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Tribological assessment of additive doped B30 biodiesel-diesel blend by using high frequency reciprocating rig test

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ABSTRACT

Biodiesel is auto-oxidative in nature. It can change its composition due to auto-oxidation. Therefore, it causes fluctuation in its lubrication property during application. The present study aims to assess the effect of Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT) additives on the sustainability and lubrication behaviour of B30 (30% biodiesel in diesel) blend on mild steel (MS) flat surface by using high frequency reciprocating rig (HFRR). The tests are conducted under a constant load of 75 N and frequency of 33 Hz at room temperature for 1 h with B30 (30% biodiesel in diesel) blend in the absence and presence of 600 ppm additives. The MS metal surfaces obtained after conducting HFRR tests are analysed by scanning electron microscopy (SEM), energy dispersive spectrometer (EDS), X-ray diffraction (XRD) and atomic force spectrometer (AFM). Tested fuels are characterized by Fourier transform infrared spectroscopy (FTIR). The tribological results indicate that PG doped B30 performs better lubricating performance than other tested additives for steel/steel contacts. Presence of PG causes the least weight loss (0.0003 g) with the least wear scar width (1.13 mm). The average coefficient of friction (CoF) is also observed to be minimal for PG doped B30 blend. The compounds formed on MS surface when tested with PG doped B30 show relatively less oxygen and high carbon content. The possible mechanism in enhancing lubricity of PG doped B30 blend could be attributed to the formation of relatively more stable and effective ester-based tribo-films at the contact surfaces.

Introduction

In recent years, the consumption of petroleum diesel throughout the whole world has been speeded up owing to the increase of population and changes in lifestyles. The growing consumption of fossil fuels in particular by transportation sector generates huge amount of greenhouse gases (GHGs) which ultimately causes environmental deterioration, global climate change and pollution-related health problems [1,2]. Unfortunately, the climate change and its adverse consequences in particular on public health are increasingly progressing, reaching an irreversible point. In the latest international report regarding health and climate change [3], the magnitude of the unfolding tragedy and its remedies has been reported. As per this report, the global mortality due to ambient fine particulate matter pollution has increased from around 2.95 million deaths in 2015 to 3.01 million deaths in 2018. It also highlights the use of renewable energy, sustainable fuel and technologies as a potential solution to avoid or reduce the need for combustion of fossil fuel. In addition, the reservation of the conventional fossil fuel is almost constant and therefore, the entire world is confronted to find the possible solution for future energy supply system. Biodiesel being derived from renewable sources like vegetable oils and/or animal fats is considered as one of the promising alternative and sustainable fuels to meet this energy concerns. It is composed of different fatty acid methyl esters (FAMEs). Biodiesel is almost similar to petroleum diesel in terms of fuel properties and combustion characteristics. However, due to compositional differences, there are some both technical advantages and limitations over petroleum diesel. The major concerns available with biodiesel over petroleum diesel include production process intensification technologies, presence of impurities, moisture absorption, auto-oxidation, corrosiveness etc. [4,5]. Although biodiesel inherently possesses better lubricity than diesel fuel, most of the drawbacks mentioned

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Nomenclature

List of Abbreviations

B5	5% biodiesel in diesel
B30	30% biodiesel in diesel
B100	Pure biodiesel
FAME	Fatty acid methyl ester
PY	Pyrogallol
PG	Propyl gallate
BHT	Butylated hydroxy toluene
PPM	Parts per million
HFRR	High frequency reciprocating rig
FTIR	Fourier transform infrared spectroscopy
ASTM	American society for testing and materials
MS	Mild steel
RMS	Root mean square roughness
SEM	Scanning electron microscopy
EDS	Energy dispersive spectrometer
AFM	Atomic force spectrometer
XRD	X-ray diffraction
CoF	Coefficient of friction
3D	Three dimensional
RPM	Rotation per minute
R&D	Research and development
GHGs	Greenhouse gases

above have adverse effect on its sustainability and lubrication behaviour during application [6,7].

Lubricity of a fuel is one of the vital properties for engine-life since it provides protection for the moving parts of the engine against the phenomenon of friction and wear [8,9]. Many moving engine parts of the fuel system such as pump, fuel injectors etc. are lubricated by the fuel itself which requires the fuel to have good lubricity. The work performed by the engine becomes useful only when the produced energy can overcome the friction generated by the moving parts. It is reported that almost 30% of mechanical energy goes wasted due to the friction produced in the engine and other moving parts of the automobile [10]. In fact, improved lubricity can reduce fuel consumption as well as increase the engine life. Lubricity of biodiesel is a complex issue as it is influenced by different other fuel properties. Presence of monoglyceride impurity in biodiesel even at lower amount causes formation of low temperature precipitation and thus, it triggers filter clogging [11] and can also influence the lubrication behaviour [4]. Many researchers [6,12,13] have carried out different studies on the lubricity of diesel, biodiesel and their blends. It is revealed that the wear and friction are decreased even for lower concentration of biodiesel in blend as compared to those of diesel. In fact, biodiesel has inherent lubricity but it can be fluctuated due change in composition during applications. This could be attributed to auto-oxidation and gyroscopic nature of biodiesel [12,13]. Biodiesel being oxidized produces aldehydes, ketones, hydroperoxides, alcohol, short chain acids and thus, it causes change in fuel properties including lubricity [14]. Consequently, it might results unstable combustion, performance and emission properties [15]. Like auto-oxidation and hygroscopic nature, the corrosiveness, density, viscosity, composition, conductivity etc. of biodiesel can also influence its lubrication behaviour [4,6]. Instead of direct use of pure biodiesel, many countries around the globe are using low-level biodiesel blends in automobile applications.

