

Exploring Nano-Graphene in Bio-Lubricants: Innovative Approaches to Reduce Friction and Wear Engineering Systems

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Abstract:

The era of Nanomaterials is very promising and provides a friendly environment there by giving it a scope for lubrication. Although conventional lubricants such as SAE 20/30/40, machine oils and grease are very popular. The naturally available bio lubricants have been recognized and still there is a scope to explore the various combination of the lubricant to make work as efficient as the with existing lubricant. The nano compounds as additives are chosen predominantly to act as anti-wear, anti-friction, and to handle extreme pressure. Their nanoscale size, thermal stability, diverse chemical compositions, and rapid reactivity with surfaces without requiring an induction period is what that explores them to field of lubrication. These benefits translate into longer operational life for equipment, improved fuel efficiency, and extended maintenance intervals. This article highlights the advantages of nano graphene as emollient extracts and their variations in various path ways of lubrication. Additionally, it focuses on combining it with natural resources to thereby reduce the cost of lube oil. The nano graphene can be synthesized by using CVD, unzipping of CNT, Microwave-assisted exfoliation method, Ball milling method, and green synthesis. This investigation focuses on the different variation and concentration in lubricant oil to explore its rheological and wear properties

Keywords: Graphene, Rheometer, Viscosity, IC engines

1.Introduction:

Primitive lubrication is an important aspect of any mechanical industry because most of the most machine's integral part is lubrication. As most of the machines are prone to generate heat and has some grits mixed along with oil contributing to wear and tear. Any industry that aiming in achieving efficiency has to work towards in reducing friction and anti-wear. In order to improve the efficiency of the lubricant oil, the most industrialist are aiming in adding nano additives to the lubricant oil. The main intension is to have smooth flow, lower friction and carry away from the generating medium. The different types of liquid lubrication can be of mineral, synthetic and biodegradable. However, the nation works on naturally and effective utilization of the lubricant as it should leave any waste on the environment nor the affect the atmosphere

Effective lubrication is essential for the reliability and efficiency of mechanical systems. Understanding the principles of lubrication and choosing the right type of lubricant for specific applications can significantly enhance performance and longevity. Regular maintenance and monitoring of lubricant condition are also critical to ensure optimal operation.

Current Status of Research: There is an era of research that is propagating over the period on materials. Lubrication have existed used either in the form of oil or semi paste as to provide good lubrication to the system. et. al [1] has given an insight on the influence of classes of nanomaterials such as Nano diamonds, ultra-dispersed boric acid and polytetrafluoroethylene (PTFE). And that has proved to enhance the lubricating properties. et. al [2] proved the effect of Nano oil on agricultural engines and performance of eight Massey Ferguson model 399. These oil sample were tested by atomic absorption spectrometry and with Particle Quantifier (PQ), total base number (TBN), viscosity, fuel and water pollution tests. This lubricant as addictive in the system would decrease wear in cylinders, gaskets, drive shafts, gears, cam shaft and valve mechanisms by 68 percent. et. al [3] examined on zinc borate ultra fine powders (ZBUFPs) on their tribological properties as lubricant additives in liquid paraffin (LP). Their effects of surface modification were examined along surface and has proved to provide a antiwear film along surface.

Relevance of the Present Research: The addition of nano lubricant in the medium has proved to reduce wear and tear in the system. Several contributions by researchers have shown that a small addition of nano compound to the base substance had a drastic change in the function of the system. et. al [4] showed lower friction coefficient for CMRO with Nano CuO that was infused as a lubricant and reduced wear in journal and thereby increasing the life of system. And also, the tribo layer formation helped to carry away heat from the system. The tribo layers were characterized during EPMA, FIB–TEM, and Nano-indentation analyses. et. al [5] analyzed that Increase in lubricant viscosity by using TiO2 nanoparticles was modelled and experimented and the results show that load could be enhanced in the while this lubricant when it was associated with other plain oils without any addition. et. al [7] considering wear in gears is a very common problem and to overcome this, they have exposed that the addition nanoparticles have led to improve thermal properties and wear. Hence the efficiency of the gear box has improved. et. al [9] explored the utilization of chemically modified rapeseed oil (CMRO) along with Nano CuO improved the efficiency of the vehicle that while experimenting with wear test with maximum load of 200N with different variation in the sample

2.**Nano Materials and bio lubricant**

Graphene has found its existence in almost all areas which needed an at most change ground breaking environment specially in fields automobile industry and with respect to lubrication owing to its exclusive properties. The physicists Andre Geim and Konstantin Novoselov, who were awarded the Nobel Prize for their work of discovering Graphene which is a two-dimensional single layer of carbon atoms. It is well-thought-out to be the basic building block of all carbon-based materials, such as graphite, carbon nanotubes, and fullerenes.

