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Research Article

PHYSIOCHEMICAL PROPERTIES OF OIL$_{JFWPB}$, RECOVERED BY THE OXIDATIVE THERMAL DEGRADATION OF THE MIXTURE OF HDPE, LDPE AND JUTE FIBER

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ABSTRACT

The Oil$_{JFWPB}$ was recovered by the oxidative thermal degradation of the mixture of HDPE, LDPE and Jute fiber. According to the GC/MS analysis, it was reported that chemically Oil$_{JFWPB}$ consisted of a phytol, two saturated fatty acids, two unsaturated fatty acids and two silica containing derivatives. Five blends of Oil$_{JFWPB}$ were prepared with Diesel (Reference fuel) and the basic physiochemical fuel properties such as Density, Viscosity, Kinematic Viscosity, Flash Point, Fire Point, Cloud Point, Pour Point and Calorific Value were determined by using ASTM methods.

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INTRODUCTION

Waste to energy (WTE) technology is a promising way to transform the municipal solid waste (MSW) into the energy resource. According to Plastic Europe Market Research Group, the reported global production of plastic is 322 million tons (PEMRG) in which only United States individually contributes 250 million tons of municipal solid waste (MSW) (Staley, 2009) which generates numerous environmental problems. Pyrolysis is a thermal degradation process of organic materials which operated at very high temperature in oxygen less environment. On pyrolysis of plastic by mixing biomass causes the improvement in liquid product yield than the plastics pyrolyzed individually (Brebu, 2010). Co-pyrolysis of plastic waste with different biomass such as karanja & niger seeds (Shadangi, 2015), red oak (Xue, 2015), rice husk (Costa, 2014), almond shell (Önal, 2013), oil shell (Aboulkas, 2012), pine cone (Brebu, 2010), wood biomass (Sharypov, 2002), forestry biomass wastes (Paradela, 2009), lignocellulosic materials (Jakab, 2001) has been studied widely. Oxidative thermal degradation of the waste High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE) by mixing Jute fiber is a novel pathway to obtained high yield of liquid fuel from polyethylene waste (Dixit, 2016).

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MATERIAL AND METHOD

The Oil$_{JFWPB}$ was recovered by the oxidative thermal degradation of the mixture of HDPE, LDPE and Jute fiber (Dixit, 2016). The five blends of Oil$_{JFWPB}$ i.e. Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40% and Oil$_{JFWPB}$-50% were prepared with the Diesel (Reference fuel) for the determination of basic physiochemical fuel properties.

Figure 1 A: Diesel, B: Oil$_{JFWPB,}$ C-G: prepared five blends, respectively

In this research work the five blends of Oil_{JFWPB} were prepared with Diesel (Reference fuel) and by following the ASTM methods the basic physiochemical properties of the blends were determined and compared with Diesel.

Preparation and nomenclature of the blends of Oil_{JFWPB} with Diesel

For the preparation of each blend, the appropriate fractions of Oil_{JFWPB} and Diesel were taken in a 1 Liter beaker by using measuring cylinder and then with the help of magnetic stirrer the mixture of Oil_{JFWPB} and Diesel were stir for 30 minutes, to make the uniform mixture of fuel. The actual picture of the Oil_{JFWPB} and their five blends with Diesel shown in Figure 1. Nomenclature and composition of the blends of Oil_{JFWPB} with Diesel were summarized in Table 1.

Table 1 Nomenclature and composition of the blends of Oil_{JFWPB}

S.N.	Name of the blend	Fraction of Oil_{JFWPB} (ml)	Fraction of Diesel (ml)
1.	Diesel (Reference fuel)	00	1000
2.	Oil_{JFWPB}-10%	100	900
3.	Oil_{JFWPB}-20%	200	800
4.	Oil_{JFWPB}-30%	300	700
5.	Oil_{JFWPB}-40%	400	600
6.	Oil_{JFWPB}-50%	500	500

Standard methods

The ASTM methods and apparatus which were used to determine the fuel properties summarized in Table 2.

