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APPENDIX A

EXPERIMENT METHOD

Dynamic mechanical thermal analysis (DMA)

The technique of DMA was used to determine the glass transition temperature of polymers via their state of molecular motion in polymers. This technique relies on impressing a small sinusoidally varying stress (usually as a function of the sine wave) on to the material under test and transducing the strain while the temperature was rise. The results indicated the sinusoidal stress-strain relationship, the phase angle between the stress wave and the strain wave is called δ.

The phase angle (δ) is a measure of the viscous response of the material to the dynamic strain. In the case of an ideal elastic solid, it follow from Hook's law that the stress is always in phase with the strain, i.e. $\delta = 0$. In contrast, the stress of an ideal viscous fluid is always 90° out of phase with the strain, i.e. $\delta = \pi/2$. At temperature below Tg, polymeric material behave more as Hookean solids at small deformation, but at higher temperature their behavior is distinctly viscoelastic. Over the test temperature range of $-150^{\circ}C$ to $50^{\circ}C$, δ will have a temperature dependence value between 0° (totally elastic) and 90° (totally viscous). For polymeric material, the maxima in tan δ occurs at Tg when the impressed frequency matches the frequency of molecular relaxation through thermally activated processes. Relaxations in the amorphous phase are labeled with the Greek alphabet (α, β, γ) with decreasing temperature.

Clarity of film testing

The light was transmitted through the sample and measured the D value. Thereafter, calculated the transmittance of film from the equation as follow

$$\log 1 / T = D$$
$$T = (1/10^{D}) * 100$$

where : T = transmittance of film (%)   D = Density of film

Melt flow index of the blend

The melt flow index of the blend from the mixing materials with different melt flow index can be calculate from the equation as follow

$$\text{MFI blend} = 10^{((W1 * \log MFI1)+(W2 * \log MFI2))}$$

where : MFIblend = Melt flow index of the blend

MFI1 = Melt flow index of component 1

MFI2 = Melt flow index of component 2

W1 = Weight fraction of component 1

W2 = Weight fraction of component 2

Density of the blend

The density of blending can be calculated from the follow equation.

$$V\ blend = W1*V1 + W2*V2$$

$$1/Dblend = W1*(1/D1) + W2*(1/D2)$$

where Vblend = Volume of the blend

W1 = Weight fraction of MLLDPE

W2 = Weight fraction of HDPE

D1 = Density of MLLDPE

D2 = Density of HDPE

Dblend = Density of the blend

APPENDIX B

THE RESULT OF EXPERIMENT

Mechanical properties of HDPE/LLDPE film at 25 micron thickness

Table A1 : Tensile strength of HDPE/LLDPE film at 25 micron thickness

LLDPE content (% by weight)		Tensile strength of HDPE/MLLDPE film (kg/cm^2)							Tensile strength of HDPE/Z-NLLDPE film (kg/cm^2)						
		1	2	3	4	5	X	σ	1	2	3	4	5	X	σ
0	MD	580	540	570	570	540	560	19	580	540	570	570	540	560	19
	TD	390	360	340	350	380	360	21	390	360	340	350	380	360	21
5	MD	570	520	540	560	560	550	20	NA	NA	NA	NA	NA	NA	NA
	TD	390	350	320	340	360	350	26	NA	NA	NA	NA	NA	NA	NA
10	MD	550	520	570	540	560	550	19	500	460	490	510	480	490	19
	TD	290	340	310	310	340	320	22	310	290	310	270	330	300	23
15	MD	490	520	510	490	480	500	16	NA	NA	NA	NA	NA	NA	NA
	TD	270	260	240	260	310	270	26	NA	NA	NA	NA	NA	NA	NA
20	MD	540	510	500	540	530	520	18	470	490	450	450	500	470	23
	TD	360	300	340	340	310	330	24	280	290	240	310	240	270	31
25	MD	500	470	460	480	470	480	15	430	430	390	400	410	410	18
	TD	260	320	280	310	280	290	24	290	220	230	260	260	250	28
30	MD	460	430	450	410	450	440	20	380	430	400	390	410	400	19
	TD	260	330	280	300	280	290	26	260	270	230	230	240	250	18
40	MD	450	390	420	450	450	430	27	380	430	400	370	380	390	24
	TD	230	250	210	270	230	240	23	170	240	190	200	180	200	27

Table A2 : Elongation at break of HDPE/LLDPE film at 25 micron thickness.

