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APPENDICES

APPENDIX A

CHARACTERIZATION OF PALM FATTY ACID DISTILLATE

A-1 Free Fatty Acids, AOCS Official methods Ca 5a-40

Definition

This method determines the free fatty acids existing in the sample.

Scope

Applicable to all palm fatty acid distillate.

Apparatus

1. Oil sample bottles 250 ml Erlenmeyer flasks.

Reagents

1. Ethyl alcohol, 95%. The alcohol must give a definite, distinct and sharp end point with phenolphtalein and must be neutralized with alkali to a faint, but permanent pink color just before using.
2. Phenolphtlein indicator solution 1% in 95% alcohol.
3. Sodium hydroxide solution accurately standardized. Table A.1 for the appropriate normality of the expected free fatty acid concentration rang in the sample.

Table A-1 Free fatty acid range, alcohol volume and strength of alkali

FFA range (%)	Sample (g)	Alcohol (ml)	Strength of alkali
0.0 to 0.2	56.4 ± 0.2	50	0.1 N
0.2 to 1.0	28.2 ± 0.2	50	0.1 N
1.0 to 30.0	7.05 ± 0.05	75	0.25 N
30.0 to 50.0	7.05 ± 0.05	100	0.25 or 0.1 N
50.0 to 100	3.525 ± 0.001	100	0.1 N

Procedure

1. Sample must be well mixed and entirely liquid before weighing; however, does not heat the sample more than 10°C over the melting point.
2. Use Table A.1 to determine the sample weight for various ranges of fatty acids. Weigh the designated sample size into and oil sample bottle or Erlenmeyer flasks
3. Add the specified amount of hot neutralized alcohol and 2 ml of indicator.
4. Titrate with standard sodium hydroxide, shaking vigorously until the appearance of the first permanent pink color of the sample. The color must persist for 30 seconds.

Calculations

1. The percentage of free fatty acids in most types of fats and oils is calculated as oleic acid, although in coconut and palm kernel oils it is frequently expressed as lauric acid and palm oil in terms palmitic acid.

   $$\text{Free fatty acid as oleic, \%} = \frac{\text{ml of alkali} \times \text{N} \times 28.2}{\text{mass, g of sample}}$$

   $$\text{Free fatty acid as luaric, \%} = \frac{\text{ml of alkali} \times \text{N} \times 20.0}{\text{mass, g of sample}}$$

   $$\text{Free fatty acid as palmitic, \%} = \frac{\text{ml of alkali} \times \text{N} \times 25.6}{\text{mass, g of sample}}$$

2. The free fatty acids are frequently expressed in terms of acid value instead of percentage free fatty acids. The acid value is defined as the number of milligrams of KOH necessary to neutralize 1 g of sample.

A-2 Acid Value (Free fatty acids content), AOCS Official Method Cd-3d-63

The acid value is the number of milligrams of potassium hydroxide necessary to neutralize the free acid in 1 gram of sample. With samples that contain virtually no free acids other than fatty acids, the acid value may be directly converted by means of suitable factor to percent free fatty acids.

Apparatus

1. Erlenmeyer flasks 250 ml and Magnetic stirring device.
2. Burette—10 ml, graduated in 0.05 ml division with a tip drawn to a fine opening and extending at least 10 cm below the stopcock.

Reagents and chemicals

1. Potassium hydroxide (KOH), 0.1 N—baker "Reagent Grade" KOH having a carbonate specification of 0.5% Max, or 0.1 N KOH is available from Baker with NIST traceable standardization to ±1part in 1000 in solvents of water, methanol or ethanol.
2. Solvent mixture consisting of equal parts by volume of isopropyl alcohol (AOCS Specification H 18-58) and toluene (AOCS Specification H 19-58).
3. Phenolphthalein indicator solution—1.0% in isopropyl alcohol.

