Electronic Supplementary Material (ESI) for RSC Advances.
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Appendix A

continence Supporting information for:

Performance, combustion and emission characteristics of a direct injection VCR CI engine using *Jatropha curcas* oil microemulsion: A comparative assessment with JCO B100, JCO B20 and Petrodiesel

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1. Experimental

1.1. Biodiesel preparation

JCO B100 was obtained by transestefication of pretreated/esterified JCO with methanol in the presence of 1 wt% NaOH (99.9%, Merck) as catalyst. NaOH was weighed separately of the total amount of oil (1200 g) using standard weighing balance and dissolved in required quantity of anhydrous methanol (mole ratio of oil to methanol was ~1:9) at 50 °C. The reaction mixture was vigorous stirred (500 rpm) and heated to at 60 °C for 30 min in 2 L capacity Jacketed Lab Reactor (Radleys) equipped with mechanical stirring and reflux condenser. After completion of the reaction, excess methanol was removed with a rotary evaporator (Heidolph Hei-VAP). The resulting product was neutralized with by washing with warm deionised water. Finally the product JCOB100 was recovered in a separatory funnel, dried in an oven (105 °C) and anhydrous Na_2SO_4 prior to use. 200 ml of the biodiesel (B100) was taken mixed with 800 ml of petroleum diesel (IOCL, LDO) to prepare the JCO B20 blend.

1.2. Determination of activation energy

Calculation of activation energy was done using Coats and Redfern method. Coats and Redfern method is an integral method used for non-isothermal kinetic analysis. This method eliminates the rate constant and gives activation energy and frequency factor directly. The equations used in calculation are:

$$\ln\left[\frac{1-(1-x)^{(1-n)}}{T^2(1-n)}\right] = \ln\left(\frac{AR}{\beta E_a}\right)\left[1-\frac{2RT}{E_a}\right] - \frac{E_a}{RT} \quad (for\ n \neq 1)$$
(1)

and

$$\ln\left[\frac{ln(1-x)}{T^2}\right] = \ln\left(\frac{AR}{\beta E_a}\right)\left[1-\frac{2RT}{E_a}\right] - \frac{E_a}{RT} \quad (for\ n=1)$$
(2)

where, x is the fractional weight loss. In Eq. (2) except fractional weight loss (x) and TGA temperature T (also refer to Figure S3), other parameters are constant. Thus plotting a graph between $\ln\left[\frac{ln(1-x)}{T^2}\right]$ and $\frac{1}{T}$ the value of $-\frac{E_a}{R}$ can be obtained, from which activation energy (E_a) can be calculated.

1.3. Equations used in the determination of performance parameters

Brake power is given by:

$$BP\ (kw) = \frac{2 \times \Pi \times W \times R}{60000}$$

$$BP\ (kw) = \frac{0.785 \times RPM \times W \times 9.81 \times arm\ lenegth}{60000} \quad (3)$$

Where, W = 9.81 kg, R = radius (m), arm length = 0.00185 (m)

Brake thermal efficiency (η_{bte}) can be expressed as follows:

$$\eta_{bte} = \frac{BP \times 3600 \times 100}{fuel\ flow\ rate\ (kg/hr) \times calorific\ value\ (KJ/kg)} \quad (4)$$

Indicated thermal efficiency (η_{ite}):

$$\eta_{ite} = \frac{indicated\ power}{fuel\ energy}$$

$$\eta_{ite} = \frac{IP \times 3600 \times 100}{fuel\ flow\ rate\ (kg/\ hr) \times calorific\ value\ (kJ/\ kg)} \quad (5)$$

Mechanical Efficiency:

$$\eta_{mech} = \frac{BP \times 100}{IP} \quad (6)$$

Volumetric efficiency (%) is given by:

$$\%\ Vol = \frac{air\ flow\ rate \times 100}{(\frac{\Pi}{4}) \times D^2 \times (\frac{N}{n}) \times no\ of\ cycle \times A_{den}} \quad (7)$$

