ISSN: 0974-5823 Vol. 6 No. 3 December, 2021

International Journal of Mechanical Engineering

Experimental investigation of Kinematic Viscosity of Vegetable oil lubricants by addition of Iron oxide nano particles

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Abstract. **The world at present is challenged with the two crisis, environmental degradation and petroleum oil depletion. The depletion of oil resources, strict norms of emission and raise in demand of oil directed the researchers to realize alternative sources for lubricants especially for IC engines. This paper made an attempt to develop an eco- friendly lubricant with non-edible vegetable oil such as Honge, Mahua and Neem oil, are selected to conduct Experiment to Investigate the effect of Iron oxide as Nano particle on thermal properties of non-edible vegetable oil blended with lubricating engine oil with esterified and non-esterified oils in weight proportion of 20%, 40%, 60%, 80% and 100% will be used after considerate the real need to recover the efficiency of the lubricant without influencing the emissions to a severe degree. An attempt will be made to blend with nano particle like Iron Oxide, blended in three proportion (0.1%,0.5% and 1% by weight%). The oils are tested for Kinematic viscosity and Corrosion resistance using ASTM standard testing methods and apparatus. The resultant properties of above oil blends are compared with commercially available synthetic oil and discussed. The results showed that, as blends increases, Kinematic Viscosity decreases and non esterified oil shows higher Kinematic Viscosity, addition of Iron oxide Nano particle decreases the Kinematic viscosity of all oil blends and all blends of esterified and non esterified oils are showing the no evidence of Corrosion.**

Keywords: Corrosion resistance Engine oil, Esterified oil, Iron oxide nano particle, Kinematic viscosity, non edible oil.

ABREVIATIONS

BSFC	- Brake Specific Fuel Consumption
KV	- Kinematic Viscosity
FFA	- Free Fatty Acids
ASTM	- American society for Testing and Materials
MWCNT	- Multi Walled Carbon Nano tubes
NOx	- Oxides of Nitrogen
H20IO0.1	-Honge20%,SAE15W4080%and0.1% Iron oxide Nano particle.

I Introduction

All over the world, petroleum-based reserves are going to exhausted in few decades which results in frequent price hike and create global warming, Acid rains environmental pollution and non degradable property. The India Lubricants Market was valued more than 237 crores kgs in 2020 and the market is estimated to expand CAGR of more than 1.5% from 2021 to 2026. The global automotive engine oil market was registered at Rs.26,11,000 crore in 2017 and is estimated to expand at CAGR of 3.7% from 2018 to 2025. Automotive vehicle sales have shown a constant rise over the past few years in all over the world, which increases the usage of lubricants and is expected to drive the demand for lubricants in the country. The engine oil are very important for all engines to minimize wear and friction of engine parts and to increase life and mileage of Automotive vehicle engines. The researchers are giving more importance to develop non corrosive, biodegradable, ecofriendly and environment friendly lubricants.

Bahaa M. Kamel et al., [1] have been studied the experiments to characterize the thermal features of MWCNTs with engine oil with six fractions of blends, and recognized the best features. The wear scar diameter, friction coefficient declines to 0.06 wt.% and reported. the size, purity, orientation, crystallinity, and shape of the MWCNTs are confirmed, flash points and pour points improved in uniformly. and then the movement is inverted due to gathering and in uniformly. The thermal conductivity and kinematic viscosity surge consistently. ***Navdeep Sharma Dugala et.al., [2]*** have been studied the Effect of thermos physical properties of bio diesels made by Jatropha and Mahua oil by triesterification. physical features blends were calculated in order to find the best blend. They found that B50 the extreme end and B40 blend can be reliable and the thermal properties of blends B10, B20, B30 are reliable to use. Mohsen **Tahmasebi Sulgani and Arash Karimipour [3]** have been conducted experiment to determine coefficient of Thermal conductive of 10w40 engine oil lubricants with an addition of different weight fractions of

