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Properties Experimental Analysis Bio-Monograde Engine Oil: Blended Mono-Grade Engine Oil SAE 40 with Fresh Coconut Oil

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Abstract: Mono-grade engine oil is the engine oil on the market and this engine oil has the lowest properties compared to multi-grade and synthetic engine oil. Mono-grade engine oil does not have viscosity index improving (VII) properties because it cannot be added polymer additive. Coconut oil is a vegetable oil produced from coconut milk that contains high fatty acids. The main objective of this study is to determine the effectiveness of fresh coconut oil being added to SAE 40 mono-grade engine oil by a different mixture composition. In this study, density, viscosity, kinematic viscosity, and viscosity index (VI) number is a measurement by using SVM 3000/G2 equipment. The engine oil used in this study is Petronas Mach 5 SAE 40 API SF mono-grade engine oil and fresh coconut oil is homemade manufactured. The results of the study show that the density and VI of the bland mono-grade engine oil increase but decrease in dynamic viscosity and kinematic viscosity concerning the percentage of fresh coconut oil mixture.

Keywords: Engine oil, Coconut oil, Mono-grade engine oil, Viscosity index, Precentage of fresh coconut oil

Introduction

Engine lubrication oil is a substance involving base oils upgraded with different added substances, especially anti-wear additives in addition to detergents, dispersants, and, multi-grades oils, and viscosity index improvers. It is utilized as the lubricant of an internal combustion engine. The fundamental function of engine lubrication oil is to reduce grating and wear on moving parts. It also neutralizes acids that start from the oxidation of the oil, improves the fixing of cylinder rings, and cools the engine by diverting heat from power strokes and moving parts. The classification of engine lubricating oils is done by the Society of Automotive Engineers (SAE). According to SAE, the engine lubricating oils can be divided into the multi-grade and the single-grade or known as mono-grade. Mono-grade engine oil does not have viscosity index improving (VII) properties because it cannot be added polymer additive. SAE J300 has established eleven viscosity grades, of which six are considered Winter-grades and given a W designation. The 11 viscosity grades are 0W, 5W, 10W, 15W, 20W, 25W, 20, 30, 40, 50, and 60 (Guan et al., 2008).

The quality of the engine oil is normally based on the viscosity of the grades of the engine oil other than a total base number (TBN) or total acid number (TAN). The quality of the engine oil is normally used to determine the life span of that engine oil. This was shown in the study done by Nordin Jamaludin et al. (2011) under the title relationship between engine oil viscosity with age and temperature and the study done by Othman Inayatullah et al. (2010) under the title development of acoustic emission viscosity model for measuring engine oil viscosity relationship with engine oil in-service age. Table 1 lists the limit for each grade of engine oil.

Table 1. SAE J300 Viscosity table (2015)

Grade	Cold cranking CCS	Cold pumping MRV	Kinematic Viscosity @ 100˚C		High-Temperature High Shear HTHS @150˚C
Unit	cP @ T ˚C	cP @ T ˚C	cSt	cSt	cP
	Maximum	Minimum	Minimum	Maximum	Minimum
0W	6,200 @ -35	60,000 @ -40	3.8		
5W	6,600 @ -30	60,000 @ -35	3.8		
10W	7,000 @ -25	60,000 @ -30	4.1		
15W	7,000 @ -20	60,000 @ -25	5.6		
20W	9,500 @ -15	60,000 @ -20	5.6		
25W	13,000 @ -10	60,000 @ -15	9.3		
8			4.0	<6.1	1.7
12			5.0	<7.1	2.0
16			6.1	<8.2	2.3
20			5.6	<9.3	2.6
30			9.3	<12.5	2.9
40			12.5	<16.3	2.9[1]
40			12.5	<16.3	3.7[2]
50			16.3	<21.9	3.7
60			21.9	<26.1	3.7

Note: [1] 0W-40, 5W-40, and 10W-40. (For 0W, 5W, and 10W, the HTHS limit is 2.9 cSt.)
[2] 15W-40, 20W-40, 25W-40 and 40. (For 15W, 20W, and SAE 40, the HTHS limit is 3.7 cST instead of 2.9 cSt.)

Coconut oil belongs to a unique group of vegetable oils called lauric oils. The chemical composition of coconut oil is given in Table 2 with lauric acid shown with a bigger percentage of 47.9 % to 51.0 %. This percentage of lauric acid was obtained through a study conducted by N.H. Jayadas and K. Prabhakaran Nair in a study titled Coconut oil as a base oil for industrial lubricants evaluation and modification of thermal, oxidative, and low-temperature properties. By using thermo-gravimetric analysis (TGA) of coconut oil, sesame oil, sunflower oil, and commercial 2T oil to study thermal and oxidative degradation. Using molecular dynamics simulation software (Spartan 02, Wavefunction Inc.) the percentage values of different saturated and unsaturated fatty acid chains (lauric, oleic, linoleic) and pour point. The results of the study showed that coconut oil showed a lower weight gain, an indicator of oxidative stability, under an oxidative environment and the highest pour point among the vegetable oils tested. This can be attributed to the saturated nature of most of its fatty acid constituents (Jayadas & Nair, 2006).

