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APPENDIX A

NUCLEAR MAGNETIC RESONANCE SPECTRA

NMR determination of poly(styrene-*co*-methyl methacrylate) is carried out using solutions of samples in deuterated chloroform. The spectrum is recorded on a high resolution NMR spectrometer with a variable temperature sample head. Tetramethyl silane is used as a reference. Resonance areas were measured by integration where the peaks were well resolved, and by planimeter where they were not. When areas were measured by planimeter, the true shape of the peak was estimated and this area was measured.

Copolymer compositions can be determined from ^1H spectra recorded at relatively low magnetic fields. The system was investigated to find the resonance area for each of these components which showed the least interference. Relative mole amounts were determined as usual by dividing the area of the characteristic resonance selected for each polymer component by the number of protons per component molecule which gives rise to the resonance.

For poly(styrene-*co*-methyl methacrylate), the styrene component was determined at the phenyl resonance (6.4-7.3 ppm) and methyl methacrylate determined at the alpha methyl resonance (0.7-1.1 ppm).

The assignments of the ^1H -NMR and ^{13}C -NMR spectrum are shown in Tables A-1 to A-2, respectively.

Table A-1 Assignments of the ^1H -NMR spectrum of poly(styrene-*co*-methyl methacrylate)

Assignments	Chemical Shift (ppm)
STY C_6H_5	6.4-7.3
MMA C-CH_3	0.25-1.1
O-CH_3	2.2-3.6

Table A-2 Assignments of the ^{13}C -NMR spectrum of poly(styrene-*co*-methyl methacrylate)

Assignments	Chemical Shift (ppm)
STY aromatic ring carbon (1)	144-146
aromatic ring carbon (2)	125-130
$^{13}\text{CH}_2$	44-49
^{13}CH	31-32
MMA ^{13}CO	175-177
$^{13}\text{CH}_2$	44-51
^{13}C	39-40
$^{13}\text{CH}_3$	18-23

Table A-3 shows the copolymer composition obtained from the above analytical procedure. Referring to Figure A-1, schematic structures of the monomer units in poly(styrene-*co*-methyl methacrylate) are given.

Table A-3 Copolymer composition of poly(styrene-*co*-methyl methacrylate)

No. ^a	STY ^{b,c} (mole%)	MMA ^{b,d} (mole%)
T1	73.56	26.44
T2	81.99	18.00
T3	81.67	18.33
T4	78.04	21.96

^aKnown mole% styrene = 75

^bCalculated mole%

^cDetermined by dividing the area of the phenyl protons peak by the number of protons.

^dDetermined by dividing the area of the methyl protons peak by the number of protons.

The structures of the monomer units are shown as below :

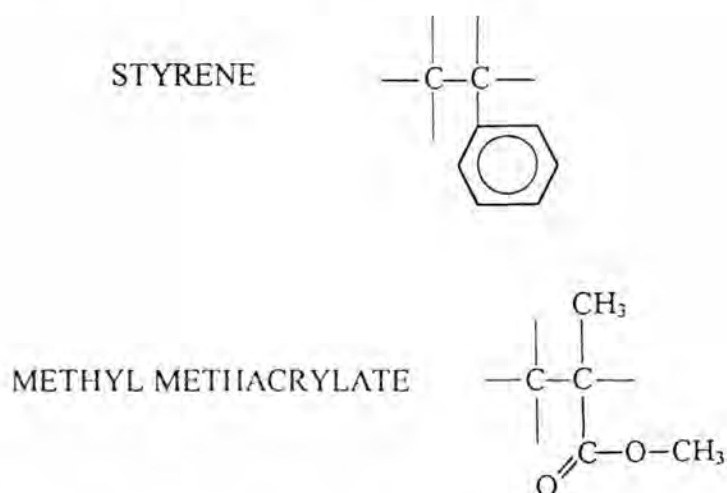


Figure A-1 Schematic structures of monomer units in poly(styrene-*co*-methyl methacrylate)

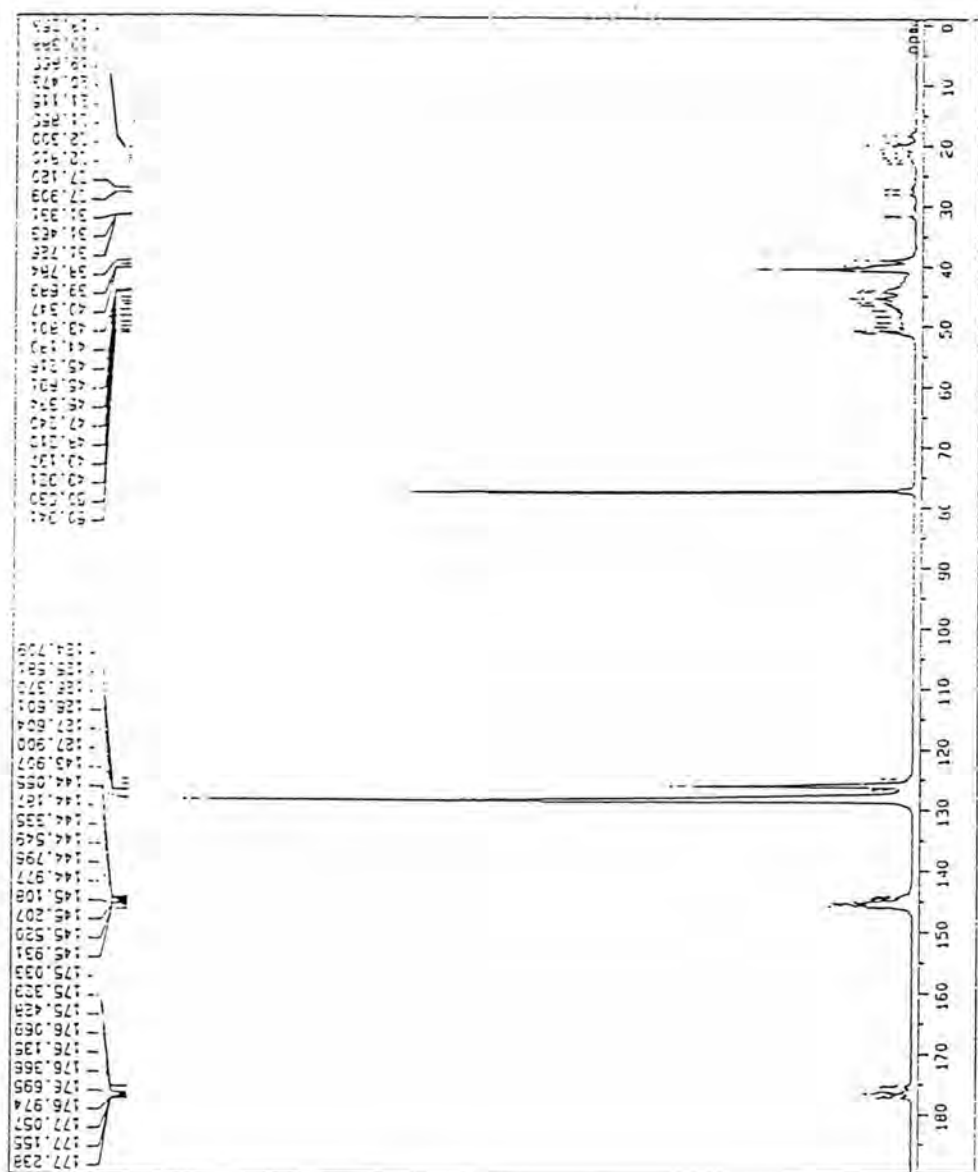


Figure A-2 ^{13}C -NMR spectrum of poly(styrene-co-methyl methacrylate)

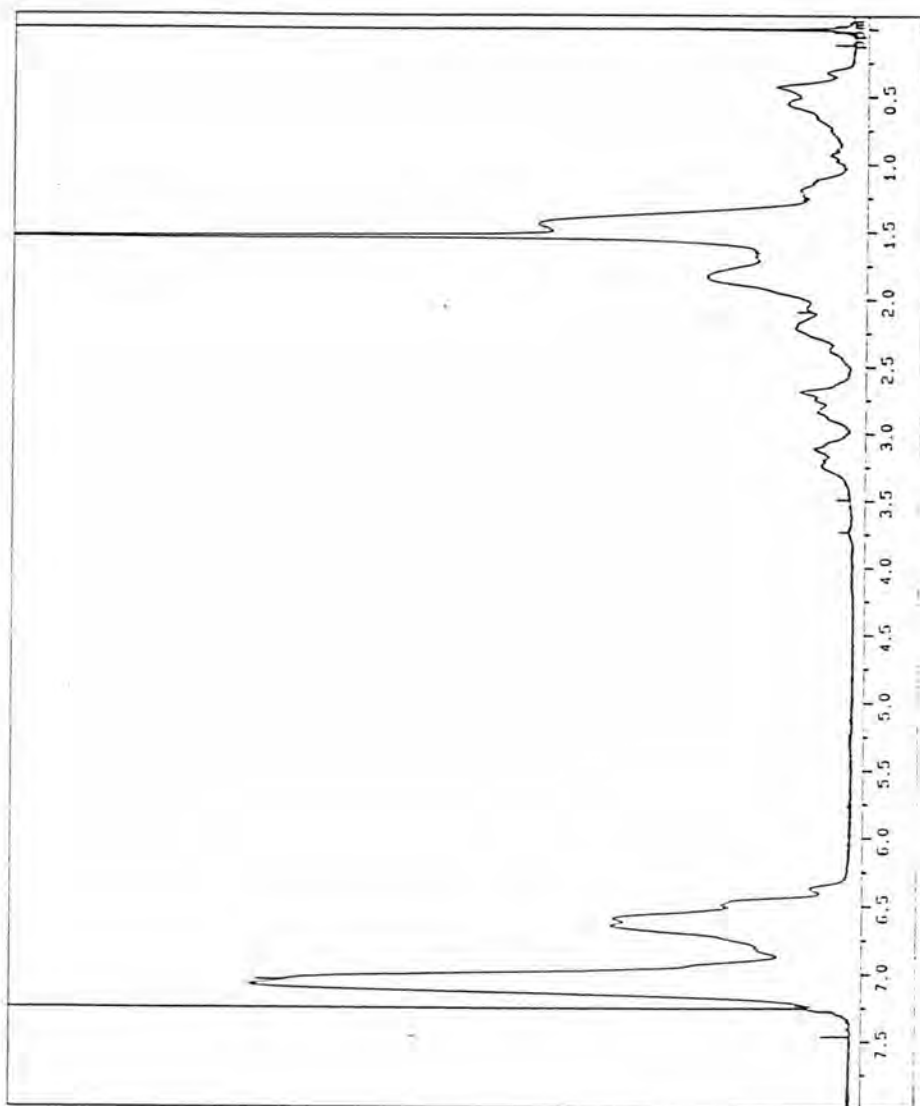


Figure A-3 ¹H-NMR spectrum of poly(styrene-co-methyl methacrylate) synthesized for 6 h reaction time

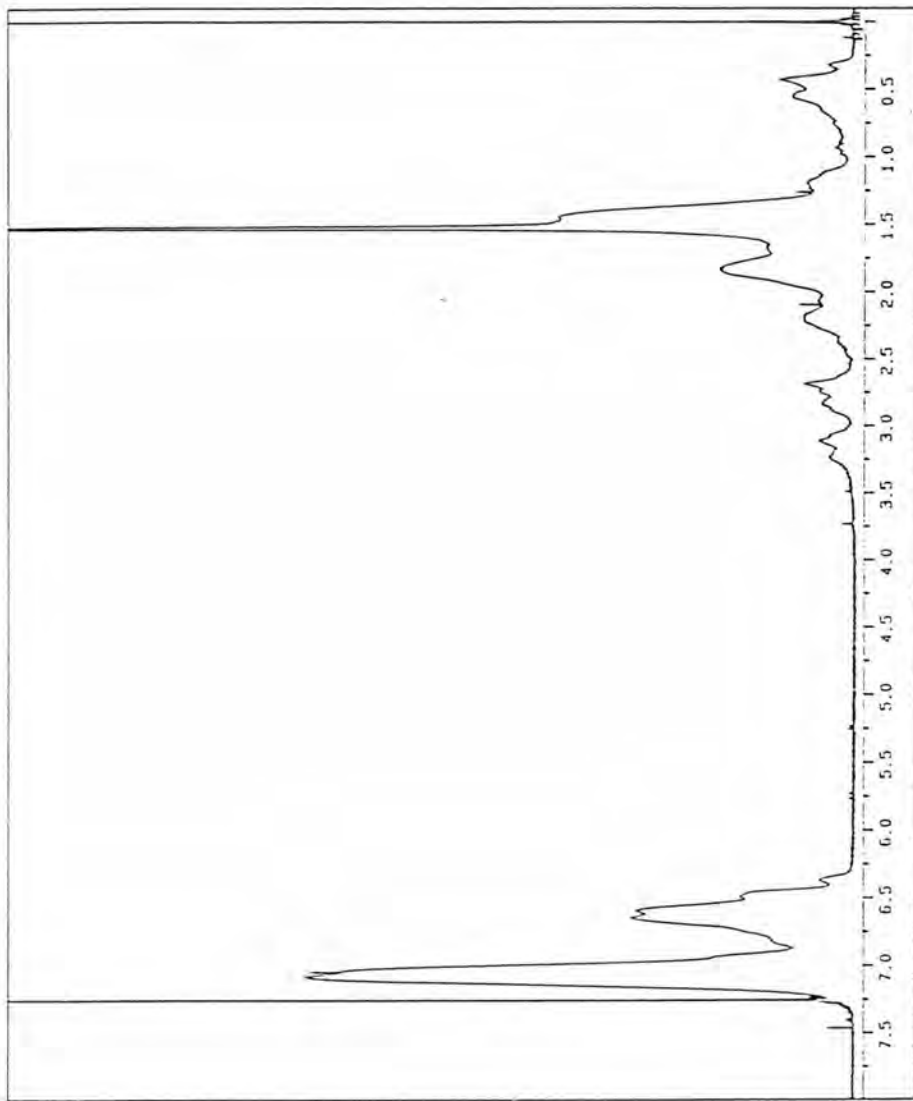


Figure A-4 ¹H-NMR spectrum of poly(styrene-co-methyl methacrylate) synthesized for 8 h reaction time

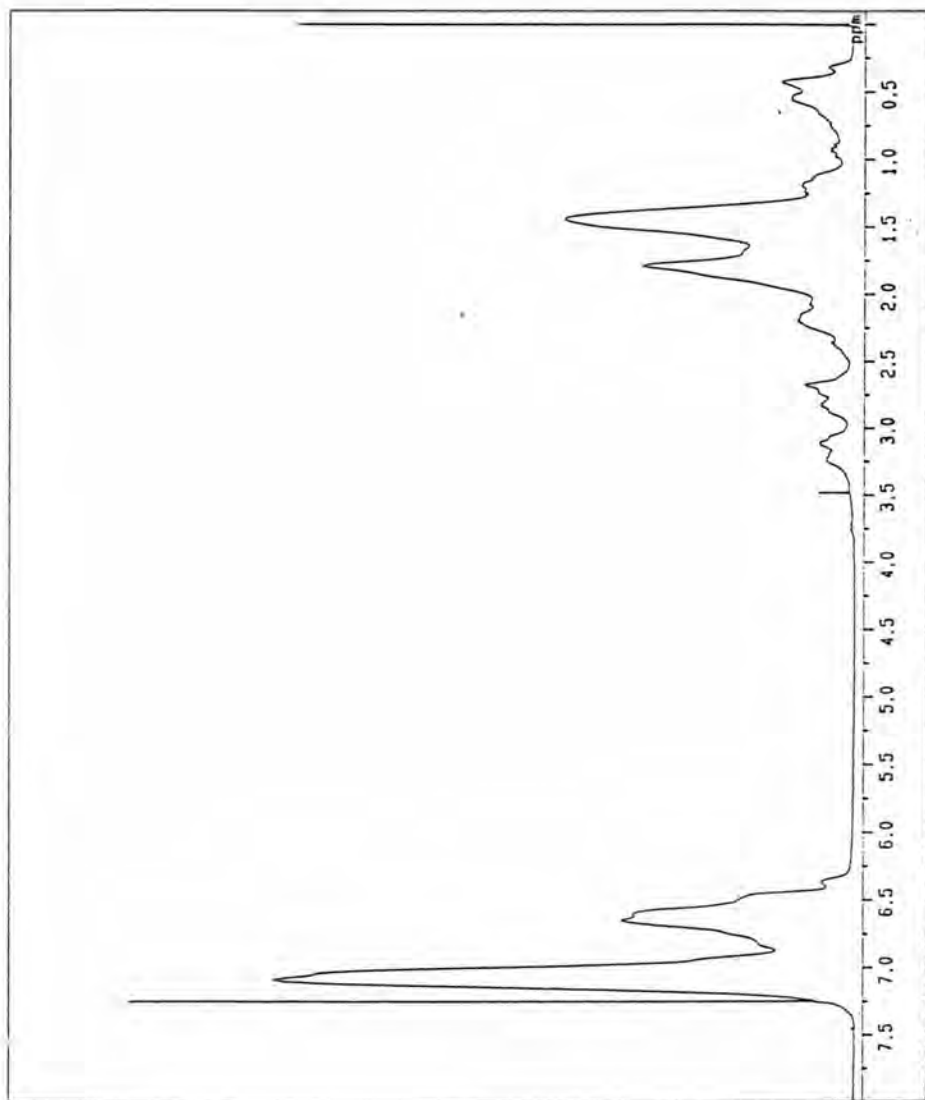


Figure A-5 ¹H-NMR spectrum of poly(styrene-*co*-methyl methacrylate) synthesized for 10 h reaction time

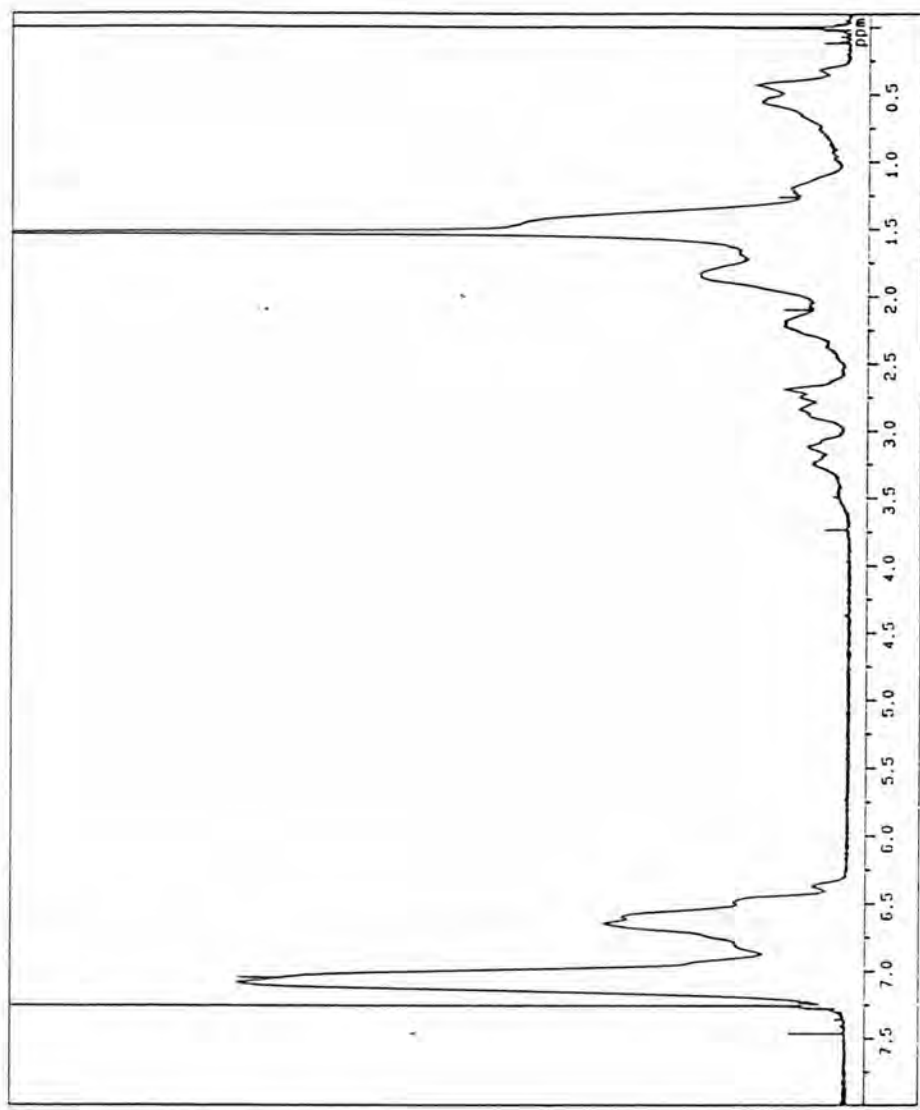


Figure A-6 ¹H-NMR spectrum of poly(styrene-co-methyl methacrylate) synthesized for 15 h reaction time

APPENDIX B

ELEMENTAL ANALYSIS

The elemental analyses were in agreement with the linear polymer structure. The analytical data of %C, %H, and %N were shown. The calculation of the copolymer composition of poly(styrene-*co*-methyl methacrylate) was determined by percent carbon.

Sample analyses of poly(styrene-*co*-methyl methacrylate) are given in Table B-1. These analyses give the ratio of styrene to methyl methacrylate as shown in Table B-2.

Table B-1 Elemental analyses data of poly(styrene-*co*-methyl methacrylate)^a

No.	%C	%H	%N
F1	59.83	8.29	0
F2	73.59	8.14	0.08
F3	78.01	7.64	0.52
F4	85.87	8.19	0.13
F5	90.33	7.98	0.29
T4	85.17	8.00	0

^aObtained by CHNS/O Analyser

Table B-2 Analytical data of the copolymer composition of
poly(styrene-*co*-methyl methacrylate)

No. ^a	STY ^b (mole%)	MMA ^b (mole%)
F1	0	100.51
F2	42.15	57.85
F3	55.85	44.15
F4	80.18	19.82
T4	78.03	21.97

^aKnown mole% styrene F1= 0, F2 = 25, F3 = 50, F4 = 75, T4 = 75

^bCalculated mole%

Calculation of Copolymer Composition

$$\% \text{STY in copolymer} = \frac{\% \text{C of STY in copolymer}}{\% \text{C of STY in copolymer} + \% \text{C of MMA in copolymer}}$$

$$\% \text{C of STY in copolymer} = \text{Average \%C in copolymer} - \% \text{C of MMA}$$

$$\% \text{C of MMA in copolymer} = \text{Average \%C in copolymer} - \% \text{C of STY}$$

APPENDIX C

FOURIER-TRANSFORM INFRARED SPECTRA

Characterization of the major constituents of the copolymer or the matrix polymer on the surface of polymer particles was determined by fourier-transform infrared spectroscopy. The assignments of infrared spectra are shown in Table C-1.