Where, air flow rate (kg/hr):

$$Air\ flow\ rate\ (kg/hr) = C_d \times \frac{\Pi}{4} \times D^2 \times \sqrt{(}2gh_{water} \times \frac{W_{den}}{A_{den}}) \times A_{den} \times 3600 \quad (8)$$

Where, C_d = Co-efficient of discharge of orifice, D = Orifice diameter in meter, g = acceleration due to gravity (m/s^2) = 9.81 m/s^2, h = differential head across orifice (m of water), W_{den}= Water density (kg/m^3) =@1000 kg/m^3, A_{den}= p/RT = Air density at working condition (kg/m^3).

Here, p is atmospheric pressure in kgf/m^2 (1 Standard atm = 1.0332 $x10^4$ kgf/m^2), R is Gas constant (29.27 kgfm/kgK) and T is atmospheric Temperature at K.

Brake specific energy consumption (BSEC) was evaluated from:

$$BSFC = \frac{fuel\ flow\ rate\ (kg/hr)}{BP} \quad (9)$$

Table S1

Technical Specifications of the CI engine test rig used in the study

Experimental test rig.	Variable Compression Ratio Diesel Engine test setup with 4 stroke single cylinder (Computerized)
Test rig. code	234
Make	Kirloskar
Type	1 cylinder, 4 stroke, D.I diesel engine
Power	3.5 KW @ 1500 rpm
Bore & stroke	87.5 mm & 110 mm
Capacity	661 CC
Cooling method	Water cooled
Compression Ratio range	12:1 to 18:1
Dynamometer	Water cooled eddy current type dynamometer with loading unit
Air box	M S fabricated with orifice meter and manometer
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Crank angle sensor	Range 5000 PSI, with low noise cable
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Data acquisition Software	"EnginesoftLV" Engine performance analysis software Version 9.0
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	DP transmitter, Range 0-500 mm WC

Table S2

Technical Specifications of the gas analyzer used in this work

Measured quality	Measuring range	Resolution	Accuracy
CO:	0-10 % vol	0.01 % vol	<0.6 % vol: ± 0.03 % vol ≥0.6 % vol: ± 5% of ind. Val.
CO_2:	0-20 % vol	0.1 % vol	<10 % vol: ± 0.5 % vol ≥10 % vol: ± 5% vol
HC:	0-20000 ppm vol	≤ 2000:1 ppm vol >2000:10 ppm vol	<200 ppm vol: ± 10 ppm vol ≥200 ppm vol: ± 5% of ind.Val.
$O_{2:}$	0-22 % vol	0.01 % vol	<2 % vol: ± 0.1 % vol ≥2 % vol: ± 5% of vol
NO:	0-5000 ppm vol	1 ppm vol	<500 ppm vol: ± 50 ppm vol ≥500 ppm vol: ± 10% of ind. Val.
Miscellaneous			
Power consumption:	≈ 25 W		
Connector CAL. Gas:	60-140 l/h, max. overpressure 450 hPa		
Connector Gas In:	≈ 180 l/h, max. overpressure 450 hPa		
Dimension (WxDxH):	270 320 x 85 mm^3		

Table S3

List of standard test methods used in the study

Parameter	Standard Methods
Density (40 ^oC, g/cc)	ASTM D-1250-08 & DIN 51757
Kinematic Viscosity (cSt)	ASTM D-445 & D-2171
Calorific value (MJ/kg)	IS: 1359 –1959, BS 1016: Part 5:1967, IP 12/63T
Acidity index (mgKOH/g)	A.O.C.S. Official Method Ca 5a-40
Flash point (^oC)	D93
Pour point (^oC)	D2500
Fatty acid composition	EN14103

