Tailpipe Emissions from Bus Engines Fueled with Diesel and Biodiesel

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1. Background and Methodology

Transportation constitutes the main source of air pollution in urban areas. In Bangkok, particulate matter and tropospheric ozone are the two major air pollutants, 80% of which is due to transportation emissions [1].

In Thailand, more than 50% of the fuel used is diesel most of which is imported. In order to reduce the dependence on imports and to improve energy security of the country, alternatives are sought to complement the demand for diesel. Also, the substitutes should not require major modifications of the engines which would add to the cost as well as have equal or lesser impacts on the environment. In this regard, biodiesel is a promising candidate as stated in several recent studies. However, in order to ensure that the substitution is economic and environmentally benign, investigations should be carried out on the characteristics of the fuel and the emissions resulting from its use.

To this end, the properties of biodiesel blends and the emissions of particulate matter (PM) and nitrogen oxides (NOx) have been documented in this study. Tests were conducted using (1) two buses: 6,500 and 8,000 cc engines of direct injection type; (2) three types of fuels: conventional diesel no. 2, palm methyl ester 20% blended with conventional diesel (PME-20%) and coconut methyl ester 20% blended with conventional diesel (CME-20%) and (3) two driving cycles: European transient cycle (ETC) and Bangkok driving cycle.

In this paper the emissions are analyzed and compared in terms of fuel types and driving cycles in order to evaluate the potential impacts of the emissions on air quality in urban areas of Thailand.

2. Results and Discussion

2.1 Characteristics of biodiesel

Table 1 summarizes the characteristics of diesel and biodiesels used in this study. It can be noticed that main properties of biodiesel blends are similar to those of conventional diesel and within the diesel standard specifications. It is thus anticipated that the biodiesel blends can replace conventional diesel without requiring engine modification. Also, it is expected that the resulting emissions would be of the same order of magnitude.

Table 1. Characteristics of PME-20% and CME-20%, compared to Diesel

Properties	Diesel	PME-20%	CME-20%	Diesel (standard specification)	Test Method
1. Specific Gravity at 15.6°C	0.830	0.840	0.838	0.81-0.87	ASTM D 1298
2. Cetane Index	57.8	56.7	54.2	>47	ASTM D 976
3. Distillation: 90% Vol. Evaporated, (°C)	354	353	347	<357	ASTM D 86
4. Sulfur Content, (%wt)	0.0236	0.0222	0.0176	<0.035	ASTM D 5453

Source: Department of Energy Business, Energy Policy and Planning Office, Ministry of Energy

