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Appendices

Appendix A

Esterification reaction

Table A1 Effect of time and power output of cellulose laurate

Power output (W)	Time			
	2 min	1.30 min	1 min	30 sec
	Weight (g)	Weight (g)	Weight (g)	Weight (g)
90	2.31	1.60	1.27	0.80
180	1.81	1.90	1.42	0.90
270	1.58	2.32	1.64	1.07
360	-	2.13	1.84	1.19
450	-	-	2.37	1.40
540	-	-	1.68	1.57
630	-	-	-	1.74
720	-	-	-	1.56

* Weight before = 1.00 g.

Table A2 Effect of equivalent weight of DMAP and lauroyl chloride of cellulose laurate at 2 min and 90 watt.

Lauroyl Chloride / DMAP	2 min 90 watt			
	5 equiv.	8 equiv.	10 equiv.	14 equiv.
	Weight (g)	Weight (g)	Weight (g)	Weight (g)
0.1 equiv.	1.70	1.80	1.86	1.84
0.5 equiv.	1.86	2.20	2.27	2.07
0.9 equiv.	2.06	2.36	2.54	2.23
1.2 equiv.	2.13	2.29	2.38	2.25

* Weight before = 1.00 g.

Appendix B

Characterization

Table B1 Gloss of a different % ester content of cellulose laurate films

Film samples of % Ester content	Gloss (unit)	Mean	SD
38.00	31.5 31.7 31.1 30.8 31.4	31.3	0.3535
36.30	27.0 25.3 25.2 24.6 26.2	25.66	0.9423
23.24	17.5 18.1 17.3 16.4 18.4	17.54	0.7765

Table B2 Contact angle of different % ester content of cellulose laurate films

Film samples of % Ester content	Contact angle (Degree)	Mean	SD
38.00	74 75 76 74	74.75	0.9574
36.30	82 86 85 82	83.75	2.0615
23.24	88 90 92 90	90.00	1.6329

Table B3 Water absorption of different % ester content of cellulose laurate films

Film samples of % Ester content	Weight before (g)	Weight after (g)	Weight increase (g)	Water absorption (%)	Mean	SD
38.00	0.3004	0.4773	0.1769	59.9	60.9	1.0504
	0.2946	0.4733	0.1787	61.0		
	0.2903	0.4703	0.1800	62.0		
36.30	0.2020	0.3209	0.1189	58.5	58.8	0.3512
	0.1976	0.3132	0.1156	58.8		
	0.1823	0.2903	0.1080	59.2		
23.24	0.1413	0.2226	0.0813	57.0	56.9	0.4944
	0.1159	0.1816	0.0657	56.6		
	0.1249	0.1964	0.0715	57.2		

Table B4 Xenotest Beta Lamp of different % ester content of cellulose laurate films

Film samples of % Ester content	Weight before (g)	Weight after (g)	Weight loss (g)	% Weight loss	Mean	SD
38.00	0.2106	0.1574	0.0532	25.26	26.66	1.2322
	0.1936	0.1402	0.0534	27.58		
	0.1831	0.1334	0.0497	27.14		
36.30	0.1404	0.1092	0.0312	22.22	21.86	1.9343
	0.2123	0.1703	0.0420	19.78		
	0.1413	0.1079	0.0334	23.60		
23.24	0.1989	0.1769	0.0220	11.00	10.23	0.8621
	0.2106	0.1886	0.0220	10.40		
	0.2073	0.1880	0.0193	9.30		

Table B5 Soil burial test of different % ester content of cellulose laurate films