Fe2O3-Al2O3 Nano powder, which showed that uniform thermal properties of the nano-lubricant. Therefore, the major development occurred at a base oil of 4%. *With* weight segment of 33% ***Leonardo Israel et.al., [4]*** have been studied the thermal ageing of Jatropha oil due to Corrosion and oiliness were calculated, and Jatropha oil was extremely oxidized by current ageing. Due to thermal ageing Friction coefficient becomes more, Wear was not altered Viscosity was high. ***Z.M. Zulfattah et.al., [5]*** have studied and compared mineral lubricant and (TMPTO) Trimethylolpropane Trioleate blends burns smoothly in the combustion chamber. Spark plug misfire may occur, Petroleum oil produces unburnt hydrocarbons at the exhaust manifold noticed. ***Arianti N et.al.,[6]*** have carried review on petroleum oil which has been used as a engine oil for IC engines. And made an investigate to recognize suitable resources to replace mineral oils. Bio oils can produce from animals' oils vegetable oils. But, bio-lubricant damages engine components easily, it need extra methods to avoid the development the corrosiveness of the bio-lubricant But, the uses of lubricants petroleum can contaminate the atmosphere and disturb global aquatic ecologies***. M.A. Kalam et.al., [7]*** have made comparative analysis of olive oil with petroleum mineral oil. the physicochemical features, lubricating features was used to of the friction and wear features of the blends are calculated using an instrument four-ball tribotester according to the ASTM methods Olive oil presented more viscosity index and kinematic viscosity compared to other vegetable oils; hence, it is better for boundary lubrication. ***S. Arumugam et.al., [8]*** have studied comparison of mineral lubricant and bio lubricant prepared from Rapeseed oil fueled for for a diesel engine, and they optimized performance and emissions using Taguchi-grey relational examination. The optimization results have showing that a rise in value of the grey relational evaluation from 0.6105 to 0.85 favors the increase in when using rapeseed bio-lubricant/biofuel for engine features combination Three issues they are, engine load, compression ratio, oil, and were better using L18 orthogonal array. ***Meena et al.,[9]*** have been made an experimented using pin-on-disc instrument and the wear rate friction of titanium oxide (TiO2) nano particles on multi-grade engine lubricant The spreading analysis of TiO2 nano particles in engine oil using UV mass spectrometer and it confirms that TiO2 nano particles have good consistency and solubility in the engine oil and improve the oiling properties of the lubricant, The experiments were performed on engine lubricant and hence improves the lubricating characteristics of lubricant. **Masoud *Dehghani et.al.,[10]*** have been conducted an experiment using the Artificial Neural Network (ANN) model. The connection among contribution of engine performance and emission are found by means of the ANN. back-circulation neural network manner has been settled for envisaging the result of unlike categories of bio oils on the engine characteristics. ***K. S. V. Krishna Reddy et.al., [11]*** have been conducted an experiment to investigate the fuel consumption and engine performance for both lubricating oil the mixtures of palm oil and commercial SAE 20W40 lubricant, they presented no substantial change in presentation features They presented that NOx emission are reduced tot 25% palm lubricants. ***Ehsan-o-llah Ettefaghi et al., [12]*** have been studied the thermo physical characteristics engine oil blended with copper oxide (CuO) nano particles at different fractions and also calculated thermal conductivity coefficient engine oil are evaluated to7.9% and 3% more and 0.1% wt. increase of flash point with respect to the base lubricant oil**.** ***Vijaykumar S. Jatti & T. P. Singh [13]*** have been conducted the experiment using an instrument pin on disc to find the effect of copper oxide nano particle additive with lubricant thermos physical features like corrosion, tribological efficiency tribological performance of copper oxide nanoparticles. The outcomes shows that nanoparticle additives enhance the lubricating properties, condenses friction coefficient, smoother worn surfaces, viscosity of lubricant with CuO is a function of nanoparticles fractions***. Arumugam and Siram [14]*** have been conducted an experiment using a high pitch responding tribotester to find friction and wear features IC engine cylinder liner and piston ring combination, and they prepared a blend of diesel-contaminated rapeseed oil bio-lubricant and diesel-contaminated commercial synthetic lubricant (SAE20W40), and they observed. decent cold flow possessions progressive corrosion stability, and decent presentation in terms of frictional force and co-efficient of frictions prepared blends of bio lubricant***. Bekal & N. R. Bhat [15]*** have been conducted an experiment on Diesel engine with mixture of Pongamia oil and petroleum Diesel (50% V/V), and mineral diesel as engine oil; and pure Honge oil, mixture of Honge oil, and mineral oil in various fractions of lubricant and fuel, Emission and performances were compared. ***Gopalasamy Sriram and Abhishek Kumar [16]*** have been conducted an experiment on Single cylinder diesel engine to find the performance and emission of (Fish oil methyl ester) B20 blends of FME on lubricating oil. The outcome of experiment results shows that, B20 FME can be used for engine, without any significant alterations in oil presentation with reverence to properties like viscosity, Total Base Number (BN), Total Acid Number (AN) & soot content can be. analyzed with different methods. **Balamurugan et.al.,** [17] have been conducted an experiment on the esterified soya bean oil (SBO) and showed mixtures of SBME (SBME+CO+POME, SAE 40+SBME) was best suited to engine, they also prepared an oil. with palm oil, castor oil and soya bean oil to improve the thermal characteristics like corrosion and wear struggle for various blends and showed same properties of lubricating oil. ***AmaiaIgartua et.al.[18]*** have been experimented on diesel engine for the behaviour of the new bio-oils and plasma deposited tribo reactive layers on piston rings have been studied in a experimental engine the Ecological, harmful and the tribological properties are also studied. The different

tribological properties of plasma deposited tribo reactive layers have been deposited on cast iron piston rings, being studied. ***Ming Zhang et al. [19]*** have been conducted an experiment on copper nanoparticles as lubricating oil, and shown a result that they are possible and can be very significant for further usefulness of copper nanoparticle additives. using an instrument end-face wear tester to identify the anti-wear device and tribological features of copper nanoparticles with available mineral oil 15W/40 using a method. Electrical contact resistance (ECR), X-ray photoelectron spectroscopy (XPS), energy dispersive spectra (EDS) and scanning electron microscope (SEM), is calculated using a universal nano and micro tester-2 tribometer. to distinguish the development of tribo-film. the results

II Experimentation

2.1 Measurement of Kinematic Viscosity of oil by Saybolt viscometer

Fill the 60 ml of oil to cup of the Saybolt instrument and pour full normal water to surrounding bowl switch on the heater till water attains a temperature of 40^0C then check the temperature of oil for 40^0C then remove the screw at bottom of the apparatus to oil to flow into measuring jar for 60ml note down the reading from stop watch then close the openings by tightening cork .Then calculate the Kinematic viscosity by following formula .
Kinematic viscosity=(0.22t-180/t) in cSt.

where' t' in seconds. The viscosity values of vegetable oils are between 9.0 and 18 cSt, whereas those of esterified vegetable oil are between5 and 7CcSt. The Kinematic viscosity of blends non edible oils and base oils are determined using ASTM D445

2.6. Measurement Corrosion resistance

Acid and sulphur mixtures are probable source to cause corrosion on engine components, copper strip corrosion tests specify the probable causes of vegetable oil on the engine components made by copper and its alloys. In this method polished copper strip is dipped in the sample and kept in a hot bowl for 2 to 5 hours. Then specimen is compared with typical chart to indicate the effect of corrosion on the model.