The properties of mechanical, thermal, and electrical with respect to graphene is extra ordinary properties. It allows for a variety of surface interactions because of large surface area and flexibility. These properties have made it highly promising in tribology—the study of friction, lubrication, and wear—where it is increasingly used as a lubricant or as an additive to improve the performance of conventional lubricants.

Pongamia pinnata belongs to the family of Fabaceae which is commonly called as Pongamia oil. Thi bio lubricant is commonly known as the Pongam tree or Karanja, is a deciduous tree native to tropical and subtropical regions of Asia, particularly India and Southeast Asia[11].

Ecological Importance

Pongamia pinnata is known for its ability to thrive in poor, saline, and alkaline soils, making it a valuable species for reforestation and land restoration. Its deep root system helps prevent soil erosion and enhances soil fertility through nitrogen fixation. The tree also provides habitat and food for wildlife. It is widely used in the production of bio disel, traditional medicine and has lots of benefits in agriculture. The Pongamia tree is widely popular in the streets of Karnataka for its environmental stability[6][7].

Fig 1 Pongamia pinnata and Nano Graphene

Graphene Details:

Particle size-D50:<1-2µm

Thickness 5-10nm

surface area: 110m2/g

viscosity: 30 to 40 centistokes (cSt) at 40°C.

3.Methodology:

The samples are blended by using an magnetic stirrer that is made of mild steel whose heating temperature is 100-150 degree Celsius. It is smooth operated and has two magnetic stirrer beads. Stainless steel hot plates speed ranges between 2000 to 2200 rpm Three samples are considered for this study, they are Blend 1, Blend 2 and Blend 3. Blend 1 consist of 250 ml of Pongamia oil and graphene in 5% and Blend 2 consist of 250 ml of Pongamia oil and graphene in 10% and Blend 3 consist of 250 ml of Pongamia oil and graphene in 15%. The methodology of the study is in the form of flow chart below in Fig 2

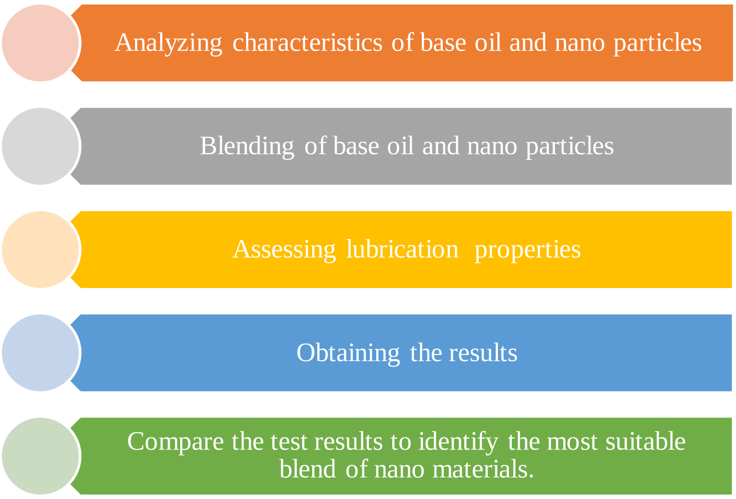

Fig 2

3.Experimentation

The blend 1, blend 2 and blend 3 are examined under a rheometer the viscosity values for these samples were obtained between data points 1 to 50. The temperature was chosen between 20 to 30 degrees Celsius. Then these blends are subjected to Hero Honda splendor a two-stroke engine for 40 hrs continuous cycles. And again the Blends of 1, blend 2 and blend 3 viscosity was obtained and compared to study the ideal viscosity range [12][13][15].

4.Result and Discussion:

The Viscosity values are obtained and tabulated in Table1. For the sake convenience the samples are identified Blend 1 and blend 2 and blend 3 whose viscosity are in the case of before run condition and their analysis is shown fig 3 and blend 4, blend 5 and blend 6 are in the case after run condition their analysis is shown fig 4. Rheometer Can measure viscosity over a wide range of shear rates and stresses. Rheometer is also Suitable for non-Newtonian fluids, providing more detailed information like shear thinning, shear thickening, and viscoelastic properties. Using anova results are analysed and plotted as shown in graph 5 and graph 6[15].

