REFERENCES

Rammad A.S.; Jayara S. j.; Muracleedharan C. (2004). Biodiesel production from high FFA rubber seed oil. Fuel 84: 335-340.

Bartholomew D. (1981). Vegetable oil fuel. J Am oil chem. Soc 58: 286A-288A.

Chang C.C.; Wan S.W. (1947). China's motor fuels from tung oil. Ind.Eng.Chem 3: 1543-1548.

Fangrui Ma.; Milford A. H. (1999). Biodiesel production: a review. Bioresearch Technology 70: 1-15.

Freedman B.; Pryde E.H.; Mounts T.L. (1984). Variables affecting the yield of fatty esters from transesterified vegetable oils. J Am oil chem. Soc 61: 1638-1643.

Freedman B.; Butterfield R.O.; Pryde, E.H. (1986). Transesterification kinetics of soybean oil. J Am oil chem. Soc 63:1375-1380.

Gemma Vicente. (2003). Integrated biodiesel production: a comparison of different homogeneous catalysts systems. Bioresource Technology 92: 297-305.

Georing C.E. and Fry B. (1984). Engine durability screening test of a diesel oil/soy oil/ alcohol microemulsion fuel. J Am Oil Chem. Soc 61: 1672-1632.

Grossley T.D.; Heyes T.D.; Hudson B.J.F. (1962). The effect of heat on pure triglycerides. J Am Oil Chem. Soc 39: 9-14.

Krisnangkura K.; Simamaharnnop R. (1992). Continuous transmethylation of palm oil in an organic solvent. J Am Oil Chem. Soc 69: 166-169.

Meher L.C.; Vidya sagar D.; Naik S.N. (2004). Technical aspects of biodiesel production by transesterification-a review. Renewable & sustainable energy reviews 68 : 1- 21

Komers, J. Machek and Stloukal R. (2001). Biodiesel from rapeseed oil and KOH Composition of solution of KOH in methanol as reaction partner of oil. J.Lipid Science. Technology 103: 359–362.

Ma F.; Clements L.D.; Hanna M.A. (1998). The effects of catalyst, free fatty acids and water on transesterification of beef tallow. Trans. ASAE 41: 1261-1264

Mohamad I.; Al – Widyan.; Ali O. Al Shyoukh. (2002). Experimental evaluation of transesterification of waste palm oil into biodiesel . Bioresource Technology 85: 253-256.

Pramote K.; Tomoyuki F.; Shuji A. (2003). Kinetic on hydrolysis of fatty acid esters in subcritical water. J Eng Chem. 99: 1-4.

Pryde E.H. (1983). Vegetable oil as diesel fuel overview. J Am Oil Chem. Soc 60: 1557-1558.

Pryde E.H. (1984). Vegetable oil as diesel fuel alternatives – symposium overview. J Am Oil Chem. Soc 61: 1609-1610.

Saka S. and Kusdiana D. (2001a). Biodiesel fuel from rapeseed oil as prepared in supercritical methanol. Fuel 80: 225-231.

Saka S. and Kusdiana D. (2001b). Kinetics of transesterification in rapeseed oil to biodiesel fuel as treated in supercritical methanol. Fuel 80: 693-698.

Saka S. and Kusdiana D. (2001c). Methyl esterification of free fatty acids of rapeseed oil as treated in supercritical methanol. Fuel 34: 383-387.

Saka S. and Kusdiana D. (2004). Effect of water on biodiesel fuel production by supercritical methanol treatment. Fuel 91: 289-295.

Sanjib Kumar Karmee and Anju Chadha. (2005). Preparation of biodiesel from crud oil of pongania pinnata. Bioresource Technology 96: 1425-1429.

Schlick M.L.; Schinstock J.L.; Hanna M.A. (1988). Soybean and sunflower oil performance in diesel engine. Trans.ASAE 31: 1345-1349.

Schuchardt R.S. and Rogerio M.V. (1997). Transesterification of vegetable oils :a review. Braz Chem 9: 199-210

Richardson J.F. (1983). An introduction to chemical engineering design. Braz Chem 6: 442- 450

Weisz P.B.; Haang W.O.; Rodeweld P.G. (1979). Catalytic production of high-grad fuel (gasoline) from biomass compounds by shape-delective catalysis. Science 206: 57-58.