Table C-1 Assignments of the infrared spectra of poly(styrene-*co*-methyl methacrylate)

	Assignments	Wave Number (cm ⁻¹)
MMA	CH stretching	3114, 2999
	C=O stretching	1731
	CH deformation	1487, 1453
	C-O stretching	1194, 1147
	COOCH ₃ stretching	989, 810
	CH ₂ rocking	693
STY	=C-H vibration (Aryl C-H)	3060, 3025
	CH aliphatic stretching	2924, 2848
	monosubstituted aromatic rings	1945, 1870, 1795, 1742
	C=C stretching	1635, 1602, 1493
	C-C stretching	1602, 1584, 1493, 1452
	C-H out of plane deformation	754

	Assignments	Wave Number (cm ⁻¹)
STY	CH out of plane ring deformation	698
PVP	CH stretching	2965, 2927
	C=O stretching	1666
	C-C stretching	1494, 1462
	C-N stretching	1424, 1290

Infrared spectra of the copolymer prepared at the styrene feed of 100% and 0%, the reaction temperature of 60°C, 70°C and 80°C, and the PVP K-30 concentration of 0 wt%, 8 wt%, 12 wt% are shown in Figures C-3 to C-10.

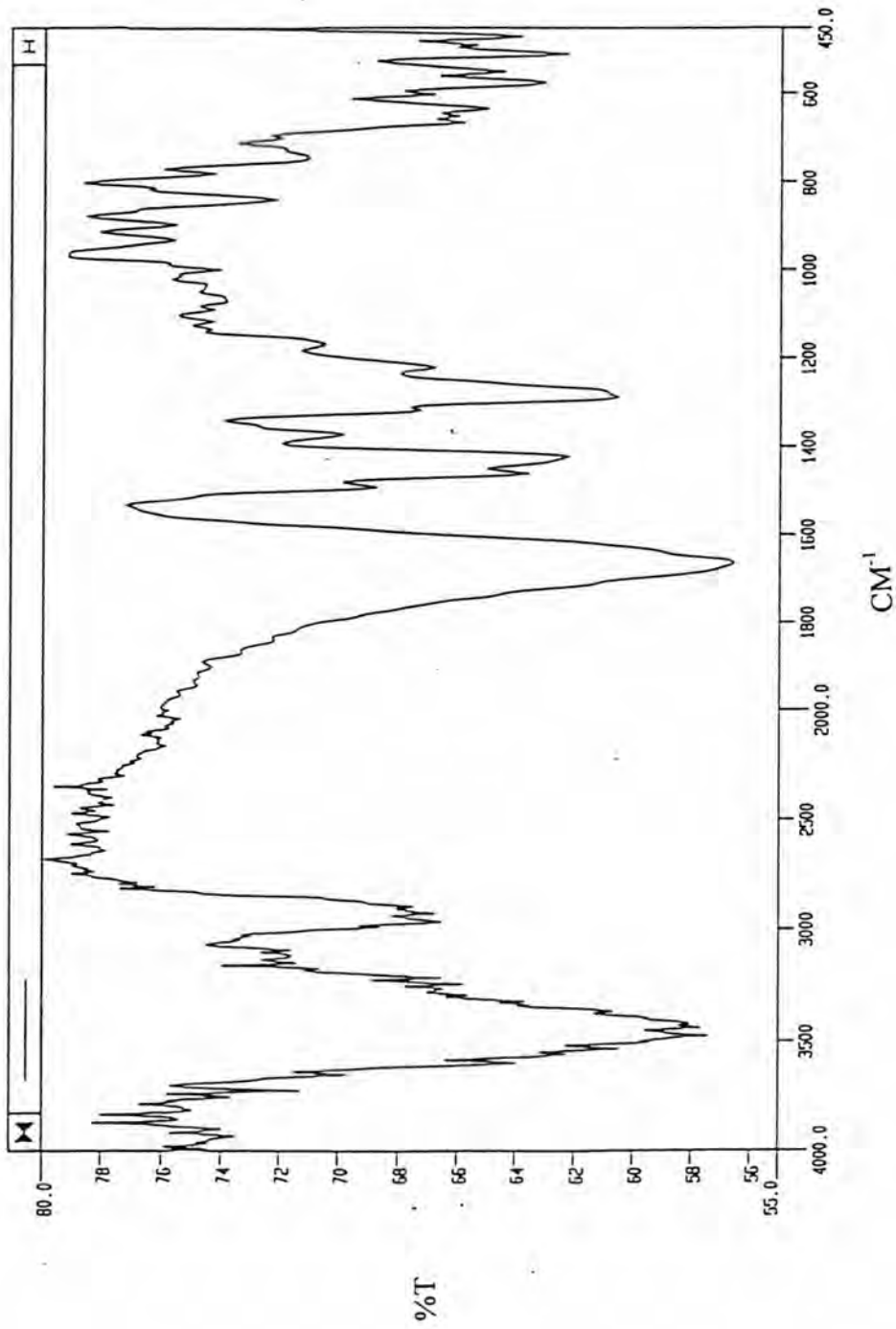


Figure C-1 FTIR spectra of poly(N-vinyl pyrrolidone)

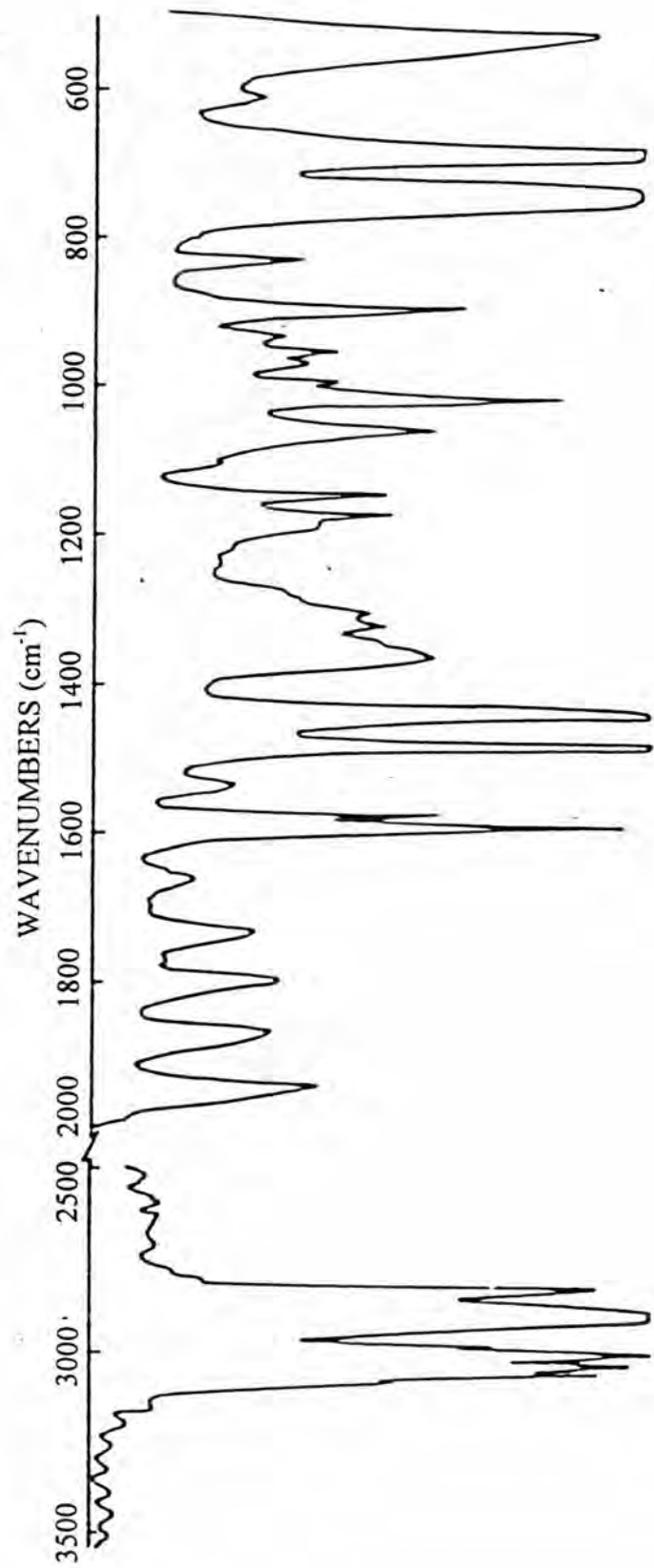


Figure C-2 FTIR spectra of polystyrene standard

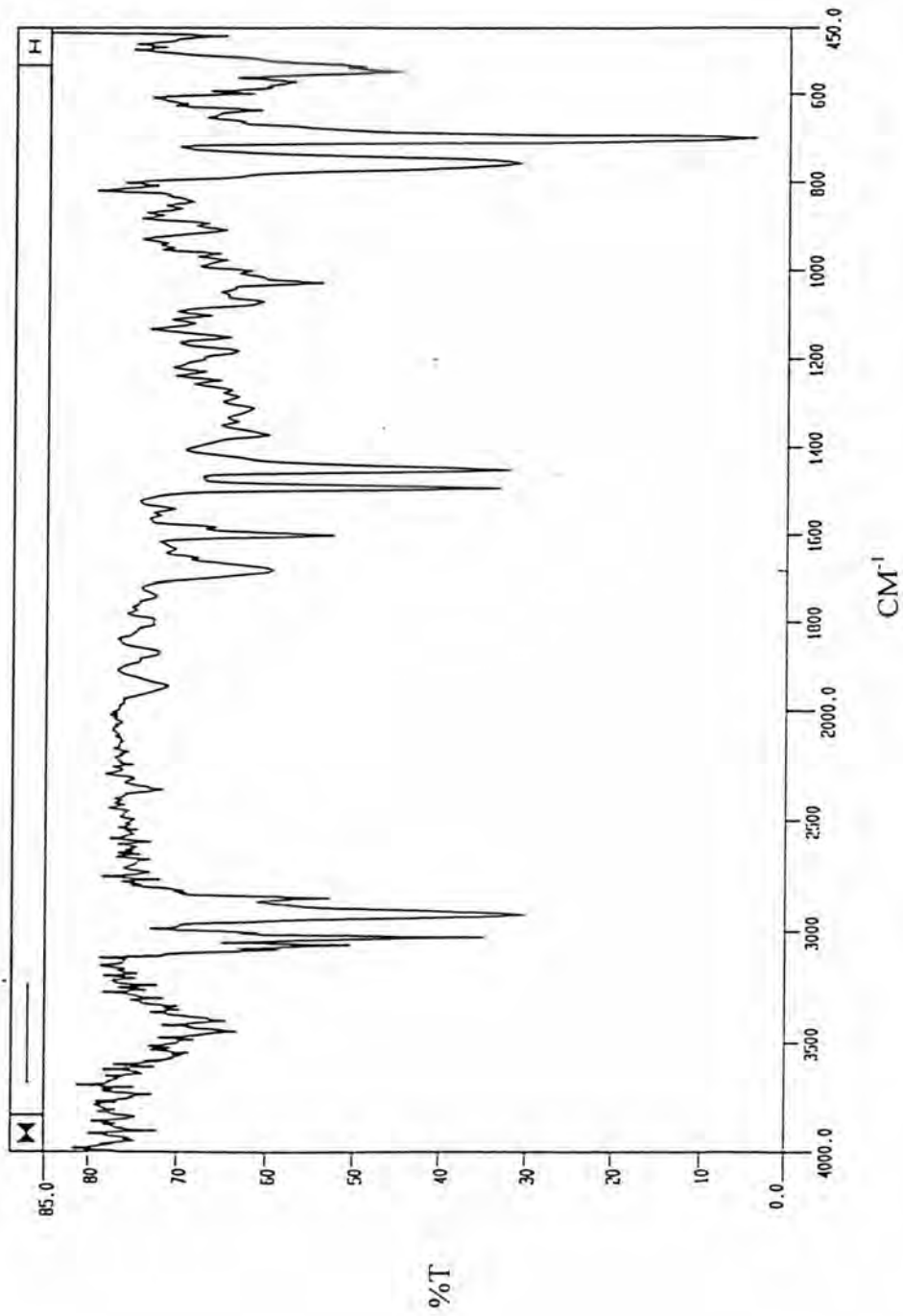


Figure C-3 FTIR spectra of polystyrene prepared by dispersion polymerization

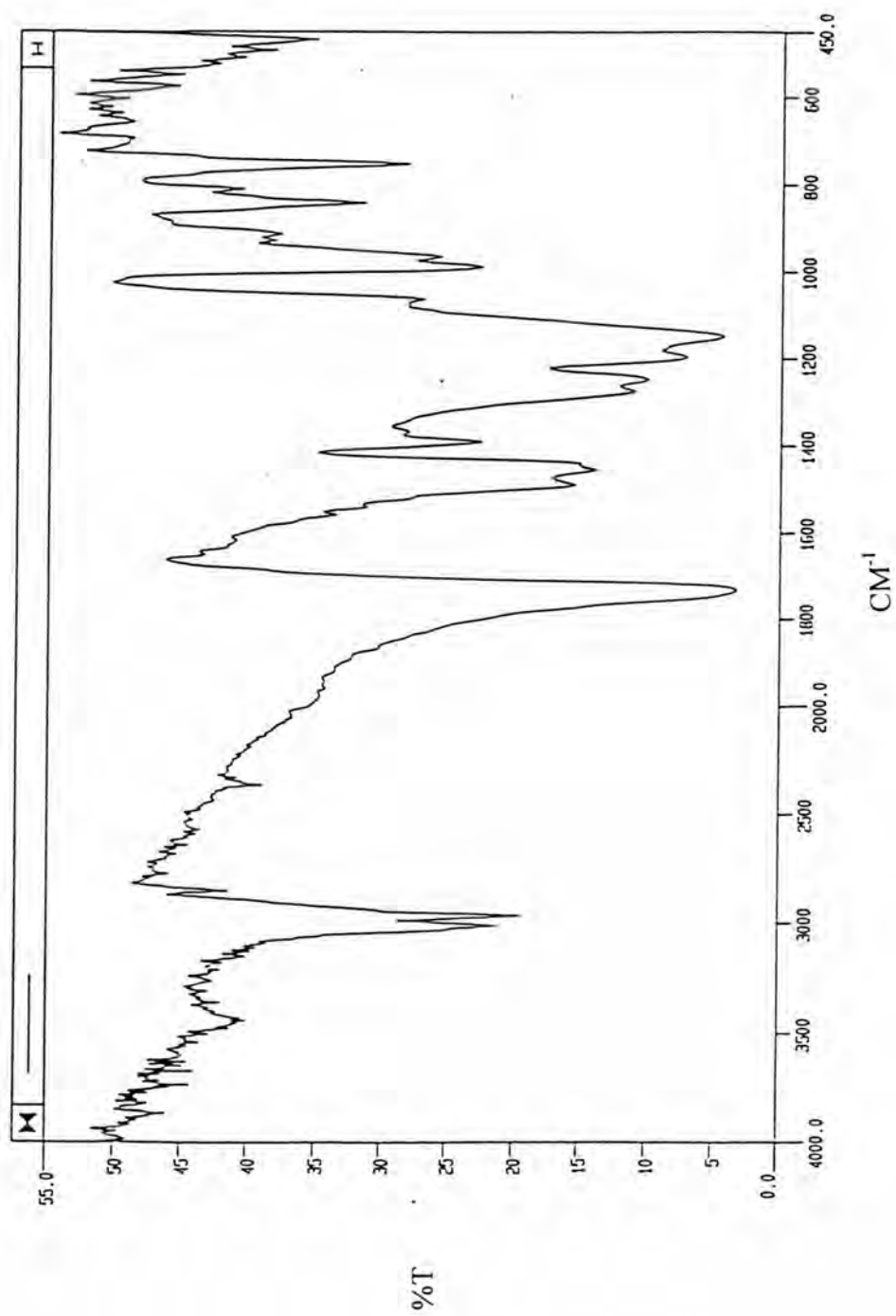


Figure C-4 FTIR spectra of poly(methyl methacrylate) prepared by dispersion polymerization

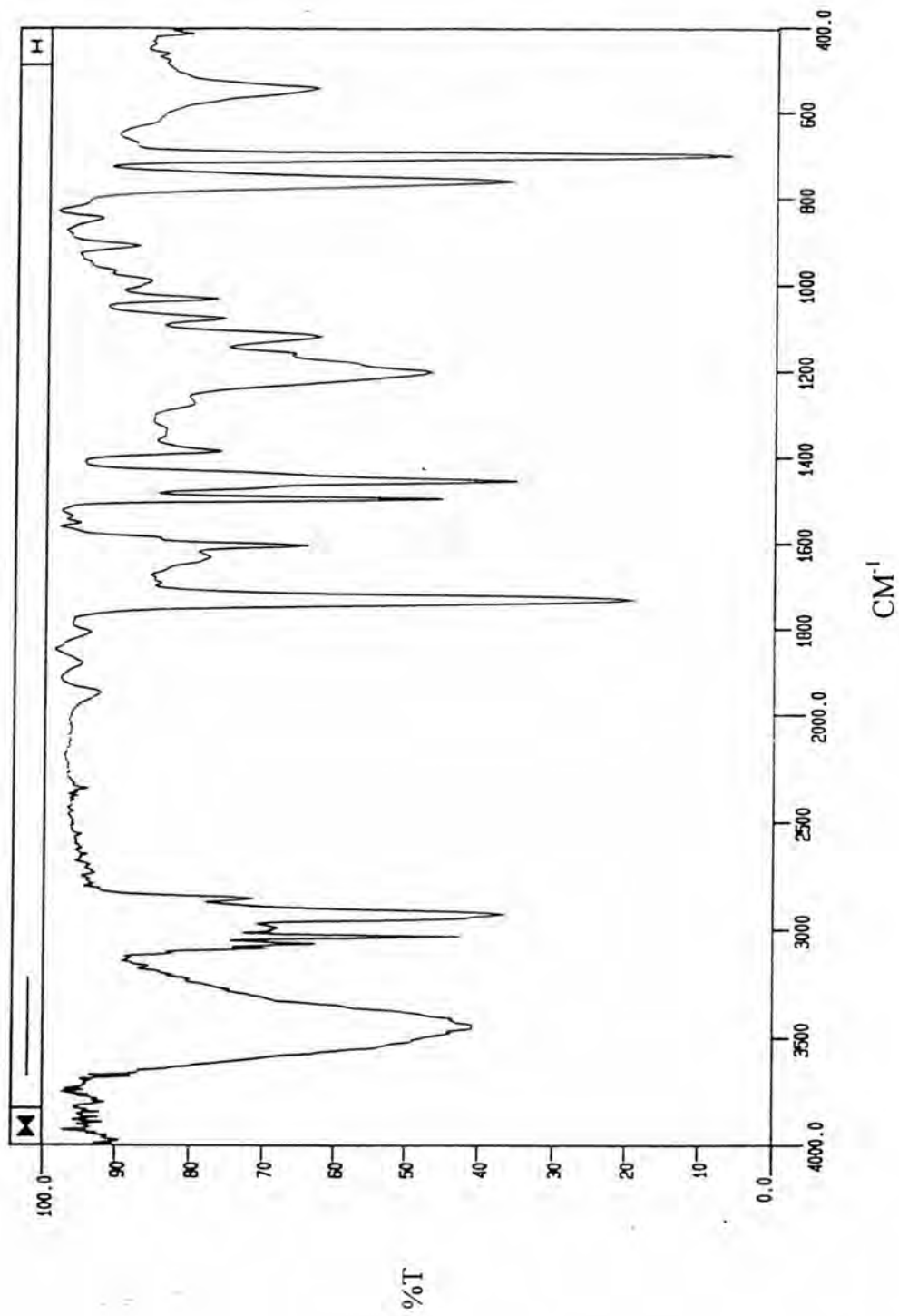


Figure C-5 FTIR spectra of poly(styrene-co-methyl methacrylate) synthesized at 60°C reaction temperature

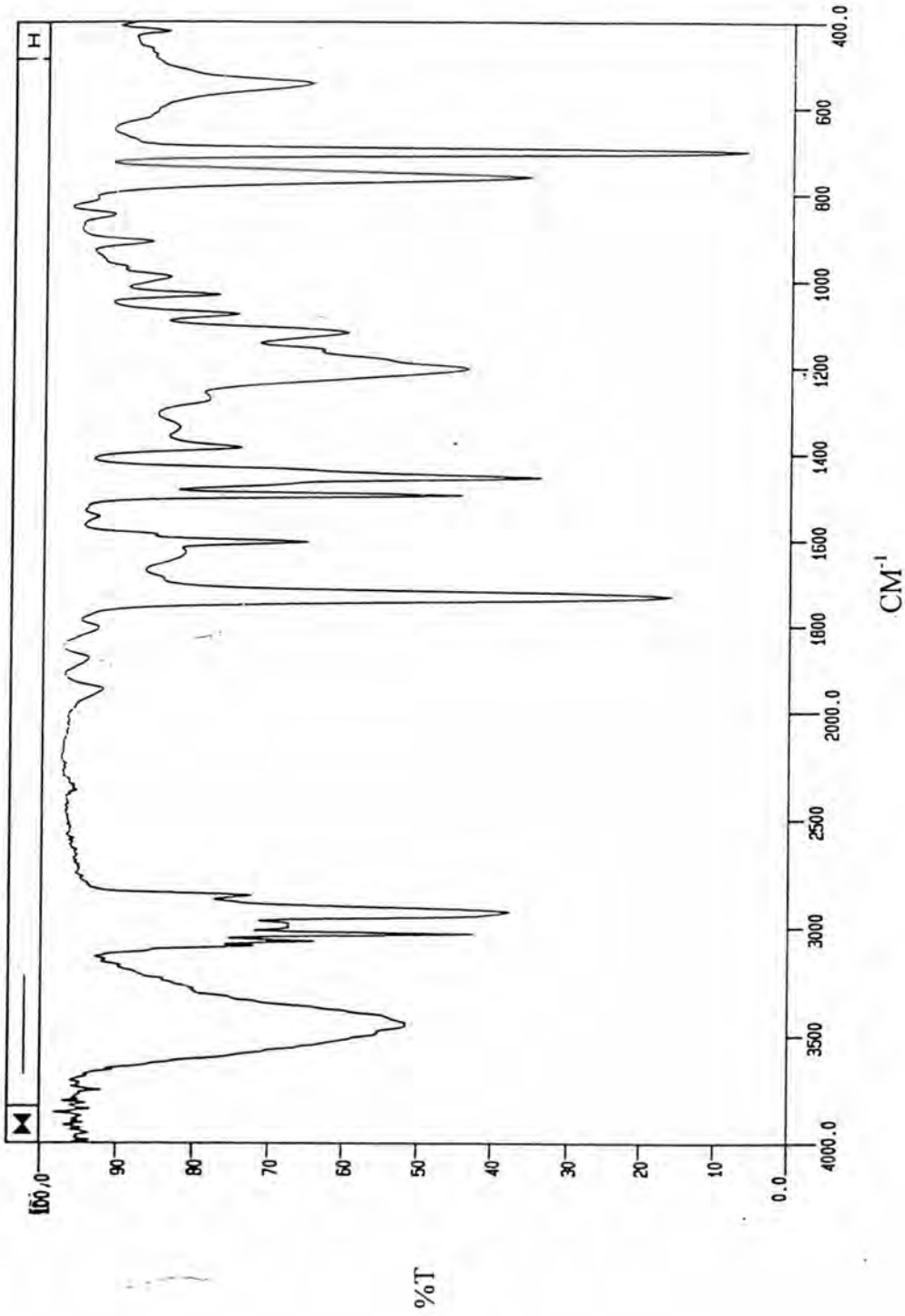


Figure C-6 FTIR spectra of poly(styrene-co-methyl methacrylate) synthesized at 70°C reaction temperature