Currently, different natural and synthetic additives are widely used to eliminate or reduce the problems associated with the applications of biodiesel or its blends. Literature study shows that the use of additives can improve the corrosion resistance [16,17], lubricity [6,18], cetane number [4,19], anti-oxidative and antimicrobial properties [20] of biodiesel or its blends. Fazal et al., [9] examined the lubricity of palm biodiesel, diesel, and biodiesel-diesel blends by using four ball tribo-test under 40 kg load with four different rotating speeds, viz., 600, 900, 1200 and 1500 rpm for 1 h at ambient temperature. They observed that wear in biodiesel was appeared to be 20% of the wear occurred in diesel. In a recent study, the four ball tribo-test is conducted by using different normal biodiesel-diesel blends and oxidized biodiesel-diesel blends under 40 kg load at 1200 rpm for 1 h [13]. The oxidized biodiesel blends is found to provide better lubricity than that of normal biodiesel blends. In fact, the lubricity level of biodiesel-diesel blend could vary depending on its oxidation conditions. Liu et al. [21] conducted high frequency reciprocating friction and wear test for investigating the lubricity of short and long term oxidized jatropha biodiesel under 200 g load, 50 Hz frequency at 60 ℃ temperature. They observed that the peroxide generated by short-time oxidation stimulated the decomposition of fatty acid chains and destroyed the stability of lubricating absorption film while highly polar products produced after long term oxidation of biodiesel would provide stable boundary film and thus, increased its lubrication property. Borugadda et al., [22] conducted high frequency reciprocating test of calona biodiesel blended with different natural additives viz. L-Ascorbic Acid 6-palmitate, caffeic acid, tannic acid and they found enhanced lubricity with the improvement in thermal and oxidative stability due to addition of additives.

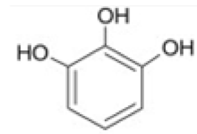
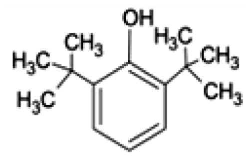
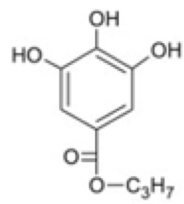
The attempts taken by different researchers in investigating the lubricity of biodiesel or its blends vary not only within a specific window but also over a wide range of parameters. However, the sustainable achievement in improving the lubricity with different approaches seems far from being complete. The present study aims to assess the lubricity characteristics of B30 blend on MS surfaces with three different additives using high frequency reciprocating rig test. The obtained findings are expected to provide an insight for the wider use of B30 biodiesel blend in automobile applications by minimizing the associated problems related to wear and friction of engine components. This in turn, is expected to promote the commercial use of B30 and thus, contribute in reducing the direct combustion of petroleum diesel and GHGs emission.

Experimental methods

The lubrication behaviours of B30 palm biodiesel blends in the absence and presence of three different additives (600 ppm each) namely, PY, PG and BHT are carried out by using HFRR. The chemical composition of the used palm biodiesel has been reported elsewhere [13]. The major components available in biodiesel are methyl palmitate (38.85%) and methyl oleate (32.51%). The molecular structure and physiochemical properties of the used additives are presented in Table 1. Each HFRR test is conducted at room temperature for 1 h under a constant load of 75 N and frequency of 33 Hz.

The schematic diagram of the used HFRR is presented in Fig. 1. The test ball is fixed into the holder and then tightened with the screw. It provides the reciprocating motion at 33 Hz and stroke length of 2 mm. The ball having 10 mm dia is made of 440c. The flat specimen (3 mm $\times$ 15 mm $\times$ 15 mm) used in this test is made of mild steel having Vickers hardness (HV30) 131–614 and a density of 7.75–7.89 g/cc. The Vickers Hardness tester was calibrated before taking the measurement. The flat MS specimen is polished properly and then washed with water and acetone. The ball being fixed with the holder is placed in frictional contact with the MS plate. During the lubrication test, the flat specimen is submerged completely with the test fuel which ensures friction in the presence of the fuel being tested. Almost 10 ml of test fuel is added in the holder to submerge the plate. Ambient temperature and constant humidity were maintained during the test. On the basis of the

Table 1
Molecular structure and physiochemical properties of Pyrogallol (PY), Butylated hydroxyl toluene (BHT) and Propyl gallate (PG).