Time (Days)	% Ester content											
	38.00			Weight loss (%)	36.30			Weight loss (%)	23.24			Weight loss (%)
	W_i	W_f	W_l		W_i	W_f	W_l		W_i	W_f	W_l	
5	0.0257	0.0210	0.0046	18.20	0.0188	0.0162	0.0026	13.80	0.0302	0.0274	0.0028	9.27
10	0.0267	0.0184	0.0083	31.08	0.0197	0.0142	0.0055	27.91	0.0196	0.0144	0.0052	26.53
15	0.0222	0.0143	0.0079	35.58	0.0197	0.0128	0.0069	35.02	0.0296	0.0215	0.0081	27.36
20	0.0289	0.0181	0.0108	37.37	0.0254	0.0165	0.0089	35.03	0.0119	0.0085	0.0034	28.57
25	0.0245	0.0153	0.0092	37.55	0.0206	0.0132	0.0074	35.92	0.0195	0.0137	0.0058	29.74
30	0.0249	0.0155	0.0094	37.75	0.0267	0.0171	0.0096	35.95	0.0180	0.0126	0.0054	30.00
35	0.0350	0.0215	0.0135	38.57	0.0254	0.0159	0.0095	37.40	0.0187	0.0126	0.0061	32.62
40	0.0259	0.0153	0.0106	40.92	0.0302	0.0188	0.0114	37.74	0.0171	0.0114	0.0057	33.21
45	0.0305	0.0179	0.0126	41.20	0.0221	0.0136	0.0085	38.46	0.0197	0.0131	0.0066	33.47
50	0.0218	0.0126	0.0092	42.80	0.0281	0.0168	0.0113	40.21	0.0125	0.0083	0.0042	33.60
55	0.0233	0.0126	0.0107	45.90	0.0304	0.0180	0.0123	40.75	0.0103	0.0068	0.0035	34.00
60	0.0378	0.0198	0.0179	47.54	0.0275	0.0159	0.0115	41.84	0.0296	0.0193	0.0102	34.50

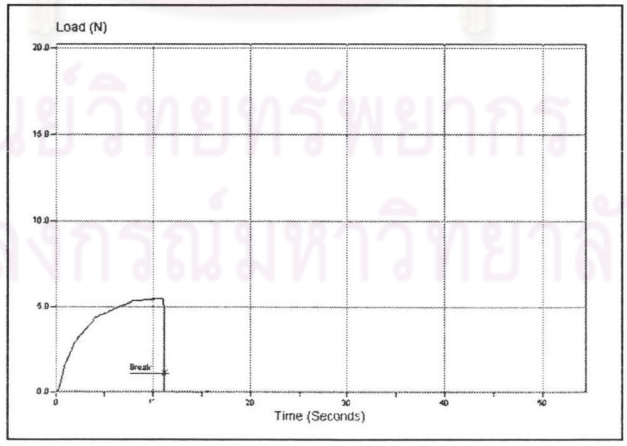
* W_i = Weight before, W_f = Weight after, and W_l = Weight loss

Table B6 Tensile stress at maximum load (Mpa) of different of cellulose laurate films

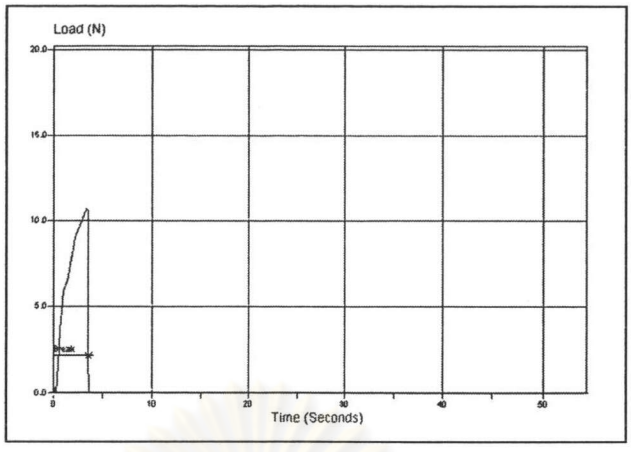
Film sample of % Ester content	Tensile stress at maximum load	Mean	SD
38.00	2.118377 2.038896 2.289764	2.1489	0.1282
36.3	2.089273 1.763076 3.96542	2.6058	1.1886
23.24	3.613268 3.993668 4.420014 3.278955	3.8264	0.4917

Table B7 Percent elongation a break of different of cellulose laurate films

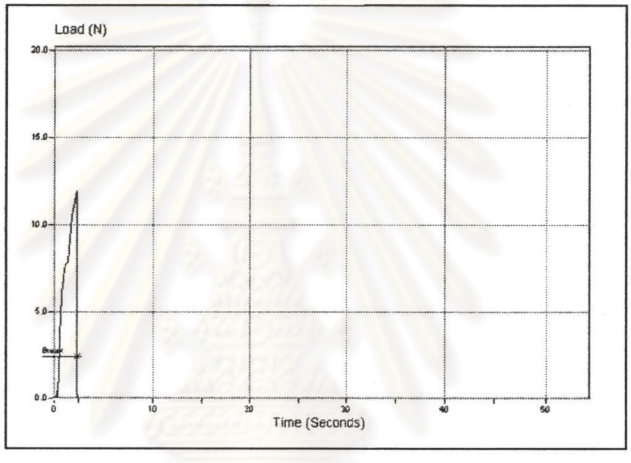
Film samples of % Ester content	Elongation at break (%)	Mean	SD
38.00	16.55604 15.37586 11.78535	14.5723	2.4847
36.3	10.74251 9.829560 11.08770	10.5531	0.6499
23.24	2.434748 3.857935 8.119200 2.375600	4.1968	2.7031