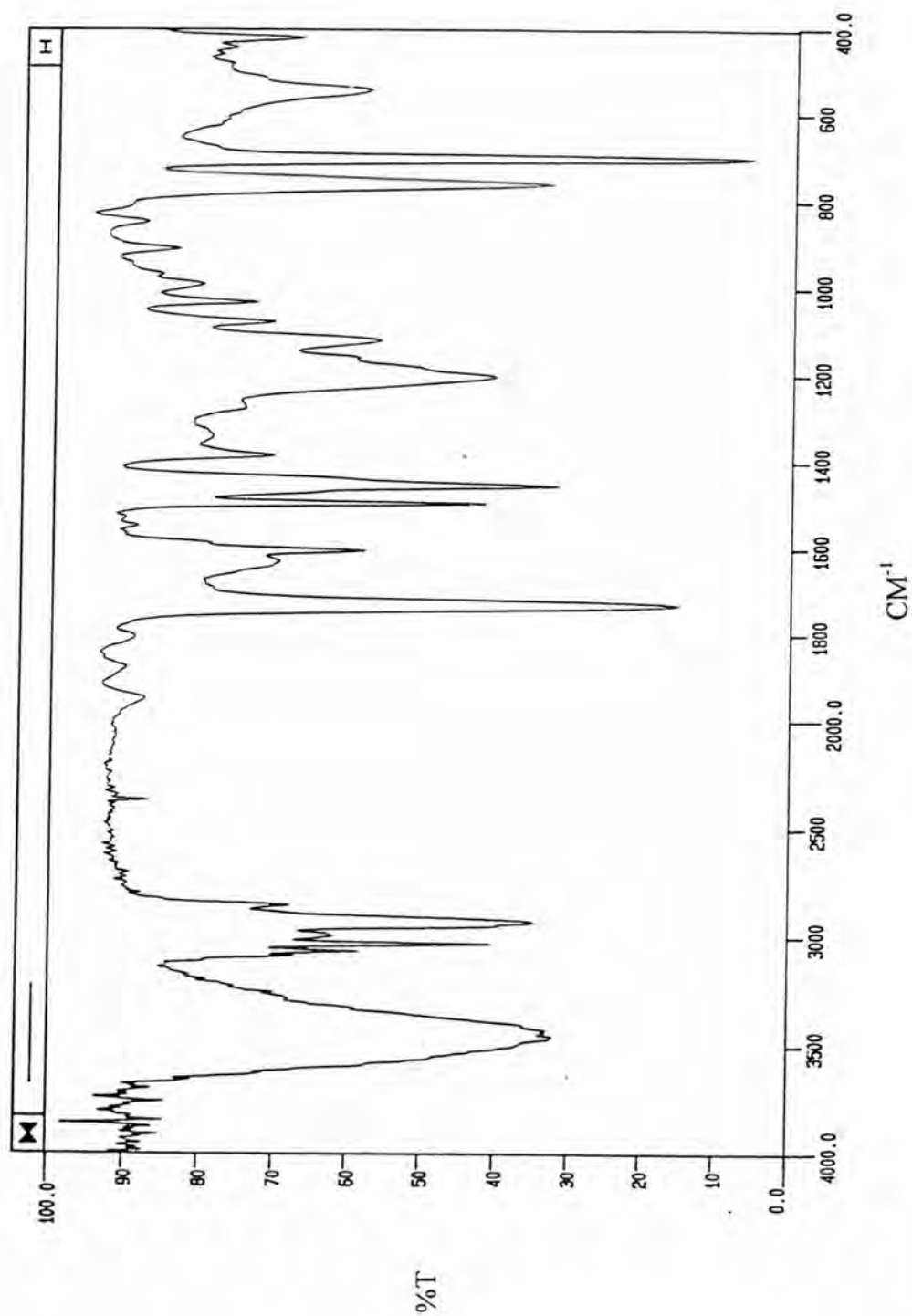


Figure C-7 FTIR spectra of poly(styrene-co-methyl methacrylate) synthesized at 80°C reaction temperature

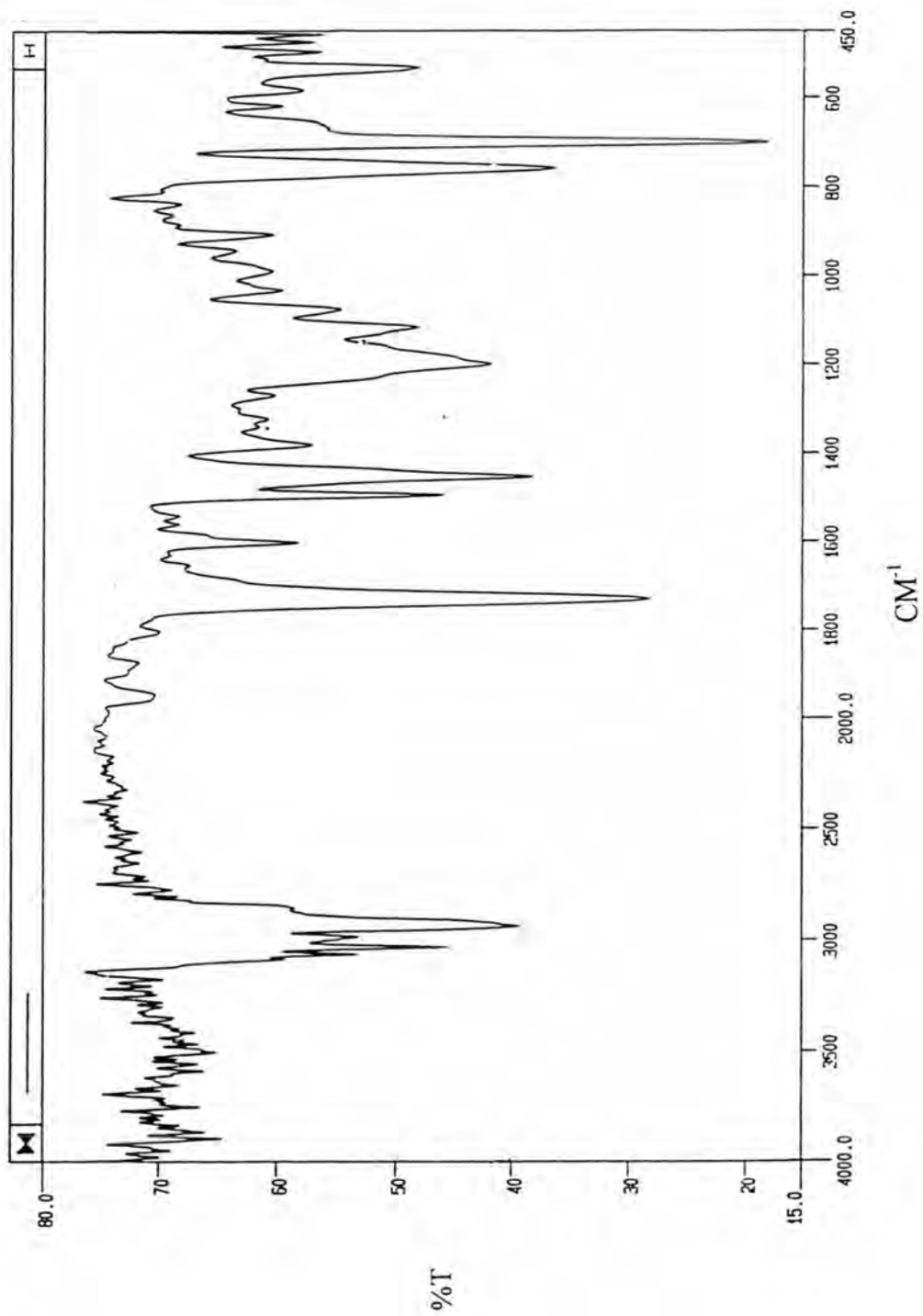


Figure C-8 FTIR spectra of poly(styrene-co-methyl methacrylate) prepared without the PVP matrix polymer

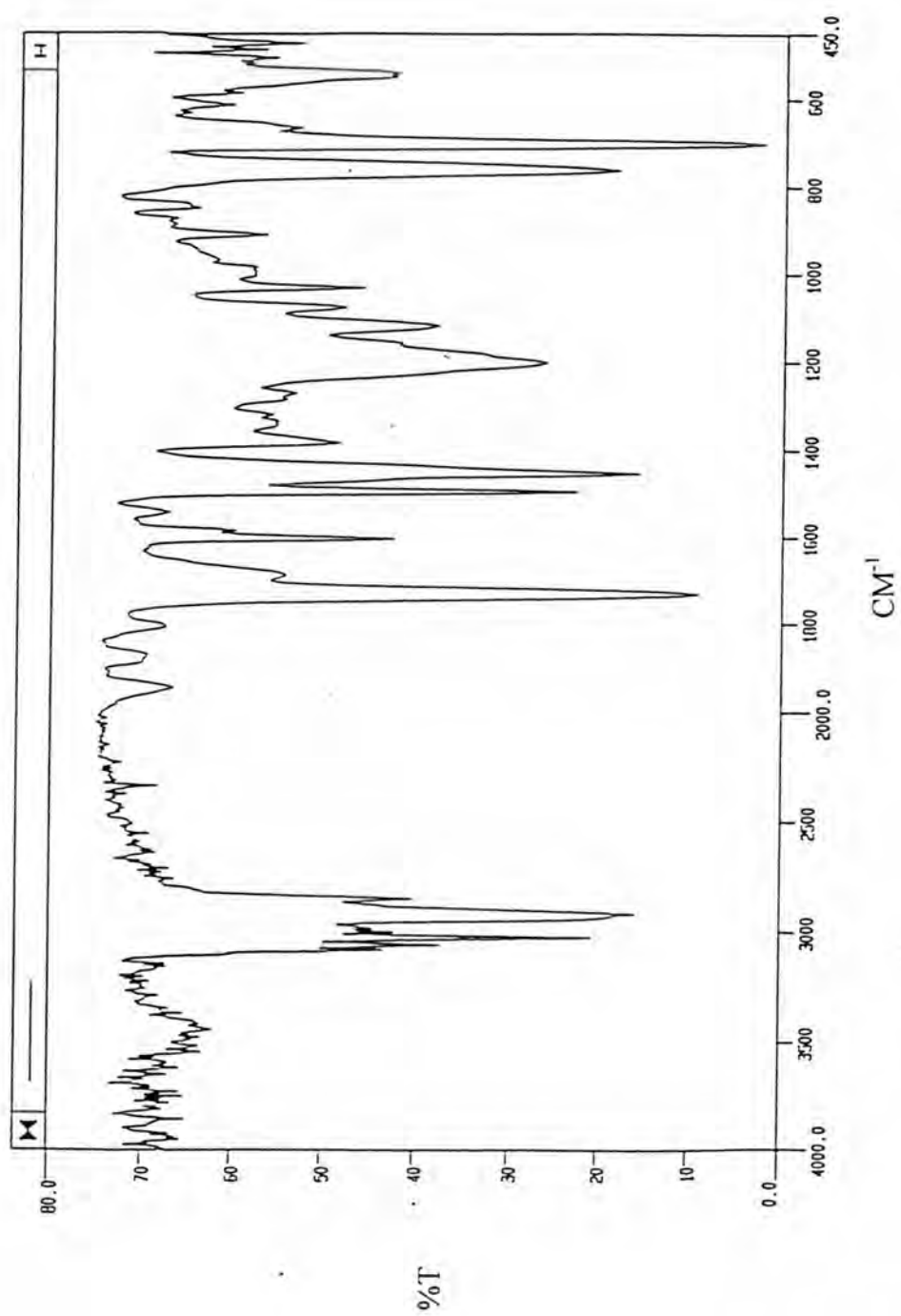


Figure C-9 FTIR spectra of poly(styrene-co-methyl methacrylate) controlled by 8 wt% PVP K-30

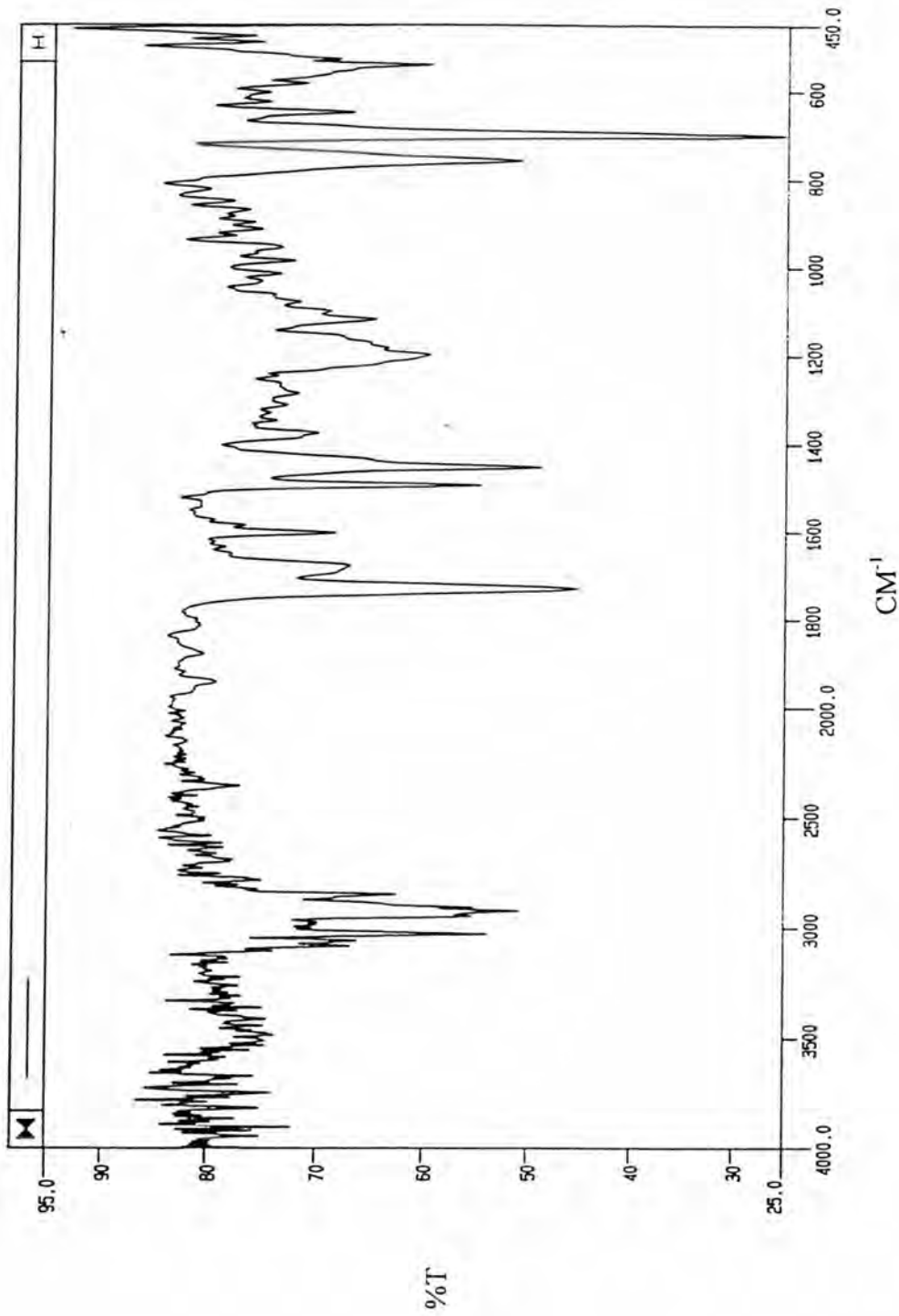


Figure C-10 FTIR spectra of poly(styrene-co-methyl methacrylate) controlled by 12 wt% PVP K-30

APPENDIX D

THE CHART OF PARTICLE SIZE DISTRIBUTION OF POLY(STYRENE-*CO*- METHYL METHACRYLATE)

The particle size distributions of poly(styrene-*co*-methyl methacrylate) were measured on photographs taken by a scanning electron microscopic technique. In each sample, 400 particles on the electron micrograph were measured, calculated for average particle size and the size distribution.

Figures D-a1 to D-e4 show the chart of particle size distribution of the copolymer prepared of different conditions.

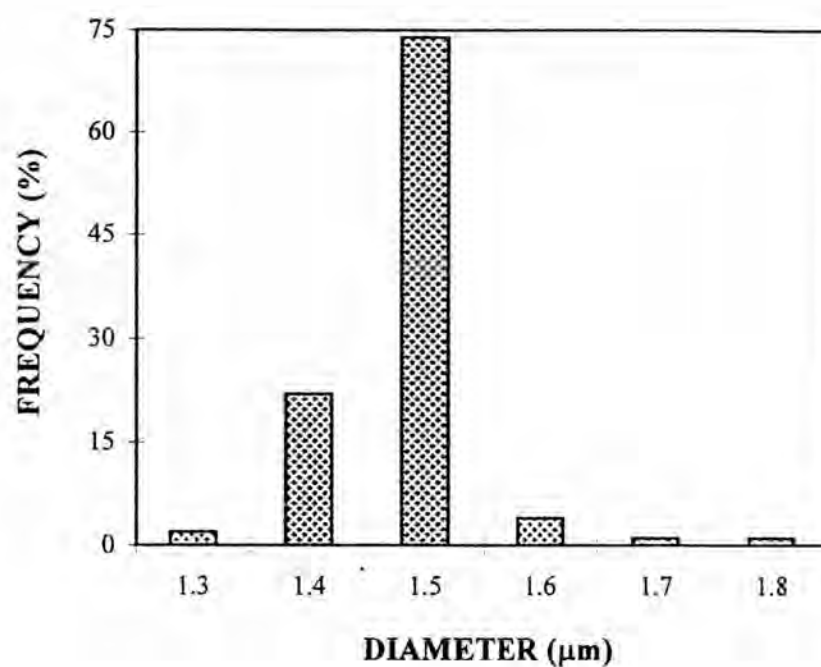


Figure D-a1 PSD of poly(styrene-*co*-methyl methacrylate) controlled by 2 wt% PVP K-30

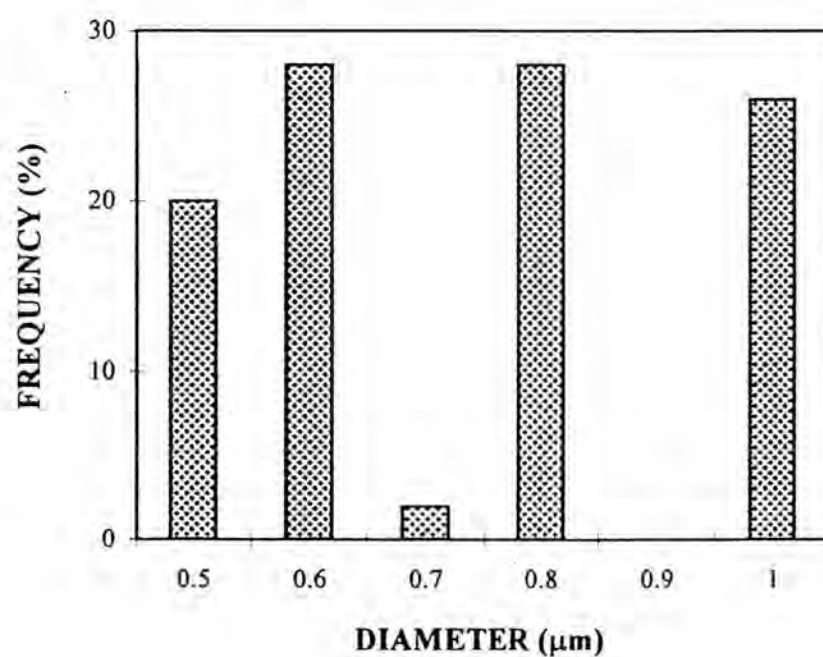


Figure D-a2 PSD of poly(styrene-*co*-methyl methacrylate) controlled by 6 wt% PVP K-30

