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APPENDICES

Appendix A Melt Flow Index (MFI) of virgin PP and PP nanocomposites

Table A1 MFI results at 210 °C

Sample	MFI (g/10 min)			Average MFI (g/10 min)
	1	2	3	
Virgin PP	3.588	3.756	3.756	3.700 ± 0.097
PPC-MPS	4.968	4.940	4.896	4.935 ± 0.036
PPC-PLASMA	4.132	4.116	4.136	4.128 ± 0.011
PPC-0.1DCP	10.956	11.156	10.800	10.970 ± 0.178
PPC-0.2DCP	12.480	12.720	12.848	12.680 ± 0.188
PPC-0.3DCP	22.192	22.132	20.092	21.470 ± 1.195

Appendix B Tensile properties of pure PP and PP nanocomposite films

Table B1 Film thickness of neat PP and PP nanocomposite films for tensile tests

Sample	Thickness (mm)	
	Machine direction	Transverse direction
Neat PP	0.029 ± 0.003	0.023 ± 0.001
PPBEN	0.044 ± 0.002	0.043 ± 0.004
PPS5BEN	0.034 ± 0.001	0.031 ± 0.001
PPS10BEN	0.034 ± 0.002	0.030 ± 0.001
PPS15BEN	0.027 ± 0.002	0.026 ± 0.001
PPS20BEN	0.024 ± 0.003	0.033 ± 0.003

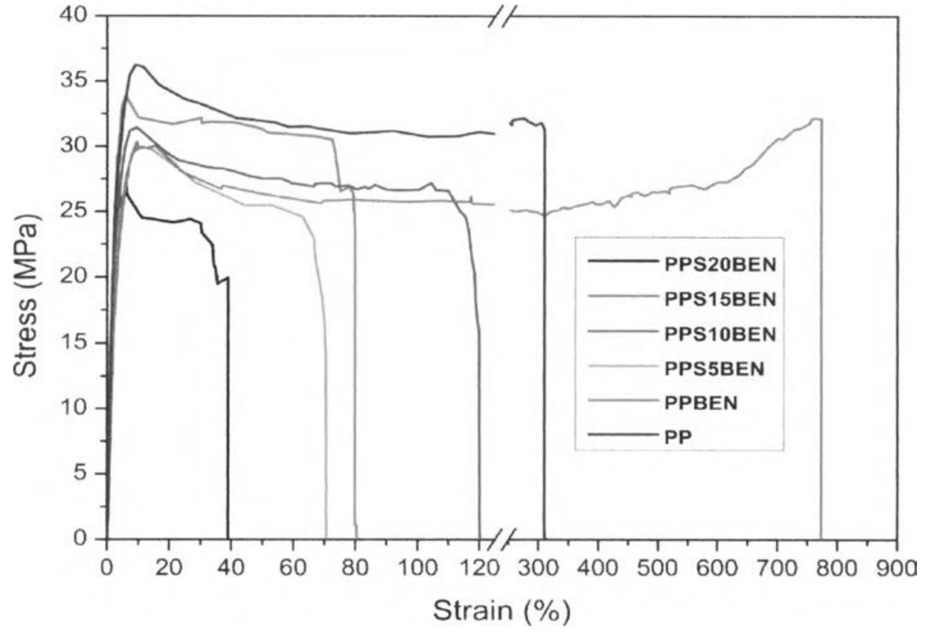

Figure B1 Stress – Strain curves of neat PP and PP nanocomposite films from tensile tests.

Appendix C Melt Flow Index (MFI) of neat PP and PP nanocomposites

Table C1 MFI results at 210 °C

Sample	MFI (g/10 min)			Average MFI (g/10 min)
	1	2	3	
Neat PP	2.184	2.184	2.224	2.197 ± 0.023
PPBEN	2.176	2.096	2.196	2.156 ± 0.053
PPS5BEN	1.908	2.036	1.924	1.956 ± 0.070
PPS10BEN	2.148	2.176	2.164	2.162 ± 0.014
PPS15BEN	2.508	2.400	2.584	2.500 ± 0.092
PPS20BEN	2.172	2.244	2.256	2.224 ± 0.045