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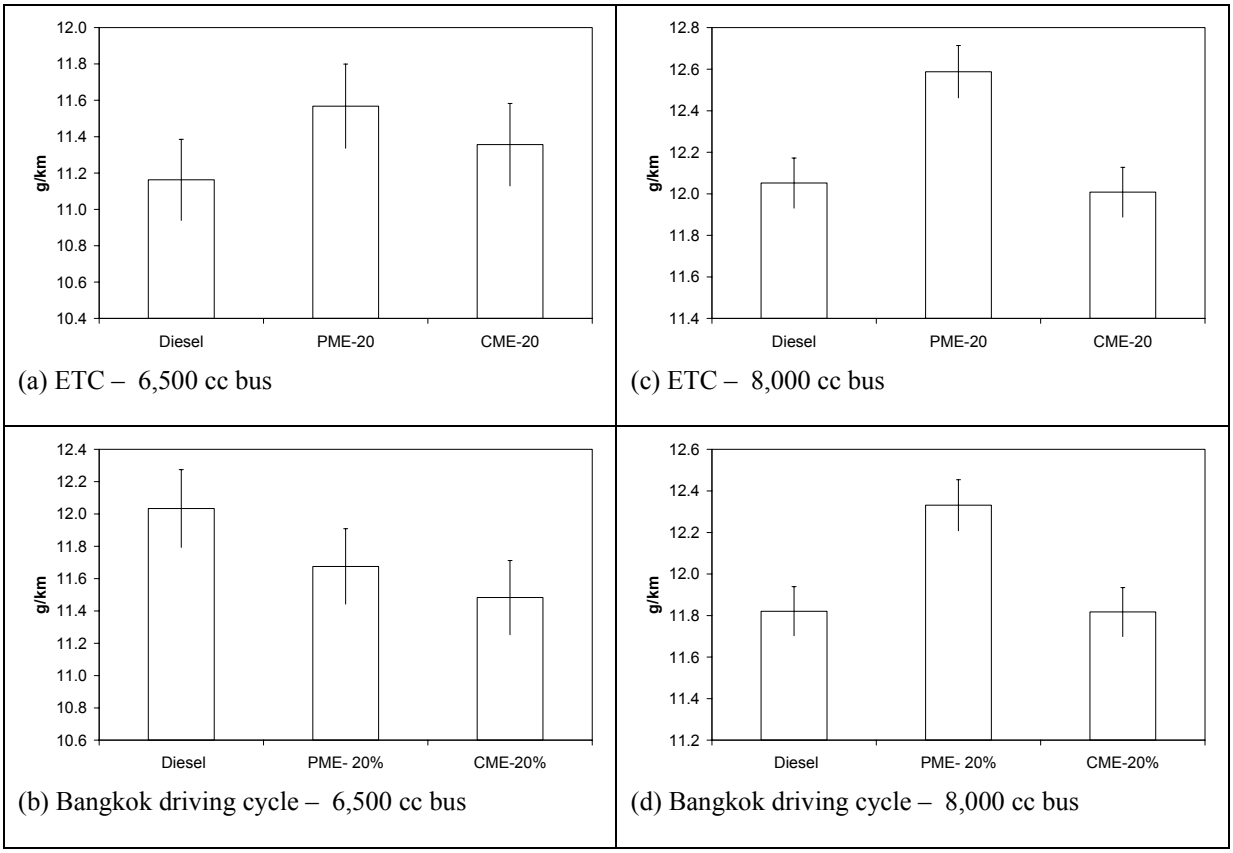
2.2 NOx emissions

Results on NOx emissions are reported in Figure 1. The emissions range from 11 to 13 g/km for both the buses and testing conditions. As anticipated, the fuel change from diesel to biodiesel blend does not affect the NOx emissions significantly. Therefore, photo-oxidant formation potential from NOx would not be increased appreciably. However, for the 8,000 cc vehicle, the NOx emissions from PME-20% are slightly higher than from conventional diesel and CME-20%. This may probably be due to the higher N-content in the feedstock (palm oil) [2]. But further investigations are required to confirm this difference.



(a) ETC – 6,500 cc bus

(c) ETC – 8,000 cc bus

(b) Bangkok driving cycle – 6,500 cc bus

(d) Bangkok driving cycle – 8,000 cc bus

Figure 1. NOx emissions for the two types of buses and operating conditions

2.3 PM emissions

Results on PM emissions are reported in Figure 2. The emissions for the 6,500 cc bus range from 2.0 to 3.5 g/km whereas those for the 8,000 cc bus range from 0.5 to 0.9 g/km. This difference is mainly because the 8,000 cc bus is equipped with a particulate matter filter to comply with Euro II standards. For the 6,500 cc bus, there is no significant reduction in PM emissions with fuel change. Whereas, in the case of the 8,000 cc bus, the emission reduction using biodiesel blends is noticeable with CME-20% having the better performance. On the other hand, the Bangkok driving cycle leads to an increase in PM emissions as compared to ETC for both the buses.