The corrosion testing equipment measures the intensity of corrosion of almost oil products, as well as fuels used in automobile aircraft, marine and other moving vehicles, engine oil and in other machineries. A plate of copper is engrossed to a hot tub which contains 30mL of oil at about 500^0C, temperature. Subsequently 2 to 5 hours, the copper plate is tested for any corrosion and compared with standard corrosion chart, the number 1-4 is allotted depending upon American Society for Testing of Materials (ASTM).

It is observed that all the blends of oil are no evidence of **CORROSION**

3.0 Results and discussions

1 Effect of blends of oil on Kinematic viscosity with No additive

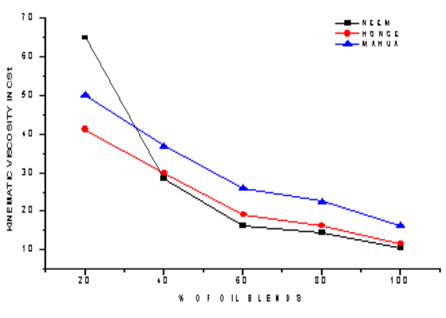

Figure.1: Effect of Kinematic viscosity with percentage blends of oil

Figure 1 shows the variation of KV of non esterified blends of oil. It is calculated that kinematic viscosity of non esterified Neem, Honge and Mahua oil were 10.5 cSt, 11.65cSt and 16.28cSt respectively. It can also be observed that as oil percentage in the blend increases, there is decrease in kinematic viscosity. This is attributed to lower volatility of vegetable oils.

2 Comparison of effect of esterified oil on Kinematic viscosity with No additive

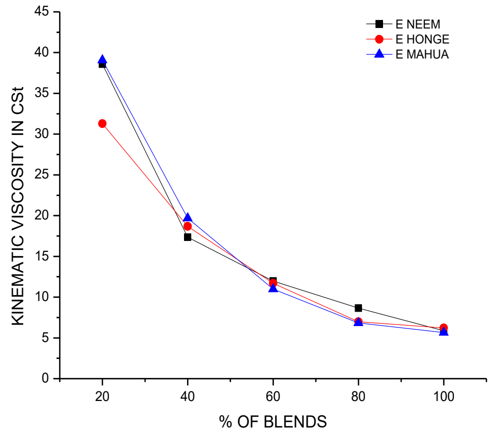

Figure.2: Effect of Kinematic viscosity with percentage of esterified oil blends

Figure 2. shows the Effect of KV with esterified oil blends. It is calculated that kinematic viscosity of esterified Neem, Honge and Mahua oil were 6.24cSt, 6.04cSt and 7.36cSt respectively. It can also be observed that as oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils and also due to the removal of fat and glycerine during esterification process

3. Effect of blend and esterification of oil on Kinematic viscosity with No additive

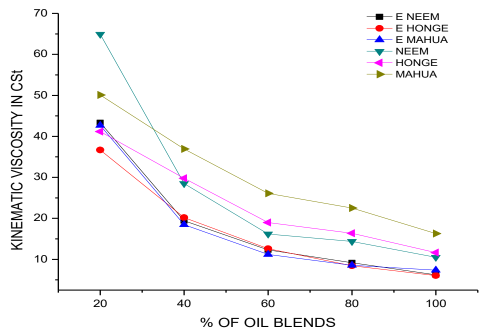

Figure 3: Effect of Kinematic viscosity with percentage of Esterified and oil blends

Figure 3. shows Comparison of Kinematic viscosity of non esterified and Esterified oil blends. It can be observed that the non esterified Mahua oil posses more kinematic viscosity(16.28cSt) which is due to presence of higher triglycerides and fatty acids lower volatility of non edible oil.

Further it can be observed that the esterified Honge oil(6.04cSt) possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification.

4 Comparison of effect of blend with base oil on kinematic Viscosity

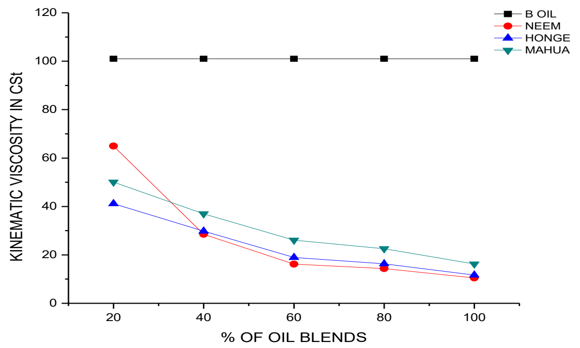

Figure 4: Effect of Kinematic viscosity with percentage of oil blends with base oil