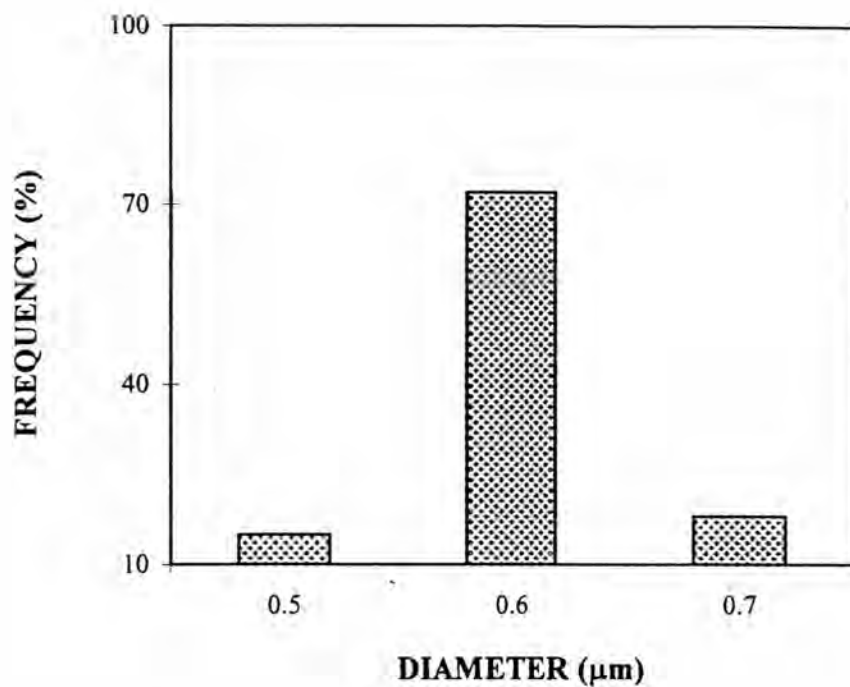


Figure D-a3 PSD of poly(styrene-*co*-methyl methacrylate) controlled by 8 wt% PVP K-30

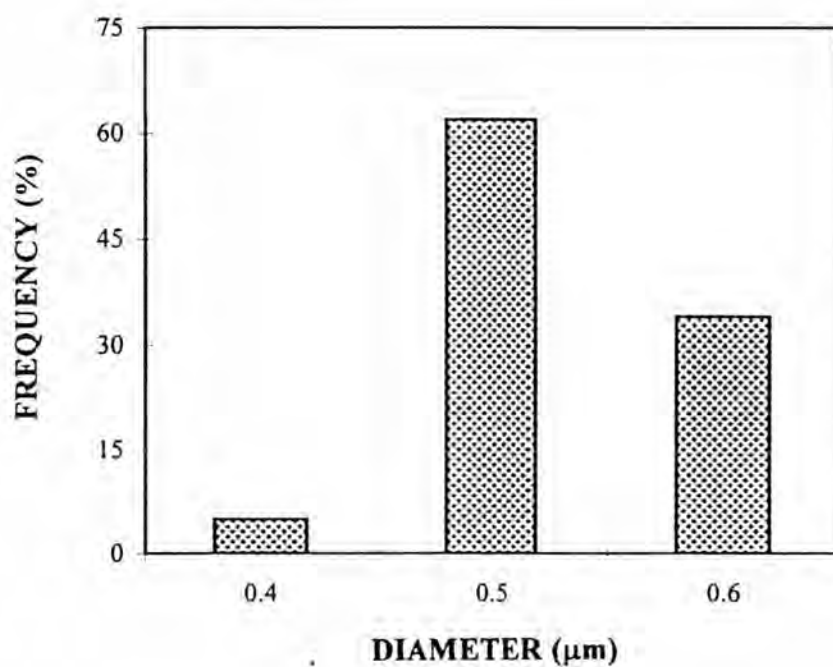


Figure D-a4 PSD of poly(styrene-*co*-methyl methacrylate) controlled by 10 wt% PVP K-30

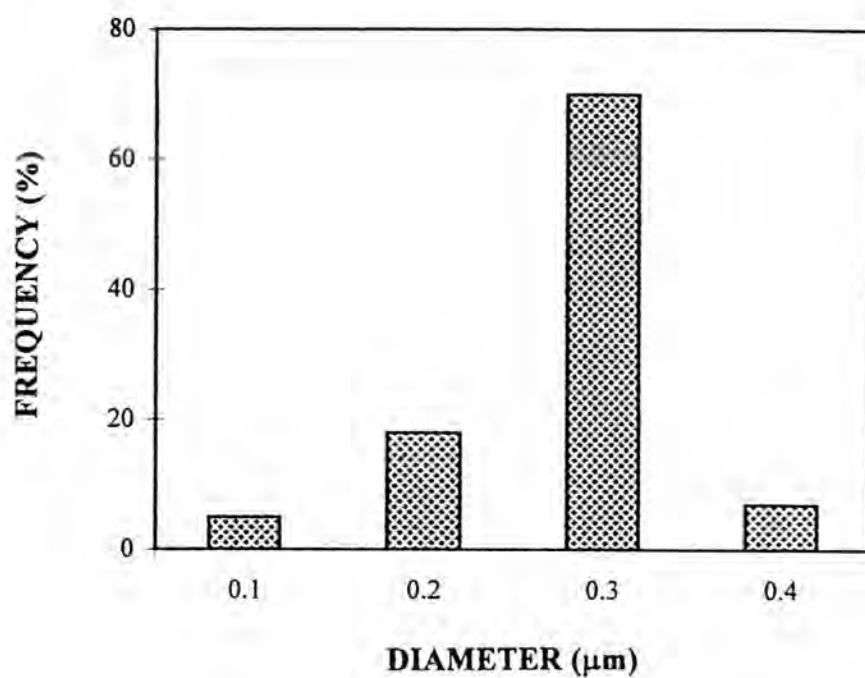


Figure D-a5 PSD of poly(styrene-co-methyl methacrylate) controlled by 12 wt% PVP K-30

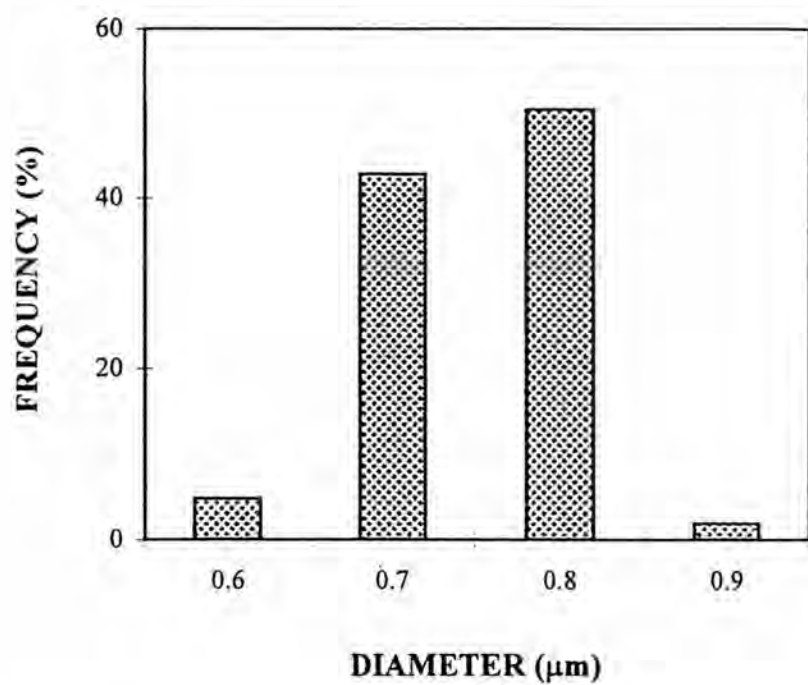


Figure D-b1 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 90/10 ethanol/water controlled by 8 wt% PVP K-30

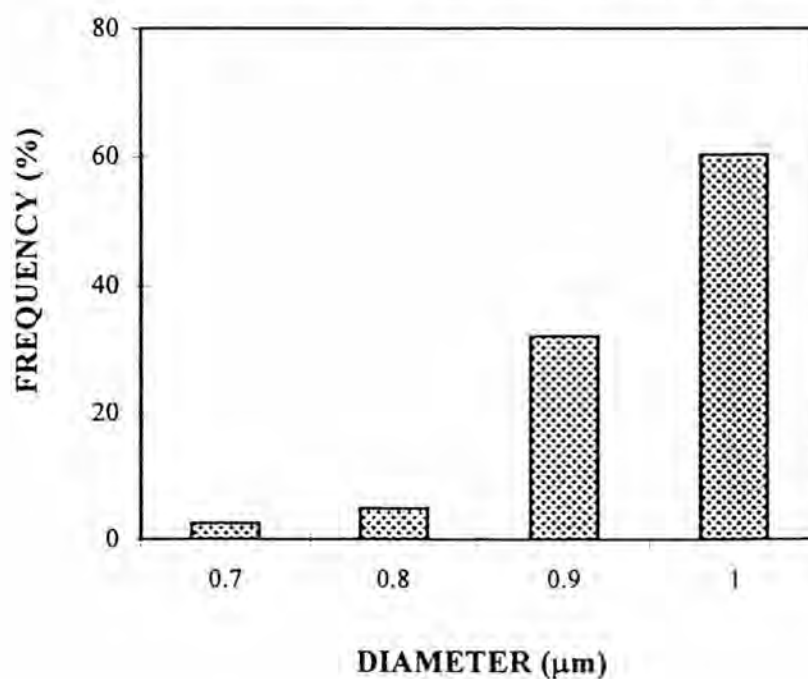


Figure D-b2 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 80/20 ethanol/water controlled by 8 wt% PVP K-30

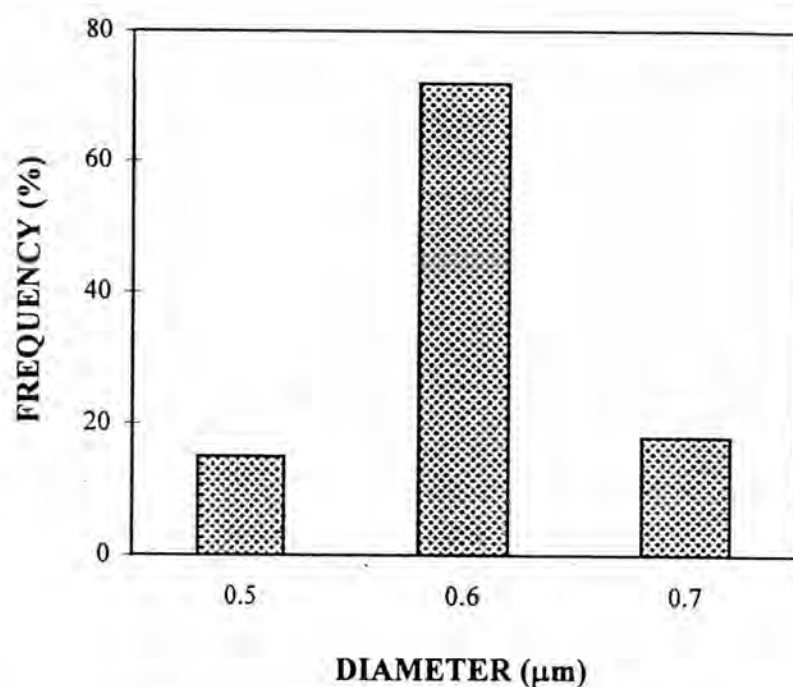


Figure D-b3 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 70/30 ethanol/water controlled by 8 wt% PVP K-30

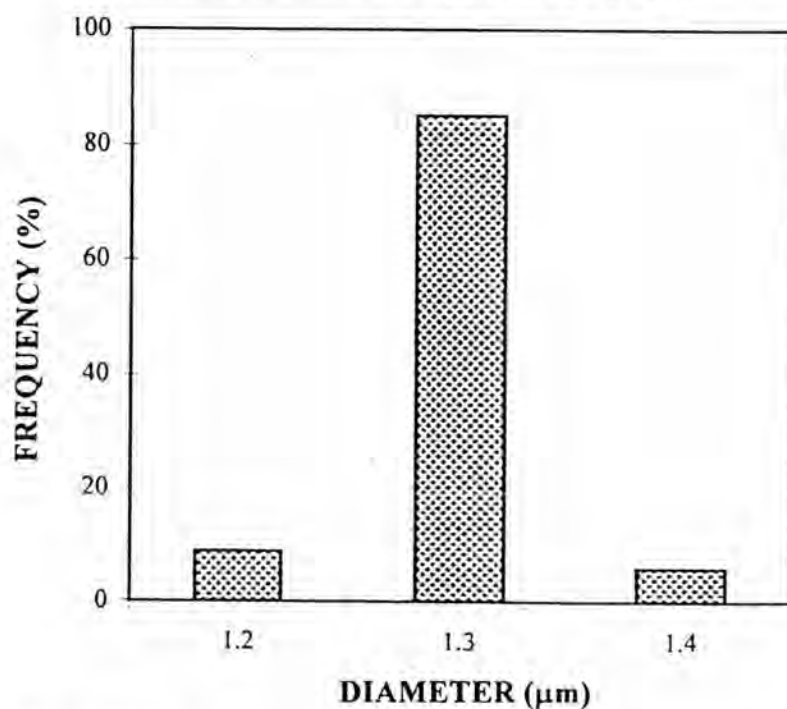


Figure D-b4 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 90/10 ethanol/water controlled by 6 wt% PVP K-30

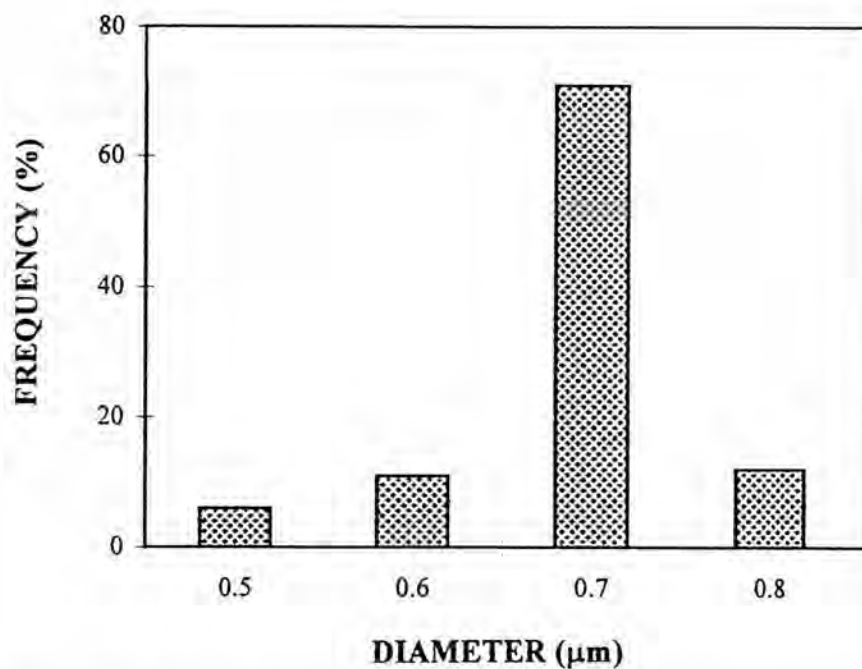


Figure D-b5 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 80/20 ethanol/water controlled by 6 wt% PVP K-30

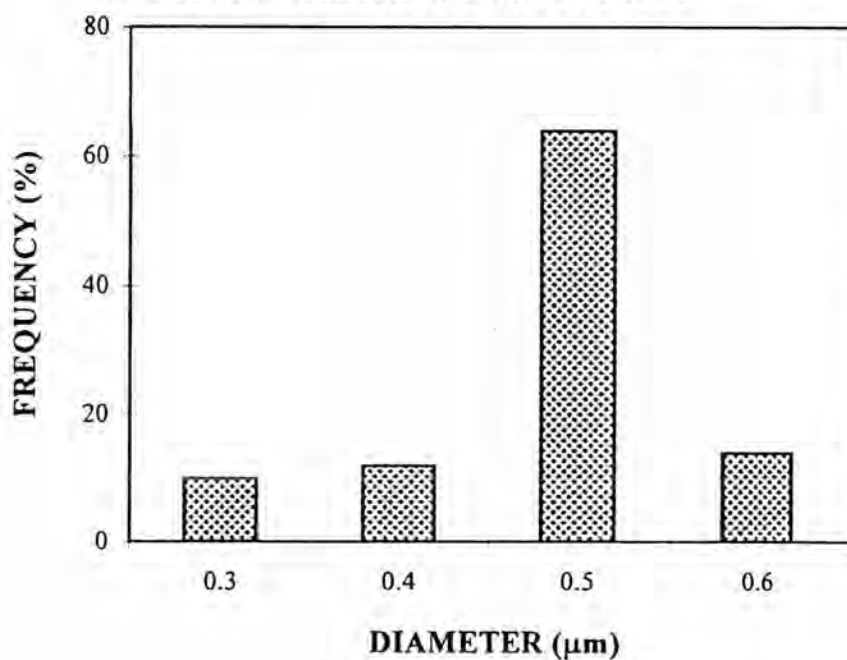


Figure D-b6 PSD of poly(styrene-*co*-methyl methacrylate) synthesized in 70/30 ethanol/water controlled by 6 wt% PVP K-30

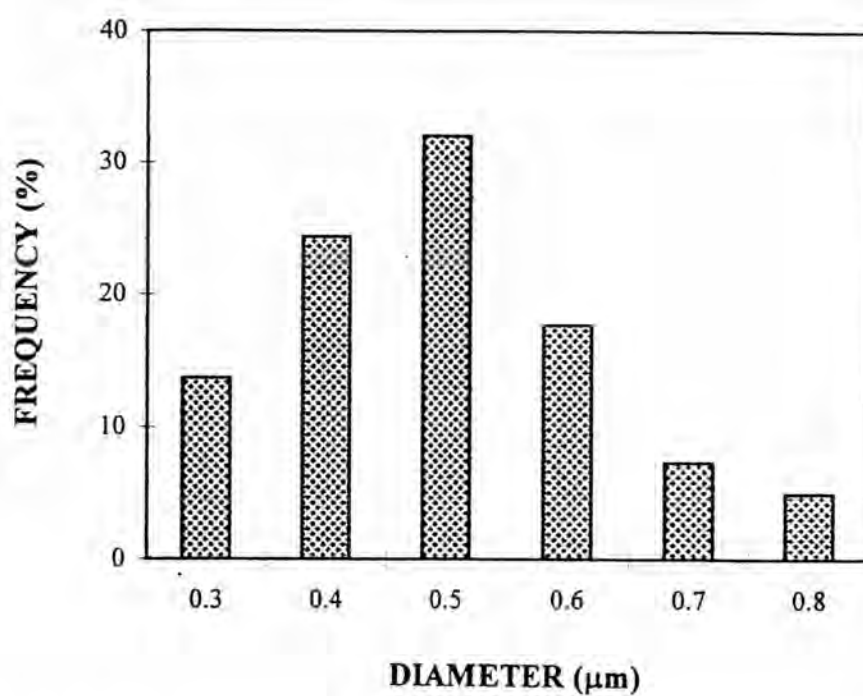


Figure D-c1 PSD of poly(styrene-co-methyl methacrylate) synthesized at 50°C
reaction temperature

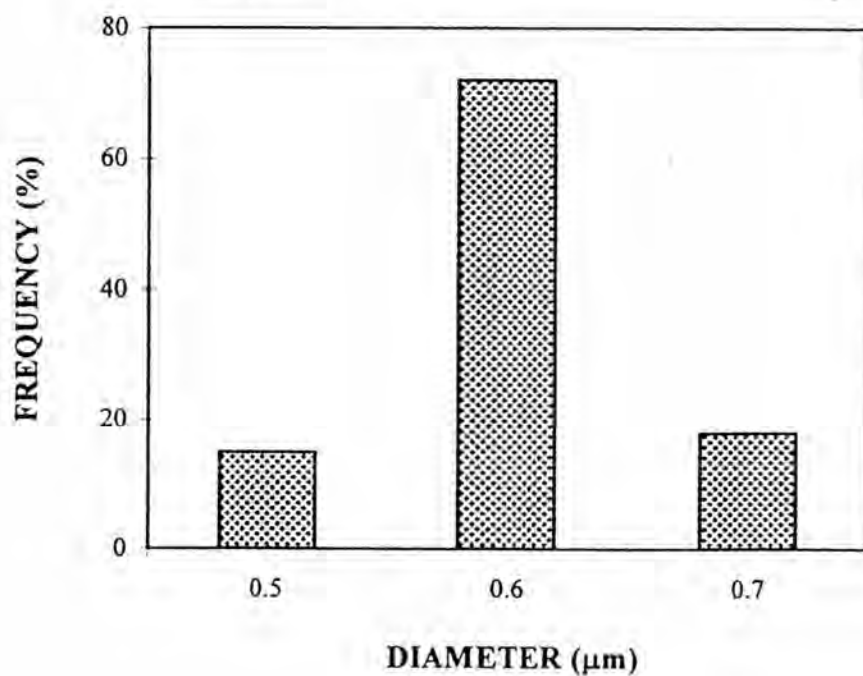


Figure D-c2 PSD of poly(styrene-co-methyl methacrylate) synthesized at 60°C
reaction temperature