Table 2 Standard apparatus and methods for the fuel properties

S.N.	Fuel properties	Standards apparatus	ASTM methods
1.	Density (g/cm^3)	Gay-Lussac specific gravity bottle	ISI 1448[P:32]:1992
2.	Viscosity (m Pa S)	A N D Viscometer SV 10	Digital Viscometer
3.	Kinematic Viscosity (c St)	Redwood Viscometer No. 1	ASTM D 445
4.	Flash Point (°C)	Abel's closed cup apparatus	ASTM D 93
5.	Fire Point (°C)	Abel's closed cup apparatus	ASTM D 93
6.	Cloud Point (°C)	Cloud Point determination apparatus	ASTM D 2500
7.	Pour Point (°C)	Pour Point determination apparatus	ASTM D 97
8.	Calorific Value (MJ/Kg)	Digital Bomb Calorimeter	IS:1448[P:6]:1984

RESULTS AND DISCUSSION

Chemical composition of the Oil_{JFWPB}

According to the GC/MS analysis of Oil_{JFWPB}, in the Total ion chromatogram (Figure 2) the 14 major peaks were recorded in which seven chemical compounds (Table 3) were, a phytol identified as 3,7,11,15- Tetramethyl -2-hexadecen-1-ol (Figure 2 (B)), two saturated fatty acids, Methyl tetradecanoate and Pentadecanoic acid, 14-methyl- methyl ester (Figure 2(C) & 2(E)), two unsaturated fatty acids, 7-Hexadecenoic acid, methyl ester, (Z) (Figure 2 (D)) and 9-Octadecenoic acid (Z)-, methyl ester (Figure 2 (F)) and 2

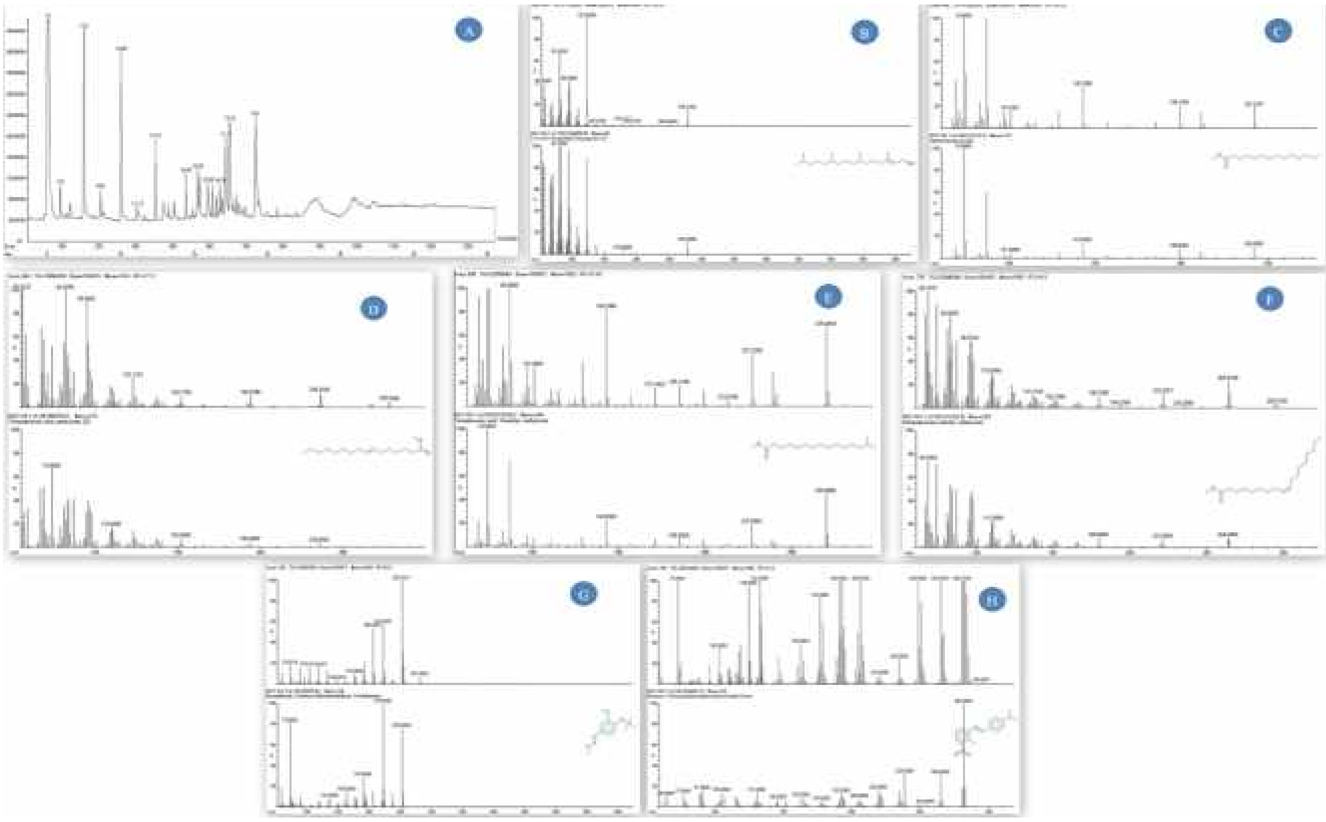
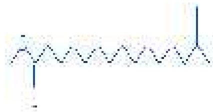
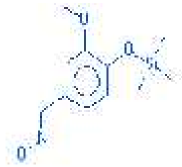
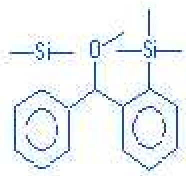


