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Green fuel as alternative fuel for diesel engine: A review

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ABSTRACT

Green fuels also called green hydrocarbons, biofuels, are fuel produced from biomass sources through a variety of biological and thermochemical processes. These products are similar to petroleum gasoline and diesel fuels and are therefore considered fully infrastructure compatible fuels. They can be utilized in engines without engine modification. This paper presents a comprehensive review on the potential of biodiesel from different waste feedstock biodiesel such as waste cooking oil and waste plastic oil. Furthermore, the effect on the engine performance, combustion and exhaust emissions including details of engine and operating condition also review in this paper. The main goal of this paper is to provide information to the engineers, industrialists and researchers who are interested on waste biodiesel and to prominence waste biodiesel as a promising alternative replacement for fossil fuels. A large number of literatures from highly rated journals in scientific indexes are reviewed including the most recent publications.

1. Introduction

Global warming has become an issue of some concern over the last couple of decades. According to the environmental protection agency (EPA), global warming is defined as the recent and ongoing rise in earth surface temperature [1–3]. Its effects can be clearly seen as an increase in extreme weather events, warming of the oceans, disappearing glaciers and polar ice, damaged coral, and wildlife distributions, changes in health, and increased activity and abundance of disease vectors. On 12 November 2015, NASA scientists reported that human-made carbon dioxide (CO_2) continues to increase above levels not seen in hundreds of thousands of years. The International Energy Agency (IEA) forecasts that the emissions of CO_2 from transport sector will increase by 92% between 1990 and 2020 and it is estimated that 8.6 billion metric tons carbon dioxide will be released to the atmosphere from 2020 to 2035 [4–6]. Currently, about half of the carbon dioxide released from the burning of fossil fuels is not absorbed by plants and the oceans and it is remains in the atmosphere [7]. Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of CO_2, from 280 ppm in 1750–400 ppm in 2015 [8,9]. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle. Anthropogenic CO_2 emissions come from combustion of carbon-based fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture [10]. The reason fossil fuels are a problem for global warming is that they are releasing additional carbon that had been sealed away in the Earth's long-term storage, away from our ecosystem. This means that burning them increases the total amount of carbon dioxide circulating through our ecosystem. In 2013, Li [11] observed that extracted fuels and use of fossil fuel is the main contributor to the greenhouse effect emission which is result to the global warming and the consequent climate change.

Energy crisis happened in the past decades due to the substantial reduction of exhaustible resources like fossil fuels. Research 2008 done by Baruch [1] observed that the rising population there is growing demand in products and services as economic development is accelerated which translates to an increased energy demand, which is projected to double by 2050. This means that in the years to come, the world's population is projected to increase and so is the demand in energy, which is in a paradoxical state with the fact that the traditional fossil fuels are finite in abundance [12]. Currently world facing two critical issues which are increased environmental degradation and depletion of fossil fuel.

Transportation system has a great importance for social and economic development of any country. It is contributes significant amount of greenhouse emission particularly in the developing and developed countries. The maximum amount of greenhouse gases added to the atmosphere are from electricity and transportation sectors and the corresponding values are 34% and 27% [13]. The rising issue for

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transportation sector is the energy which mainly fulfilled by gasoline and diesel fuel. Globally 1.1% in average energy consumption is increased in the transportation sector every year. The transportation sector accounts for the largest share (63%) of the total growth in world consumption of petroleum and other liquid fuels from 2010 to 2040 [6,14]. It is very urgent to find out alternative fuels for transportation sector as this sector is emitting higher greenhouse gas (GHG) emission and contribute to the rapid growth of global oil demand [15]. It has been anticipated quite clearly that the problem cannot be solved with the conventional fossil fuels as their reserves are limited and also the emission norms are expected to be more stringent in future [16]. Two main internal combustion engine types such as petrol engine and diesel engine contribute to degrade the air quality in the urban environment [5].

Modern Compression Ignition (CI) engines have evolved from the very first invention by Dr Rudolf Diesel in 1897 [17], thus alternatively named as diesel engine. The development of diesel engines as a new technology has steadily progressed in the past. CI engines, normally known as diesel engines, have found widespread applications as power sources in the transportation sector, mining and remote rural and regional areas, as well as in many emergency services. Their innate high efficiency, better fuel saving, lower CO_2 emission, superior torque and longer durability in comparison to the spark ignition engine and durability have resulted recently in unprecedented growth in their share of the passenger car and heavy machinery markets [18,19]. Due to high fuel efficiency, the diesel engine became the engine of choice for on-road and off-road operations such as passenger vehicles, heavy trucks, buses, trains, boats and ships [20] greatly impacting on agriculture, power generation and mass transportation sectors [21]. The diesel engines can either be two-stroke or four-stroke. These engines release power by compressing air to attain high pressure and temperature of the injected fuel, which release chemical energy and work is done when there is expansion of the combustion gases. Comparatively, a higher efficiency of diesel engine is achieved by operating at higher compression ratios and at relatively greater air to fuel ratios as well as having more rapid combustion and lower throttling loses. However, the ever increasing demand for diesel engines has led to its dominance as a source of pollutants threatening human health and the environment. Diesel engines generate exhausts containing hundreds of harmful substances, among which the emissions of particulate matters (PM) or soot, carbon monoxide (CO), unburned hydrocarbons (UHC) and oxides of nitrogen (NOx) have been restricted by standard regulations in many countries [22–25].