Table 2. Fatty acid composition of crude coconut oil (Jayadas & Nair, 2006;Ta ngsathikulchai et al., 2004)

Component	Fraction A (wt%)	Fraction B (wt%)
Lauric	51.0	47.9
Myristic	18.5	19.7
Caprylic	9.5	6.4
Palmitic	7.5	9.7
Oleic	5.0	6.6
Capric	4.5	4.5
Stearic	3.0	2.7
Linoleic	1.0	1.6

Before that, in 2004, a study titled Temperature effect on the viscosities of palm oil and coconut oil blended with diesel oil was conducted by C. Tangsathikulchai et al., this study reported viscosity data determined through a bob-and-cup viscometer swirling, for crude palm oil and coconut oil blended with diesel oil at a temperature range of 20˚C - 80°C and for different blend compositions. The output of this study is the reduction of viscosity with increasing liquid temperature. Table 3 shows the coconut oil properties as used in this study. (Tangsathikulchai et al., 2004).

In 2011, P. Nellamegam and S. Krishnaraj undergo an experiment on the viscosity of coconut oil in the temperature range of 30˚C to 90˚C by using the training pattern for associative neural networks (ASNN) and regression analysis (RA). The ASNN is a combination of memory-based and memory-less methods which offers an elegant approach to incorporating “on the fly” the user’s data (Igor & Tetko, 2002). It is an extension of the committee of machines that goes beyond a simple or weighted average of different models. The viscosity of coconut oil is determined with a calibrated Cannon-Ubbelohde viscometer at an interval of 10˚C. The measured value for the viscosity of coconut oil for different temperatures is given in Table 4 (Nellamegam & Krishnaraj, 2011).

Table 3. Coconut oil properties (Tangsathikulchai et al., 2004)

Oil Properties	ASTM Standard	Value
Density at 15.5˚C	D 1298	0.915 g/cm^3
Flash point	D 93	200˚C
Gross heating value	D 240	40,500 kJ/kg
Kinematic viscosity	D 445	
@ 40˚C		27.4 mm^2/s
@ 100˚C		6.91 mm^2/s
Reid vapor pressure @ 37.8˚C	D 323	0.027 bar
Cetane index	D 976	35
Viscosity index	D 2270	230

Table 4. Viscosity of coconut oil against temperature (Nellamegam & Krishnaraj, 2011)

Temperature, ˚C	Viscosity, 10^{-1} Pa.s
30	3.2937
40	2.7135
50	2.2217
60	1.4992
70	1.0740
80	0.8177
90	0.5500

In other words, coconut oil is consumable oil extracted from the kernel of mature coconuts gathered from the coconut palm. It has different applications due to its highly soaked fat substance; it is delayed to oxidize and, in this way, impervious to rancidification, enduring as long as a half year at 24˚C without ruining. Fresh coconut oil has a high gelling temperature (22˚C - 25˚C), a high viscosity, and a pH of 7-8. In this study, the fresh coconut oil used is homemade.

Since mono-grade engine oil cannot be added with polymers for VII and the advantage of coconut oil with a constant alkali level, this research paper presents some findings on the blending of mono-grade engine oil with fresh coconut oil. The main objective of this study is to determine the effectiveness of fresh coconut oil being added to SAE 40 mono-grade engine oil by a different mixture composition. In this study, density, viscosity, kinematic viscosity, and viscosity index (VI) number is a measurement parameters. At this stage, focusing of these studies just only on the properties of blended mono-grade engine oil with coconut oil under fresh conditions in a laboratory experiment. To fulfill the main objective of this project, the secondary objectives need to be fulfilled. The secondary objectives include,

a. Gain familiarity with a phenomenon or achieve new characteristics in the blend of SAE 40 engine oil with coconut oil.
b. Portray the properties of the mixture of SAE 40 engine oil and coconut oil such as viscosity, kinematic viscosity, density against temperature, and different compositions of the mixture.
c. Relationship between the composition of the mixture and viscosity index (VI).

Overall, contributions to knowledge in this study can be seen in the following aspects,
a. Changes in the properties of mono-grade engine oil against the composition of coconut oil blended.
b. Changes to the VI value of the composition percentage.
c. Measurable ability at temperatures below 20˚C.

Methodology

Specimen Materials

In this study, Petronas Mach 5 SAE 40 with API SF engine oil and fresh coconut oil were used as the specimen for testing. Petronas Mach 5 SAE 40 is a mono-grade crude oil-based engine oil. The product data sheet for Petronas Mach 5 SAE 40 API SF is shown in Table 5. For fresh coconut oil, the product data sheet is shown in

Table 2. However, the product data-sheet displayed in Tables 2 and 5 is only used as a reference because, in this study, the re-measurement of the properties of the two oils was carried out using the 2nd generation Stabinger Viscometer SVM 3000 (SVM 3000/G2) equipment.

Table 5. Petronas Mach 5 SAE 40 API SF product data sheet

Characteristic	Value
Density @ 15˚C (kg/m^3)	897.1
Pour point (˚C)	-6
Flashpoint (˚C)	256
Kinematic viscosity (mm^2/s)	
@ 40˚C	160.8
@ 100˚C	15.2
Viscosity index	96

In the eyes view, the original non-blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil showed darker brown compared to non-blended fresh coconut oil which is more yellowish. When more percentage composition of fresh coconut oil is blended with Petronas Mach 5 SAE 40 API SF, the color of the mixture changes slowly bright yellowish as shown in Figure 1.

