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Research Article

Emissions and Performance of Diesel Engines Correlated with Biodiesel Properties

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It has been demonstrated that B20 biodiesel can be used in diesel engines without modifying their specifications. It is still being developed to reduce dependence on diesel fuel by developing biodiesel with a higher percentage of palm oil. Alcohol is added to biodiesel to reduce problems with fuel injection due to its high viscosity. In this study, the biodiesel properties of diesel-palm cooking oil-methanol/ethanol/butanol blends are investigated in relation to diesel engine performance and potential exhaust emissions. The percentages of palm cooking oil used were 30%, 40%, 50%, 60%, 70%, 80%, and 85%. A 15% concentration of methanol, ethanol, and butanol alcohol was used. According to chemical and physical tests, biodiesel with a higher palm oil content had poorer properties. A biodiesel blend that combines diesel, palm oil, and methanol can perform almost as well as diesel fuel in terms of exhaust emissions and engine performance.

1. Introduction

The use of fuel oil in India has passed the peak of the balance between production and consumption. The tendency of this high fuel demand is reflected in the increase in the volume of motorised vehicles and the volume of fuel oil imports shown in the volume of motorised vehicles by 62% and an increase in fuel imports by 26% in 2022. Biodiesel is an alternative fuel sourced from vegetable oils or animal fats that are produced through esterification/transesterification processes [1]. B20 biodiesel is implemented as the main fuel for diesel engines. The use of biodiesel fuel results in lower engine performance than diesel fuel despite more environmentally friendly engine emissions [2]. The higher the palm oil content, the lower the engine torque and power. This is due to the low calorific value and high viscosity of palm oil compared to those of diesel fuel [3]. The decline in performance of biodiesel-fuelled diesel engines can be improved by adding alcohol to the fuel [4]. In addition, the addition of alcohols such as methanol, ethanol, and butanol also has a positive impact on reducing carbon monoxide (CO) and hydrocarbon (HC) emissions and fuel consumption produced by diesel engines [5]. The low viscosity properties, high oxygen content, and high cetane number in alcohol are the main factors for lower diesel engine exhaust emissions than when using biodiesel fuel. Therefore, in line with the programme to reduce fossil fuel dependence, this study observed diesel fuel blended with palm cooking oil and methanol or ethanol or butanol alcohol additives to improve biodiesel properties [6]. A biodiesel blend consisting of diesel-palm cooking oil-alcohol, methanol, ethanol, and butanol was investigated through its physical and chemical

properties. Furthermore, the tendency of biodiesel properties was correlated with diesel engine performance and exhaust emissions.

2. Research Methods

Palm cooking oil was obtained from a commercial shop in Chennai city. Meanwhile, methanol, ethanol, and butanol alcohols were obtained from a chemical store. In the process of making biodiesel formulation, the diesel fuel-palm cooking oil-alcohol (methanol/ethanol/butanol) were mixed according to the measurements shown in Table 1. Observations were made on the physical and chemical properties of biodiesel such as viscosity, calorific value, flash point, and density. In the process, the biodiesel testing method was carried out, as shown in Table 2. The physical and chemical properties of biodiesel B30, B40, B50, B60, B70, B80, and B100 were evaluated for quality properties. To find out the tendencies described by the physical and chemical test results, graphs were made.

Table 1: Biodiesel property testing methods.

S. no.	Type of examination	Method
1	Kinematic viscosity at 40°C	ASTM D 445-062
2	Calorific value	ASTM D 5865-133
3	Flash point	ASTM D 93-074
4	Specific gravity	ASTM D 1298-12

Table 2: Biodiesel formulation.

S.No.	Biodiesel volume	Biodiesel volume (ml)		
		Solar	Palm cooking oil	Alcohol
1	B30 = P	700	300	0
2	B30A = Q	550	300	150
3	B40A = R	450	400	150
4	B50A = S	350	500	150
5	B60A = T	250	600	150
6	B70A = U	150	700	150
7	B80A = V	50	800	150
8	B100A = W	0	850	150

