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Performance and emissions of a diesel engine fueled with biodiesel doped with a renewable antioxidant additive

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PERFORMANCE AND EMISSIONS OF A DIESEL ENGINE FUELED WITH BIODIESEL DOPED WITH A RENEWABLE ANTIOXIDANT ADDITIVE

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Fairmont Tremblant Hotel, Mont Tremblant, Quebec, Canada

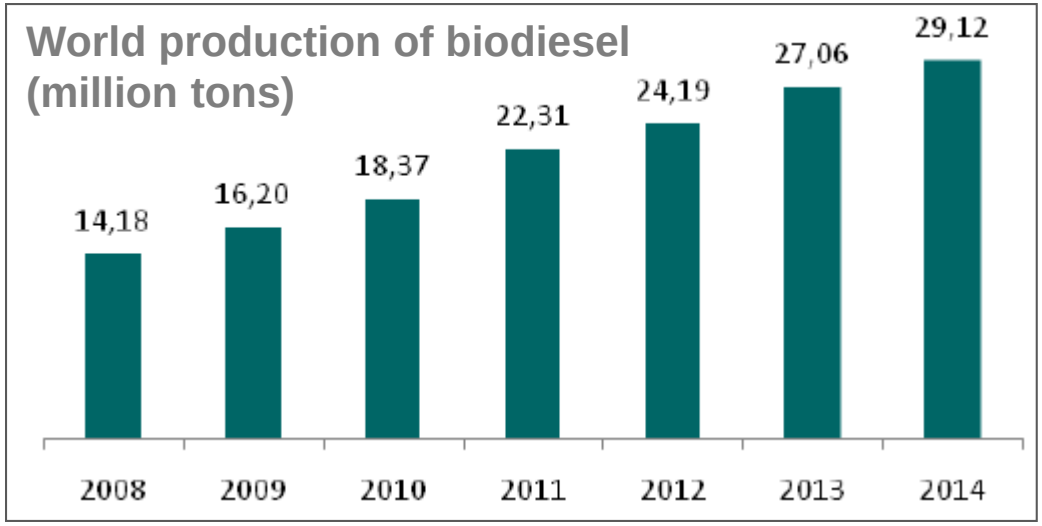
Aim of the work

BIODIESEL

- ✓ Renewable alternative to fossil diesel.
- ✓ Less harmful emissions.
- ✓ Carbon neutral.

European FAME Standard EN 14214:
Quality requirements for biodiesel commercialization

Properties
FAME Content
Oxidation stability
Viscosity at 40 ºC
Water content
CFPP



