# REFERENCES


1. Ugelstad, J., Mork, P.C., Kaggerug, K.H., Ellingsen, T., and Berge, A. Adv. Colloid Interface Sci. 13(1980):101.
2. Lovelace, A.M., Vanderhoff, J.W., Micale, F.J., El-Aasser, M.S., and Kornfeld, D.M. U.S. Patent #4,427,434 (1981).
3. Almog, Y., and Levy, M. "Dispersion Polymeriztion of Styrene; Effect of Surfactant", J. of Polym. Sci. Polym. Ed. 19(1981): 115-126.
4. ----------, and Levy, M. J. Polym. Sci. Polym. Chem. Ed., 18(1980):1.
5. Stejskal, J., Kratochvil, P., and Konak, C. "Structural parameter of spherical particles prepared by dispersion polymerization of methyl methacrylate", Polymer 32, 13(1991):2435.
6. Chujo, S., Rikukawa, M., Sanui, K., and Ogata, N. Controll of Particle Size of Polystyrene Microsphere by Morphological Changes of Matrix Polymer. Polymer Preprints, Japan, Vol. 42, No. 1 The Society of Polymer science, Japan, 1993, p E1306.
7. Gruber, J.R., and Julin, C.P. Dry Toner Technology. In B.A.Diamono(ed), Handbook of Imaging Materials. New York: Marcel Dekker, 1991: 159-162.
8. Almog,Y., and Levy M. "Studies of Particle Size Distribution and Adsorption of Stabilizers in Dispersion Polymerization", J. Polym. Sci. Polym. Chem. 20 (1982):417-429.
9. ----------, and Levy, M. "Free Radical Polymerization of Styrene and Methyl Methacrylate in Dispersed Systems and Effect of Carbon Black", Ind. Eng. Chem. Prod. Res. Dev. 21(1982): 163-170.
10. Barrett, K.E.J., and Thomas, H.R. "Kinetics and Mechanism of Dispersion Polymerization" in Dispersion Polymerization in Organic Media, ed. Barrett, K.E.J. (London: John Wiley & Sons, 1975), pp. 115-119.
11. Harkins, W.D. J. Amer. Chem. Soc. 69(1947):1428.
12. Smith, W.V., and Eward, R.H. J. Chem. Phys. 16(1948):592.
13. Roe, C.P. Ind. Eng. Chem. 60(1968):20.
14. Almog,Y., and Levy M. "Effect of Initiator on the Molecular weight Distribution in Dispersion Polymerization of Styrene", J. Polym. Sci. 18 (1980) : 1-11.
15. Lok, K.P., and Ober, C.K. "Particle size control in dispersion polymerization of polystyrene", Can. J. Chem. 63(1985):209-216.

16. Barrett, K.E.J., and Thomas, H.R. "The Preparation of Polymer Dispersion in Organic Liquids" in Dispersion Polymerization in Organic Media, ed. Barrett, K.E.J. (London: John Wiley & Sons, 1975), pp. 205-207.

17. Osmond, D.W.J., and Waite, F.A. "The Theoretical Basis for the Steric Stabilization of Polymer Dispersions Prepared in Organic Media" in Dispersion Polymerization in Organic Media, ed. Barrett, K.E.J. (London: John Wiley & Sons, 1975), pp. 9-39.

18. Walbridge, D.J. "The Design and Synthesis of Disperants for Dispersion Polymerization in Organic Media" in Dispersion Polymerization in Organic Media, ed. Barrett, K.E.J. (London: John Wiley & Sons, 1975), pp. 45-50.

19. Barrett, K.E.J., and Thomas, H.R. "Kinetics of Dispersion Polymerization of Soluble monomers. I. Methyl Methacrylate", J. Polym. Sci.: Part A-1.7(1969): 2621-2650.

20. Trommsdorff, E. Macromolekulare Chemie 1(1947): 169

21. Morton, M., Kaizerman, S., and Altier, M. W. J. Colloid Sci. 9(1952): 300.

22. Smith, W.V., and Ewart, R.H. J. Chem. Phys. 16(1948):592.

23. Barrett, K.E.J., and Thomas, H.R. "Kinetics and Mechanism of Dispersion Polymerization" in Dispersion Polymerization in Organic Media, ed. Barrett, K.E.J. (London: John Wiley & Sons, 1975), pp. 173-176.

24. Fitch, R. M.(Editor) Polym. Coll. Plenum Press, New York. 1971.

25. Lu, Y.Y., El-Aasser, M.S., and Vanderhoff, J.W. "Dispersion Polymerization of Styrene in Ethanol: Monomer Partitioning Behavior and Locus of Polymerization", J. Polym. Sci. Polym. Phy. 26(1988):1187-1203.

26. Vanderhoff, J. W., El-Aasser, M.S., Mical, F.J., Sudol, E.D., Tseng, C.M., Silwanowicz, A., Kornfeld, D.M., and Vincente. J. Dispers. Sci. Tech. 5(1984):231.

27. Tseng, C.M., Lu, Y.Y., El-Aasser, M.S., and Vanderhoff, J.W. "Uniform Polymer Particles by Dispersion Polymerization in Alcohol", J. Polym.Sci . Polym. Chem. Ed. 24(1986): 2995-3007.

28. Almog, Y., Reich, S., and Levy, M. "Monodisperse Polymeric Spheres in the Micron Size Range by a Single Step Process", The Brit. Polym. J. 14(December 1982):131-136.

29. Barrett, K.E.J. "Introduction to Dispersion Polymer Technology" in Dispersion Polymerization in Organic Media, ed Barrett, K.E.J. (London: John Willey & Sons, 1975), pp. 1-9.

30. Ober, C.K., Lok, K. P., and Hair, M.L. "Monodispersed, Micron- Sized Polystyrene Particles by Dispersion Polymerization", J. Polym. Sci. Polym. Lett: Ed. 23(1985): 103-108.

31. --------, and Hair, M.L. "The Effect of Temperature and Initiator Levels on the dispersion Polymerization of Polystyrene", J. Polym. Sci. Polym. Chem. 25(1987):1395-1407.

32. Winzor, C.L., Mrazek, Z., Winnik, M.A., Croucher, M.D., and Riess, G. "Stabilization of dispersion polymerization by poly(styrene-b-ethylene oxide)copolymer", Eur. Polym. J. 30,1(1994):121-128.

33. Jianella, G.L., Firer, E.M., and Piirma, I. J. Polym. Sci., Pt A: Polym. Chem. 30(1992):1925.

34. Khan, T.N., Mobbs, R.H., Price, C., Quintana, J.R., and Stubblersfield, R.B. Eur. Polym. J. 23(1987):191.

35. Borton, J., and Capek, I. Radical Polymerization in Disperse System. 1st ed. (New York: Ellis Horwood, 1994), pp. 216-248.

36. Odian, G. Principles of Polymerization. 2nd ed. (New York : John wiley & Sons, 1970), pp. 237.

37. ----------. Principles of Polymerization. 2nd ed. (New York : John wiley & Sons, 1970), pp.452.

38. Burrell, H., and Cifton, N.J. "Solubility Parameter Values" in Polymer Handbook, ed. Brandrup, J., and Immergut, E.H. 2nd edition. (New York: John Wiley & Sons, 1975), pp.IV-337-IV359.

39. Paine, A.J. Dispersion Polymerization of Styrene in Palor solvents . IV. solvency Control of Particle Size from Hydroxypropyl Cellulose Stabilized Polymerizations. J. Polym. Sci. Polym. Chem. 28(1990): 2485-2500.

# APPENDIX A

## X-ray Photoelectron Spectra

X-ray photoelectron spectra (XPS) were obtained on a VG ESCALAB Mk II spectrometer using an Al anode at 260 watts(13 kV and 20 mA). Samples were mounted on the sample holders of 10 mm in diameter, and photoelectrons were collected from a central area of 4x7 $mm^2$ at 5-8 $x10^{-10}$ Torr.

The wide scan spectrum shows that only carbon and oxygen were present in the sample whose concentrations are higher than 0.3% on the surfaces of 5 polymers. the peak area of C1s and O1s and the ratio of O1s/C1s each sample are summarized in Table A-1.

As shown in Table A-1, the O1s/C1s ratio decreases with an increase in the styrene feed ratio. The MMA/Sty ratios on the polymer surface reflect the bulk ratios under a hypothesis that oxygen detected in the polystyrene homopolymer is most probaby a uniformly adsorbed component.

Table A-1 Peak area of C1s, O1s and O1s/C1s

| Sample | C1s (Kcps.eV) | O1s (Kcps.eV) | O1s/C1s |
|---|---|---|---|
| PMMA | 21.550 | 22.135 | 1.03 |
| Copolymer(sty 25%) | 31.191 | 25.253 | 0.810 |
| Copolymer(sty 50%) | 26.966 | 17.724 | 0.657 |
| Copolymer(sty 75%) | 36.279 | 23.192 | 0.639 |
| PS | 28.460 | 11.441 | 0.402 |

The amount of O1s found in the PS indicated that there was some concentration of the PMVE matrix polymer still remained on the surface of the PS. However, the NMR and FT-IR spectra of PS did not indicate the presence of oxygen. This implied that, the remaining PMVE was only found on the surface of the PS.