Figure 4 shows the comparisons among kinematic viscosity of non esterified oil blends and base synthetic oil SAE15W40. It can be observed that after the kinematic viscosity of synthetic oil rank, Neem, Honge and Mahua find the preferential rank. It can be observed that the decrease in the kinematic viscosity with the rise in blend percentage and this is due to lower volatility of non edible oil. The 20% Neem oil blend value has kinematic viscosity value nearer to base oil

5. Comparison of effect of blends of Esterified oil with base oil on kinematic viscosity

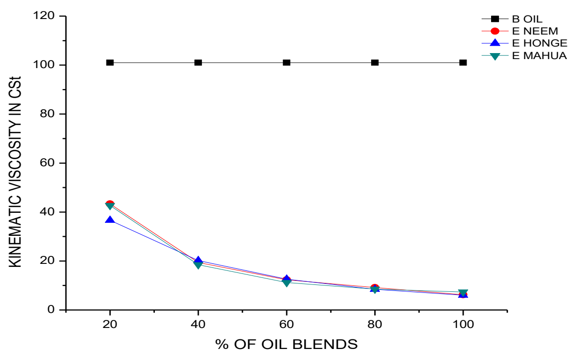

Figure 5: Effect of Kinematic viscosity with percentage of Esterified oil blends with base oil

Figure 5, shows the Comparison of effect of esterified oil with base oil on K.V for 3 Esterified non edible oil such as Esterified Neem (6.24cSt), Esterified Honge (6.04cSt) and Esterified Mahua (7.36cSt) oil, it is observed from the above figure as blend percentage increases there is a decrease in the K.V this is due to fat and Glycerine in the vegetable oil. In addition to that, it is observed Esterified Mahua oil having high K.V as compared with Esterified Oils, this is because of amount of occurrence of higher Proportion of FFA in vegetable oils, and all the esterified oil blend value has far away from the base oil.

6 Effect of blend and Esterified oil with Base oil Kinematic viscosity.

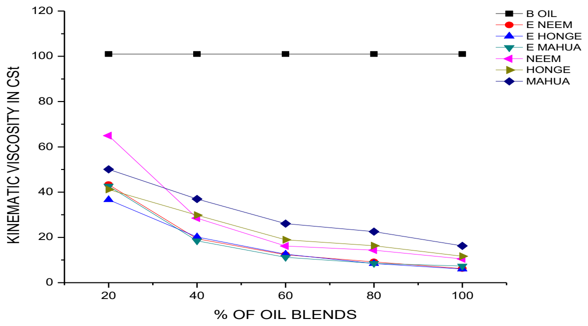

Figure 6. Graph shows the Comparison of effect of blend and esterification oil with base oil on KV.

Figure 6, shows Comparison of effect KV of blends of oil and esterified oil. It can be detected that the non esterified Neem oil possses more kinematic viscosity(16.28cSt) which is due to presence of higher triglycerides and fatty acids, lower volatility of non edible oil. Further it can be observed that the esterified Honge oil(6.04cSt) possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification. And 20% Neem oil values are nearer to base oil value.

7 Comparison of effect of blends of oil on Kinematic viscosity with 0.1% of Iron oxide as Nano particle additive

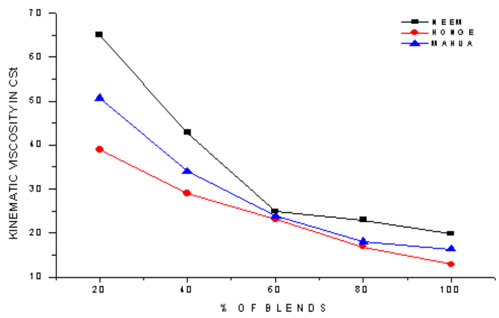

Figure 7: Effect of Kinematic viscosity with percentage of oil blends with 0.1% Iron oxide.

Figure 7, shows Effect of KV of non esterified oil blends with 0.1% Iron oxide nano particle It is calculated that kinematic viscosity of non esterified Neem, Honge and Mahua oil were 19.86cSt,12.86cStand16.36cSt respectively. It can also be observed that as oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils.

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8. Comparison of effect of esterified oil on Kinematic viscosity with 0.1% of Iron oxide Nano particle as additive

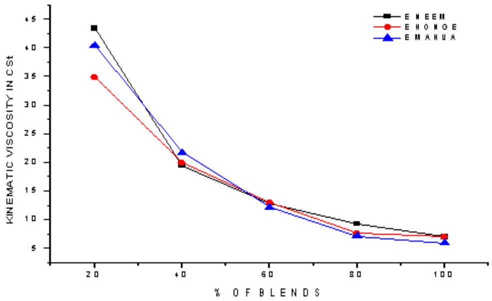


Figure 8. graph shows Effect of Kinematic viscosity with percentage of oil blends and esterified oil with 0.1% Iron oxide.

Figure 8. shows the variation of kinematic viscosity with esterified oil blends. It is calculated that kinematic viscosity of esterified Neem, Honge and Mahua oil were 6.98cSt, 6.98cSt and 5.89cSt respectively. It can also be detected that as oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils and also due to the removal of fat and glycerine during esterification process.