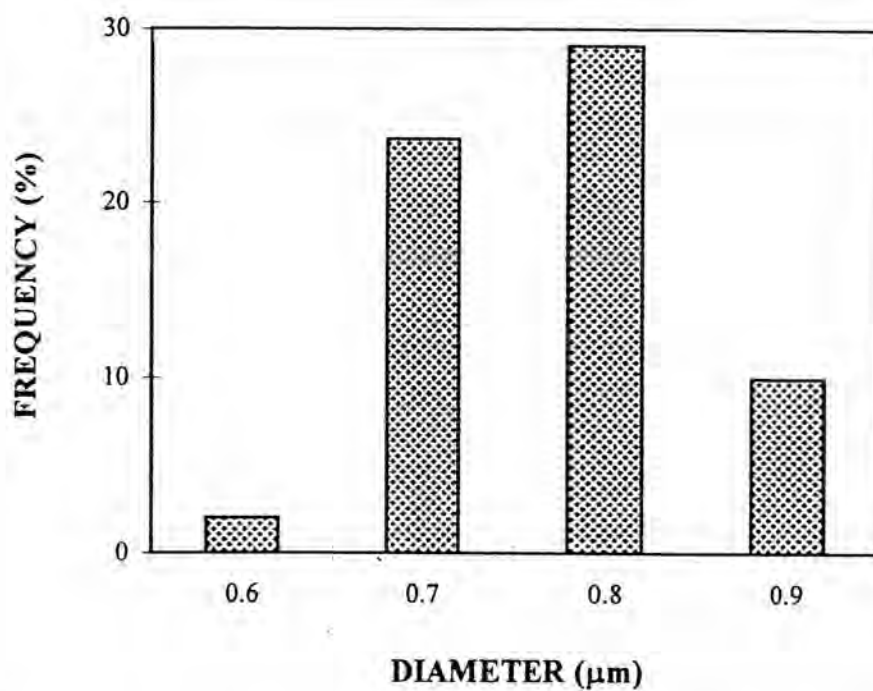


Figure D-c3 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at 70°C

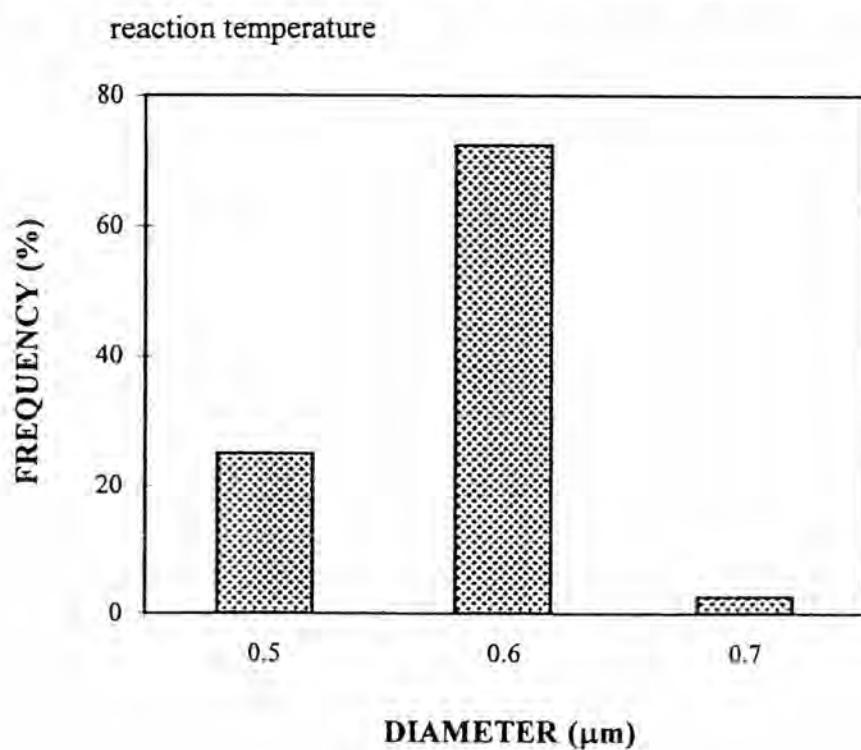


Figure D-c4 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at 80°C

reaction temperature

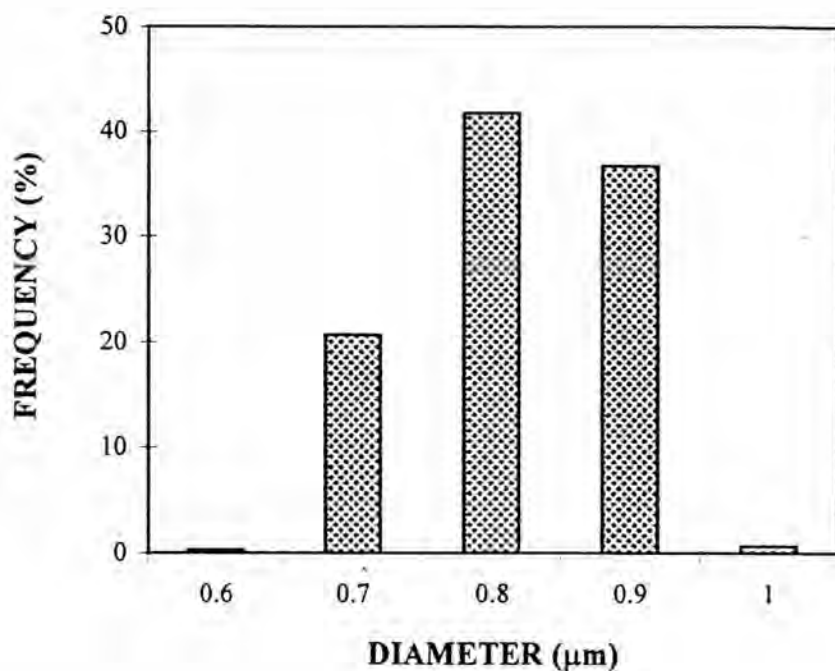


Figure D-d1 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at an agitation rate of 80 rpm

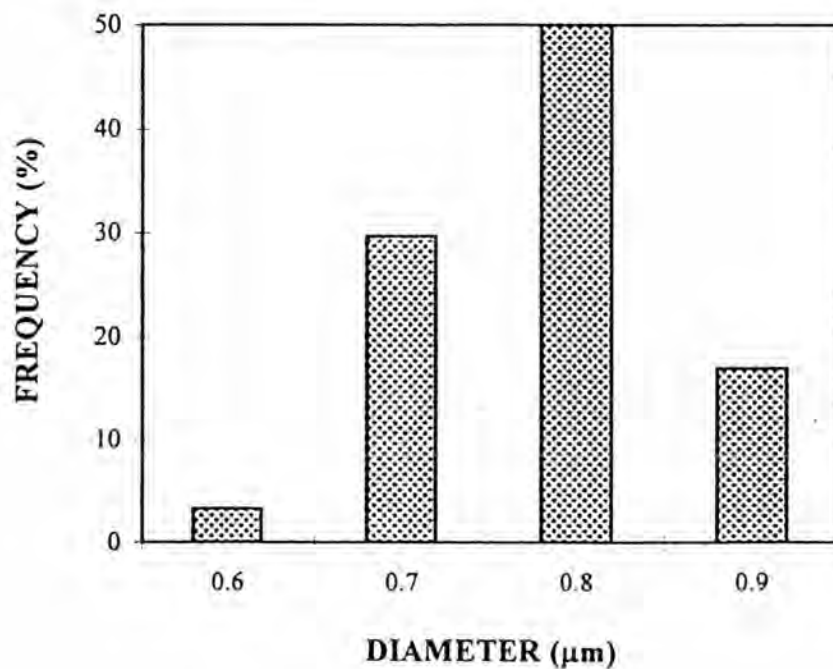


Figure D-d2 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at an agitation rate of 150 rpm

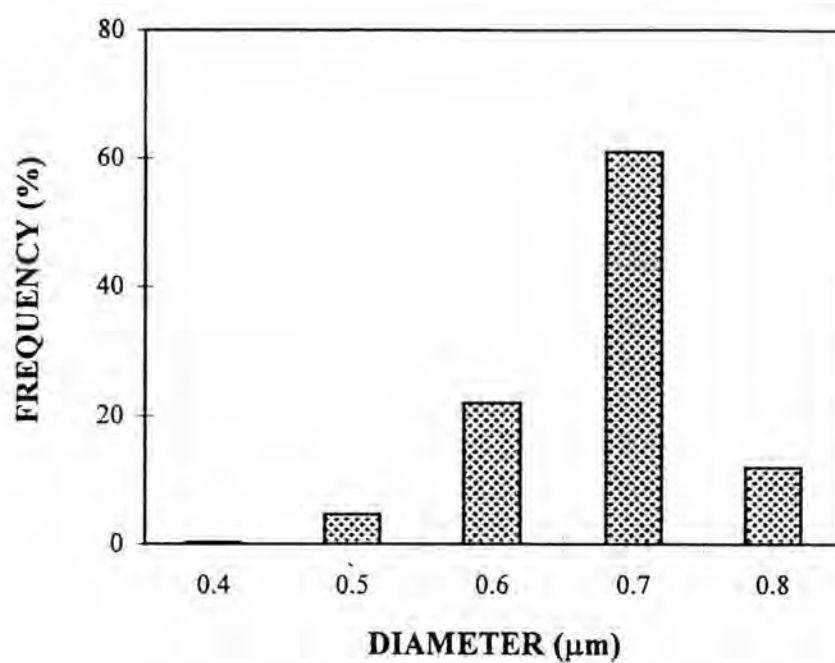


Figure D-d3 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at an agitation rate of 200 rpm

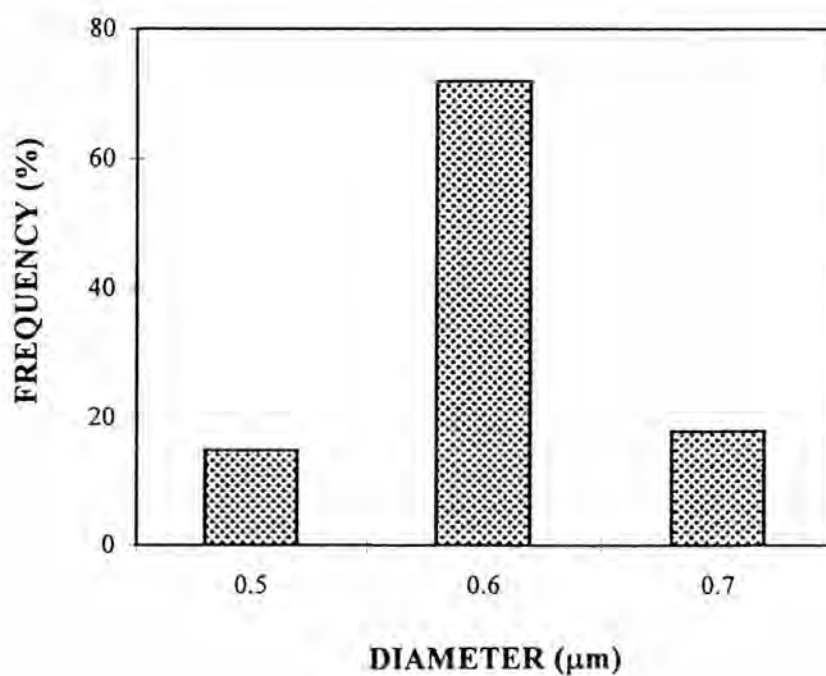


Figure D-d4 PSD of poly(styrene-*co*-methyl methacrylate) synthesized at an agitation rate of 290 rpm

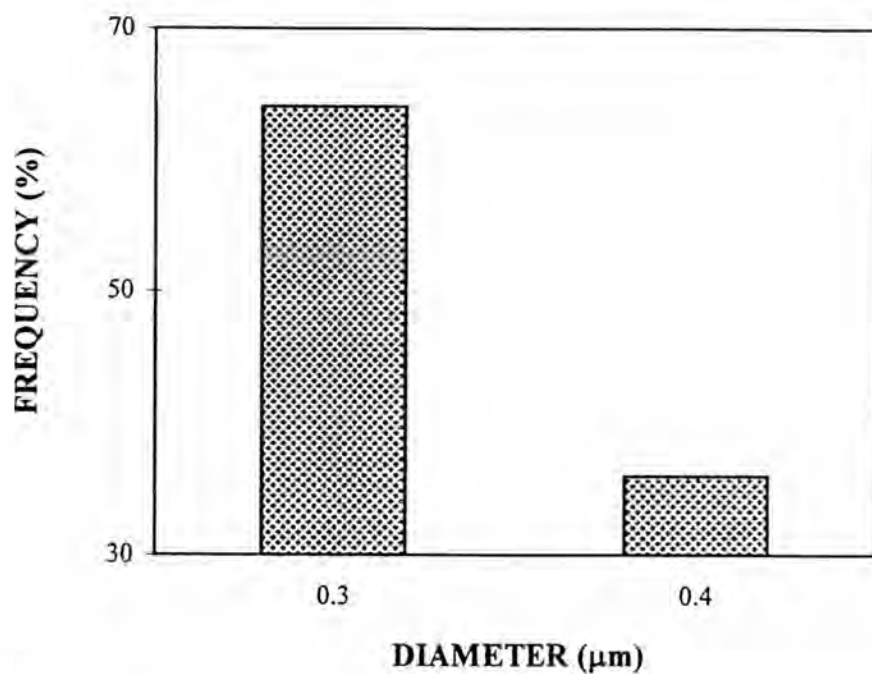


Figure D-e1 PSD of poly(styrene-*co*-methyl methacrylate) synthesized for 6 h reaction time

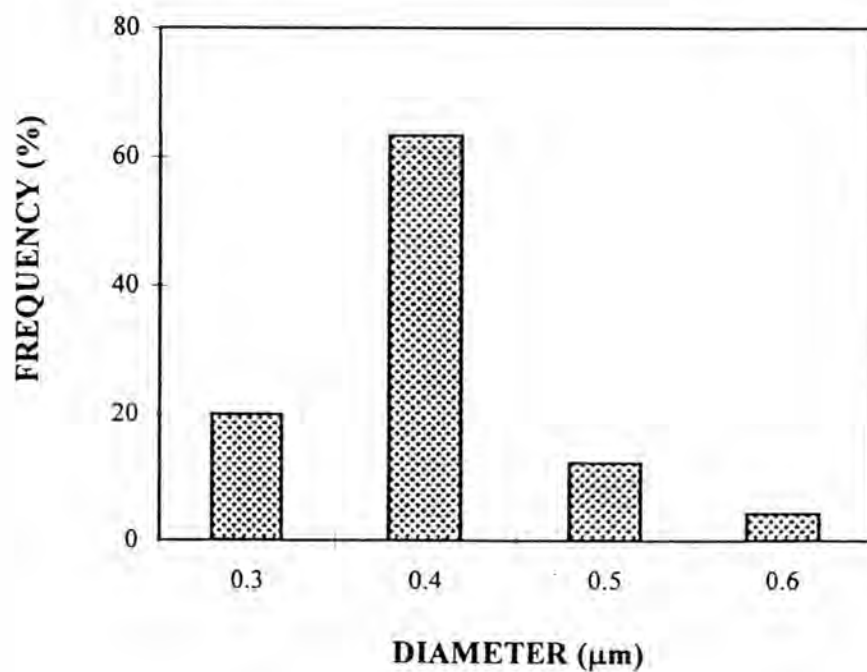


Figure D-e2 PSD of poly(styrene-*co*-methyl methacrylate) synthesized for 8 h reaction time

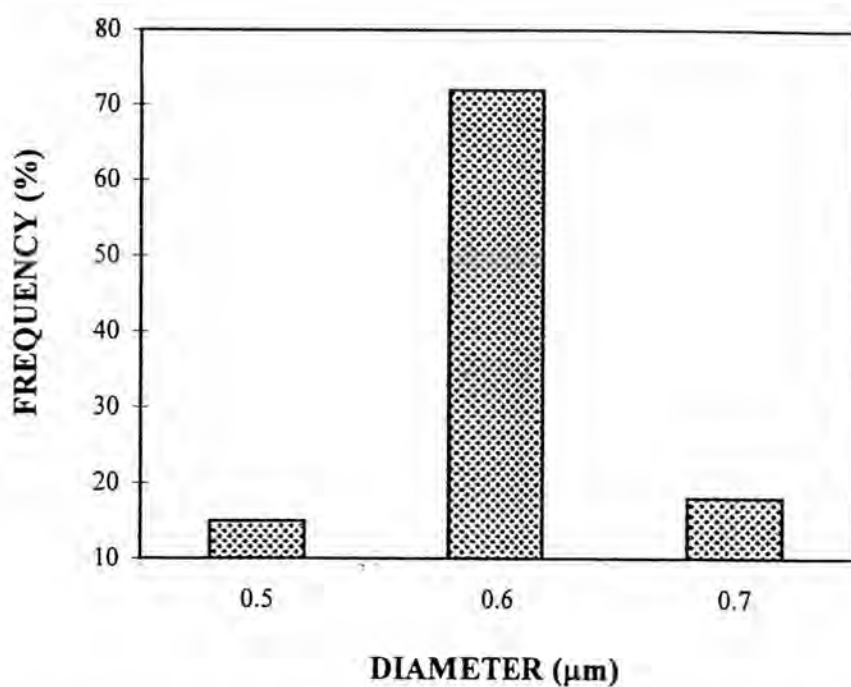


Figure D-e3 PSD of poly(styrene-*co*-methyl methacrylate) synthesized for 10 h
reaction time

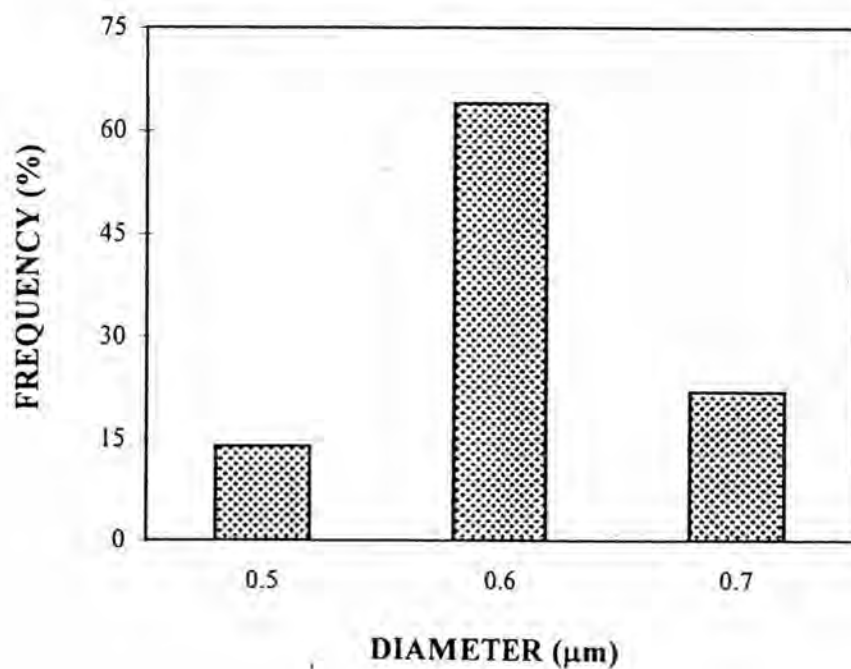


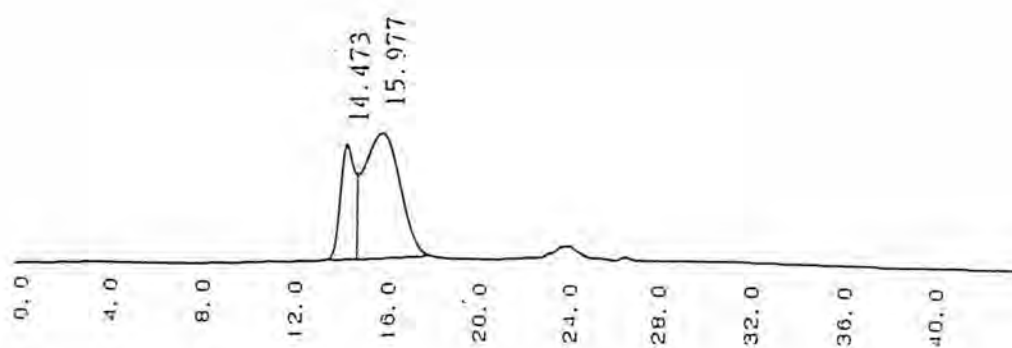
Figure D-e4 PSD of poly(styrene-*co*-methyl methacrylate) synthesized for 15 h
reaction time

APPENDIX E

GEL PERMEATION CHROMATOGRAPHY

Average molecular weights and molecular weight distribution of the copolymer were measured by gel permeation chromatography. This technique uses a bed of cross-linked polystyrene-divinylbenzene gel for the separation of the polymer taking place in the voids present in the gel particles. The pore volume available to the larger molecular size species is significantly less than the pore volume available to smaller molecules. This makes the path traveled by the larger molecules shorter than that of the small molecules, and they (the former) are eluted from the column first. Because the sorting process takes place on the basis of molecular size, a true size distribution of the polymer species takes place.

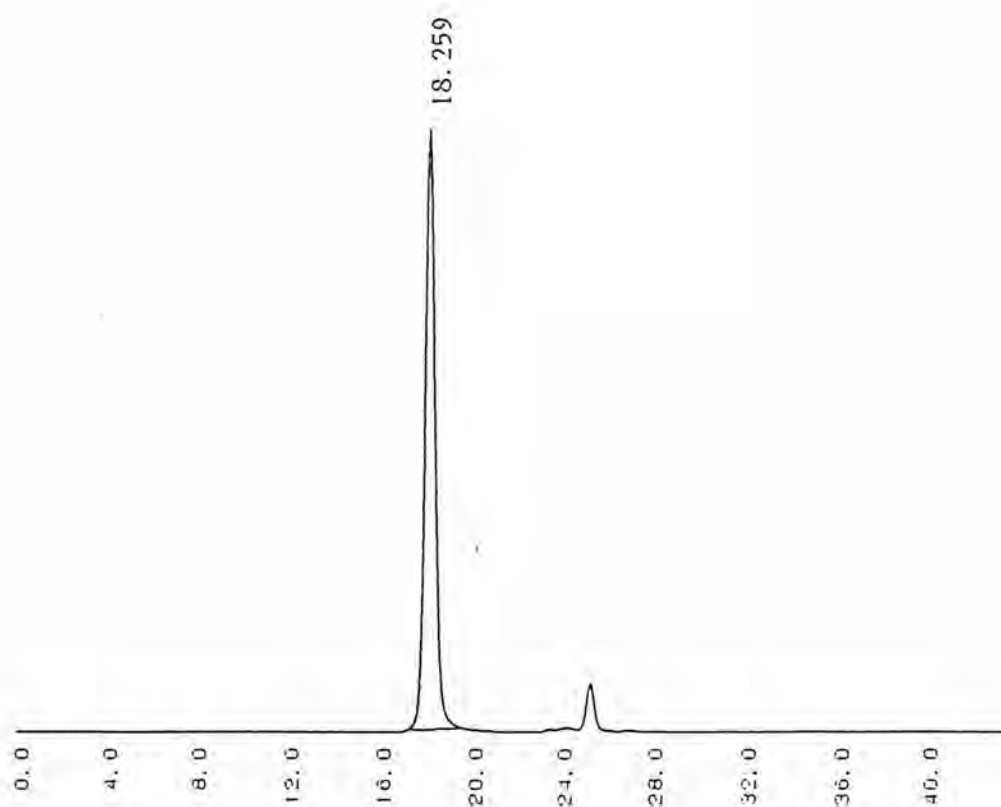
The GPC chromatograms of polystyrene standard and the copolymers are shown in Figures E-1 to E-35.