Figure 1. View inspection (Change in engine oil color against the composition percentage)

Instrumentation

In this study, the 2nd generation Stabinger Viscometer 3000 (SVM 3000/G2) as shown in Figure 2 is used to measure the density, dynamic viscosity (viscosity), kinematic viscosity, and viscosity index of the blended Petronas Mach 5 SAE 40 API SF with fresh coconut oil. The SVM 3000/G2 is designed for measuring liquid substances such as lubricant oil, hydraulic oil, and petroleum oil and also includes food liquid based. The technical specification of SVM 3000/G2 is highlighted in Table 6.

Figure 2. The 2nd generation stabinger viscometer 3000 (SVM 3000/G2)

Table 6. Technical specification of SVM 3000/G2

Characteristics	
Test methods	ASTM D7042 - Dynamic viscosity and density ASTM D445 - Kinematic viscosity ASTM D4052 - Density ISO 23581 - Kinematic viscosity ISO 12185 - Density EN 16896 - Kinematic viscosity
Kinematic viscosity (mm^2/s)	
Minimum	0.2
Maximum	30,000
Density (g/cm^3)	
Minimum	0
Maximum	3
Temperature (˚C)	
Minimum	-60
Maximum	135
Precision	
Viscosity repeatability (%)	0.1
Viscosity reproducibility (%)	0.35
Density repeatability (g/cm^3)	0.00005
Density reproducibility (g/cm^3)	0.0001
Cloud/freeze point repeatability (˚C)	<0.5/<0.5
Cloud/freeze point reproducibility (˚C)	<2.5/<1.3
Temperature repeatability (˚C)	0.005
Temperature reproducibility (˚C)	0.03 from +15 to +100 0.05 outside range
Performance	
Simple volume minimum/typical (mL)	1.5/1.5
Solvent volume minimum/typical (mL)	1.5/6.0
Maximum sample throughput (samples/hour)	33

Procedures

In this study, the mixture of the mono-grade Petronas Mach 5 SAE 40 API SF engine oil and fresh coconut oil specimen be bottled by the percentage of fresh coconut oil inside mono-grade Petronas Mach 5 SAE 40 API SF as tabled in Table 7.

Table 7. Composition of mono-grade Petronas Mach 5 SAE 40 API SF and fresh coconut oil

Mono-Grade Petronas Mach 5 SAE 40 API SF (%)	Fresh Coconut Oil (%)	Mono-Grade Petronas Mach 5 SAE 40 API SF (mL)	Fresh Coconut Oil (mL)
100	0	50	0
90	10	45	5
80	20	40	10
70	30	35	15
60	40	30	20
50	50	25	25
40	60	20	30
30	70	15	35
20	80	10	40
10	90	5	45
0	100	0	50

Each specimen needs to undergo 9 measurements due to temperature setting will be started from 20˚C to 100˚C with an interval of 10˚C. The selection of the starting temperature of the measurement at a temperature of 20˚C is due to the SVM 3000/G2 not being able to give a reading at 0˚C when fresh coconut oil is 40% and above mixed with mono-grade Petronas Mach 5 SAE 40 API SF engine oil as shown in Table 8. This happen when the blended engine oil with coconut oil was frozen inside the test chamber which lead to the instrument being unable to generate output that was far from its standard range.

Table 8. Starting temperature for measuring properties of mono-grade Petronas Mach 5 SAE 40 API SF engine oil blended with fresh coconut oil.

Temperature (˚C)	Density, ρ (g/cm^3)					
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas Mach 5 SAE 40 API SF Engine Oil					
	0%	10%	20%	30%	40%	50%
0	0.9073	0.9096	0.9106	0.9146	x	x
6	0.9032	0.9055	0.9065	0.9105	0.9138	x
9	0.9012	0.9035	0.9045	0.9085	0.9118	0.9146
10	0.9005	0.9028	0.9038	0.9078	0.9111	0.9139
13	0.8985	0.9008	0.9018	0.9058	0.9091	0.9119
15	0.8971	0.8994	0.9004	0.9044	0.9077	0.9105
16	0.8964	0.8987	0.8997	0.9037	0.9070	0.9099

Temperature (˚C)	Density, ρ (g/cm^3)				
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas Mach 5 SAE 40 API SF Engine Oil				
	60%	70%	80%	90%	100%
0	x	x	x	x	x
6	x	x	x	x	x
9	x	x	x	x	x
10	x	x	x	x	x
13	0.9149	x	x	x	x
15	0.9136	0.9163	0.9188	0.9213	x
16	0.9129	0.9156	0.9181	0.9207	0.9238

Each measure required 40 mL of the specimen. For backup, the quantity of the specimen is set at 50 mL, this quantity is required for any re-measure or re-test if any error case. A magnetic stirrer lab stir mixer plate with 200 rpm was used for the blending process as shown in Figure 3.

Figure 3. Magnetic stirrer lab stir mixer plate

Results and Discussion

From the measurement of the mixture of mono-grade Petronas SAE 40 API SF with fresh coconut oil through SVM 3000/G2, readings of density, dynamic viscosity, and kinematic viscosity at each research temperature were obtained as shown in Tables 9, 10, and 11, respectively.