9. Comparison of effect of blends of oil and esterified oil on Kinematic viscosity with 0.1% of Iron oxide as Nano particle additive

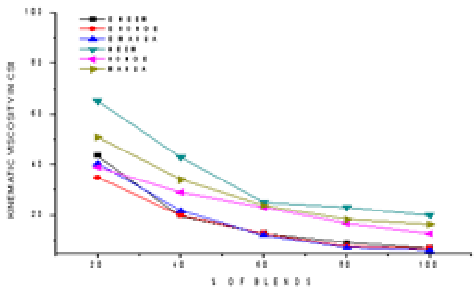


Figure 9. Graph shows variation of Kinematic viscosity with percentage of oil blends and esterified oil with 0.1% Iron oxide

Figure 9. shows Comparison of Kinematic viscosity of non esterified and Esterified oil blends with 0.1% Iron oxide as nano particle additive. It can be observed that the non esterified Neem oil posses more kinematic viscosity (19.86 cSt) which is due to presence of higher triglycerides and Alkyl esters, lower volatility of non edible oil. Further it can be observed that the esterified Mahua oil(5.89cSt) possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification.

10. Comparison of effect of blends of oil and Base oil on

Kinematic viscosity with 0.1% of Iron oxide as Nano particle additive

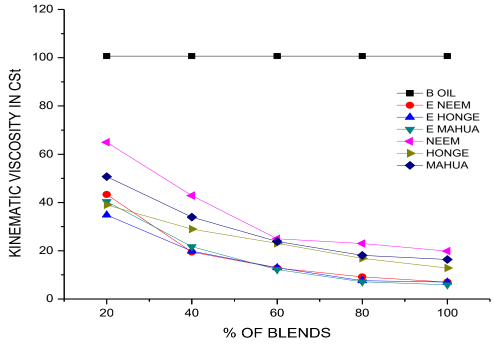


Figure 10. graph shows variation of Kinematic viscosity with percentage of oil blends and esterified oil with 0.1% Iron oxide.

Figure 10, shows the comparisons among kinematic viscosity of non esterified oil blends and base oil SAE15W40. It can be observed that after the base oil kv rank Neem, Honge and Mahua find the preferential rank. It can be observed that the decrease in the kv with the rise blend percentage and this is due to lower volatility of non edible oil. The 20% Neem oil blend value has kv value nearer to base oil

11. Comparison of effect of esterified oil blends and Base oil on KV with 0.1% of Iron oxide as Nanoparticle additive

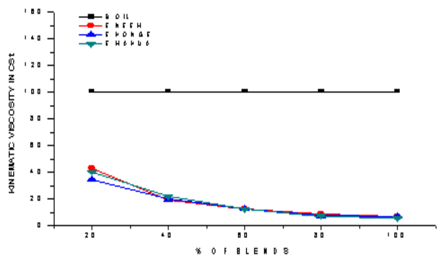


Figure 11. Graph shows variation of Kinematic viscosity with percentage of oil blends and base oil with 0.1% Iron oxide.

Figure11, shows the Comparison of effect of esterified oil and base oil with 0.1% Iron oxide as nano particle on K.V for 3 Esterified non edible oil such as Esterified Neem (6.98cSt), Esterified Honge (6.98cSt) and Esterified Mahua (5.89cSt) oil, it is observed from the above figure as blend percentage increases there is a decrease in the K.V this is due to fat and Glycerine in the vegetable oil. In addition to that, it is observed Esterified Mahua oil having less K.V as compared with other Esterified Oils, this is because of quantity of presence of higher Percentage of Free fatty acids in vegetable oils, and all the esterified oil blend values has far away from the base oil values.

12. Comparison of effect of blends of oil and esterified oil with base oil on Kinematic viscosity with 0.1% of Iron oxide as Nano particle additive

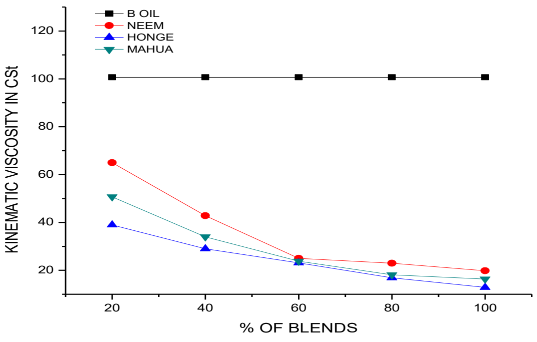


Figure 12. Graph shows Effect of KV with percentage of oil blends and esterified oil with base oil with 0.1% Iron oxide.

Figure12, shows Comparison of KV of non esterified and Esterified oil blends and base oil with 0.1% Iron oxide. It can be observed that the non esterified Neem oil possses more kinematic viscosity(19.86cSt) which is due to presence of higher triglycerides and fatty acids lower volatility of non edible oil. Further it can be observed that the esterified Mahua oil(5.89cSt) possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification. And 20% Neem oil values are nearer to base oil value.

13.Comparison of effect of blends of oil on Kinematic viscosity with 0.5% of Iron oxide as Nano particle additive**.**

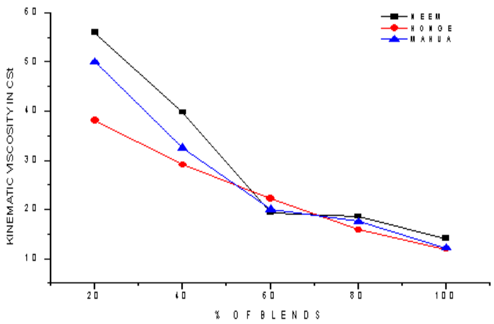


Figure 13. Effect of Kinematic viscosity with percentage of oil blends with 0.5% Iron oxide

Figure 13, shows the variation of KV of non esterified oil blends with 0.5% Iron oxide as nano particle It is calculated that kinematic viscosity of non esterified Neem, Honge and Mahua oil were 19.86cSt,12.86cSt and16.36cSt respectively. It is observed that as oil percentage in the blend increases, there is decrease in the KV. This is attributed to lower volatility of vegetable oils.

