

References

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(1997): 2005-2014.

Appendix I

Table 1 Typical data of polypropylene grade 2500 TC

Typical Data	Unit	Value	Test Method
Property			
MFI 2.16 kg/230°C	g/10 min	45	ASTM D1238
Tensile Strength at Yield	N/mm ²	21	ASTM D638
Charpy Impact Strength			
At -20°C	mJ/mm ²	5.5	DIN 53453
Shear Modulus	N/mm ²	430	DIN 53457
Ball Indentation Hardness	N/mm ²	53	DIN 53456
Heat Distortion Temp			
At 0.45 N/mm ²	°C	90	ASTM D648

Table 2 Product specification of EPDM grade EP35

Item	Unit	Value	Test Method
Volatile Matter	%	0.75 max.	JIS K6383
Ash	%	0.20 max.	JSR AE102
Iodine Value	I ₂ /EPDM 100 g	22-30	JSR AE104
Propylene Content	wt%	39-47	JSR AE103
Mooney Viscosity	ML ₁₊₄ (100°C)	75-91	JSR K6300
Tensile Strength	MPa	10.8 min.	JIS K6301
Elongation	%	280 min.	JIS K6301
200% Modulus	MPa	6.6-9.5	JIS K6301

Table 3 Product specification of Talcum no.35

Item	Unit	Specification
SiO ₂	%	35 min.
MgO	%	30 min.
Fe ₂ O ₃	%	0.3 max.
Whiteness	°GE	85 min.
Abrasiveness	mg.	15 max.
Fineness	%	99 min. Passing 325 mesh
Oil Absorption	g	30 /100

Table 4 Product specification of carbon black grade PRINTEX G

Item	Unit	Specification
Blackness Value	My	223
% Ash contents	%	0.1
Compacted Density	g/l	250
Average primary particle size	nm.	51
SiO ₂	%	35 min.

Table 5 Typical data of high density polyethylene grade V1160

Typical Data	Unit	Value	Test Method
Property			
MFI 2.16 kg/190° C	g/10 min	45	ASTM D1238
Density	g/cm ³	0.957	ASTM D792
Ultimate Elongation	%	150	ASTM D638
Charpy NI	mJ/mm ²	1.9	DIN 53453
Shear Modulus	N/mm ²	430	DIN 53457
Ball Indentation Hardness	N/mm ²	56	DIN 53456

Appendix II

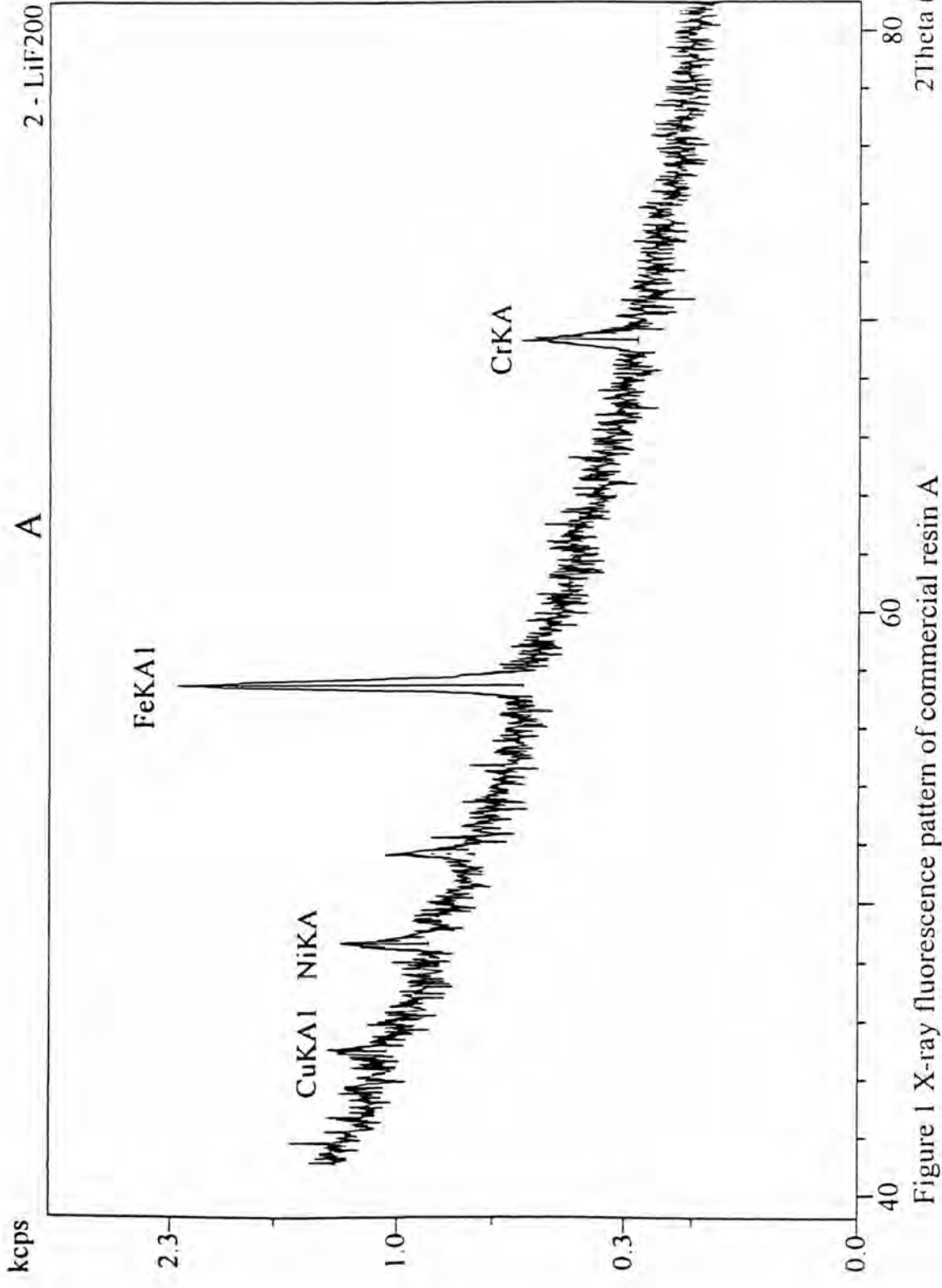


Figure 1 X-ray fluorescence pattern of commercial resin A

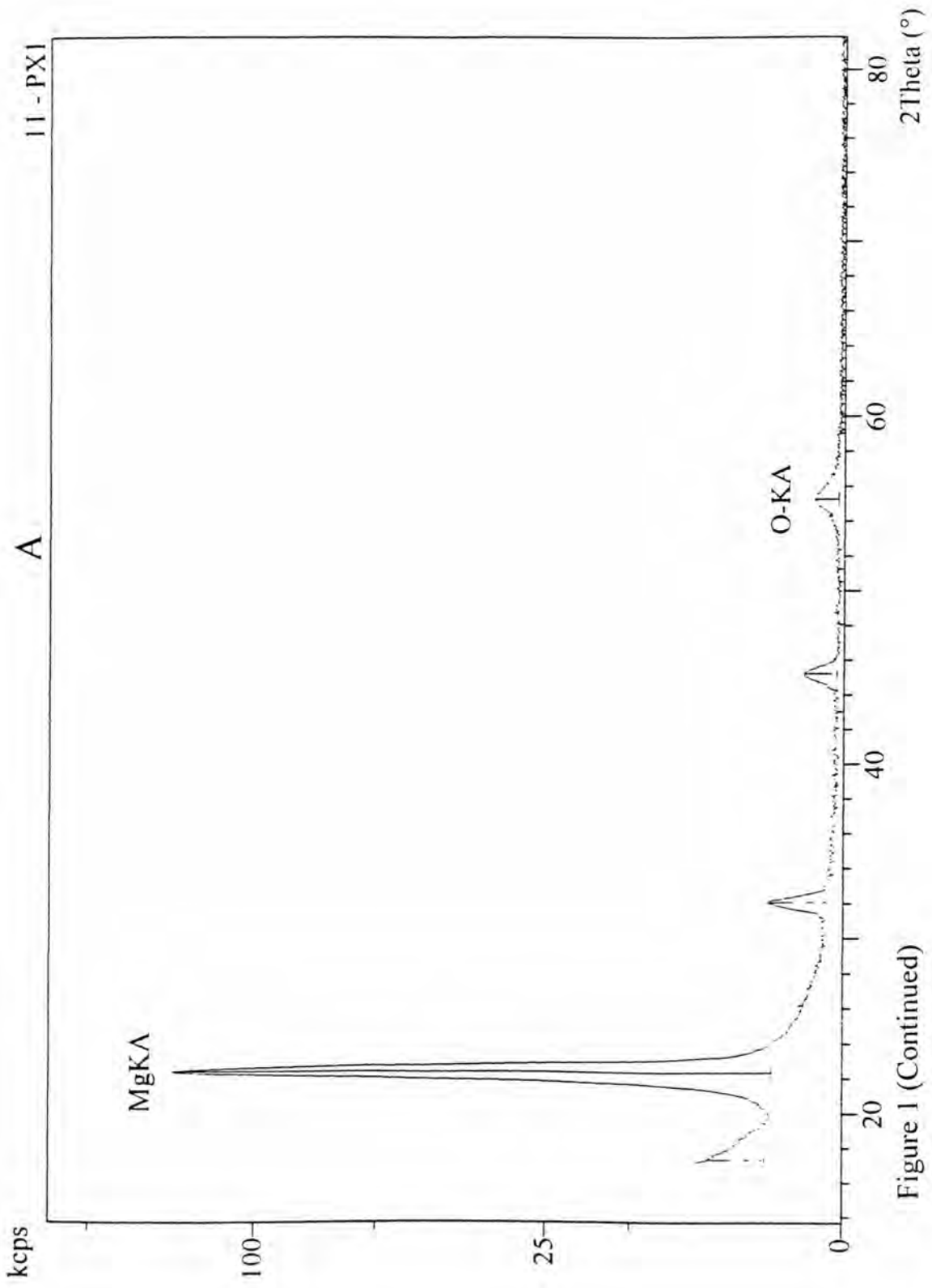


Figure 1 (Continued)