Weiliang C.; Hengv W.H.; Jingchang Zhang. (2004). Preparation of biodiesel from soybean oil using supercritical methanol and co-solvent. Fuel 84: 347- 351

Yuchiro Warabi. (2003). Reactivity of triglycerides and fatty acid of rapeseed oil in supercritical methanol. Bioresource Technology 91: 283-287.

APPENDICES

APPENDIX A

EXPERIMENTAL AND DATA ANALYSIS

A-1 Experimental data of esterification reaction in batch reactor

Table A-1.1 The percent of methyl ester at the molar ratio 1:6 for the reaction time 30 minutes, at the various temperature between 240-300(°C)

Tem(°C)	Sample			Average	SD
	%Methyl ester (1)	%Methyl ester (2)	%Methyl ester (3)		
240	39.67	41.37	57.21	46.0833	9.6733
250	66.15	70.98	55.57	64.2333	7.8817
260	75.2	62.27	56.9	64.7900	9.4066
270	73.67	56.62	76.51	68.9333	10.7577
280	75.52	64.88	77.21	72.5366	6.6844
290	79.25	96.5	81.55	85.7666	9.3662
300	92.49	98.61	92.83	94.6433	3.4394

Table A-1.2 The percent of methyl ester at 300 °C, molar ratio of palm fatty acid to methanol 1:1 to 1:12 at the reaction time 30 minutes

Molar ratio	Sample			Average	SD
	%Methyl ester (1)	%Methyl ester (2)	%Methyl ester (3)		
1:1	68.1300	71.8700	74.04	71.3467	2.9895
1:2	72.9000	78.2100	82.43	77.8467	4.7753
1:3	80.9900	87.9800	73.52	80.8300	7.2313
1:6	92.4900	98.6000	92.84	94.6433	3.4310
1:9	79.6900	85.6100	88.93	84.7433	4.6805
1:12	77.3700	65.3900	78.88	73.8800	7.3912

Table A-1.3 The percent of methyl ester at 250 °C, molar ratio of palm fatty acid to methanol 1:1 to 1:12 at the reaction time 30 minutes

Molar ratio	Sample		Average	SD
	%Methyl ester (1)	%Methyl ester (2)		
1:1	49.04	49.75	49.3950	0.5020
1:2	58.92	63.31	61.1150	3.1042
1:3	65.4	68.68	67.0400	2.3193
1:6	77.82	77.44	77.6300	0.2687
1:9	55.3	67.44	61.3700	8.5843
1:12	51.25	65.66	58.4550	10.1894

A-2 The data of the effect of water on yield of methyl esterification product

Table A-2.1 The data of effect of water on yield of methyl esterification at various water (5-30%) the reaction time 30 minutes, 300 °C

%Water	%Methyl ester (1)	% Methyl ester (2)	% Methyl ester (3)	Average	SD
5	77.66	72.39	72.9	74.3166	2.2288
10	72.87	69.83	67.15	69.9500	1.9466
15	72.51	68.32	64.6	68.4766	2.6888
20	68.51	69.95	64.43	67.6300	2.1333
25	66.18	66.21	61.85	66.1950	0.0150
30	48.41	57.3	56.8	52.8550	4.4450

A-3 The data of hydrolysis of methyl ester

Table A-3.1 The data of hydrolysis of methyl ester by hydrolysis at various the reaction time between 0-30 minutes, 300 °C at the water content to methyl ester 1 %

Times	%Methyl ester (1)	%Methyl ester (2)	Average	SD
0	100	100	100	0.0000
5	99.09	93.87	96.48	3.6911
10	91.54	89.48	90.51	1.4566
15	86.38	84.16	85.27	1.5698
20	86.12	82.12	84.12	2.8284
25	85.99	79.32	82.655	4.7164
30	74.79	82.26	78.525	5.2821

Table A-3.2 The data of hydrolysis of methyl ester by hydrolysis at various the reaction times between 0-30 minutes, 300 °C at the water content to methyl ester 10 %

Times	%Methyl ester (1)	%Methyl ester (2)	Average	SD
0	100	100	100	0.0000
5	93.13	88.74	90.94	3.1042
10	89.52	85.60	87.56	2.7719
15	88.39	81.54	84.97	4.8437
20	84.45	79.37	81.91	3.5921
25	79.22	74.99	77.11	2.9911
30	75.28	75.53	75.41	0.1768