(a)

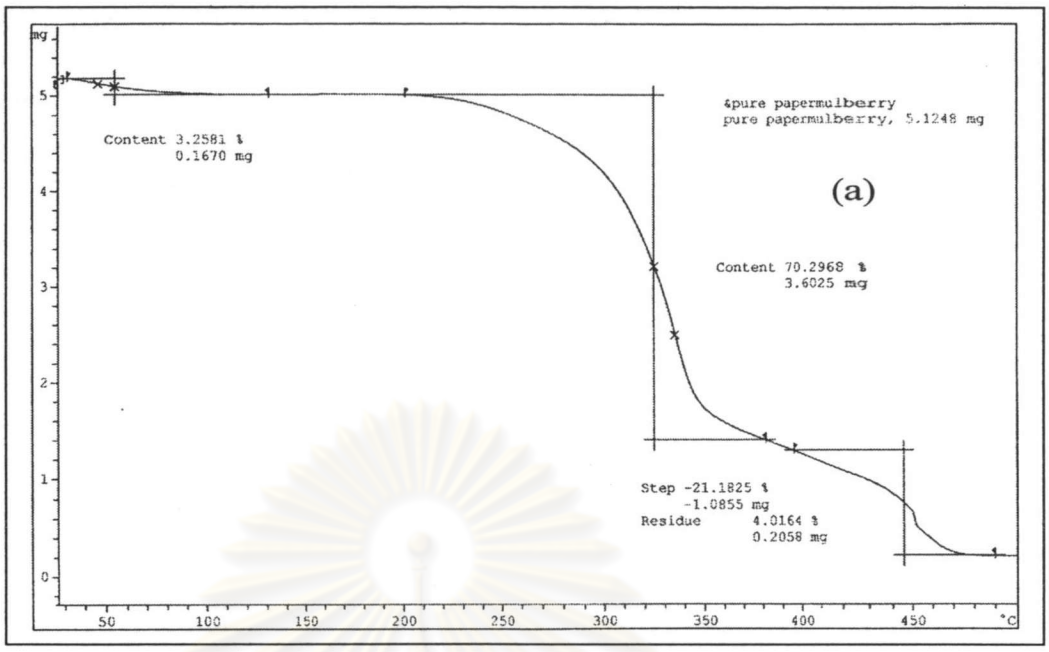


(b)



(c)

Figure B1 Effect of (a) 38, (b) 36.3, and (c) 23.24 % ester content on tensile properties