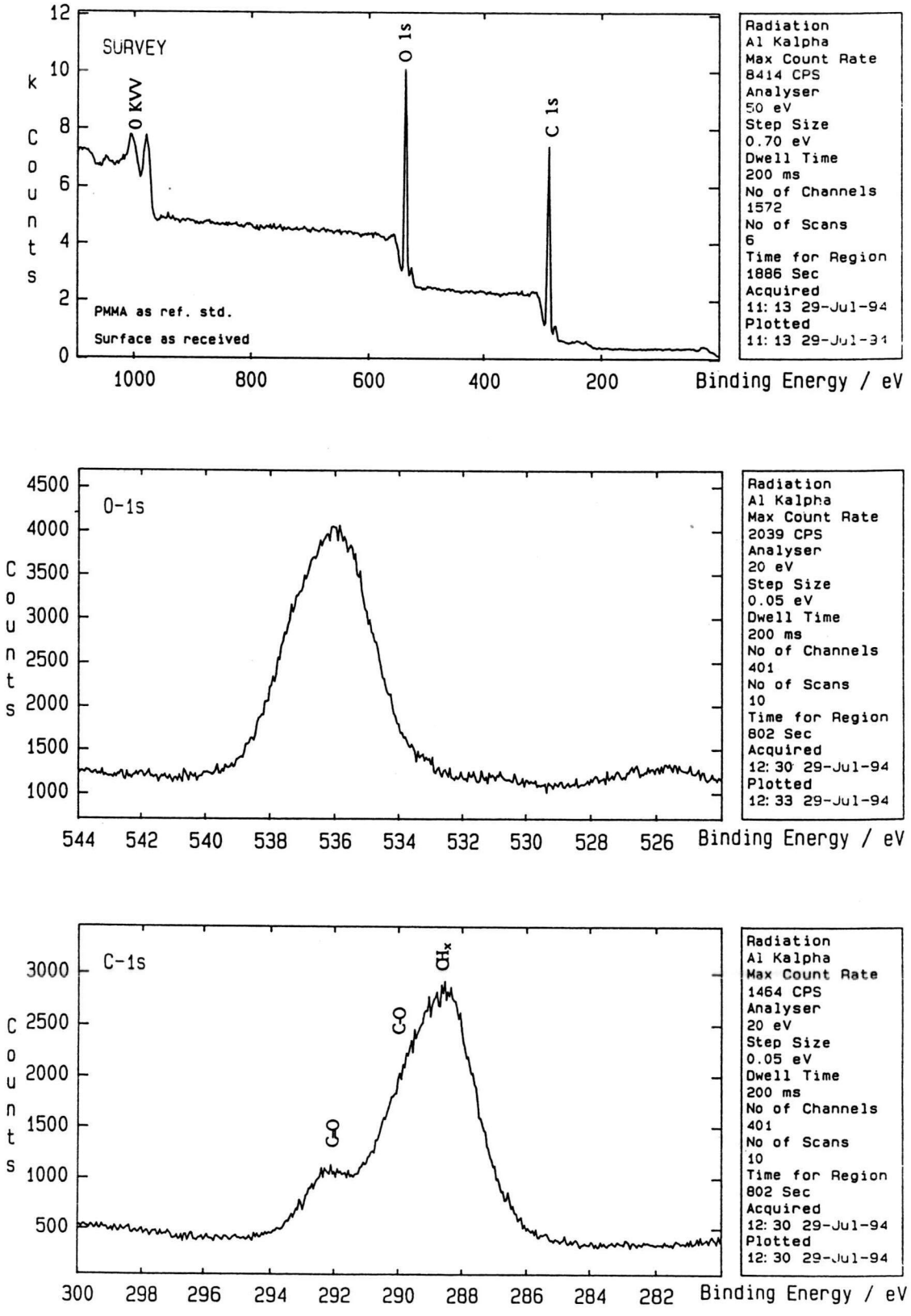



Figure A-1 XPS spectra of PMMA homopolymer

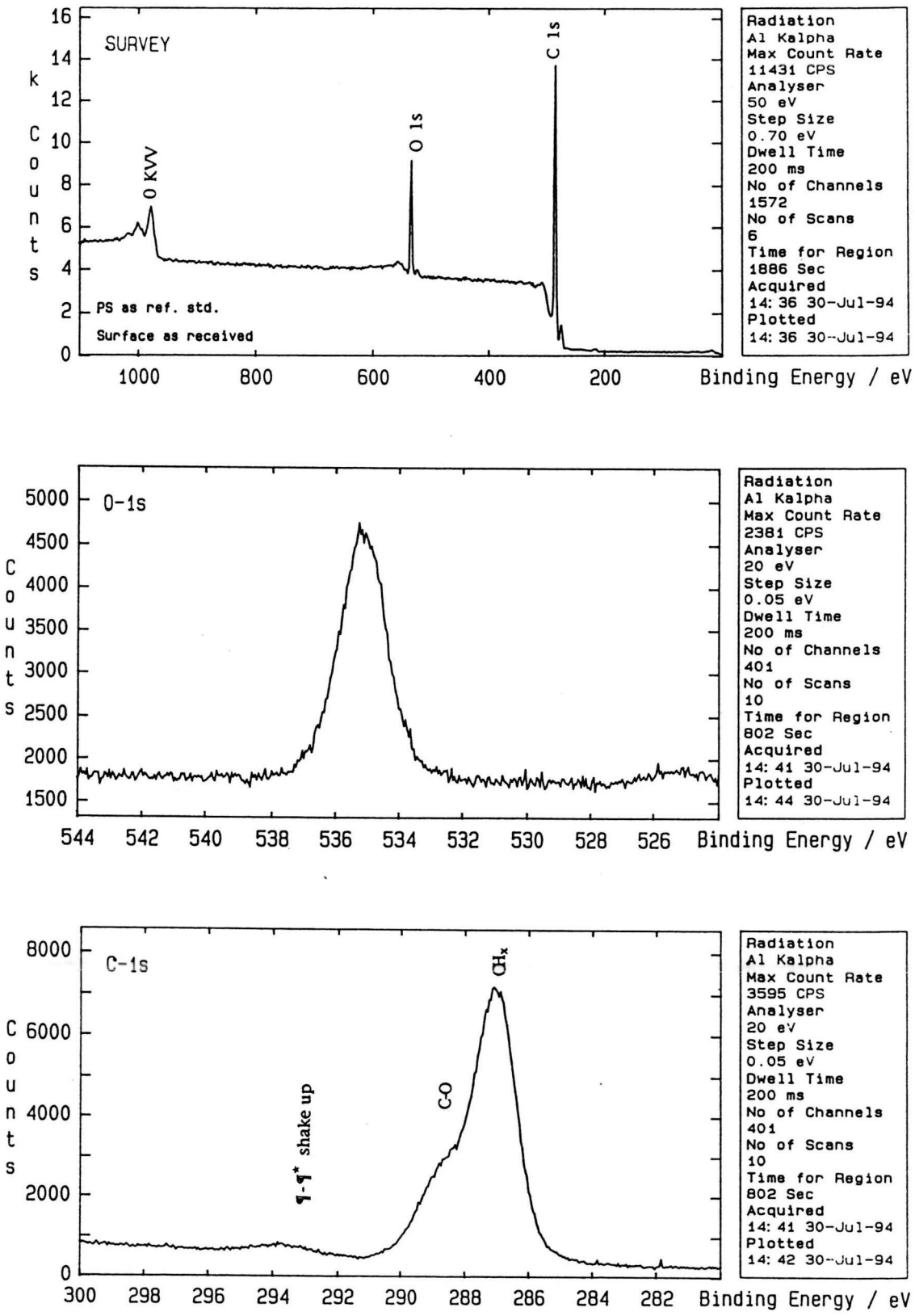



Figure A-2 XPS spectra of PS homopolymer

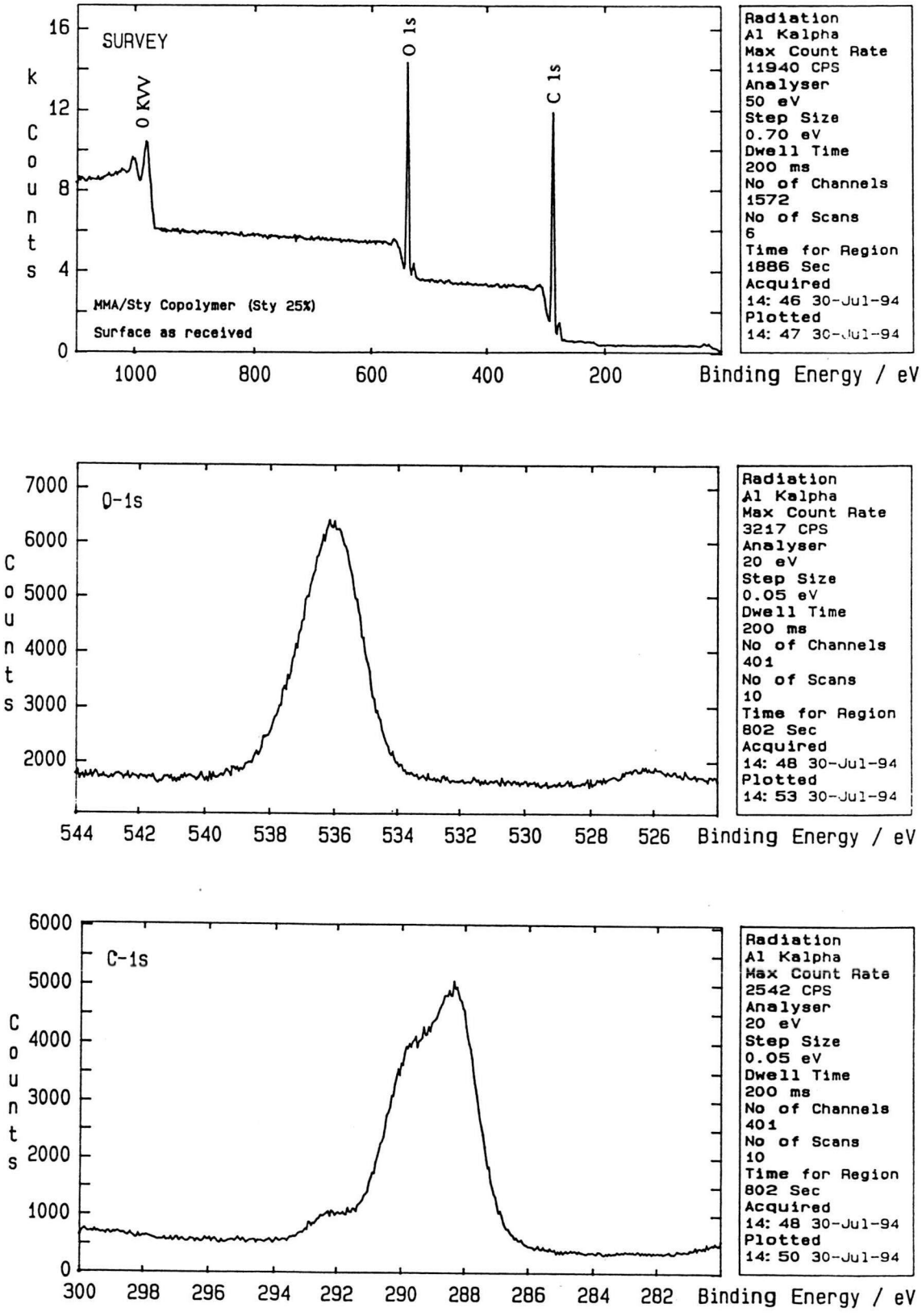



Figure A-3 XPS spectra of poly(St-co-MMA): St feed 25 %

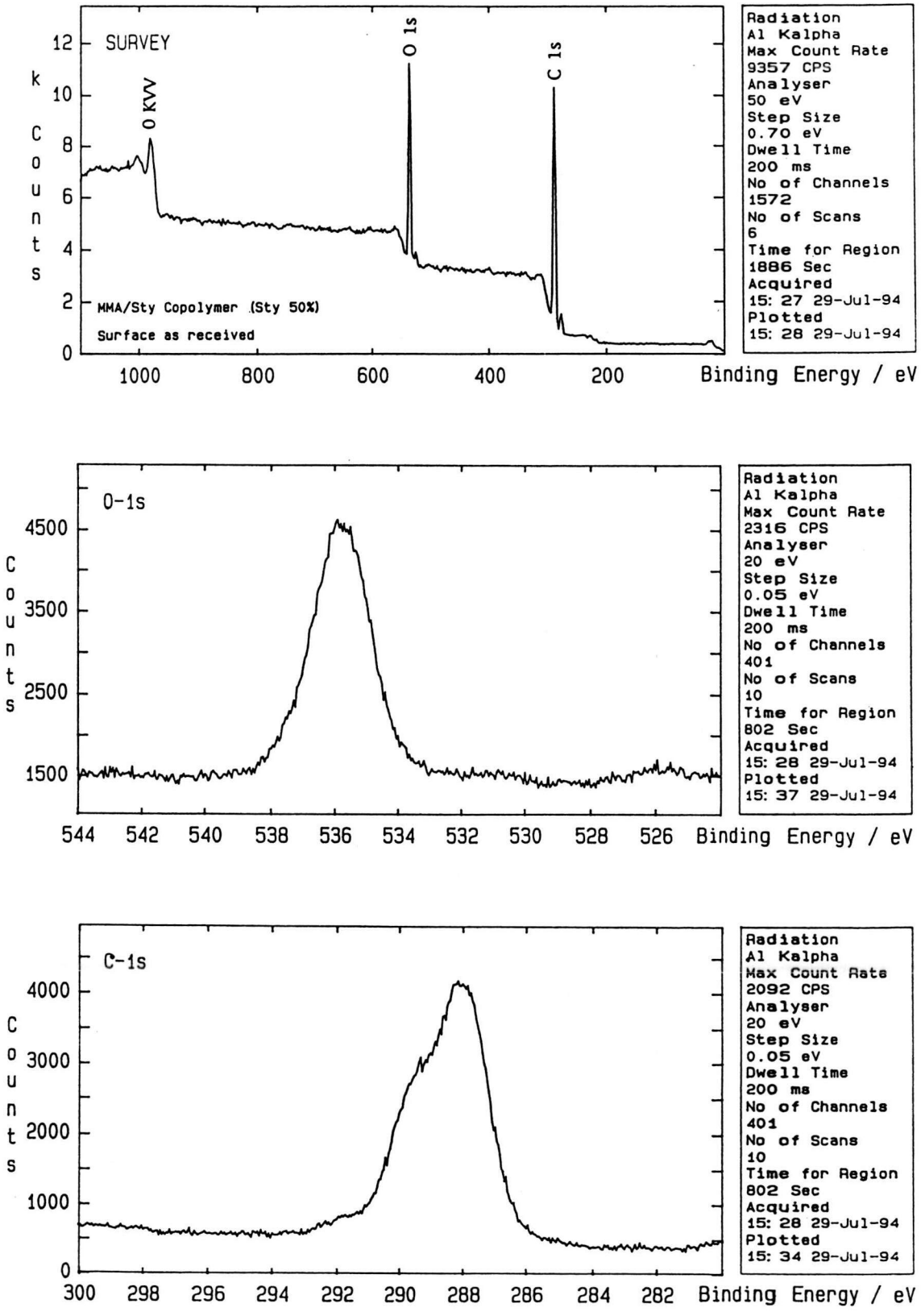



Figure A-4 XPS spectra of poly(St-co-MMA): St feed 50 %

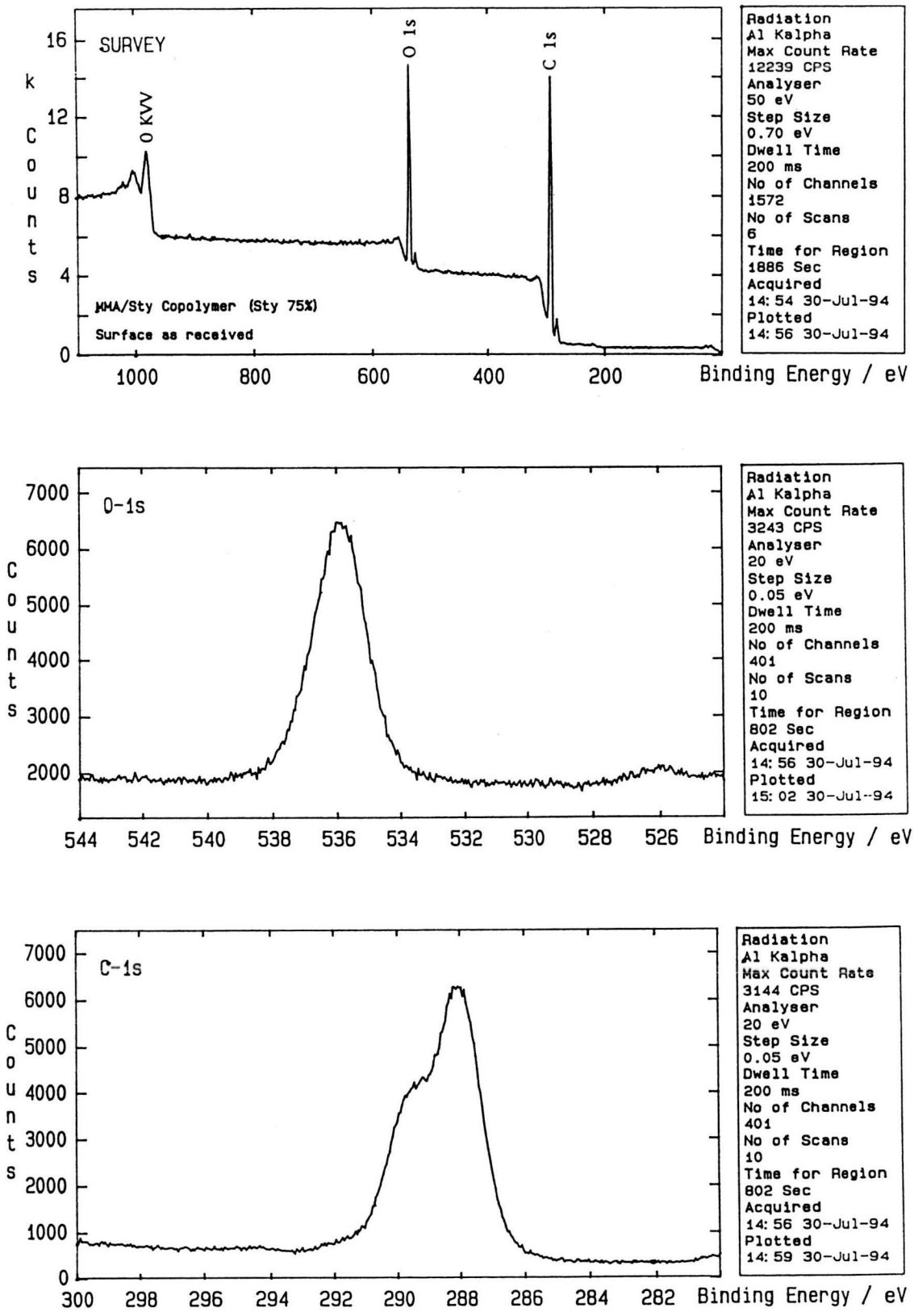



Figure A-5 XPS spectra of poly(St-co-MMA): St feed 75 %

# APPENDIX B

## Nuclear Magnetic Resonance Spectra

Measurements of $H^1$NMR and $C^{13}$NMR spectra were operated on a Japan Electron Optics Laboratory(JEOL) model JNM-GX270, 270 MHz at 45°C for all copolymers using 4% solution in deuterochloroform ($CDCl_3$). Tetramethylsilane (TMS) was used as an internal reference standard.

The assignments of the $H^1$NMR and $C^{13}$NMR spectrum were shown in Tables B-1 to B-2, respectively. The copolymers of the various styrene feeds were analysed by using the $H^1$NMR technique (Figures B-a to B-c) while only the copolmer of 75% styrene feed was analysed by using the $C^{13}$NMR(Figure B-2) in order to obtain the information of poly(styrene-co-methyl methacrylate) formation.

Determination of the copolymer composition from a high resolution $H^1$NMR spectrum was done by comparing the peak areas of the methyl proton( $-C-CH_3$; $\partial$ = 0.1-1.1 ppm) of MMA and the phenyl proton( $-C_6H_5$ ; $\partial$ = 6.6-7.5 ppm) of Sty, the peak area was measured by weighting the paper weight under the peak. The detailed method of the determination was shown by an example of calculation. The results of the calculation were shown in the Tables B-a, B-b amd B-c for the solution, bulk and dispersion copolymerizations, respectively.

It should be noted that, the resonance of the methoxy proton of the MMA($-O-CH_3$; $\partial$ = 2.2-3.6 ppm) was shown to be resolved into three peaks in the copolymer of Sty-co-MMA resulted from a diamagnetic shielding by the phenyl ring, neighboring to the methyl methacrylate group.

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

| Assignments | | Chemical Shift(ppm) |
|---|---|---|
| MMA | $O-CH_3$ methoxy proton | 2.2-3.6 |
| | $C-CH_3$ methyl proton | 0.1-1.1 |
| Sty | $C_6H_5$ phenyl proton | 6.6-7.5 |

An example of calculation

Dispersion copolymer: 25 mole% Sty feed, 80 weight% EtOH in the mixed solvent

Weight of the methyl proton peak = 80.04 mg

Weight of the phenyl proton peak = 71.93 mg

Ratio of MMA:Sty = 80.04/3 : 71.93/5

= 26.68 : 14.39

%Sty in copolymer = 14.39/(14.39+26.68) = 35

Table B-a Copolymer composition of the solution copolymer

| Sty in feed (mole %) | wt.of phenyl peak(mg) | wt.of methyl peak(mg) | Sty: MMA in copolymer | F (%Sty) |
|---|---|---|---|---|
| 25 | 65.4 | 69.2 | 13.08 : 23.07 | 36 |
| 38 | 97.9 | 58.2 | 19.58 : 19.40 | 50 |
| 50 | 81.2 | 43.0 | 16.24 : 14.33 | 53 |
| 62 | 65.6 | 24.2 | 13.12 : 8.07 | 62 |
| 75 | 56.6 | 12.3 | 11.32 : 4.10 | 73 |

F: copolymer composition

Table B-b Copolymer composition of the bulk copolymer

| Sty in feed (mole %) | wt.of phenyl peak(mg) | wt.of methyl peak(mg) | Sty: MMA in copolymer | F (%Sty) |
|---|---|---|---|---|
| 25 | 29.7 | 33.2 | 5.94 : 11.07 | 35 |
| 38 | 46.2 | 31.8 | 9.24 : 10.60 | 47 |
| 50 | 41.5 | 19.8 | 8.30 : 6.60 | 56 |
| 62 | 61.5 | 19.8 | 12.30 : 6.60 | 65 |
| 75 | 123.5 | 21.9 | 24.70 : 7.30 | 77 |

F: copolymer composition

Table B-c Copolymer composition of the dispersion copolymer

| Sty in feed (mole %) | wt. of phenyl peak(mg) | wt. of methyl peak(mg) | Sty: MMA in copolymer | F (%Sty) |
|---|---|---|---|---|
| 25 | 71.9 | 80.0 | 14.39 : 26.68 | 35 |
| 38 | 74.5 | 72.7 | 14.90 : 24.24 | 38 |
| 50 | 42.7 | 21.0 | 8.53 : 6.99 | 55 |
| 62 | 45.4 | 17.5 | 9.08 : 5.82 | 61 |
| 75 | 71.7 | 17.7 | 14.34 : 5.90 | 71 |

F: copolymer composition

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

| Assignments | | Chemical Shift(ppm) |
|---|---|---|
| MMA | C*=O carbonyl carbon | 174-178 |
| | C*$H_2$ methylene carbon | 47-54 |
| | >C*< tertiary carbon | 43-47 |
| | C-C*$H_3$ α-methyl carbon | 16-22 |
| Sty | aromatic ring carbon(1) | 142-147 |
| | aromatic ring carbon(2-6) | 125-130 |
| | C*H2 methylene carbon | 47-50 |
| | C*H methine carbon | 36-40 |

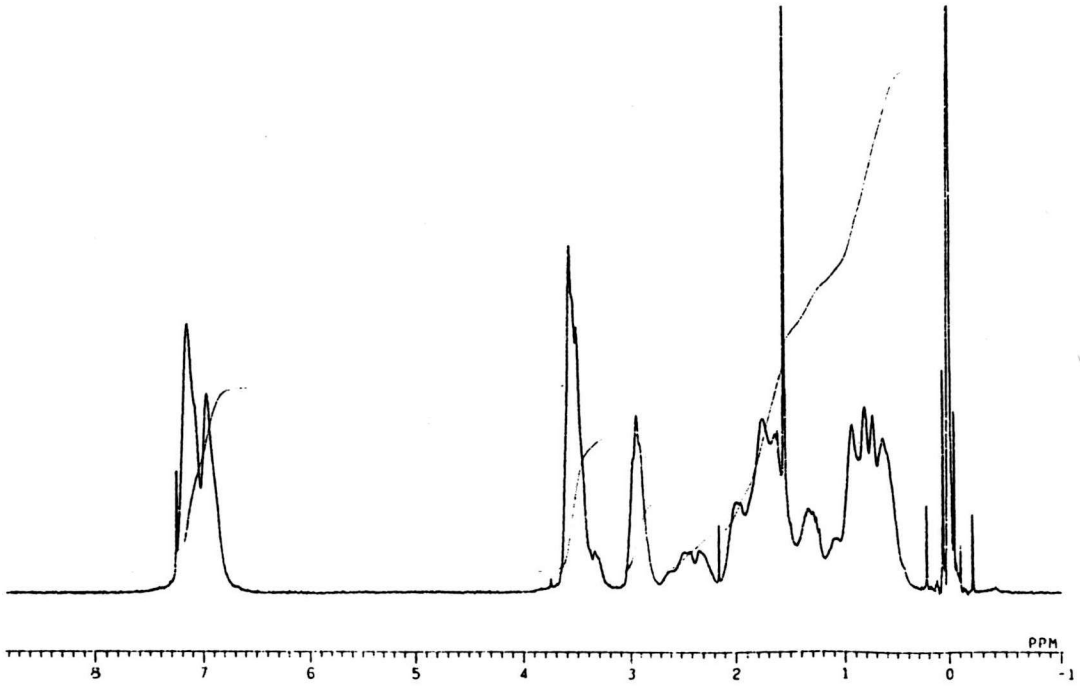



Figure B-a1 $H^1$NMR spectrum of the solution copolymer (Styrene 25 mole% feed)

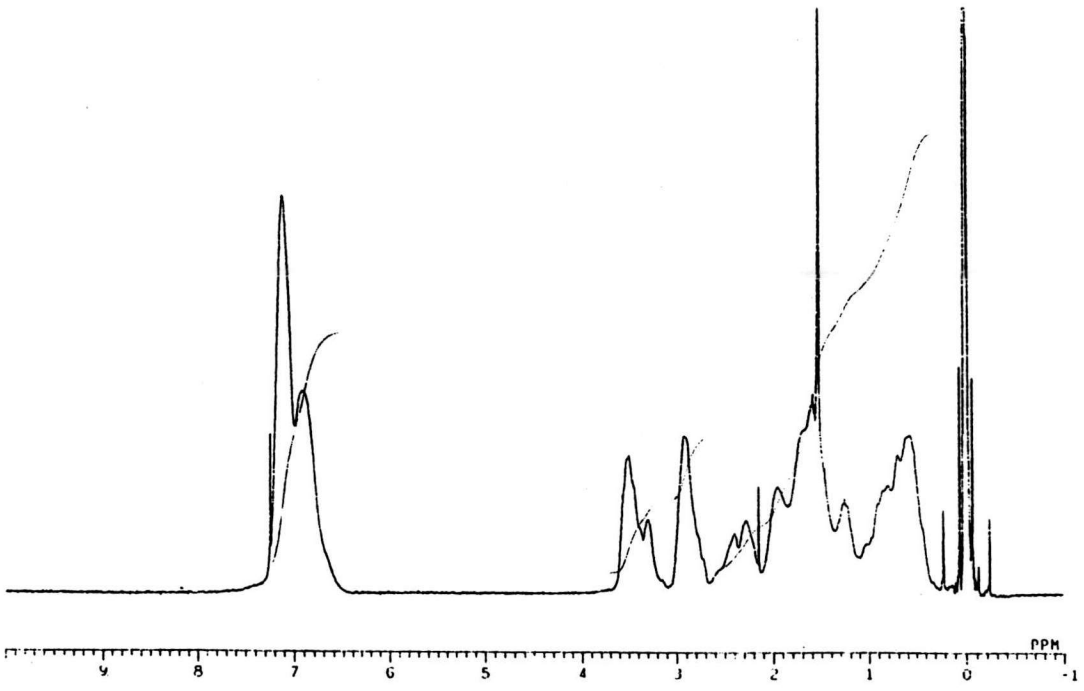



Figure B-a2 $H^1$NMR spectrum of the solution copolymer (Styrene 38 mole% feed)

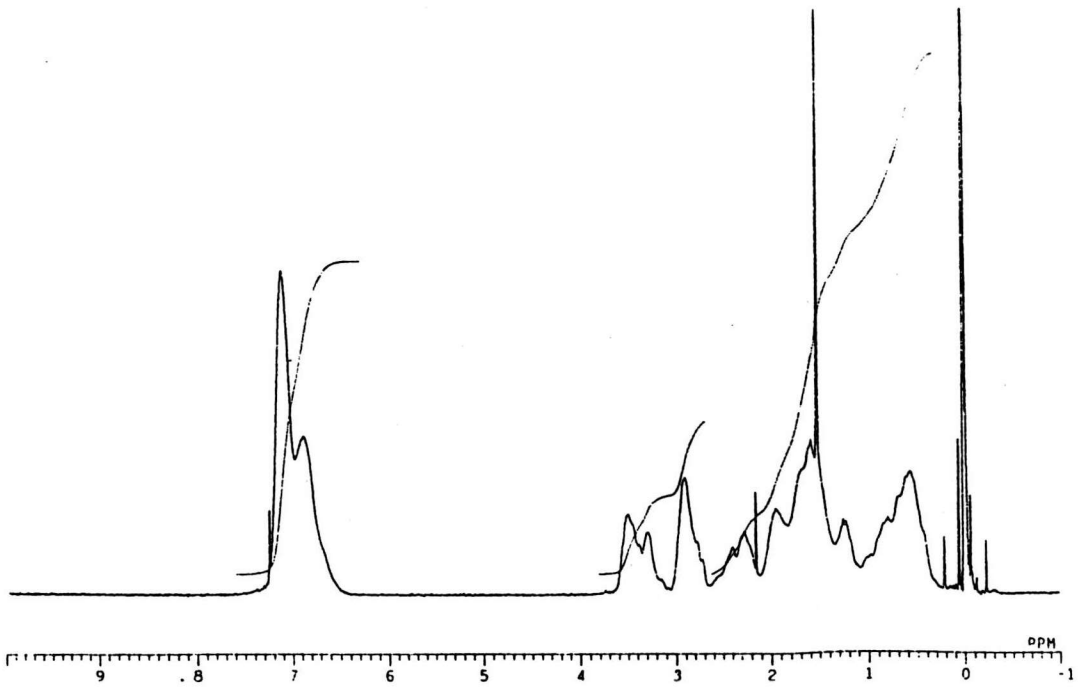



Figure B-a3 $H^1$NMR spectrum of the solution copolymer (Styrene 50 mole% feed)