Table A-3.3 The data of hydrolysis of methyl ester hydrolysis at various the reaction times between 0-30 minutes, 300 °C at the water content to methyl ester 20 %

Times	%Methyl ester (1)	%Methyl ester (2)	Average	SD
0	100	100	100	0.0000
5	86.63	88.65	87.64	1.4284
10	80.54	79.05	79.795	1.0536
15	81.32	75.99	78.655	3.7689
20	76.01	74.52	75.265	1.0536
25	73.4	75.07	74.235	1.1809
30	72.45	75.53	73.99	2.1779

Table A-3.4 The data of hydrolysis of methyl ester by hydrolysis at various the reaction times between 0-30 minutes, 300 °C at the water content to methyl ester 30 %

Times	%Methyl ester (1)	%Methyl ester (2)	Average	SD
0	100	100	100	0.0000
5	80.46	81.12	80.79	0.4667
10	76.06	80.04	78.05	2.8143
15	78.75	77.31	78.03	1.0182
20	75.57	77.50	76.535	1.3647
25	67.17	66.81	66.99	0.2546
30	42.99	45.45	44.22	1.7395

APPENDIX B

B-1 Calculation of molecular weight of palm fatty acids

The molecular weight of palm fatty acids is calculated from the weighted average of the molecular weight of the five key fatty acids: palmitic acid, oleic acid, stearic acid, linoleic acid, and linolenic acid. The compositions of palm fatty acids are shown in Table B-1.1

Table B-1.1 Composition and molecular weight of key components in of palm fatty acids.

Palm fatty acids	% Weight Fraction	Molecular weight
Palmitic acid	42.8	256.43
Oleic acid	40.5	282.47
Stearic acid	4.5	284.5
Linoleic acid	10.1	268
Linolenic acid	2.1	278.43

The data in Table B-1.1 can be used to compute the molecular weight of palm fatty acids as shown below:

1 mole of palm fatty acids

$$M_w = \text{Sum } (M_{Fa} \text{ x \% Weight fraction fatty acids}) \text{ .... } \mathbf{B\text{-}1.1}$$

Where

M_w = Molecular weight of fatty acids

M_{Fa} = Molecular weight of each fatty acids

Such as (Data in the table B-1.1) apply in equation 1

$$= (0.428 \text{ x } 256.43) + (0.405 \text{ x } 282.47) + (0.045\text{x}284.5) + (0.101\text{x } 268) + (0.021\text{x}278.43)$$

$= \quad 269.85\ (\sim 270)$

B-2 Calculate the percent yield of fatty acids to methyl esters

The percent yield methyl ester is defined as

$$\%\text{Yield of methyl ester} = \%\ Methyl\ \ ester = \frac{W_{ME}}{W_{Fa} \times (x_i)} \times 100 \quad \text{.......... } \mathbf{B\text{-}2.1}$$

$$= \frac{W_{MP} + W_{MS} + W_{MO} + W_{ML}}{(WFa) \times (x_i)} \times 100$$

Where

W_{ME}	= weight of methyl ester (g)
W_{Fa}	= weight of fatty acid (g)
W_{MP}	= weight of methyl palmitate (g)
W_{MS}	= weight of methyl stearate (g)
W_{MO}	= weight of methyl oleate (g)
W_{ML}	= weight of methyl linoleate (g)
W_P	= weight of palmitic acid (g)
W_S	= weight of stearic acid (g)
W_O	= weight of oleic acid (g)
W_L	= weight of linoleic acid (g)
x_i	= weight fraction of fatty acid

Calculation weight of each methyl ester

$$W_{ME} = \left(\frac{C \times V_{TD}}{V_S}\right) \times V_P \text{ ....} \mathbf{B\text{-}2.2}$$

Where

W_{ME}	= weight of methyl ester (g)
C	= concentration of each methyl ester from calibration curve (g/ml)
V_{TD}	= total volume dilute (ml)
V_S	= volume product dilute (ml)
V_P	= total volume of product (ml)

The weight of methyl esters for each fatty acids can be determined from GC data with corresponding calibration equation. ecosane was used as internal standard. Below are standard calibration curves for the key methyl esters (Figure B-2.2-B-2.5). Then apply in the equation **B-2.2**