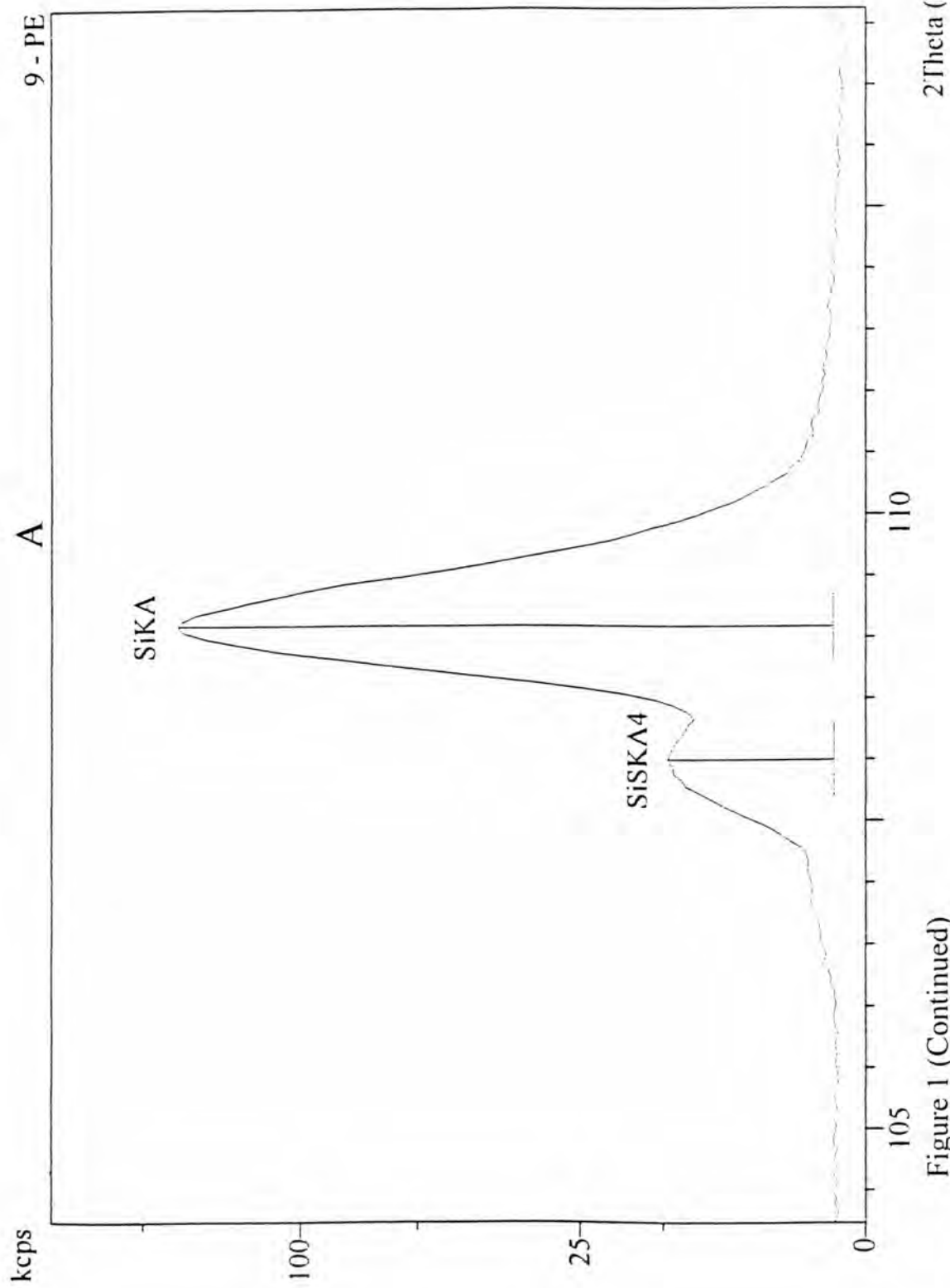


Figure 1 (Continued)