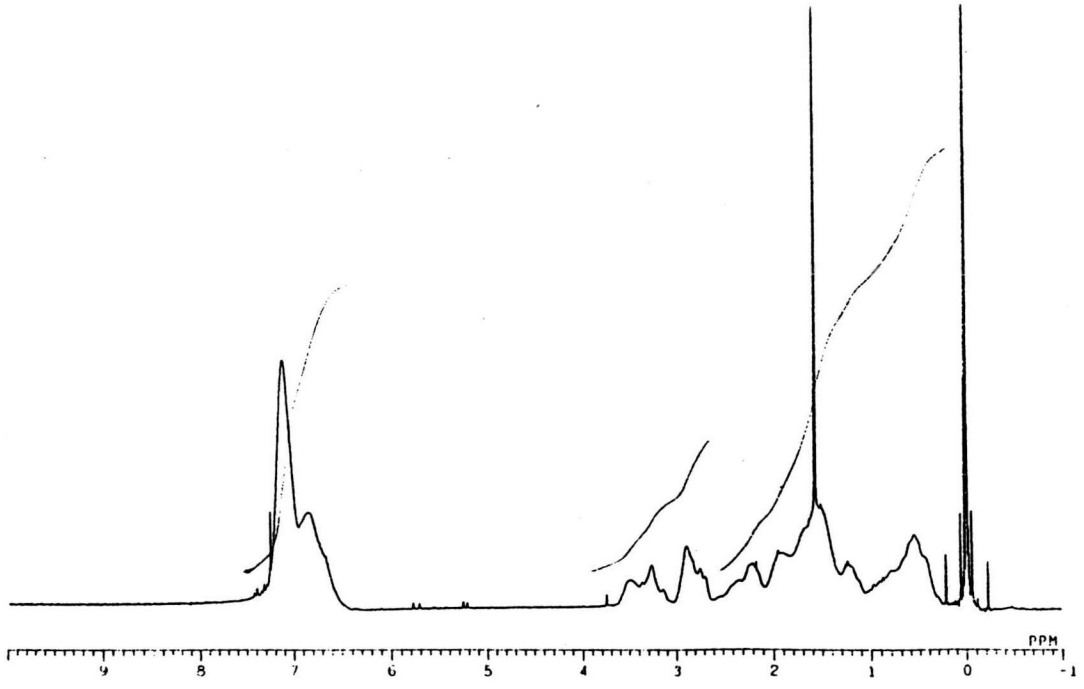



Figure B-a4 $H^1$NMR spectrum of the solution copolymer (Styrene 62 mole% feed)

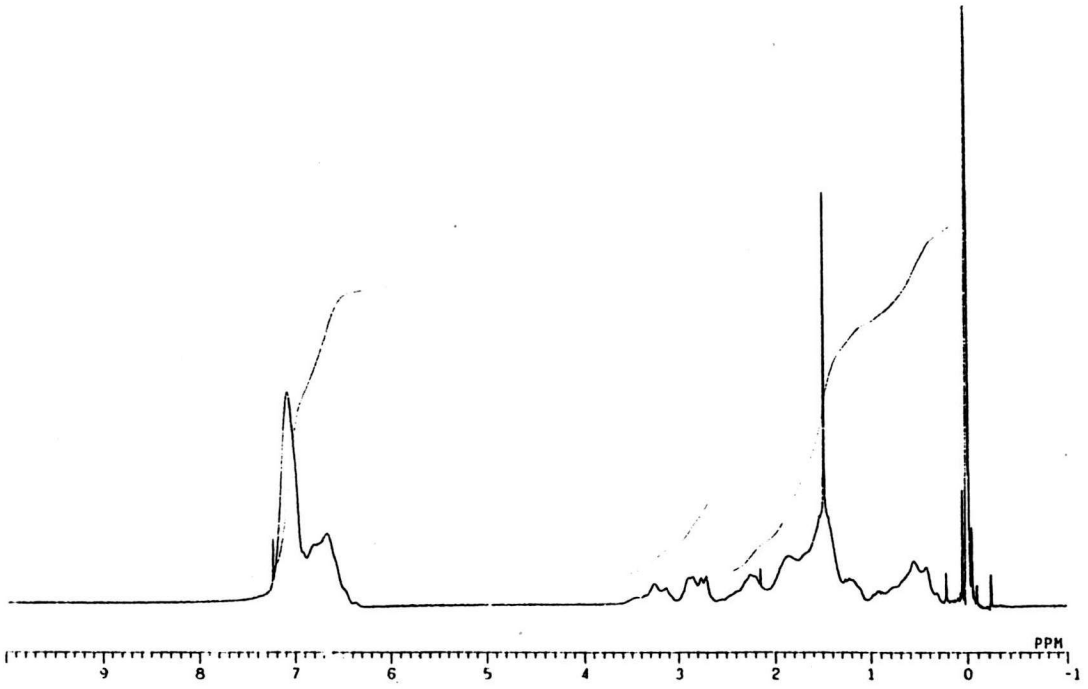



Figure B-a5 $H^1$NMR spectrum of the solution copolymer (Styrene 75 mole% feed)

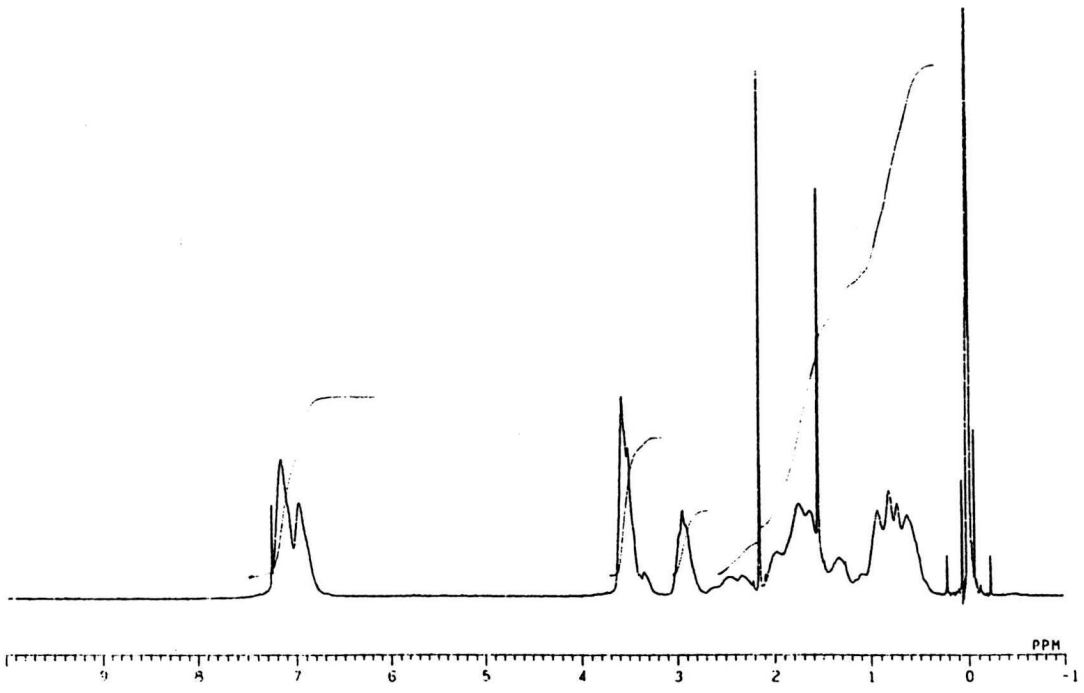



Figure B-b1 $H^1$NMR spectrum of the bulk copolymer (Styrene 25 mole% feed)

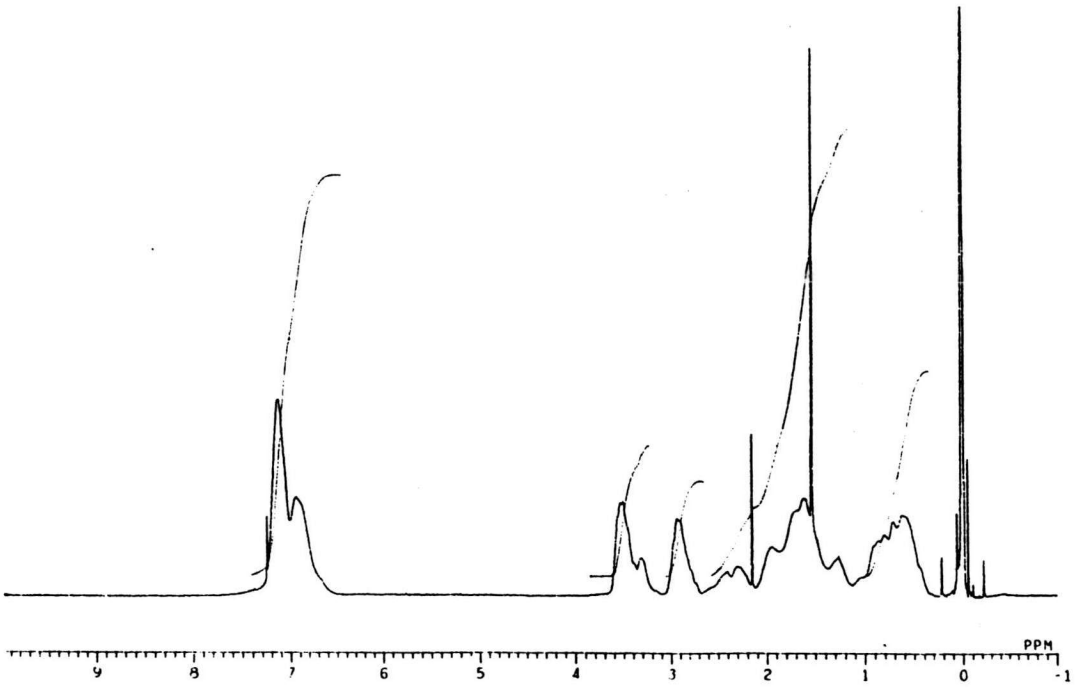



Figure B-b2 $H^1$NMR spectrum of the bulk copolymer (Styrene 38 mole% feed)

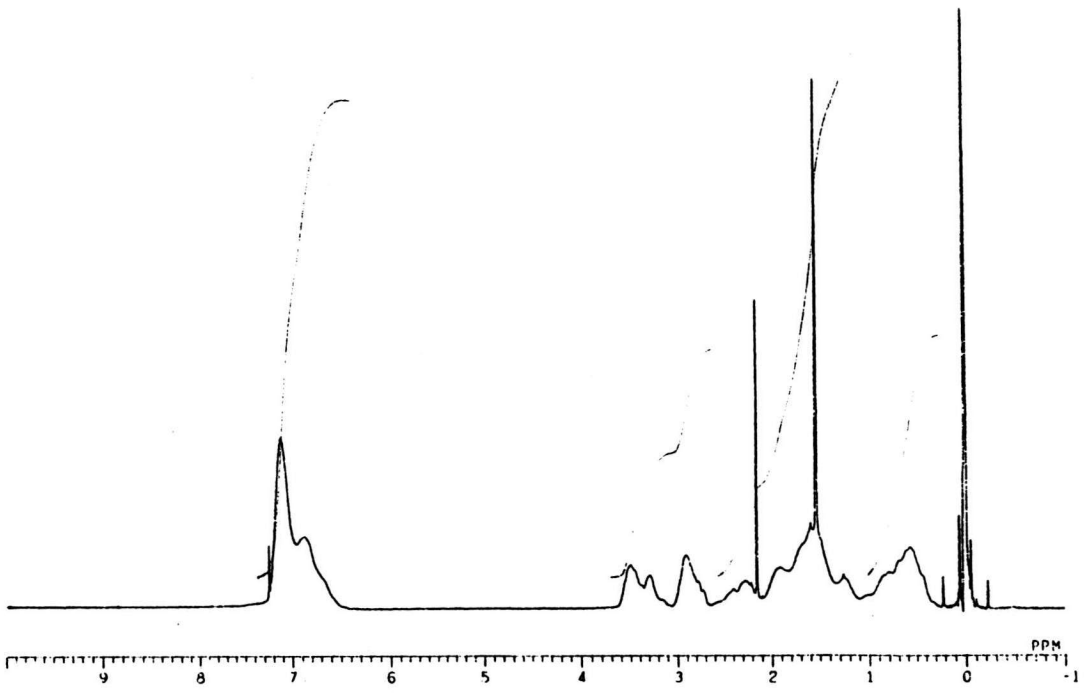



Figure B-b3 NMR spectrum of the bulk copolymer (Styrene 50 mole% feed)

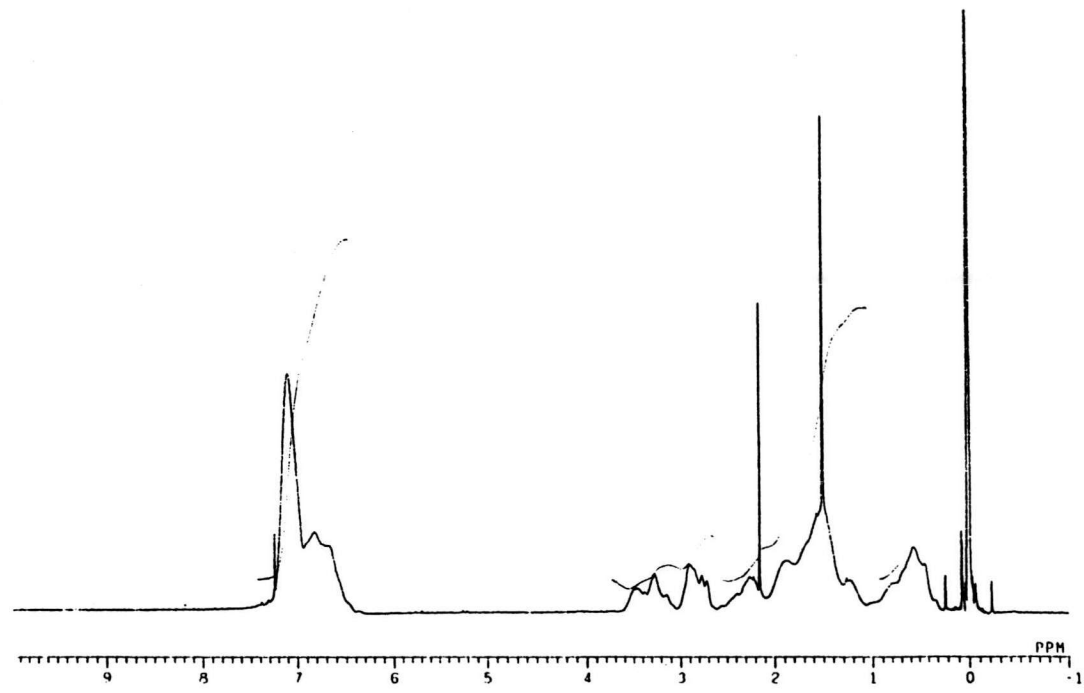



Figure B-b4 $H^1$NMR spectrum of the bulk copolymer (Styrene 62 mole% feed)

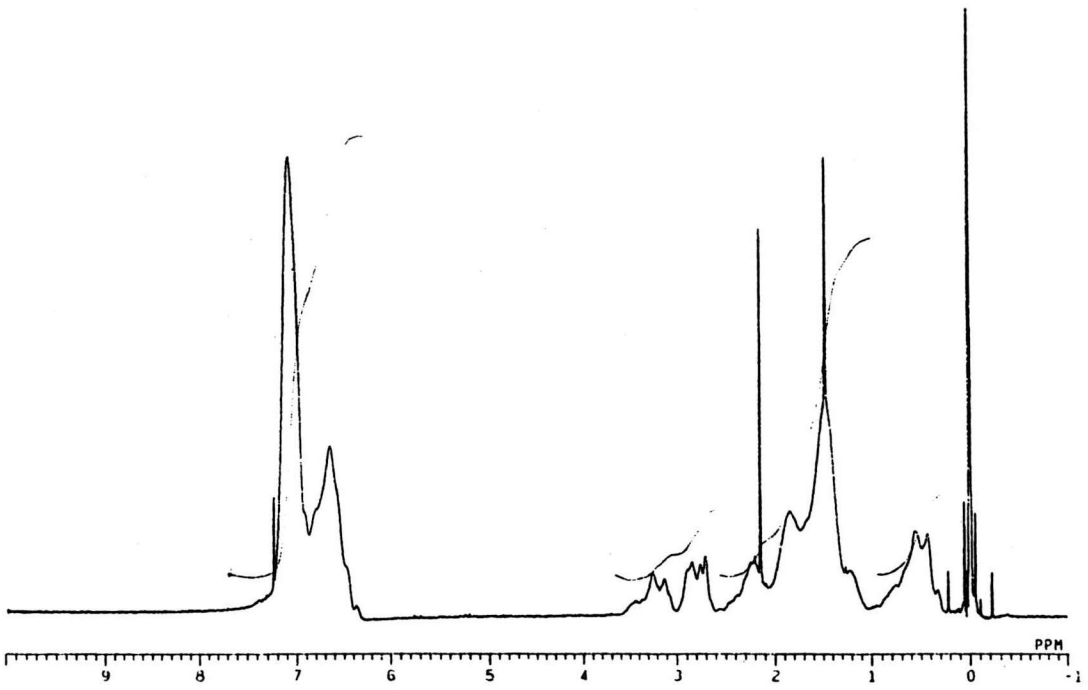



Figure B-b5 $H^1$NMR spectrum of the bulk copolymer (Styrene 75 mole% feed)

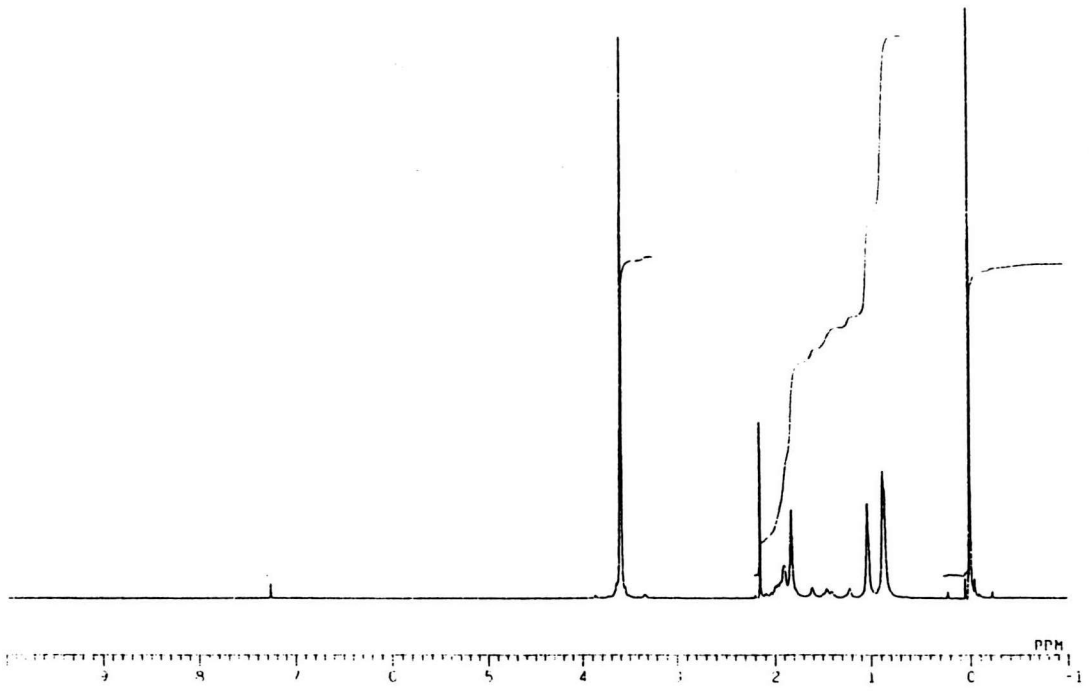



Figure B-c1 $H^1$NMR spectrum of the dispersion homopolymer (Styrene 0 mole% feed (PMMA))