14.Comparison of effect of blends of esterified oil on Kinematic viscosity with 0.5% of Iron oxide as Nano particle additive**.**

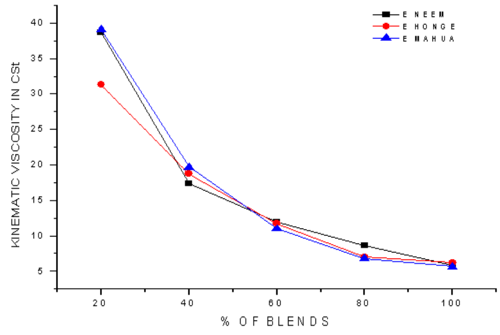


Figure 14. Graph shows Effect of Kinematic viscosity with percentage of esterified oil blends with 0.5% Iron oxide

Figure 14. shows the variation of KV with esterified blends of oil with 0.5% Iron oxide. It is calculated that kinematic viscosity of esterified Neem, Honge and Mahua oil were 5.88cSt, 6.21cSt and 5.65cSt respectively. It can also be observed that as vegetable oil percentage in the blend increases, there is decrease in the KV. This is due to less monoalkyl esters and lower volatility of vegetable oils and also due to the removal of fat and glycerine during esterification process

15. Comparison of effect of blends of oil and esterified oil on Kinematic viscosity with 0.5% of Iron oxide as Nano particle additive

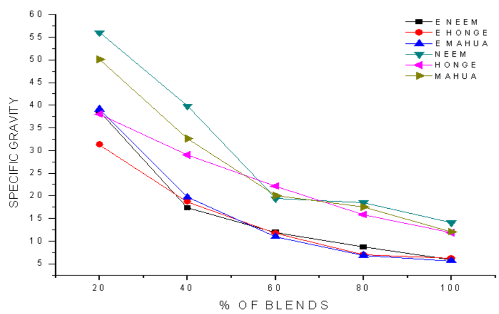
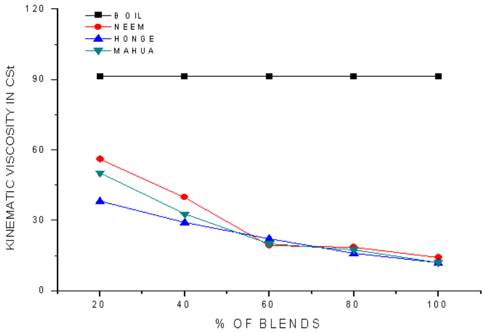


Figure 15 graph shows variation of Kinematic viscosity with percentage of oil blends and esterified oil with 0.5% Iron oxide.

Figure 15. shows Comparison of Kinematic viscosity of non esterified and Esterified oil blends with 0.5% Iron oxide as nano particle additive. It can be observed that the non esterified Neem oil posses more kinematic viscosity (14.06 cSt) which is due to presence of higher triglycerides and Alkyl esters, lower volatility of non edible oil. Further it can be observed that the esterified Mahua oil(5.65cSt) possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification.

16. Comparison of effect of blends of oil and Base oil on

Kinematic viscosity with 0.5% of Iron oxide as Nanoparticle



additive

Figure 16. Graph shows Effect of Kinematic viscosity with percentage of oil blends and base oil with 0.5% Iron oxide.

Figure 16**,** shows the variation of KV with non esterified blends oil. It is calculated that kinematic viscosity of non esterified neat Neem oil, Honge oil and Mahua oil were 14.06cSt, 11.86cSt and 12.12cSt respectively. It can also be observed that as vegetable oil percentage in the blend increases, there is decrease in the KV. This is attributed to lower volatility of vegetable oils and K.V of 20% Neem oil values are nearer to base oil values.

17.Comparison of effect of esterified oil blends and Base oil on Kinematic viscosity with 0.5% of Iron oxide as Nano particle additive

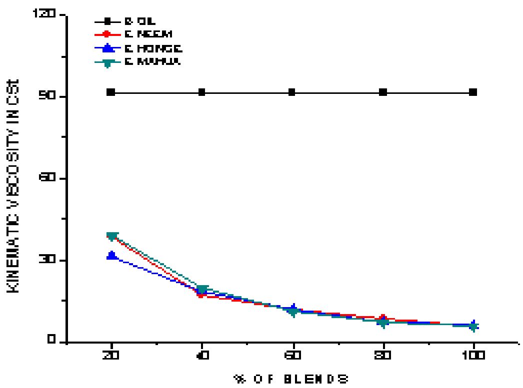


Figure 17. graph shows variation of Kinematic viscosity with percentage of esterified oil blends and base oil with 0.5% Iron oxide.

Figure 17**,** shows the variation of kinematic viscosity with esterified blends of oil. It is calculated that kinematic viscosity of esterified Neem oil, Honge oil and Mahua oil were 5.88cSt, 6.21cSt and 5.65cSt respectively. It can also be observed that as vegetable oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils and also due to the removal of FFA and glycerol during esterification process, values of K.V all blends are far away from values of SAE15W40.