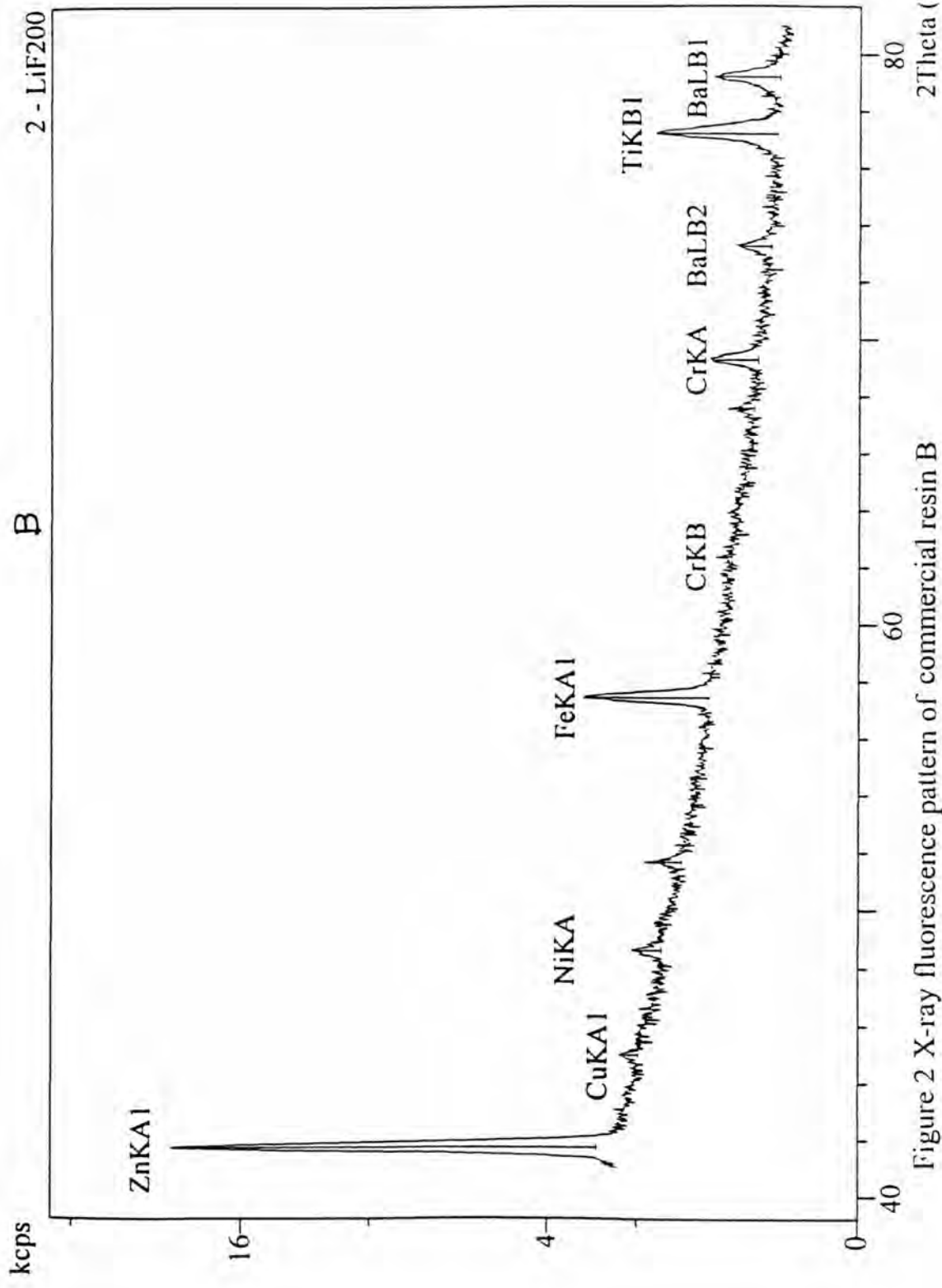


Figure 2 X-ray fluorescence pattern of commercial resin B

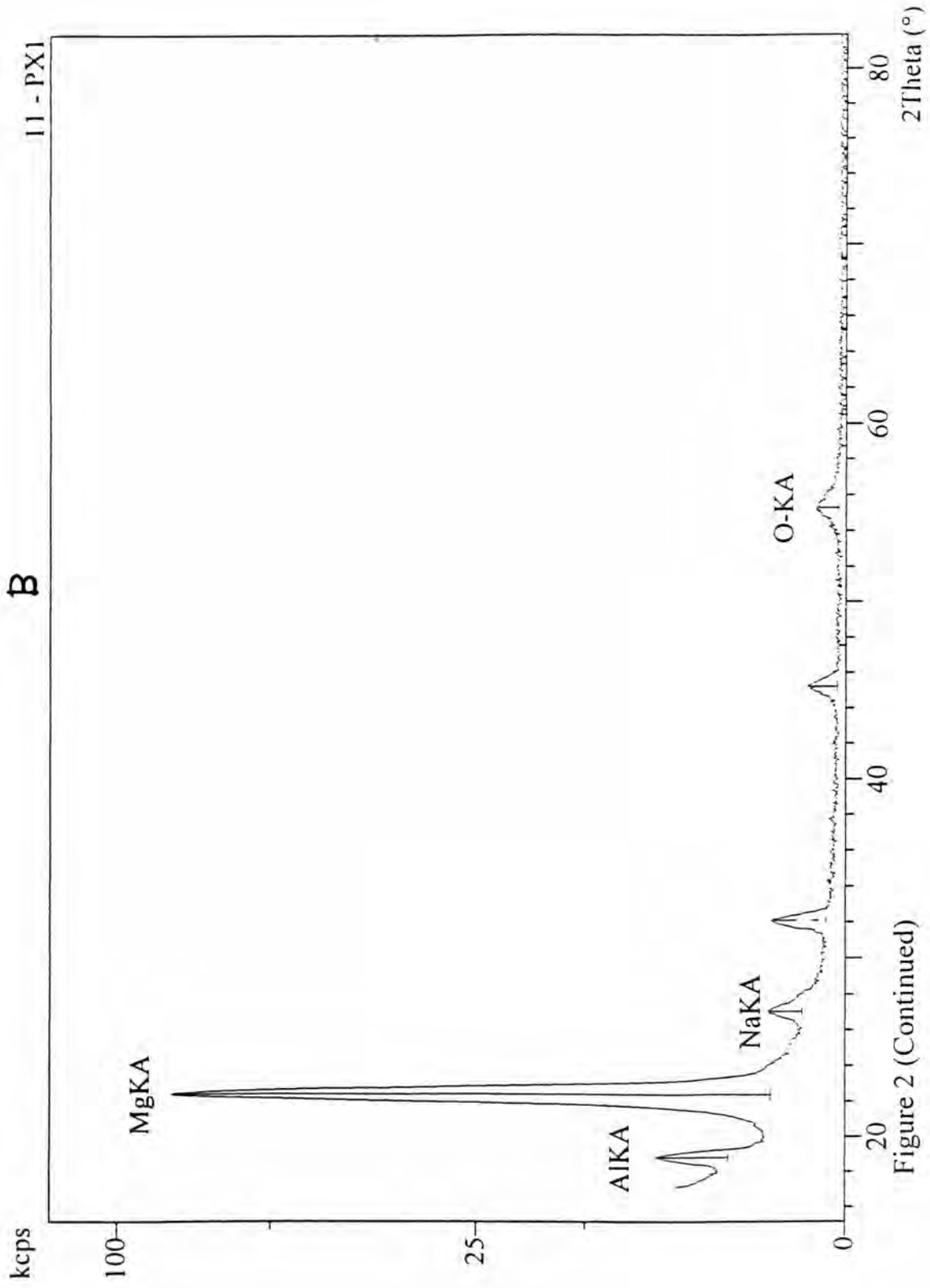


Figure 2 (Continued)

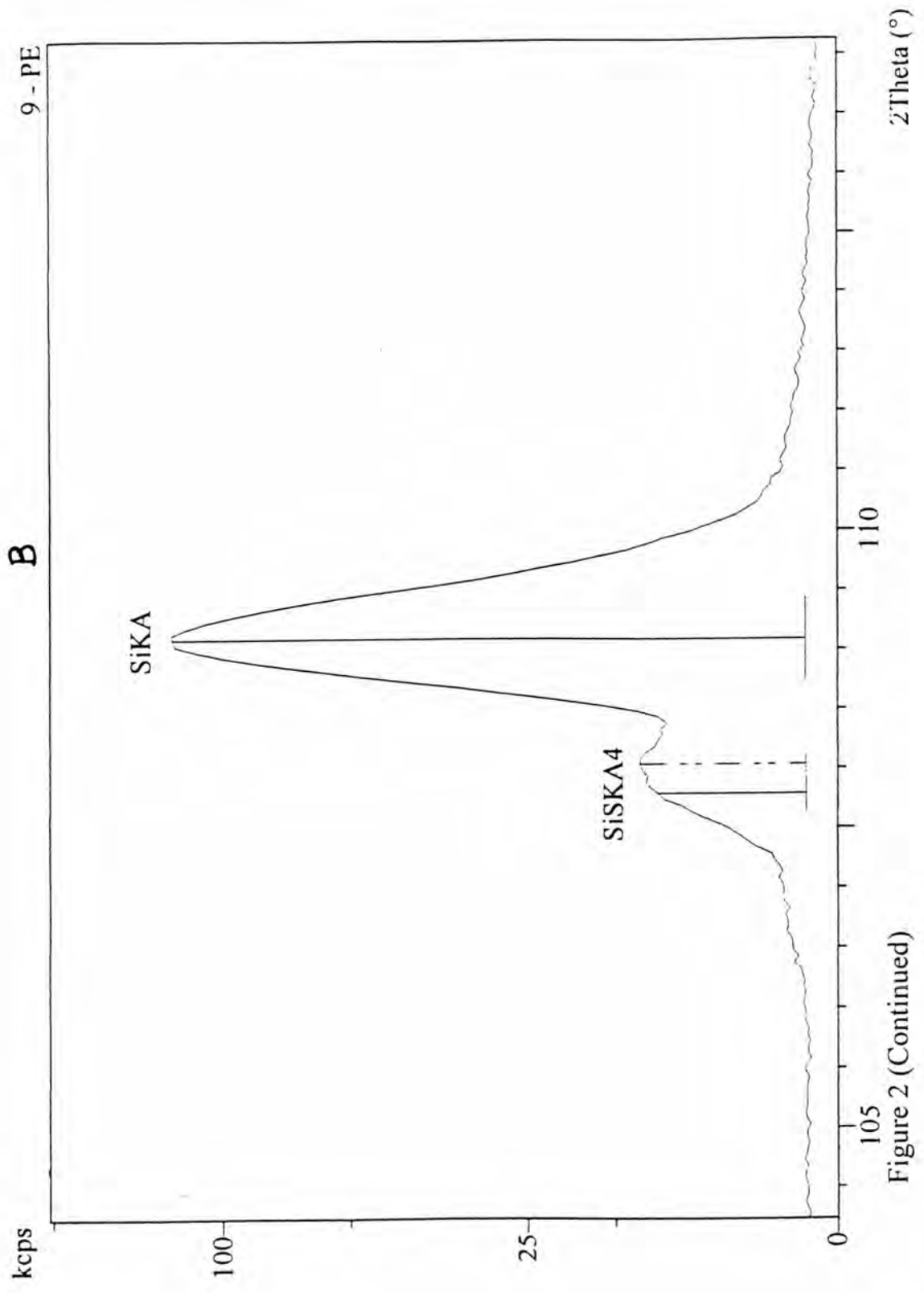


Figure 2 (Continued)