Appendix D TVBN Results

Table D1 TVBN Results

Hours	0.01 HCl (mL)	TVBN (mg N/100 g Sample)
0	0.05	3.18
3	0.45	28.59
6	0.50	32.69
9	0.65	41.30

Appendix E Gas Barrier Properties of Neat PP and PP nanocomposite Films

Table E1 Water vapor permeability rate (WVPR) of neat PP and PP-clay nanocomposite films

Sample	Film thickness (mm)	WVPR (g/m^2/day)		
		1	2	Average
PP	0.047	2.74	2.74	2.74 (0.00)[a]
PPBEN	0.065	0.63	0.61	0.62 (0.11)
PPS5BEN	0.042	0.88	0.88	0.88 (0.00)
PPS10BEN	0.052	0.64	0.94	0.79 (0.21)
PPS15BEN	0.049	0.84	0.76	0.80 (0.04)
PPS20BEN	0.045	0.87	0.87	0.87 (0.00)

[a] Standard deviation of WVPR measurement

Table E2 Oxygen transmission rate (OTR) of neat PP and PP-clay nanocomposite films

Sample	Film thickness (mm)	OTR (cc/m^2/day)			
		1	2	3	Average
PP	0.021	5261	5290	5419	5323 (84)[a]
PPBEN	0.039	3696	3287	3757	3580 (256)
PPS5BEN	0.028	4012	3736	4056	3935 (173)
PPS10BEN	0.029	4589	4538	4570	4566 (26)
PPS15BEN	0.030	4512	4150	4430	4364 (192)
PPS20BEN	0.030	3796	4227	4160	4061 (232)

[a] Standard deviation of OTR measurement

Appendix F Physical Properties of Neat EVA and Sensor Films

Table F1 Film thickness of neat EVA and EVA-SAP-CMC composite films

Sample	Thickness (mm)
Neat EVA	0.113 ± 0.013
1 wt% SAP-CMC	0.147 ± 0.043
3 wt% SAP-CMC	0.156 ± 0.052
5 wt% SAP-CMC	0.152 ± 0.033

Appendix G Color (in Hunter Lab System) of Neat EVA Films and EVA-SAP-CMC Films at Different Weights of SAP-CMC Powder

Table G1 Color (in Hunter Lab system) of Neat EVA films

No.	MATERIALS	L*	a*	b*
	WHITE STANDARD	93.13	-1.28	1.59
1	Neat EVA	15.77	-0.78	-2.38
2	Neat EVA	15.92	-1.11	-1.85
3	Neat EVA	15.81	-0.80	-2.55
4	Neat EVA	15.80	-0.64	-2.56
5	Neat EVA	15.82	-0.80	-2.15
6	Neat EVA	15.82	-0.72	-2.10
7	Neat EVA	16.00	-0.79	-2.14
8	Neat EVA	15.77	-0.39	-2.64
9	Neat EVA	15.83	-0.79	-2.43
10	Neat EVA	15.88	-0.89	-2.37
11	Neat EVA	15.87	-0.87	-2.20
12	Neat EVA	15.96	-0.93	-1.75
13	Neat EVA	15.90	-0.89	-2.14
14	Neat EVA	15.97	-0.62	-2.09
15	Neat EVA	15.91	-0.74	-2.55
16	Neat EVA	15.87	-0.81	-2.68
17	Neat EVA	15.86	-0.91	-2.64
18	Neat EVA	16.08	-1.02	-2.39
19	Neat EVA	16.03	-0.84	-2.29
20	Neat EVA	15.89	-0.95	-2.38
21	Neat EVA	16.11	-0.90	-1.97
22	Neat EVA	15.91	-1.04	-2.37
23	Neat EVA	15.96	-0.90	-2.27
24	Neat EVA	15.94	-0.90	-2.34
25	Neat EVA	16.04	-0.90	-2.13
26	Neat EVA	15.83	-0.76	-2.53
27	Neat EVA	16.12	-0.99	-2.31
28	Neat EVA	16.06	-0.85	-1.64
29	Neat EVA	16.04	-0.87	-2.19
30	Neat EVA	16.20	-1.01	-2.05
	Average	**15.93**	**-0.85**	**-2.27**
	Standard deviation	**0.11**	**0.14**	**0.26**