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	14.473	145929	3393			27.008
	2	15.977	394389	3704	V		72.992
TOTAL			540318	7096			100

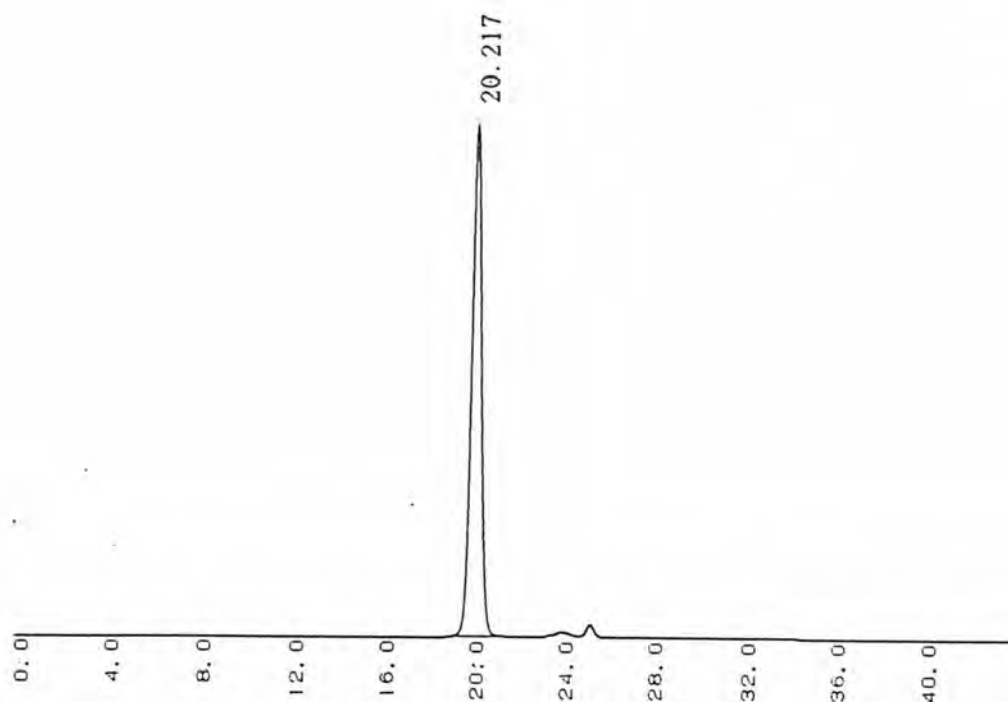
Figure E-1 The GPC chromatograph of polystyrene standard with a molecular weight of 3140000



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	18.259	1064724	35135			100
TOTAL			1064724	35135			100

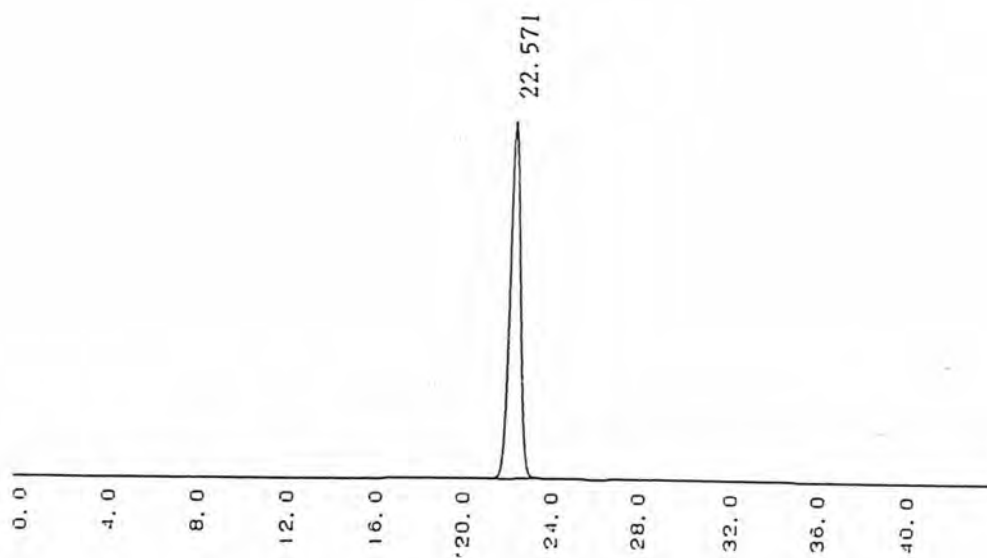
Figure E-2 The GPC chromatograph of polystyrene standard with a molecular weight of 156000



**** CALCULATION REPORT ****

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	20.217	1831333	61084			100
TOTAL			1831333	61084			100

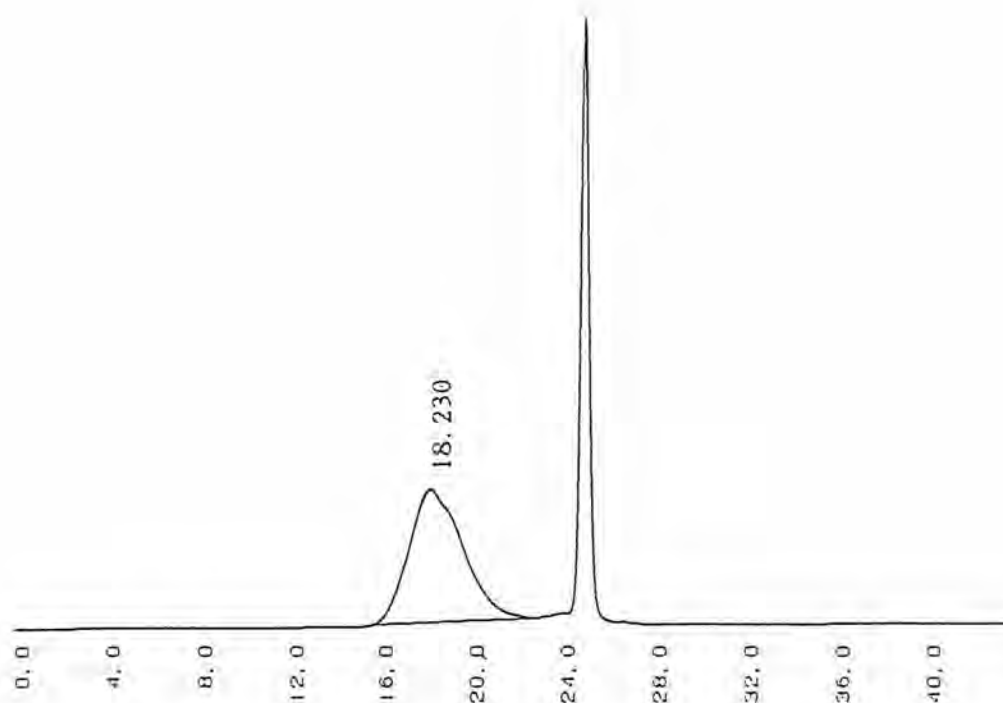
Figure E-3 The GPC chromatograph of polystyrene standard with a molecular weight of 28500



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	22.571	1428774	43461			100
TOTAL			1428774	43461			100

Figure E-4 The GPC chromatograph of polystyrene standard with a molecular weight of 2950



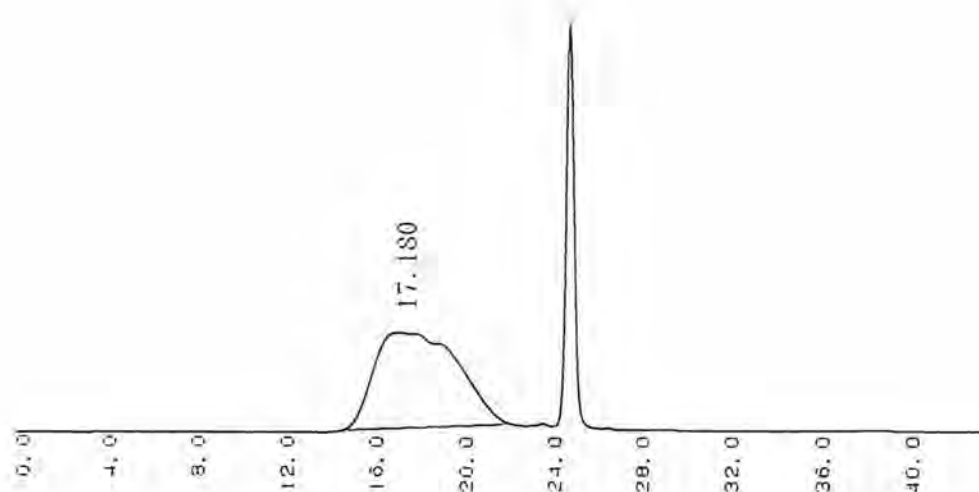
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	18.23	1290299	7858			100
TOTAL			1290299	7858			100

Peak information	Time (min)	Mol. size	Height
start	15.8	634628	32
top	18.23	72912	7858
end	22.65	1424	1

Number-A.M.W. \bar{M}_n	=	29884	Weight-A.M.W. \bar{M}_w	=	79214
z-A.M.W. \bar{M}_z	=	152079	Visc-A.M.W. \bar{M}_v	=	72200
Dispersity \bar{M}_w/\bar{M}_n	=	2.65069	Dispersity \bar{M}_z/\bar{M}_w	=	1.91984
Dispersity \bar{M}_v/\bar{M}_n	=	2.41597	I. Viscosity I. VISC	=	35.26954

Figure E-5 The GPC chromatograph of the copolymer controlled by 2 wt% PVP K-30



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.18	1458531	5707			100
TOTAL			1458531	5707			100

Peak information	Time (min)	Mol. size	Height
start	14.85	1478767	26
top	17.18	185661	5753
end	18.85	41979	5015

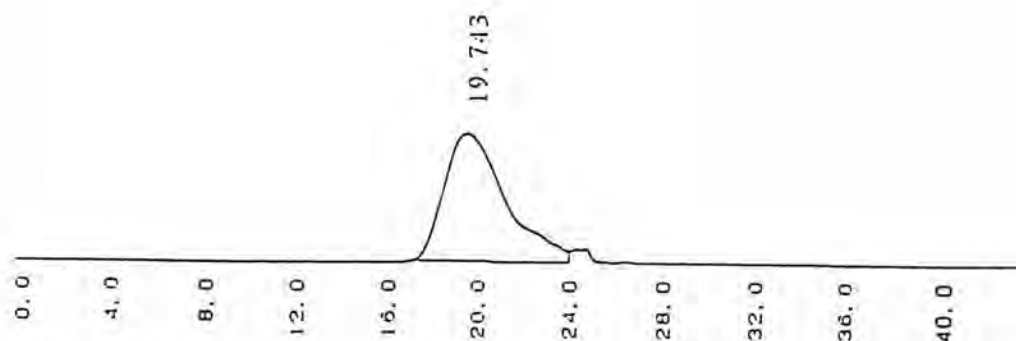
Number-A.M.W. \bar{M}_n = 119717 Weight-A.M.W. \bar{M}_w = 216576

z-A.M.W. \bar{M}_z = 376382 Visc-A.M.W. \bar{M}_v = 201178

Dispersity \bar{M}_w/\bar{M}_n = 1.80907 Dispersity \bar{M}_z/\bar{M}_w = 1.73788

Dispersity \bar{M}_v/\bar{M}_n = 1.68045 I. Viscosity I. VISC = 27.84814

Figure E-6 The GPC chromatograph of the copolymer controlled by 6 wt% PVP K-30



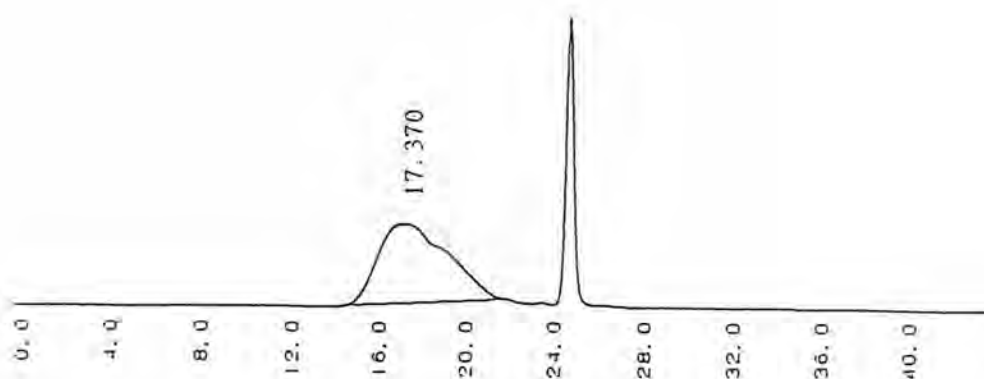
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.743	1421106	7478			100
TOTAL			1421106	7478			100

Peak information	Time (min)	Mol. size	Height
start	17.4	254133	25
top	19.743	39090	7478
end	24.3	1025	619

Number-A.M.W. \bar{M}_n	=	11619	Weight-A.M.W. \bar{M}_w	=	37123
z-A.M.W. \bar{M}_z	=	68060	Visc-A.M.W. \bar{M}_v	=	33816
Dispersity \bar{M}_w/\bar{M}_n	=	3.19503	Dispersity \bar{M}_z/\bar{M}_w	=	1.83337
Dispersity \bar{M}_v/\bar{M}_n	=	2.91044	I. Viscosity I. VISC	=	19.81758

Figure E-7 The GPC chromatograph of the copolymer controlled by 8 wt% PVP K-30



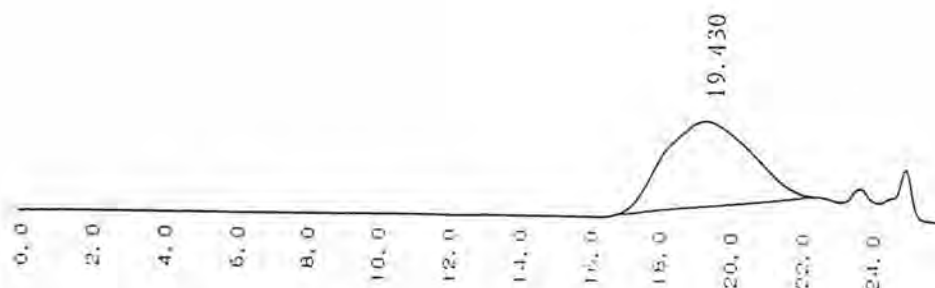
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.37	1045502	4776			100
TOTAL			1045502	4776			100

Peak information	Time (min)	Mol. size	Height
start	14.95	1352780	27
top	17.37	156857	4776
end	21.95	2656	1

Number-A.M.W. \bar{M}_n	=	39629	Weight-A.M.W. \bar{M}_w	=	157979
z-A.M.W. \bar{M}_z	=	349110	Visc-A.M.W. \bar{M}_v	=	139353
Dispersity \bar{M}_w/\bar{M}_n	=	3.98643	Dispersity \bar{M}_z/\bar{M}_w	=	2.20985
Dispersity \bar{M}_v/\bar{M}_n	=	3.51642	I. Viscosity I. VISC	=	58.13551

Figure E-8 The GPC chromatograph of the copolymer controlled by 10 wt% PVP



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.43	910880	5401			100
TOTAL			910880	5401			100

Peak information	Time (min)	Mol. size	Height
start	16.85	249154	26
top	19.43	25039	5401
end	22.5	1627	6

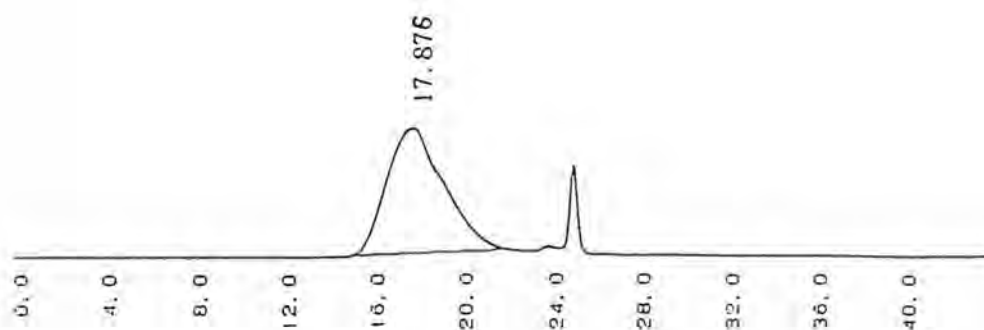
Number-A.M.W. \bar{M}_n = 15087 Weight-A.M.W. \bar{M}_w = 34016

z-A.M.W. \bar{M}_z = 63019 Visc-A.M.W. \bar{M}_v = 31175

Dispersity \bar{M}_w/\bar{M}_n = 2.25473 Dispersity \bar{M}_z/\bar{M}_w = 1.8526

Dispersity \bar{M}_v/\bar{M}_n = 2.06639 I. Viscosity I. VISC = 18.62977

Figure E-9 The GPC chromatograph of the copolymer controlled by 12 wt% PVP



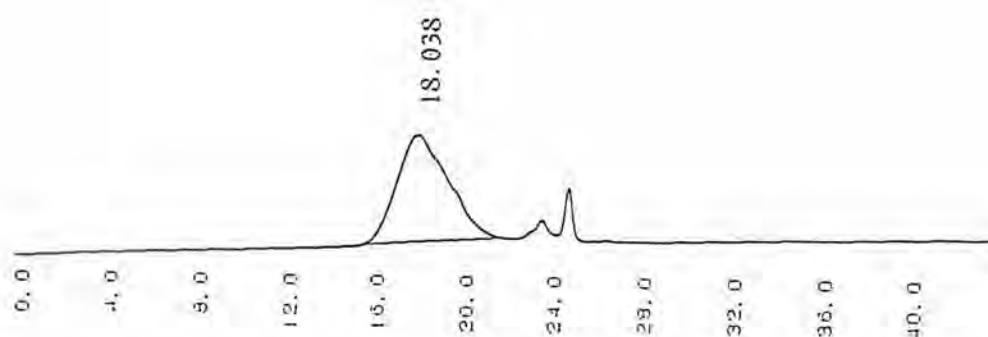
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.876	1351965	7608			100
		TOTAL	1351965	7608			100

Peak information	Time (min)	Mol. size	Height
start	15.25	1035650	29
top	17.876	99900	7608
end	22.15	2223	1

Number-A.M.W. \bar{M}_n	=	41652	Weight-A.M.W. \bar{M}_w	=	126151
z-A.M.W. \bar{M}_z	=	252835	Visc-A.M.W. \bar{M}_v	=	113828
Dispersity \bar{M}_w/\bar{M}_n	=	3.02869	Dispersity \bar{M}_z/\bar{M}_w	=	2.00422
Dispersity \bar{M}_v/\bar{M}_n	=	2.73283	I. Viscosity I. VISC	=	49.84965

Figure E-10 The GPC chromatograph of the copolymer synthesized in ethano/water ratios of 90/10 and 8 wt% PVP K-30



**** CALCULATION REPORT ****

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	18.038	1027949	6525			100
		TOTAL	1027949	6525			100

Peak information	Time (min)	Mol. size	Height
start	15.7	693730	26
top	18.038	86506	6525
end	21.85	2903	2

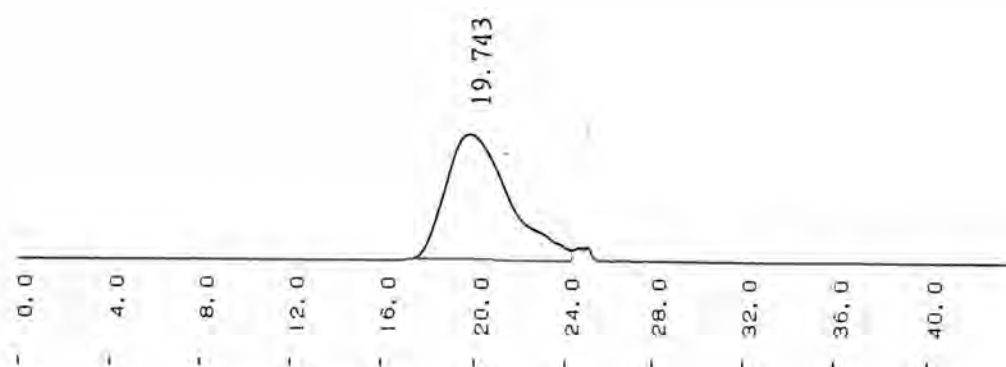
Number-A.M.W. \bar{M}_n = 38637 Weight-A.M.W. \bar{M}_w = 93526

z-A.M.W. \bar{M}_z = 172479 Visc-A.M.W. \bar{M}_v = 85715

Dispersity \bar{M}_w/\bar{M}_n = 2.42067 Dispersity \bar{M}_z/\bar{M}_w = 1.84417

Dispersity \bar{M}_v/\bar{M}_n = 2.2185 I. Viscosity I. VISC = 40.18251

Figure E-11 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 80/20 and 8 wt% PVP K-30



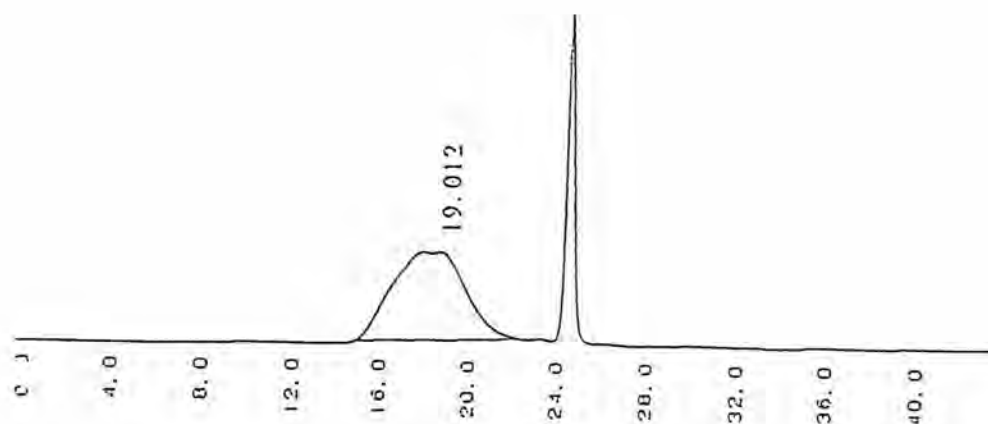
**** CALCULATION REPORT ****

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.743	1421106	7478			100
		TOTAL	1421106	7478			100

Peak information	Time (min)	Mol. size	Height
start	17.4	254133	25
top	19.743	39090	7478
end	24.3	1025	619

Number-A.M.W. \bar{M}_n	=	11619	Weight-A.M.W. \bar{M}_w	=	37123
z-A.M.W. \bar{M}_z	=	68060	Visc-A.M.W. \bar{M}_v	=	33816
Dispersity \bar{M}_w/\bar{M}_n	=	3.19503	Dispersity \bar{M}_z/\bar{M}_w	=	1.83337
Dispersity \bar{M}_v/\bar{M}_n	=	2.91044	I. Viscosity I. VISC	=	19.81758

Figure E-12 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 70/30 and 8 wt% PVP K-30



