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APPENDICES

Appendix A Determination of Molecular Weight of β -Chitin and α -Chitin

Table A1 Running time of solvent and β -chitin solution

Concentration (g/100 mL)	Time (second)			
	1	2	3	Average
0.000	352.06	352.34	352.93	352.44
0.001	358.15	358.78	358.75	358.56
0.002	384.69	384.47	384.59	384.56
0.003	406.72	406.5	406.66	406.62
0.004	428	428.03	428.13	428.05
0.005	449.03	449.25	4498	449.35

Table A2 The data of relative viscosity (η_{rel}), specific viscosity (η_{sp}), reduced viscosity (η_{red})

Concentration (g/100 mL)	η_{rel}	η_{sp}	η_{red}	$\ln(\eta_{rel})/c$
0.000				
0.001	1.01735	0.01735	17.35513	17.20625
0.002	1.09119	0.09119	45.59603	43.63537
0.003	1.15373	0.15373	51.24547	47.66858
0.004	1.21453	0.21453	53.63276	48.58951
0.005	1.27496	0.27496	54.99326	48.58395

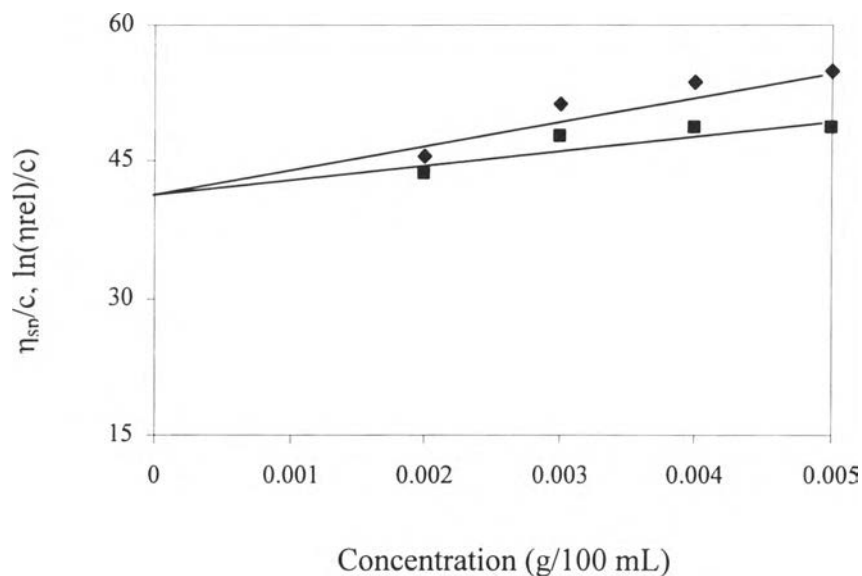


Figure A1 The plot of reduced viscosity (η_{sp}/c) and $\ln(\eta_{rel})/c$ versus concentration of β -chitin solution: ◆ = (η_{sp}/c) and ■ = $\ln(\eta_{rel})/c$.

The viscosity-average molecular weight of chitin was determined based on Mark-Houwink equation. The K and a values were according to Lee, (1974).

$$[\eta] = 8.93 \times 10^{-4} M^{0.71}$$

where $[\eta]$ = intrinsic viscosity

M = Viscosity-average molecular weight

Interception: $[\eta] = 40.6$

From calculation; $M = 3.64 \times 10^6$

The viscosity-average molecular weight of β -chitin obtained from calculation was 3.64×10^6 g/mol.

Table A3 Running time of solvent and α -chitin solution

Concentration (g/100 mL)	Time (second)			
	1	2	3	Average
0.000	323.41	323.57	323.9	323.63
0.001	335.66	335.50	335.75	335.63
0.002	344.41	344.50	344.65	344.52
0.003	355.66	355.75	355.75	355.72
0.004	367.50	367.94	367.85	367.76
0.005	377.29	377.25	377.32	377.28

Table A4 The data of relative viscosity (η_{rel}), specific viscosity (η_{sp}), reduced viscosity (η_{red})

