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APPENDICES

Appendix A Gas Chromatography

Table A1 Gas chromatograph's Feed Biodiesel

Peak	Retention Time	Type	Width	Area	Start Time	End Time	FAME	%
1	1.849	BB	0.054	8680489	1.973	2.457	solvent	
2	1.98	BB	0.074	9856072	10.347	10.673	solvent	
3	2.147	BB	0.062	2399	11.773	11.99	solvent	
2	10.427	BB	0.074	2590	10.347	10.673	C12:0	0.37
4	17.282	BB	0.09	11465	17.157	17.64	C14:0	1.63
6	25.744	BV	0.138	471120	25.323	26.19	C16:0	66.93
7	29.878	BB	0.089	971	29.747	30.047	C18:0	0.14
8	34.102	BB	0.106	29911	33.91	34.48	C18:1	4.25
9	34.962	BV	0.106	149995	34.623	35.073	C18:1	21.31
10	35.15	VB	0.097	6600	35.073	35.41	C18:1	0.94
11	36.794	BV	0.118	29408	36.56	37.243	C18:2	4.18
12	42.497	BB	0.131	1790	42.303	42.757	C22:0	0.25
				703850				**100.00**

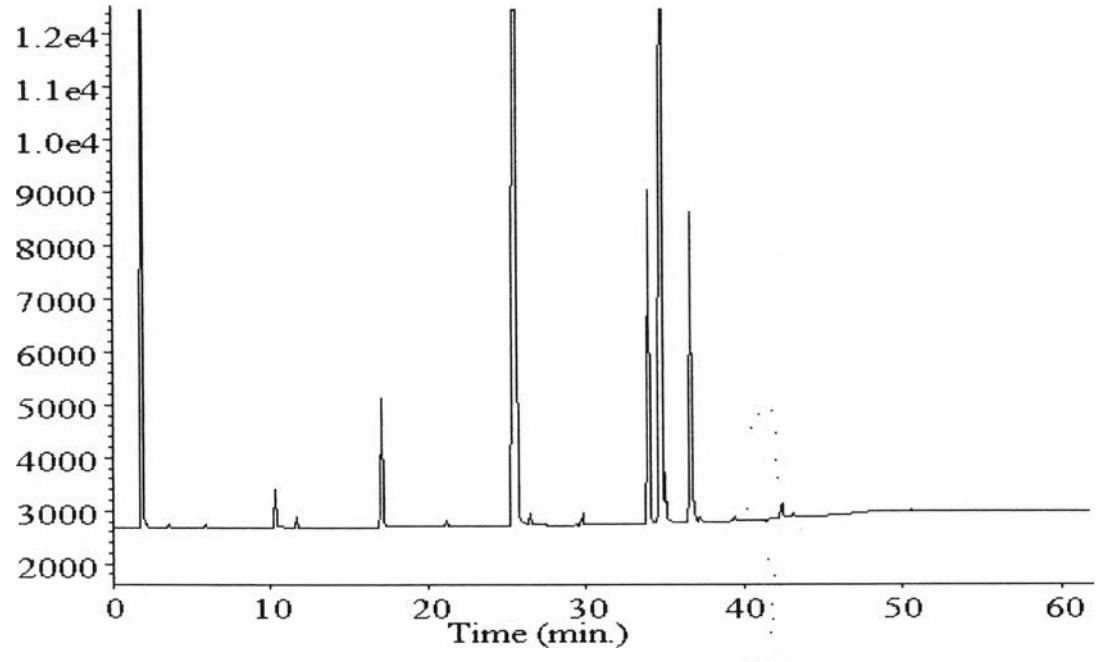

Figure A1 Peak of Gas chromatograph's Feed Biodiesel.