18.Comparison of effect of blends of oil and esterified oil with base oil on Kinematic viscosity with 0.5% of Iron oxide as Nano particle additive

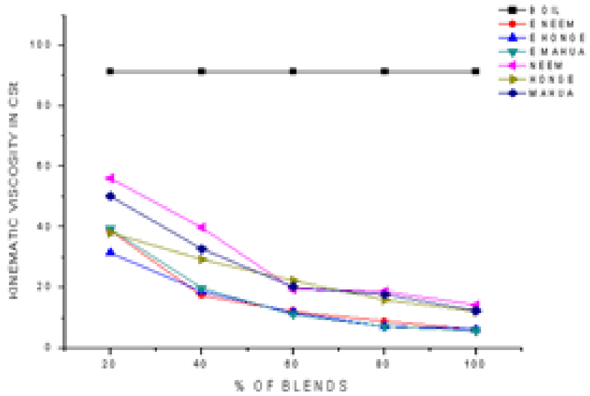


Figure18. graph shows variation of Kinematic viscosity with percentage of blends of oil and esterified oil and base oil with 0.5% Iron oxide

Figure 18, shows Comparison of Kinematic viscosity non esterified and Esterified oil blends with 0.5% Iron oxide as a nano particle. It can be observed that the non esterified Neem oil possses more kinematic viscosity which is due to presence of higher triglycerides and Linoleic acid in Neem oil compared to other oil. Further it can be observed that the esterified Mahua oil possess lower Kinematic viscosity compared with other oils tested which is due to separation of triglycerides and fatty acids during esterification.

19.Comparison of effect of blends of oil on Kinematic viscosity with 1% of Iron oxide as Nano particle additive

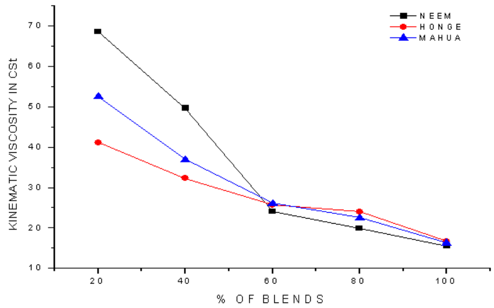


Figure 19. Graph shows Effect of Kinematic viscosity with percentage of oil blends with 1% Iron oxide

Figure 19 shows the comparisons among kinematic viscosity of non esterified oil blends and 1% Iron oxide with base synthetic oil SAE15W40. It is also observed that after the synthetic oil kinematic viscosity rank, Honge, Mahua and Neem find the preferential rank. It can be observed that the decrease in the KV with the rise blend percentage and this is due to lower volatility of non edible oil. The 20% Honge oil blend value has kinematic viscosity values higher than with other oils.

20.Comparison of effect of esterified oil blends on Kinematic viscosity with 1% of Iron oxide as Nano particle additive

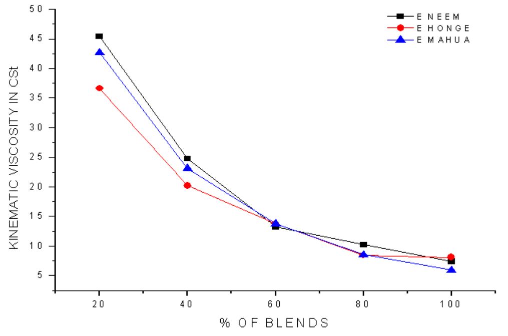


Figure 20 Graph shows Effect of Kinematic viscosity with percentage of esterified oil blends with 1% Iron oxide

Figure 20**,** shows the comparisons among kinematic viscosity of esterified blends of oil with 1% Iron oxide. It is also observed that kinematic viscosity rank, Neem, Honge and Mahua find the preferential rank. It can be observed that the decrease in the kinematic viscosity with the rise blend percentage and this is due to less monoalkyl esters and lower volatility of vegetable oils and also due to the removal of fat and glycerine during esterification process

21. Comparison of effect of blends of oil and esterified oil on Kinematic viscosity with 1% of Iron oxide as Nano particle additive

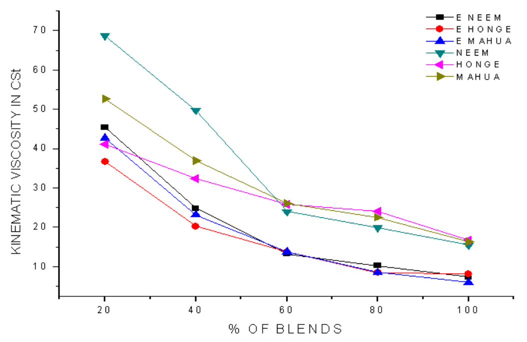


Figure 21. Graph shows Effect of Kinematic viscosity with percentage of oil blends and esterified oil with 1% Iron oxide

Figure 21. shows Comparison of Kinematic viscosity of non esterified and Esterified oil blends with 1% Iron oxide as nano particle additive. It can be observed that the non esterified Neem oil posses more kinematic viscosity (11.95 cSt) which is due to presence of higher triglycerides and Alkyl esters, lower volatility of non edible oil. Further it can be observed that the esterified Mahua oil(5.07cSt) possess lower Kinematic viscosity compared with other oils tested which is due to removal of triglycerides and fatty acids during esterification.