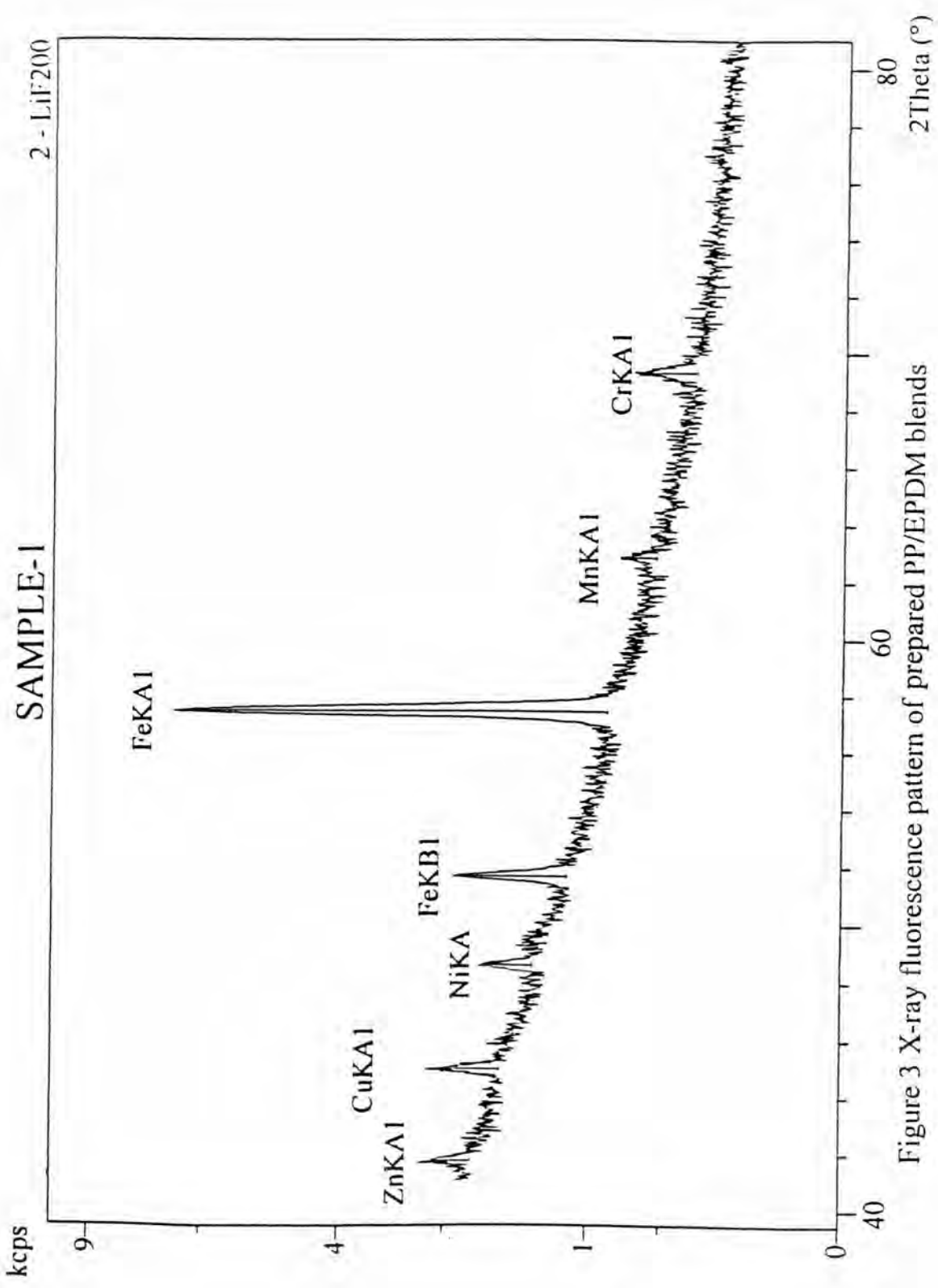


Figure 3 X-ray fluorescence pattern of prepared PP/EPDM blends

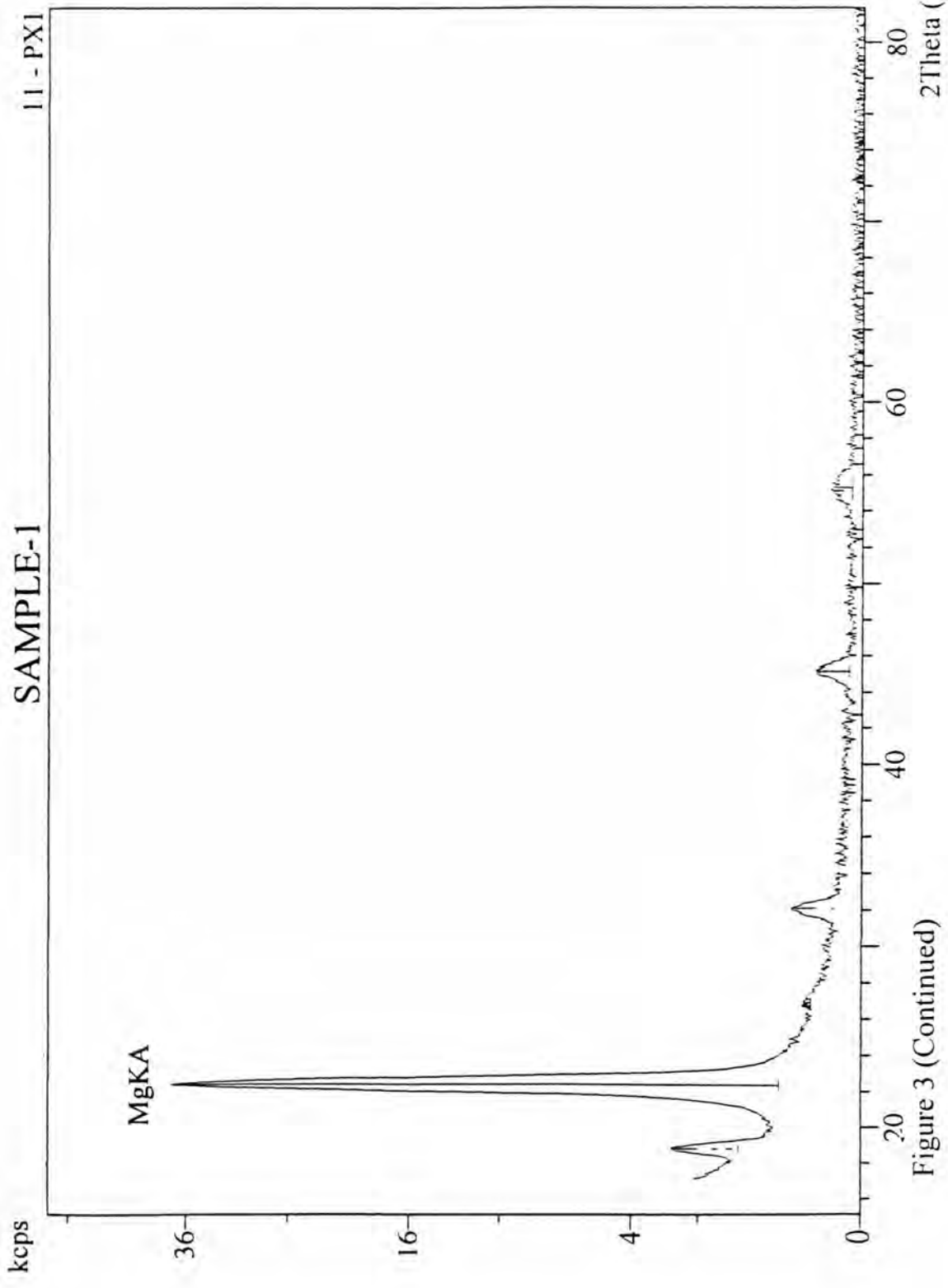


Figure 3 (Continued)

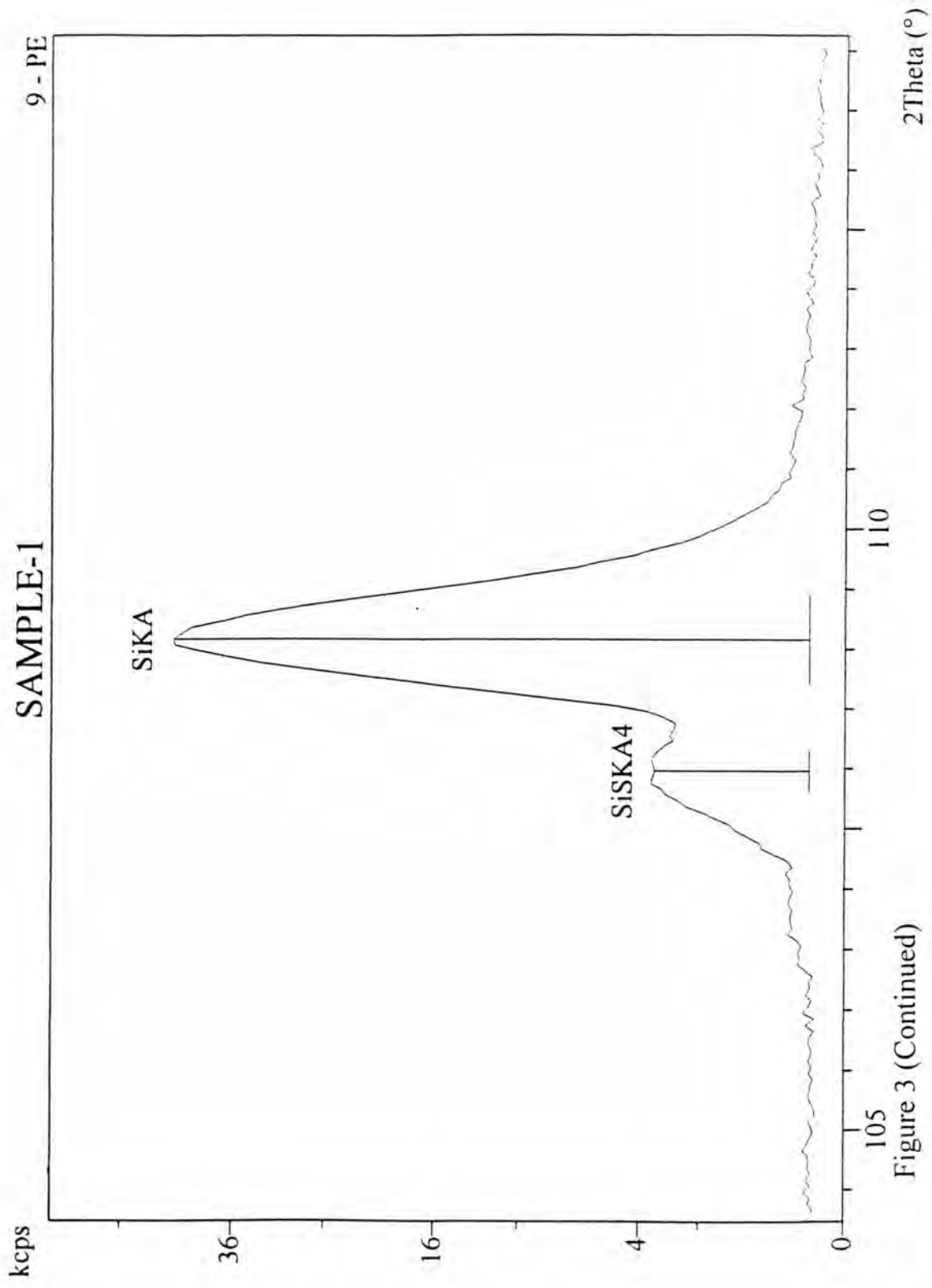


Figure 3 (Continued)