Procedure

1. Add indicator solution to the required amount of solvent in ratio of 2 ml and neutralize with alkali to a faint but permanent pink color.
2. Determine the sample size from the following table:

Table A-2 Table of predict sample size for acid value determination

Acid value	Mass of sample (±10), g	Weighting accuracy, ±g
0 – 1	20	0.05
1 – 4	10	0.02
4 – 15	2.5	0.01
15 – 75	0.5	0.001
75 and over	0.1	0.0002

3. Weight the specified amount of well-mixed liquid sample into an Erlenmeyer flask.
4. Add 125 ml of the neutralized solvent mixture. Be sure that the sample is completely dissolved before titrating. Warming may be necessary in some case.
5. Shake the sample vigorously while titrating with standard alkali to the first permanent pink color of the same intensity as that of the neutralized solvent before the latter was added to the sample. The color must persist for 30 sec.

Calculations

Acid value (A.V.), mg KOH/g of sample = $\frac{(A-B)\times N\times 56.1}{W}$

Where

A = volume, ml of standard alkali used in the totration

B = volume, ml of standard alkali used in the titrating blank

N = normality of standard alkali

W = mass, grams of sample

To express in terms of free fatty acids as percent oleic, lauric or palmitic acid device the acid value by 1.99, 2.81 or 2.19, respectively.

A-3 Saponification Value, AOCS official Method Cd-3b-76

The saponification value is the amount of alkali necessary to saponify a definite quantity of the sample. It is expressed as the number of milligrams of potassium hydroxide required to saponify 1 gram of sample.

Apparatus

1. Erlenmeyer flasks—alkali resistant, 250 or 300 ml with ground-glass joint.
2. Air condensers—minimum 65 cm long, with ground-glass joint to fit Erlenmeyer flasks.
3. Distillation flask—2L with ground-glass joint fitted with water-cooled condenser, for refluxing and distilling 95% ethanol as noted in Reagent.

Reagents

1. Hydrochloric acid, 0.5 N—accurately standardized.
2. Phenolphthalein indicator solution—1.0% in 95% ethyl alcohol.
3. Toluene—reagent grade
4. Alcoholic potassium hydroxide (KOH) 0.5 N solution in 95% ethanol.

Procedure

1. Weigh into a 250 ml. conical flask about 4 g. filtered fat with an accuracy of 1mg.
2. Add, accurately measured, 50 ml. 0.5 N ethanol potassium hydroxide solution to the cold fat and attach the reflux condenser to the flask.

3. Heat, and as soon as the ethanol boil, occasionally shake the flask until the fat is completely dissolved. Boil the solution for half an hour after the fat is completely dissolved.
4. Add 1 ml. phenolphthalein indicator and slowly titrate the hot soap solution obtained with 0.5 N HCl.
5. Carry out a blank determination upon the same quantity of potassium hydroxide solution at the same time and under the same conditions.

Calculations

Saponification value (S.V.), mg KOH/g of sample = $\frac{(B-S)\times N\times 56.1}{W}$

Where

B = ml 0.5 HCL required to titrate blank

S = ml 0.5 HCL required to titrate sample

N = normality of HCL solution

W = weight of sample in grams

A-4 Calculation of molecular weight of palm fatty acid distillate

Molecular weight of palm fatty acid distillate was analyzed by gas chromatography (GC) method which shown free fatty acid composition of palm fatty acid distillate.

Table A-4 Calculation molecular weight of palm fatty acid distillate

Free fatty acid composition	Mole fraction	MW of FFA (g/mole)	Molecular weight (g/mole)
Myristic acid	0.011	228	2.51
Palmitic acid	0.469	256	120.06
Stearic acid	0.042	284	11.93
Oleic acid	0.383	282	108.01
Linoleic acid	0.086	280	24.08
Linolenic acid	0.009	278	2.5
		Total	269.09

Molecular weight of palm fatty acid distillate is 269.09 g/mole.