Table G2 Color (in Hunter Lab system) of 1 wt% SAP-CMC in EVA-SAP-CMC films

No.	MATERIALS	L*	a*	b*
	WHITE STANDARD	93.13	-1.28	1.59
1	1% SAP-CMC	25.86	1.87	0.93
2	1% SAP-CMC	21.26	2.04	1.00
3	1% SAP-CMC	23.30	0.89	1.06
4	1% SAP-CMC	23.10	1.15	0.86
5	1% SAP-CMC	23.69	1.20	0.70
6	1% SAP-CMC	23.31	1.70	0.93
7	1% SAP-CMC	23.37	1.63	1.02
8	1% SAP-CMC	23.29	1.49	0.98
9	1% SAP-CMC	22.95	0.49	0.63
10	1% SAP-CMC	21.61	0.70	0.84
11	1% SAP-CMC	21.63	0.61	0.67
12	1% SAP-CMC	21.69	0.65	0.55
13	1% SAP-CMC	23.12	0.49	0.76
14	1% SAP-CMC	23.15	0.47	0.81
15	1% SAP-CMC	23.76	1.77	1.39
16	1% SAP-CMC	25.11	0.88	0.73
17	1% SAP-CMC	25.48	1.08	0.70
18	1% SAP-CMC	25.71	0.90	1.10
19	1% SAP-CMC	25.67	0.83	1.00
20	1% SAP-CMC	25.68	0.97	0.96
21	1% SAP-CMC	22.51	1.16	0.60
22	1% SAP-CMC	22.53	1.26	0.55
23	1% SAP-CMC	22.50	1.23	0.55
24	1% SAP-CMC	25.03	1.68	1.35
25	1% SAP-CMC	24.82	1.73	1.55
26	1% SAP-CMC	21.59	1.07	0.57
27	1% SAP-CMC	21.68	1.09	0.75
28	1% SAP-CMC	21.73	0.73	0.59
29	1% SAP-CMC	23.71	1.18	0.72
30	1% SAP-CMC	22.66	1.37	0.54
	Average	**23.38**	**1.14**	**0.85**
	Standard deviation	**1.44**	**0.44**	**0.26**

Table G3 Color (in Hunter Lab system) of 3 wt% SAP-CMC in EVA-SAP-CMC films

No.	MATERIALS	L*	a*	b*
	WHITE STANDARD	93.13	-1.28	1.59
1	3% SAP-CMC	20.83	4.71	2.33
2	3% SAP-CMC	21.09	4.68	2.64
3	3% SAP-CMC	20.97	4.79	2.32
4	3% SAP-CMC	20.97	4.68	2.25
5	3% SAP-CMC	20.80	4.90	2.10
6	3% SAP-CMC	20.59	4.99	1.89
7	3% SAP-CMC	20.55	4.14	2.26
8	3% SAP-CMC	21.21	3.53	1.98
9	3% SAP-CMC	20.94	3.68	1.72
10	3% SAP-CMC	21.18	3.73	1.95
11	3% SAP-CMC	21.03	3.55	1.50
12	3% SAP-CMC	21.35	3.71	1.97
13	3% SAP-CMC	21.53	3.68	2.22
14	3% SAP-CMC	21.46	4.02	1.88
15	3% SAP-CMC	21.29	4.16	2.49
16	3% SAP-CMC	21.34	4.22	2.65
17	3% SAP-CMC	21.34	4.28	2.14
18	3% SAP-CMC	21.35	4.10	2.31
19	3% SAP-CMC	21.26	4.20	2.69
20	3% SAP-CMC	21.23	4.24	2.29
21	3% SAP-CMC	22.39	3.72	2.27
22	3% SAP-CMC	22.93	3.82	2.09
23	3% SAP-CMC	22.90	3.54	2.19
24	3% SAP-CMC	22.94	3.47	2.08
25	3% SAP-CMC	22.95	3.60	2.23
26	3% SAP-CMC	22.05	3.71	2.01
27	3% SAP-CMC	22.39	3.70	2.07
28	3% SAP-CMC	23.47	3.85	1.75
29	3% SAP-CMC	22.10	3.69	1.82
30	3% SAP-CMC	23.90	3.57	1.98
	Average	**21.68**	**4.02**	**2.14**
	Standard deviation	**0.90**	**0.46**	**0.28**