Table 9[a]. The density value (composition of fresh coconut oil from 0% to 50%)

Temperature (˚C)	Density, ρ (g/cm^3)					
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil					
	0%	10%	20%	30%	40%	50%
20	0.8936	0.8960	0.8970	0.9010	0.9043	0.9072
30	0.8868	0.8891	0.8902	0.8942	0.8975	0.9004
40	0.8799	0.8822	0.8833	0.8873	0.8907	0.8936
50	0.8729	0.8753	0.8764	0.8805	0.8839	0.8868
60	0.8660	0.8684	0.8694	0.8736	0.8770	0.8799
70	0.8590	0.8614	0.8625	0.8666	0.8701	0.8730
80	0.8520	0.8544	0.8555	0.8597	0.8632	0.8661
90	0.8450	0.8474	0.8485	0.8527	0.8562	0.8592
100	0.8379	0.8404	0.8415	0.8457	0.8493	0.8523

Table 9[b]. The density value (composition of fresh coconut oil from 60% to 100%)

Temperature (˚C)	Density, ρ (g/cm^3)				
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil				
	60%	70%	80%	90%	100%
20	0.9102	0.9129	0.9154	0.9180	0.9211
30	0.9035	0.9062	0.9087	0.9113	0.9145
40	0.8967	0.8994	0.9020	0.9046	0.9078
50	0.8899	0.8926	0.8952	0.8978	0.9011
60	0.8831	0.8858	0.8884	0.8911	0.8943
70	0.8762	0.8790	0.8816	0.8843	0.8875
80	0.8694	0.8721	0.8748	0.8775	0.8808
90	0.8625	0.8653	0.8679	0.8706	0.8739
100	0.8555	0.8584	0.8610	0.8638	0.8671

From Table 9[a] and Table 9[b], increasing the composition of fresh coconut oil, will increase the density at all set temperatures. Figure 4, shows more clearly the increase in the density of blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil with fresh coconut oil at temperatures of 40˚C and 100˚C for each composition of fresh coconut oil. This proves that the mixture of fresh coconut oil in the engine oil can change the density value of the engine oil.

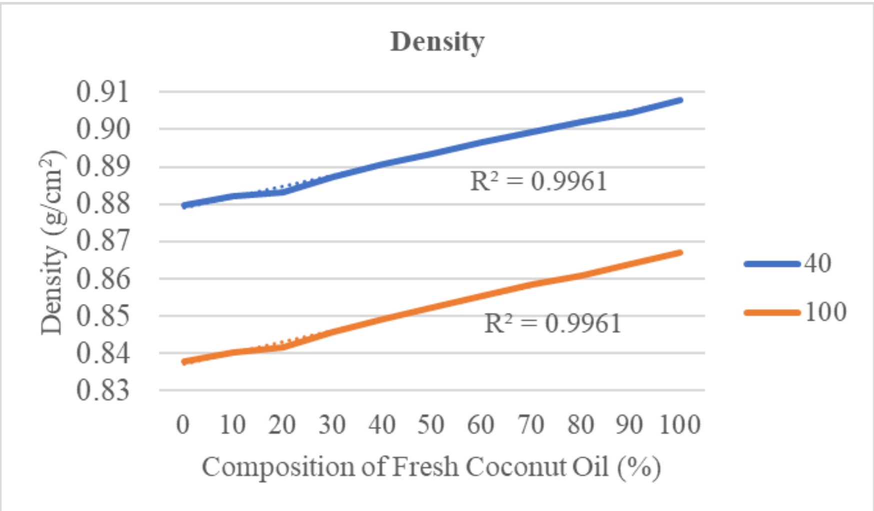

Figure 4. Increasing density of blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil with fresh coconut oil at temperatures 40˚C and 100˚C.

This is due to fresh coconut oil is predominantly composed of saturated fatty acids (about 94%), with a good percentage (above 62%) of medium-chain fatty acids and it has been shown the density of fresh coconut oil is higher than mono-grade Petronas Mach 5 SAE 40 API SF engine oil. This is clearly shown in Table 9(a), where

0% of the composition is referred to as 100% of mono-grade Petronas Mach 5 SAE 40 API SF engine oil, and in Table 9(b), 100% of the composition is referred to 100% of fresh coconut oil as shown in Figure 5.

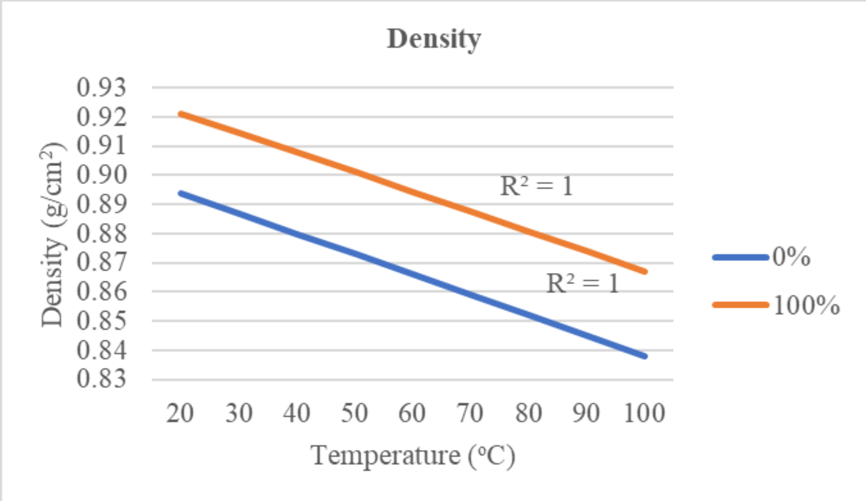

Figure 5. Density for 100% mono-grade Petronas Mach 5 SAE 40 API SF (0% composition) and 100% fresh coconut oil (100% composition)