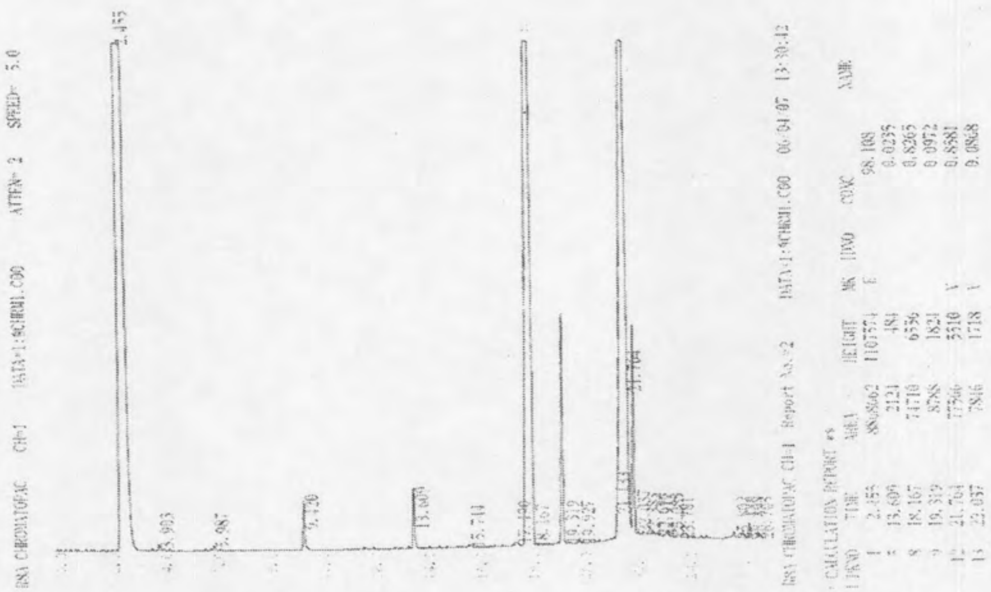


Figure B-2.1 Profile of component of each palm fatty acid from GC. At ole fraction of palm fatty acids and methanol (1:6)

Table B-2.1 Data of time and area in figure B-2.1

Time	Area
Hexane	8868662
Methyl Palmitate	74716
Ecosane	8788
Methyl Oleate	77566
Methyl Streate	7846

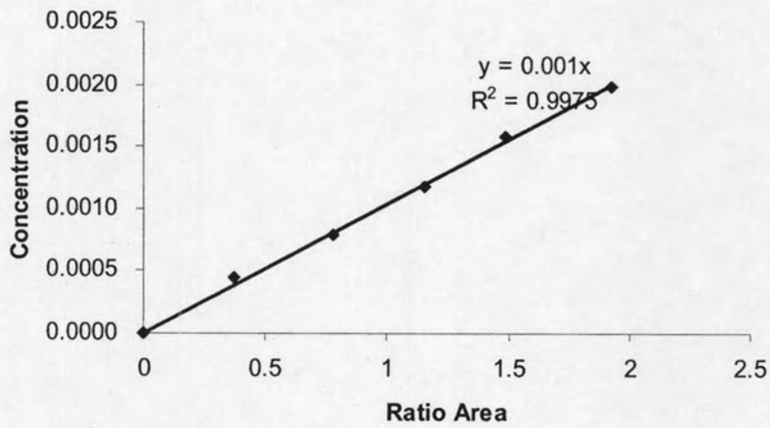


Figure B-2.2 Standard calibration curve for methyl plamitate (corrected with use of ecosane as an internal standard).