Table G4 Color (in Hunter Lab system) of 5 wt% SAP-CMC in EVA-SAP-CMC films

No.	MATERIALS	L*	a*	b*
	WHITE STANDARD	93.13	-1.28	1.59
1	5% SAP-CMC	18.73	8.27	4.65
2	5% SAP-CMC	18.37	8.84	4.13
3	5% SAP-CMC	18.76	8.37	4.07
4	5% SAP-CMC	17.83	7.21	3.43
5	5% SAP-CMC	17.92	7.18	3.19
6	5% SAP-CMC	17.97	6.98	3.72
7	5% SAP-CMC	19.62	7.66	4.09
8	5% SAP-CMC	19.82	7.35	4.23
9	5% SAP-CMC	17.91	7.53	4.32
10	5% SAP-CMC	18.14	7.61	4.56
11	5% SAP-CMC	17.80	7.97	3.61
12	5% SAP-CMC	18.01	7.98	4.19
13	5% SAP-CMC	18.13	7.89	4.36
14	5% SAP-CMC	18.19	5.24	2.63
15	5% SAP-CMC	18.22	4.72	3.03
16	5% SAP-CMC	18.38	4.80	2.25
17	5% SAP-CMC	18.76	7.37	2.34
18	5% SAP-CMC	18.80	7.02	2.09
19	5% SAP-CMC	18.99	6.51	3.16
20	5% SAP-CMC	18.85	6.32	3.75
21	5% SAP-CMC	18.89	7.45	2.99
22	5% SAP-CMC	18.85	7.07	2.79
23	5% SAP-CMC	19.16	6.72	2.95
24	5% SAP-CMC	19.01	6.32	2.77
25	5% SAP-CMC	18.88	6.02	2.2
26	5% SAP-CMC	18.99	5.91	2.39
27	5% SAP-CMC	19.00	5.71	2.64
28	5% SAP-CMC	18.96	5.97	2.52
29	5% SAP-CMC	19.09	5.71	2.64
30	5% SAP-CMC	18.96	5.42	3.01
	Average	**18.63**	**6.84**	**3.29**
	Standard deviation	**0.53**	**1.08**	**0.79**

Appendix H Changes in pH of standard ammonia

Table H1 Changes in pH of standard ammonia

Standard solution	Concentration (mg/mL)	pH
Water (blank)	0	7.56
1	0.10	9.25
2	0.20	9.54
3	0.30	9.60
4	0.40	9.80
5	0.50	9.92
6	1.00	10.27
7	5.00	10.76
8	10.00	10.87
9	15.00	10.98
10	20.00	11.09
11	25.00	11.11
12	30.00	11.27
13	35.00	11.31

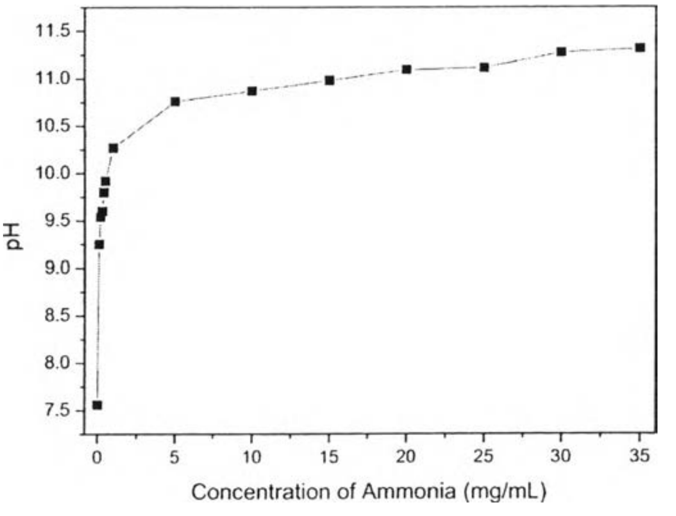

Figure H1 Changes in pH of standard ammonia.