Calculation

$$C = \frac{(\sum A) - A_{EI}}{A_{EI}} * \frac{C_{EI} * V_{EI}}{m} * 100 \qquad \text{Eq (1)}$$

C	Methyl ester content
$\sum A$	The overall area of methyl ester from C12:0 to C22:0
A_{EI}	The peak area which is assigned to methyl heptadecanoate solution
C_{EI}	Concentration in mg/ml of methyl heptadecanoate solution
V_{EI}	Volume of methyl heptadecanoate solution
m	Weight in mg of biodiesel sample

%FAME calculation

% C12:0 = (100 × 2590) / 703,850
= 0.37 %

% C14:0 = (100 × 11465) / 703,850
= 1.63 %

% C16:0 = (100 × 47112) / 703,850
= 66.93 %

% C18:0 = (100 × 971) / 703,850
= 0.14 %

% C18:1 = (100 × 29911) / 703,850
= 4.25 %

% C18:1 = (100 × 149995) / 703,850
= 21.31 %

% C18:1 = (100 × 6600) / 703,850
= 0.94 %

% C18:2 = (100 × 29408) / 703,850
= 4.18 %

% C22:0 = (100 × 1790) / 703,850
= 0.25 %

Table A2 Pd/carbon aerogel on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C , 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.38	1.58	66.80	22.83	7.71	0.45	0.26
1.00	0.39	1.61	66.06	28.85	2.79	0.04	0.27
1.50	0.37	1.59	65.28	32.27	0.22	0.00	0.26
2.00	0.34	1.49	63.95	33.90	0.00	0.00	0.31
3.00	0.39	1.61	65.27	32.45	0.00	0.00	0.28
4.00	0.39	1.59	65.01	32.75	0.00	0.00	0.27

Table A3 Pd/carbon aerogel on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C , 2 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.39	1.63	66.70	19.13	10.44	1.47	0.24
1.00	0.41	1.66	66.53	27.53	3.60	0.00	0.27
1.50	0.39	1.60	65.18	32.13	0.42	0.00	0.28
2.00	0.38	1.59	64.49	33.23	0.00	0.00	0.30
3.00	0.30	1.88	67.23	30.59	0.00	0.00	0.00
4.00	0.39	1.61	64.99	32.72	0.00	0.00	0.29

Table A4 Pd/carbon aerogel on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C , 4 bar, 30 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.40	1.56	65.66	18.46	12.20	1.44	0.27
1.00	0.41	1.66	66.37	24.53	5.98	0.79	0.25
1.50	0.36	1.86	67.86	29.10	0.63	0.00	0.19
2.00	0.37	1.54	63.73	34.02	0.00	0.00	0.35
3.00	0.39	1.63	65.13	32.57	0.00	0.00	0.28
4.00	0.38	1.60	65.93	31.84	0.00	0.00	0.25

Table A5 Pd/carbon aerogel on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C , 2 bar, 30 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.39	1.60	65.48	24.40	7.60	0.24	0.29
1.00	0.39	1.63	65.01	26.26	6.21	0.21	0.30
1.50	0.40	1.61	64.97	31.88	0.85	0.00	0.30
2.00	0.40	1.61	64.97	31.88	0.85	0.00	0.30
3.00	0.39	1.63	65.16	32.54	0.00	0.00	0.29
4.00	0.40	1.67	65.76	31.91	0.00	0.00	0.25

Table A6 Batch#1, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C ,4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.36	1.53	65.55	6.51	24.12	1.71	0.22
1.00	0.39	1.62	66.86	8.60	22.05	0.26	0.24
1.50	0.39	1.66	67.69	10.47	19.39	0.17	0.22
2.00	0.38	1.67	67.45	13.45	17.00	0.00	0.25
3.00	0.39	1.64	67.45	18.44	11.80	0.00	0.28
4.00	0.39	1.64	67.46	22.99	7.26	0.00	0.25

Table A7 Batch#1, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 2 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.5	0.41	1.56	65.16	5.83	24.41	2.41	0.23
1	0.43	1.64	67.01	6.18	23.27	1.26	0.20
1.5	0.37	1.41	68.29	7.14	21.99	0.56	0.24
2	0.46	1.71	68.01	9.73	19.31	0.59	0.20
3	0.48	1.76	68.21	12.56	16.26	0.51	0.21
4	0.43	1.63	64.87	17.95	14.64	0.24	0.25

Table A8 Batch#1, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 1 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.35	1.52	65.58	4.81	24.61	2.95	0.18
1.00	0.38	1.62	66.27	4.95	24.44	2.18	0.16
1.50	0.37	1.60	67.45	5.70	23.27	1.41	0.20
2.00	0.38	1.61	66.75	6.18	23.99	0.87	0.23
3.00	0.38	1.63	69.28	7.23	20.76	0.50	0.22
4.00	0.38	1.64	67.23	10.00	19.86	0.50	0.22