Table B-1 Calculation of the amount of alcohols

Alcohol	PFAD (g)	Molecular weight of alcohol (g/mole)	Amount of alcohol (g)
Hexanol	300	102.17	227.0
4-methyl-2-pentanol	300	102.17	227.0
Cyclohexanol	300	100.16	222.6
Octyl acohol	300	157.45	349.9
Lauryl-myristyl alcohol	300	191.83	426.3
Cetyl-stearyl alcohol	300	262.42	583.2

B-2 Calculation of the theoretical amount of alkyl esters

The theoretical amount of alkyl esters can determine from mass balance was following as

$$\text{Palm fatty acid distillate} + \text{Alcohol} \rightleftharpoons \text{Alkyl esters} + \text{Water}$$

$$\text{Theoretical amount of alkyl esters} = \frac{\text{Wt.of PFAD (g)}}{\text{MW.of PFAD}} \times \text{MW. of alkyl esters}$$

Where

Wt. of PFAD = Weight of PFAD (g)

MW. of PFAD = Molecular weight of PFAD (g/mole)

MW. of alkyl esters = Molecular weight of alkyl esters (g/mole)

APPENDIX B

CALCULATION

B-1 Calculation of the amount of alcohols

The amount of alcohols used in esterification reaction of palm fatty acid distillate with various alcohols was 100% excess from stoichiometric (2:1 of molar ratio). The calculation is based on mole of palm fatty acid distillate (PFAD).

$$\text{Amount of alcohol (g)} = \frac{\text{Wt.of PFAD (g)}}{\text{MW.of PFAD}} \times 2 \times \text{MW. of alcohol}$$

Where

Wt. of PFAD = Weight of PFAD (g)

MW. of PFAD = Molecular weight of PFAD (g/mole)

MW. of alcohol = Molecular weight of alcohol (g/mole)

For example: Hexanol

The amount of hexanol for esterification reaction with 300 g of palm fatty acid distillate was calculated follows:

Wt. of PFAD = 300 g

MW. of PFAD = 270 g/mole

MW. of hexanol = 103.17 g/mole

$$\therefore \text{Amount of hexanol} = \frac{300\ (g)}{270\ (g/mole)} \times 2 \times 102.17 (g/mole)$$

$$= 227.0\ (g)$$

For example : If 300 g of palm fatty acid distillate converts to hexyl esters completely, the theoretical amount of hexyl esters would be:

$$\text{Theoretical amount of alkyl esters} = \frac{300\ (g)}{270\ (g/mole)} \times 354.17\ (g/mole)$$

$$= 393.52\ g$$

Table B-2 Calculation of the theoretical amount of alkyl esters

Alkyl esters	**PFAD (g)**	**Molecular weight of alkyl esters (g/mole)**	**Theoretical amount of alkyl esters (g)**
Hexanol	300	354.17	393.52
4-methyl-2-pentanol	300	354.17	393.52
Cyclohexanol	300	352.16	391.29
Octyl acohol	300	409.45	454.94
Lauryl-myristyl alcohol	300	443.83	493.14
Cetyl-stearyl alcohol	300	514.42	571.58

B-3 Calculation the percentage of yield of alkyl esters

The percentage of yield (%yield) of alkyl esters was defined as:

$$\%\text{Yield} = \frac{\dfrac{\text{Mass of alkyl esters (g)}}{\text{Molecular weight of alkyl esters}}}{\dfrac{\text{Mass of PFAD (g)}}{\text{Molecular weight of PFAD (g/mole)}}} \times 100$$

For example: Calculation %yield of hexyl esters which produced from 300 g of palm fatty acid distillate with hexanol

$$\text{Total weight of hexyl esters} = \frac{\frac{370.8(g)}{354.17(g/mole)}}{\frac{300(g)}{270(g/mole)}} \times 100$$

$$= 94.23\ \%$$

$\therefore$ %Yield of hexyl esters was 94.23

B-4 Calculation of viscosity index from kinematic viscosity at 40 and 100°C, ASTM D2270

Calculate the viscosity index (VI), of the alkyl esters as follows:

VI = [((antilog N) – 1) / 0.00715] + 100

N = (log H – log U) / log Y

Where

H = Kinematic viscosity at 40°C of alkyl esters of 100 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated mm^2/s (cSt), frpm Table ASTM D2270 as show in APPENDIX E

U = Kinematic viscosity at 40°C of the oil whose viscosity index is to be calculated mm^2/s (cSt)

Y = Kinematic viscosity at 100°C of the oil whose viscosity index is to be calculated mm^2/s (cSt)