Source: Oil World Statistic Update

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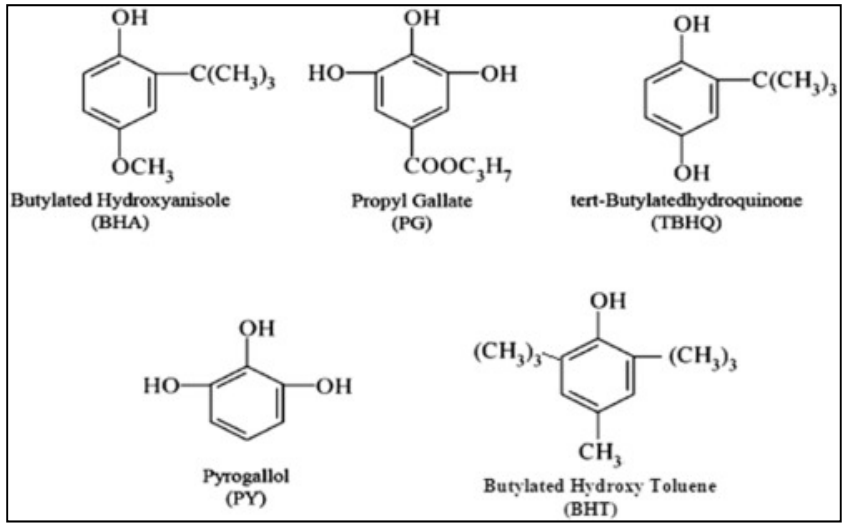
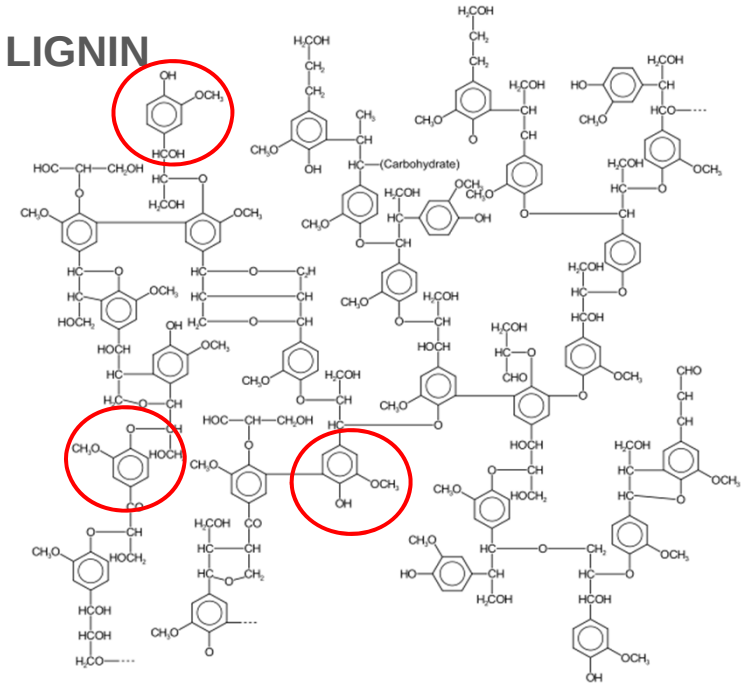
Aim of the work