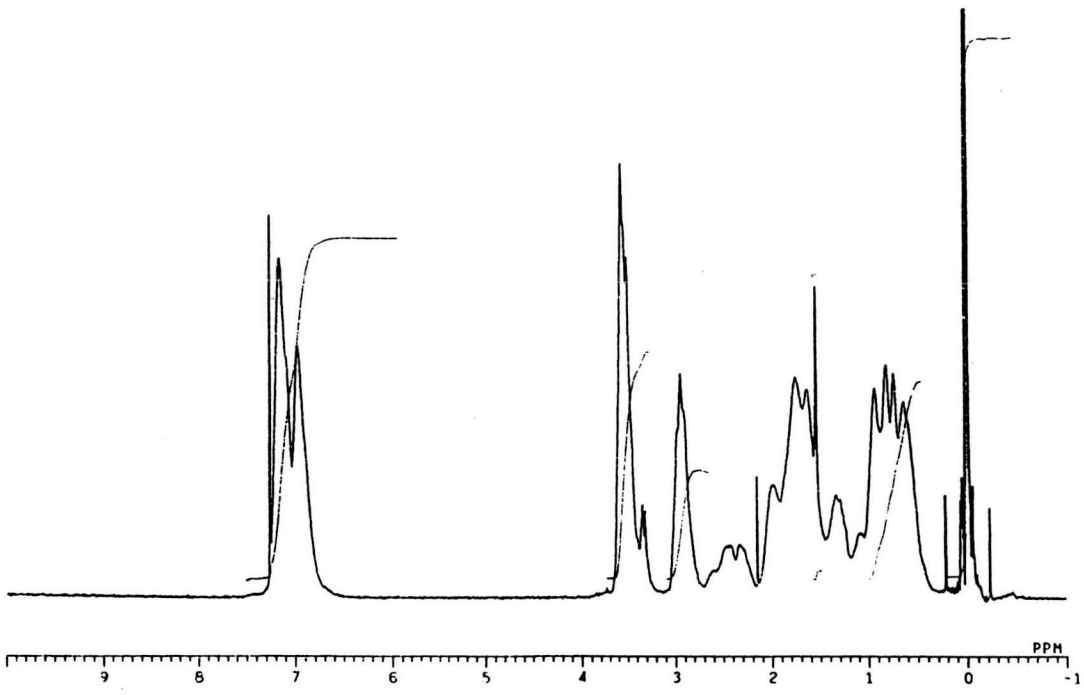



Figure B-c2 $H^1$NMR spectrum of the dispersion copolymer (Styrene 25 mole% feed)

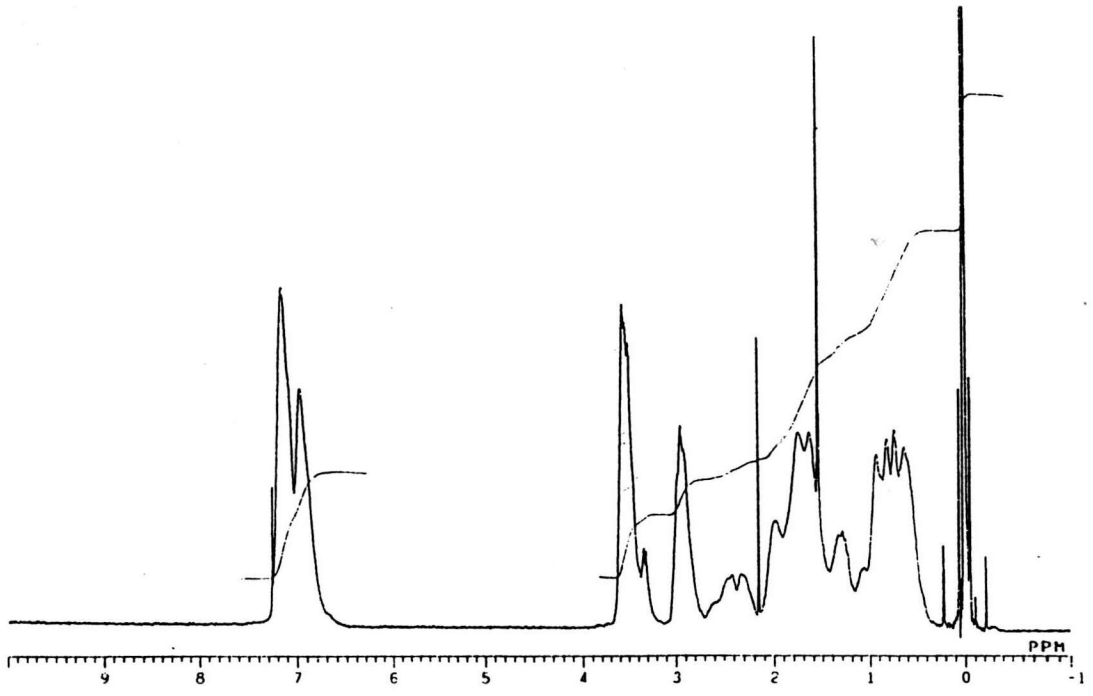



Figure B-c3 $H^1$NMR spectrum of the dispersion copolymer (Styrene 38 mole% feed)

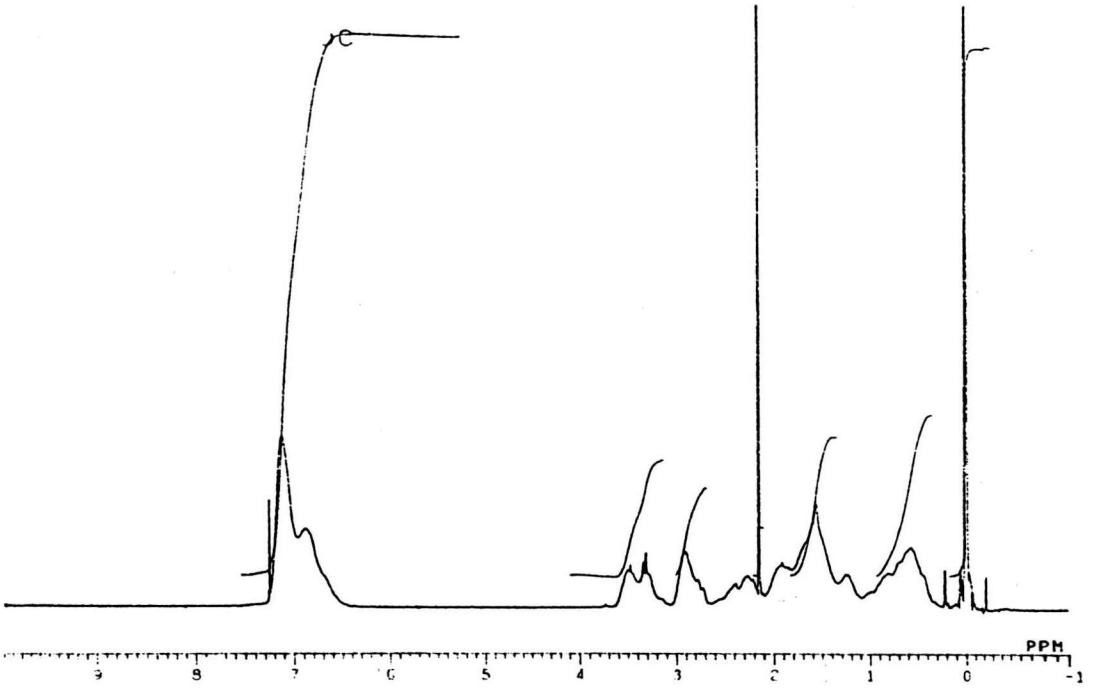



Figure B-c4 $H^1$NMR spectrum of the dispersion copolymer (Styrene 50 mole% feed)

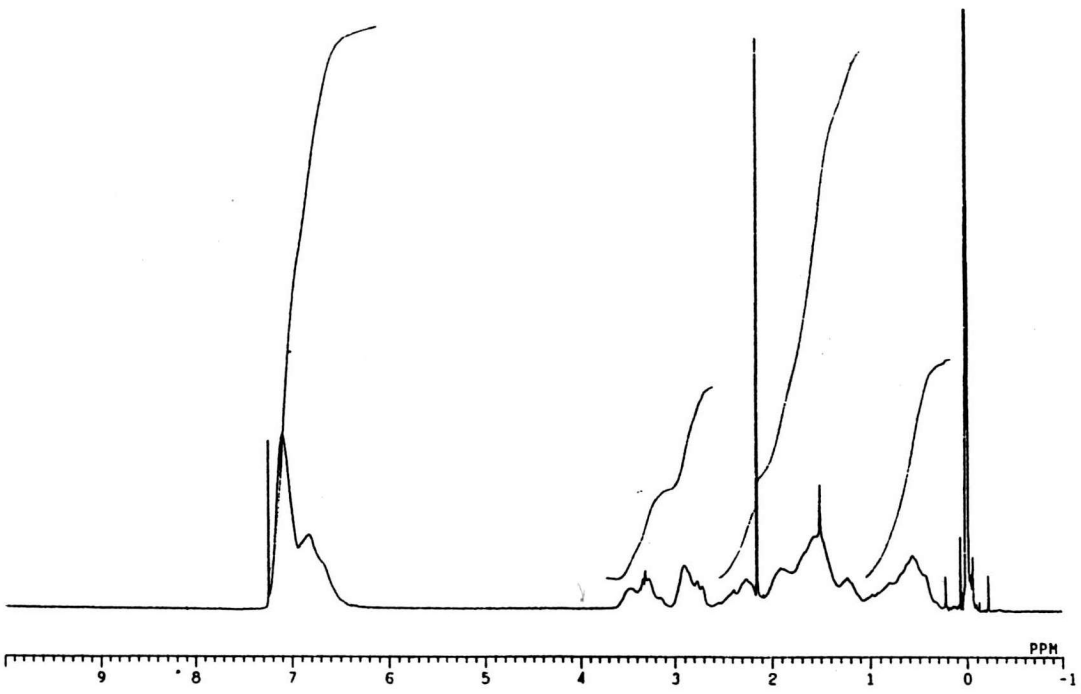



Figure B-c5 $H^1$NMR spectrum of the dispersion copolymer (Styrene 62 mole% feed)

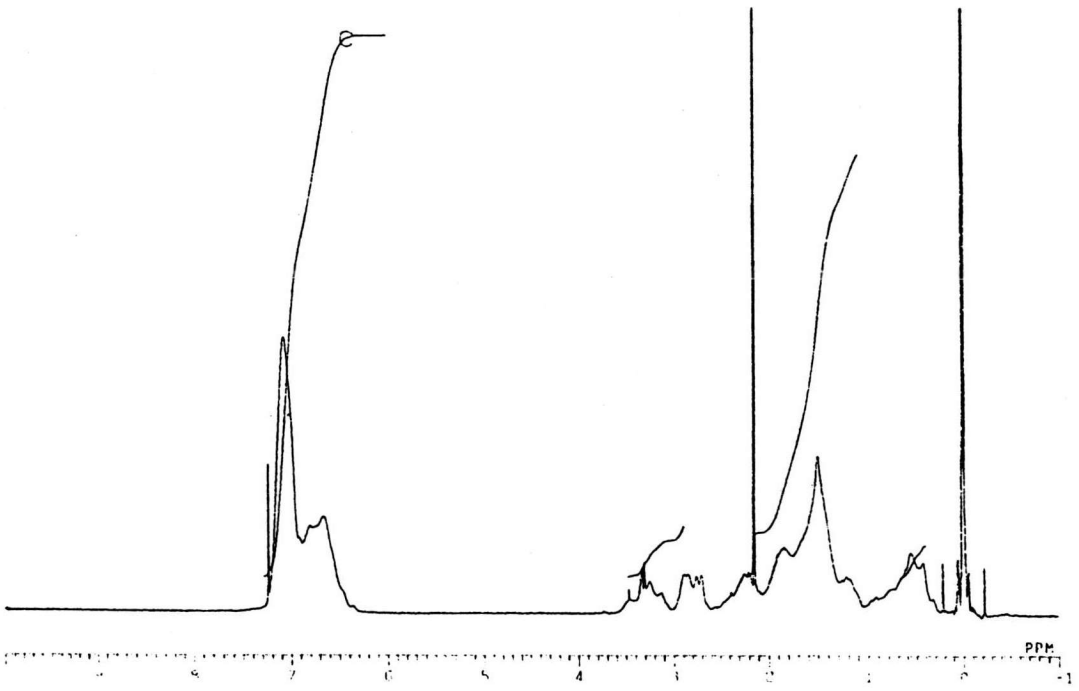



Figure B-c6 $H^1$NMR spectrum of the dispersion copolymer (Styrene 75 mole% feed)

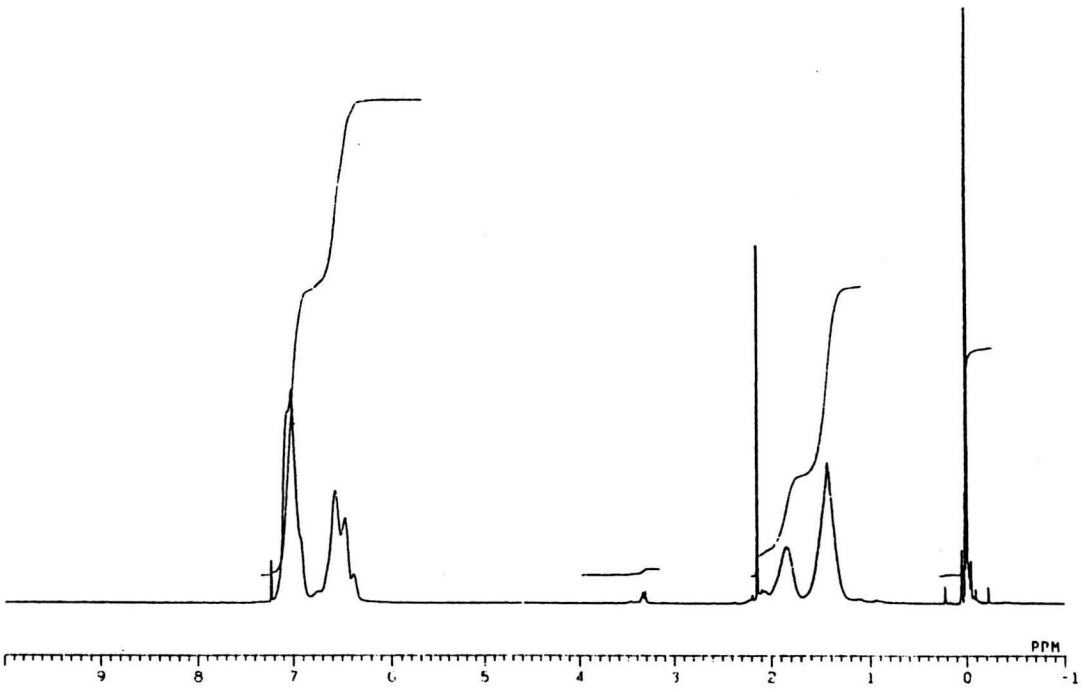



Figure B-c7 $H^1$NMR spectrum of the dispersion homopolymer (Styrene 100 mole% feed (PS))

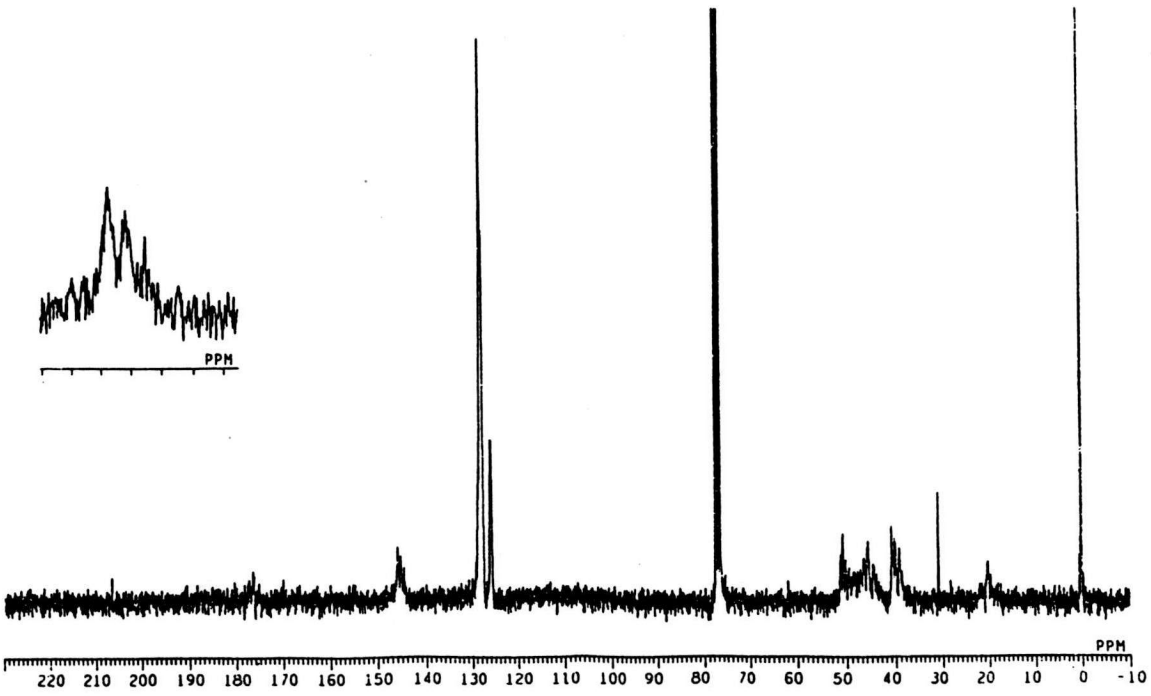



Figure B-2 $C^{13}$NMR spectrum of the dispersion copolymer (Styrene 75 mole% feed, ethanol 80 weight%)

## APPENDIX C

## Fourier-Transform Infrared Spectra

The FT-IR spectra of all copolymers were operated on the NICOLET 740 with the TGS detector. The product samples were prepared by using the method of KBr pellet; the standard samples, on the other hand, were prepared by using the solution method of chloroform ($CHCl_3$) as a solvent.

Table C-1 shows the assignments of the FT-IR spectrum. The FT-IR spectrum of PMMA product (Figure C-b1) shows the C=O stretch at 1728 $cm^{-1}$, and the PS product shows the C-H benzene ring stretch at 698 $cm^{-1}$ (Figure C-b7). Both of the C=O and C-H benzene ring stretchs were obtained in all the poly(styrene-co-methyl methacrylate) spectra. By considering these two stretching vibrations, a calibration curve was made by finding the relationship between the mole% styrene in the standard and the ratio of absorbance ($A_{698}/A_{1728}$) that was obtained from the FT-IR spectrum (Figures C-a1 to C-a5 and Table C-2). The calibration curve was shown in Figure C-1.

Figures C-b2 to C-b6 show the FT-IR spectra of the copolymer products. From these spectra, the ratios of the absorbance at 698 $cm^{-1}$ to the absorbance at 1728 $cm^{-1}$ ($A_{698}/A_{1728}$) of all the copolymers were calculated (Table C-3). The copolymer compositions were therefore, measured by using the above calibration curve (Table C-4).