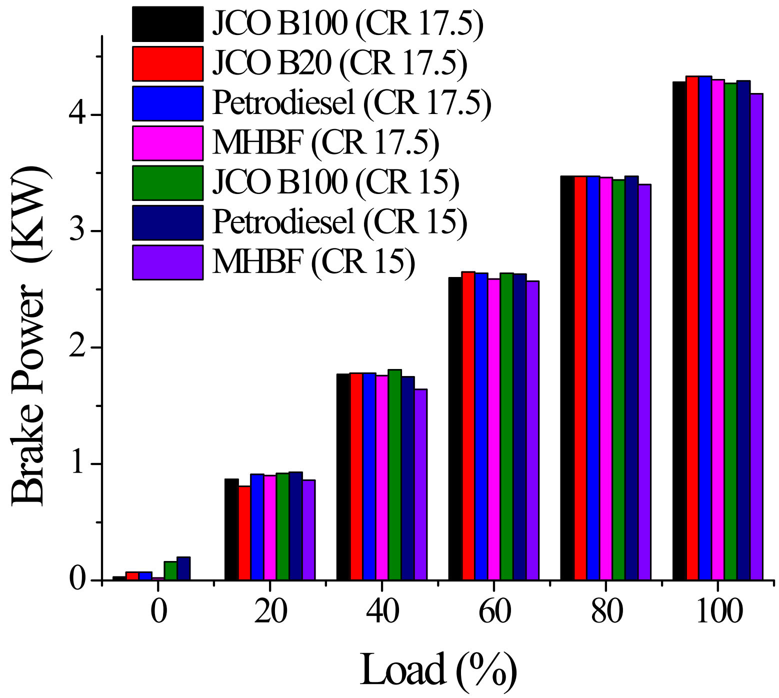

Figure S1. Brake power as a function of engine load for the test fuels (the engine was operating at constant speed of 1500 rpm)

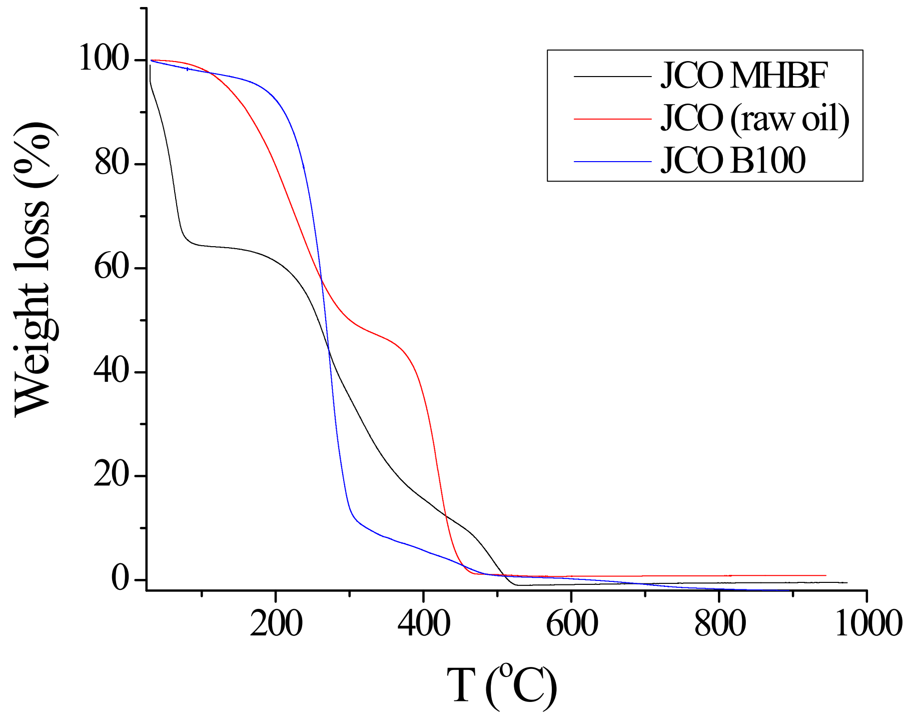

Figure S2. TGA patterns of JCO MHBF, JCO oil and JCO B100 in air.