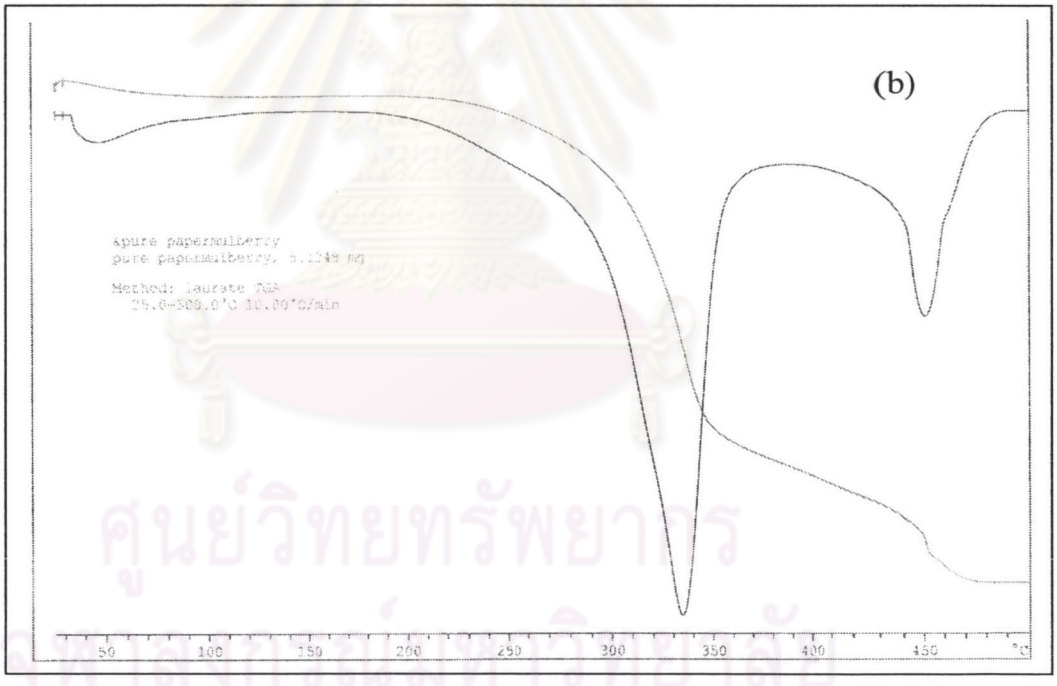


Figure B2 Thermogravimetric analysis of paper mulberry (a) and (b) derivative of paper mulberry.

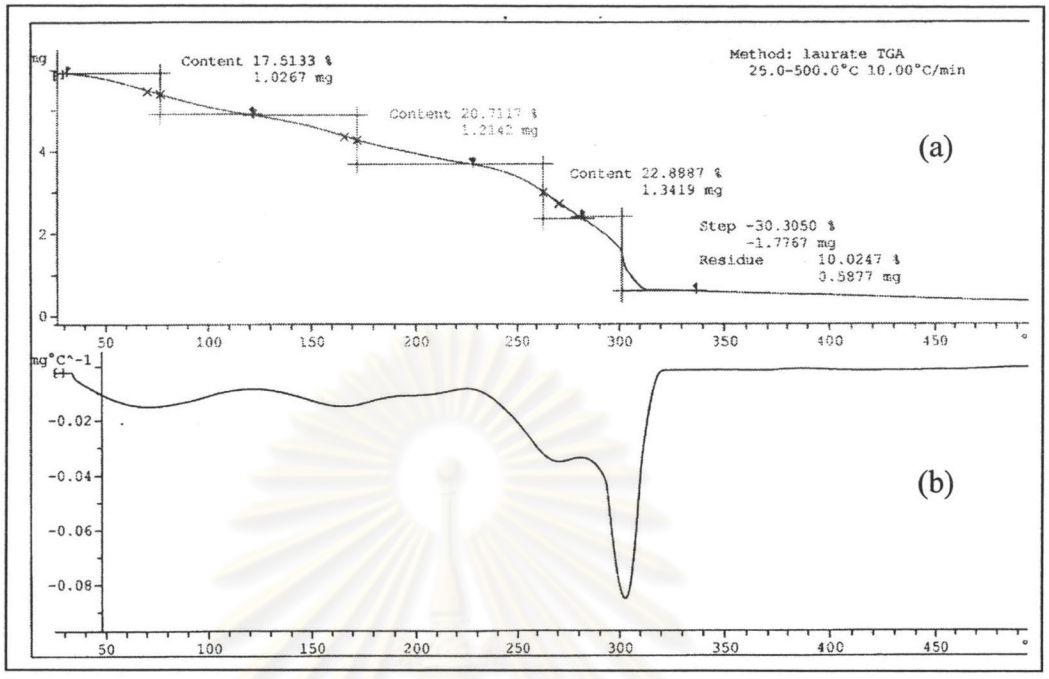


Figure B3 Paper mulberry sample esterified with lauroyl chloride (a) and (b) derivative of modify paper mulberry.

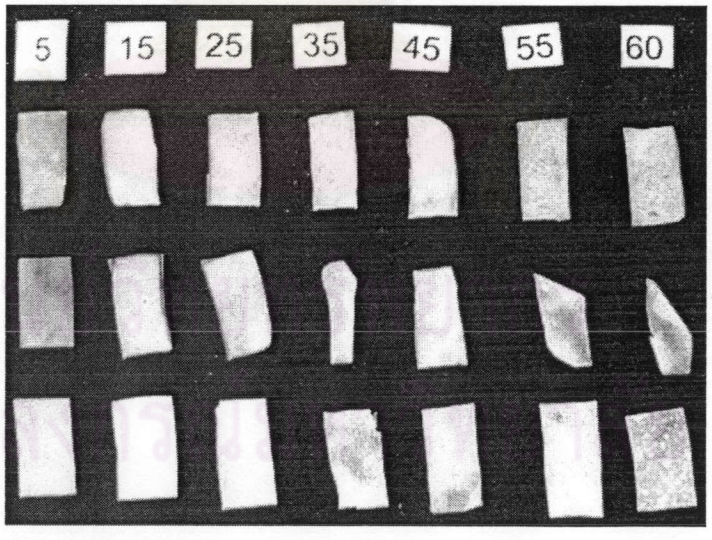


Figure B4 Soil burial method of different % ester content in 60 days; (a) 38 %, (b) 36.3 %, and (c) 23.24 % ester content.