22. Comparison of effect of blends of oil with Base oil on Kinematic viscosity with 1% of Iron oxide as Nano particle additive.

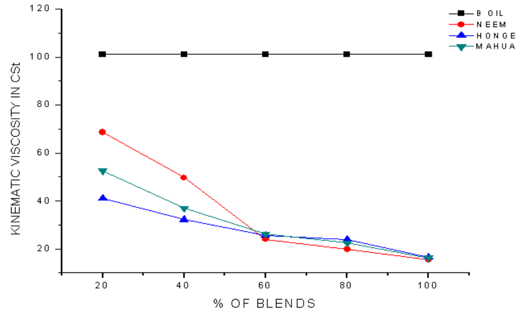


Figure 22. Graph shows variation of Kinematic viscosity with percentage of oil blends and base oil with 1% Iron oxide.

Figure 22**,** shows the variation of kinematic viscosity with non esterified oil blends and base oil with 1% Iron oxide. It is calculated that kinematic viscosity of non esterified neat Neem oil, Honge oil and Mahua oil were 11.95cSt, 11.06cSt and 11.77cSt respectively. It can also be observed that as vegetable oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils and K.V of 20% Neem oil values are nearer to base oil values

23. Comparison of effect of esterified oil blends and Base oil on Kinematic viscosity with 1% of Iron oxide as Nanoparticle additive

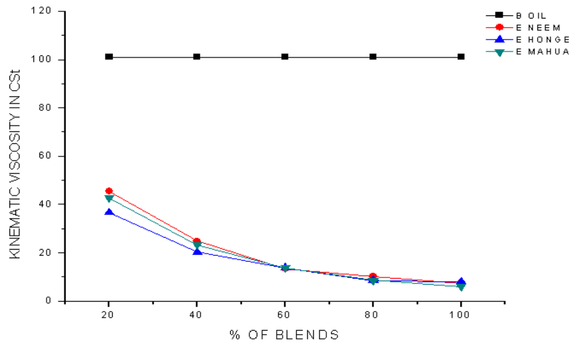


Figure23. graph shows Effect of Kinematic viscosity with percentage of esterified oil blends and base oil with 1% Iron oxide

Figure 23**,** shows the variation of kinematic viscosity with non esterified blends of oil It is calculated that kinematic viscosity of esterified Neem, Honge and Mahua oil were 5.52cSt, 5.99cSt and 5.07cSt respectively. It can also be observed that as oil percentage in the blend increases, there is decrease in the kinematic viscosity. This is attributed to lower volatility of vegetable oils and also due to the removal of fat and glycerine during esterification process. All values of K.V are far away from values of SAE 15W 40 base oil.

24.Comparison of effect of blends of oil and esterified oil and base oil on Kinematic viscosity with 1% of Iron oxide as Nano particle additive

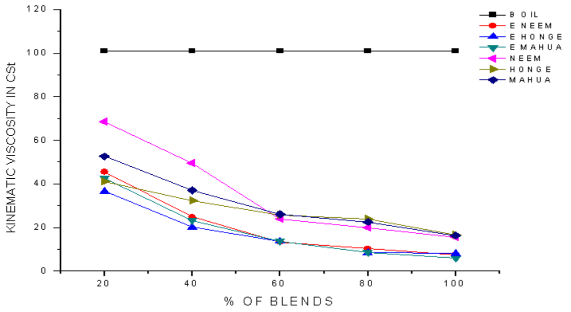


Figure24. Graph shows variation of Kinematic viscosity with percentage of blends of oil and esterified oil and base oil with 1% Iron oxide.

Figure24, shows Comparison of Kinematic viscosity of non esterified and Esterified oil blends and base oil with 1% Iron oxide. It can be observed that the non esterified Neem oil possses more kinematic viscosity(11.95cSt) which is owing to occurrence of more triglycerides, Linoleic acid and fatty acids lower volatility of non edible oil. Further it can be observed that the esterified Mahua oil(5.07cSt) possess lesser Kinematic viscosity compared with other oils tested which is due to removal of triglycerides and fatty acids during esterification. And K.V values of 20% Neem oil values are nearer to base oil value.

4. CONCLUSIONS

- There is increase in the kinematic viscosity with the increase of vegetable oil proportion in the blends. This is attributed to lower volatility of vegetable oils.
- The KV of non esterified oils found Higher than that of esterified oils, this is due to Monoalkyl esters and FFA in vegetable oils
- The Neem oil with 20% blend with SAE15W40 oil possess comparatively good kinematic viscosity and it is close to synthetic mineral oil, this is due to Linoleic acid in Neem oil.
- It is observed values of Kinematic viscosity of Esterified oil blends are far away from the values of base oil, this is due to separation of glycerine and fat during Esterification process.
- There are no Significant variations by adding of less proportion of Iron oxide Nano particle.
- It is observed that 20% decrease in the kinematic viscosity with the addition 1% Iron oxide Nano particle to the blends, this is due to more specific gravity of Iron oxide Nano particle.
- The Experimental results are in line with the literature.
- Addition of Nano particle Increases the Volatility of Vegetable oils.
- It is observed that all the blends of oil are no evidence of corrosion.

ACKNOWLEDGMENT

The authors are very much thank full to the Sri Siddhartha Academy of Higher Education Tumkur, Karnataka, India for provided those necessary lab facility to effectively achieve this research work.

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