Antioxidants	Molecular formula	Molecular weight (g/mol)	Molecular structure	Melting point (°C)	Boiling point (°C)	Water solubility (mg/L)
Pyrogallol (PY)	$C_6H_6O_3$	126.11		131–135	309	High (400 g/L)
Butylated hydroxyl toluene (BHT)	$C_{15}H_{24}O$	220.35		70	265	Extremely low (1.1 mg/L at 20 °C)
Propyl gallate (PG)	$C_{10}H_{12}O_5$	212.2		146–149	312.03	Low (3.5 g/L at 25 °C)

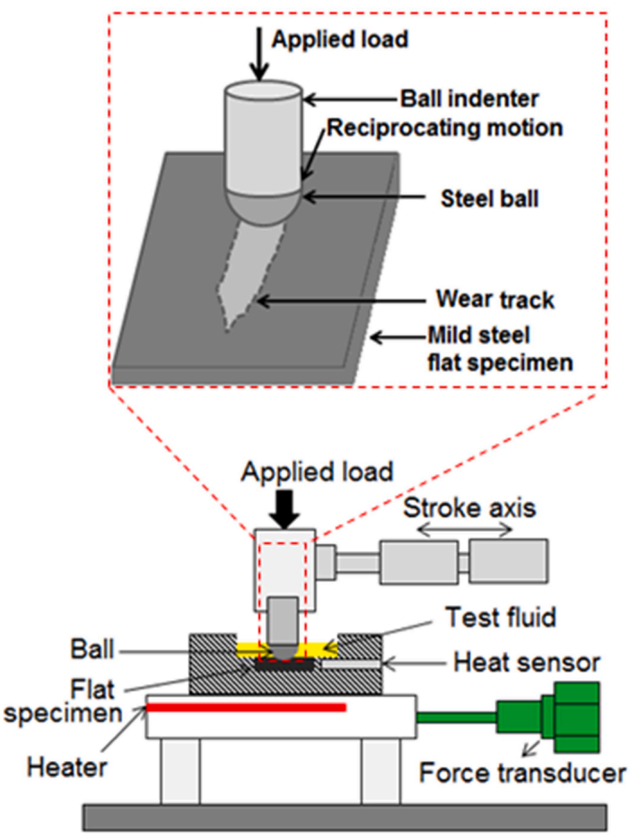


Fig. 1. Schematic diagram of the used high frequency reciprocating rig (HFRR) machine.

measurements conducted, the coefficient of friction (μ) is determined by using equation (1).

$$\mu = \frac{F}{P} \tag{1}$$

Where, F = Frictional force (N), and P = Normal load (N)

Weight loss of the MS plate is recorded by taking the weight of the plate before and after the HFRR test. The wear scar width left on the flat specimen due to the reciprocating motion of the ball during performing the test is measured by SEM machine. The metal surface characterization is conducted by using SEM/EDS, XRD and AFM. On the other hand, fuel analysis is carried out by FTIR.

Results and discussion

Figure 2 presents the wear scar width and weight loss of the MS flat specimens after conducting HFRR tests with B30 doped with or without additives. It is observed from Fig. 2a that B30 causes a high wear scar width (1.21 mm) which is decreased when the blend B30 is doped with additives PY (1.17 mm) and PG (1.13 mm). Similar trends of results as shown in Fig. 2b are also observed for the weight loss for the different tested fuels. Data presented for both wear scar width and weight demonstrate that BHT is less effective while PG is more effective in improving materials sustainability through reducing the surface damage of the tested MS.

As per Fig. 2, the HFRR test conducted with B30 blend causes wear scar width of 1.21 mm and weight loss of 0.0005 g. Both wear scar width and weight loss decrease at different levels with the addition of PY and PG additives. Around 6.6% reduction in wear scar width and 40% reduction in weight loss are observed when 600 ppm of PG is used. The molecules in biodiesel are mainly fatty acid methyl esters which have higher dynamic viscosity and metal affinity as compared to diesel fuel and thus, it reduces wear [23]. In absence of effective additive, auto-oxidation process might decompose fatty acids chains and thus, slightly increase the wear and weight loss during test by destroying the stability of lubricating absorption film generated. However, PG could be effective in reducing wear and weight loss by suppressing the auto-oxidation process partly by providing a relatively more stable lubricating film at the contact surfaces. This is consistent with the findings report by Ribeiro et al., [24] at where it is stated that some additives can be effective in producing the lubrication film with beneficial anti-wear properties.

The CoFs for B30 blends doped with and without additives are presented in Fig. 3. It is seen that B30 and B30 doped with BHT biodiesel blends presents comparatively high and unsteady CoF. On other hand, B30 doped with 600 ppm of PG gives almost smooth and liner till the end of the test run.