Table 1

			BR			AR	
		B1	B2	B3	B4	B5	B6
Point No.	Time	Viscosity	Viscosity	Viscosity	Viscosity	Viscosity	Viscosity
	CC						
	[s]	[mPa·s]	[mPa·s]	[mPa·s]	[mPa·s]	[mPa·s]	[mPa·s]
1	6	935.8	398.1	301.9	1326.3	1298.9	2175
2	12	431.8	264.1	232.9	1059.5	1174.2	1827.9
3	18	338.3	240.3	207.7	945.9	1036.3	1643.6
4	24	291.9	227.2	202.5	865.6	885.3	1574
5	30	278.1	226.5	211.7	864.4	913	1576.6
6	36	273.2	201.4	190.2	860.6	933	1563.5
7	42	263.2	203.8	193.3	838.2	884.5	1547.3

8	48	259.2	193.8	184.1	839.7	906	1540.4
9	54	253	197	186.2	831.1	899.7	1539.3
10	60	252.1	185.2	176.8	802.6	843.6	1529.7
11	66	248.7	185.6	174.2	818.4	861.1	1518.8
12	72	243.7	183.8	172.7	818	873.2	1510.3
13	78	240.3	180.3	171	808.6	867.3	1515.7
14	84	237.8	179.1	171.2	798.6	854.4	1508.4
15	90	236.6	179	170.1	789.6	842.2	1508.9
16	96	235.4	179.4	169.4	790	826.7	1500.3
17	102	242.3	172.5	164.5	784.7	812.6	1496.1
18	108	234.3	179.1	170.2	792	807.4	1478.8
19	114	231	176.8	168.4	792	804.6	1483.2
20	120	231.1	176.7	168.3	791	804.3	1467.8
21	126	230.7	176.3	168.7	791.8	806.8	1471.9
22	132	229.6	176.2	168.1	792.9	806.5	1468.5
23	138	229.5	175.6	168.1	792.6	807.9	1460.5
24	144	230.3	176.7	170	794.3	809.8	1460.4
25	150	228.4	175.1	168.3	791.9	809.2	1448.8
26	156	228.6	175.4	169.3	793	808.3	1445.9
27	162	228.7	175.4	169.1	793.8	805.4	1436.9
28	168	228.3	175.3	168.6	792.6	806.2	1421.6
29	174	227.7	174.5	168.6	793.2	802.3	1397.4
30	180	227.1	175	168.4	792.5	802.9	1387
31	186	226.8	174.1	169.2	791.8	801.9	1378.6
32	192	227	173.8	168.6	791.4	799.6	1361.3
33	198	225.6	173.1	168.2	790.6	796.8	1350.8
34	204	226.2	174	169.2	791.5	798.6	1351.5
35	210	226.3	174.5	169.6	791.8	797.3	1337.1
36	216	225.1	173.4	169	791.4	795.7	1340.1
37	222	224.8	172.5	168.2	789.9	794.4	1329.6
38	228	226.1	173.9	169.5	791.3	793.7	1321.1
39	234	224.7	172.6	168.5	789.8	792.8	1317.3
40	240	224.6	173.2	169.4	790	792.2	1298.6
41	246	224.8	173.5	169.3	790.3	792.7	1294.7
42	252	224.6	172.8	169.1	789.7	792.6	1330.7
43	258	224.5	172.5	169	789.9	791.6	1358.3
44	264	224.7	173	169.2	790.5	792.7	1362.2
45	270	223.6	172.4	169.2	789.4	790.5	1363.2
46	276	224.6	173.1	169.2	790.5	791.4	1366.2
47	282	223.1	171.6	168.2	789.7	789.7	1364.7
48	288	222.7	171.6	168.5	789	790.7	1365.8
49	294	222.5	171.4	168.3	789.2	789.3	1363
50	300	222.8	171.2	168	789.4	788	1363.9