For example: Calculation viscosity index of hexyl esters

Kinematic viscosity at 40°C of hexyl esters = 7.021 cSt

Kinematic viscosity at 100°C of hexyl esters = 2.49 cSt

∴ From Table ASTM D2270 (interpolation); H = 9.006

H substituting in: N = (log9.006 – log7.021)/log2.49

= 0.2729

N substituting in: VI = [((antilog 0.2729) – 1)/0.00715] + 100

= 222.35

∴ Viscosity index of hexyl esters is 222.35

APPENDIX C

THE RAW DATA OF ESTERIFICATION OF PALM FATTY ACID DISTILLATE

Table C-1 The esterification of palm fatty acid distillate with various alcohols

Sample	Step	Reactant				Temp. (°C)	Time (Hrs.)	Product		
		PFAD (g)	Alkyl esters (g)	Alcohol (g)	H_2SO_4 (g)			Total (g)	Top phase (g)	Bottom phase (g)
Hexyl esters	1	300	-	227	9	130	3	533	509	22.7
	2	-	356	184.8	9	130	3	547	547	-
4-methyl-2-pentyl esters	1	300	-	227	9	130	3	534	509	22.5
	2	-	358	185.9	9	130	3	550	550	-
Cyclohexyl esters	1	300	-	222.6	9	130	3	529	506	22.7
	2	-	363	185.8	9	130	3	555	555	-

Table C-1 The esterification of palm fatty acid distillate with various alcohols (continued)

Sample	Step	Reactant				Temp. (°C)	Time (Hrs.)	Product		
		PFAD (g)	Alkyl esters (g)	Alcohol (g)	H_2SO_4 (g)			Total (g)	Top phase (g)	Bottom phase (g)
Octyl esters	1	300	-	349.9	9	130	3	656	634	21.6
	2	-	423	292.8	9	130	3	720	720	-
Lauryl-myristyl esters	1	300	-	426.3	9	130	3	731	709	20.6
	2	-	478	413.2	9	130	3	887	887	-
Cetyl-stearyl esters	1	300	-	583.2	9	130	3	890	866	22.1
	2	-	546	557.06	9	130	3	1110	1110	-

C-2 Total product of alkyl esters

Sample	Step	Alkyl esters (g)	Alkyl esters after remove alcohol (g)	Total product		
				Final alkyl esters (g)	Water all step (g)	% Yield of alkyl esters
Hexyl esters	1	509	356	-	22.7	-
	2	547	370	370	-	94.23
4-methyl-2-pentyl esters	1	509	358	-	22.5	-
	2	550	376	376	-	95.55
Cyclohexyl esters	1	506	363	-	23.1	-
	2	555	366	366	-	93.58
Octyl esters	1	634	423	-	21.7	-
	2	720	430	430	-	94.51
Lauryl-myristyl esters	1	709	478	-	19.9	-
	2	887	465	465	-	94.29
Cetyl-stearyl esters	1	866	546	-	18.5	-
	2	1110	534	534	-	93.42

APPENDIX D

PHYSICAL AND CHEMICAL PROPERTIES OF ALKYL ESTERS

Table D-1 The physical and chemical properties of hexyl esters

Properties	Hexyl esters Ex. 1	Hexyl esters Ex. 2	Hexyl esters Ex. 3	Average	S.D.
Color, ASTM	L 7.0	L 7.0	L 7.0	L 7.0	-
Kinematic viscosity at 40°C, cSt	7.023	7.019	7.023	7.021	0.2004
Kinematic viscosity at 100°C, cSt	2.494	2.486	2.491	2.49	0.401
Viscosity Index	223.54	221.16	222.32	222.35	2.6061
Pour point, °C	5	5	5	5	0
Flash point, °C	190	190	190	190	0
API gravity at (60°F/60°F)	32.14	32.16	32.16	32.15	1.01
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