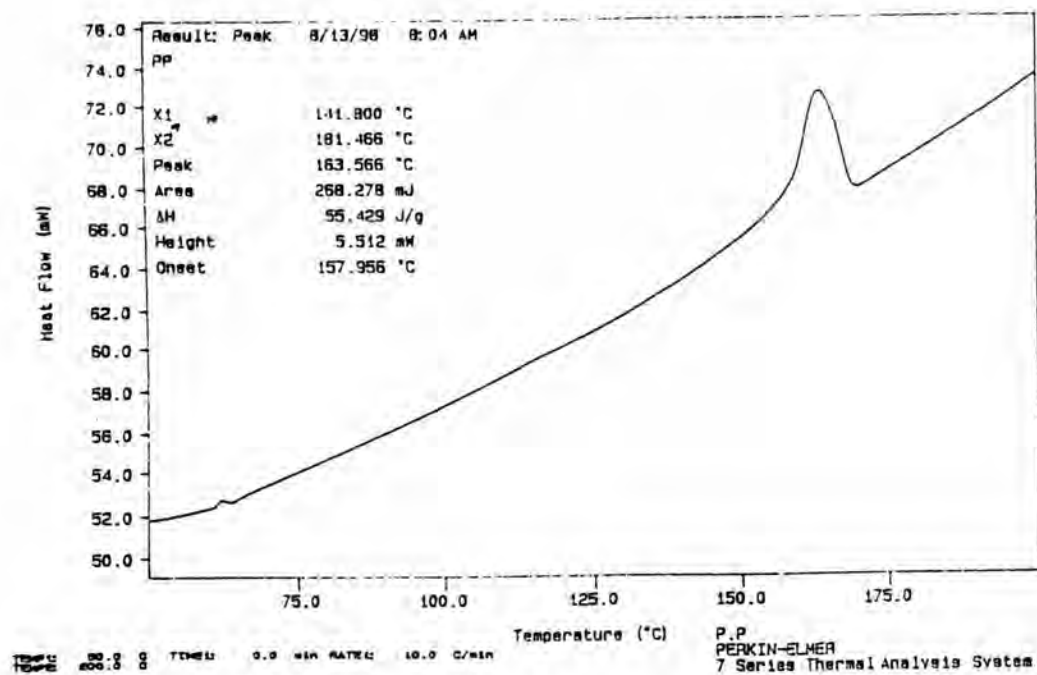


Figure 4 DSC curve of pure PP

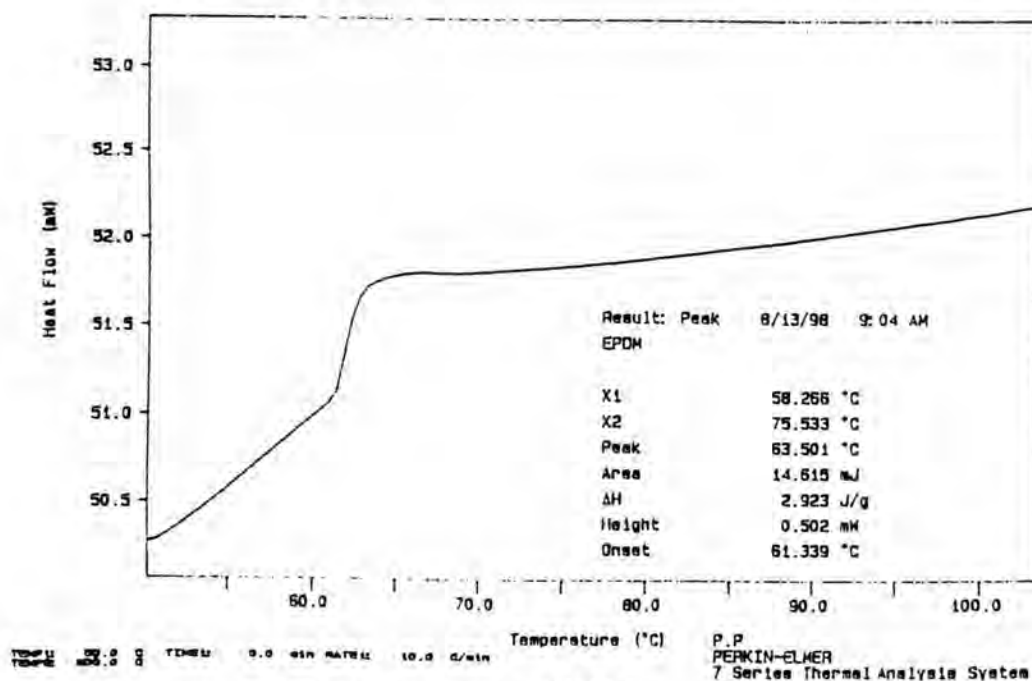


Figure 5 DSC curve of pure EPDM

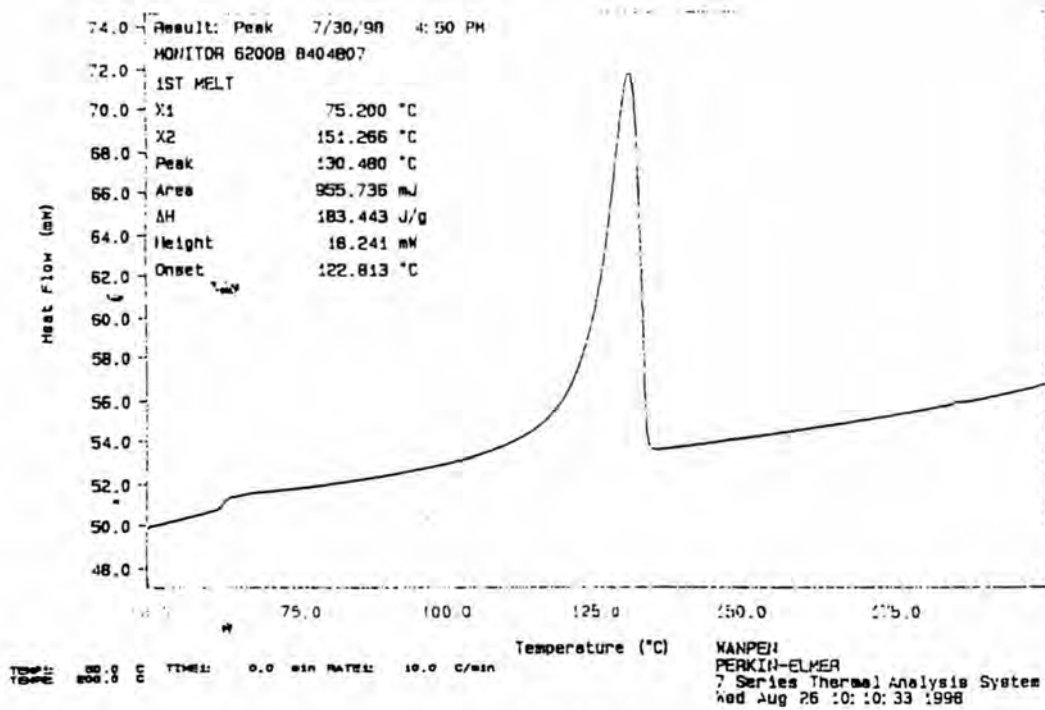


Figure 6 DSC curve of pure HDPE

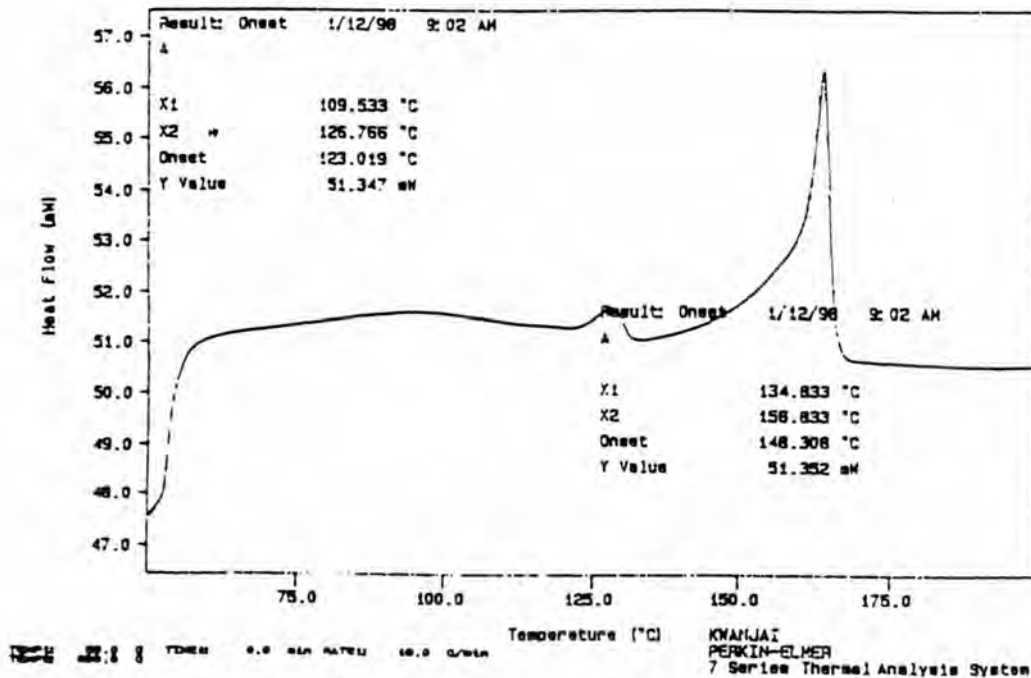


Figure 7 DSC curve of pure commercial resin A

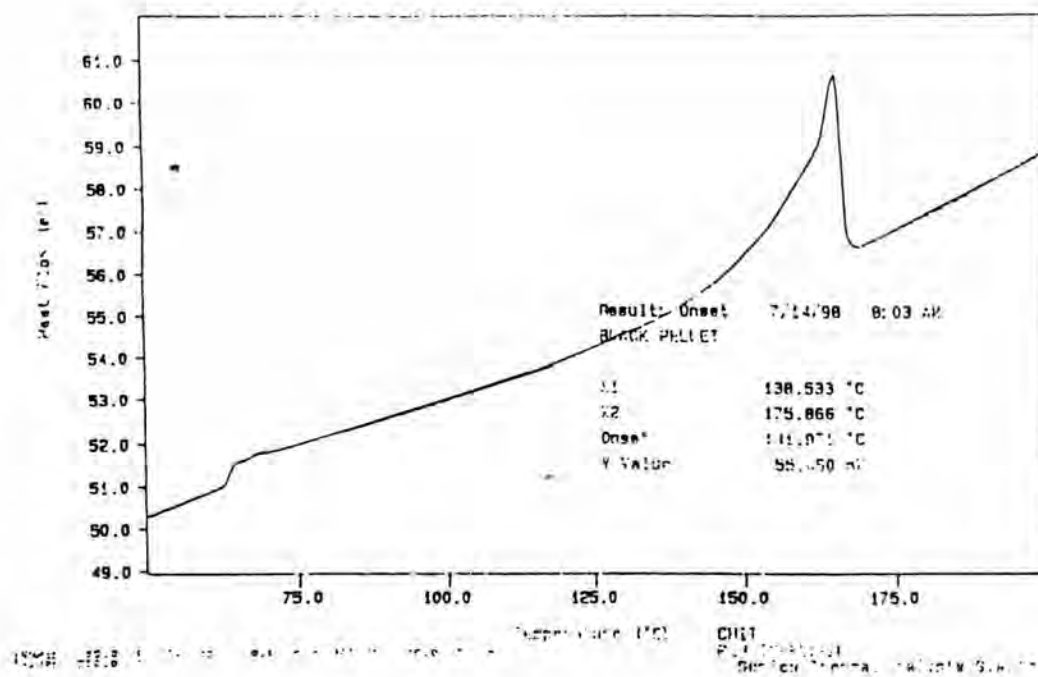
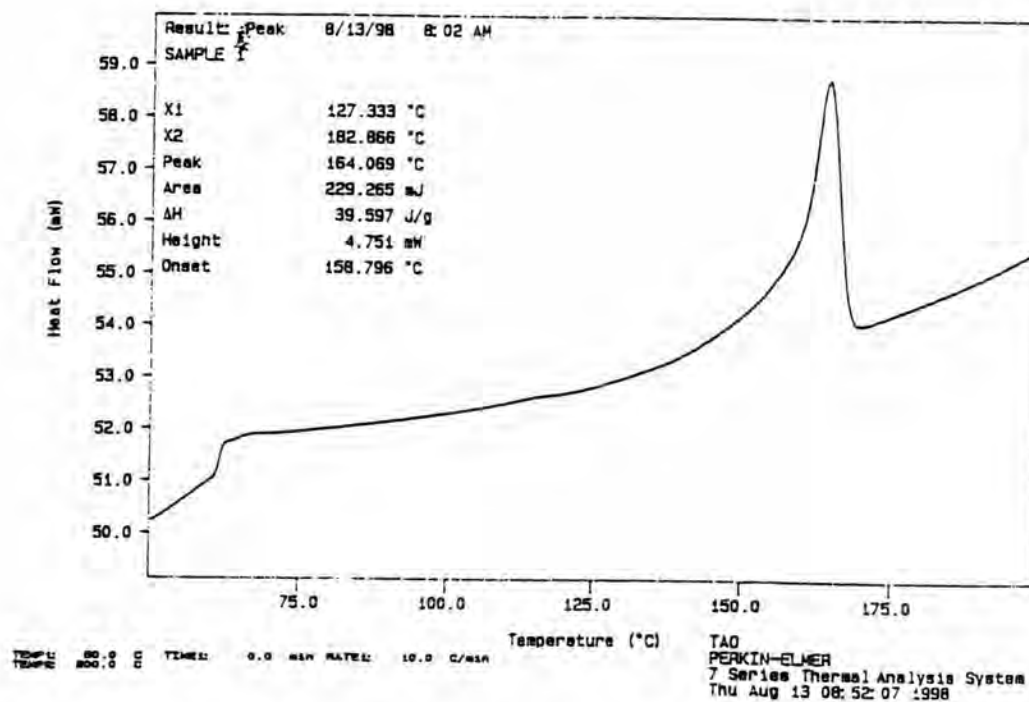