Table C-1 Assigments of the FT-IR spectrum of poly(styrene-co-methyl methacrylate)

| Assignments | | Wave Number($cm^{-1}$) |
|---|---|---|
| MMA | C=O stretch | 1728 |
| | C-O stretch | 1250-1100 |
| | $COOCH_3$ stretch | 990, 755 |
| Sty | C-H benzene ring stretch | 3061, 3029 |
| | C-H aliphatic stretch | 2923, 2851 |
| | C=O benzene ring stretch | 1602, 1493 |
| | C-H benzene ring stretch | 760, 700 |

Table C-2 The ratios of the absorbance of the standard

| Sty wt% | 25.0 | 33.3 | 50.0 | 66.7 | 75.0 |
|---|---|---|---|---|---|
| Sty mole% | 24.3 | 32.5 | 49.0 | 65.8 | 74.3 |
| $A_{698}/A_{1728}$ | 0.36 | 0.48 | 0.76 | 1.11 | 1.45 |

Table C-3 The ratios of the absorbance of the products

| Sty% feed | 25 | 38 | 50 | 62 | 75 |
|---|---|---|---|---|---|
| $A_{698}/A_{1728}$ | 0.43 | 0.55 | 0.72 | 0.81 | 1.04 |

Table C-4 The copolymer composition of the products

| f ( mole% Sty) | 25 | 38 | 50 | 62 | 75 |
|---|---|---|---|---|---|
| F ( % Sty) | 29 | 37 | 47 | 52 | 63 |

f: monomer feed composition F: monomer composition in the copolymer

# FT-IR

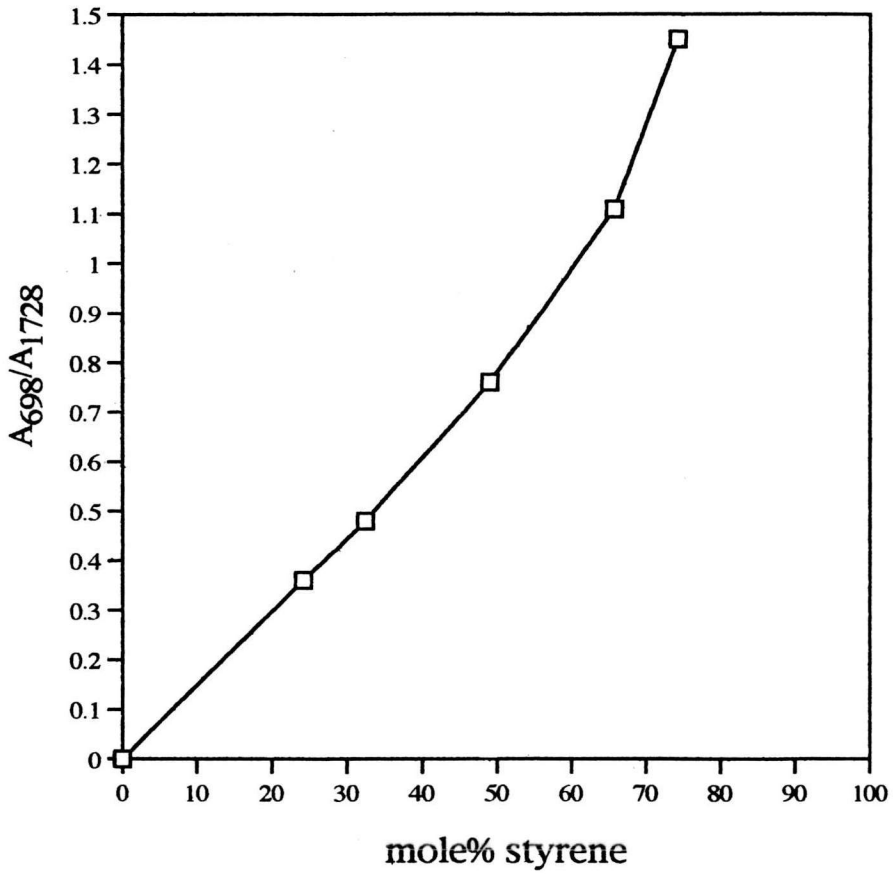



Figure C-1 FT-IR calibration curve

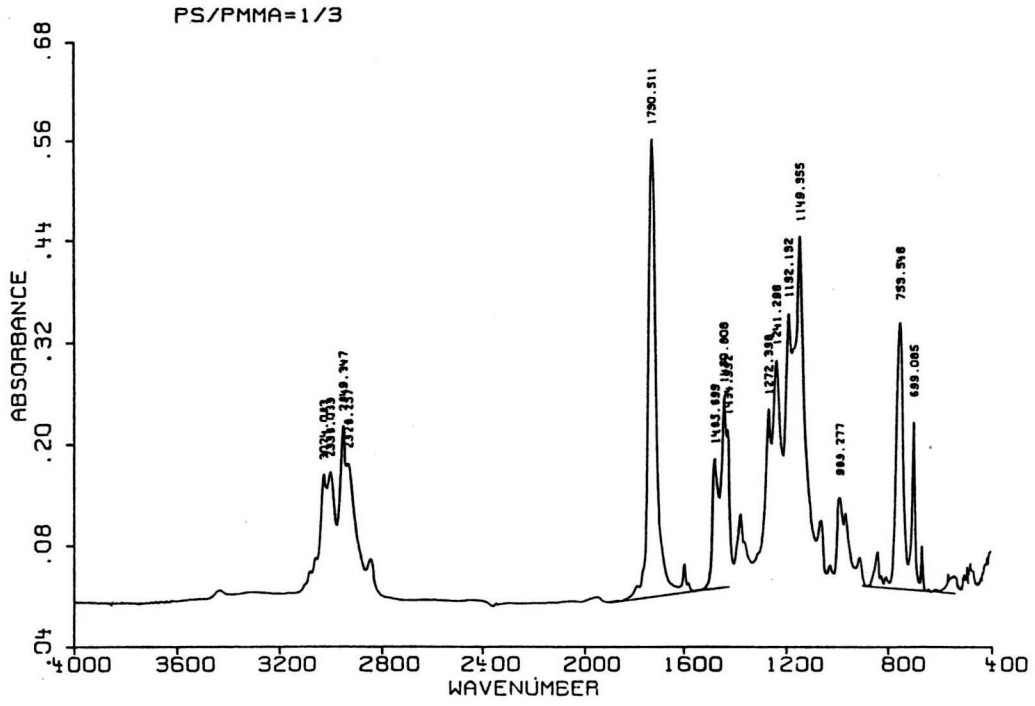



Figure C-a1 FT-IR spectrum of the standard copolymer at 25.0 weight% weight% styrene/methyl methacrylate

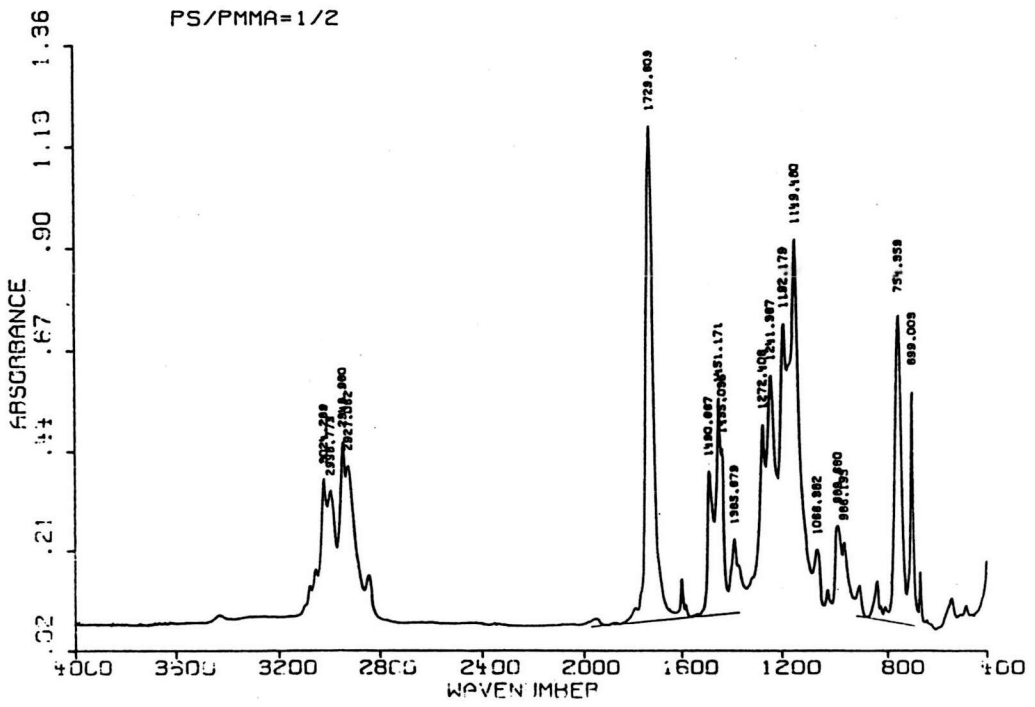



Figure C-a2 FT-IR spectrum of the standard copolymer at 33.3 weight% styrene/methyl methacrylate

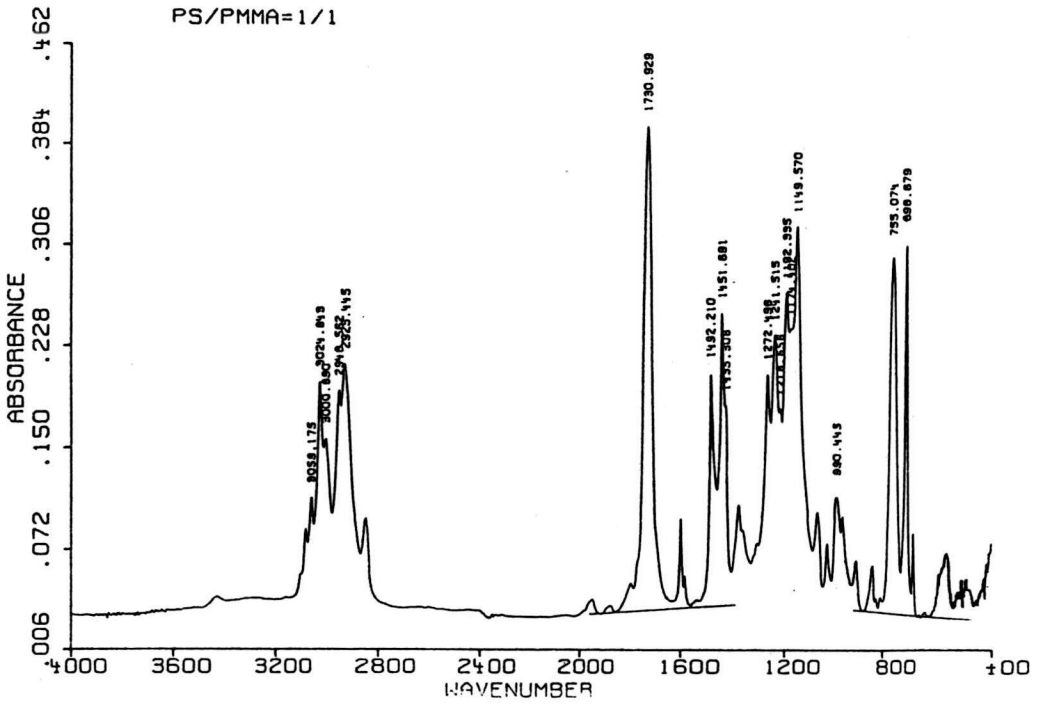



Figure C-a3 FT-IR spectrum of the standard copolymer at 50.0 weight% styrene/methyl methacrylate

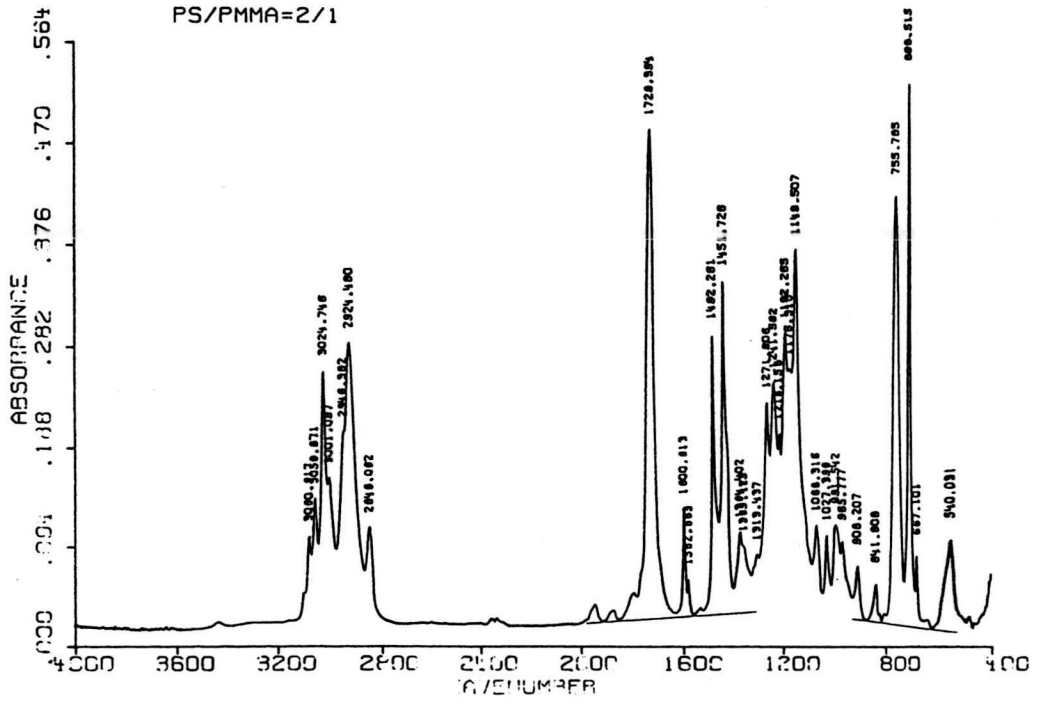



Figure C-a4 FT-IR spectrum of the standard copolymer at 66.7 weight% styrene/methyl methacrylate

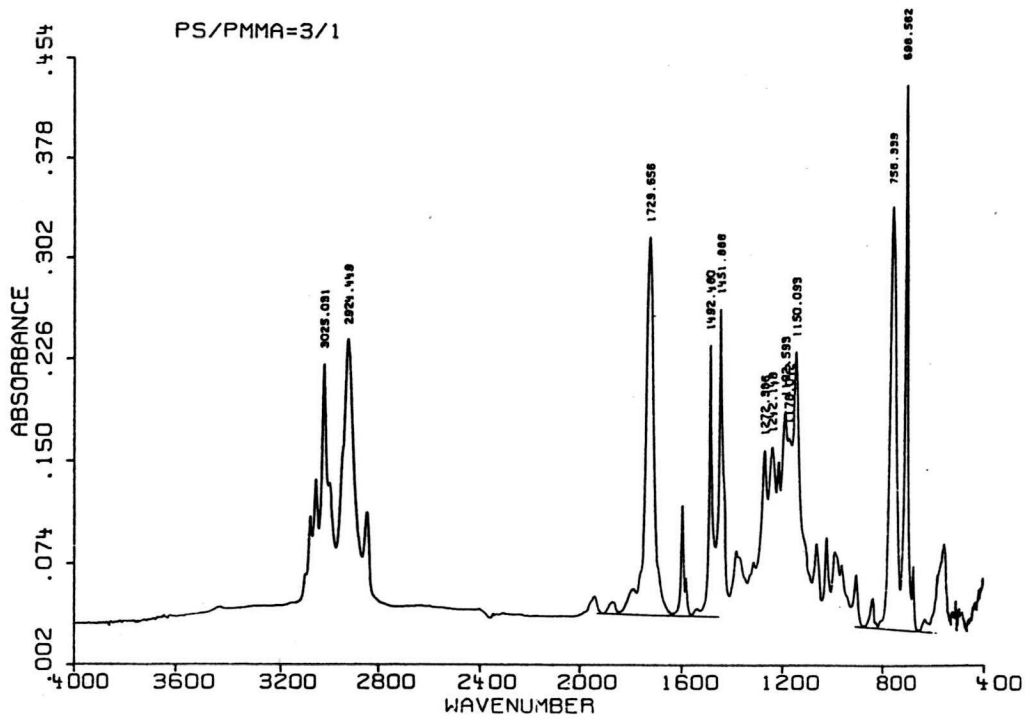



Figure C-a5 FT-IR spectrum of the standard copolymer at 75.0 weight% styrene/methyl methacrylate

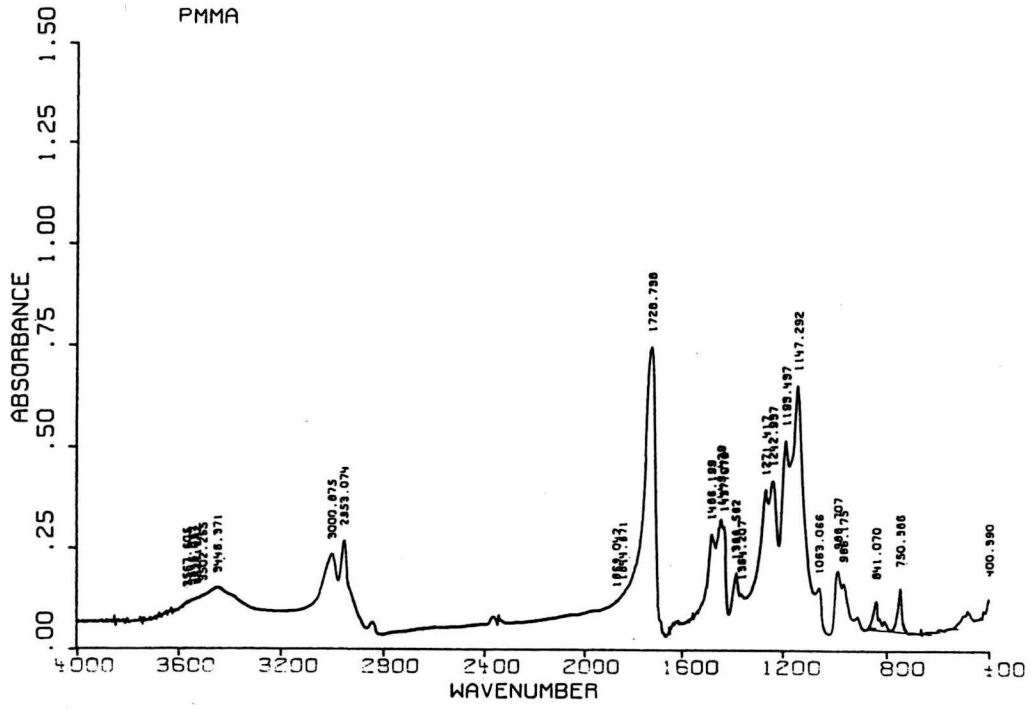



Figure C-b1 FT-IR spectrum of the product homopolymer at 0 mole% styrene or 100% methyl methacrylate feed (PMMA)