Table D-2 The physical and chemical properties of 4-methyl-2-pentyl esters

Properties	4-methyl-2-pentyl esters Ex. 1	4-methyl-2-pentyl esters Ex. 2	4-methyl-2-pentyl esters Ex. 3	Average	S.D.
Color, ASTM	L 7.0	L 7.0	L 7.0	L 7.0	-
Kinematic viscosity at 40°C, cSt	7.634	7.638	7.636	7.636	0.2002
Kinematic viscosity at 100°C, cSt	2.531	2.531	2.533	2.531	0.0816
Viscosity Index	184.93	184.63	184.76	184.78	0.1725
Pour point, °C	-2	-2	-2	-2	0
Flash point, °C	186	186	186	186	0
API gravity at (60°F/60°F)	31.75	31.77	31.77	31.76	1.01
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

Table D-3 The physical and chemical properties of cyclohexyl esters

Properties	Cyclohexyl esters Ex. 1	Cyclohexyl esters Ex. 2	Cyclohexyl esters Ex. 3	Average	S.D.
Color, ASTM	L 7.5	L 7.5	L 7.5	L 7.5	-
Kinematic viscosity at 40°C, cSt	12.02	12.04	12.04	12.03	1.016
Kinematic viscosity at 100°C, cSt	3.391	3.389	3.388	3.39	0.1001
Viscosity Index	168.91	167.91	168.26	168.41	0.75
Pour point, °C	15	15	15	15	0
Flash point, °C	202	202	202	202	0
API gravity at (60°F/60°F)	-	-	-	-	-
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

Table D-4 The physical and chemical properties of octyl esters

Properties	Octyl esters Ex. 1	Octyl esters Ex. 2	Octyl esters Ex. 3	Average	S.D.
Color, ASTM	D 8.0	D 8.0	D 8.0	D 8.0	-
Kinematic viscosity at 40°C, cSt	8.631	8.633	8.631	8.632	0.1001
Kinematic viscosity at 100°C, cSt	2.842	2.838	2.841	2.84	0.2004
Viscosity Index	205.35	204.19	204.78	204.77	0.9164
Pour point, °C	4	4	4	4	0
Flash point, °C	216	216	216	216	0
API gravity at (60°F/60°F)	31.39	31.41	31.41	31.40	1.016
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

Table D-5 The physical and chemical properties of lauryl-myristyl esters

Properties	Lauryl-myristyl esters Ex. 1	Lauryl-myristyl esters Ex. 2	Lauryl-myristyl esters Ex. 3	Average	S.D.
Color, ASTM	D 8.0	D 8.0	D 8.0	D 8.0	-
Kinematic viscosity at 40°C, cSt	12.846	12.834	12.839	12.84	0.6036
Kinematic viscosity at 100°C, cSt	3.748	3.752	3.751	3.75	0.2004
Viscosity Index	201.39	202.43	201.84	201.91	0.7904
Pour point, °C	-	-	-	-	-
Flash point, °C	224	224	224	224	0
API gravity at (60°F/60°F)	-	-	-	-	-
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

Table D-6 The physical and chemical properties of cetyl-stearyl esters

Properties	Cetyl-stearyl esters Ex. 1	Cetyl-stearyl esters Ex. 2	Cetyl-stearyl esters Ex. 3	Average	S.D.
Color, ASTM	D 8.0	D 8.0	D 8.0	D 8.0	-
Kinematic viscosity at 40°C, cSt	-	-	-	-	-
Kinematic viscosity at 100°C, cSt	-	-	-	-	-
Viscosity Index	-	-	-	-	-
Pour point, °C	-	-	-	-	-
Flash point, °C	-	-	-	-	-
API gravity at (60°F/60°F)	-	-	-	-	-
Appearance	Dark	Dark	Dark	Dark	-
Copper Strip Corrosion	1a	1a	1a	1a	-

APPENDIX E

TABLE FOR VISCOSITY INDEX CALCULATION

Table E-1 Basic value for L and H for kinematic viscosity at 40°C and 100°C systems