It is observed in Fig. 3 that initially there is a sharp increase in coefficient of friction which becomes smooth as the time increases. This

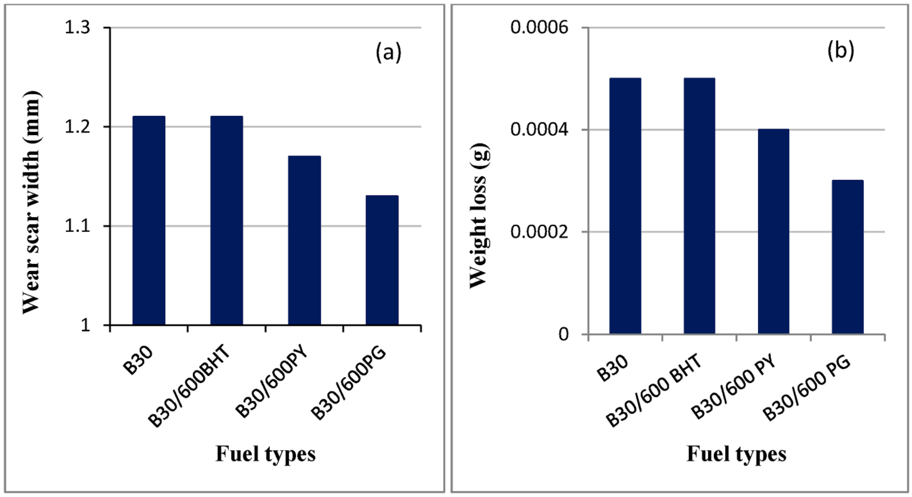


Fig. 2. Wear scar width (mm) and weight loss (g) bar graphs of tested mild steel flat specimens obtained after HFRR test with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT).

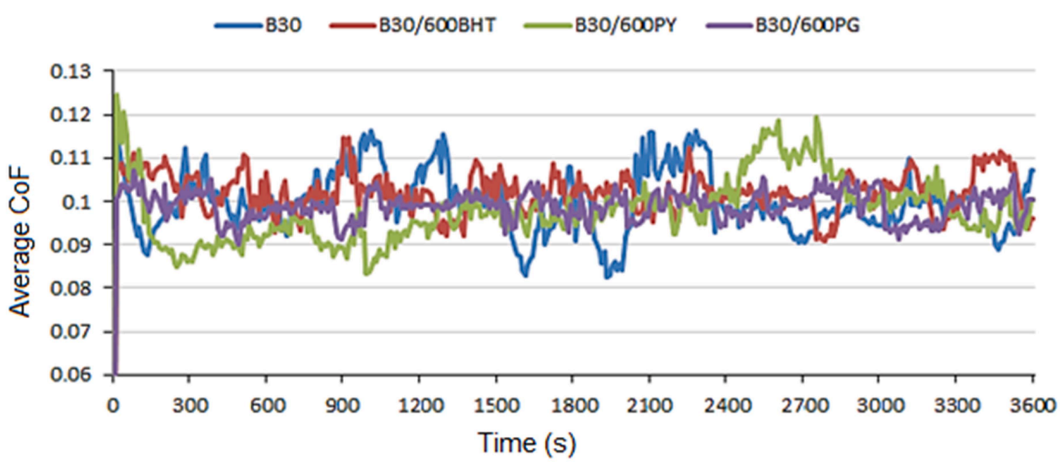


Fig. 3. Average coefficient of friction (CoF) for the tested mild steels lubricated with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT) during HFRR tests.

sharp increase in CoF during so called run-in period could be attributed to the surface asperities which cause non-smooth contact between mating surfaces. The surface asperities get flattened with the passage of time which results in smooth contact afterwards. Relatively high and unsteady friction can cause comparatively more surface damage. This is reflected by the SEM micrographs presented in Fig. 4. Surface roughness for the sample tested with PG doped B30 is relatively less than other the samples. Surface cracks and also crack propagation are clearly marked with arrow. Observation made on SEM micrographs clearly demonstrates that the surface roughness is significantly decreased with the use of 600 ppm PG additive in B30 biodiesel blend and thus, it improves the materials sustainability.

Surface morphology of the worn scar shows that surface cracks are produced on the contact points due to reciprocating movement of the balls. The unsaturated fatty acid esters present in biodiesel is more prone to auto-oxidation [25]. The surface deformation of the flat sample exposed in B30 occurs due to the changes in molecular composition of biodiesel through the auto-oxidation process. The effective additive like PG prevents the propagation of oxidation and disrupts the oxidation chain reactions and thus, ensures the stability of the lubrication film formed. The presence of durable protective layer over the metal tested with PG doped B30 more likely prevents the surface deformation. Among the additives tested, BHT showed the least improvement in surface smoothness. Degradation of metal surface could be ascribed to the metal surface oxidation and tribological friction. Metal oxides are normally loosely bonded with base metal and therefore, the metal subjected to oxidation can cause more weight loss and wear scar width during tribological test. Results obtained from wear scar width (mm), weight loss and SEM images demonstrate that PG is better than other additives tested. Surface deformation is reduced when the test is carried out with PG additive doped B30 blend. Oxidation of fuel could also increase the wear rate [12]. These indicate that PG is more effective in suppressing the oxidation of metal and biodiesel blend. This could be due to its higher number of labile hydrogen. PG and PY have three hydroxyl (–OH) groups attached to their aromatic rings whereas BHT has only one.