Concentration (g/100 mL)	η_{rel}	η_{sp}	η_{red}	$\ln(\eta_{red})/c$
0.000				
0.001	1.03711	0.03710	37.10959	36.43761
0.002	1.06455	0.06455	32.27945	31.28026
0.003	1.09916	0.09916	33.05554	31.51743
0.004	1.13638	0.13638	34.09506	31.96200
0.005	1.16580	0.16580	33.16143	30.68273

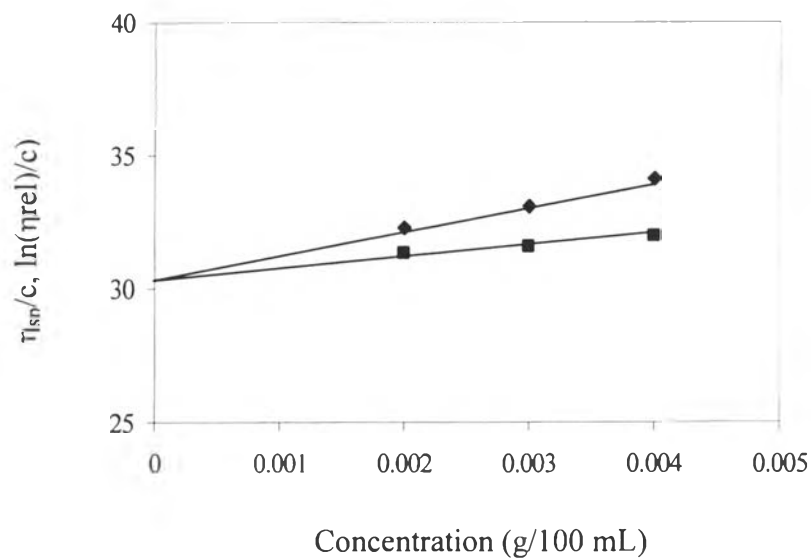


Figure A2 The plot of reduced viscosity (η_{sp}/c) and $\ln(\eta_{rel})/c$ versus concentration of α -chitin solution: ◆ = (η_{sp}/c) and ■ = $\ln(\eta_{rel})/c$.

The viscosity-average molecular weight of chitin was determined based on Mark-Houwink equation. The K and a values were according to Lee, (1974).

$$[\eta] = 8.93 \times 10^{-4} M^{0.71}$$

where $[\eta]$ = intrinsic viscosity

M = Viscosity-average molecular weight

Interception: $[\eta] = 35.7$

From calculation; $M = 2.42 \times 10^6$

The viscosity-average molecular weight of α -chitin obtained from calculation was 2.42×10^6 g/mol.

Appendix B Determination of Molecular Weight of Chitosan

Table B1 Running time of solvent and chitosan solution Treatment 1

Concentration (g/100 mL)	Time (second)			
	1	2	3	Average
0.00	213.69	213.49	213.78	213.65
0.01	259.67	259.10	259.35	259.37
0.02	311.31	311.29	311.11	311.23
0.03	369.26	369.00	369.10	369.12
0.04	437.48	437.53	437.35	437.45
0.05	506.06	506.04	506.10	506.06

Table B2 The data of relative viscosity (η_{rel}), specific viscosity (η_{sp}), reduced viscosity (η_{red})

Concentration (g/100 mL)	η_{rel}	η_{sp}	η_{red}	$\ln(\eta_{rel})/c$
0.00				
0.01	1.21399	0.21399	21.39917	19.39139
0.02	1.45673	0.45673	22.83685	18.80995
0.03	1.72765	0.72765	24.25529	18.22557
0.04	2.04749	1.04749	26.18729	17.91539
0.05	2.36863	1.36863	27.37270	17.24628