K.V. @100°C (cSt)	*L*	*H*	K.V. @100°C (cSt)	*L*	*H*	K.V. @100°C (cSt)	*L*	*H*
2.00	7.994	6.394	7.00	78.00	48.57	12.0	201.9	108.0
2.10	8.640	6.894	7.10	80.25	49.61	12.1	204.8	109.4
2.20	9.309	7.410	7.20	82.39	50.69	12.2	207.8	110.7
2.30	10.00	7.944	7.30	84.53	51.78	12.3	210.7	112.0
2.40	10.71	8.496	7.40	86.66	52.88	12.4	213.6	113.3
2.50	11.45	9.063	7.50	88.85	53.98	12.5	216.6	114.7
2.60	12.21	9.647	7.60	91.04	55.09	12.6	219.6	116.0
2.70	13.00	10.25	7.70	93.20	56.20	12.7	222.6	117.4
2.80	13.80	10.87	7.80	95.43	57.31	12.8	225.7	118.7
2.90	14.63	11.50	7.90	97.72	58.45	12.9	228.8	120.1
3.00	15.49	12.15	8.00	100.0	59.60	13.0	231.9	121.5
3.10	16.36	12.82	8.10	102.3	60.74	13.1	235.0	122.9
3.20	17.26	13.51	8.20	104.6	61.89	13.2	238.1	124.2
3.30	18.18	14.21	8.30	106.9	63.05	13.3	241.2	125.6
3.40	19.12	14.93	8.40	109.2	64.18	13.4	244.3	127.0
3.50	20.09	15.66	8.50	111.5	65.32	13.5	247.4	128.4
3.60	21.08	16.42	8.60	113.9	66.48	13.6	250.6	129.8
3.70	22.09	17.19	8.70	116.2	67.64	13.7	253.8	131.2
3.80	23.13	17.97	8.80	118.5	68.79	13.8	257.0	132.6
3.90	24.19	18.77	8.90	120.9	69.94	13.9	260.1	134.0
4.00	25.32	19.56	9.00	123.3	71.10	14.0	263.3	135.4
4.10	26.50	20.37	9.10	125.7	72.27	14.1	266.6	136.8
4.20	27.75	21.21	9.20	128.0	73.42	14.2	269.8	138.2
4.30	29.07	22.05	9.30	130.4	74.57	14.3	273.0	139.6
4.40	30.48	22.92	9.40	132.8	75.73	14.4	276.3	141.0
4.50	31.96	23.81	9.50	135.3	76.91	14.5	279.6	142.4
4.60	33.52	24.71	9.60	137.7	78.08	14.6	283.0	143.9
4.70	35.13	25.63	9.70	140.1	79.27	14.7	286.4	145.3
4.80	36.79	26.57	9.80	142.7	80.46	14.8	289.7	146.8
4.90	38.50	27.53	9.90	145.2	81.67	14.9	293.0	148.2
5.00	40.23	28.49	10.0	147.7	82.87	15.0	296.5	149.7
5.10	41.99	29.46	10.1	150.3	84.08	15.1	300.0	151.2
5.20	43.76	30.43	10.2	152.9	85.30	15.2	303.4	152.6
5.30	45.53	31.40	10.3	155.4	86.51	15.3	306.9	154.1
5.40	47.31	32.37	10.4	158.0	87.72	15.4	310.3	155.6
5.50	49.90	33.34	10.5	160.6	88.95	15.5	313.9	157.0
5.60	50.87	34.32	10.6	163.2	90.19	15.6	317.5	158.6
5.70	52.64	35.29	10.7	165.8	91.40	15.7	321.1	160.1
5.80	54.42	36.26	10.8	168.5	92.65	15.8	324.6	161.6
5.90	56.20	37.23	10.9	171.2	93.92	15.9	328.3	163.1
6.00	57.97	38.19	11.0	173.9	95.19	16.0	331.9	164.6
6.10	59.74	39.17	11.1	176.6	96.45	16.1	335.5	166.1
6.20	61.52	40.15	11.2	179.4	97.71	16.2	339.2	167.7
6.30	63.32	41.13	11.3	182.1	98.97	16.3	342.9	169.2
6.40	65.18	42.14	11.4	184.9	100.2	16.4	346.6	170.7
6.50	67.12	43.18	11.5	187.6	101.5	16.5	350.3	172.3
6.60	69.16	44.24	11.6	190.4	102.8	16.6	354.1	173.8
6.70	71.29	45.33	11.7	193.3	104.1	16.7	358.0	175.4
6.80	73.48	46.44	11.8	196.2	105.4	16.8	361.7	177.0
6.90	75.72	47.51	11.9	199.0	106.7	16.9	365.6	178.6