Figure 8 DSC curve of commercial resin B

Figure 9 DSC curve of the prepared PP/EPDM/talc at
80/20/10

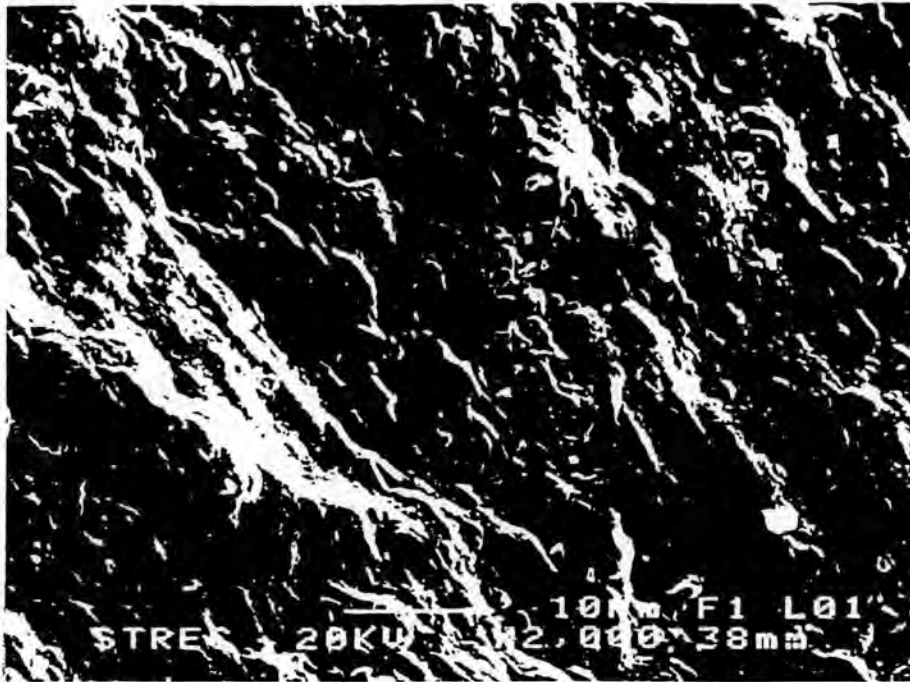


Figure 10 SEM micrograph of commercial resin A

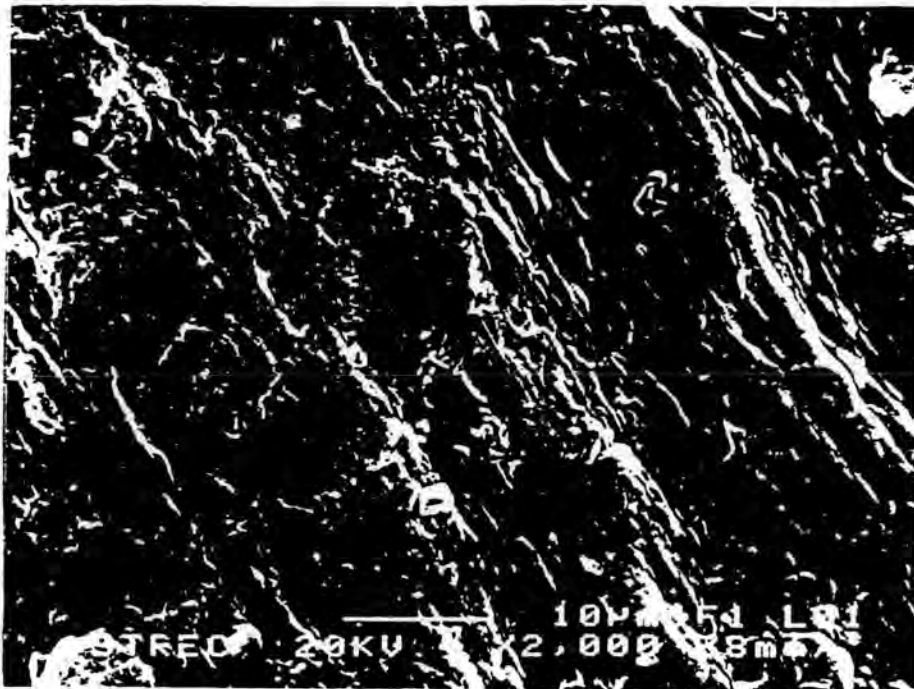


Figure 11 SEM micrograph of commercial resin B



Figure 12 SEM micrograph of prepared PP/EPDM/talc at 80/20/20

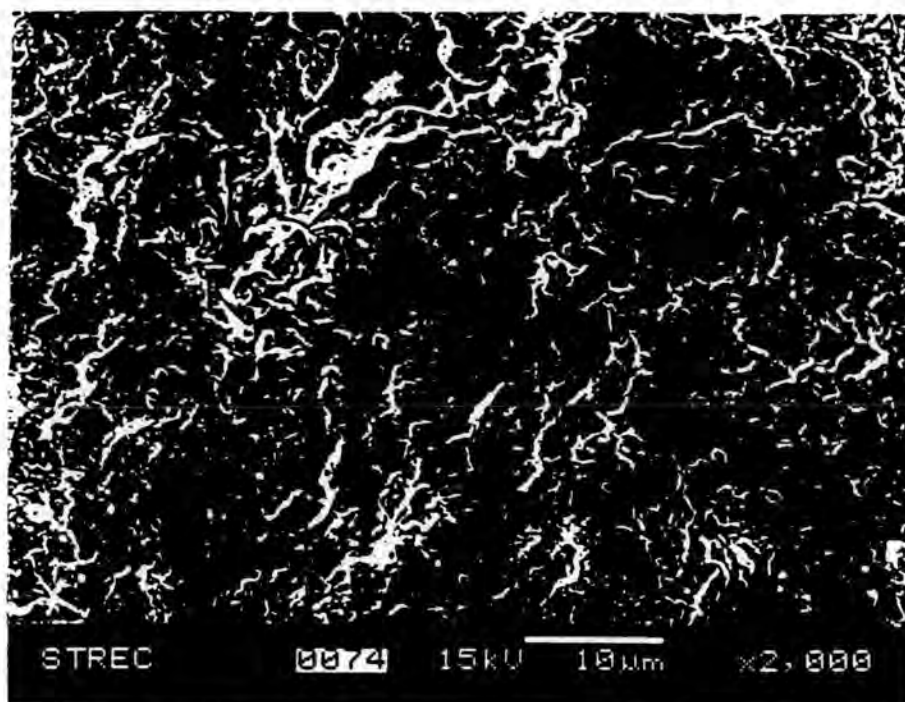


Figure 13 SEM micrograph of prepared PP/EPDM/talc/carbon black
at 90/10/15/15

Table 6 Mechanical analysis data sheet of PP/EPDM composites

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
1	1	19.8	3.8	195	954	42.0
	2	20.2	4.3	198	969	42.1
	3	19.8	3.7	198	972	41.9
	Average	19.9	3.9	197	965	42.0
2	1	14.8	4.7	166	811	40.6
	2	14.4	4.9	168	824	40.4
	3	14.7	4.7	164	803	40.7
	Average	14.6	4.8	166	813	40.6
3	1	11.1	6.1	140	685	36.4
	2	10.7	6.3	134	655	36.4
	3	10.9	6.2	137	670	36.3
	Average	10.9	6.2	137	670	36.4
4	1	7.6	8.1	121	594	33.3
	2	8.6	7.7	130	635	33.7
	3	7.8	8.0	128	625	33.8
	Average	8.0	7.9	126	618	33.6
5	1	5.6	9.8	105	514	30.1
	2	5.8	9.6	103	504	30.2
	3	5.8	9.6	107	524	30.1
	Average	5.7	9.7	105	514	30.1
6	1	3.9	12.6	82	404	27.7
	2	3.9	12.5	81	395	27.6
	3	4.0	12.8	82	404	27.8
	Average	3.9	12.6	82	401	27.7
7	1	3.1	13.0	57	280	23.9
	2	3.0	13.1	56	276	23.8
	3	3.1	12.9	54	267	23.9
	Average	3.1	13.0	56	274	23.9