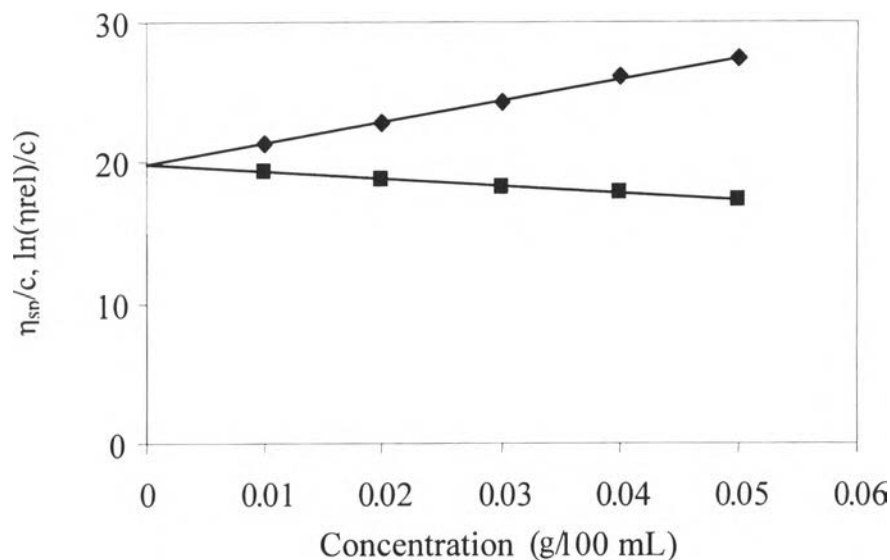


Figure B1 The plot of reduced viscosity (η_{sp}/c) and $\ln(\eta_{rel})/c$ versus concentration of chitosan solution: ◆ = (η_{sp}/c) and ■ = $\ln(\eta_{rel})/c$.

The viscosity-average molecular weight of chitosan was determined based on Mark-Houwink equation. The K and a values were according to Wang *et al.*, (1991)

$$[\eta] = 6.95 \times 10^{-5} M^{0.88}$$

where $[\eta]$ = intrinsic viscosity

M = Viscosity-average molecular weight

Interception: $[\eta] = 19.8$

From calculation; $M = 1.58 \times 10^6$

The viscosity-average molecular weight of α -chitin obtained from calculation was 1.58×10^6 g/mol.

Table B3 Running time of solvent and chitosan solution Treatment 2

Concentration (g/100 mL)	Time (second)			
	1	2	3	Average
0.00	213.49	213.48	213.04	213.33
0.01	258.10	258.23	258.29	258.20
0.02	312.01	312.03	312.00	312.01
0.03	371.30	371.47	371.85	371.54
0.04	436.94	436.98	436.98	436.96
0.05	512.85	512.85	512.73	512.81

Table B4 The data of relative viscosity (η_{rel}), specific viscosity (η_{sp}), reduced viscosity (η_{red})

Concentration (g/100 mL)	η_{rel}	η_{sp}	η_{red}	$\ln(\eta_{rel})/c$
0.00				
0.01	1.21032	0.21032	21.03246	19.08886
0.02	1.46253	0.46253	23.12697	19.00871
0.03	1.74156	0.74156	24.71888	18.49283
0.04	2.04824	1.04824	26.20622	17.92463
0.05	2.40375	1.40375	28.07518	17.54067

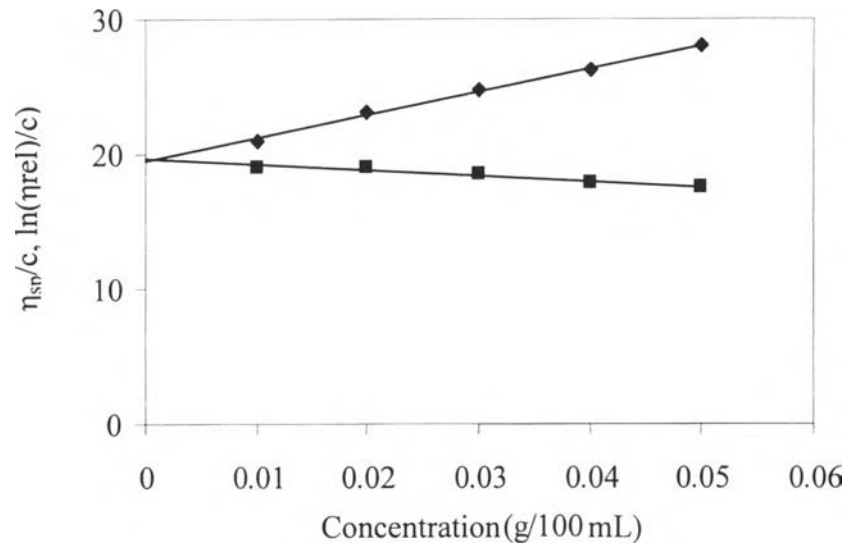


Figure B2 The plot of reduced viscosity (η_{sp}/c) and $\ln(\eta_{rel})/c$ versus concentration of chitosan solution: ◆ = (η_{sp}/c) and ■ = $\ln(\eta_{rel})/c$.

