International Journal of Ambient Energy

ISSN: 0143-0750 (Print) 2162-8246 (Online) Journal homepage: https://www.tandfonline.com/loi/taen20

Study on the outcome of a cetane improver on the emission characteristics of a diesel engine

A. Devaraj, D. Yuvarajan & I. Vinoth Kanna

To cite this article: A. Devaraj, D. Yuvarajan & I. Vinoth Kanna (2020) Study on the outcome of a cetane improver on the emission characteristics of a diesel engine, International Journal of Ambient Energy, 41:7, 798-801, DOI: 10.1080/01430750.2018.1492452

To link to this article: https://doi.org/10.1080/01430750.2018.1492452

Published online: 11 Jul 2018.

INTERNATIONAL JOURNAL OF AMBIENT ENERGY
2020, VOL. 41, NO. 7, 798–801
https://doi.org/10.1080/01430750.2018.1492452

Study on the outcome of a cetane improver on the emission characteristics of a diesel engine

A. Devaraj, D. Yuvarajan and I. Vinoth Kanna

Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India

ABSTRACT

Dimethyl carbonate (DMC), a cetane improver, is used as a fuel additive to investigate the exhaust emission in diesel engine. Neem oil biodiesel (B100), neem oil biodiesel + dimethyl carbonate (B100+DMC) and diesel were used as test fuels. DMC is added 0.5% by volume to biodiesel. This research work was executed in a four-stroke, single-cylinder diesel engine. Owing to the percentage of DMC in biodiesel, carbon monoxide (CO) and hydrocarbon (HC) emissions were dropped corresponding to diesel. A considerable amount of nitrogen oxide (NO_x) is decreased when diesel is used, and by the addition of B100+DMC, NO_x were slightly reduced compared to B100.

ARTICLE HISTORY
Received 3 May 2018
Accepted 14 June 2018

KEYWORDS
Dimethyl carbonate; neem oil biodiesel; emissions; engine

1. Introduction

Petroleum-based fuels are commonly used in light, medium and heavy-duty applications, by virtue of their high efficiency and trustworthiness Yuvarajan, Venkata Ramanan, and Christopher Selvam 2016. The rapid exhaustion of the petroleum resources, continuous unsteady in fuel prices and harmful pollution to the environment are some of the most alarming problem in the automobile sector (Xue, Grift, and Hansen 2011). Diesel engine emits on harmful emissions like hydrocarbon, smoke and carbon monoxide emission. To overcome the brick-wall emission norms and to improve the performance characteristics, biodiesel is a widely accepted substitute for conventional petroleum fuel which is renewable, feasible and alternative fuel for compression ignition engine (Rashedul et al. 2014). The merits of using biodiesel decreasing the addictedness of imported petroleum, diminishing global warming, piling up lubricity and reducing harmful emission in behalf of inbuilt oxygen content Vinoth Kanna, Vasudevan, and Subramani 2018. Although biodiesel has some demerits like affecting in-cylinder like parameters like atomization, vapourization and fuel–air mixing, running a diesel engine with inadequate cetane quality gives root to poor starting characteristics, high noise level, elevated fuel consumption and exhaust emission Yuvarajan et al. 2017. To overcome these difficulties, fuel additives are to be added for efficacious atomization and fuel–air mixing. Cetane number is the magnitude of fuel ignition delay; fuel upon high cetane number has lower ignition delay, providing lower duration for the fuel combustion process to get completed (Shahabuddin et al. 2013; Kishore Pandian et al. 2017; Anderson, Devarajan, and Nagappan 2017).

The addition of an oxygenated blend with cetane improver has proved good inflation in the engine performance and kickback in the emissions (Mahalingam et al. 2018; Pandian et al. 2018). Ditertiary butyl peroxide (DTBP), chemical formula $C_8H_{18}O_2$, a cetane improver additive, helps to reduce ignition delay and cause low cylinder temperature and reduction in NO_x emission (Venkateswarlu, Murthy, and Subbarao 2016; Pandian et al. 2018). Arul Gnana Dhas et al. (2018) conducted an experiment on the addition of a cetane number improver in compression ignition engine with ethanol–diesel blends. They divulge that with an increase in the addition of 2-ethyl hexyl nitrate, diffusive combustion phase, total combustion duration and brake thermal efficiency have increased and reduction in ignition delay period, particulate matter and smoke emission. Kumar and Raj (2016) have conducted an experiment on bioethanol-blended cotton seed methyl ester with the effect of DTBP. The results showed that the presence of a cetane improver significantly reduced oxides of nitrogen and unburned hydrocarbon for overall engine speed.