Synthetic antioxidants



Natural antioxidants

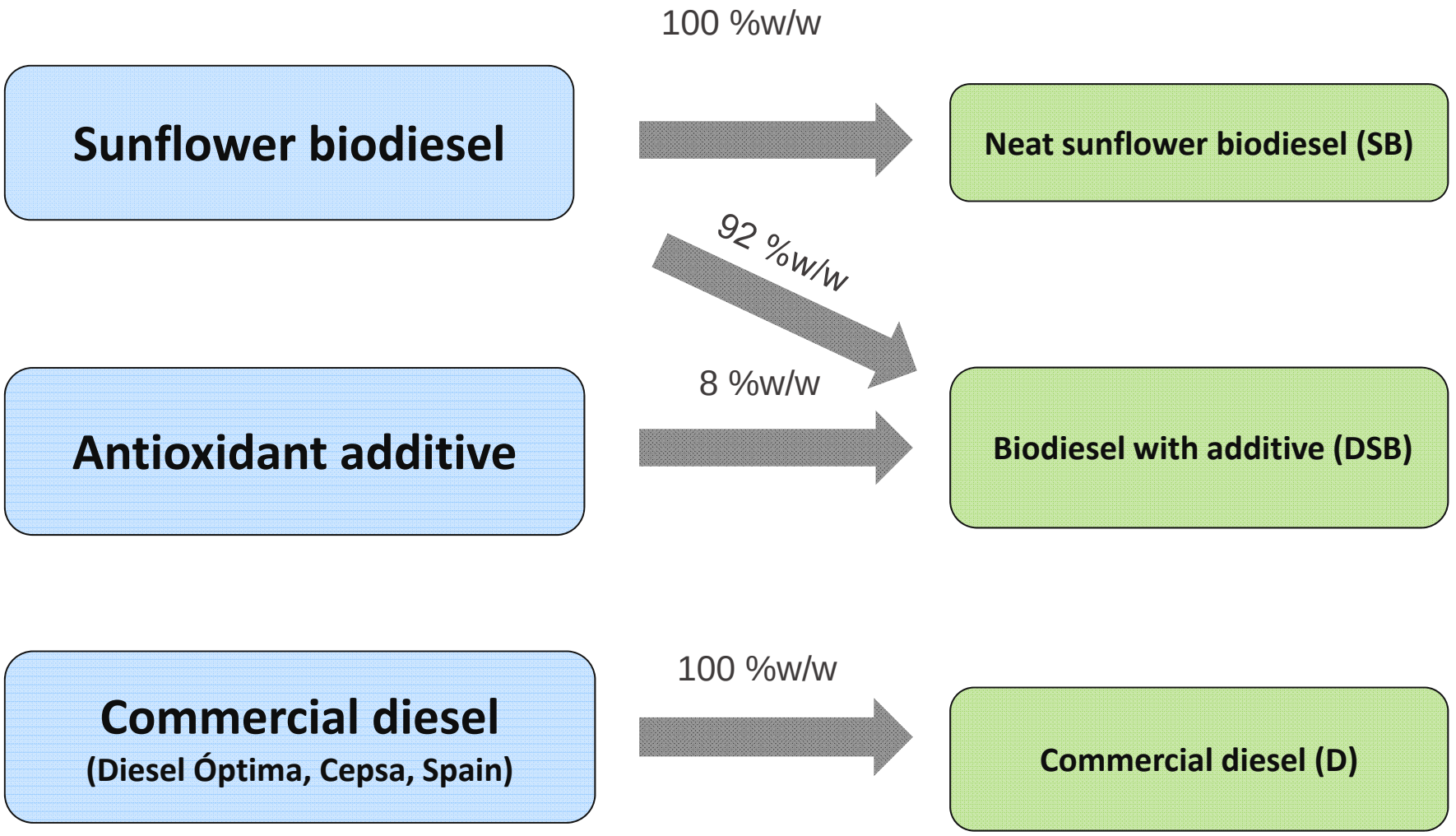


In previous works, lignin derivatives, such as bio-oils from biomass or residues, have demonstrated to be a source of phenols (antioxidants) increasing the oxidation stability till 500%.

Aim of the work

- To test bio oil additivated biodiesel in a diesel engine and compare performance and emissions with those of neat biodiesel and commercial diesel.

FUELS TO ENGINE TESTS



Experimental

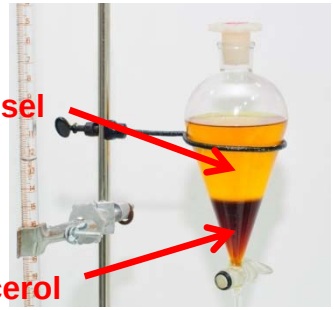
BIODIESEL PREPARATION

o Raw materials: Sunflower oil, MeOH, KOH (catalyst)

Oil / alcohol = 1:6 molar ratio.

Catalyst weight = 1 wt.% of oil mass.

o Reaction conditions: 60 ºC, 3h, stirring.