The viscosity-average molecular weight of chitosan was determined based on Mark-Houwink equation. The K and a values were according to Wang *et al.*, (1991).

$$[\eta] = 6.95 \times 10^{-5} M^{0.88}$$

where $[\eta]$ = intrinsic viscosity

M = Viscosity-average molecular weight

Interception: $[\eta] = 19.4$

From calculation; $M = 1.55 \times 10^6$

The viscosity-average molecular weight of α -chitin obtained from calculation was 1.55×10^6 g/mol.

Table B5 Running time of solvent and chitosan solution Treatment 3

Concentration (g/100 mL)	Time (second)			
	1	2	3	Average
0.00	214.57	214.34	214.44	214.45
0.01	259.50	259.41	259.34	259.41
0.02	306.81	306.56	306.28	306.55
0.03	362.19	362.00	362.13	362.10
0.04	423.10	423.09	423.69	423.29
0.05	494.66	494.93	494.25	494.61

Table B6 The data of relative viscosity (η_{rel}), specific viscosity (η_{sp}), reduced viscosity (η_{red})

Concentration (g/100 mL)	η_{rel}	η_{sp}	η_{red}	$\ln(\eta_{rel})/c$
0.00				
0.01	1.20968	0.20968	20.96837	19.03589
0.02	1.42947	0.42947	21.47354	17.86521
0.03	1.68853	0.68853	22.95122	17.46207
0.04	1.97385	0.97385	24.34639	16.99972
0.05	2.30642	1.30642	26.12855	16.71399

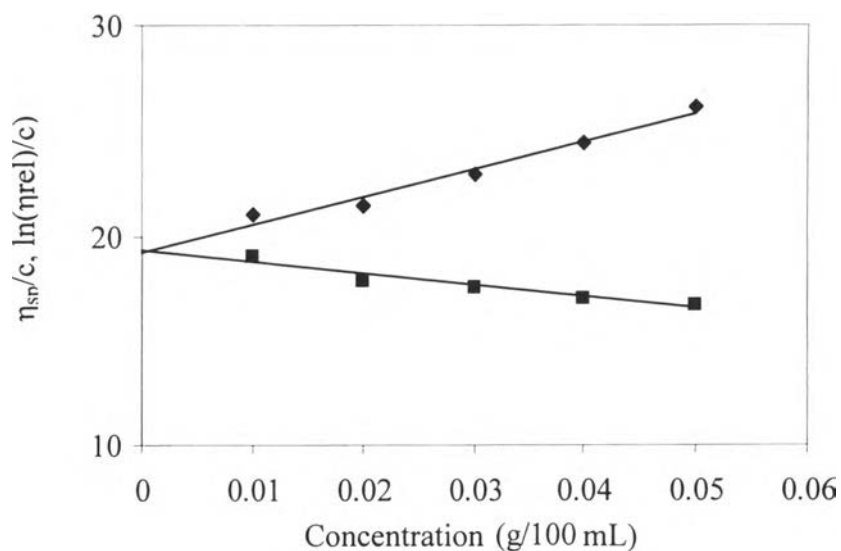


Figure B3 The plot of reduced viscosity (η_{sp}/c) and $\ln(\eta_{rel})/c$ versus concentration of chitosan solution: ◆ = (η_{sp}/c) and ■ = $\ln(\eta_{rel})/c$.

The viscosity-average molecular weight of chitosan was determined based on Mark-Houwink equation. The K and a values were according to Wang *et al.*, (1991).

$$[\eta] = 6.95 \times 10^{-5} M^{0.88}$$

where $[\eta]$ = intrinsic viscosity

M = Viscosity-average molecular weight

Interception: $[\eta] = 19.2$

From calculation; $M = 1.53 \times 10^6$

The viscosity-average molecular weight of α -chitin obtained from calculation was 1.53×10^6 g/mol.