Appendix C

Calculation

C1 Amount of chemical substance

The amounts of chemical substance of DMAP as catalyst and lauroyl chloride as esterifying agent were calculated from equivalent weight of DMAP and lauroyl chloride, respectively. Using the following equation:

X equivalent weight of cellulose = 1 mol lauroyl chloride

X / M.w. cellulose = (1 / M.w.lauroyl chloride) × DV

M.w.cellulose = 162.27 g/mol

M.w.lauroyl chloride = 218.77 g/mol

M.w.DMAP = 122.17 g/mol

Density of lauroyl chloride = 0.921

Example 10 equivalent weight of lauroyl chloride

Method

$$V = \frac{(10 \times 218.77)}{(162.27 \times 0.921)} \text{ ml}$$

$$= 14.64 \text{ ml}$$

Therefore, volume of lauroyl chloride at 10 equivalent is 14.64 ml.

Example 0.9 equivalent weight of DMAP

Method

$$m = DV$$

Therefore,

$$m = \frac{(0.9 \times 122.17)}{162.27} \text{ g}$$

$$m = 0.678 \text{ g}$$

Hence, weight of o.9 equivalent weight of DMAP is 0.678 g.

C2 Weight loss

The weight loss of the films was measured by weighing the sample before and after biodegradation. The percentage weight loss of the films samples was calculated using the following equation.

$$\text{Weight loss (\%)} = \frac{w_i - w_f}{w_i} \times 100$$

Where: w_i = initial weight of sample before degradation (g)

w_f = final weight of sample after degradation (g)

Example Soil burial test at 5 days

w_i = 0.0257 g

w_f = 0.0210 g

Therefore

$$\text{Weight loss (\%)} = \frac{0.0257 - 0.0210}{0.0257} \times 100$$

$$= 18.28$$

Therefore, % weight loss is 18.28 at 5 days of soil burial test.

C3 % Esterification

The ester content of the cellulose laurate was calculated by peak high of IR spectra. The percent ester content of cellulose laurate sample was calculated using the following equation.

$$A = \log \frac{\text{base peak of sample}}{\text{high peak of sample}}$$

$$C_1 / C_2 = A_1 \text{ sample} / A_2 \text{ cellulose}$$

Fix $C_2 = 100$

Therefore; $C_1 = (A_1/A_2) \times 100$

Hence, % ester content $= 100 - C_1$

Example base-peak 75 and high peak 28.62 of 10 equiv of lauroyl chloride, 0.9 equiv of DMAP and cellulose have base peak 75 and high peak 15.91.

$$A_1 = \log (75 / 28.62)$$
$$= 0.418$$
$$A_2 = \log (75 / 15.91)$$
$$= 0.67$$

Fix $C_2 = 100$

Therefore, $C_1 = (0.418 / 0.67) \times 100$
$$= 62.38$$

% Esterification $= 100 - 62.38$
$$= 38$$

Example IR spectra of cellulose

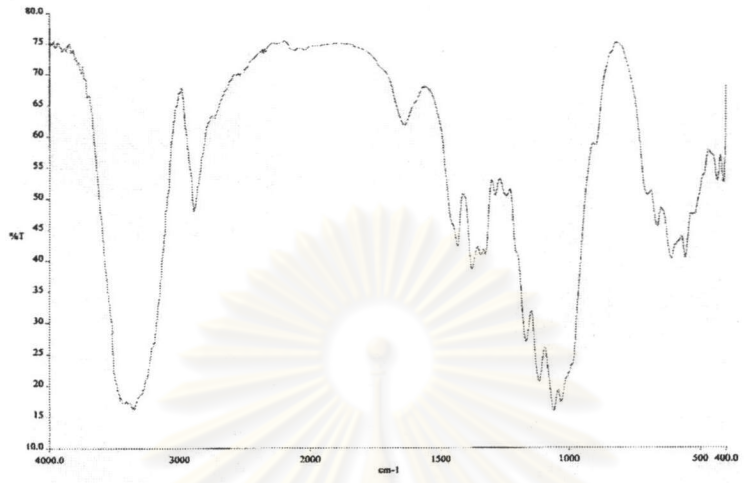


Figure C1 IR spectra of cellulose.