2. Materials and reagents

Transesterification approach was intended to extract biodiesel from raw oil. Fuel properties were shown in Table 1. The experiment was carried in a four-stroke, water-cooled, single-cylinder engine at 1500 rpm (constant speed). Engine layout with data acquisition is shown in Figure 1. Engine exhaust was measured by a gas analyser (QROTECH type 402) and AVL437 is employed to measure smoke emission. Table 2 provides the properties of the diesel used, neem biodiesel (Table 3).

3. Results and discussion

The emission characteristics of diesel, neem biodiesel and DMC for different proportions are discussed below.

3.1. Carbon monoxide (CO)

The outcome of B100, B100+DMC and diesel for carbon monoxide emission with load variation is shown in Figure 2.

CONTACT D. Yuvarajan dyuvarajan2@gmail.com

Table 1. Properties of dimethyl carbonate.

Molecular structure	$C_3H_6O_3$
Molar Mass C18:0	90.08 g/mol
Appearance	Clear liquid
Density	1.069–1.073 g/mol
Melting point	275–277 K
Boiling point	363 K

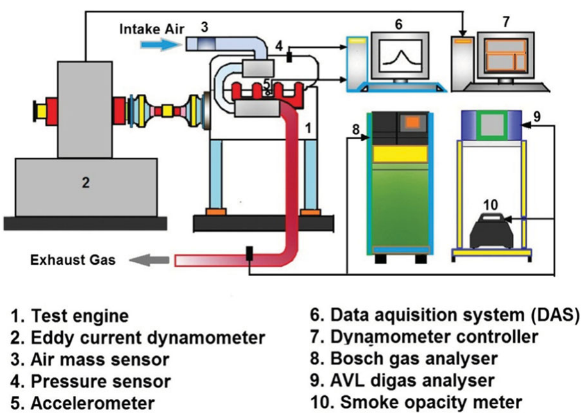

Figure 1. Engine block diagram.

Table 2. Properties of tested fuels.

Properties	Diesel	Neem oil methyl ester	Method
Chemical formula	C14H22	C18H34O2	
Specific gravity	.823	.926	
Kinematic viscosity at 40°C in cSt.	3.9	38	ASTM D445
Calorific value (MJ/kg)	43.2	39	ASTM D240
Cetane number	48	51	ASTM D976
Flash point in °C	56	245	
Fire point in °C	64	278	

Note: cSt stands for Centistokes.

Table 3. Specification of experimental setup.

Make, Model	Simpson – S217
Stroke	4
Cylinder	Two
Rated power	4.5 kW
Rated speed	1800 rpm
Bore diameter (D)	91.44 mm
Stroke (L)	127 mm
Compression ratio	18.5:1
Injection timing	23° BTDC
Injection pressure	200 bar

Note: BTDC stands for Before Top Dead Centre.

Incomplete burning of fuel in the combustion process results in CO emission. Major reasons for CO emission are insufficient oxygen, poor mixing, affluent local regions and deficient combustion (Devarajan et al., 2017a "Performance, Combustion and Emission Analysis on the Effect," 2017; Pandian, Ramakrishnan, and Devarajan 2017; Yuvarajan, Pradeep, and Magesh Kumar 2016; Yuvarajan et al. 2018). The neem oil biodiesel deserves less CO emission corresponding to the diesel by virtue of redundant oxygen molecules. By the addition of BD+DMC, CO decreases gradually by increasing the load conditions compared to diesel and neem Biodiesel.

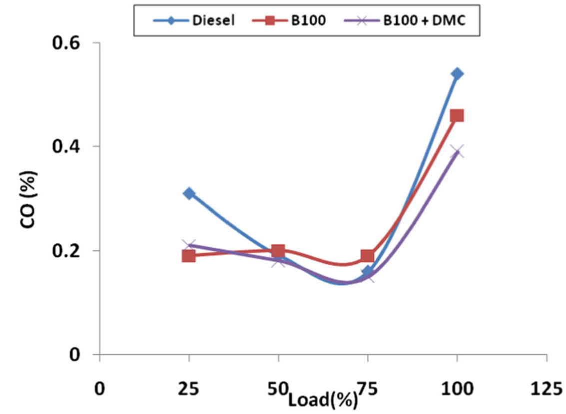

Figure 2. Fluctuation of CO emission with the load.