Appendix I Changes in pH of total volatile basic nitrogen (TVBN) of fresh fish during storage at room temperature

Table I1 Changes in pH of total volatile basic nitrogen (TVBN) of fresh fish during storage at room temperature

Hour	pH
0	6.20
3	6.22
6	6.36
9	6.53
12	6.59

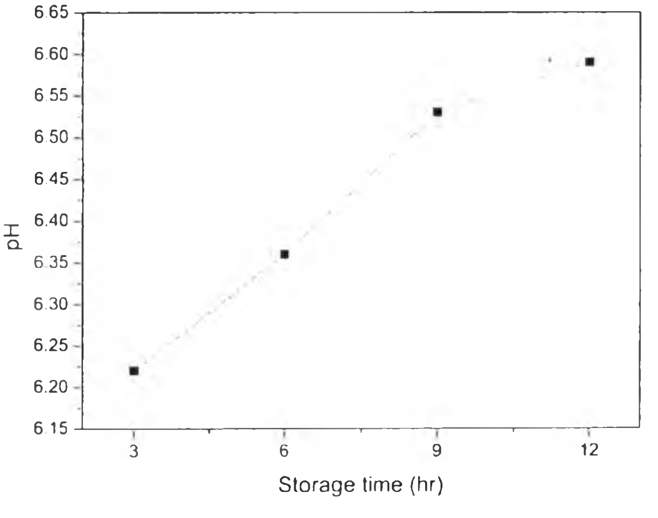

Figure I1 Changes in pH of total volatile basic nitrogen (TVBN) of fresh fish during storage at room temperature.

Appendix J Change in Hunter color (L*, a*, b*) and total color difference (ΔE) values of the EVA- 5wt% SAP-CMC film

Table J1 Changes in Hunter color (L*, a*, b*) and total color difference (ΔE) values of the indicator film during the fish storage at room temperature

Time (Hours)	L	a	b	ΔL*	Δa*	Δb*	ΔE*	Average ΔE*
3	17.17	6.84	4.68	-1.46	0.19	1.38	2.02	
3	17.05	6.99	4.54	-1.58	0.34	1.24	2.04	1.82
3	18.08	6.87	4.58	-0.55	0.22	1.28	1.41	
6	21.45	7.54	5.6	2.82	0.89	2.30	3.74	
6	21.33	7.54	5.68	2.70	0.89	2.38	3.70	3.79
6	21.81	7.36	5.5	3.18	0.71	2.20	3.93	
9	23.57	7.57	5.64	4.94	0.92	2.34	5.54	
9	24.33	7.7	5.66	5.70	1.05	2.36	6.25	6.03
9	24.42	7.6	5.63	5.79	0.95	2.33	6.31	
12	26.06	6.73	6.16	7.43	0.08	2.86	7.96	
12	25.61	6.91	6.36	6.98	0.26	3.06	7.62	7.71
12	25.55	6.84	6.29	6.92	0.19	2.99	7.54	

CURRICULUM VITAE

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Proceedings:

1. Suyjiw, S.; and Magaraphan, R. (2013, April 23rd) Performance of Natural Dye-Plastic Sensor for Fish Freshness. Proceedings of the 19th PPC Symposium in Petroleum, Petrochemical and Polymers, Bangkok, Thailand.

Presentations:

1. Suyjiw, S.; and Magaraphan, R. (2012, December 11th - 15rd) Preparation of Polypropylene/Clay Nanocomposites via a Reactive Processing. Poster presented at the 28th International Conference of The Polymer Processing Society (PPS-28), Pattaya, Chonburi, Thailand.

2. Suyjiw, S.; and Magaraphan, R. (2013, April 23rd) Performance of Natural Dye-Plastic Sensor for Fish Freshness. Poster presented at the 19th PPC Symposium in Petroleum, Petrochemical and Polymers, Bangkok, Thailand.

3. Suyjiw, S.; and Magaraphan, R. (2013, May 21st - 23rd) Characterization of Silver/Clay Nanoparticles Polypropylene Nanocomposite Films Fabricated by a Cold Plasma Technique, Followed by Blown Film Extrusion. Poster presented at the 3rd International Symposium Frontiers in Polymer Science in association with Journal Polymer, Sitges (near Barcelona), Spain.