



Effect on direct injection naturally aspirated diesel engine characteristics fuelled by pine oil, ceiba pentandra methyl ester compared with diesel



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ABSTRACT

This paper explores the experimental investigation of the performance, emission and combustion characteristics of bio fuels from ceiba pentandra methyl ester (CPME), ceiba pentandra methyl ester-pine oil blends (CPMEP) and pine oil and the results are compared with diesel. In ceiba pentandra seed oil the CPME yield is 92% by using transesterification process with the optimum conditions of 560 rpm, reaction time 58 min, catalyst concentration 13 g and methanol amount 500 ml. The viscosity of CPME is high when compare with diesel. So the low viscosity of pine oil is blended with CPME and it can be directly used in diesel engine without any modification. At different loads the Pine oil, CPME and CPMEP blends were used in direct injection naturally aspirated compression ignition engine. The outcomes exhibited that at full load conditions for CPME and CPMEP blends increased brake specific fuel consumption, and decreased brake thermal efficiency, CO, HC emissions. NOx emissions decreased and smoke emissions are increased on CPME and CPMEP blends, expect B25 blend compared with diesel. The combustion analysis like the heat release rate, peak cylinder pressure, cumulative heat release rate and ignition delay for CPME, CPMEP blends slightly lower and combustion duration higher than diesel and pine oil. At the Same engine operating condition, the engine fuelled with pine oil the values of brake thermal efficiency 4.79%, peak cylinder pressure, heat release rate, cumulative heat release rate and ignition delay are increased. Brake specific fuel consumption, CO, HC, and smoke were 9.46%, 16.66%, 14.89% and 8.33% decreased. However, the NOx emission is 8.29% higher than that of diesel. Experimental fuels up to B50 (50% pine oil and 50% CPME) blends have proved good potential for future energy is needed.

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1. Introduction

As global oil reserves decline and climate change resulting from the burn of fossil fuels becomes more apparent, it's plays a vital role to develop and exploit sustainable and non-polluting (ie carbon neutral) energy sources. At the same time, it has

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been estimated that oil production will show a downward trend to become just 35% of today's production by the year 2075 (Aliyy et al., 2011; Calero et al., 2014). Another drawback is the combustion of fossil fuel created from diesel engines has polluted the environment through the exhaust emissions of particulate matter (PM), unburned hydrocarbons (HC), oxides of nitrogen (NO_x), carbon dioxides (CO₂) and oxides of sulphur (Sox) and also the conventional fossil fuel used in diesel engines contains higher amounts of sulphur and aromatics, which creates environmental pollution (Prem Anand et al., 2010). On the other hand; biofuels appear to be a potential alternative green energy substitute for fossil fuels owing to the reason is that it is available and renewable throughout the world. Oxygen content of biofuels produces complete combustion in comparison with conventional diesel fuel (Sbihi et al., 2014). Further, the environmental benefit is also another motivation factor due to a lesser greenhouse effect, less air pollution, less contamination for water and soil and a reduction in health risk (Schumacher et al., 1996; AL-Hamamre and Yamin, 2014). Shukla et al. (2015) performed experiments for a comparative evaluation of jatropha, polanga and karanja biodiesels for their performance and emission characteristics. They stated slight reduction in power output while using biodiesel blends in compared with base diesel. Dhar and Agarwal (2014) reported slightly higher brake thermal efficiency, when the engine was fuelled with karanja biodiesel, particularly at high loads in comparison to base diesel. Increased 1.5% to 3% in brake thermal efficiency for rice bran biodiesel blends in compared with diesel (Sinha and Agarwal, 2005). Generally bio-diesel fuelled engine and its blends lead to reduction in carbon monoxide (CO), unburned hydrocarbon (HC), carbon dioxide (CO₂), particulate matter (PM), sulphur oxides (SO_x), smoke and increased oxide of nitrogen (NO_x) emissions in compared to mineral diesel (Mofijur et al., 2013). So Bio-diesel generally produced from vegetable oil or waste oils or animal fat, through transesterification method in the presences of at elevated temperature. This conversion of triglycerides into ethyl ester or methyl ester, through transesterification process, the molecular weight was reduced to one third that of the triglycerides and also the viscosity was reduced, with a marginally increased in volatility. Thus after transesterification process, the properties of the biodiesel are so conducive for its use in diesel engine (Panneerselvam et al., 2015).

From the above brief literature review, it is clear that several studies have been carried out with different biodiesel as an alternative fuel in diesel engine. In general, pine tree widely growth for its, bark, turpentine, wood and essential oil, can growing up to approximately 40 m. The important oil obtained from pine tree is called as pine oil, which is a fresh forest smell. There are three different types of pine oil knows, wood, gum and sulfate pine oil, each being produced from different parts of pine tree and has their own distinctions. Seemingly, a pine tree can deliver an average of 2.75 kg of pine oleoresin, which contains 65% rosin and 20% turpentine and the turpentine current in it used as a raw material for producing pine oil. The estimated world production of pine oil was reported to be 30,000 tons per annum and the demand for pine oil by 2022 was predicted to be 8, 53, 894 tons (Vallinayagam et al., 2014a,b). The pine oil remarkable fuel properties such as lower cetane number, viscosity, flash point, and higher calorific value compared to diesel. The ceiba pentandra pods were collected at Thottiyankadu, Kottapalayam, Palamedu village, Tamilnadu, India on October 2014. It was grown naturally in agricultural land. Ceiba pentandra seed occupy about 35–42% (W/W) of each fruit. The oil seed yield was producing on average 2850 kg/ha and the oil extracted by using steam treatment process shadowed by mechanical crushing process. Ceiba pentandra seed were low feeding value owing to its higher fiber content. Furthermore, the possibility of kapok (ceiba pentandra) fiber as bio-ethanol feed stock. The found that kapok fiber contains 34–64% of cellulose higher potential to produce cellulosic ethanol. Traditionally kapok fiber is utilized as stuffing material for pillows and bed (Panneerselvam et al., 2016).

2. Materials and methods

2.1. Fuel properties of diesel, pine oil, bio-diesel and its properties

Production of ceiba pentandra methyl ester (CPME) as biodiesel was carried out by using transesterification process. The optimum conditions for transesterification process were stirrer speed 560 rpm, reaction time 58 min, catalyst concentration 13 g and methanol amount 500 ml with the conditions the optimal CPME yield achieved was 92%. As far as the author know, none of them used ceiba pentandra methyl ester and pine oil blends as a fuel for diesel engine. The objective of this current study is to produce CPME from ceiba pentandra seed oil through transesterification process. The produced biodiesel and its pine oil blends (CPMEP) as a fuel for direct injection diesel engine. To evaluate the performance, emissions and combustion characteristics. The properties of ceiba pentandra methyl ester (CPME) blended with pine oil (CPMEP), B25 (25% and 75% pine oil), B50 (50% CPME and 50% Pine oil), B75 (75% CPME and 25% Pine), B100 (CPME100%) compared with diesel and pine oil. As per the ASTM standards presented in Table 1. When the blend ratio increases, specific gravity, kinematic viscosity

Table 1
Physical and chemical properties of diesel, pine oil, CPME and CPMEP blends.

Properties	Diesel	Pine oil	B25	B50	B75	B100
Kinematic viscosity (cSt) at 40 °C	3.21	1.10	2.56	3.24	3.92	4.58
Specific gravity	0.838	0.841	0.852	0.863	0.875	0.887
Calorific value (kJ/kg)	42,800	42,961	42,218	41,485	40,746	40,016
Flash point °C	52	48	57	73	114	148
Cetane number	53	14	–	–	–	55

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