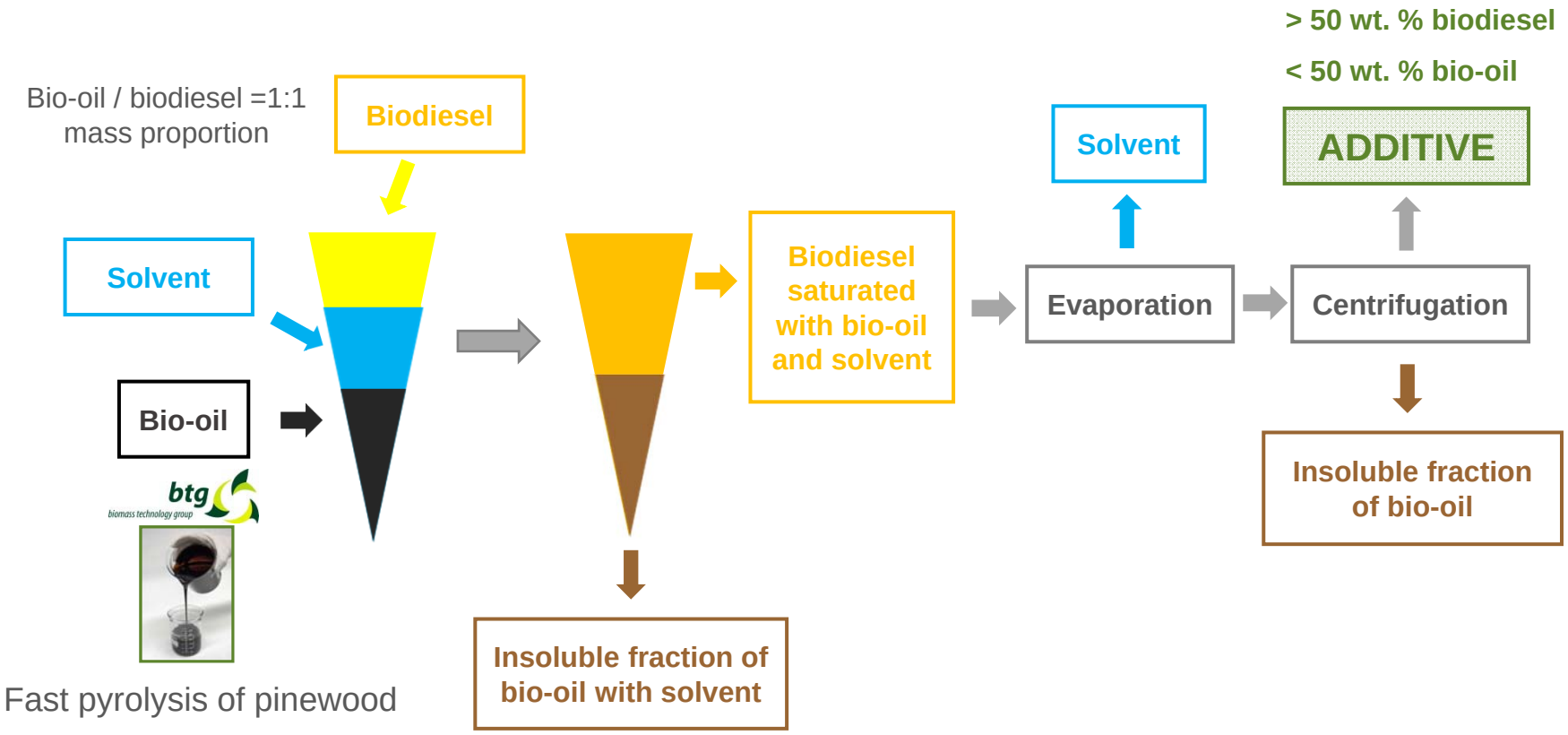
o Biodiesel upgrading:

- ✓ excess methanol removal
- ✓ acid washing
- ✓ residual moisture removal

o Composition: Predominance of methyl linoleate (C18:2) followed by methyl oleate (C18:1).

Experimental

ADDITIVE PREPARATION



✓As biodiesel in additive is >> 50%

✓Addition of 8 wt. % to biodiesel.

→ ✓FAME in final biodiesel > 96.5% (UNE 14214)

Experimental

FUEL PROPERTIES

C, H, N, S
(Leco CHN628 Macro and Leco S628 for Sulphur determination)

Higher Heating Value (HHV)
(C2000 IKA bomb calorimeter)