3. Results and Discussion

3.1. Viscosity of Biodiesel. Viscosity is used as a parameter to measure fuel quality. The higher the viscosity of biodiesel, the more viscous the fuel and the more difficult it is to mix with air, making the fuel injection process difficult [7]. Figure 1 shows the viscosity of biodiesel with varying volumes. In general, biodiesel blended with alcohol produces higher viscosity than 30% biodiesel without alcohol (B30). The viscosity of biodiesel with ethanol alcohol blends was higher than that of biodiesel methanol and biodiesel butanol blends. Meanwhile, the viscosity of biodiesel with methanol alcohol blends was lower than that of biodiesel ethanol and biodiesel butanol blends. The highest viscosity was obtained in fuel with 85% palm cooking oil and 15% ethanol or B100A. The lowest viscosity was obtained in the fuel with 30% palm cooking oil and 15% butanol or B30A. Biodiesel fuel with high viscosity properties is detrimental to the fuel injection process [8]. The use of ethanol alcohol blends in biodiesel compared to methanol or butanol alcohol blends could produce high emissions and high fuel consumption.

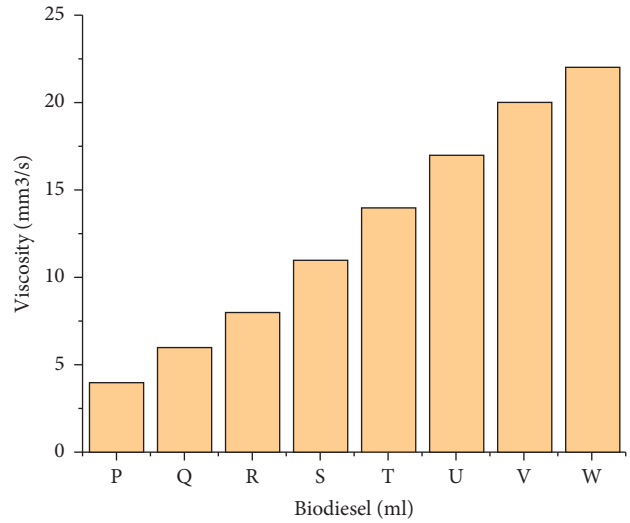

Figure 1: The viscosity of biodiesel with varying volumes.

3.2. Calorific Value of Biodiesel. The calorific value of fuel indicates the amount of energy produced during the combustion process [9]. The amount is influenced by the composition of the fuel. Figure 2 shows the trend of the decreasing calorific value of biodiesel with alcohol blends compared to that of biodiesel without alcohol. The higher the palm cooking oil content, the lower the calorific value. In this case, the lowest calorific value belongs to the fuel with 85% palm cooking oil and 15% ethanol alcohol blends (B100A). The calorific value of biodiesel with butanol alcohol blends appears to be higher than that of biodiesel with ethanol or methanol alcohol blends. In this case, the highest calorific value belongs to the fuel with 30% palm cooking oil and 15% butanol alcohol blends [10]. The lowest calorific value belongs to the biodiesel with ethanol alcohol blends. The use of fuel with a high calorific value will improve engine performance. This is due to the large amount of calorific energy produced so that the quality of the combustion process is better. Therefore, biodiesel with butanol alcohol blends has the potential for better combustion quality and emissions than biodiesel with methanol or ethanol alcohol blends.

3.3. Flash Point of Biodiesel. The flash point of a fuel is an indicator that the fuel can burn when it comes into contact with heat or fire. The lower the flash point, the more flammable the fuel [11]. Fuel flammability affects the rate of combustion, thereby accelerating the increase in combustion chamber temperature and maximising the combustion process. This benefits the working power of the engine. However, an excessive increase in the combustion chamber temperature triggers the formation of NOx emissions. Figure 3 shows the flash point test results with varying

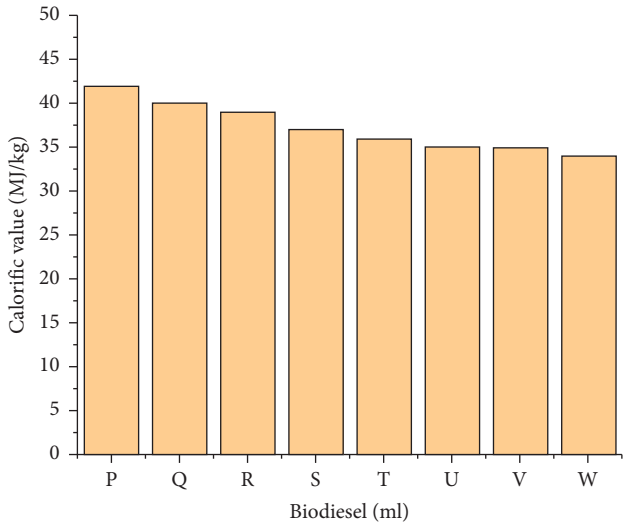

Figure 2: The trend of decreasing calorific values of biodiesel.