Peak information	Time (min)	Mol. size	Height
start	15.2	1082801	32
top	19.012	36351	5274
end	22.65	1424	1
Number-A.M.W. \bar{M}_n	= 27426	Weight-A.M.W. \bar{M}_w	= 106925
z-A.M.W. \bar{M}_z	= 269552	Visc-A.M.W. \bar{M}_v	= 92896
Dispersity \bar{M}_w/\bar{M}_n	= 3.89872	Dispersity \bar{M}_z/\bar{M}_w	= 2.52095
Dispersity \bar{M}_v/\bar{M}_n	= 3.38721	I. Viscosity I. VISC	= 42.71599

Figure E-13 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 60/40 and 8 wt% PVP K-30

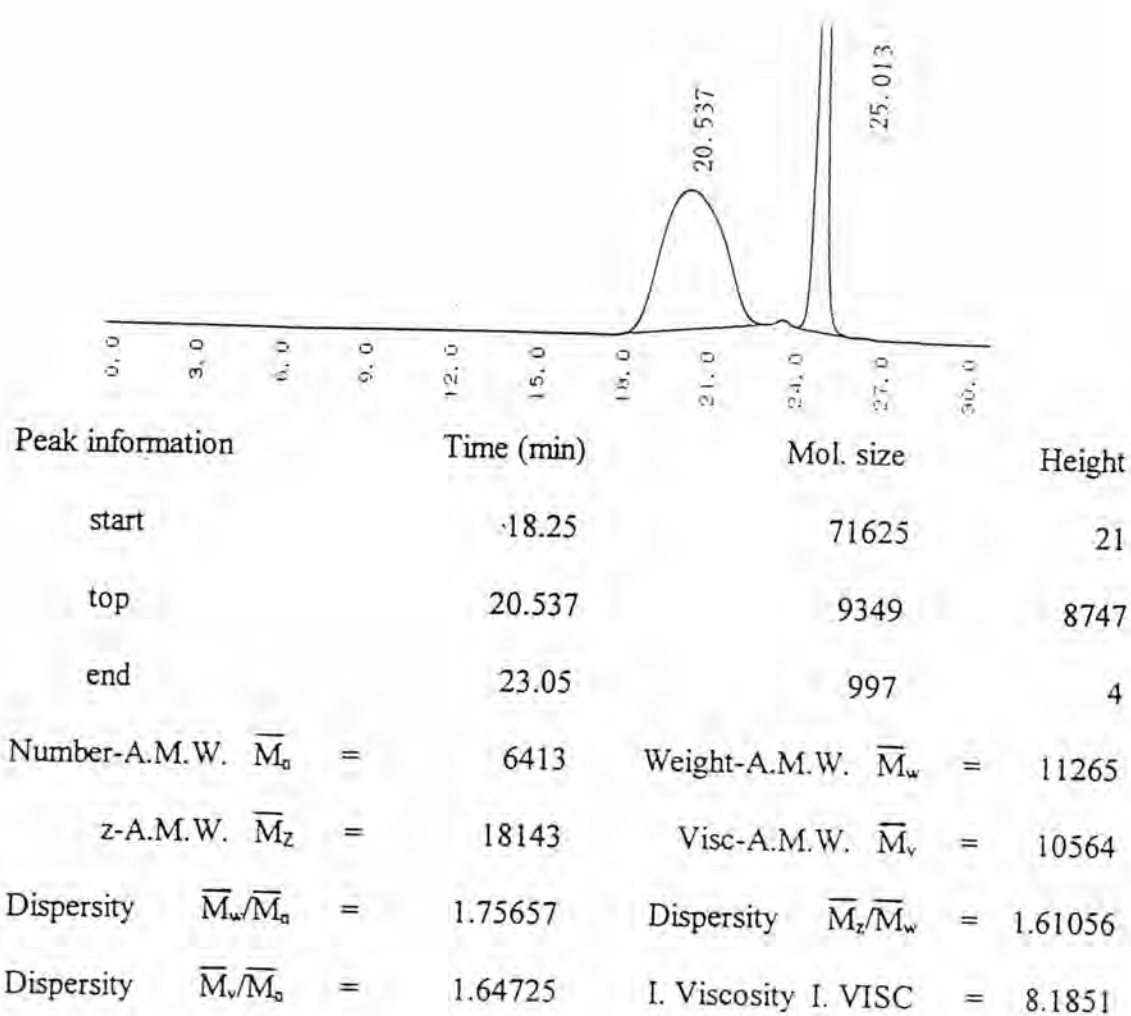
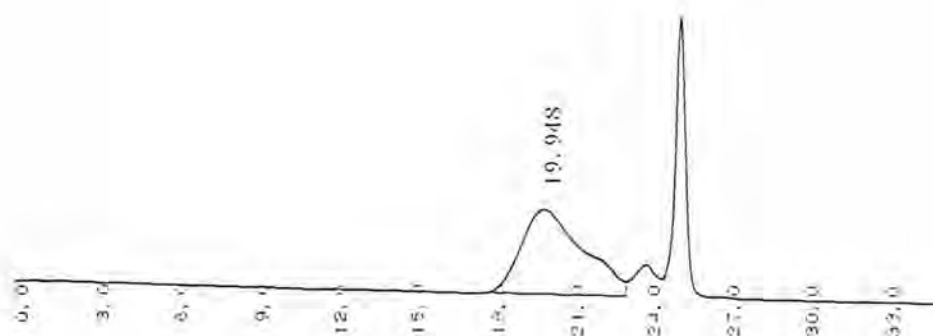


Figure E-14 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 100/0 and 6 wt% PVP K-30



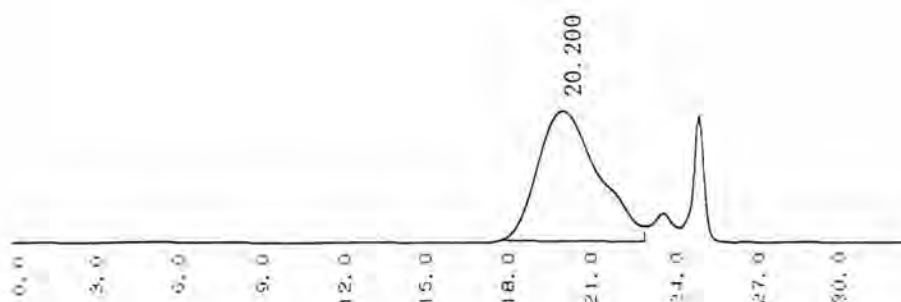
**** CALCULATION REPORT ****

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.948	947719	5696			100
		TOTAL	947719	5696			100

Peak information	Time (min)	Mol. size	Height
start	17.85	102270	23
top	19.948	15791	5696
end	23.15	912	940

Number-A.M.W. \bar{M}_n	=	5839	Weight-A.M.W. \bar{M}_w	=	15008
z-A.M.W. \bar{M}_z	=	27400	Visc-A.M.W. \bar{M}_v	=	13717
Dispersity \bar{M}_w/\bar{M}_n	=	2.57037	Dispersity \bar{M}_z/\bar{M}_w	=	1.82562
Dispersity \bar{M}_v/\bar{M}_n	=	2.34928	I. Viscosity I. VISC	=	9.98252

Figure E-15 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 90/10 and 6 wt% PVP K-30



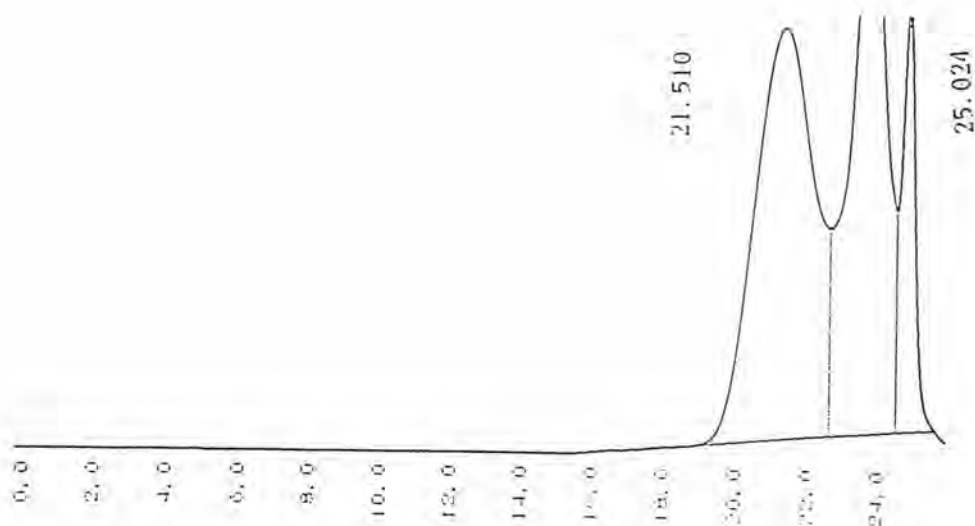
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	20.2	1308210	8567			100
TOTAL			1308210	8567			100

Peak information	Time (min)	Mol. size	Height
start	17.95	93557	28
top	20.2	12614	8567
end	23.15	912	945

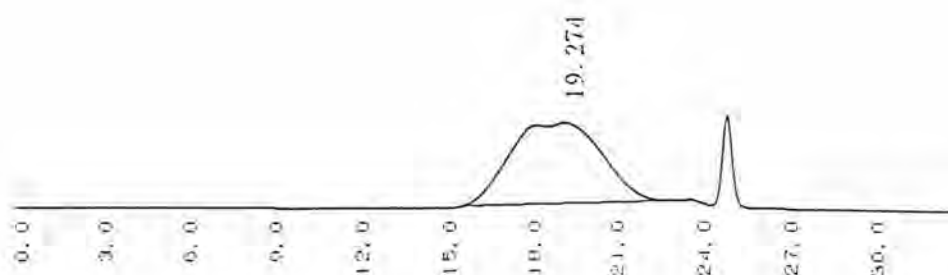
Number-A.M.W. \bar{M}_n	=	6001	Weight-A.M.W. \bar{M}_w	=	13283
z-A.M.W. \bar{M}_z	=	23172	Visc-A.M.W. \bar{M}_v	=	12273
Dispersity \bar{M}_w/\bar{M}_n	=	2.2136	Dispersity \bar{M}_z/\bar{M}_w	=	1.74441
Dispersity \bar{M}_v/\bar{M}_n	=	2.04519	I. Viscosity I. VISC	=	9.173

Figure E-16 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 80/20 and 6 wt% PVP K-30



Peak information	Time (min)	Mol. size	Height
start	19.2	30738	20
top	21.51	3929	25938
end	22.85	1192	13102
Number-A.M.W. \bar{M}_n =	3222	Weight-A.M.W. \bar{M}_w =	4691
z-A.M.W. \bar{M}_z =	6783	Visc-A.M.W. \bar{M}_v =	4479
Dispersity \bar{M}_w/\bar{M}_n =	1.45602	Dispersity \bar{M}_z/\bar{M}_w =	1.44599
Dispersity \bar{M}_v/\bar{M}_n =	1.39029	I. Viscosity I. VISC =	4.26403

Figure E-17 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 70/30 and 6 wt% PVP K-30



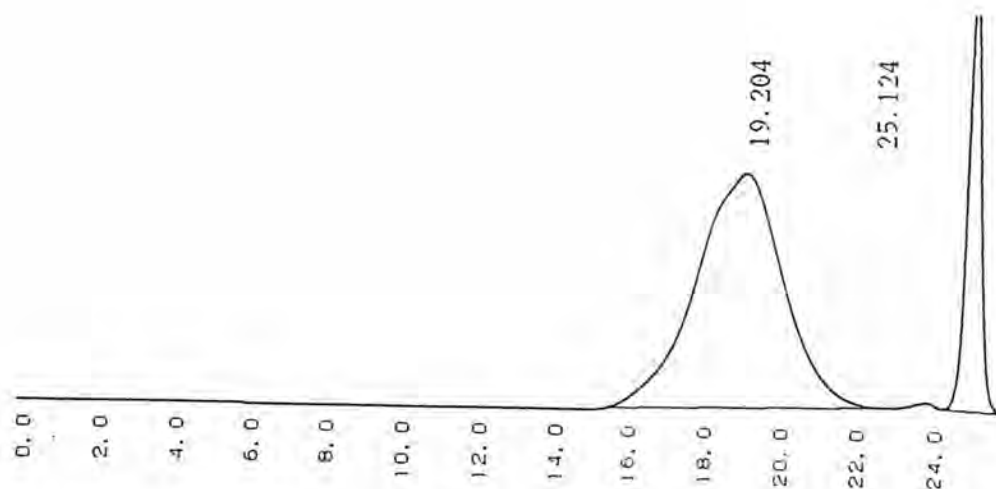
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.274	1142716	5040			100
TOTAL			1142716	5040			100

Peak information	Time (min)	Mol. size	Height
start	15.75	663521	32
top	19.274	28778	5040
end	22.75	1303	1

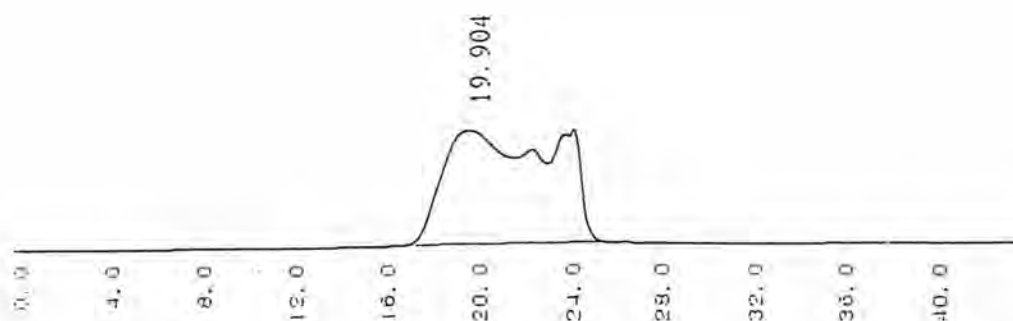
Number-A.M.W. \bar{M}_n	=	18807	Weight-A.M.W. \bar{M}_w	=	67170
z-A.M.W. \bar{M}_z	=	162445	Visc-A.M.W. \bar{M}_v	=	58793
Dispersity \bar{M}_w/\bar{M}_n	=	3.57162	Dispersity \bar{M}_z/\bar{M}_w	=	2.41841
Dispersity \bar{M}_v/\bar{M}_n	=	3.12619	I. Viscosity I. VISC	=	30.17179

Figure E-18 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 60/40 and 6 wt% PVP K-30



Peak information	Time (min)	Mol. size	Height
start	15.65	725314	35
top	19.204	30629	13915
end	22.7	1362	1
Number-A.M.W. \bar{M}_n =	22518	Weight-A.M.W. \bar{M}_w =	56538
z-A.M.W. \bar{M}_z =	135766	Visc-A.M.W. \bar{M}_v =	50562
Dispersity \bar{M}_w/\bar{M}_n =	2.51081	Dispersity \bar{M}_z/\bar{M}_w =	1.40132
Dispersity \bar{M}_v/\bar{M}_n =	2.24541	I. Viscosity I. VISC =	26.90409

Figure E-19 The GPC chromatograph of the copolymer synthesized in ethanol/water ratios of 0/100 and 6 wt% PVP K-30



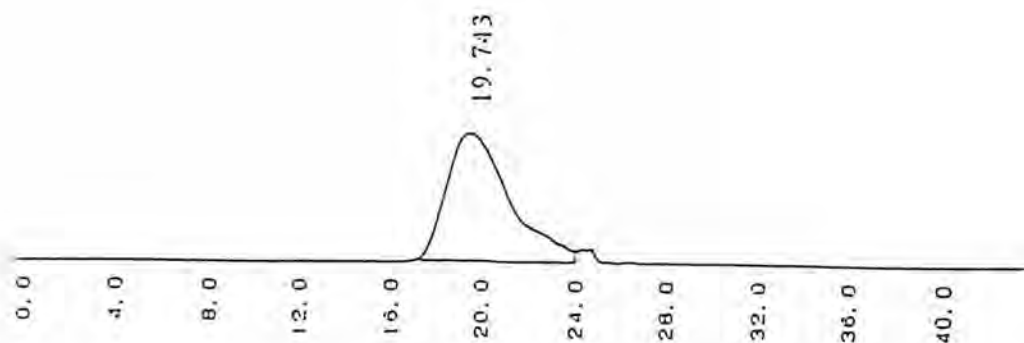
**** CALCULATION REPORT ****

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.904	2193525	6661			100
		TOTAL	2193525	6661			100

Peak information	Time (min)	Mol. size	Height
start	17.35	159628	30
top	19.904	16422	6631
end	21.75	3174	4990

Number-A.M.W. \bar{M}_n	=	10461	Weight-A.M.W. \bar{M}_w	=	21714
z-A.M.W. \bar{M}_z	=	40997	Visc-A.M.W. \bar{M}_v	=	19885
Dispersity \bar{M}_w/\bar{M}_n	=	2.07578	Dispersity \bar{M}_z/\bar{M}_w	=	1.88805
Dispersity \bar{M}_v/\bar{M}_n	=	1.9009	I. Viscosity I. VISC	=	3.23691

Figure E-20 The GPC chromatograph of the copolymer synthesized at 50°C reaction temperature



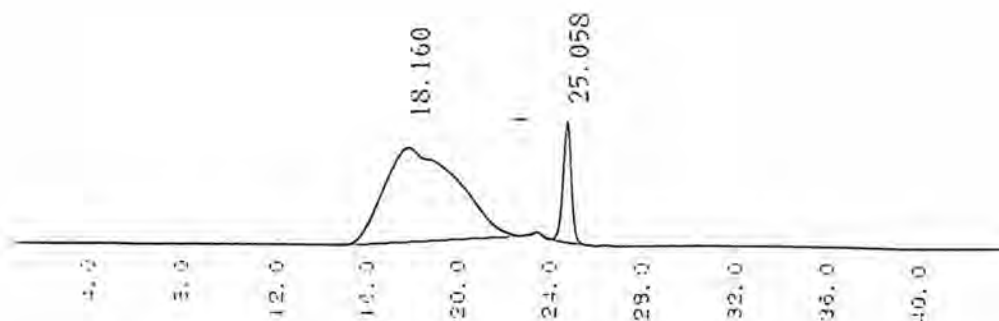
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.743	1421106	7478			100
TOTAL			1421106	7478			100

Peak information	Time (min)	Mol. size	Height
start	17.4	254133	25
top	19.743	39090	7478
end	24.3	1025	619

Number-A.M.W. \bar{M}_n	=	11619	Weight-A.M.W. \bar{M}_w	=	37123
z-A.M.W. \bar{M}_z	=	68060	Visc-A.M.W. \bar{M}_v	=	33816
Dispersity \bar{M}_w/\bar{M}_n	=	3.19503	Dispersity \bar{M}_z/\bar{M}_w	=	1.83337
Dispersity \bar{M}_v/\bar{M}_n	=	2.91044	I. Viscosity I. VISC	=	19.81758

Figure E-21 The GPC chromatograph of the copolymer synthesized at 60°C reaction temperature



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	18.16	1222489	5560			87.3152
	2	25.058	177597	7148			12.6847
TOTAL			1400086	12708			100

Peak information	Time (min)	Mol. size	Height
start	15.65	725314	29
top	18.16	77578	5508
end	19.05	35131	4755

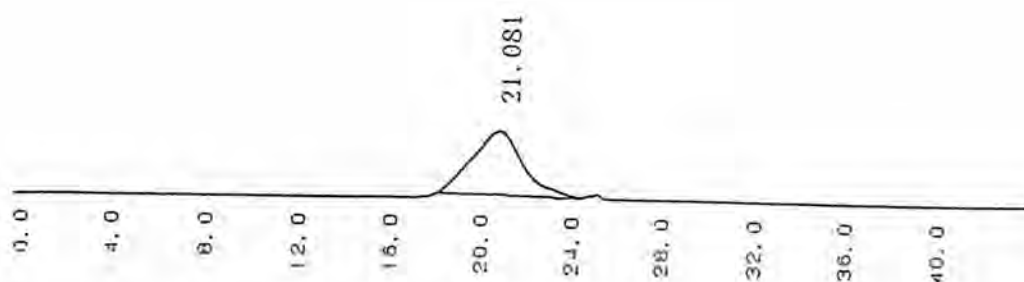
Number-A.M.W. \bar{M}_n = 82445 Weight-A.M.W. \bar{M}_w = 125050

z-A.M.W. \bar{M}_z = 196962 Visc-A.M.W. \bar{M}_v = 118242

Dispersity \bar{M}_w/\bar{M}_n = 1.51677 Dispersity \bar{M}_z/\bar{M}_w = 1.57506

Dispersity \bar{M}_v/\bar{M}_n = 1.43419 I. Viscosity I. VISC = 51.3121

Figure E-22 The GPC chromatograph of the copolymer synthesized at 70°C reaction temperature



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	21.081	1161739	7503			100
TOTAL			1161739	7503			100

Peak information	Time (min)	Mol. size	Height
start	18.35	65523	77
top	21.081	5760	7503
end	24.55	262	0

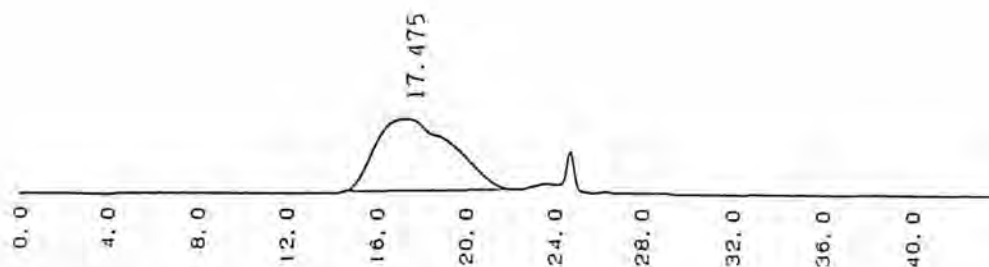
Number-A.M.W. \bar{M}_n = 3676 Weight-A.M.W. \bar{M}_w = 9217

z-A.M.W. \bar{M}_z = 18314 Visc-A.M.W. \bar{M}_v = 8376

Dispersity \bar{M}_w/\bar{M}_n = 2.5077 Dispersity \bar{M}_z/\bar{M}_w = 1.98693

Dispersity \bar{M}_v/\bar{M}_n = 2.27883 I. Viscosity I. VISC = 6.86146

Figure E-23 The GPC chromatograph of the copolymer synthesized at 80°C



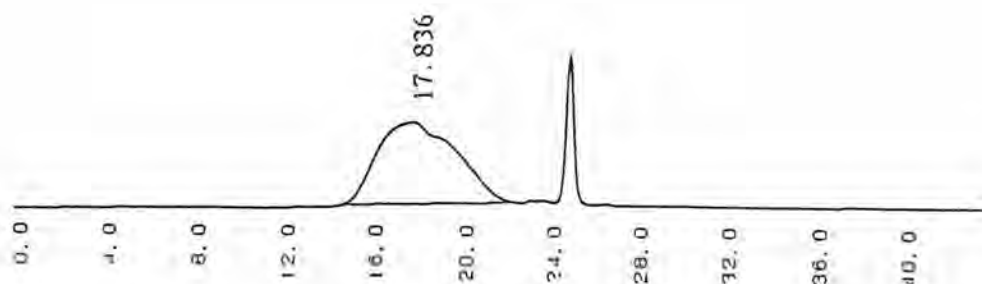
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.475	1035663	4393			100
TOTAL			1035663	4393			100