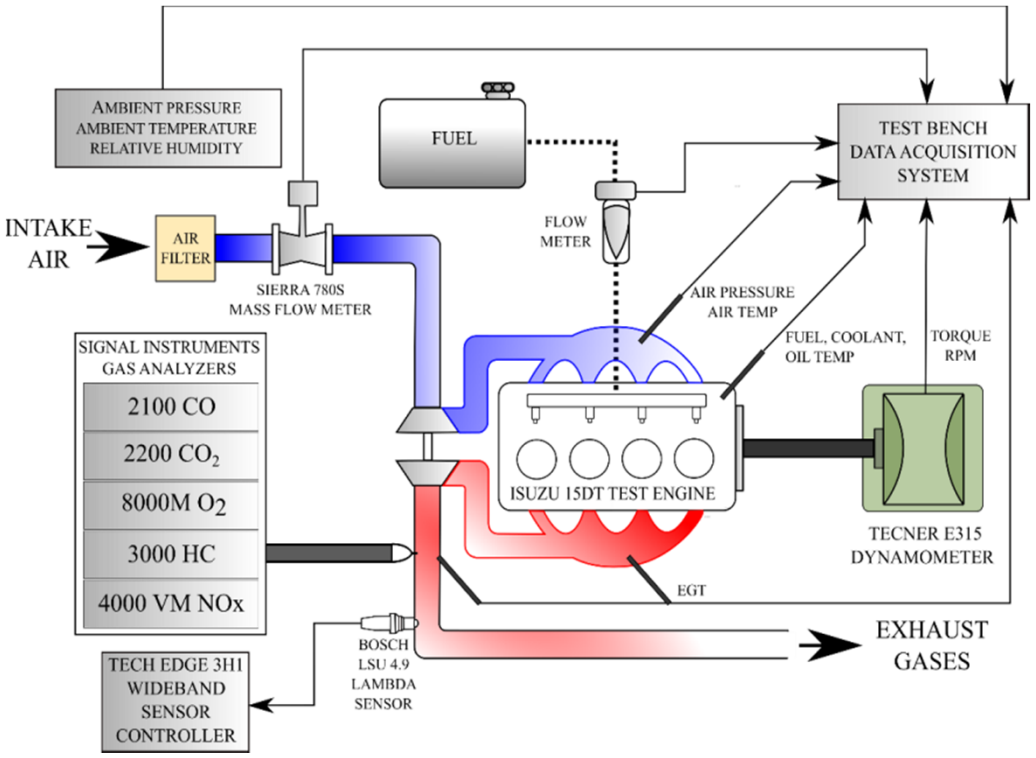
Density at 15 ºC
(Densito 30 PX Mettler Toledo)

Cold Filter Plugging Point (CFPP) (ISL FPP 5GS)

Viscosity at 40 ºC
(Cannon Instrument Co., model 150 T845)

Oxidation Stability (Oxy)
(PetroOXY, ASTM D2274)

Engine



Engine	**Isuzu T4EC1 15DT turbocharged**
Original Fuel	Diesel
Number of Cylinders	4 in line
Displaced Volume	1487 cm^3
Bore x Stroke	76 x 82 mm
Compression ratio	22:1
Valve timing	12-48-50-10
Fuel delivery system	Mechanical indirect fuel injection

Engine Tests

- Several tests running the engine from 1500 to 4000 rpm at full load were performed to compare the behavior of the different biofuels.

- Exhaust emission characteristics in a European Stationary Cycle (ESC) with 13 phases (European Directive 2005/55/CE)

Phase	Load (%)	Engine speed (rpm)	Weight factor
1	0	1020	0,15
2	100	2500	0,08
3	50	3250	0,10
4	75	3250	0,10
5	50	2500	0,05
6	75	2500	0,05
7	25	2500	0,05
8	100	3250	0,09
9	25	3250	0,10
10	100	4000	0,08
11	25	4000	0,05
12	75	4000	0,05
13	50	4000	0,05