LLDPE content (% by weight)		Elongation of HDPE/MLLDPE film (%)							Elongation of HDPE/Z-NLLDPE film (%)						
		1	2	3	4	5	X	σ	1	2	3	4	5	X	σ
0	MD	300	260	250	250	290	270	23	300	260	250	250	290	270	23
	TD	430	400	390	410	390	400	17	430	400	390	410	390	400	17
5	MD	260	280	290	300	260	280	18	NA	NA	NA	NA	NA	NA	NA
	TD	460	390	450	420	410	430	29	NA	NA	NA	NA	NA	NA	NA
10	MD	280	300	260	250	280	270	19	240	310	250	270	250	260	28
	TD	450	420	400	410	460	430	26	440	390	390	420	450	420	28
15	MD	310	260	290	280	320	290	24	NA	NA	NA	NA	NA	NA	NA
	TD	470	450	420	420	460	440	23	NA	NA	NA	NA	NA	NA	NA
20	MD	310	290	270	260	280	280	19	230	290	300	270	270	270	27
	TD	460	420	450	430	460	440	18	430	370	390	410	420	400	24
25	MD	300	260	260	280	310	280	23	320	260	280	260	270	280	25
	TD	490	420	450	470	440	450	27	450	400	390	410	380	400	27
30	MD	290	290	270	300	310	290	15	300	260	290	250	270	270	21
	TD	440	460	420	450	410	440	21	400	440	430	450	440	430	19
40	MD	310	340	290	350	320	320	24	310	320	280	260	270	290	26
	TD	470	420	470	460	480	460	23	410	400	450	420	460	430	26

Table A3 : Impact strength of HDPE/LLDPE film at 25 micron thickness

LLDPE content (% by weight)	Impact strength of HDPE/MLLDPE film (kg cm/cm)							Impact strength of HDPE/Z-NLLDPE film (kg cm/cm)						
	1	2	3	4	5	X	σ	1	2	3	4	5	X	σ
0	4200	3600	3800	3900	4100	3920	239	4200	3600	3800	3900	4100	3920	239
5	4100	3800	3900	3500	3900	3800	219	NA	NA	NA	NA	NA	NA	NA
10	3900	3800	3900	3600	3200	3700	295	3600	3400	3500	3500	3200	3400	152
15	3000	3200	3500	3700	3300	3300	270	NA	NA	NA	NA	NA	NA	NA
20	3300	3000	2900	2700	3200	3000	239	2900	3400	3100	2800	2900	3000	239
25	3300	2700	3400	2700	3200	3100	336	3300	2800	2900	2900	2700	2900	228
30	2800	3100	2600	2900	2800	2800	182	2400	2700	2800	2400	2900	2600	230
40	2700	3100	2800	2800	3300	2900	251	2700	2700	2600	2400	2600	2600	122

Table A4 : Heat seal strength of HDPE/LLDPE film at 25 micron thickness

LLDPE content (% by weight)	Seal temperature (°C)	Heat seal strength of HDPE/MLLDPE film (kg)							Heat seal strength of HDPE/Z-NLLDPE film (kg)						
		1	2	3	4	5	X	σ	1	2	3	4	5	X	σ
0	130	0.63	0.65	0.64	0.72	0.60	0.65	0.04	-	-	-	-	-	-	-
	140	0.78	0.79	0.71	0.80	0.74	0.76	0.04	-	-	-	-	-	-	-
	150	0.83	0.85	0.74	0.79	0.77	0.80	0.04	-	-	-	-	-	-	-
5	130	0.68	0.65	0.70	0.75	0.60	0.68	0.06	NA	NA	NA	NA	NA	NA	NA
	140	0.65	0.71	0.74	0.69	0.74	0.71	0.04	NA	NA	NA	NA	NA	NA	NA
	150	0.82	0.69	0.77	0.79	0.67	0.75	0.06	NA	NA	NA	NA	NA	NA	NA
10	130	0.69	0.70	0.67	0.77	0.78	0.72	0.05	0.73	0.69	0.75	0.64	0.70	0.70	0.04
	140	0.84	0.89	0.81	0.84	0.89	0.85	0.04	0.75	0.76	0.82	0.80	0.77	0.78	0.03
	150	0.86	0.92	0.97	0.85	0.89	0.90	0.05	0.82	0.77	0.87	0.74	0.80	0.80	0.05
15	130	0.80	0.78	0.75	0.73	0.70	0.75	0.04	NA	NA	NA	NA	NA	NA	NA
	140	0.90	0.93	0.82	0.90	0.88	0.89	0.04	NA	NA	NA	NA	NA	NA	NA
	150	1.03	0.96	1.00	0.98	0.91	0.98	0.05	NA	NA	NA	NA	NA	NA	NA
20	130	0.84	0.90	0.89	0.83	0.78	0.85	0.05	0.85	0.70	0.79	0.78	0.77	0.78	0.05
	140	1.16	1.13	0.99	1.17	1.07	1.10	0.07	0.96	0.89	0.92	0.82	0.89	0.90	0.05
	150	0.95	0.93	0.95	0.87	0.85	0.91	0.05	0.85	0.97	0.94	0.89	0.96	0.92	0.05
25	130	0.93	0.97	0.94	1.05	0.90	0.96	0.06	0.85	0.95	1.00	0.92	0.89	0.92	0.06
	140	1.09	1.14	1.12	1.10	0.98	1.09	0.06	0.99	1.08	0.95	1.10	1.07	1.04	0.06
	150	1.01	0.97	0.96	1.05	0.96	0.99	0.04	0.89	0.84	0.99	0.90	0.88	0.90	0.06
30	130	1.02	0.95	0.90	0.92	0.89	0.94	0.05	0.99	0.89	0.91	0.87	0.97	0.93	0.05
	140	0.93	0.79	0.88	0.82	0.80	0.84	0.06	0.89	0.81	0.79	0.90	0.87	0.85	0.05
	150	0.75	0.67	0.64	0.68	0.74	0.70	0.05	0.84	0.73	0.80	0.79	0.72	0.78	0.05
40	130	1.08	1.07	0.99	1.12	0.97	1.05	0.06	0.97	1.01	0.92	0.95	1.03	0.98	0.04
	140	0.82	0.85	0.92	0.90	0.80	0.86	0.05	0.85	0.76	0.78	0.86	0.74	0.80	0.05
	150	0.66	0.70	0.59	0.59	0.69	0.65	0.05	0.77	0.69	0.78	0.78	0.67	0.74	0.05