The elemental analysis of the fuel exposed flat metal surface is conducted by EDS. The obtained data on the occurrence of Iron (Fe), Carbon (C), Oxygen (O) and Chromium (Cr) are presented in Table 2. Metal surface tested with B30 shows the highest percentage (16.8%) of oxygen indicating the presence of more oxide compounds. On the other hand, MS surface tested with PG doped B30 shows the least percentage (5.8%) of oxygen refereeing less oxide compounds. This is consistent with the findings obtained from metal surface degradations and weight loss measurements. Any metal surface forming loosely bonded oxides can be subjected to high wear. Presence of higher percentage of carbon

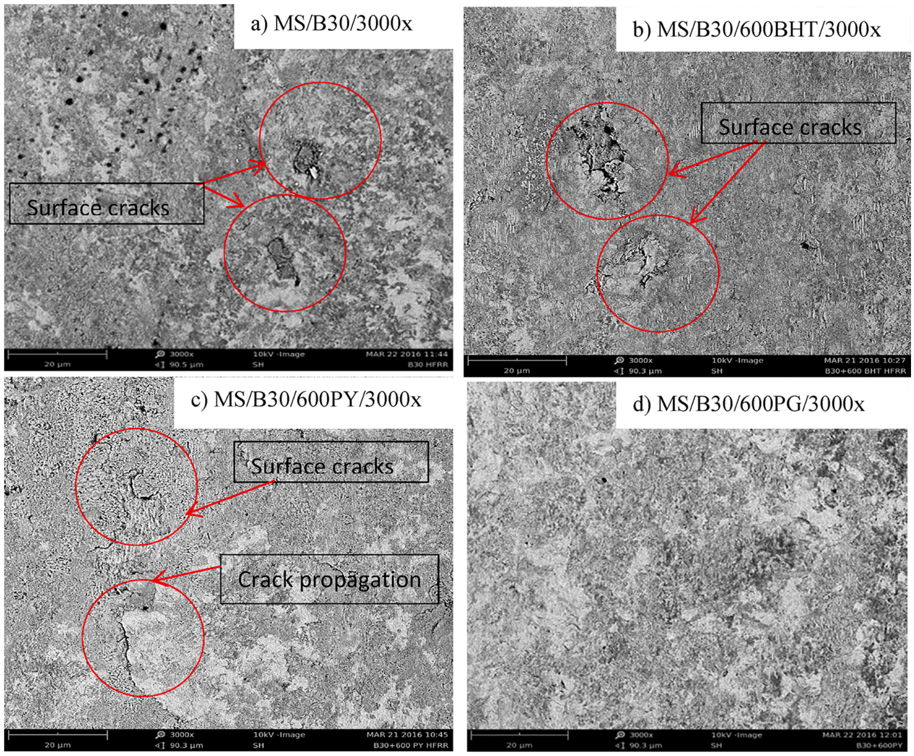


Fig. 4. SEM micrographs of the mild steel (MS) flat specimen after conducting HFRR test with with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT).

Table 2
Elemental analysis of EDS results obtained from mild steel (MS) surface before and after conducting HFRR test with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT).

Fuel/Blend	Iron (Fe) %	Oxygen (O) %	Carbon (C) %	Chromium (Cr) %
MS/B30	82.0	16.8	0.9	0.3
MS/B30/600BHT	85.3	11.2	3.4	0.1
MS/B30/600PY	82.3	8.7	8.1	0.9
MS/B30/600PG	81.3	5.8	9	0.9

could be attributed to the presence of absorbed film on metal surface generated by biodiesel molecules. Similarly, reduction of oxygen percentage on metal surface when tested with PG doped biodiesel indicates the formation of less metal oxide compounds.

The antioxidant, PG prevents biodiesel from oxidation and thus, results in lesser percentage of oxygen on tested mild steel surface. Furthermore, as received fatty acid molecules in biodiesel could be attached to the metal surface by one of its polar sites. In fact, an assembly of the molecular tails projecting into the fuel and the polar heads are adsorbed on the metal surface and thus, it forms a surface film to enhance the lubricity [26]. Therefore, the decrease in oxygen percentage for PG doped B30 could also be attributed to the formation of carbon based protective layer on the metal surface.