Tables 10[(a)] and 10[(b)], display the results of dynamic viscosity measurements, also known as absolute viscosity. It is clearly shown increasing the composition of fresh coconut oil will reduce the dynamic viscosity of the blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil as shown in Figure 6. Figure 6, also shows the range of differences in dynamic viscosity reading reduction against the percentage of fresh coconut oil composition narrows at high temperatures. The best comparison is the dynamic viscosity reading at 40˚C and 100˚C. It is the opposite of the output of density as shown in Tables 9[(a)] and 9[(b)].

Table 10[(a)]. The dynamic viscosity value (composition of fresh coconut oil from 0% to 50%)

Temperature (˚C)	Dynamic Viscosity, μ (mPa.s) Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil (%)					
	0	10	20	30	40	50
20	533.964	490.643	446.385	403.371	359.678	315.517
30	262.044	241.691	220.930	200.769	180.278	159.560
40	141.488	131.039	120.370	110.034	99.533	88.898
50	82.720	76.952	71.045	65.346	59.544	53.665
60	51.700	48.296	44.799	41.447	38.025	34.556
70	34.169	32.028	29.830	27.722	25.575	23.394
80	23.675	22.290	20.866	19.508	18.121	16.711
90	17.072	16.155	15.208	14.311	13.394	12.461
100	12.736	12.084	11.410	10.772	10.121	9.458

Table 10[(b)]. The dynamic viscosity value (composition of fresh coconut oil from 60% to 100%)

Temperature (˚C)	Dynamic Viscosity, μ (mPa.s) Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil (%)				
	60	70	80	90	100
20	271.096	226.301	181.197	135.857	90.307
30	138.736	117.713	96.541	75.259	53.889
40	78.210	67.416	56.549	45.618	34.647
50	47.756	41.787	35.777	29.731	23.667
60	31.074	27.550	24.002	20.434	16.854
70	21.205	18.990	16.758	14.513	12.262
80	15.298	13.864	12.421	10.969	9.514
90	11.526	10.577	9.619	8.656	7.693
100	8.791	8.116	7.434	6.749	6.064

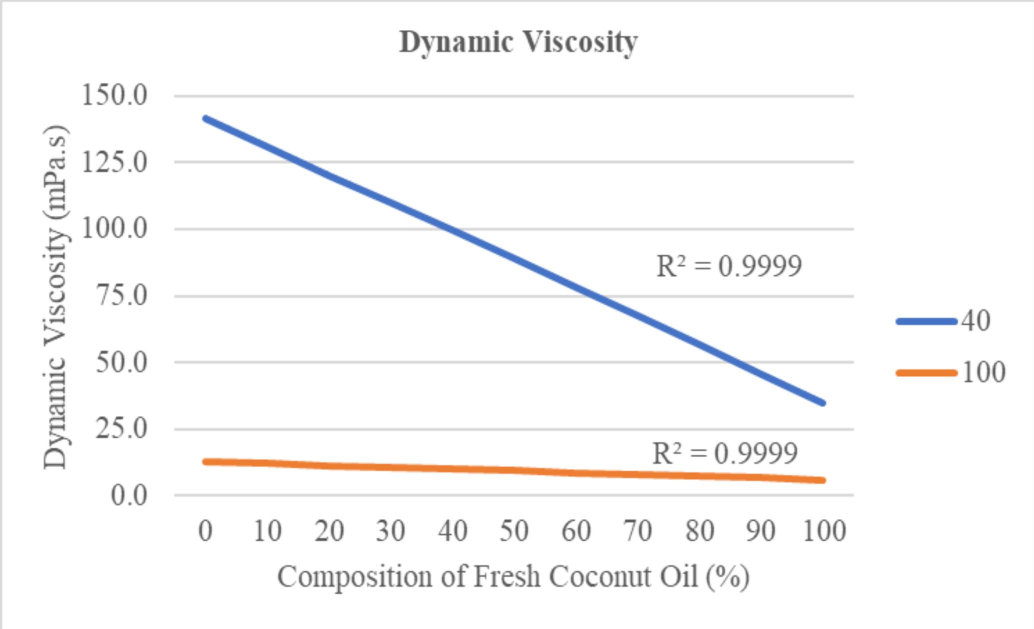

Figure 6. Decreasing dynamic viscosity of blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil with fresh coconut oil at temperatures 40˚C and 100˚C.

