# EFFECT OF AROMATIC AMINE ANTIOXIDANTS ON EMISSION CHARACTERISTICS WITH MORINGA BIODIESEL BLEND IN A MULTI-CYLINDER DIESEL (MCD) ENGINE

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**Abstract:** *Two most effective aromatic amine antioxidants N, N'-diphenyl-1, 4-phenylenediamine (DPPD) and N-phenyl-1, 4-phenylenediamine (NPPD) were used at a volume of 2000 ppm concentration. The impact of antioxidant on engine emissions were analyzed in a multi-cylinder diesel engine fuelled with MB20 (20% Moringa oil methyl ester and 80% diesel fuel blend) biodiesel blends. Addition of antioxidants showed no remarkable negative impact on biodiesel physicochemical properties, while the stability of biodiesel increased. Among these two aromatic amine antioxidants DPPD exhibits better stability. The results also showed decreased NOX emission of about 3.04%-7.4%, however the HC and CO increased for all blends. For this reason MB20 blends with amine antioxidants can be used in diesel engine without any modification.*

**Keywords:** *Moringa oleifera; Physico-chemical properties; Emissions, amine antioxidants.*

## INTRODUCTION

Production of biodiesel from vegetable oils as a sources of edible oil were considered as one of the potential feedstocks [1]. Storage stability and coarse oxidative are the significant disadvantage of biodiesel fuel [2]. It is all around record that auto-oxidation occur due to the presence of oxygen comes from atmosphere and that is why biodiesel goes to degrades [3]. There are various investigated literature for stability of biodiesel blends [4, 5]. Varatharajan et al [6] investigated the impact of adding two aromatic amine antioxidant (DPPD and NPPD) blended with soybean biodiesel on NOx emission in a single cylinder diesel engine. They found that CO and HC increases 10.52% and 9.096% respectively, while the NO reduce 9.35% added DPPD antioxidant. In another study, Varatharajan et al [7] observed the effect of antioxidants on NOx emission of jatropha biodiesel with different antioxidants additives like as 0.025%-m of additives, p-phenylenediamine, ethylenediamine, l-ascorbic acid, α-Tocopherol acetate, and BHT in a single cylinder diesel engine (SCDE) and found that p-phenylenediamine produce 43.55% average lower NOx compare with pure biodiesel. The objectives of this study is to experimentally find out the effect of two most promising aromatic amine antioxidant (DPPD and NPPD) on engine emission in a multi cylinder diesel (MCD) engine fuelled with Moringa biodiesel blends. There are no experimental work have been found on the basis of MCD engine by using two aromatic amine antioxidant (DPPD and NPPD) with Moringa biodiesel.

## MATERIALS AND METHODS

In this present study, the tested engine was Mitsubishi pajero, 4D56T at 55 kW with multi-cylinder computerized radiator cooling system inline diesel engine. The engine specification is given in **table 1** and the experimental setup is shown in **fig 1.** The experimental investigation was carried out by using diesel and with different blends with and without antioxidant (MB0, MB20, MB20+DDPD and MB20+NPPD). All experiment were taken with variation of engine speed starting from 1000 rpm to 4000 rpm at an interval of 500 rpm at constant load condition.

**Table 1.** Specification of the engine

| Model | 4 cylinder inline diesel engine |
|---|---|
| Type | Four cylinder, four stroke |
| Displacement (cc) | 2476 |
| Cylinder bore x strok ( mm) | 92 x 96 |
| Compression ratio | 21:1 |
| Maximum engine speed (rpm) | 4200 |
| Maximum power ( kW ) | 55 |
| Fuel system | Distribution type jet pump (indirect injection) |
| Lubrication System | Pressure feed and full flow system |
| Combustion chamber | Swirl type |
| Cooling system | Radiator cooling |
| Air flow | Turbocharged |
| Valve mechanism | SHOC |

**Table 2.** Physico-chemical properties of used fuels

| Properties | Diesel (B0) | MB100 | MB20 | MB20+DPPD | MB20+NPPD |
|---|---|---|---|---|---|
| Calorific value (Mj/kg) | 45.453 | 40.36 | 44.02 | 44.10 | 44.08 |
| Kinematic viscosity @ 40°C (cSt) | 3.10 | 4.80 | 3.56 | 3.572 | 3.59 |
| Density @ 40°C (kg/m$^3$) | 828 | 862 | 837 | 833.2 | 833 |
| Flash point (°C) | 67 | 169 | 85.2 | 87.3 | 85.0 |
| Oxidation stability (h) | 58.2 | 3.79 | 5.28 | 22.3 | 18.9 |

## RESULTS AND DISCUSSION

### NOx Emission

**Fig. 2** demonstrate the NOx variation with the speed. The NOx were increased linearly up to speed 3000 rpm and then decreased very slowly. By adding antioxidant (DPPD, NPPD) with MB20, the NOx emission comparatively shows lower. The average NOx emission in all tested fuels are 209.85 ppm, 248.28 ppm, 229.85 ppm and 240.71 ppm for the B0, MB20, MB20+DPPD, MB20 +NPPD accordingly and the average increase NOx emission 15.47%, 8.7%, and 12.82% compare to B0.