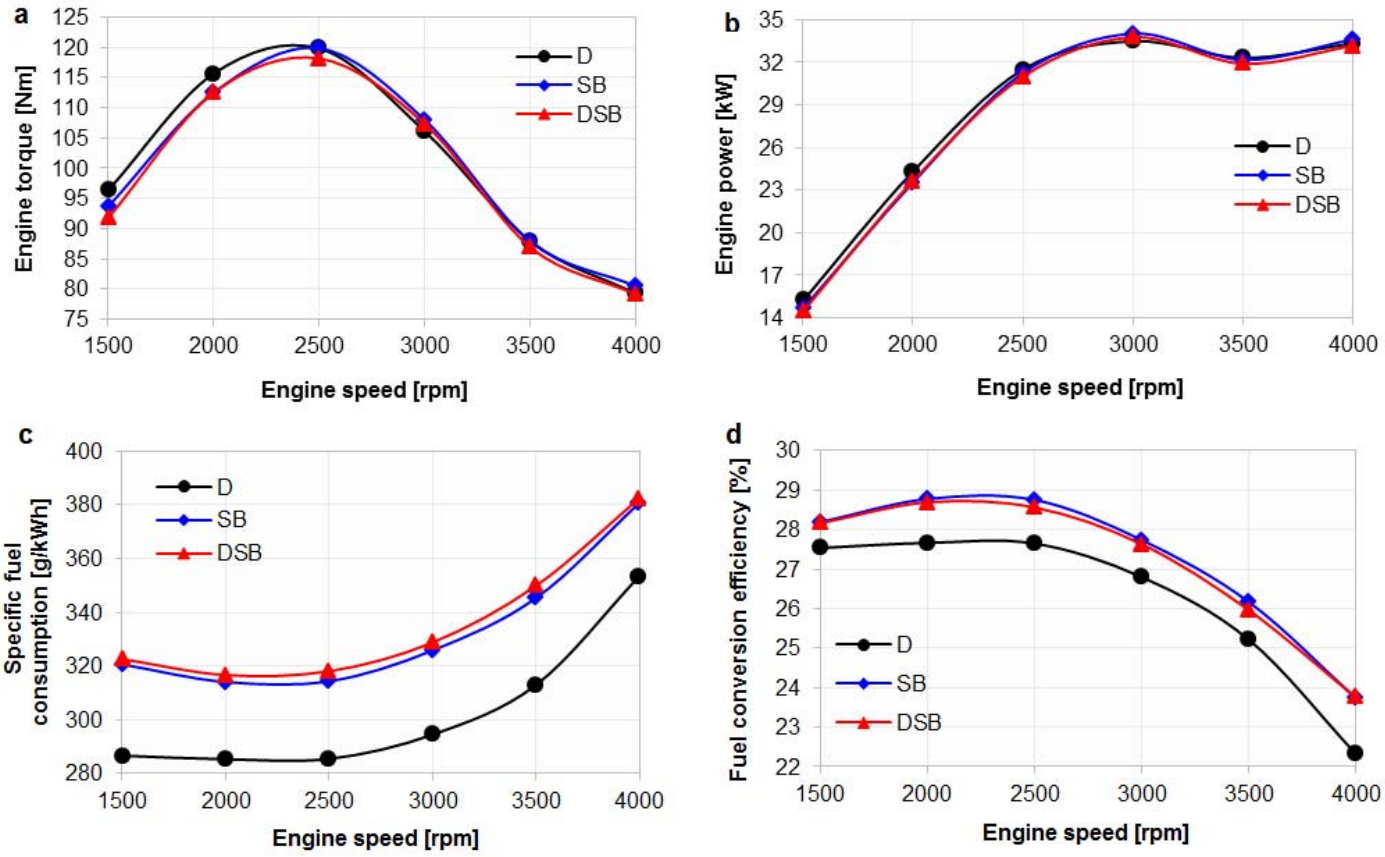
Results

Fuel properties

Fuel	Molar ratio				Density (kg/m³)	Viscosity (cst)	Water content (ppm)	HHV (kJ/kg)	OXY (min)	CFPP (ºC)
	H/C	S/C	N/C	O/C						
D	1.82	0.0001	0.0018	0	840	2.80	75	45620	94.2	-16.1
SB	1.84	0.0001	0.0018	0.09	883	4.47	579	39830	13.8	-5.1
DSB	1.85	0.0001	0.0018	0.09	886	4.30	587	39630	37.6	-2.9

Results

Full load tests



Results

ESC Cycle

Fuel	Specific emissions (g/kWh)				Opacity (mg/m³)
	NO_x	HC	CO	CO_2	
D	2.62	0.64	4.16	1186.6	4.94
SB	2.96	0.35	2.92	1207.3	1.59
DSB	2.87	0.40	2.94	1221.6	1.52

CONCLUSIONS

- Biodiesel doped with the antioxidant produced from bio-oil increased noticeably its oxidation stability, while CFPP slightly increased.
- Other properties, such as density or viscosity, were not affected.
- At full load operation of the engine, torque and power were very similar for the three fuels, but efficiency of the two biodiesels were higher than fossil diesel. In general, performances of neat biodiesel and doped biodiesel in the diesel engine were very similar.
- The presence of additive from bio-oil in the biodiesel doesn´t significatively change the engine emissions.
- The emissions of the three fuels showed the expected result: lower unburned hydrocarbons, CO and opacity for biodiesels.

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