Table E-1 Basic value for L and H for kinematic viscosity at 40°C and 100°C systems (continued)

K.V. @100°C (cSt)	*L*	*H*	K.V. @100°C (cSt)	*L*	*H*	K.V. @100°C (cSt)	*L*	*H*
17.0	369.4	180.2	24.0	683.9	301.8	42.5	1935	714.9
17.1	373.3	181.7	24.2	694.5	305.6	43.0	1978	728.2
17.2	377.1	183.3	24.4	704.2	309.4	43.5	2021	741.3
17.3	381.0	184.9	24.6	714.9	313.0	44.0	2064	754.4
17.4	384.9	186.5	24.8	725.7	317.0	44.5	2108	767.6
17.5	388.9	188.1	25.0	736.5	320.9	45.0	2152	780.9
17.6	392.7	189.7	25.2	747.2	324.9	45.5	2197	794.5
17.7	396.7	191.3	25.4	758.2	328.8	46.0	2243	808.2
17.8	400.7	192.9	25.6	769.3	332.7	46.5	2288	821.9
17.9	404.6	194.6	25.8	779.7	336.7	47.0	2333	835.5
18.0	408.6	196.2	26.0	790.4	340.5	47.5	2380	849.2
18.1	412.6	197.8	26.2	801.6	344.4	48.0	2426	863.0
18.2	416.7	199.4	26.4	812.8	348.4	48.5	2473	876.9
18.3	420.7	201.0	26.6	824.1	352.3	49.0	2521	890.9
18.4	424.9	202.6	26.8	835.5	356.4	49.5	2570	905.3
18.5	429.0	204.3	27.0	847.0	360.5	50.0	2618	919.6
18.6	433.2	205.9	27.2	857.5	364.6	50.5	2667	933.6
18.7	437.3	207.6	27.4	869.0	368.3	51.0	2717	948.2
18.8	441.5	209.3	27.6	880.6	372.3	51.5	2767	962.9
18.9	445.7	211.0	27.8	892.3	376.4	52.0	2817	977.5
19.0	449.9	212.7	28.0	904.1	380.6	52.5	2867	992.1
19.1	454.2	214.4	28.2	915.8	384.6	53.0	2918	1007
19.2	458.4	216.1	28.4	927.6	388.8	53.5	2969	1021
19.3	462.7	217.7	28.6	938.6	393.0	54.0	3020	1036
19.4	467.0	219.4	28.8	951.2	396.6	54.5	3073	1051
19.5	471.3	221.1	29.0	963.4	401.1	55.0	3126	1066
19.6	475.7	222.8	29.2	975.4	405.3	55.5	3180	1082
19.7	479.7	224.5	29.4	987.1	409.5	56.0	3233	1097
19.8	483.9	226.2	29.6	998.9	413.5	56.5	3286	1112
19.9	488.6	227.7	29.8	1011	417.6	57.0	3340	1127
20.0	493.2	229.5	30.0	1023	421.7	57.5	3396	1143
20.2	501.5	233.0	30.5	1055	432.4	58.0	3452	1159
20.4	510.8	236.4	31.0	1086	443.2	58.5	3507	1175
20.6	519.9	240.1	31.5	1119	454.0	59.0	3563	1190
20.8	528.8	243.5	32.0	1151	464.9	59.5	3619	1206
21.0	538.4	247.1	32.5	1184	475.9	60.0	3676	1222
21.2	547.5	250.7	33.0	1217	487.0	60.5	3734	1238
21.4	556.7	254.2	33.5	1251	498.1	61.0	3792	1254
21.6	566.4	257.8	34.0	1286	509.6	61.5	3850	1270
21.8	575.6	261.5	34.5	1321	521.1	62.0	3908	1286
22.0	585.2	264.9	35.0	1356	532.5	62.5	3966	1303
22.2	595.0	268.6	35.5	1391	544.0	63.0	4026	1319
22.4	604.3	272.3	36.0	1427	555.6	63.5	4087	1336
22.6	614.2	275.8	36.5	1464	567.1	64.0	4147	1352
22.8	624.1	279.6	37.0	1501	579.3	64.5	4207	1369
23.0	633.6	283.3	37.5	1538	591.3	65.0	4268	1386
23.2	643.4	286.8	38.0	1575	603.1	65.5	4329	1402
23.4	653.8	290.5	38.5	1613	615.0	66.0	4392	1419
23.6	663.3	294.4	39.0	1651	627.1	66.5	4455	1436
23.8	673.7	297.9	39.5	1691	639.2	67.0	4517	1454
			40.0	1730	651.8	67.5	4580	1471
			40.5	1770	664.2	68.0	4645	1488
			41.0	1810	676.6	68.5	4709	1506
			41.5	1851	689.1	69.0	4773	1523
			42.0	1892	701.9	69.5	4839	1541
						70.0	4905	1558