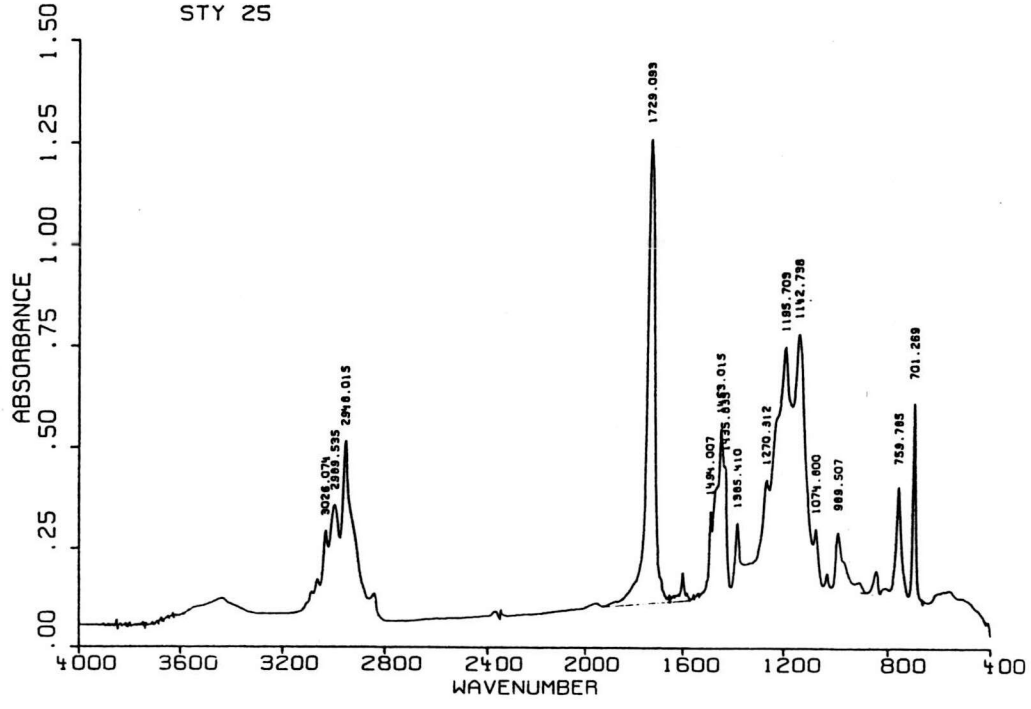



Figure C-b2 FT-IR spectrum of the product copolymer at 25.0 mole% styrene/methyl methacrylate feed

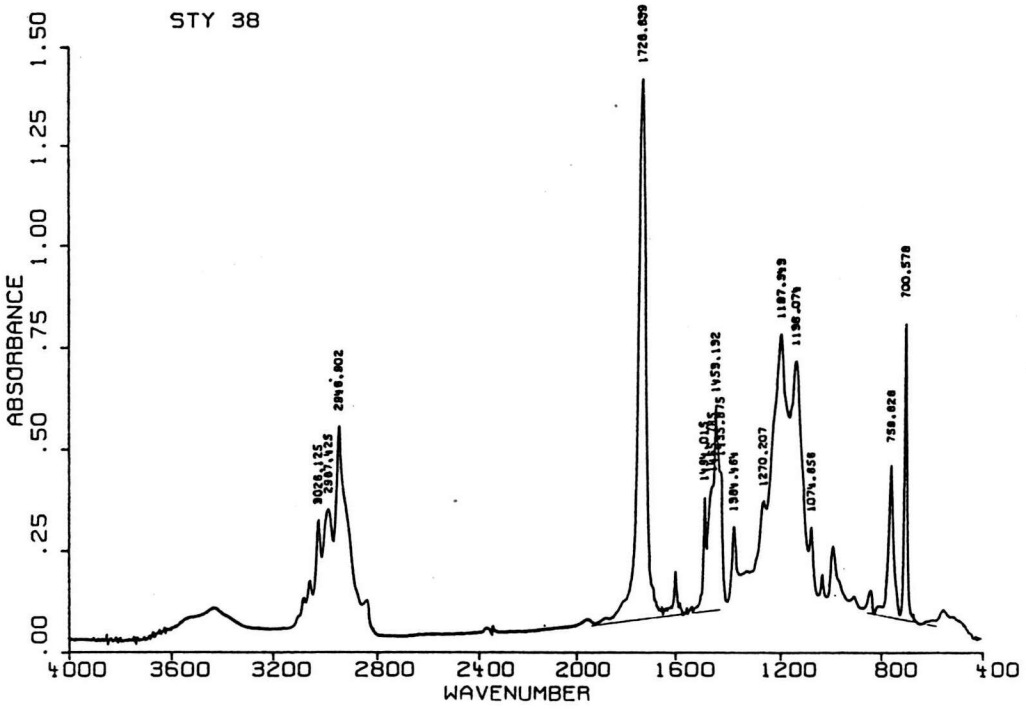



Figure C-b3 FT-IR spectrum of the product copolymer at 38.0 mole% styrene/methyl methacrylate feed

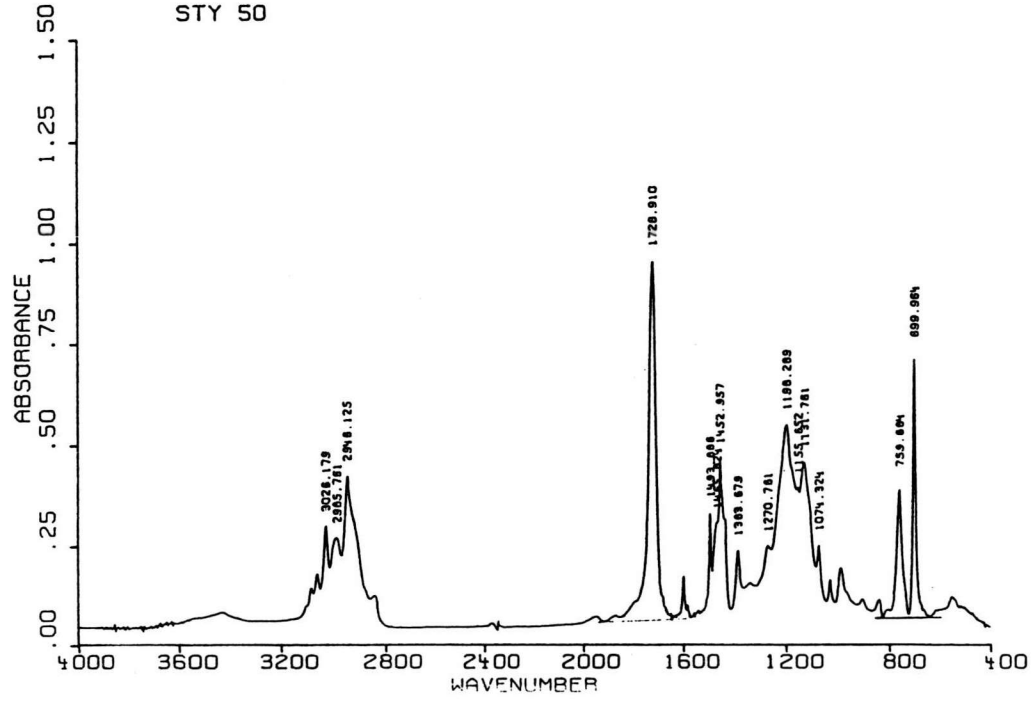



Figure C-b4 FT-IR spectrum of the product copolymer at 50.0 mole% styrene/methyl methacrylate feed

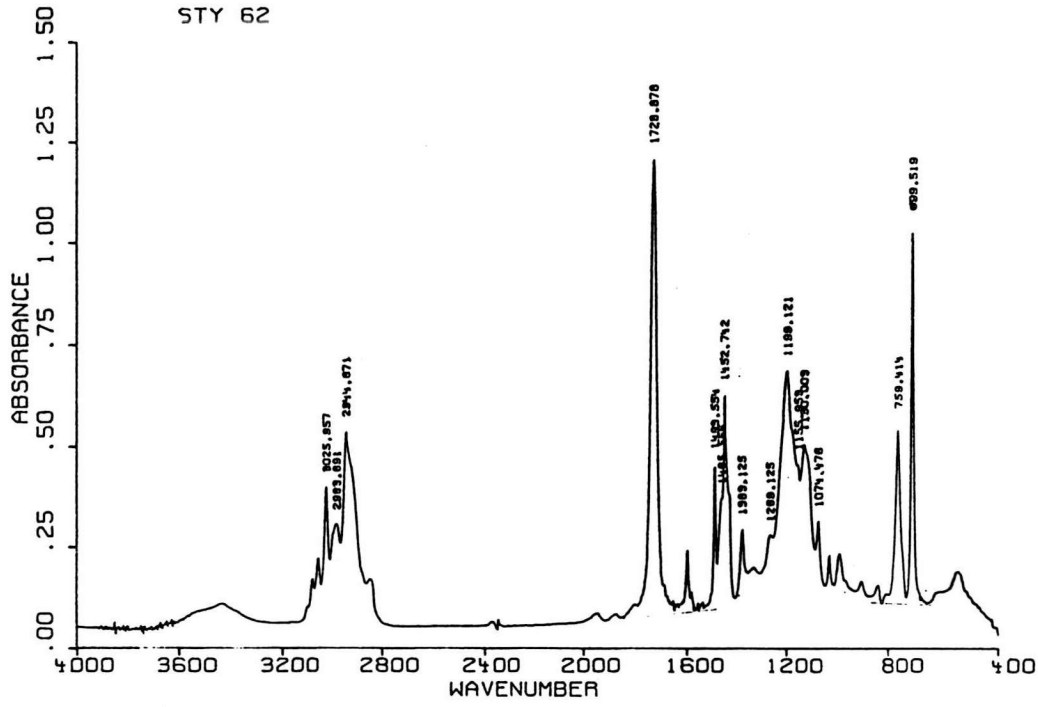



Figure C-b5 FT-IR spectrum of the product copolymer at 62.0 mole% styrene/methyl methacrylate feed

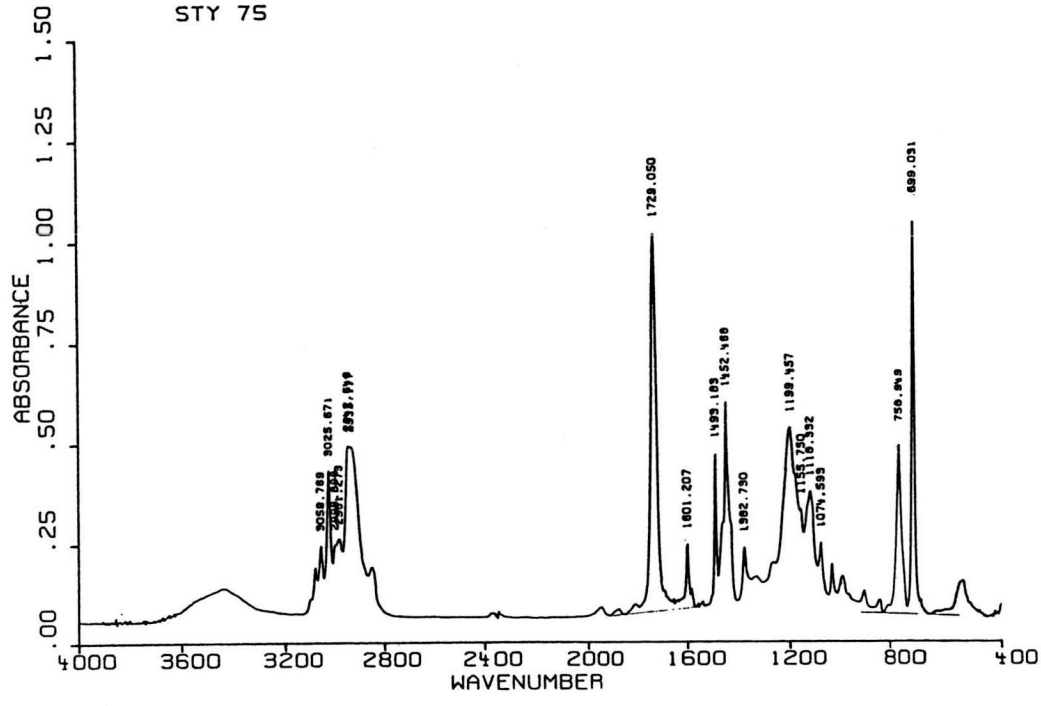



Figure C-b6 FT-IR spectrum of the product copolymer at 75.0 mole% styrene/methyl methacrylate feed

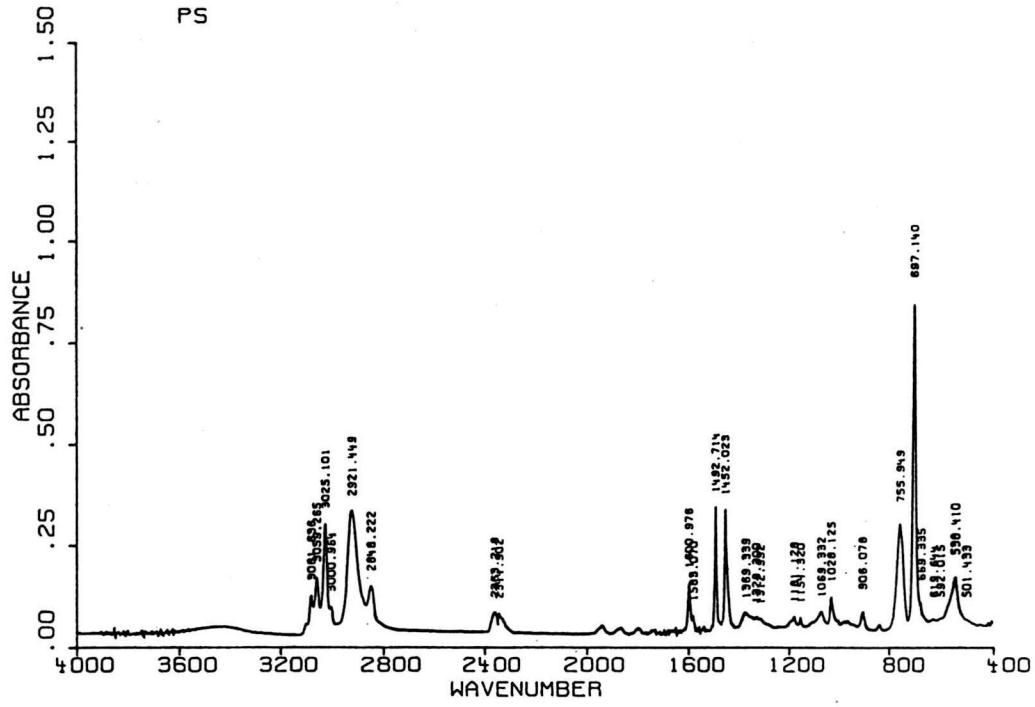



Figure C-b7 FT-IR spectrum of the product homopolymer at 100 mole% styrene or 0% methyl methacrylate feed (PS)

# APPENDIX D

## SEM Micrographs and Particle Size Distributions

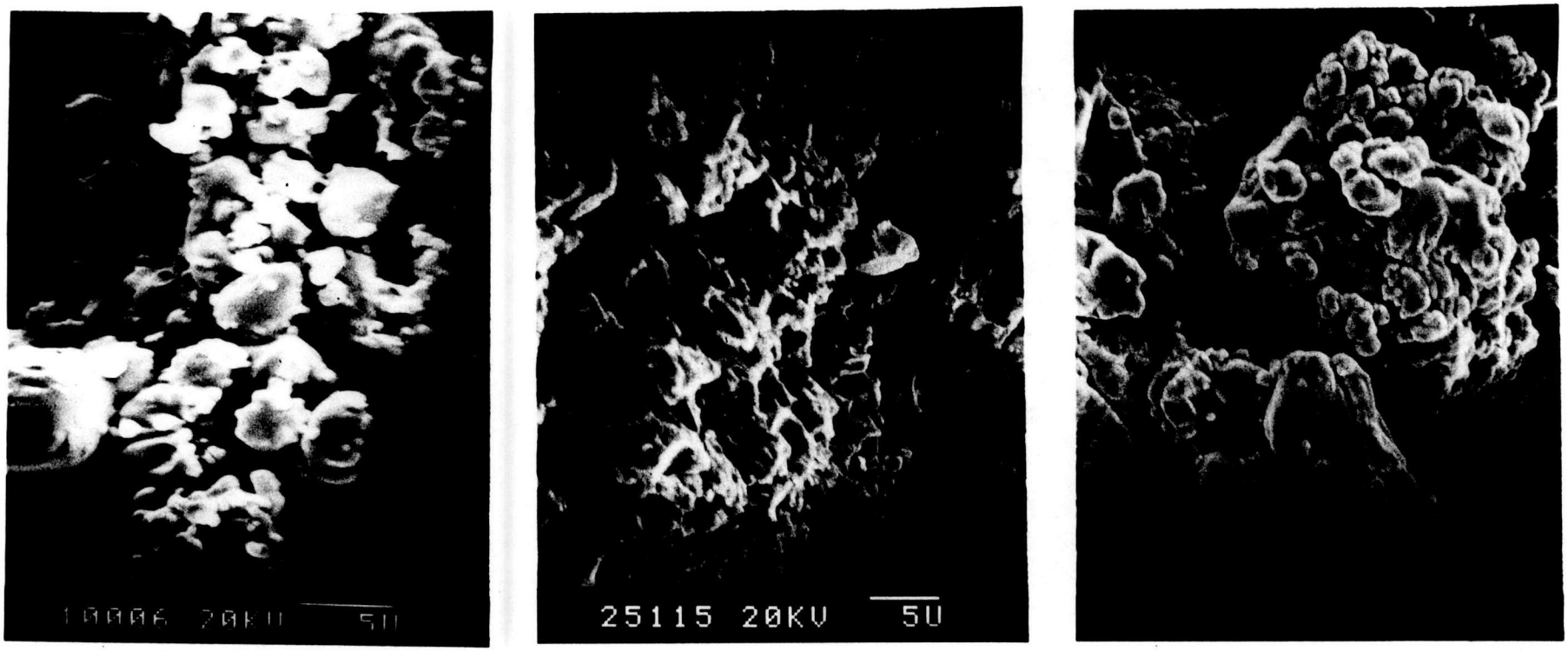
The SEM micrographs of all copolymer were operated on a HITACHI model S430 at various magnification powers : 800, 1.2k, 2.5k and 5k. The particle size was measured by the direct size measurement of particle on the micrograph in comparison with the scale showed that was set by the microscopic magnification. On a particle size distribution, the frequency of each particle size range was counted and the standard deviation for each sample was also calculated from the respective frequency.

Figures D-1 to D-4 show the scanning electron micrographs of the copolymer by solution and dispersion copolymerizations.

Figure D-a1 to D-a7 show the particle size distribution of the dispersion copolymer at various styrene feeds.

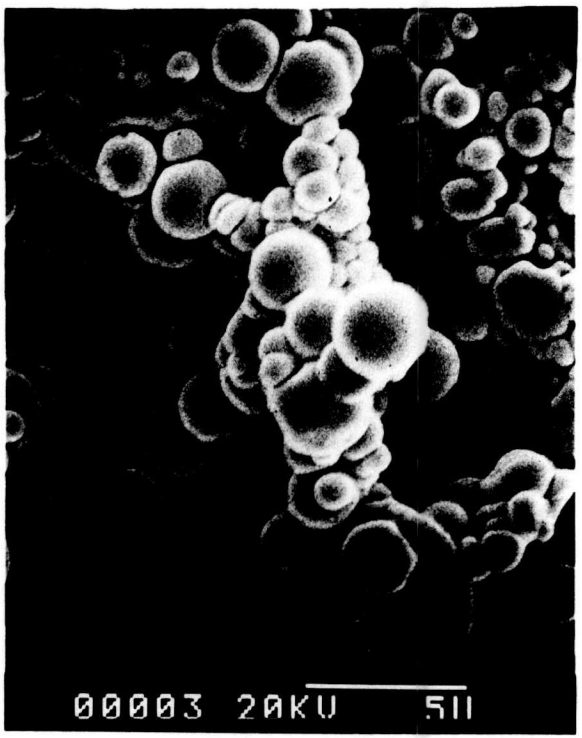
Figure D-b1 to D-b7 show the particle size distribution of the dispersion copolymer at various percents of ethanol in the mixed solvent.

Figure D-c1 to D-c3 show the particle size distribution of the dispersion copolymer at various temperatures.




