. Eventually it leads to demand succeed supply and finally increase the fossil fuel price. There are a few alternatives to overcome those problems such as the use of hybrid engine to minimize the fuel consumption and the exhaust emission; improvement on the diesel engine with modifications such as HCCI (Homogenous Charge Compression Ignition) engine and others. However, those solutions are still under continuous research and not yet be produced commercially even for hybrid. The most preferred solution is using the renewable alternative fuels that can fuel the diesel engine without difficulty. All biodiesels are not produced by the fossil fuel distillation but are extracted through a chemical process called transesterification process to produce methyl ester or ethyl ester. Those alternative fuel properties are similar to diesel fuel but produce less emission, same or higher performance than the diesel fuel itself [103–105].

1.2. Current trend of biodiesel fuel

According to the report prepared by a non-profit organization, REN21, the total global biodiesel production achieved an estimated production level of 19 billion liters (5.02 billion gallons) in 2010, which means an increasing of 12% from the previous year [106]. While the EU topped as the world's largest biodiesel producing region in 2010, with approximately 65% percent from the world total biodiesel production, producing 9.57 million tons [107]. As for United States, the total biodiesel production declined to 311 million gallons in 2010 from 532 million gallons in 2009 (EIA & Administration, 2011). Retail price subsidies and tax exemption on the use of biodiesel accounted to 90% are among the factors, which the EU Parliament is considered to encourage the public to use the biodiesel fuel for the transportation (Balat & Balat, 2008). Those are the substantial reasons why European Union has become the largest biodiesel producer with the estimation of 9.6 million metric tons in 2010 and responsible for over half of the world's biodiesel production [107].

Table 1
Advantages of biodiesel.

Advantages	Ref.
Comparable fuel properties with conventional diesel	[49–51]
Biodiesel can be used directly to operate diesel engine up to 20% blend with mineral diesel with no or little modification if higher blending ratio are used.	[52–54]
Biodiesel is an oxygenated fuel with 10–12% oxygen content that contributes to higher combustion characteristics.	[16,17,41,55,56]
Great potential to reduce the CO_2 emission up to 78% in the lifecycle basis and decrease the smoke emission with minimal soot.	[12,57–59]
Lubricity improvement on the engine that helps cleaning the engine and protects the engine from rusting. Smoothness in engine crank movement increases the engine efficiency.	[16,41,60]
Decrease in ignition delay due to higher Cetane number of biodiesel (averagely 60–70 as regards to the type of vegetable oil source)	[12,43,56]
Short period production process is required to produce the biodiesel from the raw vegetable oil.	[61–63]
Unlimited sources from non-edible and edible oil as well as animal fats and waste cooking oil.	[43,61,62,64–66]
Low toxicity, biodegradable and environmental-friendly	[67,68]
Safe to storage due to higher temperature of ignitability (non-flammable) and higher flash point	[24,56,59,69–74]