Figure 5 illustrates the FTIR spectra for pure biodiesel and the fuels collected after conducting HFRR test. FTIR analysis of B100 shows that some peaks are higher in height from those of B30 blend and the blend with additives indicating their presence at higher concentrations. These peaks are found to be attributed to H-C = functional group (at 2990 cm^{-1}) and C-O bond in the ester functional group (at 1160 cm^{-1} and 1180 cm^{-1}). However, –CH_2- group (at 2916 and 2848 cm^{-1}), carboxylic acid and its derivative C = O (at 1748 cm^{-1}) are observed to be

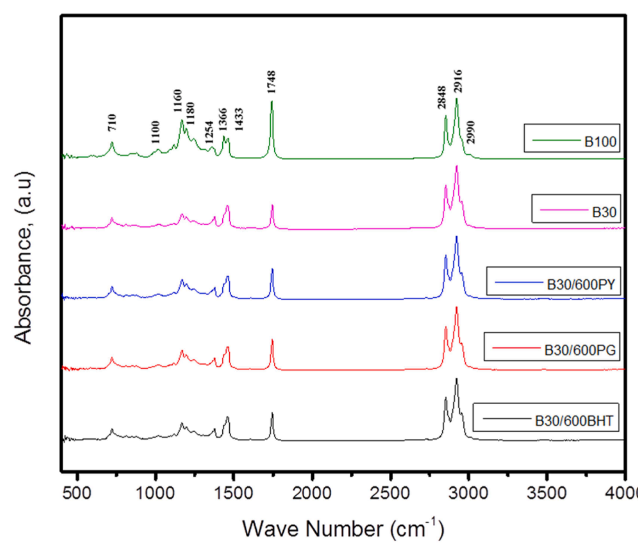


Fig. 5. FTIR analysis of pure biodiesel (B100) and the fuel residues collected after conducting HFRR tests with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT).

major in concentration for each tested samples.

The small peak for B100 at about of 2990 cm^{-1} is due to the H-C = functional group while the other two peaks at 2916 and 2848 cm^{-1} are from the –CH_2- group. Similar peaks are also observed for B30 and the additives doped B30 blends. The 1748 cm^{-1} absorption is ascribed to the carboxylic acid and its derivative C = O. This is found in all the tested fuels but B100 shows the biggest peak indicating higher concentration of fatty acids. Similarly, the peaks in B100 at 1160 cm^{-1} and 1180 cm^{-1} attributed to C-O bond in the ester functional group are observed to be higher than those for B30 blends doped with or without additives. This demonstrates that the concentration of ester in B100 is comparatively more than that in B30. The rest peaks at 710 cm^{-1} (attributed to long -$(CH_2)_n$-sequences in the aliphatic chains of the fatty acids), 1100 cm^{-1} (ester C-O), 1740 cm^{-1} (ester C = O) are characteristic of FAME biodiesel [19] and do not show significant difference with those of B30 blends.

Figure 6 presents the XRD spectra of the MS metal surface after conducting HFRR test with and without additive doped B30 biodiesel blend. Compounds such as $Fe(OH)_3$, Fe_2O_3, $Fe_2O_2CO_3$ are found on MS surface. Iron can form these compounds in the presence of water and oxygen [27]. The detection of the compound $Fe_2O_2CO_3$ can be attributed to the absorption of high level of water, oxygen and carbon dioxide absorbed from surrounding air [28]. The occurrence of $Fe(OH)_3$, and Fe_2O_3 ceases to be in B30 blend with PG and PY. This indicates that the additives reduce the oxidation process of biodiesel and thus, confirm the formation of reduced metal oxides on the surface of mild steel.

The atomic force microscopic analysis (AFM) is used to study surface roughness of the MS surface after conducting HFRR test with B30 and B30 doped with PG. In fact, it is ideal for quantitatively measuring surface roughness and visualizing surface texture. The three dimensional (3D) images of MS surfaces after conducting HFRR tests with B30 and PG doped B30 blends are shown in Fig. 7. The surface roughness (R_a) of the tested MS surface is found to be reduced from 16.8 nm to 12.1 nm when PG is added in B30.

The observation of more dark regions along with peaks and valleys in the 3D-AFM image as shown in Fig. 7a indicates the coarse surface when tested with B30 blend. By contrast, the MS surface tested with PG doped B30 shows the regions with relatively much lighter in shade and less peaks and valleys. The corresponding mean surface roughness (R_a) value of wear scar made on mild steel plate tested with B30 is 16.8 nm whereas, it is 12.1 nm for PG doped B30. The root mean square roughness values (RMS) for the surface tested with B30 and PG doped B30 are 26.3 nm and 16.7 nm respectively. The obtained results clearly demonstrate that the surface obtained after testing with PG doped B30 is smother than those of others. These findings are in good agreement with results obtained by SEM analysis. Similar agreements were also reported by Fazal et al., [17] at where use of Tert-butylamine upon reduction of the corrosiveness of biodiesel caused less surface degradation and reduced surface roughness.