Appendix C Mechanical Properties of Chitin Whisker-Reinforced Films

Table C1 Mechanical properties of whisker-reinforced PVA films

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
0	1	59.65	16.13
	2	56.90	16.67
	3	51.18	11.71
	4	54.61	15.47
	5	55.11	13.71
	Average	55.49	14.74
	STD	3.11	2.03
0.74	1	63.52	11.63
	2	66.58	11.11
	3	58.94	12.14
	4	67.29	13.03
	5	61.15	11.71
	Average	63.49	11.92
	STD	3.54	0.72
1.48	1	72.84	8.88
	2	69.88	9.53
	3	79.93	8.95
	4	63.67	8.87
	5	66.60	11.11
	Average	70.58	9.47
	STD	6.26	0.96

Table C1 (Continued)

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
2.96	1	81.78	7.80
	2	82.20	8.87
	3	85.49	7.61
	4	85.70	8.08
	5	81.35	6.63
	Average	83.30	7.80
	STD	2.11	0.81
7.40	1	85.10	8.62
	2	83.29	7.64
	3	84.97	6.89
	4	85.97	8.05
	5	82.70	7.60
	Average	84.41	7.76
	STD	1.36	0.63
14.8	1	92.54	6.42
	2	83.42	5.71
	3	89.08	5.59
	4	83.49	7.69
	5	81.83	5.64
	Average	86.07	6.21
	STD	4.54	0.89

Table C1 (Continued)

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
22.2	1	82.21	7.11
	2	82.90	6.74
	3	87.24	6.96
	4	85.19	6.20
	5	94.42	6.34
	Average	86.39	6.67
	STD	4.90	0.39
29.6	1	93.11	5.52
	2	86.10	5.23
	3	80.59	5.81
	4	83.29	4.92
	5	85.72	5.08
	Average	85.76	5.31
	STD	4.66	0.35

Table C2 Mechanical properties of whisker-reinforced chitosan films

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
0	1	65.20	12.58
	2	65.77	12.16
	3	64.27	11.25
	4	64.18	11.35
	5	65.31	11.38
	Average	64.94	11.74
	STD	0.69	0.59
0.74	1	68.39	11.23
	2	65.07	10.24
	3	68.40	10.68
	4	71.02	11.69
	5	71.17	10.39
	Average	68.81	10.84
	STD	2.49	0.61
1.48	1	78.70	10.24
	2	73.34	9.919
	3	75.49	10.46
	4	76.38	9.99
	5	73.43	9.86
	Average	75.47	9.95
	STD	2.23	0.48

Table C2 (Continued)

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
2.96	1	79.89	7.38
	2	82.23	7.15
	3	84.53	7.86
	4	85.28	7.02
	5	87.26	8.83
	Average	83.84	7.65
	STD	2.85	0.73
7.40	1	81.40	8.40
	2	81.51	10.06
	3	79.07	6.06
	4	82.40	6.07
	5	79.15	5.82
	Average	80.71	7.28
	STD	1.51	1.87
14.8	1	85.07	6.09
	2	80.76	8.27
	3	75.97	9.07
	4	84.57	7.06
	5	73.85	7.01
	Average	80.04	7.50
	STD	5.03	1.17

Table C2 (Continued)

Chitin Whisker Content wt (%)	Specimens	Tensile Strength (MPa)	Elongation at Break (%)
22.2	1	72.15	6.60
	2	75.40	7.68
	3	76.45	8.03
	4	80.78	6.82
	5	83.64	6.60
	Average	77.68	7.14
	STD	4.54	0.66
29.6	1	72.95	6.49
	2	74.90	5.77
	3	81.95	7.42
	4	76.45	6.39
	5	72.43	8.52
	Average	75.74	6.92
	STD	3.82	1.07

Appendix D Percent Weight Loss of Chitin Whisker-Reinforced Films

Table D1 Percent weight loss of reinforced PVA films after immersing in distilled water for 24 h.

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
0	1	91.38	90.82	3.08
	2	87.50		
	3	93.59		
0.74	1	91.94	86.90	6.90
	2	79.03		
	3	89.74		
1.48	1	88.60	84.25	8.77
	2	90.00		
	3	74.15		
2.96	1	87.14	82.25	5.39
	2	83.14		
	3	76.47		
7.40	1	60.19	65.46	8.98
	2	60.38		
	3	75.83		
14.8	1	60.41	60.38	1.48
	2	58.88		
	3	61.83		

Table D1 (Continued)

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
22.2	1	63.33	60.30	5.60
	2	63.75		
	3	53.84		
29.6	1	62.13	60.29	1.81
	2	60.21		
	3	58.51		

Table D2 Percent weight loss of reinforced PVA films (autoclaved at 110°C for 5 min) after immersion in distilled water for 24 h.