The dynamic viscosity measurement results obtained in this study are on the right track, which is by referring to the results of the P. Nellamegam & S. Krishnaraj, 2011 study stated in Table 4. Even the results of the study also prove that the dynamic viscosity of Petronas mono-grade Mach 5 SAE 40 API SF is higher than the dynamic viscosity of fresh coconut oil as shown in Figure 7. That addition of fresh coconut oil into mono-grade Petronas Mach 5 SAE 40 API SF engine oil, will reduce the dynamic viscosity of that engine oil.

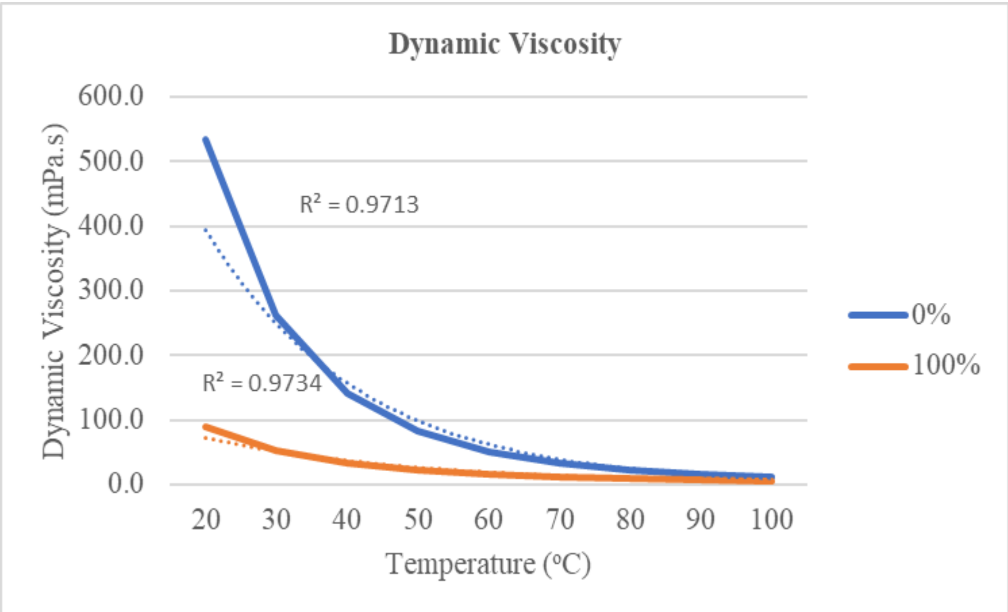

Figure 7. Dynamic viscosity for 100% mono-grade Petronas Mach 5 SAE 40 API SF (0% composition) and 100% fresh coconut oil (100% composition)

In the context of kinematic viscosity, typically the pattern of the SVM 3000/G2 output for this study, looks similar to dynamic viscosity. Tables 11[(a)] and 11[(b)] display the measurement results of kinematic viscosity and viscosity index. In general, the viscosity index is obtained from 2 kinematic viscosity readings at different temperatures. The first reading is at a temperature of 40˚C and the second reading is at a temperature of 100˚C. By using the VI calculator provided by Anton Paar who is the manufacturer of the SVM 3000/G2, it simplifies the calculation of the VI. The result of the VI value obtained from the Anton Paar calculator is a result based on the ASTM D2270 standard and ISO 2909.

Table 11[(a)]. The kinematic viscosity and viscosity index value (composition of fresh coconut oil from 0% to 50%)

Temperature (˚C)	Kinematic Viscosity, *v* (mm^2/s)					
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil (%)					
	0	10	20	30	40	50
20	597.542	547.592	497.642	447.692	397.742	347.793
30	295.494	271.837	248.181	224.524	200.867	177.211
40	160.800	148.537	136.273	124.010	111.746	99.483
50	94.765	87.915	81.065	74.215	67.365	60.515
60	59.700	55.615	51.529	47.444	43.358	39.273
70	39.778	37.182	34.586	31.989	29.393	26.797
80	27.787	26.089	24.390	22.692	20.993	19.295
90	20.204	19.064	17.924	16.784	15.644	14.504
100	15.200	14.379	13.559	12.738	11.917	11.097
Viscosity Index (VI)						
	94.6	94.2	94.1	94.2	94.8	96.2

Table 11[(b)]. The kinematic viscosity and viscosity index value (composition of fresh coconut oil from 60% to 100%)

Temperature (˚C)	Kinematic Viscosity, *v* (mm^2/s)				
	Composition of Fresh Coconut Oil Blended in Mono-Grade Petronas SAE 40 API SF Engine Oil (%)				
	60	70	80	90	100
20	297.843	247.893	197.943	147.993	98.043
30	153.554	129.897	106.240	82.584	58.927
40	87.220	74.956	62.693	50.429	38.166
50	53.665	46.815	39.965	33.115	26.265
60	35.188	31.102	27.017	22.931	18.846
70	24.201	21.605	19.008	16.412	13.816
80	17.596	15.898	14.199	12.501	10.802
90	13.363	12.223	11.083	9.943	8.803
100	10.276	9.455	8.634	7.814	6.993
Viscosity Index (VI)					
	98.5	102.7	110.0	122.0	146.1

Tables 11[(a)] and 11[(b)], display the results of kinematic viscosity and viscosity index (VI) measurements. It is clearly shown increasing the composition of fresh coconut oil will reduce the kinematic viscosity of the blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil as shown in Figure 8. For kinematic viscosity, it is directly proportional to dynamic viscosity.