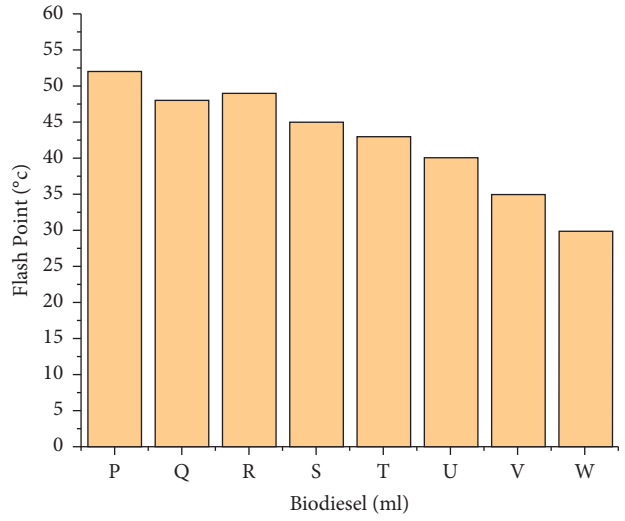

Figure 3: The flash point test results with varying biodiesel volumes.

biodiesel volumes. In general, biodiesel with alcohol blends has a higher flash point than 30% biodiesel fuel without alcohol blends. The flash point of biodiesel with methanol alcohol blends is lower than that of biodiesel with ethanol or butanol alcohol blends. Therefore, biodiesel with methanol alcohol blends has the potential to produce higher engine performance and emissions than biodiesel with ethanol or butanol alcohol blends.

3.4. Biodiesel Density. The density of biodiesel is very important to determine the quality of the fuel combustion process. The higher the fuel density, the better the fuel quality, which supports the perfect combustion process [12]. The higher the fuel density, the higher the fuel consumption. Figure 4 presents the density of the fuel with varying palm cooking oil content. Biodiesel has a higher density when it contains more palm cooking oil. The density of biodiesel

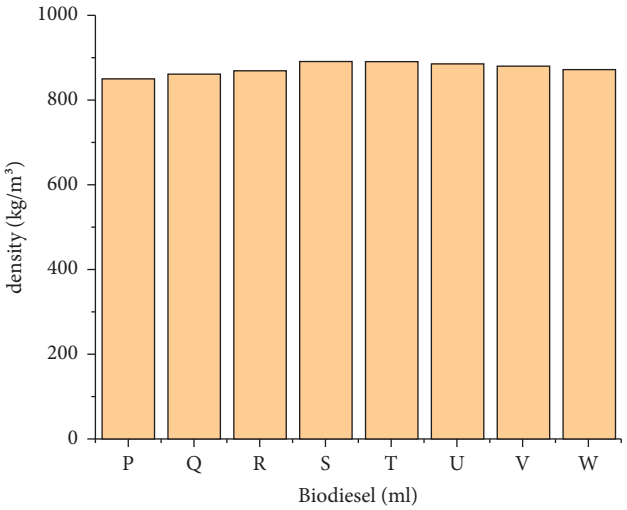

Figure 4: The density of the fuel with varying biodiesel volumes.

with methanol alcohol blends is lower than that of biodiesel with ethanol or butanol alcohol blends. However, the increase in the biodiesel density value is not significant between methanol alcohol-blended biodiesel and ethanol/butanol alcohol-blended biodiesel density.

4. Conclusion

The diesel-palm cooking oil-methanol blend biodiesel fuel has the highest flash point, lowest viscosity, high calorific value, and low density compared to diesel-palm cooking oil-ethanol or butanol blends. The diesel-palm cooking oil-methanol blend biodiesel has the potential to produce better performance and emissions than diesel-palm cooking oil-ethanol or butanol blends.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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