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
0	1	37.50	36.79	0.94
	2	35.71		
	3	37.14		
0.74	1	30.77	28.67	3.19
	2	25.00		
	3	30.23		
1.48	1	17.86	18.58	1.50
	2	17.57		
	3	20.31		
2.96	1	20.45	19.29	1.20
	2	18.05		
	3	19.35		
7.40	1	17.75	18.00	0.22
	2	18.08		
	3	18.18		
14.8	1	18.75	18.70	1.87
	2	20.54		
	3	16.81		

Table D2 (Continued)

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
22.2	1	15.08	17.76	2.58
	2	17.98		
	3	20.22		
29.6	1	19.16	17.05	2.44
	2	14.38		
	3	17.60		

Table D3 Percent weight loss of reinforced PVA films (autoclaved at 110°C for 10 min) after immersion in distilled water for 24 h.

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
0	1	15.25	13.58	1.75
	2	11.76		
	3	13.72		
0.74	1	12.07	12.03	0.24
	2	11.76		
	3	12.24		
1.48	1	9.17	10.20	1.84
	2	12.32		
	3	9.09		
2.96	1	10.20	9.53	0.66
	2	8.88		
	3	9.52		
7.40	1	9.60	8.92	0.95
	2	7.82		
	3	9.34		
14.8	1	6.08	7.81	1.51
	2	8.93		
	3	8.41		

Table D3 (Continued)

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
22.2	1	6.06	7.03	2.24
	2	5.43		
	3	9.60		
29.6	1	7.84	7.22	0.61
	2	6.61		
	3	7.21		

Table D4 Percent weight loss of reinforced chitosan films (autoclaved at 110°C for 5 min) after immersion in distilled water for 24 h.

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
0	1	14.85	15.37	0.45
	2	15.59		
	3	15.66		
0.74	1	14.01	13.41	1.09
	2	14.07		
	3	12.15		
1.48	1	12.38	12.31	0.136
	2	12.41		
	3	12.16		
2.96	1	14.49	12.10	2.40
	2	12.14		
	3	9.67		
7.40	1	10.65	12.24	2.99
	2	10.37		
	3	15.70		
14.8	1	10.83	12.62	2.67
	2	11.34		
	3	15.68		

Table D4 (Continued)

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
22.2	1	9.02	10.06	1.63
	2	9.23		
	3	11.94		
29.6	1	11.30	10.64	0.57
	2	10.27		
	3	10.34		

Table D5 Percent weight loss of reinforced chitosan films (autoclaved at 110°C for 10 min) after immersion in distilled water for 24 h.

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
0	1	13.88	11.27	2.36
	2	10.63		
	3	9.30		
0.74	1	9.45	10.27	0.71
	2	10.57		
	3	10.80		
1.48	1	10.00	10.06	0.11
	2	10.00		
	3	10.20		
2.96	1	10.27	10.04	0.21
	2	10.00		
	3	9.84		
7.40	1	9.45	9.30	0.55
	2	9.77		
	3	8.69		
14.8	1	8.59	9.58	0.93
	2	9.72		
	3	10.44		

Table D5 (Continued)

Chitin Whisker Content wt (%)	Specimens	% Weight Loss	Average	STD
22.2	1	9.37	9.01	0.31
	2	8.82		
	3	8.84		
29.6	1	8.33	9.62	2.50
	2	8.02		
	3	12.5		