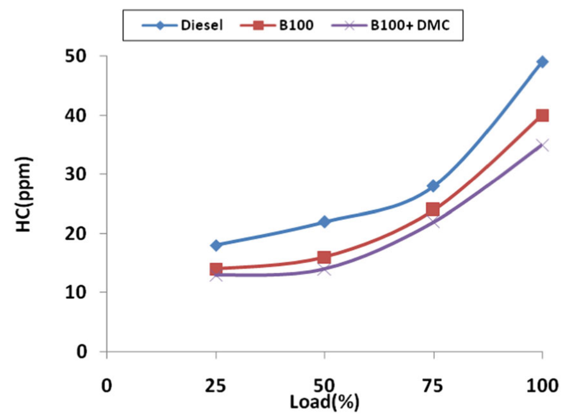

Figure 3. Fluctuation of HC emission with the load.

3.2. Hydrocarbons (HC)

Effect of DMC on HC emission with load for diesel, B100 and BD+DMC are shown in Figure 3. At lower loads, a diesel engine runs on a leaner mixture which leads to higher hydrocarbon emission, when the mixture inside the cylinder is overmixed (Venkata Ramanan and Yuvarajan 2015; Radhakrishnan 2017; Devarajan et al., 2017b "Performance, Combustion, and Emission Analysis of Neat Palm Oil," 2017). Due to lower wall temperature fuel droplet, evaporation is poor resulting in the deficient combustion of fuel and surpassing HC emission (Devarajan et al., "Performance, Combustion and Emission Analysis on the Effect," 2017; Joy et al. 2017). Neem oil biodiesel shows lesser HC emission corresponding to diesel, owed to surplus oxygen molecules in neem oil biodiesel. Addition of BD+DMC reduces the HC emission to accelerate the combustion process Devaraj, Vinoth kanna et al. 2017.

3.3. Oxides of nitrogen (NO_x)

The outcome of diesel, B100 and BD+DMC for nitrogen oxide with load variations is shown in Figure 4. It is found that B100 is surpassing of all test fuels on behalf of the high temperature of burning process and due to excess oxygen content (Devarajan et al. 2018). Addition of B100+DMC reduces the ignition delay and promotes oxidation effect, resulting in the reduction in NO_x

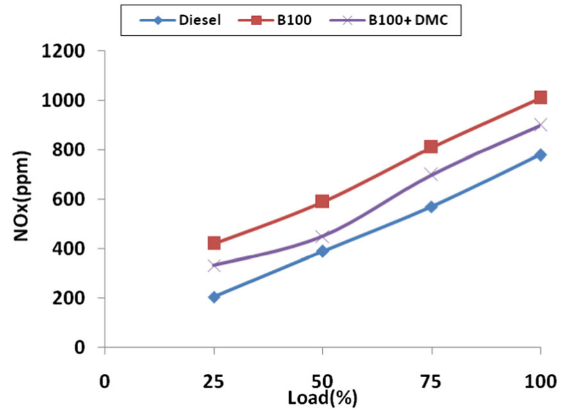

Figure 4. Fluctuation of NO_x emission with the load.

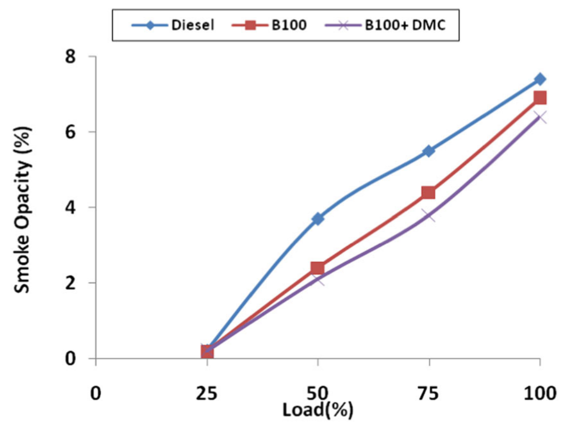

Figure 5. Fluctuation of smoke opacity with the load.

emission compared to B100. It is found that B100 is surpassing of all test fuels on behalf of the high temperature of burning process and due to excess oxygen content.

3.4. Smoke concentration (BSU)

Smoke emissions are shown in Figure 5, with an increase in the oxygen level of fuels and a considerable decrease in smoke emission. Smoke is formed mainly in the region of the rich fuel mixture zone and hence it will be higher at the maximum load for tested fuels Yuvarajan et al. 2016. Smoke value for all biofuels was lower when compared with diesel fuel, and this is because of higher content oxygen in the fuel tends to increase the oxidation reaction (Devarajan et al., "Performance, Combustion and Emission Analysis on the Effect," 2017; Devarajan et al. 2018; Joy et al. 2017). It is found B100 is surpassing all test fuels on behalf of the high temperature of burning process and due to excess oxygen content (Devarajan et al. 2018). Addition of B100+DMC reduces the ignition delay and promotes oxidation effect, resulting in the reduction in smoke emission compared to B100. It is found that B100 is surpassing all test fuels on behalf of the high temperature of burning process and due to excess oxygen content.