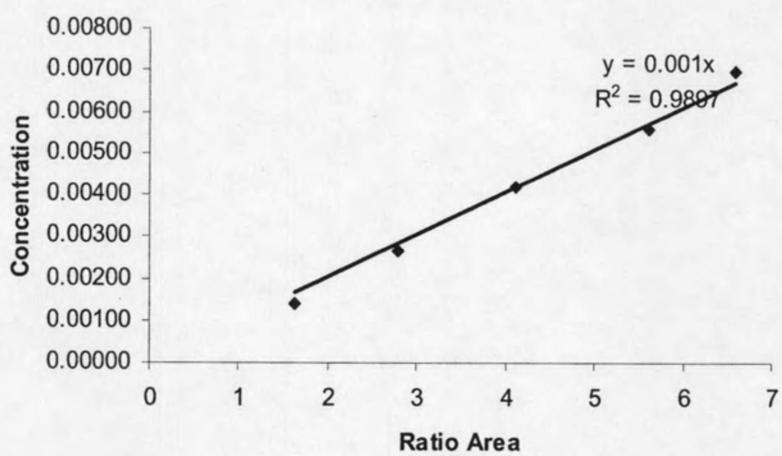


Figure B-2.3 Standard calibration curve for methyl oleate (corrected with use of ecosane as an internal standard).

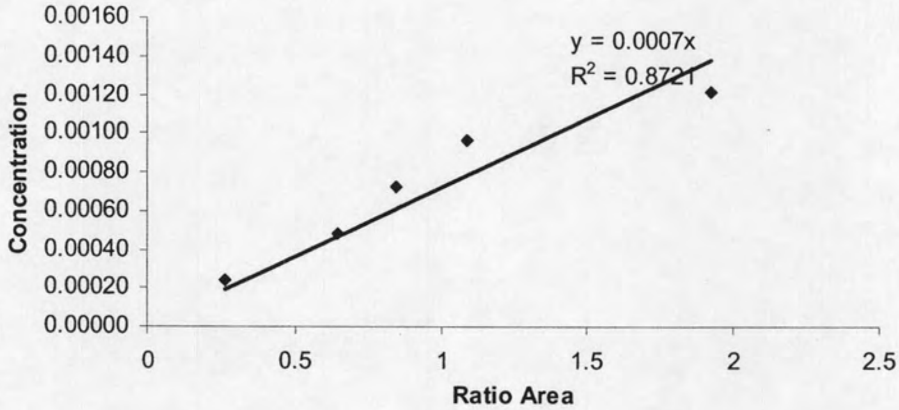


Figure B-2.4 Standard calibration curve for methyl stearate (corrected with use of ecosane as an internal standard).

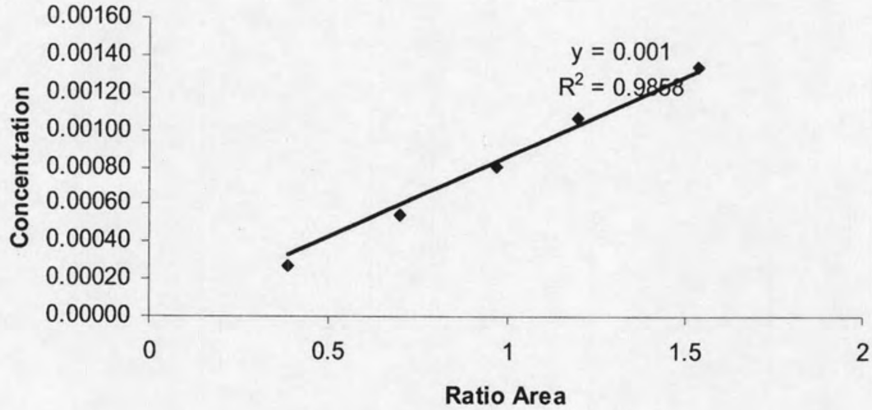


Figure B-2.5 Standard calibration curve for methyl linoleate (corrected with use of ecosane as an internal standard).

Example percent yield of methyl ester based on the data from the chromatogram in Figure B-2.1 and the standard calibration curves for different methyl esters figure B-2.2-B-2.5). From the data of peak GC, it can convert to concentration of each methyl ester and then apply in equation B-2.2

Concentration of each of fatty acid (g/ml) = ratio peak area x calibration constant

Example Concentration of palmitate = ratio peak area of area of palmitate x 0.001

$$= \frac{74716}{8788} \times 0.001 = 6.21 \times 10^{-3} \text{ g/ml}$$

Thus, wt. of methyl palmitate $= \frac{6.21 \times 10^{-3} \times 1 \text{ ml} \times 6 \text{ ml}}{0.1 \text{ ml}} = 0.3729$ g

Wt of methyl oleate and methyl linoleate

Because the chromatographic peaks of methyl oleate and methyl linoleate are not separated but the calibration factors are exactly the same, the amount of the two can be calculated using the total peak area.