Table A9 Batch#2, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.5	0.37	1.58	66.08	7.40	22.78	1.57	0.22
1	0.35	1.55	67.66	10.79	19.16	0.26	0.23
1.5	0.40	1.68	68.79	13.00	15.90	0.00	0.22
2	0.40	1.67	68.32	16.29	13.13	0.00	0.19
3	0.43	1.79	68.33	21.35	7.80	0.00	0.30
4	0.38	1.62	68.57	24.00	5.19	0.00	0.25

Table A10 Batch#2, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 100°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.5	0.41	1.55	65.94	6.87	22.85	2.14	0.25
1	0.41	1.60	66.13	9.67	21.11	0.83	0.24
1.5	0.41	1.58	67.43	12.55	17.60	0.16	0.26
2	0.43	1.63	68.58	14.97	14.12	0.00	0.27
3	0.37	1.46	67.36	19.39	11.11	0.00	0.31
4	0.39	1.49	66.74	23.48	7.59	0.00	0.30

Table A11 Batch#2, Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 80°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.5	0.37	1.59	65.94	4.94	24.70	2.24	0.23
1	0.38	1.61	66.13	8.35	22.41	0.92	0.19
1.5	0.40	1.66	67.43	9.65	20.49	0.20	0.16
2	0.37	1.57	68.58	12.17	16.98	0.10	0.23
3	0.41	1.67	67.36	16.69	13.66	0.00	0.22
4	0.37	1.67	66.74	22.00	9.00	0.00	0.22

Table A12 Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 100 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.5	0.37	1.55	66.81	6.96	22.41	1.67	0.22
1	0.39	1.65	66.90	8.89	21.77	0.22	0.22
1.5	0.40	1.71	70.52	10.05	17.04	0.00	0.27
2	0.40	1.69	68.35	12.61	16.79	0.00	0.16
3	0.36	1.57	67.19	20.06	10.17	0.00	0.29
4	0.31	1.73	68.92	23.74	4.90	0.00	0.21

Table A13 Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.35	1.52	65.58	4.81	24.61	2.95	0.18
1.00	0.38	1.62	66.27	4.95	24.44	2.18	0.16
1.50	0.37	1.60	67.45	5.70	23.27	1.41	0.20
2.00	0.38	1.61	66.75	6.18	23.99	0.87	0.23
3.00	0.38	1.63	69.28	7.23	20.76	0.50	0.22
4.00	0.38	1.64	67.23	10.00	19.86	0.50	0.22

Table A14 Pd/granule activated carbon on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 30 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.39	1.55	66.34	6.54	22.18	2.74	0.25
1.00	0.43	1.68	66.93	7.41	22.11	1.24	0.18
1.50	0.39	1.57	65.00	9.91	22.13	0.77	0.24
2.00	0.44	1.73	67.78	12.02	17.73	0.10	0.20
3.00	0.39	1.64	67.15	14.27	16.17	0.12	0.25
4.00	0.41	1.65	67.08	18.77	11.47	0.36	0.26

Table A15 Pd/ activated carbon(40μm) on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.37	1.59	66.36	20.87	9.56	0.96	0.28
1.00	0.37	1.63	67.11	26.89	3.73	0.00	0.27
1.50	0.38	1.59	65.40	31.31	1.03	0.00	0.29
2.00	0.36	1.54	66.10	31.70	0.00	0.00	0.30
3.00	0.40	1.67	65.81	31.89	0.00	0.00	0.23
4.00	0.42	1.67	65.57	32.08	0.00	0.00	0.25

Table A16 Pd/ activated carbon(850μm) on FAME composition of biodiesel after partial hydrogenation reaction (Reaction conditions: 120°C, 4 bar, 50 ml/min of H_2 flow rate, 500 rpm of stirring rate, and 1.5 wt.% of catalyst compared with starting oil)

Reaction Time	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C22:0
0.00	0.37	1.63	66.93	0.14	26.50	4.18	0.25
0.50	0.38	1.55	66.67	13.61	16.27	1.25	0.27
1.00	0.40	1.62	66.70	19.93	10.86	0.20	0.28
1.50	0.39	1.61	66.85	24.49	5.47	0.94	0.26
2.00	0.39	1.59	65.53	29.94	2.20	0.09	0.26
3.00	0.39	1.64	67.15	30.00	0.45	0.12	0.25
4.00	0.37	1.57	64.72	32.91	0.14	0.00	0.29

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