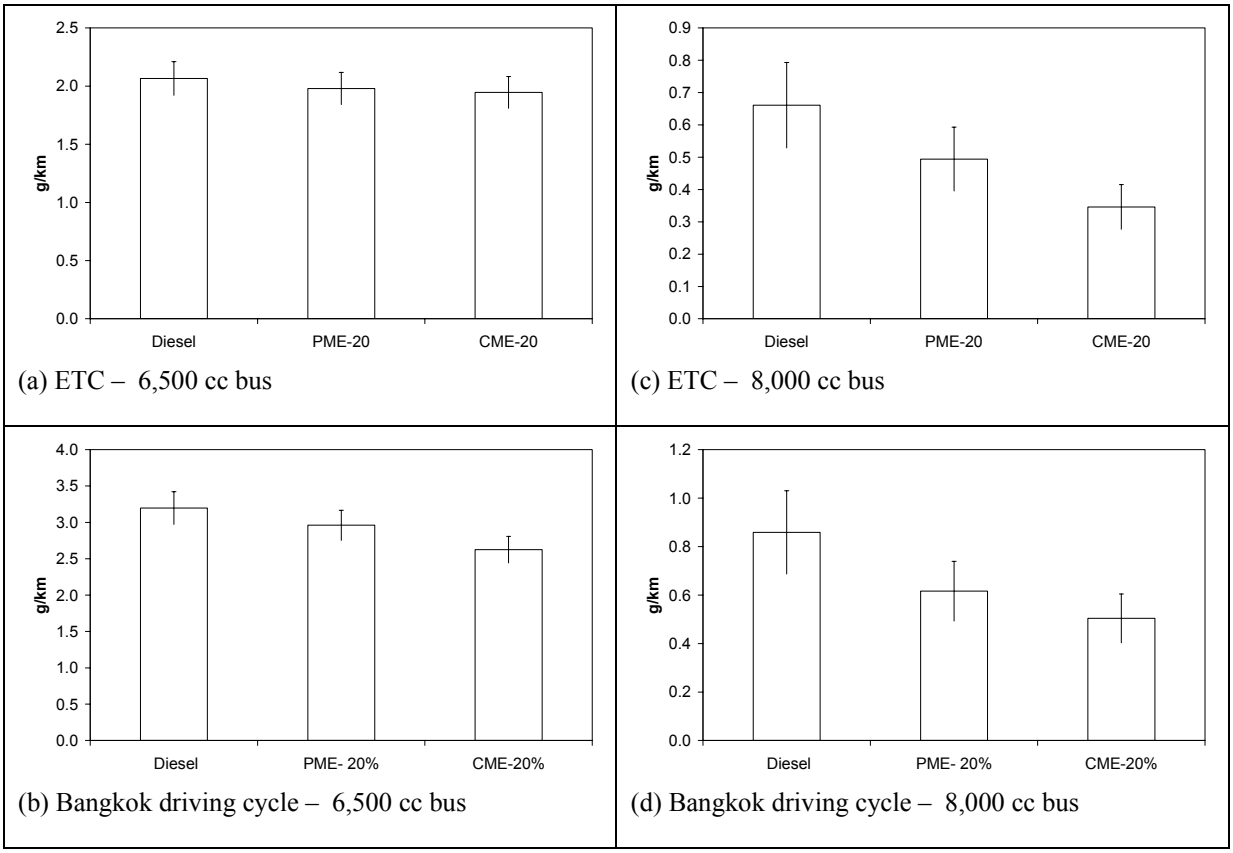


Figure 2. PM emissions for the two types of buses and operating conditions

3. Conclusions

Comparing biodiesel blends to diesel revealed that substitution of diesel by biodiesel will lead to some improvement of the air quality, especially in terms of PM. Regarding NOx emissions, further investigations are required to confirm the relationship between N-content in the fuel and consequent emissions. As at present, biodiesel can be produced with physical characteristics similar to conventional diesel, substitution in existing engines can be effectuated without modifications. Tests conducted in this study confirmed this. This represents a double economic advantage for a developing country like Thailand since it will reduce import of petroleum as well as the fuel switch can be made at low cost.

4. References

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