Remark: MFI = Melt flow index (g/10 min)
 NI = Impact strength (Kg.cm/cm²)
 FS = Flexural strength (Kg/cm²)
 FM = Flexural modulus (MPa)
 HR = Hardness (Shore D)

Table 6 (Continued)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
8	1	10.5	6.1	148	724	37.6
	2	10.4	6.3	145	711	37.9
	3	10.4	6.0	144	707	37.7
	Average	10.4	6.1	146	714	37.7
9	1	10.4	6.1	148	723	38.2
	2	10.5	6.2	149	729	38.3
	3	10.1	6.0	146	715	37.9
	Average	10.3	6.1	147	722	38.1
10	1	10.1	6.0	153	748	38.7
	2	10.0	5.9	150	737	39.0
	3	9.9	6.1	152	743	38.9
	Average	10.0	6.0	152	743	38.9
11	1	10.8	6.0	140	687	39.4
	2	10.7	5.8	139	682	39.0
	3	10.6	5.7	140	684	38.7
	Average	10.7	5.8	140	684	39.0
12	1	10.5	5.6	138	678	37.8
	2	10.5	5.7	139	683	37.9
	3	10.4	5.9	139	681	38.1
	Average	10.5	5.7	139	681	37.9
13	1	10.1	5.9	139	679	37.4
	2	9.9	5.5	137	672	37.0
	3	9.9	5.6	139	680	37.2
	Average	10.0	5.7	138	677	37.2
14	1	10.5	7.4	130	639	38.3
	2	10.4	7.1	129	631	38.1
	3	10.6	7.3	134	659	37.7
	Average	10.5	7.3	131	643	38.0
15	1	8.6	9.6	132	649	39.0
	2	8.6	9.4	130	639	39.1
	3	8.6	9.2	131	643	39.3
	Average	8.6	9.4	131	644	39.1
16	1	7.9	11.0	132	645	40.3
	2	8.0	11.3	137	672	40.1
	3	7.8	11.1	135	661	40.3
	Average	7.9	11.1	135	659	40.2

Table 6 (Continued)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
17	1	10.7	10.0	175	857	52.4
	2	10.1	9.6	169	828	52.7
	3	10.4	9.5	171	840	52.6
	Average	10.4	9.7	172	842	52.6
18	1	11.1	8.2	208	1021	54.0
	2	11.0	8.4	211	1034	54.2
	3	11.3	8.7	204	1000	53.9
	Average	11.1	8.4	208	1018	54.0
19	1	10.8	7.6	222	1090	54.1
	2	11.0	7.6	214	1051	54.4
	3	11.1	7.4	211	1036	54.3
	Average	11.0	7.5	216	1059	54.3
20	1	10.4	6.5	233	1141	53.2
	2	10.3	6.5	229	1122	53.6
	3	10.5	6.4	232	1139	53.6
	Average	10.4	6.5	231	1134	53.5
21	1	9.1	5.8	249	1221	53.3
	2	9.1	5.9	246	1203	53.4
	3	9.1	5.6	252	1235	53.8
	Average	9.1	5.8	249	1220	53.5
22	1	8.3	7.8	224	1100	53.8
	2	8.6	7.9	236	1154	54.1
	3	8.5	8.2	232	1139	53.9
	Average	8.5	8.0	231	1131	53.9
23	1	7.5	7.8	265	1299	57.2
	2	7.7	7.6	260	1274	57.1
	3	8.0	8.1	267	1306	57.4
	Average	7.7	7.8	264	1293	57.2
24	1	6.9	6.0	272	1335	57.8
	2	6.7	5.7	274	1341	57.9
	3	7.2	5.8	275	1348	58.3
	Average	6.9	5.8	274	1341	58.0

Table 6 (Continued)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
25	1	9.5	6.6	233	1142	51.4
	2	9.4	6.4	236	1157	50.2
	3	9.5	6.3	232	1139	49.9
	Average	9.5	6.4	234	1146	50.5
26	1	9.4	6.3	208	1019	49.1
	2	9.5	6.2	209	1025	49.6
	3	9.5	6.4	207	1012	49.2
	Average	9.5	6.3	208	1019	49.3
27	1	9.4	6.2	227	1112	49.0
	2	9.4	6.3	229	1124	49.5
	3	9.4	6.3	232	1136	49.4
	Average	9.4	6.3	229	1124	49.3

Table 7 Mechanical analysis data sheet of PP/EPDM composites (repeated)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
1-1	1	20.7	3.9	197	966	43.5
	2	20.2	3.3	195	955	43.6
	3	20.7	3.8	194	953	43.9
	Average	20.5	3.7	196	958	43.7
2-1	1	15.1	4.6	166	811	40.9
	2	15.2	4.8	169	827	41.1
	3	15.4	4.7	167	819	41.0
	Average	15.2	4.7	167	819	41.0
3-1	1	11.1	6.1	139	683	36.8
	2	11.3	6.1	146	713	36.8
	3	11.1	6.1	141	693	37.2
	Average	11.2	6.1	142	696	36.9
4-1	1	8.2	7.5	123	602	33.7
	2	8.7	7.7	131	640	34.1
	3	8.9	7.6	128	625	34.2
	Average	8.6	7.6	127	622	34.0
5-1	1	5.8	9.8	108	530	32.6
	2	5.8	9.7	109	535	31.2
	3	5.6	9.8	108	528	31.8
	Average	5.7	9.8	108	531	31.9
6-1	1	4.4	12.6	81	398	27.5
	2	4.0	12.6	90	440	27.8
	3	4.0	12.7	84	414	28.0
	Average	4.1	12.7	85	417	27.8
7-1	1	3.2	13.0	60	295	23.7
	2	3.4	13.1	58	286	23.5
	3	3.2	12.8	59	288	24.0
	Average	3.3	13.0	59	290	23.7
8-1	1	10.5	6.1	145	712	38.1
	2	10.7	6.2	143	701	38.0
	3	10.7	6.2	145	711	37.9
	Average	10.6	6.2	144	708	38.0
9-1	1	10.2	6.1	146	713	38.1
	2	10.1	6.1	147	720	38.3
	3	10.2	6.2	147	722	38.3
	Average	10.2	6.1	147	718	38.2
10-1	1	9.7	6.1	153	749	39.1
	2	9.8	6.0	150	735	38.9
	3	10.0	6.0	153	748	38.9
	Average	9.8	6.0	152	744	39.0

Table 7 (Continued)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
11-1	1	10.6	5.6	139	680	38.6
	2	10.7	5.9	138	677	38.8
	3	10.6	6.1	140	684	38.6
	Average	10.6	5.9	139	680	38.7
12-1	1	10.4	5.8	138	678	37.7
	2	10.2	5.8	139	680	37.7
	3	10.2	5.9	139	681	37.9
	Average	10.3	5.8	139	680	37.8
13-1	1	10.0	5.7	137	670	37.6
	2	9.7	5.9	138	674	37.0
	3	9.9	5.8	138	676	37.2
	Average	9.9	5.8	137	673	37.3
14-1	1	10.4	7.7	129	633	37.7
	2	10.1	7.3	128	629	37.7
	3	10.3	7.4	132	648	37.9
	Average	10.3	7.5	130	637	37.8
15-1	1	8.4	9.5	132	647	38.7
	2	8.9	9.4	134	659	38.8
	3	8.8	9.3	129	633	38.8
	Average	8.7	9.4	132	646	38.8
16-1	1	8.2	11.4	133	653	40.2
	2	8.0	11.5	134	658	40.4
	3	7.9	11.1	136	664	40.5
	Average	8.0	11.3	134	658	40.4
17-1	1	10.7	10.0	173	849	52.1
	2	10.3	9.7	181	889	52.3
	3	10.4	10.1	177	868	52.5
	Average	10.5	9.9	177	869	52.3
18-1	1	11.2	8.0	210	1027	54.5
	2	11.0	8.8	208	1018	54.4
	3	11.5	8.4	205	1006	54.1
	Average	11.2	8.4	208	1017	54.3

Table 7 (Continued)

Sample No.	Analysis No.	MFI	NI	FS	FM	HR
19-1	1	10.9	7.7	219	1074	54.5
	2	10.9	7.8	222	1089	54.6
	3	11.1	7.5	220	1076	54.2
	Average	11.0	7.7	220	1080	54.4
20-1	1	10.2	6.4	229	1122	53.1
	2	10.2	6.2	232	1139	53.2
	3	10.4	6.1	227	1111	53.4
	Average	10.3	6.2	229	1124	53.2
21-1	1	9.3	5.9	251	1230	53.2
	2	9.2	6.0	247	1210	53.8
	3	9.1	6.2	246	1204	53.7
	Average	9.2	6.0	248	1215	53.6
22-1	1	8.7	8.3	235	1150	53.8
	2	8.9	8.1	231	1131	54.2
	3	8.6	7.8	229	1122	54.1
	Average	8.7	8.1	231	1134	54.0
23-1	1	7.7	7.8	244	1198	57.5
	2	7.9	8.2	237	1161	57.6
	3	7.6	7.9	249	1220	57.4
	Average	7.7	8.0	243	1193	57.5
24-1	1	7.1	6.0	276	1354	58.2
	2	7.1	5.9	275	1346	58.3
	3	7.0	6.0	279	1367	57.9
	Average	7.1	6.0	277	1356	58.1
25-1	1	9.5	6.5	235	1151	49.8
	2	9.5	6.4	238	1164	49.9
	3	9.4	6.6	234	1147	50.1
	Average	9.5	6.5	236	1154	49.9
26-1	1	9.6	6.4	207	1012	48.4
	2	9.5	6.3	204	1002	48.3
	3	9.5	6.4	211	1034	48.7
	Average	9.5	6.4	207	1016	48.5
27-1	1	9.3	6.4	228	1117	50.8
	2	9.3	6.3	230	1129	50.4
	3	9.3	6.3	233	1143	50.7
	Average	9.3	6.3	231	1130	50.6