Figure 2 GC/MS analysis of Oil_{JFWPB}

Table 3 The GC/MS analysis of Oil$_{JFWPB}$

Retention time	Compound name	Fragmentation (m/z)	Molecular formula	Molecular structure
15.25	Methyl tetradecanoate	242,199,143,74	$C_{15}H_{30}O_2$	
16.78	3,7,11,15- Tetramethyl -2-hexadecen-1-ol	296,278,249,193,179, 138,123,96,81,56	$C_{20}H_{40}O$	
17.17	7-Hexadecenoic acid, methyl ester, (Z)	278,236,194,152,123, 110,95,82,74	$C_{17}H_{32}O_2$	
17.43	Pentadecanoic acid,14-methyl-, methyl ester	270,227,213,185,171, 143,101,86	$C_{17}H_{34}O_2$	
19.2	9-Octadecenoic acid (Z)-, methyl ester	296,264,235,222,194,180,152,137,110,96,83,69	$C_{19}H_{36}O_2$	
5.9	Benzaldehyde,3-methoxy-4-[(trimethylsilyl]-, O-methyloxime	281,253,223,207,191,149,119,104,73	$C_{12}H_{25}O_3NSi$	
8.65	2,2'- Bis-trimethylsilyl benzhydryl methyl ether	355,327,281,223,207,133, 89,73	$C_{20}H_{42}OSi_2$	

silica containing derivatives (Figure 2 (G) & 2 (H)). On the basis of the molecular structure the tentative average chemical formula of the Oil$_{JFWPB}$ can be calculated and obtained as $C_{17.14}H_{34.14}0_{1.85}N$ (Silica not included) whiles the average chemical formula of Diesel is $C_{12}H_{23}$).

Physiochemical properties of Oil$_{JFWPB}$

Density

The variation in Density of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (A), were 0.7751 g/ml, 0.7734 g/ml, 0.7717 g/ml, 0.7700 g/ml, 0.7683 g/ml and 0.7768 respectively. The Density of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% is decreased by 0.21%, 0.43%, 0.65%, 0.87%, 1.09% as compared to Diesel respectively. According to the physical properties of the blends, it was clear that Density decreases with increase of the fraction of Oil$_{JFWPB}$ in each blend. Decrease in Density indicates that every blend getting lighter than Diesel respectively.

Viscosity

The variation in Viscosity of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (B), were 3.6, 3.45, 3.34, 3.2, 3.05 and 3.66 respectively.

The Viscosity of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% are decreased by 1.63%, 5.73%, 8.74%, 12.56%, 16.66% as compared to Diesel. Decrease Viscosity indicates that every blend getting thinner than Diesel respectively.

Kinematic Viscosity

The variation in Kinematic Viscosity of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (C), were 10.07, 9.09, 7.73, 5.93, 3.99 and 10.41 respectively. The Kinematic Viscosity of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% were decreased by 3.26%, 12.68%, 25.74%, 43.03%, 61.67% as compared to Diesel.