4. Conclusion

This work describes emission parameters of a diesel engine running with cetane improver (DMC) and NOME.

The following conclusions were found during the experiment:

(1) Neem biodiesel shows less CO emission corresponding to diesel fuel; by addition of DMC with neem biodiesel, it further gets reduced on behalf of higher oxygen content in the additive.
(2) HC emissions for neem biodiesel with the addition of DMC were found to be less than diesel and neem biodiesel (B100).
(3) NO_x emission is found more for neem biodiesel and cetane additive compared to diesel at all loads, but by adding a cetane additive, it is lower than neat biodiesel.
(4) Smoke emission is significantly reduced by the addition of DMC with biodiesel for all loads while comparing to neem biodiesel (B100) and diesel.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

I. Vinoth Kanna http://orcid.org/0000-0001-8194-8781

References

Anderson, A., Y. Devarajan, and B. Nagappan. 2017. "Effect of Injection Parameters on the Reduction of NOx Emission in Neat Bio-Diesel Fuelled Diesel Engine." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 40 (2): 186–192. doi:10.1080/15567036.2017.1407844.

Arul Gnana Dhas, A., Y. Devarajan, and B. Nagappan. 2018. "Analysis of emission reduction in ethyne-biodiesel-aspirated diesel engine." *International Journal of Green Energy* 15(7): 436–440. doi:10.1080/15435075.

Devarajan, Y., D. B. Munuswamy, and A. Mahalingam. 2017a. "Performance, Combustion and Emission Analysis on the Effect of Ferrofluid on Neat Biodiesel." *Process Safety and Environmental Protection* 111: 283–291. doi:10.1016/j.psep.2017.07.021.

Devarajan, Y., D. B. Munuswamy, A. Mahalingam, and B. Nagappan. 2017b. "Performance, Combustion, and Emission Analysis of Neat Palm Oil Biodiesel and Higher Alcohol Blends in a Diesel Engine." *Energy & Fuels* 31 (12): 13796–13801. doi:10.1021/acs.energyfuels.7b02939.

Devarajan, Y., D. B. Munuswamy, B. Nagappan, and A. K. Pandian. 2018. "Performance, Combustion and Emission Analysis of Mustard Oil Biodiesel and Octanol Blends in Diesel Engine." *Heat and Mass Transfer*. doi:10.1007/s00231-018-2274-x.

Devaraj, A., I. Vinoth kanna, K. Manikandan, and Jishuchandran. 2017. "Impact of Engine Emissions From HCCI Engine, An Overview." *International Journal of Mechanical and Production Engineering Research and Development* 7 (6): 501–506. doi:10.24247/ijmperddec201757.

Joy, N., Y. Devarajan, B. Nagappan, and A. Anderson. 2017. "Exhaust Emission Study on Neat Biodiesel and Alcohol Blends Fueled Diesel Engine." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 40 (1): 115–119. doi:10.1080/15567036.2017.1405119.

Kishore Pandian, A., D. B. Munuswamy, S. Radhakrishana, R. B. Bathey Ramakrishnan, B. Nagappan, and Y. Devarajan. 2017. "Influence of an Oxygenated Additive on Emission of an Engine Fueled with Neat Biodiesel." *Petroleum Science* 14 (4): 791–797. doi:10.1007/s12182-017-0186-x.

Kumar, K. S., and R. T. K. Raj. 2016. "Effect of Di-Tertiary Butyl Peroxide on the Performance, Combustion and Emission Characteristics of Ethanol Blended Cotton Seed Methyl Ester Fuelled Automotive Diesel Engine." *Energy Conversion and Management* 127: 1–10. doi:10.1016/j.enconman.2016.08.091.

Mahalingam, A., D. B. Munuswamy, Y. Devarajan, and S. Radhakrishnan. 2018. "Emission and performance analysis on the effect of exhaust gas recirculation in alcohol-biodiesel aspirated research diesel engine." *Environmental Science and Pollution Research* [Internet]. Springer Nature; February 21. doi:10.1007/s11356-018-1522-4.