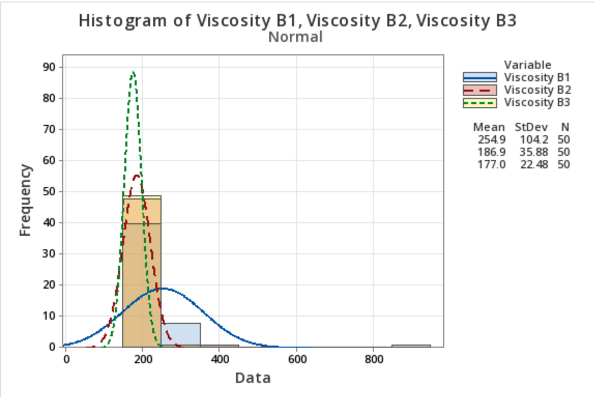

Fig 3

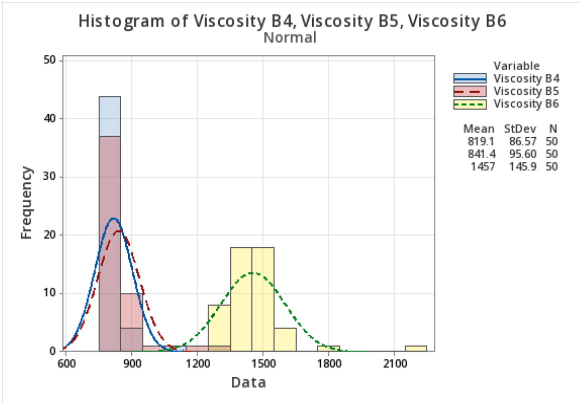

Fig 4

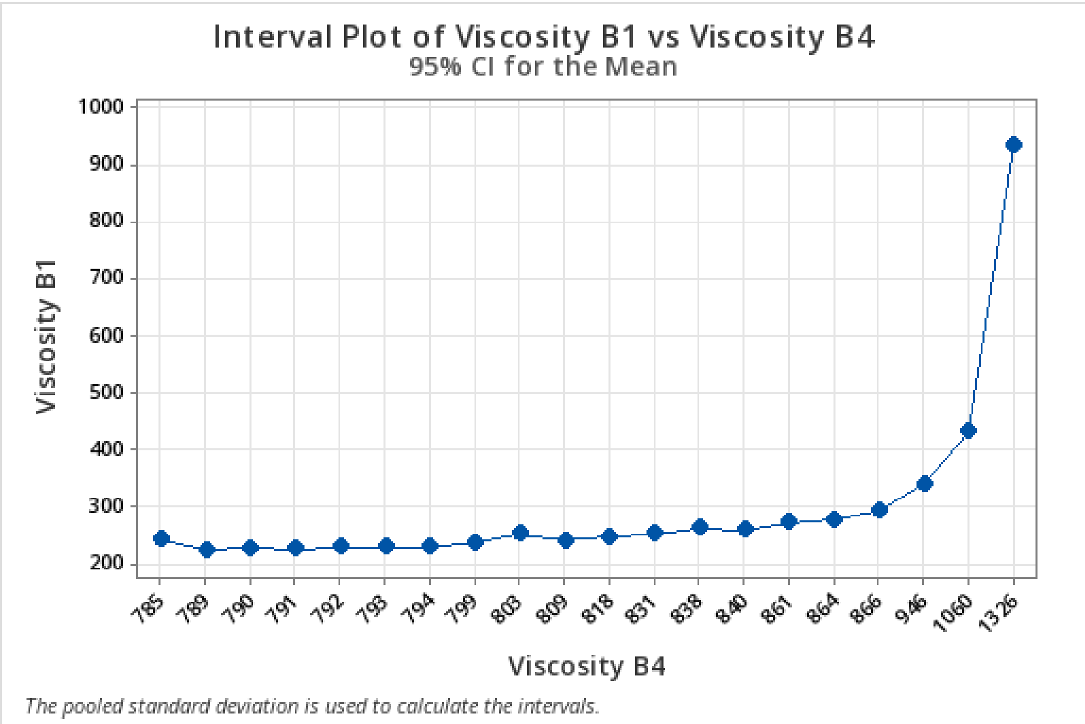

Fig 5

Equal variances were assumed for the analysis.