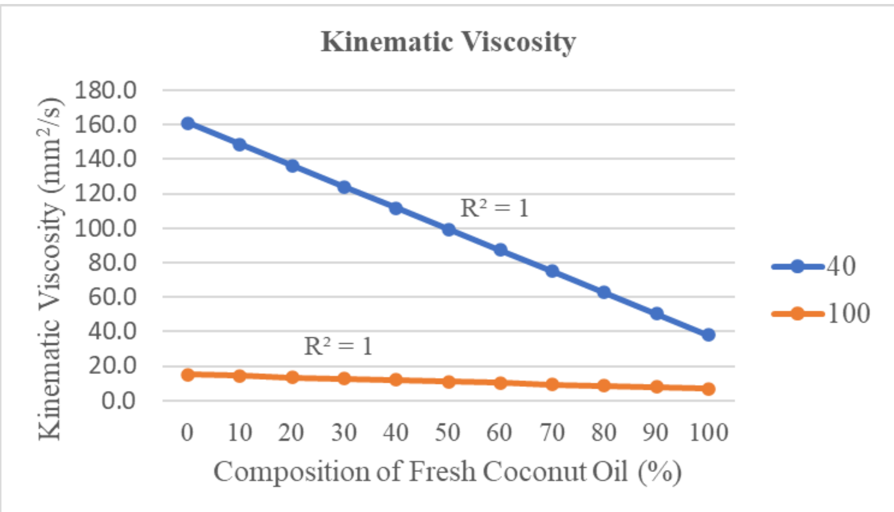

Figure 8. Decreasing kinematic viscosity of blended mono-grade Petronas Mach 5 SAE 40 API SF engine oil with fresh coconut oil at temperatures 40˚C and 100˚C

Figure 8, also shows the range of differences in kinematic viscosity reading reduction against the percentage of fresh coconut oil composition narrows at high temperatures. The best comparison is the kinematic viscosity reading at 40˚C and 100˚C. It is similar to the output of dynamics viscosity as shown in Tables 10(a) and 10(b). This similarity between dynamic viscosity and kinematic viscosity can refer to the value of R^2. For dynamic viscosity, R^2 for 40˚C is 0.9845 and for 100˚C is 0.9893. For kinematic viscosity, R^2 for 40˚C and 100˚C is 1.0 and for dynamic viscosity for 40˚C is 0.9713 and for 100˚C is 0.9734.

The kinematic viscosity measurement results obtained in this study are on the right track, which is by referring back to Tables 3 and 5. Even the results of the study also prove that the kinematic viscosity of Petronas mono-grade Mach 5 SAE 40 API SF is higher than the kinematic viscosity of fresh coconut oil as shown in Figure 9. That addition of fresh coconut oil into mono-grade Petronas Mach 5 SAE 40 API SF engine oil, will reduce the kinematic viscosity of that engine oil.

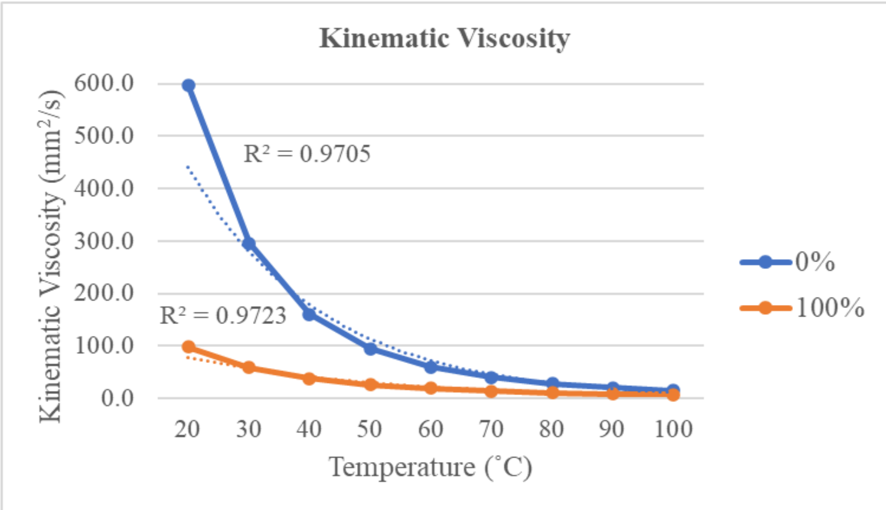

Figure 9. Kinematic viscosity for 100% mono-grade Petronas Mach 5 SAE 40 API SF (0% composition) and 100% fresh coconut oil (100% composition)

The last in this study is the discovery of the viscosity index. This viscosity index is important to classify lubricating oil, especially cooking oil. To the viscosity index data released by Anton Paar, mineral oil-based lubricating oil, its VI is between 95 to 105, multi-grade oil between 140 to 200, PAO oil between 135 to 160, and vegetable oil between 195 to 210. However, Petronas Mach 5 mono-grade mixture SAE 40 API SF engine oil with fresh coconut oil show composition of the fresh coconut oil from 0% to 70%, and blended SAE 40 engine oil is under mineral oil-based lubricating. Other than that, it is under multi-grade oil. This is as shown in Tables 11[(a)] and 11[(b)] with Figure 10.