Pandian, A. K., D. B. Munuswamy, S. Radhakrishanan, Y. Devarajan, R. B. B. Ramakrishnan, and B. Nagappan. 2018. “Emission and Performance Analysis of a Diesel Engine Burning Cashew Nut Shell Oil Bio Diesel Mixed with Hexanol.” *Petroleum Science*. doi:10.1007/s12182-017-0208-8.

Pandian, A. K., R. B. B. Ramakrishnan, and Y. Devarajan. 2017. “Emission Analysis on the Effect of Nanoparticles on Neat Biodiesel in Unmodified Diesel Engine.” *Environmental Science and Pollution Research* 24 (29): 23273–23278.

Radhakrishnan, S. 2017. “Emissions Analysis on Diesel Engine Fueled with Palm Oil Biodiesel and Pentanol Blends.” *Journal of Oil Palm Research*, 380–386. doi:10.21894/jopr.2017.2903.11.

Rashedul, H. K., H. H. Masjuki, M. A. Kalam, A. M. Ashraful, S. M. Ashrafur Rahman, and S. A. Shahir. 2014. “The Effect of Additives on Properties, Performance and Emission of Biodiesel Fuelled Compression Ignition Engine.” *Energy Conversion and Management* 88: 348–364. doi:10.1016/j.enconman.2014.08.034.

Shahabuddin, M., A. M. Liaquat, H. H. Masjuki, M. A. Kalam, and M. Mofijur. 2013. “Ignition Delay, Combustion and Emission Characteristics of Diesel Engine Fueled with Biodiesel.” *Renewable and Sustainable Energy Reviews* 21: 623–632. doi:10.1016/j.rser.2013.01.019.

Venkata Ramanan, M., and D. Yuvarajan. 2015. “Performance Study of Preheated Mustard Oil Methyl Ester on Naturally Aspirated CI Engine.” *Applied Mechanics and Materials* 787: 761–765. doi:10.4028/www.scientific.net/amm.787.761.

Venkateswarlu, K., B. S. R. Murthy, and V. V. Subbarao. 2016. “An Experimental Investigation to Study the Effect of Fuel Additives and Exhaust Gas Recirculation on Combustion and Emissions of Diesel–Biodiesel Blends.” *Journal of the Brazilian Society of Mechanical Sciences and Engineering* 38 (3): 735–744. doi:10.1007/s40430-015-0376-7.

Vinoth Kanna, I., A. Vasudevan, and K. Subramani. 2018. “Internal Combustion Engine Efficiency Enhancer by Using Hydrogen.” *International Journal of Ambient Energy*, 1–4. doi:10.1080/01430750.2018.1456961.

Xue, J., T. E. Grift, and A. C. Hansen. 2011. “Effect of Biodiesel on Engine Performances and Emissions.” *Renewable and Sustainable Energy Reviews* 15 (2): 1098–1116. doi:10.1016/j.rser.2010.11.016.

Yuvarajan, D., M. Dinesh Babu, N. BeemKumar, and P. Amith Kishore. 2018. “Experimental Investigation on the Influence of Titanium Dioxide Nanofluid on Emission Pattern of Biodiesel in a Diesel Engine.” *Atmospheric Pollution Research* 9 (1): 47–52. doi:10.1016/j.apr.2017.06.003.

Yuvarajan, D., K. Pradeep, and S. Magesh Kumar. 2016. “Impact of Oxygenated Additives on Performance Characteristics of Methyl Ester in IC Engine.” *Applied Mechanics and Materials* 852: 724–728. doi:10.4028/www.scientific.net/amm.852.724.

Yuvarajan, D., M. V. Ramanan, D. C. Selvam, M. Arulprakasajothi, and N. B. Kumar. 2017. “Emission Analysis of Mustard Oil Methyl Oil Methyl Ester at Varying Injection Timing.” *Indian Journal of Science and Technology* 9 (S1). doi:10.17485/ijst/2016/v9is1/103312.

Yuvarajan, D., R. Surendran, V. Vinoth Kumar, and R. Devanathan. 2016. “Role of Additives on Emission Characteristics of Methyl Ester in Constant Speed Diesel Engine.” *Applied Mechanics and Materials* 852: 729–733. doi:10.4028/www.scientific.net/amm.852.729.

Yuvarajan, D., M. Venkata Ramanan, and D. Christopher Selvam. 2016. “Performance Analysis on Mustard Oil Methyl Ester as a Potential Alternative Fuel.” *Indian Journal of Science and Technology* 9 (37). doi:10.17485/ijst/2016/v9i37/101982.