Appendix E Effect of Time on Degree of Swelling of the Reinforced Films

Table E1 Degree of swelling of PVA film (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	413.46	410.23	415.23	412.97	2.53
1.0	421.15	415.26	420.13	418.85	3.14
1.5	430.76	420.16	425.23	425.39	5.30
2.0	438.46	428.21	430.11	432.26	5.45
2.5	469.23	450.02	460.23	459.82	9.61
3.0	484.61	460.26	475.13	473.33	12.27
3.5	486.53	469.26	480.12	478.64	8.73
4.0	498.07	480.23	485.11	487.80	9.22
4.5	500	495.33	495.13	496.82	2.75
5.0	505.76	500.11	502.32	502.73	2.85
7.5	509.61	505.16	507.25	507.34	2.22
10.0	513.46	510.23	511.23	511.64	1.65
15.0	515.38	515.22	515.32	515.31	0.08
20.0	519.23	518.20	519.71	519.04	0.77
25.0	521.15	520.11	521.03	520.76	0.56
30.0	523.07	522.31	523.06	522.82	0.43
40.0	526.92	526.23	526.33	526.49	0.37
50.0	532.69	530.13	530.16	530.99	1.46
60.0	536.53	535.46	535.48	535.82	0.61
120.0	548.07	540.01	545.13	544.40	4.08

Table E2 Degree of swelling of PVA reinforced with 7.40 wt% chitin whisker content (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	315.38	310.45	315.46	313.76	2.87
1.0	334.06	329.00	333.01	332.02	2.67
1.5	343.95	338.00	343.11	341.69	3.22
2.0	354.94	349.36	355.12	353.14	3.27
2.5	357.14	353.72	357.16	356.01	1.97
3.0	361.53	358.27	360.28	360.03	1.64
3.5	364.83	359.54	364.11	362.83	2.86
4.0	368.13	366.27	368.26	367.55	1.11
4.5	373.62	371.81	373.49	372.97	1.00
5.0	376.92	375.90	376.18	376.33	0.52
7.5	380.21	380.27	380.16	380.21	0.05
10.0	381.31	387.26	381.46	383.35	3.39
15.0	393.40	393.12	390.16	392.23	1.79
20.0	397.80	395.45	397.12	396.79	1.20
25.0	405.49	399.18	405.15	403.27	3.55
30.0	412.08	423.63	410.16	415.29	7.28
40.0	414.28	432.72	416.49	421.16	10.07
50.0	423.07	447.27	423.16	431.17	13.94
60.0	424.17	454.36	430.94	436.49	15.83
120.0	439.56	460.90	439.59	446.68	12.31

Table E3 Degree of swelling of PVA reinforced with 29.6 wt% chitin whisker content (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	264.47	260.49	264.26	263.08	2.24
1.0	276.32	273.47	275.16	274.98	1.43
1.5	294.74	290.13	293.15	292.67	2.34
2.0	300.00	298.14	300.17	299.44	1.12
2.5	307.89	305.24	305.07	306.07	1.59
3.0	311.84	310.65	311.86	311.45	0.69
3.5	315.79	315.84	315.65	315.76	0.10
4.0	318.42	318.30	318.75	318.49	0.24
4.5	321.05	320.65	321.59	321.10	0.47
5.0	327.63	325.61	327.16	326.80	1.06
7.5	331.58	330.65	330.19	330.81	0.71
10.0	334.21	335.26	334.59	334.69	0.53
15.0	338.16	338.85	338.57	338.53	0.35
20.0	342.11	342.66	342.59	342.45	0.30
25.0	344.74	344.30	344.26	344.43	0.26
30.0	347.37	345.47	347.59	346.81	1.17
40.0	348.68	348.65	348.66	348.66	0.02
50.0	350.00	350.34	350.26	350.20	0.18
60.0	351.32	353.26	353.16	352.58	1.10
120.0	352.63	355.62	355.05	354.43	1.59

Table E4 Degree of swelling of chitosan film (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	185.09	182.41	188.26	185.25	2.93
1.0	187.72	186.11	187.55	187.13	0.88
1.5	188.60	188.89	188.33	188.60	0.28
2.0	192.98	194.44	190.47	192.63	2.01
2.5	193.86	196.30	190.26	193.47	3.03
3.0	198.25	198.15	198.24	198.21	0.05
3.5	202.63	204.63	202.16	203.14	1.31
4.0	206.14	206.48	206.23	206.29	0.18
4.5	207.89	212.04	208.27	209.40	2.29
5.0	209.65	213.89	209.35	210.96	2.54
7.5	213.16	214.81	211.24	213.07	1.79
10.0	215.79	217.59	215.27	216.22	1.22
15.0	225.44	220.37	218.23	221.35	3.70
20.0	227.19	225.00	227.16	226.45	1.26
25.0	230.70	226.85	230.15	229.24	2.08
30.0	232.46	231.48	233.27	232.40	0.89
40.0	234.21	234.26	234.26	234.24	0.03
50.0	236.84	244.44	238.24	239.84	4.05
60.0	237.72	250.93	244.27	244.30	6.60
120.0	240.35	251.85	248.46	246.89	5.91