Literature studies [4,29,30] shows that the use of biodiesel or its blends instead petroleum diesel can significantly reduce emission and increase the engine performance. Qi et al., [31] investigated diesel engine emission with soybean biodiesel and observed reduction of 27% CO, 27% HC, 5% NOx and 52% smoke production. However, due of some technical limitations including instability of fuel properties and lubrication behaviour of biodiesel, low-level biodiesel diesel blends instead of pure biodiesel are made compulsory in many countries for its commercial use in automobile applications. ASTM has already approved B5 biodiesel blend for safe operation in any compression-ignition engine designed to be operated on petroleum diesel. Some countries like Belgium, Denmark and Netherlands set a probable target of 9.55%, 7.6%, and 17.5% biofuel energy respectively by 2021 with an intention to reduce 6% GHG intensity of fuel [32]. Such kind of endeavours boosted the production capability of biodiesel in many parts of the globe. By 2050, the U.S. Department of Agriculture (USDA) has declared a target for biofuel to make up 30% of the transportation fuels [33]. Many researchers around the world are continuously paying tremendous efforts to make it economically viable and technologically sustainable [34,35]. The overall findings of the present study demonstrate that doping of PG in B30 can reduce wear and friction of the engine components. Upon addition of PG additive, the commercial use of B30 is expected to be technologically more sustainable. Use of PG doped B30 if accepted for the commercial application in automobile sector can significantly contribute to reduce the direct combustion of conventional fuels and GHG emission.

Conclusions and future prospects

The conclusions and future prospects drawn from the current study

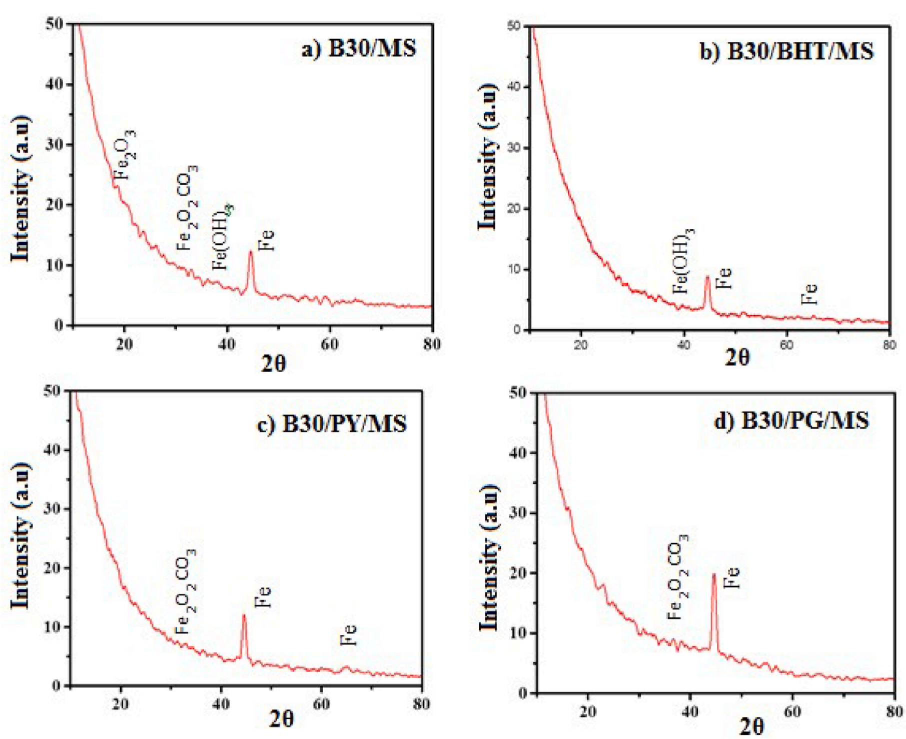


Fig. 6. XRD patterns of mild steel (MS) surface after conducting HFRR test with B30 (30% biodiesel in diesel) in the absence and presence of additives (600 ppm): Pyrogallol (PY), Propyl gallate (PG) and Butylated hydroxy toluene (BHT).