Flash Point

The variation in Flash Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (D), were 48 °C, 42 °C, 32 °C, 30 °C, 29 °C and 58 °C respectively. The Flash Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% are decreased by 17.2%, 27.5%, 44.8%, 48.2%, 50% as compared to Diesel respectively.

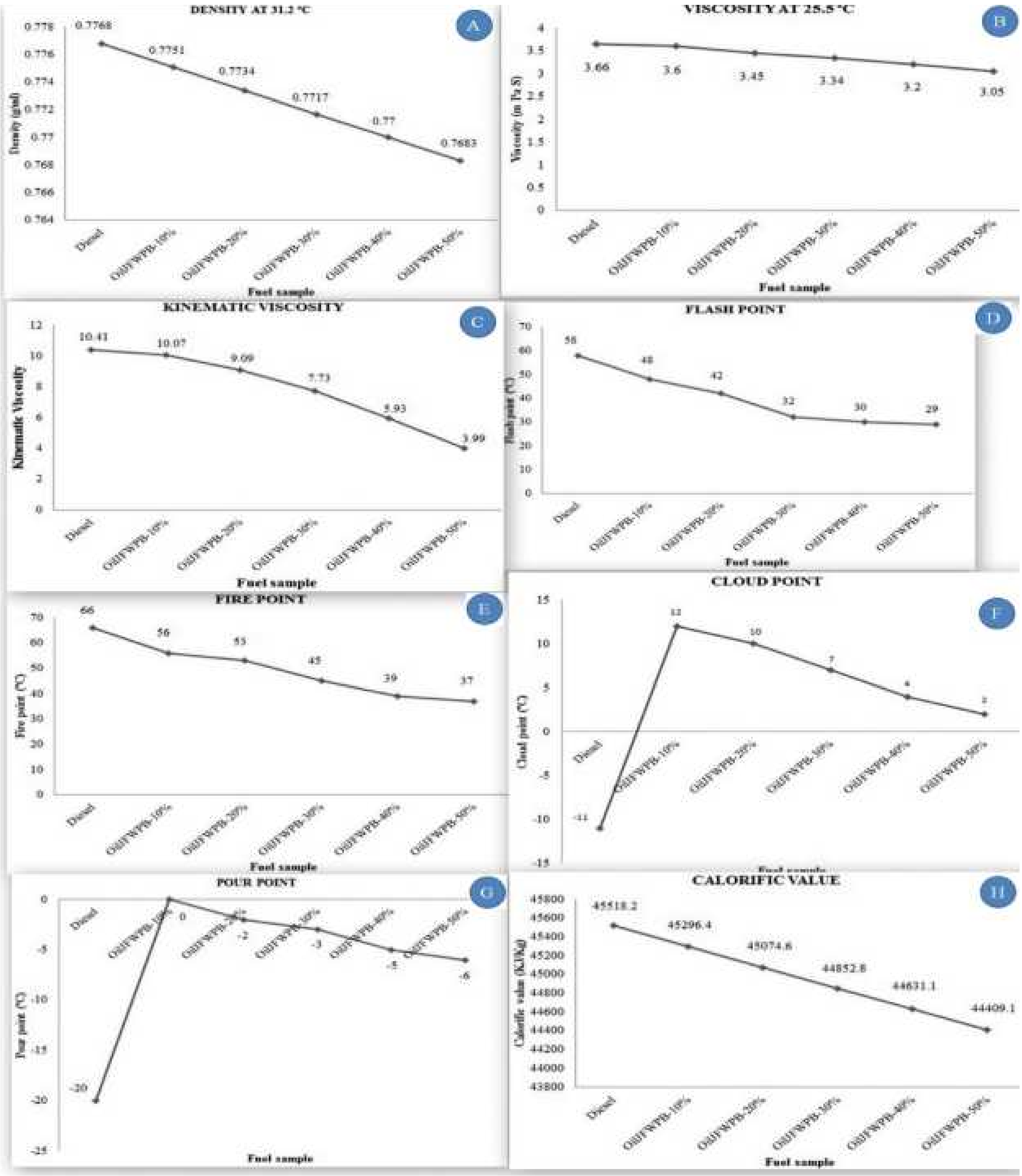


Figure 3 Physiochemical properties of Oil_{JFWPB}, A: Density, B: Viscosity, C: Kinematic Viscosity, D: Flash Point, E: Fire Point, F: Cloud Point, G: Pour Point, H: Calorific Value respectively.