Table A5 : Stiffness of HDPE/LLDPE sheet

LLDPE content (% by weight)	Stiffness of HDPE/MLLDPE sheet (kg/cm^2)							Stiffness of HDPE/Z-NLLDPE sheet (kg/cm^2)						
	1	2	3	4	5	X	σ	1	2	3	4	5	X	σ
0	8700	8300	8400	8600	8500	8500	158	8700	8300	8400	8600	8500	8500	158
5	8400	8000	8100	8100	8300	8200	164	NA	NA	NA	NA	NA	NA	NA
10	8600	8400	8100	8400	8300	8400	182	8600	8400	8300	8200	8400	8400	148
15	8500	8100	8300	8200	7900	8200	224	NA	NA	NA	NA	NA	NA	NA
20	7900	7600	7500	7700	7700	7700	148	7700	8200	8200	8300	7400	8000	391
25	7400	7200	7500	7300	7500	7400	130	7700	7700	7600	7500	7400	7600	130
30	6900	7200	7200	7300	7100	7100	152	7200	7500	7000	7600	7400	7300	241
40	6800	6700	6400	6500	6500	6600	164	6700	7400	6900	7200	7300	7100	292
100	2400	2500	2300	2500	2000	2300	207	3600	3200	2900	3400	3300	3300	259

Sample characterization

Table A6 : DSC test of HDPE/LLDPE blend

LLDPE content (% by weight)	HDPE/MLLDPE blend		HDPE/Z-NLLDPE blend	
	Melt temperature (°C)	% crystallinity	Melt temperature (°C)	% crystallinity
0	128.0	68.5	128	68.5
5	127.7	56.0	NA	NA
10	127.1	54.7	NA	NA
15	126.5	55.1	NA	NA
20	126.5	55.6	NA	NA
25	126.0	52.6	126.7	49.8
30	126.0	50.3	NA	NA
40	125.6	50.4	NA	NA
100	121.7	NA	123.7	NA

Mechanical properties of HDPE/MLLDPE film at 15 micron thickness

Table A7 : Tensile strength of HDPE/MLLDPE film at 15 micron thickness

MLLDPE content (% by weight)		Tensile strength of HDPE/MLLDPE film (kg/cm^2)						
		1	2	3	4	5	X	σ
10	MD	520	490	510	530	550	520	22
	TD	330	270	310	280	280	290	25
20	MD	430	460	420	420	470	440	23
	TD	220	280	270	290	210	250	36
30	MD	460	450	470	420	410	440	26
	TD	260	240	240	210	260	240	20

Table A8 : Elongation at break of HDPE/MLLDPE film at 15 micron thickness

MLLDPE content (% by weight)		Elongation at break of HDPE/MLLDPE film (%)						
		1	2	3	4	5	X	σ
10	MD	240	260	250	250	210	240	19
	TD	350	360	390	400	350	370	23
20	MD	270	300	290	240	320	280	30
	TD	340	390	370	340	410	370	31
30	MD	290	300	270	330	350	310	32
	TD	370	370	410	390	360	380	20

Table A9 : Impact strength of HDPE/MLLDPE film at 15 micron thickness

MLLDPE content (% by weight)	Impact strength of HDPE/MLLDPE film (kg cm/cm)						
	1	2	3	4	5	X	σ
10	3700	3100	3500	2900	3300	3300	316
20	2700	2600	3300	2500	3000	2800	327
30	2600	2200	2600	2100	2700	2400	270

VITA

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