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APPENDICES

Appendix A Cure Characteristic Data

Data of cure characteristic result shown in chapter IV were obtained from Moving Die Rheometer (MDR). They conclude the data of compounded NR vulcanize by EV system at Acc:S ratio of 12, DCP system at DCP content of 3 phr, and DBPH system at DBPH content of 3 phr. These data are shown in Tables A1-A3.

Table A1 Parameter results of compounded NR with EV system at Acc:S ratio of 12

Sample ID	ML (lbf·in)	MH (lbf·in)	ts2 (min:sec)	tc90 (min:sec)
EV ratio 12, 150 °C	0.33	11.33	02:50.9	09:04.2
EV ratio 12, 160 °C	0.29	9.02	01:52.9	04:57.0
EV ratio 12, 170 °C	0.21	4.61	01:36.7	03:39.6
EV ratio 12, 180 °C	0.12	1.86	>(30:00.0)	02:09.6
EV ratio 12, 190 °C	0.08	1.57	>(30:00.0)	01:21.6
EV ratio 12, 200 °C	0.09	1.45	>(30:00.0)	00:57.6

Table A2 Parameter results of the compounded NR by DCP system at DCP content of 3 phr

Sample ID	ML (lbf·in)	MH (lbf·in)	ts2 (min:sec)	tc90 (min:sec)
3 DCP, 150 °C	2.79	10.27	03:49.8	23.20.4
3 DCP, 160 °C	2.12	9.82	02:19.2	16:15.6
3 DCP, 170 °C	1.10	4.12	04:17.4	10:00.6
3 DCP, 180 °C	0.91	2.38	>(30:00.0)	02:54.0
3 DCP, 190 °C	0.85	2.16	>(30:00.0)	01:33.6
3 DCP, 200 °C	0.80	2.01	>(30:00.0)	00:55.2

Table A3 Parameter results of the compounded NR by DBPH system at DBPH content of 3 phr

Sample ID	ML (lbf·in)	MH (lbf·in)	ts2 (min:sec)	tc90 (min:sec)
3 DBPH, 150 °C	0.82	3.30	08:54.0	25:33.6
3 DBPH, 160 °C	0.81	4.91	08:51.0	23:56.4
3 DBPH, 170 °C	0.81	5.69	03:48.0	16:52.8
3 DBPH, 180 °C	0.80	5.34	01:48.6	07:13.2
3 DBPH, 190 °C	0.87	4.89	01:02.4	02:48.0
3 DBPH, 200 °C	0.82	4.39	00:41.5	01:13.8

Data of cure characteristic result shown in chapter V were also obtained from Moving Die Rheometer (MDR). They conclude the data of compounded NR vulcanize by CV and EV system and the data of 50NR/50 PVDF thermoplastic vulcanizates. The Acc:S ratio of 0.5 and 2 were used to vulcanize compounded NR in CV and EV system, respectively. DBPH system was used in vulcanization of 50NR/50PVDF thermoplastic vulcanizates at 180 °C and the content of DBPH was varied at 1, 3, 5, and 7 phr. These data are shown in Table A4-A5.

Table A4 Parameter results of the compounded NR by CV and EV systems

Sample ID	ML (lbf·in)	MH (lbf·in)	tc50 (min:sec)	tc90 (min:sec)
CV system, 150 °C	1.27	12.42	04:25.8	08:08.4
EV system, 150 °C	0.89	14.19	04:37.8	08:10.2
CV system, 180 °C	0.25	2.14	01:06.0	01:40.8
EV system, 180 °C	0.17	2.89	01:13.2	01:43.2

Table A5 Parameter results of the thermoplastic vulcanizates with the NR/PVDF composition of 50/50 vulcanized by peroxide system at 180 °C

Sample ID	ML (lbf·in)	MH (lbf·in)	tc50 (min:sec)	tc90 (min:sec)
DBPH 1 phr	0.31	1.31	02:43.2	08:19.8
DBPH 3 phr	0.88	4.22	02:09.0	06:13.8
DBPH 5 phr	0.68	6.94	02:09.6	06:10.8
DBPH 7 phr	0.91	8.13	01:55.8	05:37.8

Appendix B Calculations of Crystallinity Percentage

The calculated crystallinity percentages include percents crystallinity of PVDF; PHBV; 80PVDF/20PHBV thermoplastic blend; and 50NR/40PVDF/10PHBV at various ESO content of 0, 1, 2, 5, 7, and 10 phr. The used enthalpies of melting per gram of 100 % crystalline are 109 J/g for PHBV, and 104.7 J/g for PVDF. All calculations are shown below.

From $X_c\,(\%) = \frac{\Delta H^{*}_{sample}}{\Delta H^{0}_{ref}} \times 100,$

ΔH^{*}_{sample} is the measured enthalpy of sample, and ΔH^{0}_{ref} is the enthalpy of melting per gram of 100 % crystalline of sample.

Percent Crystallinity of PVDF

From the result, ΔH^{*}_{PVDF} is 34.4 J/g and ΔH^{0}_{PVDF} is 104.7 J/g.