Table 4 Physiochemical fuel properties of all the five blends of Oil_{JFWPB} with respect to Diesel

S.N.	Name of the blend	Density at 31.2 °C (g/ml)	Viscosity at 25.5 °C (m Pa S)	Kinematic Viscosity	Flash Point (°C)	Fire Point (°C)	Cloud Point (°C)	Pour Point (°C)	Calorific Value (KJ/Kg)
1.	Diesel	0.7768	3.66	10.41	58	66	-11	-20	45518.2
2.	Oil_{JFWPB}-10%	0.7751	3.60	10.07	48	56	12	0	45296.4
3.	Oil_{JFWPB}-20%	0.7734	3.45	9.09	42	53	10	-2	45074.6
4.	Oil_{JFWPB}-30%	0.7717	3.34	7.73	32	45	7	-3	44852.8
5.	Oil_{JFWPB}-40%	0.7700	3.20	5.93	30	39	4	-5	44631.1
6.	Oil_{JFWPB}-50%	0.7683	3.05	3.99	29	37	2	-6	44409.1

Fire Point

The variation in Fire Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (E), were 56 °C, 53 °C, 45 °C, 39 °C, 37 °C and 6°C. The Fire Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% are decreased by 15.1%, 19.6%, 31.8%, 40.9%, 43.9% as compared to Diesel respectively. It was clear that flash and Fire Point decreases with increase of the fraction of Oil$_{JFWPB}$ in each blend. Decrease in Density and Viscosity indicates that every blend getting lighter and thinner than Diesel respectively, hence the Flash and Fire Point of each blend also decreases.

Cloud Point

The variation in Cloud Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (F), were 12 °C, 10 °C, 7 °C, 4 °C, 2 °C and -11 °C respectively.

Pour Point

The variation in Pour Point of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (G), were 0 °C, -2 °C, -3 °C, -5 °C, -6 °C and -20 °C respectively.

Calorific Value

The variation in Calorific Value of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% and Diesel shown in Figure 3 (H), were 45296.4 KJ/Kg, 45074.6 KJ/Kg, 44852.8 KJ/Kg, 44631.1 KJ/Kg, 44409.1 KJ/Kg and 45518.2 KJ/Kg respectively. The Calorific Value of Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40%, Oil$_{JFWPB}$-50% are decreased by 0.48%, 0.97%, 1.46%, 1.94%, 2.43% as compared to Diesel respectively.

The characteristic basic physiochemical fuel properties of all the five blends of Oil$_{JFWPB}$ i.e. Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40% and Oil$_{JFWPB}$-50% with respect to Diesel summarized in Table 4.

CONCLUSION

It was concluded that, for all the five blends i.e. Oil$_{JFWPB}$-10%, Oil$_{JFWPB}$-20%, Oil$_{JFWPB}$-30%, Oil$_{JFWPB}$-40% and Oil$_{JFWPB}$-50%;

1. The Density decreased by 0.21%, 0.43%, 0.65%, 0.87% and 1.09% as compared to Diesel.
2. The Viscosity decreased by 1.63%, 5.73%, 8.74%, 12.56% and 16.66% as compared to Diesel.
3. The Kinematic Viscosity decreased by 3.26%, 12.68%, 25.74%, 43.03% and 61.67% as compared to Diesel.
4. The Flash Point decreased by 17.2%, 27.5%, 44.8%, 48.2% and 50% as compared to Diesel.
5. The Fire Point decreased by 15.1%, 19.6%, 31.8%, 40.9% and 43.9% as compared to Diesel.
6. The variation in Cloud Point was 12 °C, 10 °C, 7 °C, 4 °C and 2 °C as compared to Diesel.
7. The variation in Pour Point was 0 °C, -2 °C, -3 °C, -5 °C and -6 °C as compared to Diesel.
8. The Calorific Value decreased by 0.48%, 0.97%, 1.46%, 1.94% and 2.43% as compared to Diesel respectively.

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