Table 2

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Viscosity B4	19	532005	28000.3	2724.18	0.000
Error	30	308	10.3		
Total	49	532314			

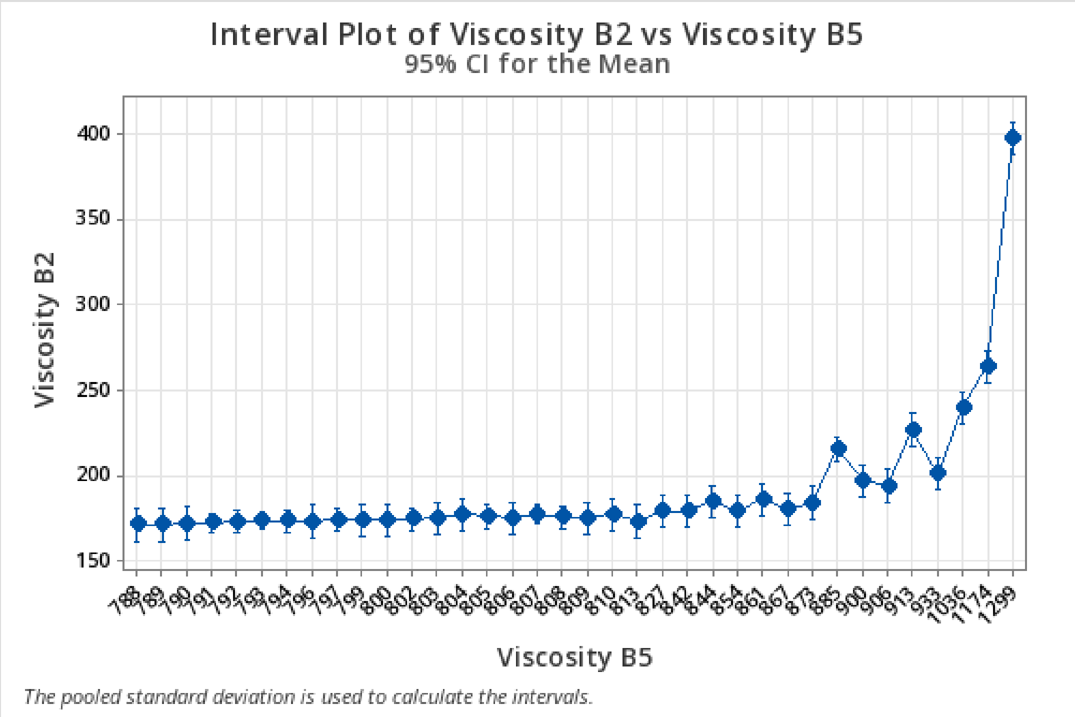

Fig 6

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Viscosity B5	35	62797.1	1794.20	90.55	0.000
Error	14	277.4	19.82		
Total	49	63074.5			

Conclusion:

1) Viscosity B1: The large spread and high standard deviation suggest that this material or condition has a high variability in its viscosity measurements, which could be due to factors such as temperature fluctuations, shear rate sensitivity, or inconsistencies in material composition.
2) Viscosity B2 and B3: Both are relatively consistent, with similar mean values and much tighter distributions. Viscosity B3 appears to be the most stable and consistent of the three, as it has the smallest standard deviation and the narrowest distribution.
3) Viscosity B4 and B5 appear to represent similar materials or conditions with closely related viscosity characteristics.
4) Viscosity B6, however, represents a material or condition with significantly higher viscosity and more variation, indicating that it behaves differently compared to B4 and B5.
5) Given the higher standard deviation for Viscosity B6, there could be environmental or compositional factors affecting its viscosity measurements, leading to wider fluctuations.
6) The F-value (2724.18) is extremely high, and the P-value (0.000) is very small. This indicates that there is a highly significant difference in the viscosity of B4 across the different groups or levels.
7) The F-value of 90.55 is quite large, and the P-value of 0.000 confirms that the differences in the viscosity values for Viscosity B5 are statistically significant. This suggests that the factors or conditions being tested with Viscosity B5 cause significant variation in the viscosity across different groups or levels
8) Viscosity for the blend 6 indicates higher % of graphene which indicates higher viscosity.

Hence may not be suitable for application, which can be the scope for next experiment

Hence in conclusion these viscosity measurements represent different samples, it is likely that B1 behaves more erratically or is influenced by external factors, while B2 and B3 exhibit more uniform behaviour. B3, in particular, has the most stable viscosity profile And with case of B4 and B5 are more consistent in viscosity, while B6 could represent a material that is either more viscous or more sensitive to changes in shear rates, temperature, or other factors affecting viscosity.

DATA AVAILABILITY

All data that were used to support the conclusion are included in this article.

CITATIONS

All citations in the text are in the reference list

CONFLICTS OF INTEREST

Conflicts of interest the author the authors declare that there are no conflicts of interest

ACKNOWLEDGEMENT

The author is grateful in general for the support to the Principal, Head of the Department and the department of Mechanical Engineering for providing a conducive Environment

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