St 25% feed St 38% feed St 62% feed

Figure D-1 Scanning electron micrographs of the copolymers by solution copolymerization in the mixed solvent content of 80:20 weight% ethanol/n-hexane



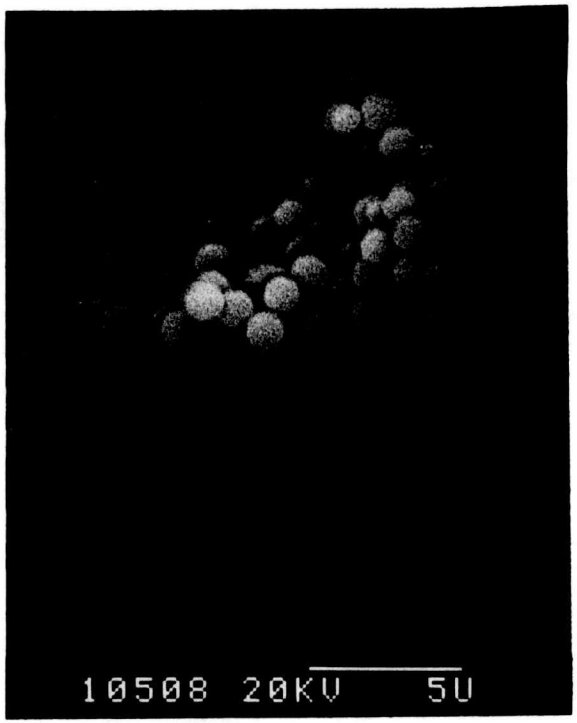
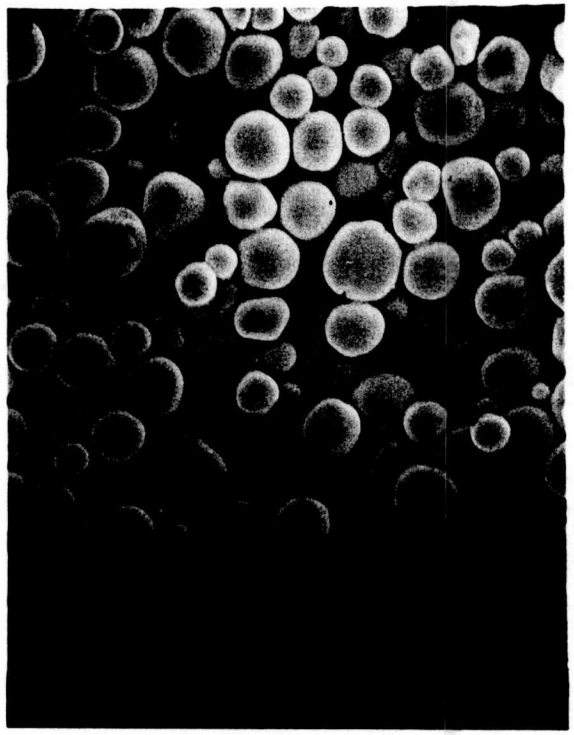
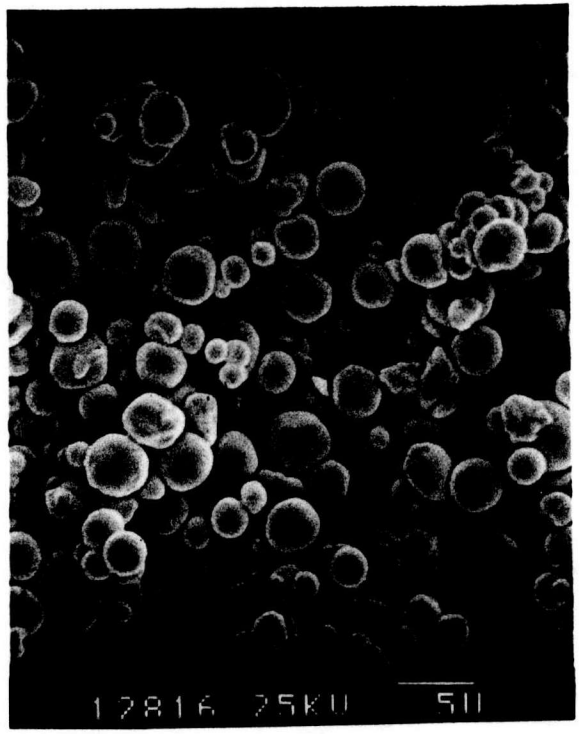




Figure D-2 Scanning electron micrographs of the PMMA (left) and PS (right) by dispersion polymerization in the mixed solvent content of 80:20 weight% ethanol/n-hexane

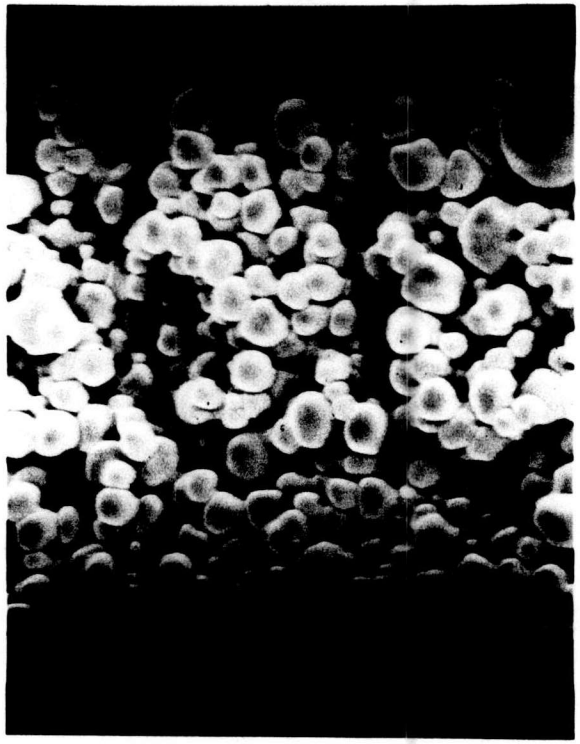


St 38% feed

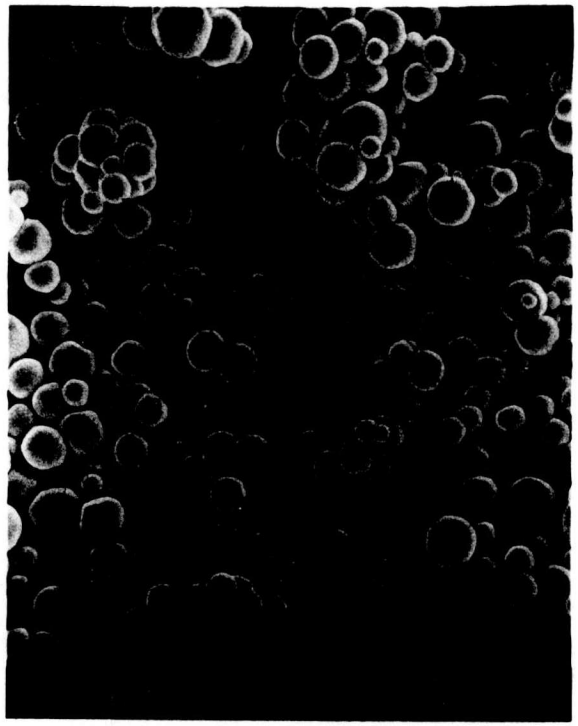



St 62% feed

Figure D-3 Scanning electron micrographs of the copolymers by dispersion copolymerization in the mixed solvent content of 80:20 weight% ethanol/n-hexane



EtOH 80% feed



EtOH 100% feed

Figure D-4 Scanning electron micrographs of the copolymers by dispersion copolymerization in the feed content of 25:75 mole% St/MMA in the homogeneous system

St 0% feed (PMMA)

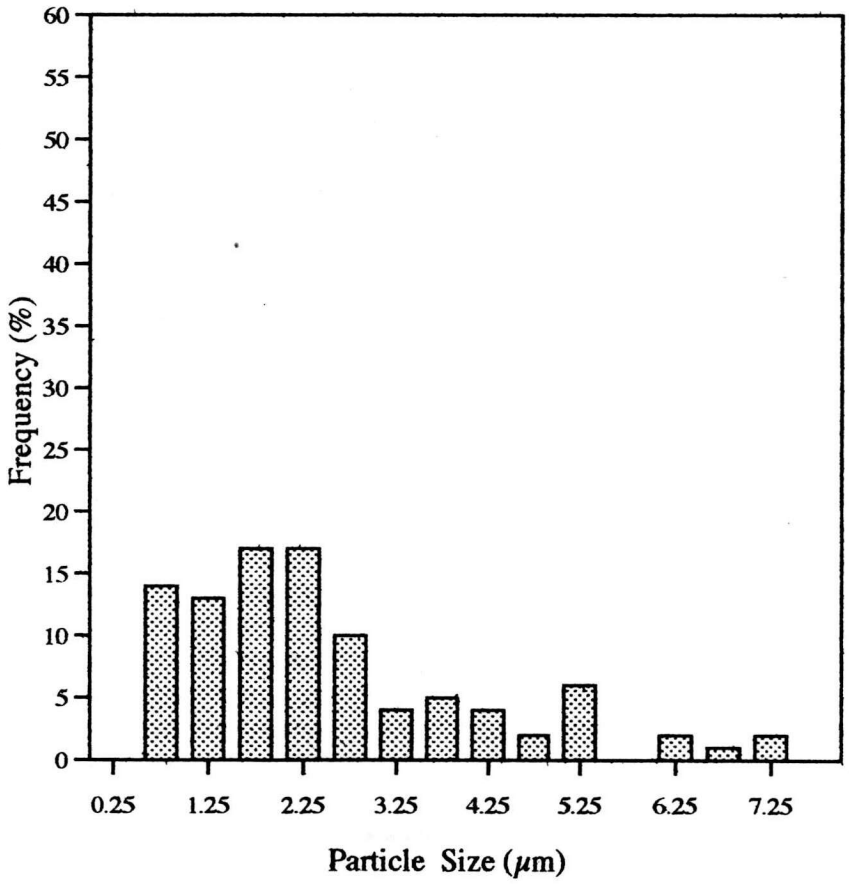



Figure D-a1 Particle size distribution of the dispersion copolymer (MMA 100% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 25 % feed

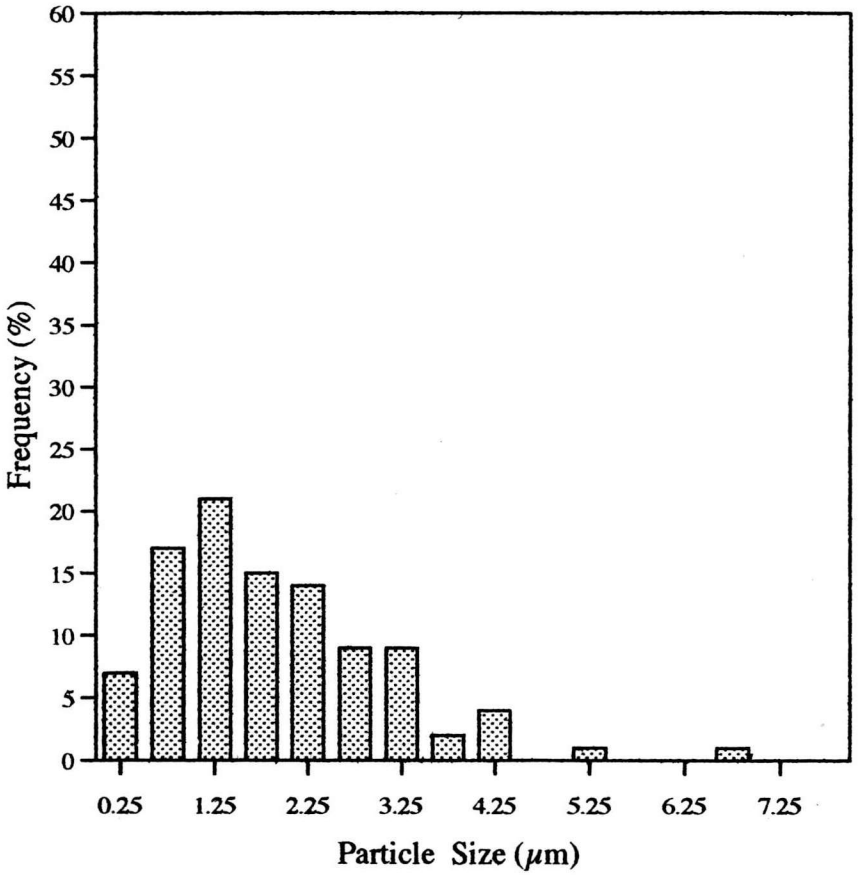



Figure D-a2 Particle size distribution of the dispersion copolymer (St 25% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 38 % feed

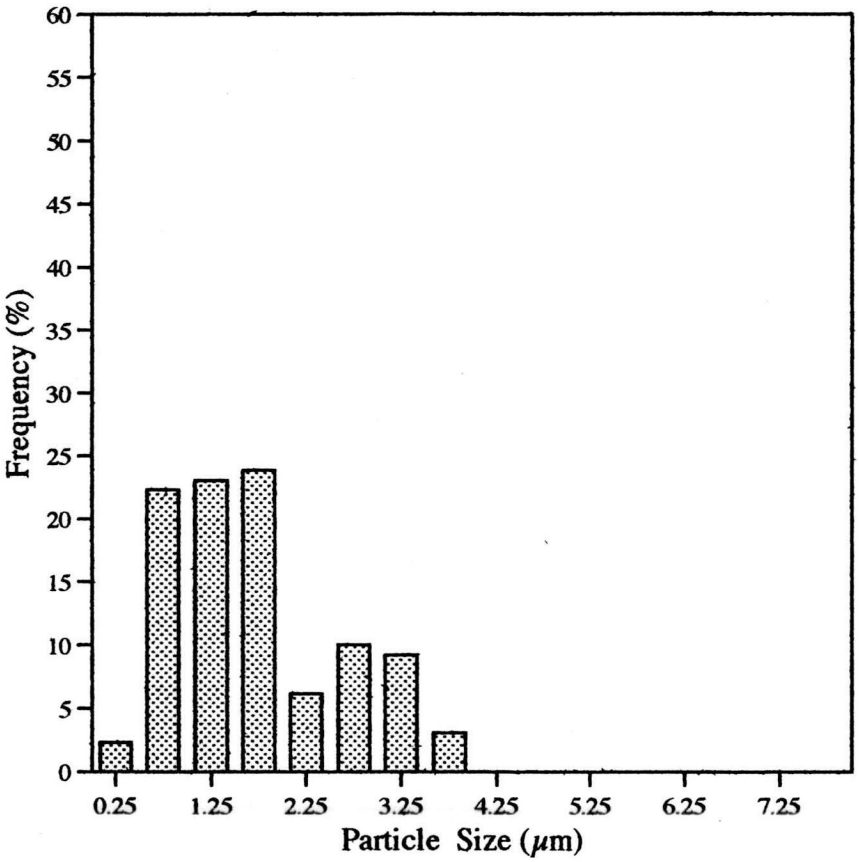



Figure D-a3 Particle size distribution of the dispersion copolymer(St 38% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 50 % feed

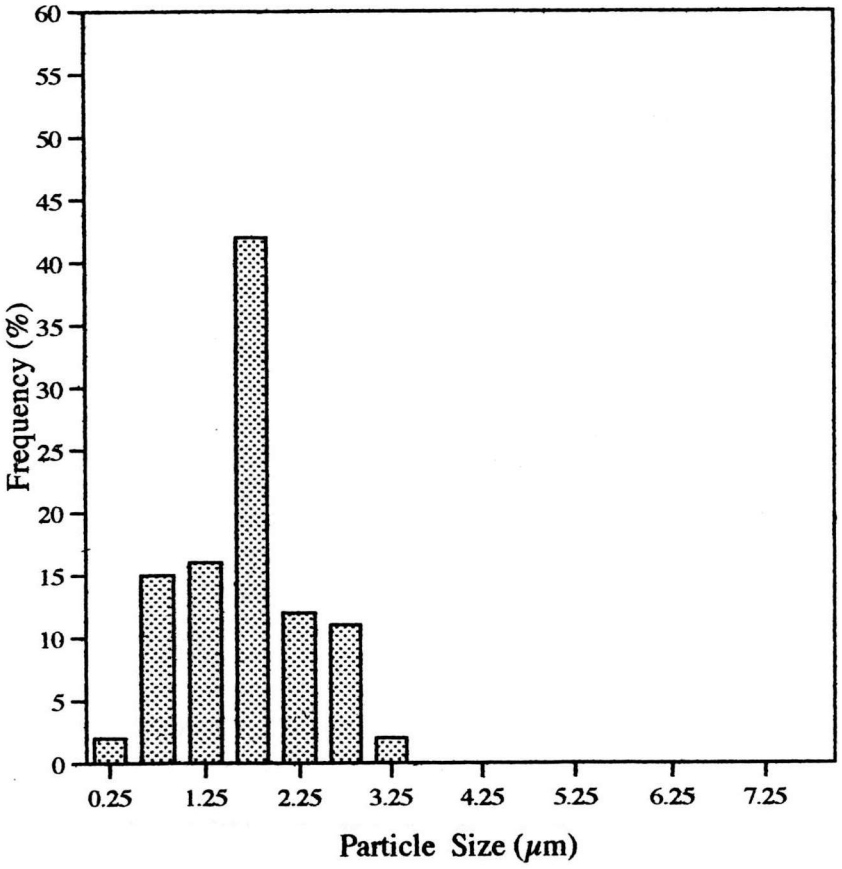



Figure D-a4 Particle size distribution of the dispersion copolymer(St 50% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 62 % feed

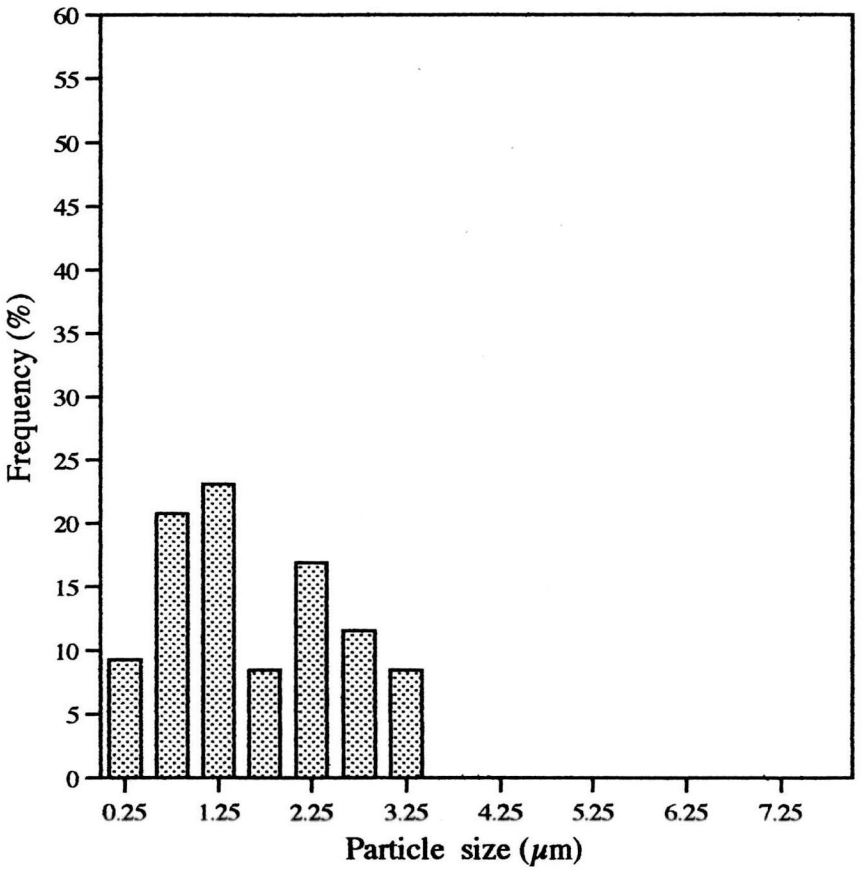



Figure D-a5 Particle size distribution of the dispersion copolymer(St 62% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 75 % feed