Example 10 equivalent weight of lauroyl chloride and o.9 equivalent weight of DMAP

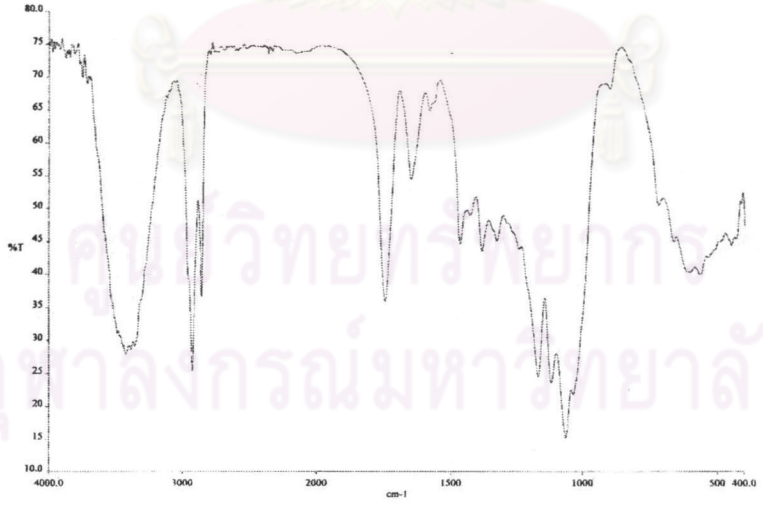
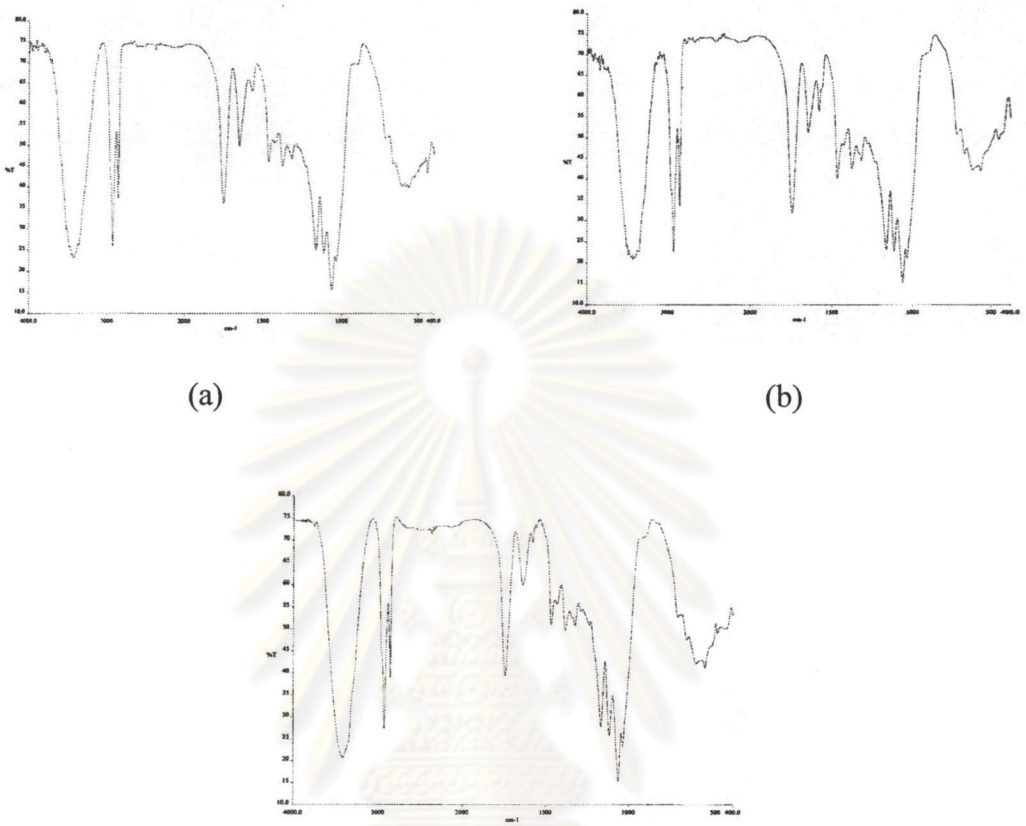


Figure C2 10 equivalent weight of lauroyl chloride and o.9 equivalent weight of DMAP.

