



## A review on the properties, performance and emission aspects of the third generation biodiesels

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### ABSTRACT

In the effect of robust industrialization and rapid augmentation of a number of fleets, there has been a huge rise in the fossil fuel consumption. Tremendous increase in global warming threatens the ecological balance of the earth. Based on the recent sorts of hardship about the fuel, researchers are profoundly pondered over the field of renewability, environmentally friendly and economically doable. In recent decades biodiesel fuel becomes the center of attraction among researchers since it is renewable, bio degradable, non-noxious, eco-friendly and sustainable. This review paper highlights and reviews the properties of prosperous variety of the biodiesel fuels derived from non-edible feedstocks which are termed as third generation biodiesel and its effects on the performance and emissions of the diesel engines. It was observed that the physicochemical properties of the biodiesel differ based on the types of feedstocks and also have a considerable effect on the potential performance of engine and dynamic characteristics of emission level. Also, the usage of biodiesel commonly leads to a reduction in noxious pollutants like carbon monoxide, unburnt hydrocarbon and particulate matter with an obvious increase in fuel consumption and NOx emission. This review provides a prospective strategy for the researchers for enhancing the engine performance and emission characteristics by using the third generation biofuels and its blends with the productive marvelous outcomes.

### 1. Introduction

With the simultaneous expansion of population and industrialization, the diminution of fossil fuel reserves leads to increased petroleum price [1]. The various sectors like transport, industry and agriculture consume the major part of the energy produced by the different sources like coal, petroleum, wood, wind, solar, nuclear [2–4]. On analyzing sector wise fuel oil consumption, transportation sector contributes 64.5% of total world's oil consumption in 2014 and is displayed in Fig. 1. This is nearly 42% hike when compared to 1973 [5]. Since the major prime mover used for the transportation fleets are diesel engines, biofuels gain thriving attention among the researchers a potential substitute for diesel fuels [6,7]. In the environmental aspects, diesel engine emits harmful pollutants like particulate matter, unburnt hydrocarbon, Nitrogen oxides, carbon monoxide and smoke. Among the diverse pollutants, the most noteworthy are oxides of nitrogen and smoke [8–12]. Also, the carbon dioxide accumulation and other green house gases in the atmosphere are responsible for climatic change and other global consequences for life on earth realm [13]. The atmospheric CO<sub>2</sub> concentration has been predicted to rise by 80% in the year 2030

above the levels of the year 2007 [14]. The deterioration of fossil fuel reserves and mounting environmental concerns has moved researchers to develop alternate sources for traditional petro based fuels [15–17]. Vegetable oil becomes one of the most important sources of alternatives to fossil fuels due to its economic perspective and emission quality [18–20]. Biodiesel is the mono alkyl ester derived from the fatty acid esters of raw vegetable oil or animal tallow [21,22]. Even though biodiesel possesses enhanced properties than crude vegetable oils, the major setbacks of biodiesel are high viscosity, low volatility, poor spray characteristics, lower energy content, augmented nitrogen oxide (NO<sub>x</sub>) emission, high cloud point and pour point, when compared to diesel fuel [23]. Many studies have been empirically carried out to resolve all sorts of hardships within the ambit of biodiesel utilization by using various strategies like using various feedstocks, engine modifications and by using fuel additives.

#### 1.1. Indian scenario

In a highly populated country like India, the need for petro based products is quite imperative and inevitable to a greater extent as

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Nomenclature		NO <sub>x</sub>	Oxides of Nitrogen
BTE	Brake Thermal Efficiency	PM	Particulate matter
BSFC	Brake Specific Fuel Consumption	ASTM	American Society for Testing Materials
BFCE	Brake Fuel Conversion Efficiency	EN	European Standards
HC	Hydrocarbon	D	Diesel
CO	Carbon monoxide	B	Biodiesel
CO <sub>2</sub>	Carbon dioxide	CRDI	Common Rail Direct Injection

compared to other countries. In India, diesel fuel consumption is five times higher than gasoline [24]. Due to the mass energy insecurity and a huge hike in energy prices, India will face a serious energy shortage within next couple of decade [25]. According to a report by Greenpeace on March 24, 2009, renewable energy can lucratively meet over 35% of power requirement in India by 2030 [26]. In India, Ministry of New and Renewable Energy (MNRE) have prepared the National Policy on bio-fuels which propose the 20% blending of biofuels to traditional petro based fuels by 2017 [27]. According to British Petroleum's statistical review of world energy 2016, India's oil consumption has increased from 180.8 Million tons to 195.5 Million tons which are 8.1% increase in 2015 when compared to 2014 which is 4.5% of world's total oil consumption. In biofuel production India holds 0.5% of global share and also there was 13.1% lift up in biofuel production in 2015 over 2014. In 2015 India's primary energy consumption was satisfied by coal (407.2 Mtoe) and oil (195.5 Mtoe). The primary energy consumption was increased by 5.1% in 2015. India also shows a drastic amplification in the CO<sub>2</sub> level of 5.3% in 2015 which is 6.6% of total share of world's CO<sub>2</sub> emission. India became third largest electricity producer in 2013 with 4.8% of global share but the rate of electricity generation in India has increased in 2015 with a global share of 5.4% [28]. Despite the energy generation, India is still facing energy deficit which forces the government to take serious steps towards promoting renewable energy sources which in turn provides energy security.