1.1. Objective of this paper

This paper presents a comprehensive review on the potential of biodiesel from different waste feedstock biodiesel such as waste cooking oil and waste plastic oil. Furthermore, the effect on the engine performance, combustion and exhaust emissions including details of engine and operating condition also review in this paper. The main goal of this paper is to provide information to the policy maker, engineers, industrialists and researchers who are interested on waste biodiesel and to prominence waste biodiesel as a promising alternative replacement for fossil fuels. A large number of literatures from highly rated journals in scientific indexes are reviewed including the most recent publications.

2. Different feedstocks for biodiesel

Table 1 shows primary biodiesel feedstock for some selected countries around the world. There are more than 350 oil-bearing crops recognized worldwide as potential sources for biodiesel production. The broad range of existing feedstock for biodiesel production represents one of the most important advantages of biodiesel. According to some researches, feedstock acquisition currently accounts for over 75% of biodiesel production expenses as show in Fig. 1. In general, biodiesel feed- stocks can be divided into four main categories as below [26–29]:

Table 1
Current potential feedstocks for biodiesel production worldwide [26].

Country	Feedstock
USA	Soybeans / waste oil/peanut
Canada	Rapeseed/animal fat/soybeans/yellow greaseand tallow/ mustard/flax
Mexico	Animal fat / waste oil
Germany	Rapeseed
Italy	Rapeseed/sunflower
France	Rapeseed/sunflower
Spain	Linseed oil / sunflower
Greece	Cottonseed
UK	Rapeseed / waste cooking oil
Sweden	Rapeseed
Ireland	Frying oil/animal fats
India	Waste plastic oil/waste tyre oil /Jatropha/Pongamiapinnata (karanja)/soybean/rapeseed/sunflower/peanut
Malaysia	Palm oil
Indonesia	Palm oil/jatropha/coconut
Singapore	Palm oil
Philippines	Coconut/jatropha
Thailand	Palm/jatropha/coconut
China	Jatropha/waste cooking oil/rapeseed
Brazil	Soybeans/palm oil/castor/cotton oil
Argentina	Soybeans
Japan	Waste cooking oil
New Zealand	Waste cooking oil/tallow

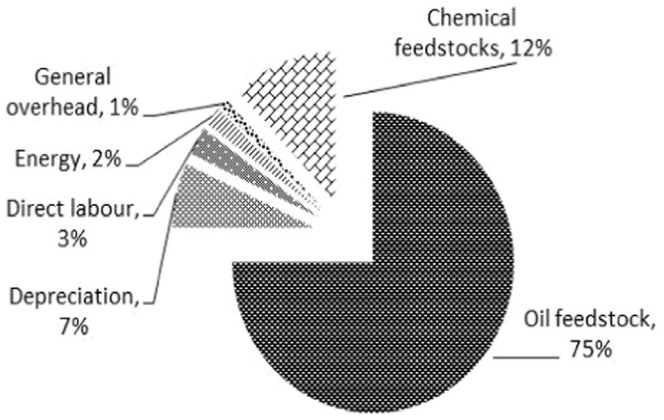

Fig. 1. General cost breakdown for production of biodiesel [26,28–33].

1. Edible vegetable oil: canola, soybean, peanut, sunflower, palm and coconut oil.
2. Non-edible vegetable oil: Jatropha curcas, calophylluminophyllum, moringaoleifera and croton megalocarpus.
3. Animal fats: chicken fat, pork lard, beef tallow and poultry fat.
4. Waste or recycled oil.

3. Waste fuel

Recently, many investigators have focused on finding and utilizing new energy sources that are renewable and also environmentally friendly [34–36]. The researchers have tried to advance new technologies that make possible for recycling and/or reusing waste materials as a resource of energy [37]. As a result of such studies, alternative energy use has increased day by day. Large quantities of various “waste” energy sources, such as waste plastics and waste cooking oil have been utilized for this purpose, in recent years. Most of the current challenges are targeted to reduce its production cost, as the cost of biodiesel is still higher than its petro-diesel counterpart. This opens a golden opportunity for the use of waste fuel as its production feedstock.