Wt. of methyl oleate and methyl linoleate $= \frac{6.43 \times 10\text{-}3 \text{ g/ml} \times 1 \text{ ml} \times 6 \text{ ml}}{0.1 \text{ ml}}$

$= 0.3861$ g

Wt. of methyl stearate $= \frac{6.26 \times 10\text{-}4 \text{ g/ml} \times 1 \text{ ml} \times 6 \text{ ml}}{0.1 \text{ ml}} = 0.0376$ g

Sum of wt fatty acid = 0.7966 g

Then apply in equation B-2.1

$$\% \text{ Yield of Methyl Ester} = \frac{0.7966 \times 100}{0.92 \times 0.979} = 88.44 \%$$

B-3 Calculate mole fraction

Example Mole fraction of palm fatty acids and methanol such as 1:3

Palm fatty acids = 270 g Density = 0.92 g/ml

Methanol = 96.12 g Density = 0.79 g/ml

If we used 1 ml of palm fatty acids = 0.0034 mol.

Calculate methanol 3 x 0.0034 = 0.0102 mol, will use methanol = 0.3264 g

∴ volume methanol = 0.3264/0.79 = 0.4132 ml

APPENDIX C

Table C-1.1 Critical Property Increment Lydersen's Structural Contribution

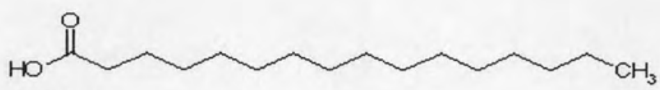
Symbols	ΔT	ΔP	ΔV
Nonring increments			
$-CH_3$	0.020	0.227	55
$-CH_2-$	0.020	0.227	55
$>CH-$	0.012	0.210	51
$>C<$	0.00	0.210	41
$=CH_2$	0.018	0.198	45
$=CH-$	0.018	0.198	45
$=C<$	0.0	0.198	36
$=C=$	0.0	0.198	36
$\equiv CH$	0.005	0.153	(36)
$\equiv C-$	0.005	0.153	(36)
Ring increments			
$-CH_2-$	0.013	0.184	44.5
$>CH-$	0.012	0.192	46
$>C<$	(−0.007)	(0.154)	(31)
$=CH-$	0.011	0.154	37
$=C<$	0.011	0.154	36
$=C=$	0.011	0.154	36
Halogen increments			
$-F$	0.018	0.221	18
$-Cl$	0.017	0.320	49
$-Br$	0.010	(0.50)	(70)
$-I$	0.012	(0.83)	(95)
Oxygen increments			
$-OH$ (alcohols)	0.082	0.06	(18)
$-OH$ (phenols)	0.031	(−0.02)	(3)
$-O-$ (nonring)	0.021	0.16	20
$-O-$ (ring)	(0.014)	(0.12)	(8)
$>C=O$ (nonring)	0.040	0.29	60

Symbols	ΔT	ΔP	ΔV
Oxygen increments (cont)			
$-\overset{\vert}{C}=O$ (ring)	(0.033)	(0.2)	(50)
$\overset{\vert}{H}C=O$ (aldehyde)	0.048	0.33	73
$-COOH$ (acid)	0.085	(0.4)	80
$-COO-$ (ester)	0.047	0.47	80
$=O$ (except for combinations above)	(0.02)	(0.12)	(11)
Nitrogen increments			
$-NH_2$	0.031	0.095	28
$-\overset{\vert}{N}H$ (nonring)	0.031	0.135	(37)
$-\overset{\vert}{N}H$ (ring)	(0.024)	(0.09)	(27)
$-\overset{\vert}{N}-$ (nonring)	0.014	0.17	(42)
$-\overset{\vert}{N}-$ (ring)	(0.007)	(0.13)	(32)
$-CN$	(0.060)	(0.36)	(80)
$-NO_2$	(0.055)	(0.42)	(78)
Sulfur increments			
$-SH$	0.015	0.27	55
$-S-$ (nonring)	0.015	0.27	55
$-S-$ (ring)	(0.008)	(0.24)	(45)
$=S$	(0.003)	(0.24)	(47)
Miscellaneous			
$-\overset{\vert}{\underset{\vert}{Si}}-$	0.03	(0.54)	
$-\overset{\vert}{\underset{\vert}{B}}-$	(0.03)		