Peak information	Time (min)	Mol. size	Height
start	14.95	1352780	30
top	17.475	142771	4393
end	22.25	2033	0

Number-A.M.W. \bar{M}_n	=	35125	Weight-A.M.W. \bar{M}_w	=	156218
z-A.M.W. \bar{M}_z	=	360985	Visc-A.M.W. \bar{M}_v	=	136489
Dispersity \bar{M}_w/\bar{M}_n	=	4.44746	Dispersity \bar{M}_z/\bar{M}_w	=	2.31077
Dispersity \bar{M}_v/\bar{M}_n	=	3.88577	I. Viscosity I. VISC	=	7.22502

Figure E-24 The GPC chromatograph of the copolymer synthesized at an agitation rate of 80 rpm



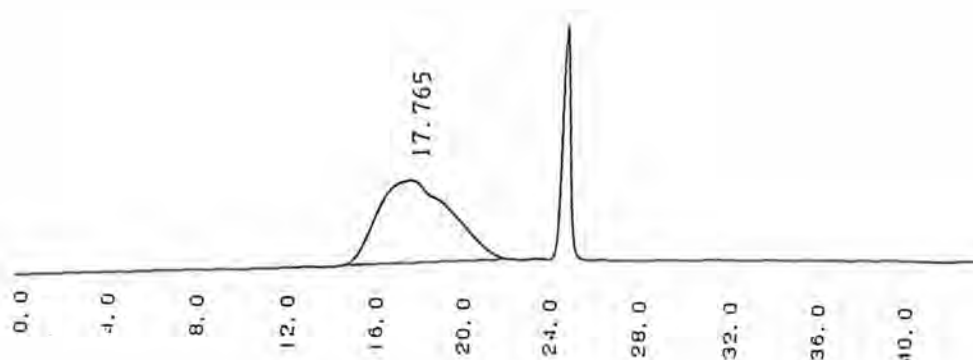
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.836	1196143	4980			100
TOTAL			1196143	4980			100

Peak information	Time (min)	Mol. size	Height
start	14.95	1352780	31
top	17.836	103522	4980
end	22.5	1627	1

Number-A.M.W. \bar{M}_n	=	31336	Weight-A.M.W. \bar{M}_w	=	143985
z-A.M.W. \bar{M}_z	=	347890	Visc-A.M.W. \bar{M}_v	=	124991
Dispersity \bar{M}_w/\bar{M}_n	=	4.59493	Dispersity \bar{M}_z/\bar{M}_w	=	2.41615
Dispersity \bar{M}_v/\bar{M}_n	=	3.98879	I. Viscosity I. VISC	=	53.52313

Figure E-25 The GPC chromatograph of the copolymer synthesized at an agitation rate of 150 rpm



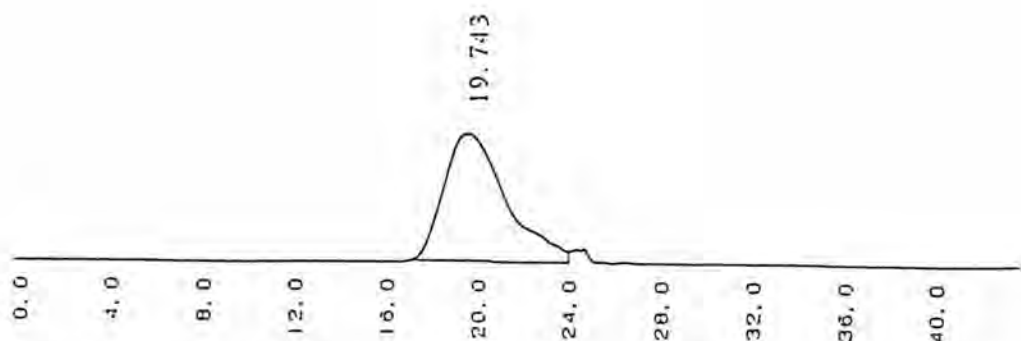
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.765	1148088	4975			100
TOTAL			1148088	4975			100

Peak information	Time (min)	Mol. size	Height
start	14.95	1352780	30
top	17.765	110344	4975
end	22.35	1860	2

Number-A.M.W. \bar{M}_n	=	34413	Weight-A.M.W. \bar{M}_w	=	150799
z-A.M.W. \bar{M}_z	=	350612	Visc-A.M.W. \bar{M}_v	=	131839
Dispersity \bar{M}_w/\bar{M}_n	=	4.38206	Dispersity \bar{M}_z/\bar{M}_w	=	2.32503
Dispersity \bar{M}_v/\bar{M}_n	=	3.8311	I. Viscosity I. VISC	=	55.73726

Figure E-26 The GPC chromatograph of the copolymer synthesized at an agitation rate of 200 rpm



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.743	1421106	7478			100
TOTAL			1421106	7478			100

Peak information	Time (min)	Mol. size	Height
start	17.4	254133	25
top	19.743	39090	7478
end	24.3	1025	619

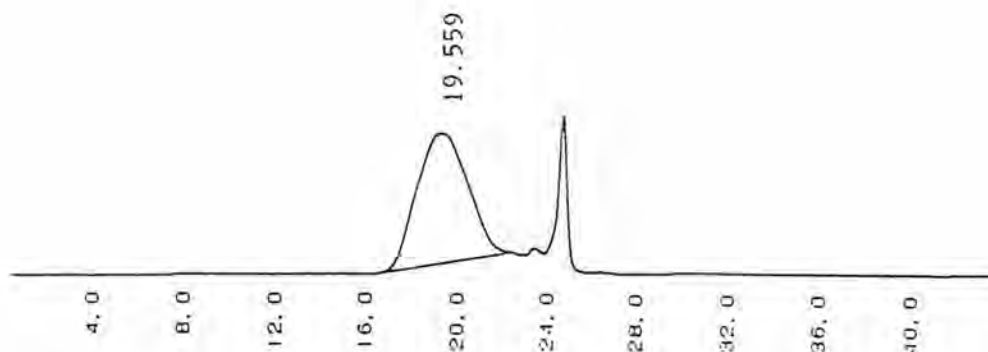
Number-A.M.W. \bar{M}_n = 11619 Weight-A.M.W. \bar{M}_w = 37123

z-A.M.W. \bar{M}_z = 68060 Visc-A.M.W. \bar{M}_v = 33816

Dispersity \bar{M}_w/\bar{M}_n = 3.19503 Dispersity \bar{M}_z/\bar{M}_w = 1.83337

Dispersity \bar{M}_v/\bar{M}_n = 2.91044 I. Viscosity I. VISC = 19.81758

Figure E-27 The GPC chromatograph of the copolymer synthesized at an agitation rate of 290 rpm



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.559	1197215	7730			100
TOTAL			1197215	7730			100

Peak information	Time (min)	Mol. size	Height
start	17.1	199429	18
top	19.559	22328	7730
end	22.6	1489	6

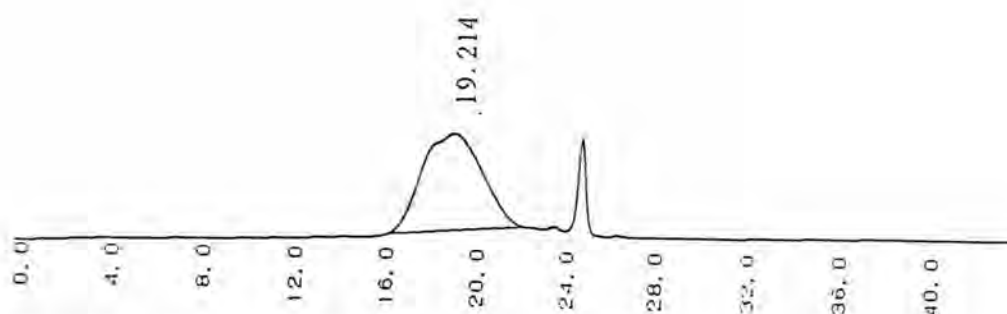
Number-A.M.W. \bar{M}_n = 14099 Weight-A.M.W. \bar{M}_w = 28198

z-A.M.W. \bar{M}_z = 48558 Visc-A.M.W. \bar{M}_v = 26157

Dispersity \bar{M}_w/\bar{M}_n = 2.00004 Dispersity \bar{M}_z/\bar{M}_w = 1.72206

Dispersity \bar{M}_v/\bar{M}_n = 1.8553 I. Viscosity I. VISC = 6.30345

Figure E-28 The GPC chromatograph of the copolymer synthesized for 6 h reaction
time

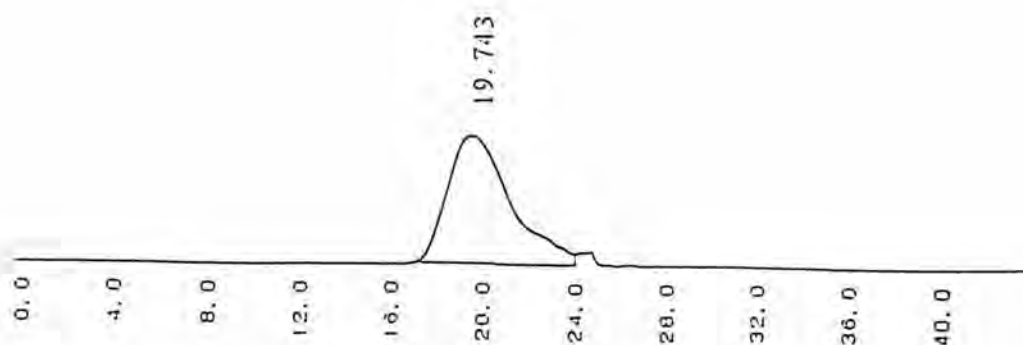


** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.214	1061348	5757			100
TOTAL			1061348	5757			100

Peak information	Time (min)	Mol. size	Height
start	16.35	388888	26
top	19.214	30367	5757
end	22.45	1702	2
Number-A.M.W. \bar{M}_n	= 19183	Weight-A.M.W. \bar{M}_w	= 48559
z-A.M.W. \bar{M}_z	= 95891	Visc-A.M.W. \bar{M}_v	= 44027
Dispersity \bar{M}_w/\bar{M}_n	= 2.53142	Dispersity \bar{M}_z/\bar{M}_w	= 1.97472
Dispersity \bar{M}_v/\bar{M}_n	= 2.29518	I. Viscosity I. VISC	= 24.21824

Figure E-29 The GPC chromatograph of the copolymer synthesized for 8 h reaction time



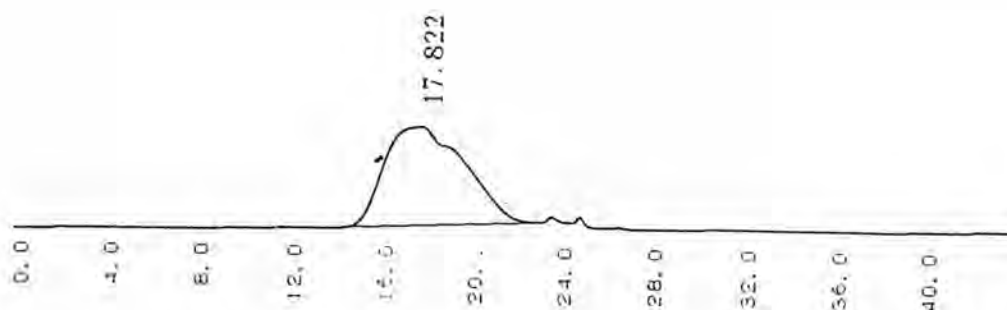
** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.743	1421106	7478			100
TOTAL			1421106	7478			100

Peak information	Time (min)	Mol. size	Height
start	17.4	254133	25
top	19.743	39090	7478
end	24.3	1025	619

Number-A.M.W. \bar{M}_n	=	11619	Weight-A.M.W. \bar{M}_w	=	37123
z-A.M.W. \bar{M}_z	=	68060	Visc-A.M.W. \bar{M}_v	=	33816
Dispersity \bar{M}_w/\bar{M}_n	=	3.19503	Dispersity \bar{M}_z/\bar{M}_w	=	1.83337
Dispersity \bar{M}_v/\bar{M}_n	=	2.91044	I. Viscosity I. VISC	=	19.81758

Figure E-30 The GPC chromatogram of the copolymer synthesized for 10 h reaction time



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	17.822	1472143	5952			100
TOTAL			1472143	5952			100

Peak information	Time (min)	Mol. size	Height
start	14.85	1478767	29
top	17.822	104852	5860
end	19	36730	4594

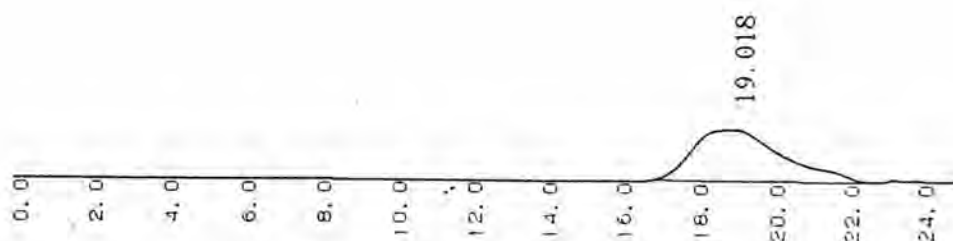
Number-A.M.W. \bar{M}_n = 112036 Weight-A.M.W. \bar{M}_w = 214032

z-A.M.W. \bar{M}_z = 385290 Visc-A.M.W. \bar{M}_v = 197629

Dispersity \bar{M}_w/\bar{M}_n = 1.91038 Dispersity \bar{M}_z/\bar{M}_w = 1.80015

Dispersity \bar{M}_v/\bar{M}_n = 1.76398 I. Viscosity I. VISC = 75.81563

Figure E-31 The GPC chromatograph of the copolymer synthesized for 15 h reaction time



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.018	508947	3114			100
TOTAL			508947	3114			100

Peak information	Time (min)	Mol. size	Height
start	16.95	227926	31
top	19.018	36157	3114
end	22.7	1362	0

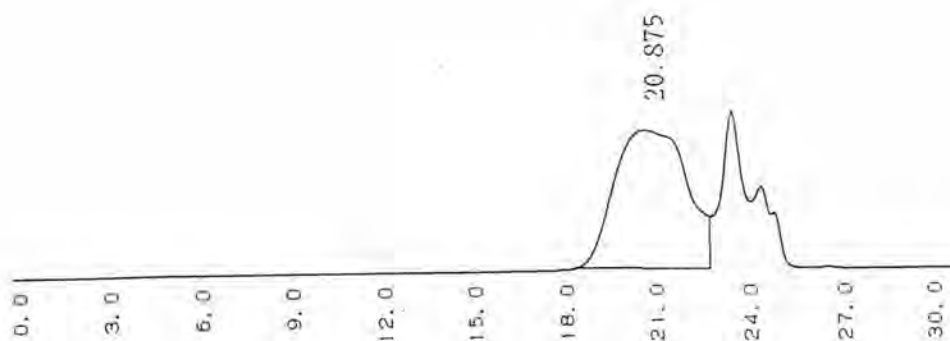
Number-A.M.W. \bar{M}_n = 16278 Weight-A.M.W. \bar{M}_w = 41078

z-A.M.W. \bar{M}_z = 70446 Visc-A.M.W. \bar{M}_v = 37866

Dispersity \bar{M}_w/\bar{M}_n = 2.52358 Dispersity \bar{M}_z/\bar{M}_w = 1.71492

Dispersity \bar{M}_v/\bar{M}_n = 2.32626 I. Viscosity I. VISC = 21.59667

Figure E-32 The GPC chromatograph of the copolymer synthesized at the styrene feed of 25 mole%



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	20.875	1405253	8491			100
TOTAL			1405253	8491			100

Peak information	Time (min)	Mol. size	Height
start	18.55	54834	29
top	20.875	6917	8491
end	23	1043	3157

Number-A.M.W. \bar{M}_n = 4097 Weight-A.M.W. \bar{M}_w = 7916

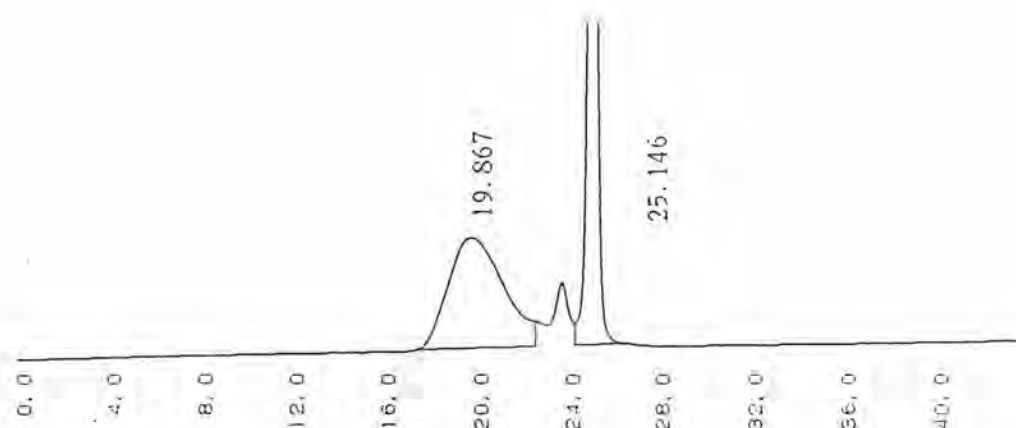
z-A.M.W. \bar{M}_z = 13765 Visc-A.M.W. \bar{M}_v = 7337

Dispersity \bar{M}_w/\bar{M}_n = 1.93209 Dispersity \bar{M}_z/\bar{M}_w = 1.73899

Dispersity \bar{M}_v/\bar{M}_n = 1.79086 I. Viscosity I. VISC = 6.20452

Figure E-33 The GPC chromatograph of the copolymer synthesized at the styrene

feed of 50 mole%



Peak information	Time (min)	Mol. size	Height
start	17.55	133587	28
top	19.867	16967	6662
end	22.7	1362	1474

Number-A.M.W. \bar{M}_n = 8044 Weight-A.M.W. \bar{M}_w = 18901

z-A.M.W. \bar{M}_z = 34561 Visc-A.M.W. \bar{M}_v = 17330

Dispersity \bar{M}_w/\bar{M}_n = 2.34967 Dispersity \bar{M}_z/\bar{M}_w = 1.82851

Dispersity \bar{M}_v/\bar{M}_n = 2.15438 I. Viscosity I. VISC = 11.92362

Peak information	Time (min)	Mol. size	Height
start	24.4	300	1319
top	25.146	154	64629
end	26.5	46	1

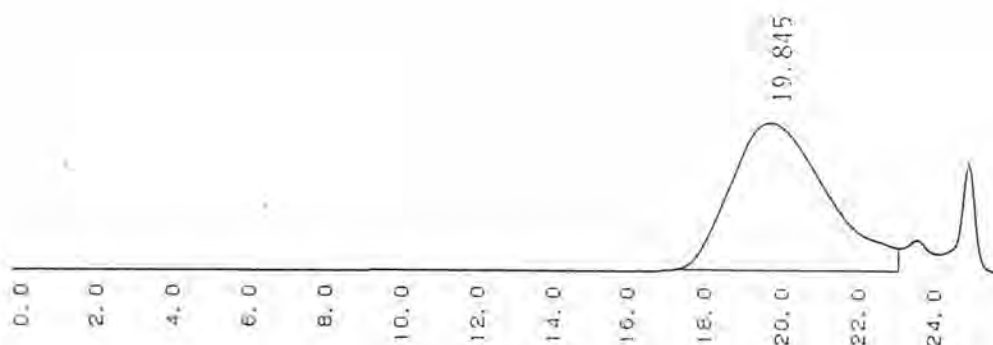
Number-A.M.W. \bar{M}_n = 151 Weight-A.M.W. \bar{M}_w = 156

z-A.M.W. \bar{M}_z = 161 Visc-A.M.W. \bar{M}_v = 156

Dispersity \bar{M}_w/\bar{M}_n = 1.03243 Dispersity \bar{M}_z/\bar{M}_w = 1.03259

Dispersity \bar{M}_v/\bar{M}_n = 1.02851 I. Viscosity I. VISC = 0.33194

Figure E-34 The GPC chromatograph of the copolymer synthesized in the styrene feed of 75 mole%



** CALCULATION REPORT **

CH	PKNO	TIME	AREA	HEIGHT	MK	IDNO	CONC
1	1	19.845	1541714	8909			100
TOTAL			1541714	8909			100

Peak information	Time (min)	Mol. size	Height
start	17.45	146028	23
top	19.845	17313	8909
end	23.25	835	1370

Number-A.M.W. \bar{M}_n	=	6757	Weight-A.M.W. \bar{M}_w	=	18779
z-A.M.W. \bar{M}_z	=	35625	Visc-A.M.W. \bar{M}_v	=	17084
Dispersity \bar{M}_w/\bar{M}_n	=	2.77915	Dispersity \bar{M}_z/\bar{M}_w	=	1.89704
Dispersity \bar{M}_v/\bar{M}_n	=	2.52834	I. Viscosity I. VISC	=	11.79466

Figure E-35 The GPC chromatograph of the copolymer synthesized at the styrene feed of 100 mole%

VITA

Miss Arunsri Anantaphiphat was born on April 24, 1973, in Bangkok. She received her B.Sc. in Chemistry from Faculty of Science, Kasetsart University in 1994. She began her masters degree study in Polymer Science, Multi-disciplinary Program of Petrochemistry and Polymer, Chulalongkorn University in 1994.