Example 0.9 equivalent weight of DMAP and 5, 8, 14 equivalent weight of lauroyl chloride

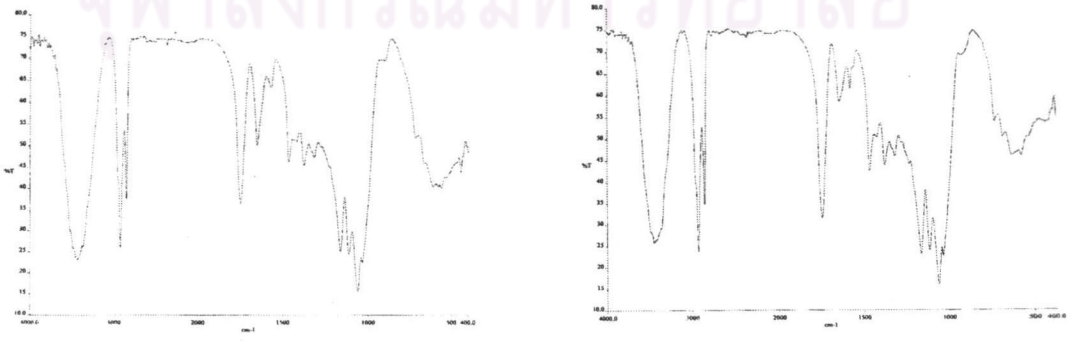


(a) (b)

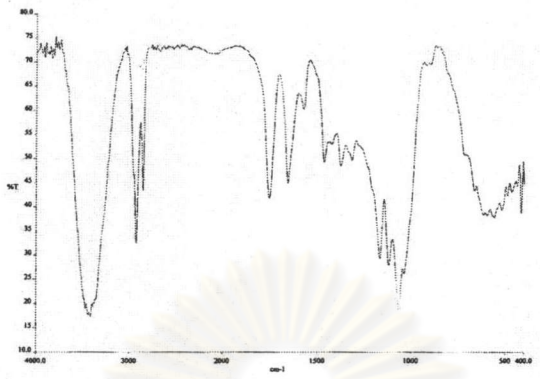
(c)

Figure C3 0.9 equivalent weight of DMAP and 5 (a), 8 (b), 14 (c) equivalent weight of lauroyl chloride.

Example 0.1, 0.5, 1.2 equivalent weight of DMAP and 10 equivalent weight of lauroyl chloride

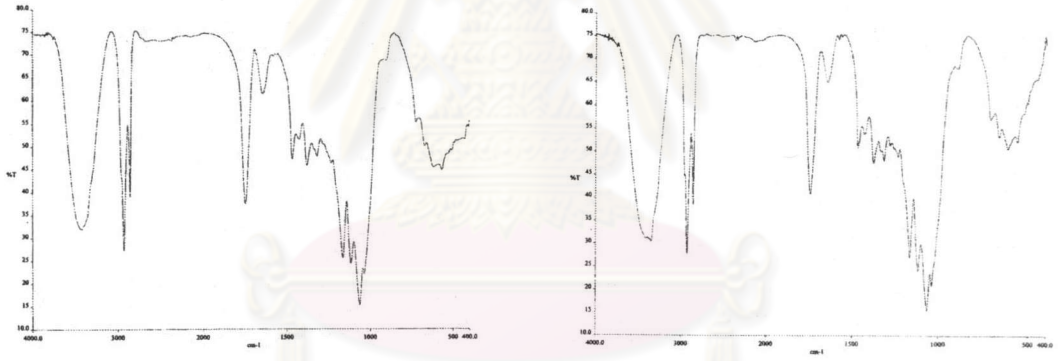


(a) (b)