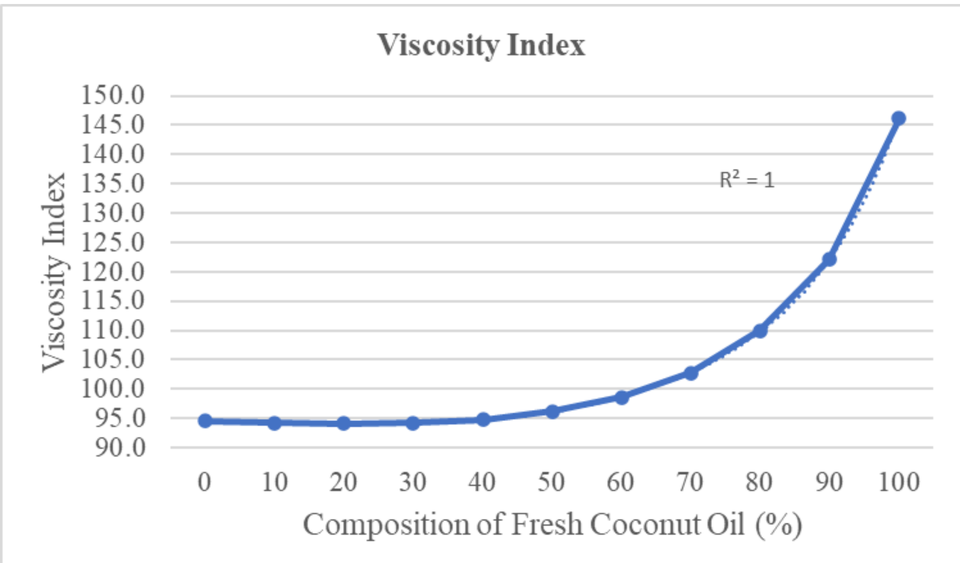

Figure 10. Viscosity index (VI) for each composition of fresh coconut oil

It can be said that at the composition of fresh coconut oil 0% to 70%, blended mono-grade Petronas Mach 5 SAE 40 API SF is still a mineral base lubricant. At a composition of 80% fresh coconut oil, this oil mixture seems to be fully influenced by fresh coconut oil and can be categorized as semi-synthetic base oil. However, this statement still requires continued research involving other vegetable oils such as palm oil and olive oil to see if the VI mixture of palm oil and olive oil is similar to the results of this study.

Conclusion

From this study, in general, the mixture of fresh coconut oil in mono-grade engine oil has changed the properties of the engine oil in terms of density, dynamic viscosity, kinematic viscosity, and viscosity index. By looking at the viscosity index, the properties of mono-grade engine oil have changed into the properties of multi-grade engine oil as a result of mixing mono-grade engine oil with fresh coconut oil. The viscosity index obtained from this study can be divided into 2 regions, namely the mono-grade engine oil region with a mixture of 0% to 70% coconut oil, the multi-grade region with a mixture of 80% to 100% coconut oil, and it looks as semi-synthetic oil. Even so, increasing the percentage of fresh coconut oil causes an increase in the melting temperature of the blend of mono-grade engine oil with fresh coconut oil. This is due to the fatty acids found in fresh coconut oil. This affects the usability of this oil mixture in the internal combustion engine.

Recommendations

This study can be used as a catalyst for further research proposals such as

a. Study blends of mono-grade engine oil with other vegetable oils such as palm oil and olive oil.

b. Further studies on the properties of engine oil that are not specified in this study such as temperature at the pour point, the temperature at the flash point, total base number, and total acid number.

c. Conducting a study on the usability of a blend of mono-grade engine oil with vegetable oil in an internal combustion engine to see the real performance of the new blend of engine oil.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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References

Guan, L., Feng, X. L., & Xiong, G. (2008). Engine lubricating oil classification by SAE grade and source based on dielectric spectroscopy data. *Analytica Chimica Acta*, *628,* 117-120.

Inayatullah, O., Jamaludin, N., Nor, M. J. M., Ali, Y., & Mat, F. (2010). Development of acoustic emission viscosity model for measuring engine oil viscosity relationship with engine oil in-service age. *Tribology Online, 5*(6), 255-261.

Jamaludin, N., Inayatullah, O., Nor, M. J. M., & Mat, F. (2011). Relationship between engine oil viscosity with age and temperature. *Sains Malaysiana, 40*(5), 509-513.

Jayadas, N. H., & Nair, K. P. (2006). Coconut oil as a base oil for industrial lubricants-evaluation and modification of thermal, oxidative, and low-temperature properties. *Tribology International*, *39,* 873-878.

Nellamegam, P., & Krishnaraj, S. (2011). Estimation of liquid viscosities of oils using associative neural networks. *Indian Journal of Chemical Technology, 18,* 463-468.

Tangsathitkulchai, C., Sittichaitaweekul, Y.. & Tangsathitkulchai, M. (2004). Temperature effect on the viscosities of palm oil and coconut oil blended with diesel oil. *Journal of the American Oil Chemists' Society, 81*, 401-405.

Tetko, I. V. (2002) Neural network studies: Introduction to associative neural networks. *Journal of Chemical Information and Computer Science, 42*, 717-728.

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