Advanced blends as avisable extended option for thermal engines: emissions and performance on a Diesel Engine

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Introduction

The stricter emission regulation for the automobile sector to achieve reduction in pollution that caused GHG in the atmosphere, have resulted in the search of alternative clean fuels which satisfy the demand of this sector. In this context, the incorporation of bio-based oxygenated compounds can be considered as an alternative to both, contribute to the decarbonisation of the energetic system and to reduce the fossil fuel dependence. A significant interest has been growing in long-chain additive alcohols as ternary Biodiesel-Petrodiesel-Oxigenated blends [1, 2], and indeed, bio-butanol has attracted interest as oxygenated compound because of its closer properties to the fossil-sourced fuels [3].

This contribution focuses on the study and development of different optimized Biodiesel-Petrodiesel-(bio)Butanol ternary advanced fuel blends and their performance on the different engine parameters and gas-emissions in a real diesel engine.

Materials and Methods

Engine tests were conducted in a dynamometer engine test bench composed of 4 cylinders – 2000cm^3 RHY DW10TD HDI diesel engine with *common rail* injection system and a dynamometer TECNER E145. In addition, pollutants exhaust gas concentration (NO, NO_2, CO, CO_2 and O_2) was measured directly to the manifold outlet by a PG-350E (HORIBA Inc.). The experiments were performed at different driving modes maintaining the revolutions (2000-3000rpm) and modifying torque from 30 to 90N·m. Overall, a series of $B_xP_yO_z$ blends have been prepared and some of them are presented in this work, including commercial diesel, petrodiesel, a binary petro-biodiesel mixture for comparative purposes and ternary petro-biodiesel-biobutanol mixtures, with butanol as oxygenate; “x” is the composition pure palm-biodiesel supplied by BIO-OILS S.A., “y” refers to pure non-sulphur Petrodiesel supplied by CEPSA and “z” to pure butanol provided by Sigma.

Results and Discussion

Firstly, Figure 1 shows the in-cylinder pressure in steady-state conditions versus crank angle for all tested fuels at 2000rpm and 30N·m of torque. It could be inferred how the impact of the fuel affected to maximum pressure and ignition delay. Indeed, the presence of 9%v/v of biodiesel and butanol (1%v/v) in ternary technical fuel blends led to an increase of ignition delay of 1.5% and max

pressure rise of 7.2% respect to petrodiesel data registered in the same conditions. However, at higher loadings, all ternary blends showed similar behavior with respect to pure petrodiesel and no noticeable differences in engine performance (energy efficiency and overall consumption) were observed, concluding that engine conditions had more influence than the used fuel blends.

Regarding pollutant emissions, Figure 2 shows the concentration of NO_x in the exhaust gas in each performed experiment varying the revolutions and loading, i.e., obtaining different Brake-Specific Fuel Consumption (BSFC) for each test. It can be observed how for low BSFC values the difference and the decrease in NO_x concentration became more noticeable for the fuel blend $B_9P_{90}O_1$ compared to Petrodiesel as base fuel (reduction of 40%). Furthermore, as BSFC increases, the variation in NO_x concentration became less dependent on the biodiesel content and the oxygen-alcohol fuel fraction, although for all tests, a low butanol content in the ternary blend reduced NO_x, CO_2 and CO emissions.

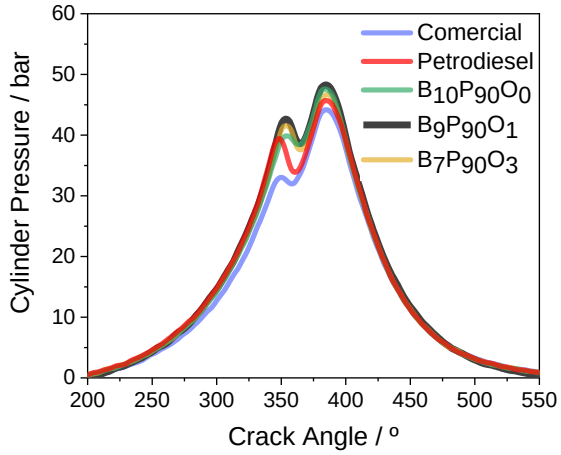

Figure 1. Cylinder Pressure versus crank angle for 2000 rpm and 30 N·m of Torque for tested fuels.

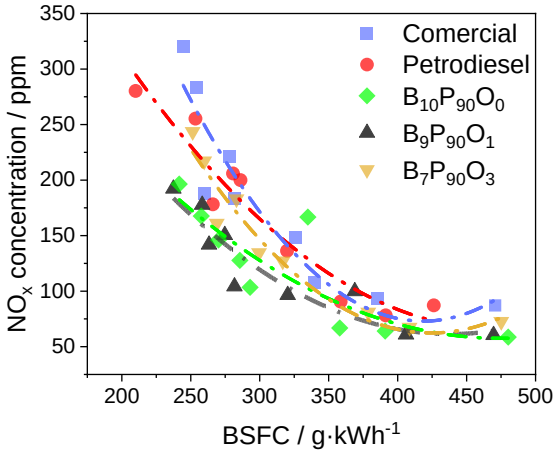

Figure 2. Comparative NO_x emissions for tested fuels for different BFSC.

Conclusions

The incorporation up to a content of 1% of butanol causes a better combustion with an increase in the cylinder pressure and a reduction of the NO_x emission compared to petrodiesel, commercial or even binary mixtures. BPO advanced ternary fuel blends have been shown to be an avisable option for diesel-powered vehicle fleet, reducing vehicle emissions, lowering consumption to achieve the same power and performance. Furthermore, the combination of hydrogen co-injection, these new technical blends and an appropriated hybrid catalytic system (SCR+NSR) is an appropriate technology to achieve zero emissions.

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