Table E5 Degree of swelling of chitosan reinforced with 7.40 wt% chitin whisker content (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	149.54	140.25	145.27	145.02	4.65
1.0	155.05	150.20	155.26	153.50	2.86
1.5	156.88	153.03	156.26	155.39	2.07
2.0	158.72	155.46	158.12	157.43	1.73
2.5	164.22	160.25	162.25	162.24	1.99
3.0	167.89	165.23	167.23	166.79	1.39
3.5	169.72	169.23	169.48	169.48	0.24
4.0	170.64	172.59	170.16	171.13	1.29
4.5	175.23	176.37	175.24	175.61	0.65
5.0	177.06	178.27	177.30	177.55	0.64
7.5	178.90	178.25	178.61	178.59	0.33
10.0	179.82	180.22	180.27	180.10	0.25
15.0	182.57	182.21	182.00	182.26	0.29
20.0	188.07	186.23	187.24	187.18	0.92
25.0	188.99	188.23	188.48	188.57	0.39
30.0	191.74	191.22	191.27	191.41	0.29
40.0	193.58	193.22	193.02	193.27	0.28
50.0	200.00	198.26	200.17	199.48	1.05
60.0	202.75	202.32	202.17	202.41	0.30
120.0	203.67	205.32	203.17	204.05	1.12

Table E6 Degree of swelling of chitosan reinforced with 29.6 wt% chitin whisker content (autoclaved at 110°C for 5 min)

Time (minutes)	Degree of swelling (%)			Average	STD
	X1	X2	X3		
0.0	0.00	0.00	0.00	0.00	0.00
0.5	95.96	101.68	98.28	98.64	43.94
1.0	97.98	104.20	100.86	101.01	44.78
1.5	98.99	106.72	102.59	102.77	45.37
2.0	100.00	109.24	104.31	104.52	45.96
2.5	102.02	110.92	106.03	106.33	46.54
3.0	103.03	111.76	107.76	107.52	46.84
3.5	105.05	114.29	109.48	109.61	47.56
4.0	107.07	115.13	112.93	111.71	48.26
4.5	111.11	117.65	115.52	114.76	49.37
5.0	112.12	119.33	118.10	116.52	49.95
7.5	117.17	121.01	119.83	119.34	50.03
10.0	118.18	123.53	121.55	121.09	49.72
15.0	121.21	125.21	123.28	123.23	48.42
20.0	122.22	126.89	125.00	124.70	46.85
25.0	126.26	129.41	126.72	127.47	45.84
30.0	131.31	130.25	128.45	130.00	44.74
40.0	132.32	131.09	130.17	131.20	40.79
50.0	135.35	131.93	133.62	133.64	37.42
60.0	138.38	135.29	136.21	136.63	34.29
120.0	143.43	136.97	138.79	139.73	9.13

Appendix F Decomposition Temperature of Reinforced Films

Table F1 Decomposition temperatures of whisker-reinforced PVA films from thermogravimetric analysis

Chitin whisker content (wt%)	Decomposition temperature of PVA nanocomposite films (°C)	Decomposition temperature of Chitin (°C)
0	274.8	-
0.74	283.0	-
1.48	277.5	-
2.96	270.1	-
7.40	286.5	-
14.8	286.4	-
22.2	290.1	-
29.6	291.4	-
100	-	347.6

Table F2 Decomposition temperatures of whisker-reinforced chitosan films from thermogravimetric analysis

Chitin whisker content (wt%)	Decomposition temperature of chitosan nanocomposite films (°C)	Decomposition temperature of Chitin (°C)
0	290.8	-
0.74	290.4	-
1.48	291.1	-
2.96	289.1	-
7.40	290.3	-
14.8	290.8	-
22.2	289.9	-
29.6	286.9	-
100	-	347.6

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