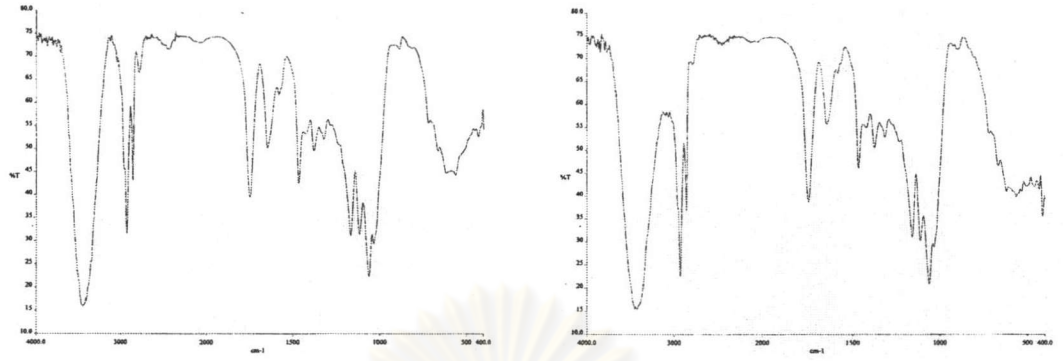
(c)

Figure C4 0.1 (a), 0.5 (b), 1.2 (c) equivalent weight of DMAP and 10 equivalent weight of lauroyl chloride.

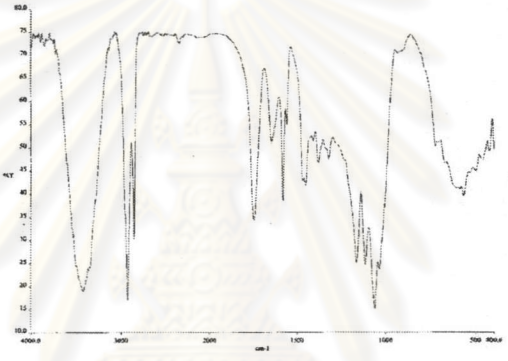


(a) (b)

Figure C5 0.075 equivalent weight of DMAP and 8 (a), 14 (b) equivalent weight of lauroyl chloride.

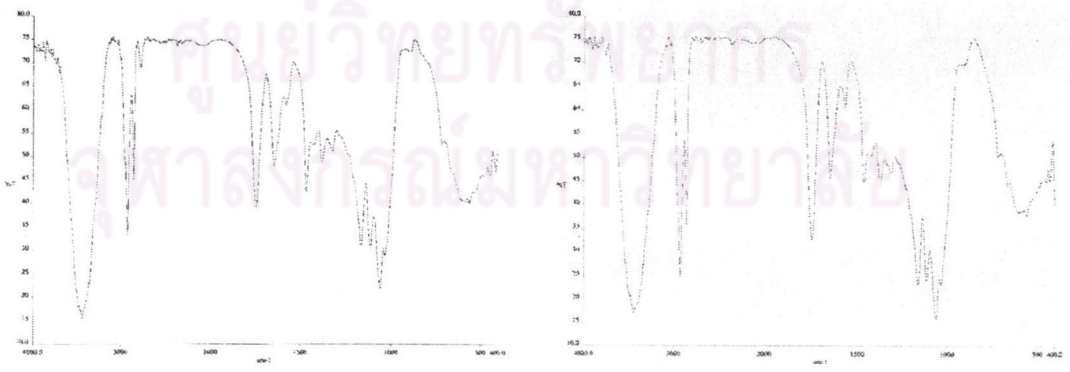


(a) (b)

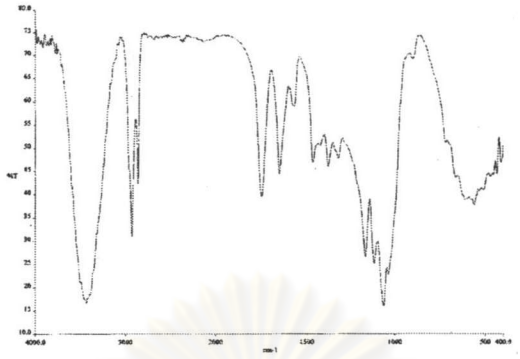


(c)

Figure C6 0.5 equivalent weight of DMAP and 5 (a), 8 (b), and 14 (c) equivalent weight of lauroyl chloride.



(a) (b)



(c)

Figure C7 1.2 equivalent weight of DMAP and 5 (a), 8 (b), and 14 (c) equivalent weight of lauroyl chloride.

Biography

Mr. Kiathisak Uthamang was born on June 25, 1979 in Nakornsrithumarat province, Thailand. He received his Bachelor degree of engineering majoring in petrochemicals and polymeric materials from the Department of Materials Science at Sinpakorn University in 2002. After that, he continued out the Department of Materials Science, Faculty of Science, doing his Master degree in the field of applied polymer science and textile technology at Department of Material Science, Faculty of Science, Chulalongkorn University in 2004.