1.2. Global scenario

Global carbon dioxide emissions from the petroleum based fuels and mushroom growth of industries increased to a new height of 35.3 billion tons of CO<sub>2</sub> in 2013 [29]. In 2014, the consumption of fossil fuels has been increased by 2.6% and 1.2% higher than that of 2013 for China and United states, whereas the global biofuel increased gradually by 7.4% [30]. In the 8.5% of Brazilian agricultural territory, about 0.9% of the land is entirely devoted to sugarcane cultivation (for ethanol production). In the Sao Paulo state of Brazil, bioethanol contributes

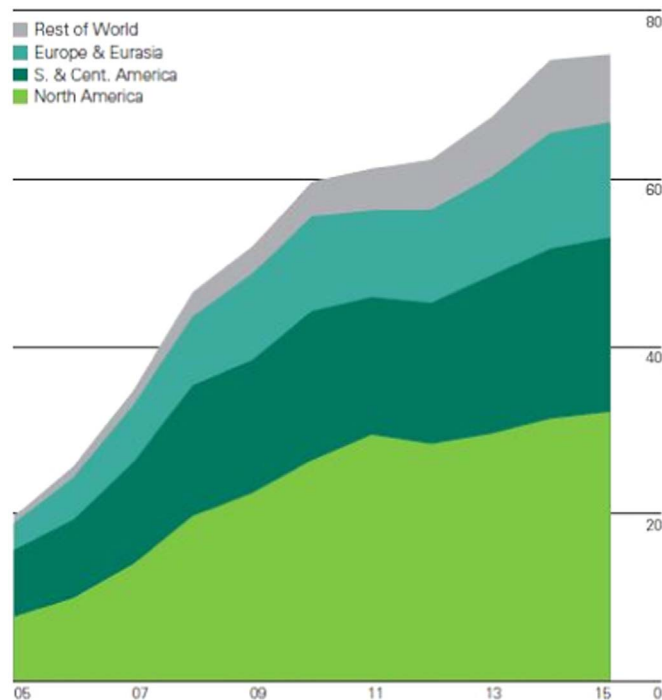


Fig. 2. World biofuel production (in million tonnes of oil equivalent).

57% of fuels consumed by flex fuel vehicles during 2012 [31]. In the United States and Brazil, soybean is commonly used as feedstocks for biodiesel production whereas palm oil gets a top major source of biodiesel in Malaysia and Indonesia [32,33]. The leading producers of biofuel in the world are the United States, Brazil and Germany whose global share of biofuel production is 41.4%, 23.6% and 4.2% respectively in 2015. While analyzing the world's biofuel production, it can be clearly seen that North America contributes a spectacularly maximum of 42.9% and total Africa contributes a minimum share of 0.1%. From Fig. 2, it can be clearly seen that the global biofuel production raised by 0.9% in 2015. In a global perspective, Ukraine and Venezuela show a radical decline in oil consumption rates of 16.1% and 12.7% in 2015 when compared to 2014. On the other side, Philippines and Slovakia shows a prominent increase of oil consumption rates of 14.3% and 11.3% in 2015. The most important context in the global view is that Organization for Economic Cooperation and Development (OECD) countries contribute 47.5% and Non-OECD countries contribute 52.5% of global oil consumption [28].

1.3. Feedstocks for biodiesel production

From the literature survey conducted, there are copious feedstocks reported for the production of biodiesel. The selection of feedstocks depends upon the availability and economic aspects of the concerned country. In countries like USA and Brazil, soybean oil is broadly used for biodiesel production whereas canola oil is main raw material in Canada. Meanwhile, Finland, UK Germany and Italy depend on

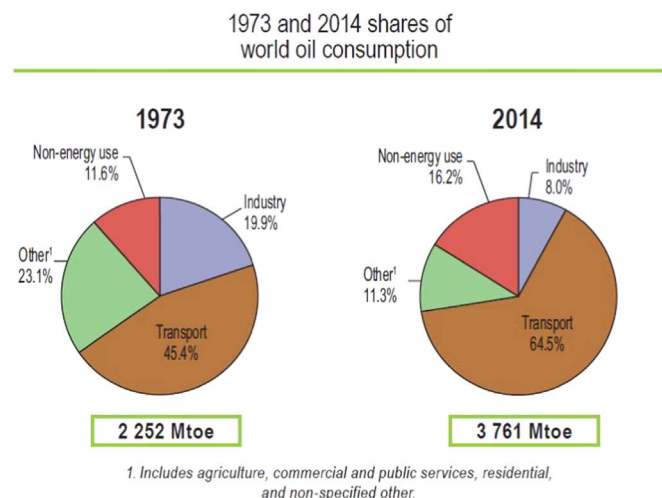


Fig. 1. Worldwide oil consumption by sector (in Million Tonnes of Oil Equivalent).

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