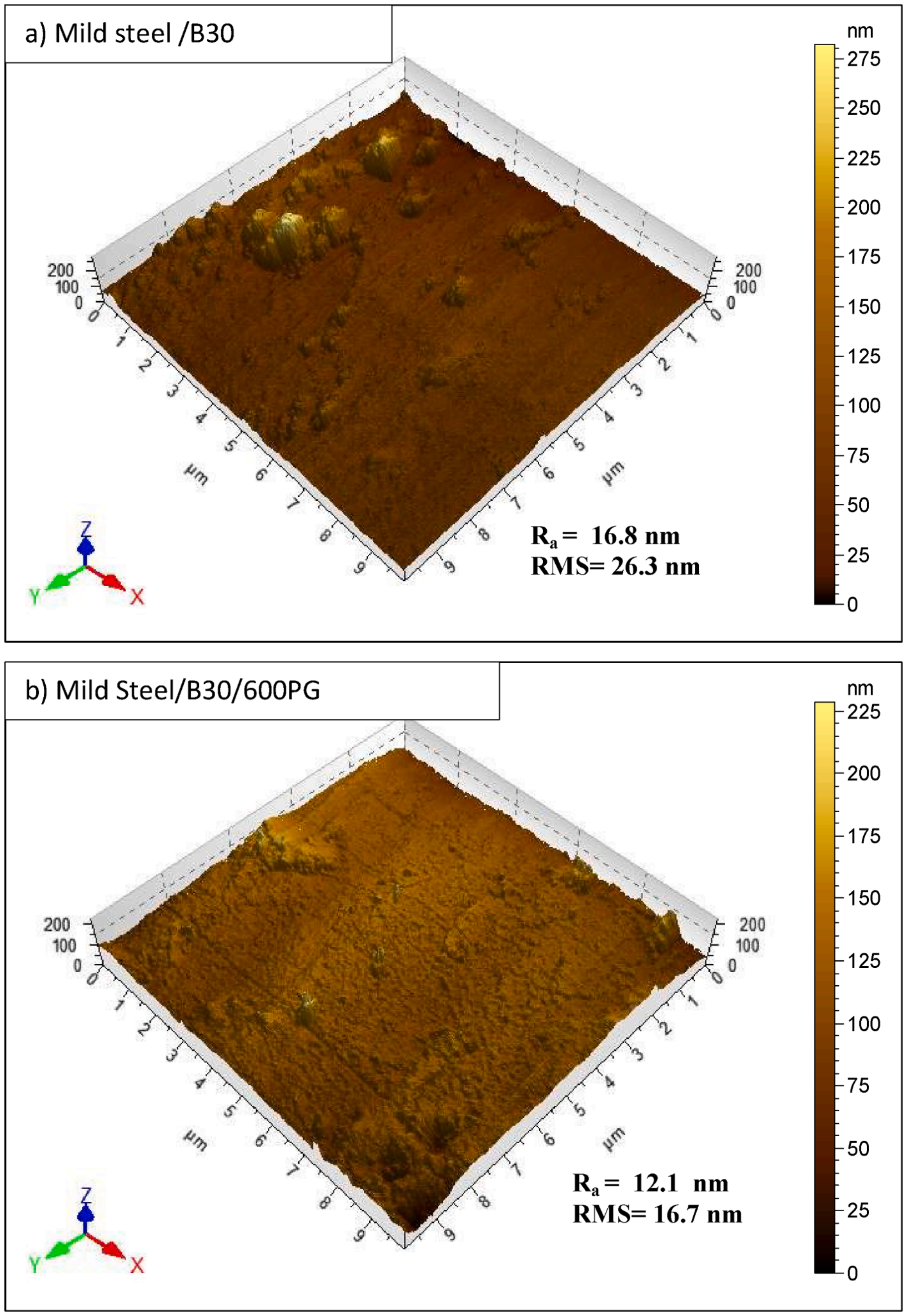


Fig. 7. The three dimensional (3D) AFM images of mild steel surface after conducting HFRR test with a) B30 (30% biodiesel in diesel) and b) B30 doped with 600 ppm Propyl gallate (PG).

are listed below:

i) The friction coefficient for B30 blend is found to be comparatively higher and more unsteady than those of additive doped B30 biodiesel blend. The addition of additives significantly enhances the sustainability in terms of anti-wear and anti-friction characteristics of B30 blend. PG is found to be more effective in reducing wear and friction coefficient.

ii) Data obtained from weight loss and wear scar width clearly demonstrates that PG performed better in enhancing lubricity as compared with PY and BHT. PG showed the least weight loss and width dare width of mild steel. This is further confirmed by AFM analysis through measuring surface roughness.

iii) The compounds formed on metal with PG doped B30 showed relatively less percentage of oxygen and high percentage of carbon. It demonstrates that the presence of absorbed carbon based biodiesel molecules is increased and formation of metal oxides is decreased when PG is added in biodiesel.

iv) AFM and SEM analysis demonstrate that the surface morphology of mild steel is relatively smoother when tested with PG doped B30 blend. The absorbed carbon based ester compounds as detected by XRD and EDS seem to provide stable lubricating film and thus, the overall lubrication performance is observed to be improved when B30 is doped with PG.

v) Future prospects: The commercial use of PG doped B30 is expected to be technologically more sustainable. Its application in automobile sector will be able to contribute significantly in reducing the direct combustion of conventional fuels and GHG emission. Further study should be conducted to justify economic aspects and the engine performance and emission for PG doped B30 biodiesel blend.

CRediT authorship contribution statement

M.A. Fazal: Conceptualization, Project administration, Methodology, Data curation, Writing - original draft. **F. Sundus:** Project administration, Writing - review & editing, Validation. **H.H. Masjuki:** Project administration, Writing - review & editing, Validation. **Saeed Rubaiee:** Validation, Writing - review & editing. **M.M. Quazi:** Writing - review & editing, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

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