### HC Emission

**Fig. 4** demonstrates the fluctuation of HC emission with varying speed for all tested blends. The HC emission is gradually decreased with increasing speed. The maximum and minimum HC emission are shown at 1000 rpm and 4000 rpm respectively. It is point noted that the mean reduction of HC emission is 27.64%, 19.07% and 10.04 % for MB20, MB20 +DPPD and MB20 +NPPD respectively to compare with B0.

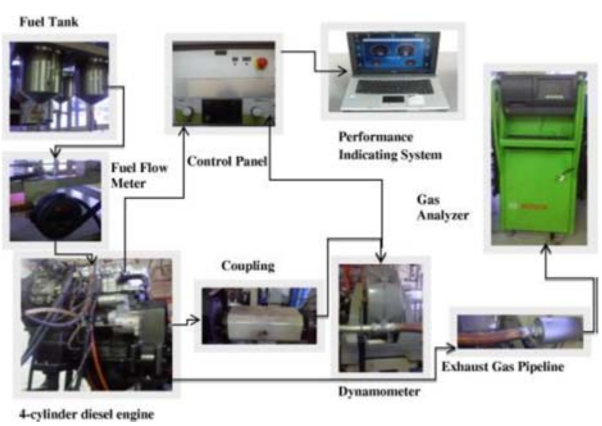


**Fig 1:** The experimental setup.

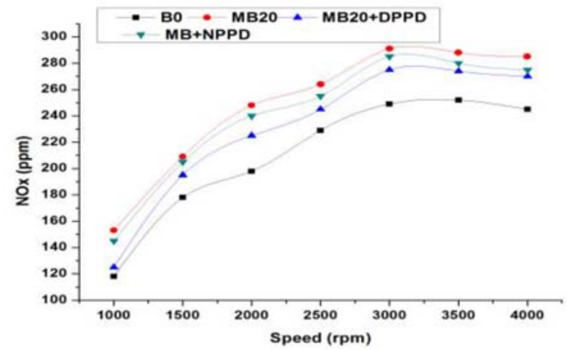


**Fig 2**: Fluctuation of NOx emission at different speed

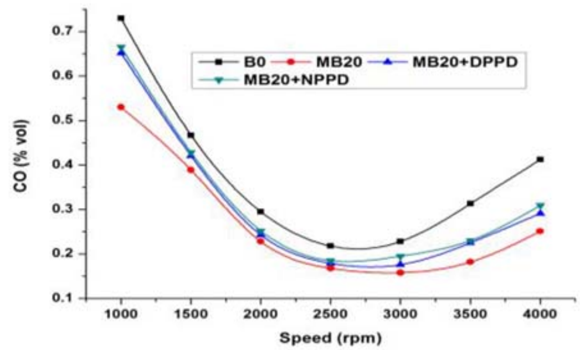


**Fig 3**: Fluctuation of CO emission at different speed

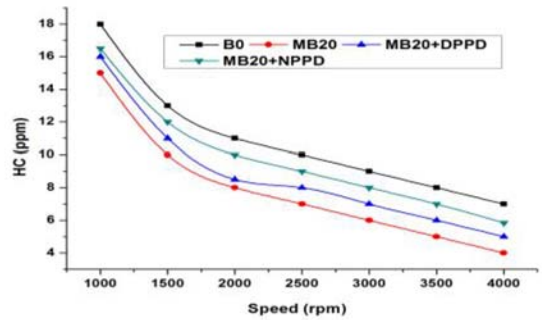


**Fig 4**: Fluctuation of HC emission with respect to speed

### CO Emission

**Fig. 3** demonstrate the fluctuation of CO emission with varying speed for all tested fuels with and without antioxidant in a multi cylinder diesel engine at full load condition. It was point out that, CO emission lessens adequately in all blends compare with pure biodiesel (B0). The maximum CO emission was found from pure biodiesel. The mean lessens of CO emission are

28.41%, 17.87% and 15.98% for MB20, MB20 +DPPD, MB20 +NPPD to compare with B0. However, the addition of antioxidant of 2000 ppm of DPPD and NPPD into the biodiesel enhanced the CO emission adequately. The amount CO emission is still less by adding antioxidant in biodiesel compared to pure diesel.

## CONCLUSION

Morinnga biodiesel (20% by volume) blends meets the ASTM specification standards. Addition of amine antioxidant additives (DPPD, NPPD), reduce the calorific value but enhance the kinematic viscosity, density, flash point and oxidation stability. By comparing two amine antioxidant (DPPD, NPPD), DPPD having higher oxidation stability with MB20. MB20 produces 15.57% higher NOx compared to neat biodiesel. The addition of DPPD and NPPD with MB20 reduce the NOx emission compared to MB20. The addition of DPPD and NPPD antioxidant additives in moringa biodiesel blends increase the CO emission adequately for MB20 blend. But this increase was comparatively lower than diesel. The additive lessens the oxidation capability of CO and for this reason, the CO emission increase. HC emission increased due to addition of DPPD and NPPD with MB20, but compared to diesel it was lower.

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