Table 8 Avarage mechanical analysis of PP/EPDM composites

Sample No.	PP/EPDM/talc/clay/cb/gf/HDPE	MFI	NI	FS	FM	HR
A		9.3	8.7	271	1328	48.3
B		18.9	5.7	226	1107	43.9
1	90/10/10	20.2	3.8	196	962	42.8
2	85/15/10	14.9	4.7	166	816	40.8
3	80/20/10	11.0	6.2	139	683	36.7
4	75/25/10	8.3	7.8	127	620	33.8
5	70/30/10	5.7	9.7	107	523	31.0
6	65/35/10	4.0	12.6	84	409	27.7
7	60/40/10	3.2	13.0	58	282	23.8
8	80/20/15	10.5	6.2	145	711	37.9
9	80/20/20	10.3	6.1	147	720	38.2
10	80/20/25	9.9	6.0	152	743	38.9
11	80/20/10/5	10.7	5.9	139	682	38.9
12	80/20/10/10	10.4	5.8	139	680	37.9
13	80/20/10/15	9.9	5.7	138	675	37.2
14	80/20/10/-/5	10.4	7.4	131	640	37.9
15	80/20/10/-/10	8.7	9.4	132	645	39.0
16	80/20/10/-/15	8.0	11.2	134	659	40.3
17	85/15/15/-/15	10.4	9.8	175	855	52.4
18	90/10/15/-/15	11.2	8.4	208	1018	54.2
19	90/10/20/-/15	11.0	7.6	218	1069	54.4
20	90/10/25/-/15	10.3	6.4	230	1129	53.4
21	90/10/30/-/15	9.2	5.9	248	1217	53.5
22	90/10/15/-/15/5	8.6	8.0	231	1133	54.0
23	90/10/15/-/15/10	7.7	7.9	254	1243	57.4
24	90/10/15/-/15/15	7.0	5.9	275	1349	58.1
25	90/10/30/-/15/-/5	9.5	6.5	235	1150	50.2
26	90/10/25/-/15/-/10	9.5	6.4	208	1121	48.9
27	90/10/30/-/15/-/10	9.4	6.3	230	1127	50.0

Remark: cb = carbon black
 gf = glass fiber
 HDPE = hide density polyethylene

Appendix III

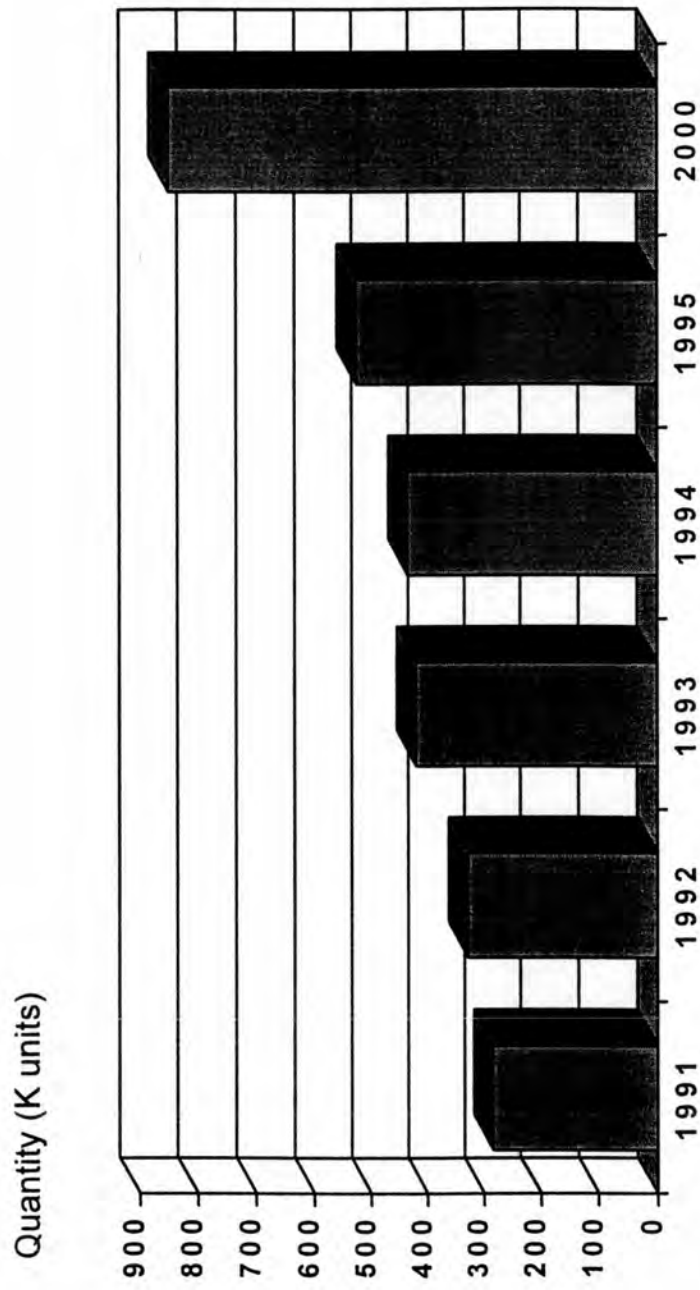


Figure 14 The growth rate of car industry in Thailand

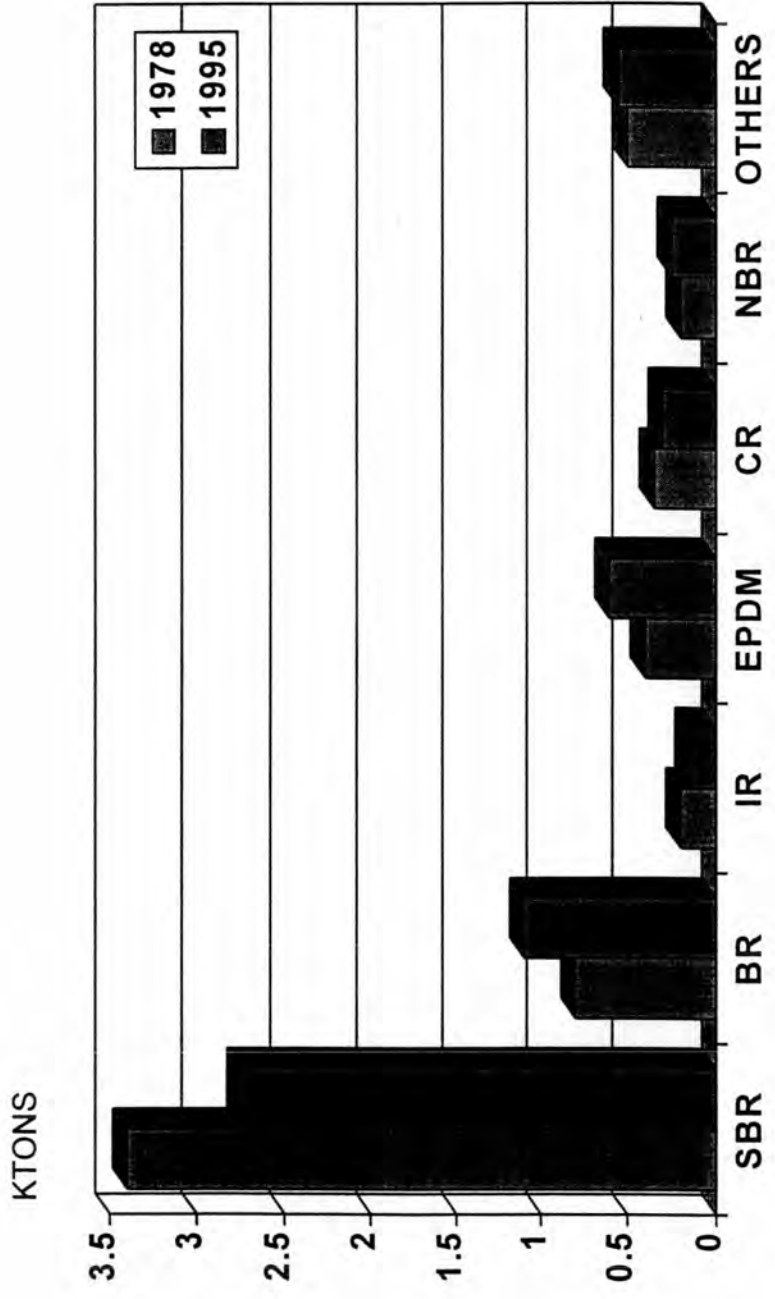


Figure 15 Worldwide rubber industry

Table 9 Value of imported auto part and auto equipment

Auto part and auto equipment	1991	1992	1993	1994	1995
Mechanical belting	51.69	73.45	76.86	145.27	73.00
Safety glass	0.72	7.00	9.35	19.67	15.00
Gasoline engine	2,169.73	1,803.96	1,635.96	2,135.86	2,410.00
Diesel engine	6,193.33	3,117.48	2,377.44	2,155.73	2,150.00
Fuel filter	143.02	166.89	215.48	272.08	420.00
Air filter	53.60	52.56	62.17	60.33	72.00
Wire harness	52.25	80.84	149.39	127.46	174.00
Auto body	60.69	235.32	228.90	172.16	200.00
Bumper and Part	18.15	21.62	121.37	69.86	380.00
Safety belt	30.05	87.89	186.66	164.92	175.00
Radiator	7.00	8.61	61.94	19.98	40.00
Clutch and Part	202.63	179.54	251.08	312.89	280

Source: Custom Department

VITAE

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