APPENDIX F

Certificate of mineral base oil 150 SN

THAI LUBE BASE PUBLIC COMPANY LIMITED

165/19 Moo. 7 Thungsukla, Sriracha Chonburi 20230 Thailand

TEL. +66(0) 3835-4400-99 FAX. +66(0) 3835-1334

THAILUBE

Test Certificate

Sample Name :	Lube Base Oil Grade 150SN	COQ No.	150SN 084/2007
Sample ID. :	1477686	Customer	Logistics Department
Sampling Date :	19/10/2007	Condition of Sample	Normal
Sampling Point :	3000L-T-116C	Approved By	
Sample Received Date :	19/10/2007 03.55 hrs	(Waranya Chitpradit)	Waranya C.
Sample Tested Date :	19/10/2007	(Lab Manager)	Approved Signatory
Reported By :	Seksan K.	Approved Date/Time	19/10/2007, 16.44 hrs.
	(Laboratory Technician)	Page	1 of 1
		Reported Date	19/10/2007

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Specific Gravity @ 60/60 °F	ASTM D-1298 Equivalent to D-4052	-	Report	0.8710
Kinematic Viscosity @ 40 °C	ASTM D-445	cSt	[illegible]	30.30
Kinematic Viscosity @ 100 °C	ASTM D-445	cSt	-	5.245
Viscosity Index	ASTM D-2270		Min. 100	104
Pour Point	ASTM D-97	°C	Max. -9	-9
Total Sulfur Content	ASTM D-4294	Mass%	-	0.381
ASTM Colour	ASTM D-1500	-	Max. 1.0	L0.5
Acid Number	ASTM D-664	Mg KOH/g	Max. 0.05	0.02
Flash Point (COC)	ASTM D-92	°C	Report	234
Flash Point (PMCC)	ASTM D-93	°C	Min. 204	211.0
Carbon Residue, Micro Method	ASTM D-4530	% (m/m)	Max. 0.05	0.01
Water Content	ASTM D-95	%vol	Nil	0.00
Appearance	Visual	-	Bright & Clear	B & C
Copper Strip Corrosion @ 100 °C for 3 Hrs.	ASTM D-130	-	Max. 1b	1a
Evaporation Loss (NOACK)	DIN 51581	%wt	Max. 16	9.8
Water Separability (Demulsibility @ 54 °C)	ASTM D-1401	min	Max. 20	40-40-0(5)
Ash Content	ASTM D-482	Mass%	Max. 0.01	0.009

1. This report is certified only the tested sample. Copy of some part of this report without permission from Laboratory Manager is not allowed
2. ◆ : Supplement Data

Remark: PASSED

Density @ 15 °C = 0.8704 kg/l

FR-INS-13-00-01

Rev. 8 Effective Date 1 มิถุนายน 2550 File Name [illegible]

VITA

Mr. Chanwit Pornvisetsirikul was born in Roi-et, Thailand on March16, 1985. He finished high school in 2003 from Khonkaen wittayayon School, Khonkaen. In 2007, he received a Bachelor's degree of Chemical Engineering from the Faculty of Engineering Khonkaen University.