The critical point of each fatty acids used the Lydersen's Structural Contribution and calculate the critical property in the equation C-1.1-C-1.4

- Critical Temperature (Tc) = $\dfrac{boiling\ point\ FFA}{0.567+(N\Delta T)-(N\Delta T)^2}$ C-1.1
- Critical Pressure (Pc) = $\dfrac{molecular\ weight\ of\ FFA}{[0.34+(N\Delta P)]^2}$ C-1.2
- Critical Volume (Vc) = $40+(N\Delta V)$ C-1.3
- Zc = $\dfrac{Pc\times Vc}{82.06\times Tc}$ C-1.4

Palmitic Acids



C00249

Table C-1.2 The property of critical palmitic acid with Lydersen's Structural

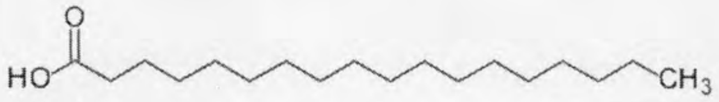
Mw	bp (oC)	bp (K)		N	ΔT	NΔT	ΔP	NΔP	ΔV	NΔV
256.42	271.5	544.65	COOH	1	0.085	0.085	0.4	0.4	80	80
			CH3	1	0.02	0.02	0.227	0.227	55	55
			CH2	14	0.02	0.28	0.227	3.178	55	770
			SUM			0.385		3.805		905
			total			0.385		3.805		905

The data in the table C-1.2 apply in the equation C-1.1-C-1.4

Tc (K)	Pc (atm)	Vc (cm3/(g.mol)	Zc
677.62	14.92	945	0.25

R = 82.06 cm3atm/g.mol K

Stearic acid



C01530

Table C-1.3 The property of critical stearic acid with Lydersen's Structural Contribution

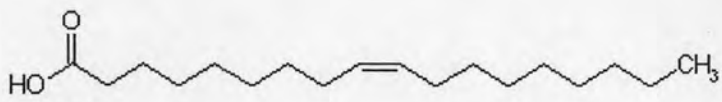
Mw	bp (oC)	bp (K)		N	ΔT	NΔT	ΔP	NΔP	ΔV	NΔV
284.47	291	564.15	COOH	1	0.085	0.085	0.4	0.4	80	80
			CH3	1	0.02	0.02	0.227	0.227	55	55
			CH2	16	0.02	0.32	0.227	3.632	55	880
			SUM			0.425		4.259		1015
			total			0.425		4.259		1015

The data in the table C-1.3 apply in the equation C-1.1-C-1.4

Tc (K)	Pc (atm)	Vc (cm3/(g.mol)	Zc
695.30	13.45	1055	0.25

R = 82.06 cm3atm/g.mol K

Oleic acid



C00712

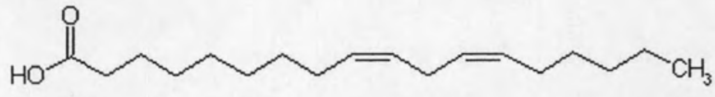
Table C-1.4 The property of critical oleic acid with Lydersen's Structural Contribution

Mw	bp (oC)	bp (K)		N	ΔT	NΔT	ΔP	NΔP	ΔV	NΔV
282.2559	285	558.15	COOH	1	0.085	0.085	0.4	0.4	80	80
			CH3	1	0.02	0.02	0.227	0.227	55	55
			CH2	14	0.02	0.28	0.227	3.178	55	770
			HC=	2	0.018	0.036	0.198	0.396	45	90
			SUM			0.421		4.201		995
			total			0.421		4.201		995

Tc (K)	Pc (atm)	Vc (cm3/(g.mol)	Zc
688.43	13.69	1035	0.25

R = 82.06 cm3atm/g.mol K

Linoleic acid



C01595

Table C-1.5 The property of critical linoleic acid with Lydersen's Structural Contribution

Mw	bp (oC)	bp (K)		N	ΔT	NΔT	ΔP	NΔP	ΔV	NΔV
280.4455	229.445	502.595	COOH	1	0.085	0.085	0.4	0.4	80	80
			CH3	1	0.02	0.02	0.227	0.227	55	55
			CH2	12	0.02	0.24	0.227	2.724	55	660
			HC=	4	0.018	0.072	0.198	0.792	45	180
			SUM			0.417		4.143		975
			total			0.417		4.143		975