Percent crystallinity of PVDF $= \frac{\Delta H^{*}_{PVDF}}{\Delta H^{0}_{PVDF}} \times 100,$

$= \frac{34.4}{104.7} \times 100,$

$=$ 32.8 %.

Percent Crystallinity of PHBV

From the result, ΔH^{*}_{PVDF} is 98.7 J/g and ΔH^{0}_{PHBV} is 109 J/g.

Percent crystallinity of PHBV $= \frac{\Delta H^{*}_{PHBV}}{\Delta H^{0}_{PHBV}} \times 100.$

$= \frac{98.7}{109} \times 100,$

$=$ 90.6 %.

For the blend, the relative percent crystalliniity was calculated relatively to the composition of PVDF/PHBV which was 80/20 from the following equation:

$$X_{Blend}(\%) = \frac{\Delta H^{*}_{Blend}}{(0.8 \times \Delta H^{0}_{PVDF}) + (0.2 \times \Delta H^{0}_{PHBV})} \times 100,$$

X_{Blend} is the relative percent crystallinity of the blend samples. ΔH^{*}_{Blend} is the measured enthalpy of the blend samples. ΔH^{0}_{PVDF} is 104.7 J/g, and ΔH^{0}_{PHBV} is 109 J/g.

Relative Percent Crystallinity of 80/20 PVDF/PHBV Blend

From the result, ΔH^{*}_{Blend} is 57.9 J/g,

$$X_{Blend}(\%) = \frac{\Delta H^{*}_{Blend}}{(0.8\times\Delta H^{0}_{PVDF}) + (0.2\times\Delta H^{0}_{PHBV})} \times 100,$$

$$= \frac{57.9}{(0.8\times104.7) + (0.2\times109)} \times 100,$$

$$= 54.9\ \%.$$

For thermoplastic vulcanizates (TPV), The crystallization was occurred from only PVDF and PHBV. The relative percent crystalliniity was calculated relatively to the composition of PVDF and PHBV in NR/PVDF/PHBV blend which were 40 and 10, respectively. The equation used in calculation relative percent crystallinity of thermoplastic vulcanizate is shown below:

$$X_{TPV}(\%) = \frac{\Delta H^{*}_{TPV}}{(0.4\times\Delta H^{0}_{PVDF}) + (0.1\times\Delta H^{0}_{PHBV})} \times 100.$$

X_{TPV} is the relative percent crystallinity of the TPV samples. ΔH^{*}_{TPV} is the measured enthalpy of the TPV samples. ΔH^{0}_{PVDF} is 104.7 J/g, and ΔH^{0}_{PHBV} is 109 J/g. The calculations of relative percent crystallinity of TPVs are shown as follow.

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 0 phr

From the result, ΔH^{*}_{TPV} of TPVs at ESO 0 phr is 16.9 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^{*}_{TPV}}{(0.4\times\Delta H^{0}_{PVDF}) + (0.1\times\Delta H^{0}_{PHBV})} \times 100.$$

$$= \frac{16.9}{(0.4\times104.7) + (0.1\times109)} \times 100,$$

$$= 32.0\ \%.$$

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 1 phr

From the result, ΔH^*_{TPV} of TPVs at ESO 1 phr is 15.2 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^*_{TPV}}{(0.4\times\Delta H^0_{PVDF}) + (0.1\times\Delta H^0_{PHBV})} \times 100.$$

$$= \frac{15.2}{(0.4\times104.7) + (0.1\times109)} \times 100,$$

$$= 28.8\ \%.$$

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 2 phr

From the result, ΔH^*_{TPV} of TPVs at ESO 2 phr is 15.4 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^*_{TPV}}{(0.4\times\Delta H^0_{PVDF}) + (0.1\times\Delta H^0_{PHBV})} \times 100.$$

$$= \frac{15.4}{(0.4\times104.7) + (0.1\times109)} \times 100,$$

$$= 29.2\ \%.$$

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 5 phr

From the result, ΔH^*_{TPV} of TPVs at ESO 5 phr is 15.5 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^*_{TPV}}{(0.4\times\Delta H^0_{PVDF}) + (0.1\times\Delta H^0_{PHBV})} \times 100.$$

$$= \frac{15.5}{(0.4\times104.7) + (0.1\times109)} \times 100,$$

$$= 29.4\ \%.$$

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 7 phr

From the result, ΔH^*_{TPV} of TPVs at ESO 7 phr is 15.7 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^*_{TPV}}{(0.4\times\Delta H^0_{PVDF}) + (0.1\times\Delta H^0_{PHBV})} \times 100.$$

$$= \frac{15.7}{(0.4\times104.7) + (0.1\times109)} \times 100,$$

$$= 29.8\ \%.$$

Relative Percent Crystallinity of 50/40/10 TPV at ESO content 10 phr

From the result, ΔH^{*}_{TPV} of TPVs at ESO 10 phr is 14.3 J/g.

$$X_{TPV}(\%) = \frac{\Delta H^{*}_{TPV}}{(0.4 \times \Delta H^{0}_{PVDF}) + (0.1 \times \Delta H^{0}_{PHBV})} \times 100.$$

$$= \frac{14.3}{(0.4 \times 104.7) + (0.1 \times 109)} \times 100,$$

$$= 27.1\ \%.$$

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