Tc (K)	Pc (atm)	Vc (cm3/(g.mol)	Zc
620.40	13.95	1015	0.28

R = 82.06 cm3atm/g.mol K

Table C-1.6 The critical property of total fatty acid by average with fraction fatty acids

Fatty acids	T_c	%FFA	MW	Mol	Mol%	% Fraction	Tc Fraction	Pc	Pc Fraction	Vc	Vc Fraction	Zc	Zc Fraction
Palmitic	607.32	42.8	256.42	0.1669	46.0786	0.4608	279.8443	14.92	6.8749	945	435.44	0.22	0.1014
Stearic	695.30	4.5	284.47	0.0158	4.3670	0.0437	30.3637	13.45	0.5874	1055	46.07	0.22	0.0096
oleic	688.43	40.5	282.25	0.1435	39.6121	0.3961	272.7017	13.69	5.4229	990	392.16	0.23	0.0911
linoleic	620.40	10.1	280.44	0.0360	9.9423	0.0994	61.6822	13.95	1.3870	925	91.97	0.3	0.0298
Total	2611.45	97.9		0.3622		1	644.5919		14.2721		965.64		0.2319

The critical point of mixture between palm fatty acids with methanol used Lorentz-Berthelot-type rules for binary mixture method, the data in the table C-1.6 apply in the equation the critical point of mixture binary system

Critical point of mixture (binary system)

The critical points of mixture were calculated by Lorentz-Berthelot-type mixing rules as following equations:

$$T_{cm}V_{cm} = \sum_i \sum_j x_i x_j T_{ij} V_{ij} = x_i^2 T_{ci} V_{ci} + 2x_i x_j T_{cij} V_{cij} + x_j^2 T_{cj} V_{cj}$$

$$V_{cm} = \sum_i \sum_j x_i x_j V_{cij} = x_i^2 V_{ci} + 2x_i x_j V_{cij} + x_j^2 V_j$$

$$Z_{cm} = \sum_i \sum_j x_i x_j Z_{cij} = x_i^2 Z_{ci} + 2x_i x_j Z_{cij} + x_j^2 Z_{cj}$$

$$P_{cm} = \frac{Z_{cm} R T_{cm}}{V_{cm}}$$

The terms of T_{cij}, V_{cij} and Z_{cij} were calculated by the combining rule as the following equations:

$$T_{cij} = \sqrt{T_{ci} T_{cj}}$$

$$P_{cij} = \frac{1}{V_{cij}} \sqrt{P_{ci} P_{cj} V_{ci} V_{cj}}$$

$$Z_{cij} = 0.5\left(Z_{ci} + Z_{cj}\right)$$

$$V_{cij}^{1/3} = \frac{1}{2}\left(V_{ci}^{1/3} + V_{cj}^{1/3}\right)$$

Where

i and j = subscripts for component i and j

x = mole fraction

T_{cm} = critical temperature of mixture

V_{cm} = critical volume of mixture

P_{cm} = critical pressure of mixture

Z_{cm} = critical compressibility factor of mixture

Example the critical point of mixture at the molar ratio 1:6

	mole	mole fraction
MeOH	6	0.86
PFA	1	0.14
total	7	1

	Tc (K)	**Pc (atm)**	**Vc (L/mol)**	**Zc**
MeOH	512.6	79.9	0.118	0.224
PFA	644.59	14.27	0.96	0.23

Tcij =	574.819	K	301.819	C
$Vcij^{1/3}$ =	0.73849		Vcij =	0.402742
Pcij =	28.2186			
Zcij =	0.227			
Vcm =	0.20			
TcmVcm =	113.763	Tcm =	555.17	K
			282.17	C
Zcm =	0.22			
Pcm =	48.89			

VITA

Miss Duangkamol Yujaroen was born on 5 july,1982 in Ayutthaya, Thailand. He received a Bachelor's degree of Chemical Engineering from the Faculty of Engineering Burapha University in 2005. . The last education is studying in Master Degree in Chemical Engineering, Chulalongkorn University that began in 2004.