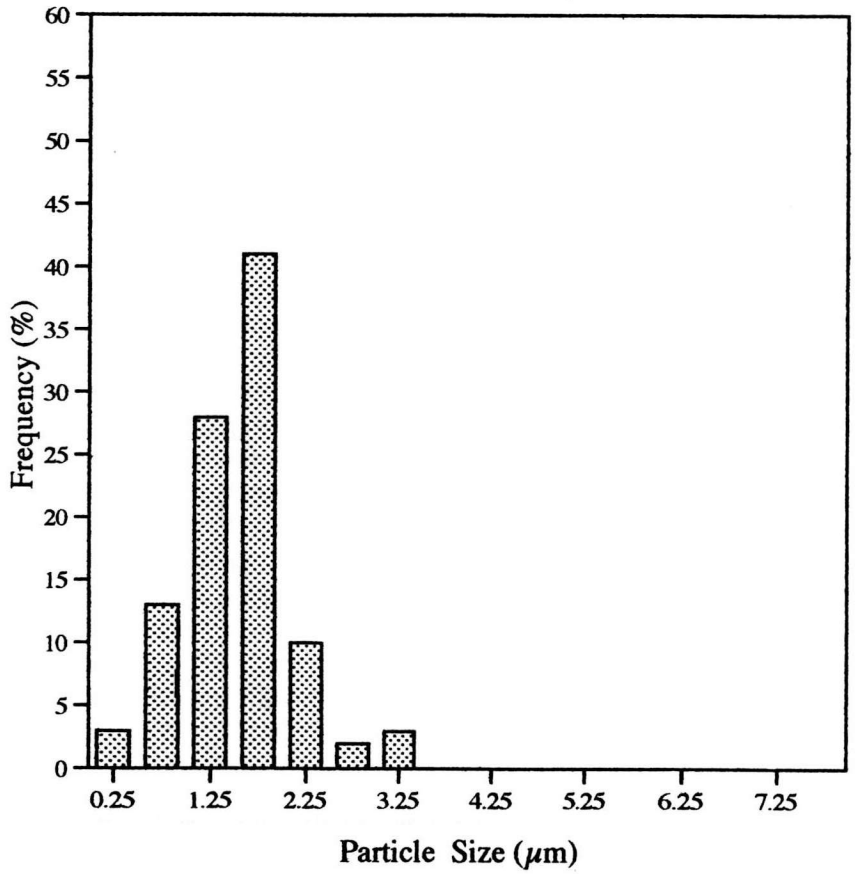
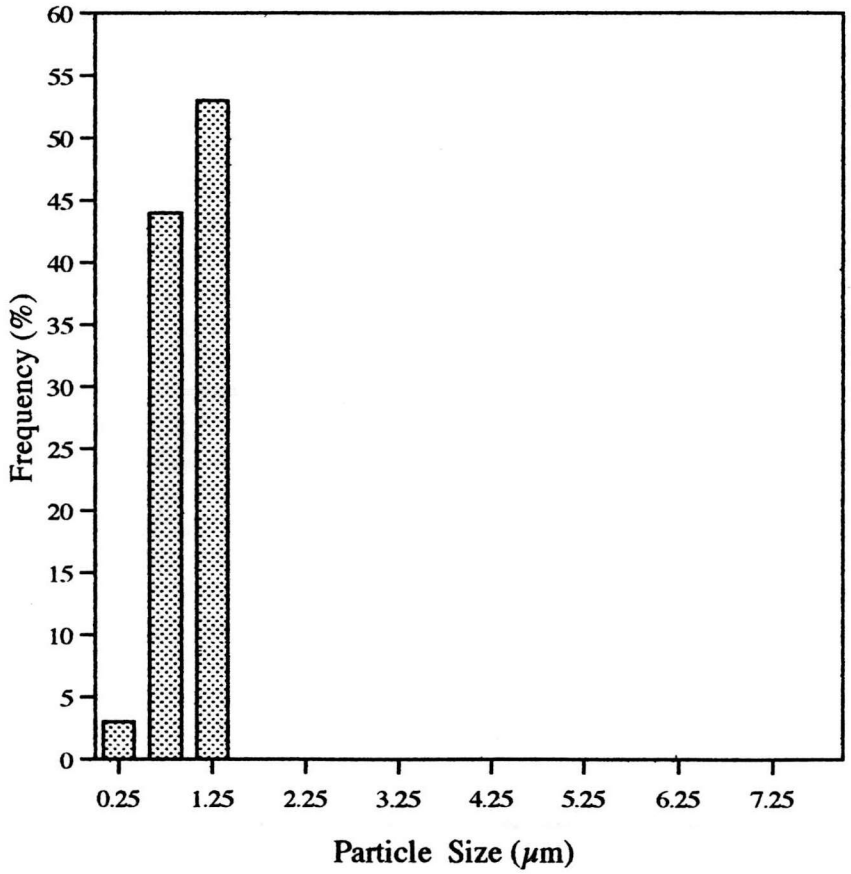



Figure D-a6 Particle size distribution of the dispersion copolymer (St 75% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

St 100% feed (PS)




FigureD-a7 Particle size distribution of the dispersion copolymer(St 100% feed) in the mixed solvent of 80:20 weight% ethanol/n-hexane

EtOH 0 %

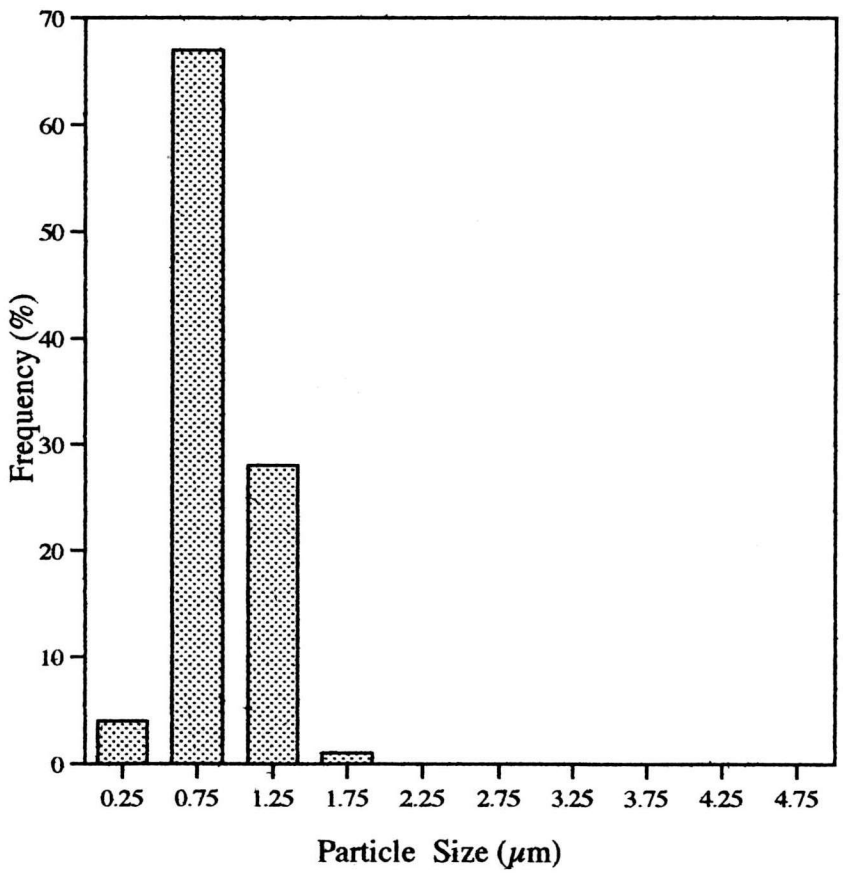



Figure D-b1 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% St/MMA in homogeneous system (100 weight% n-hexane)

EtOH 20 %

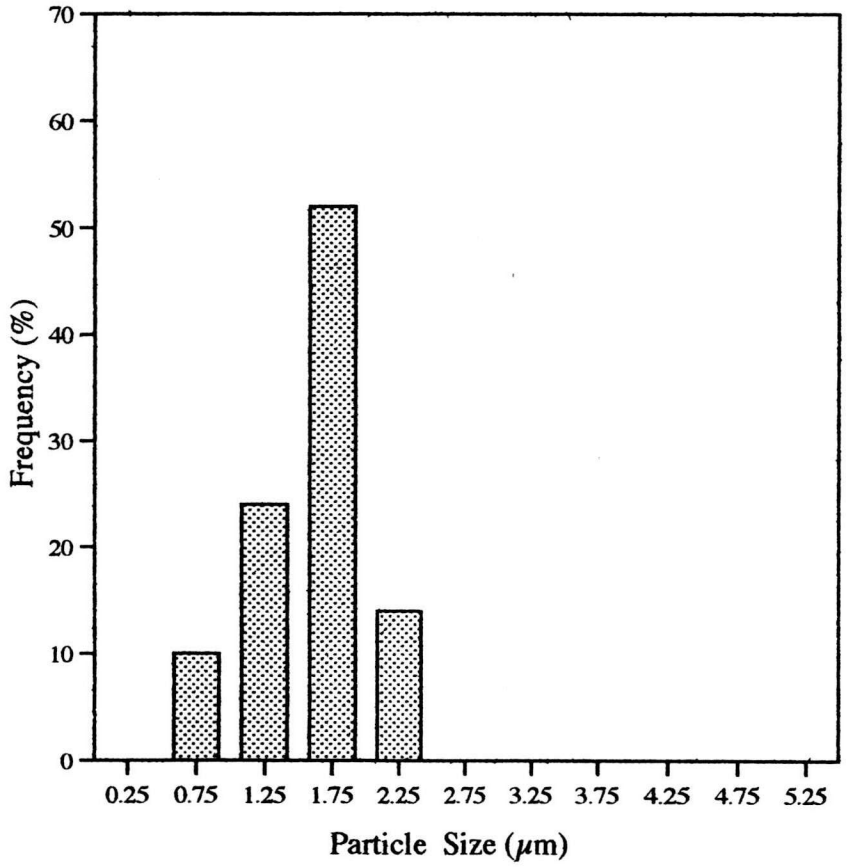



Figure D-b2 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% St/MMA in homogeneous system (EtoH 20 weight%)

EtOH 35 %

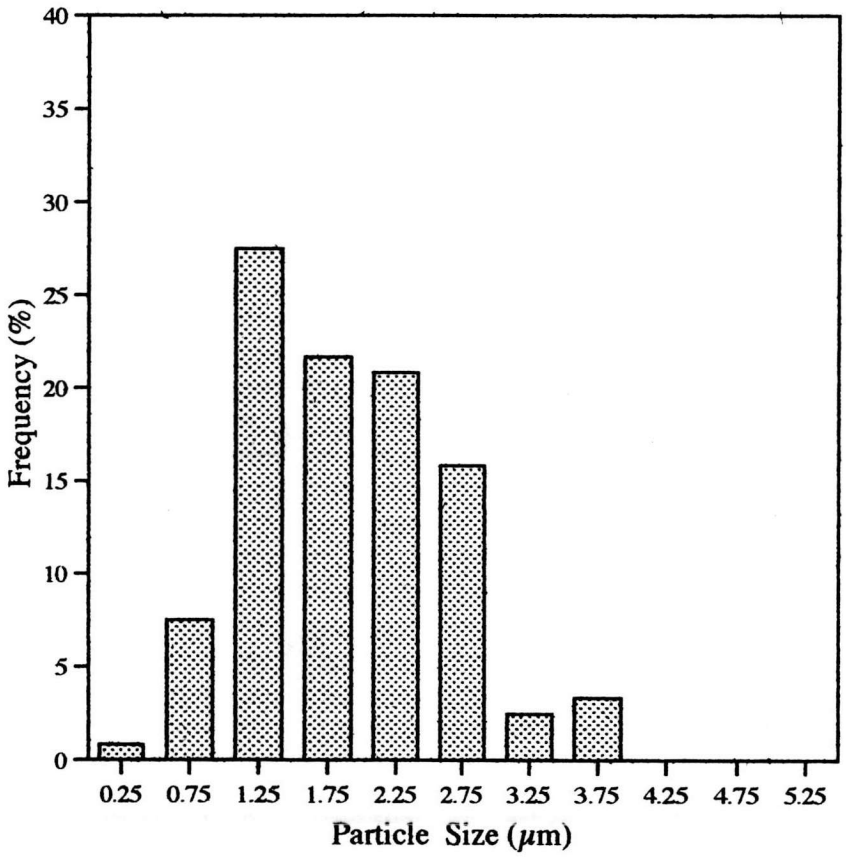



Figure D-b3 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole % St/MMA in homogeneous system (EtOH 35 weight%)

EtOH 50 %

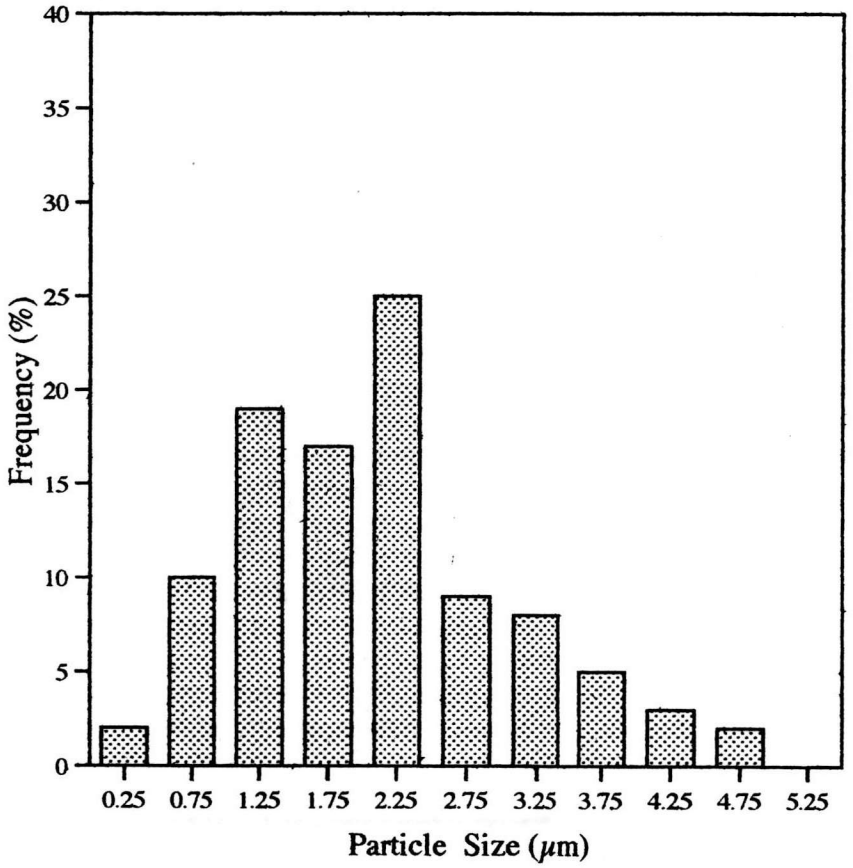



Figure D-b4 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% St/MMA in heterogeneous system (EtOH 50 weight%)

EtOH 65 %

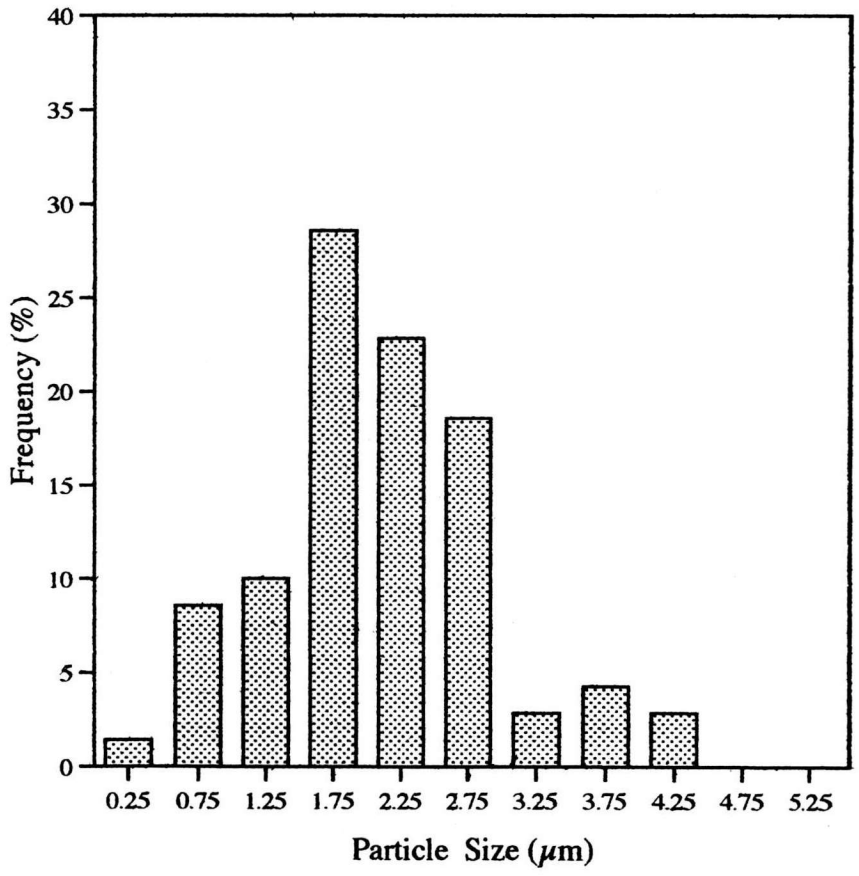



Figure D-b5 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% St/MMA in heterogeneous system (EtOH 65 weight%)

EtOH 80 %

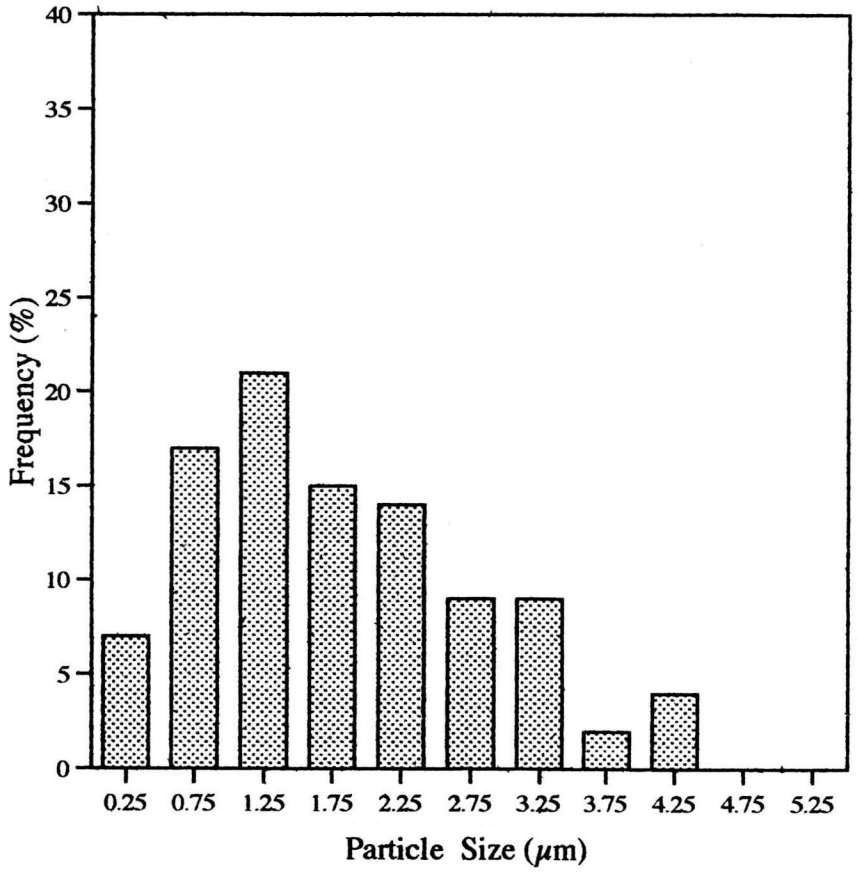



Figure D-b6 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% mole% St/MMA in homogeneous system (EtOH 80 weight%)

EtOH 100 %

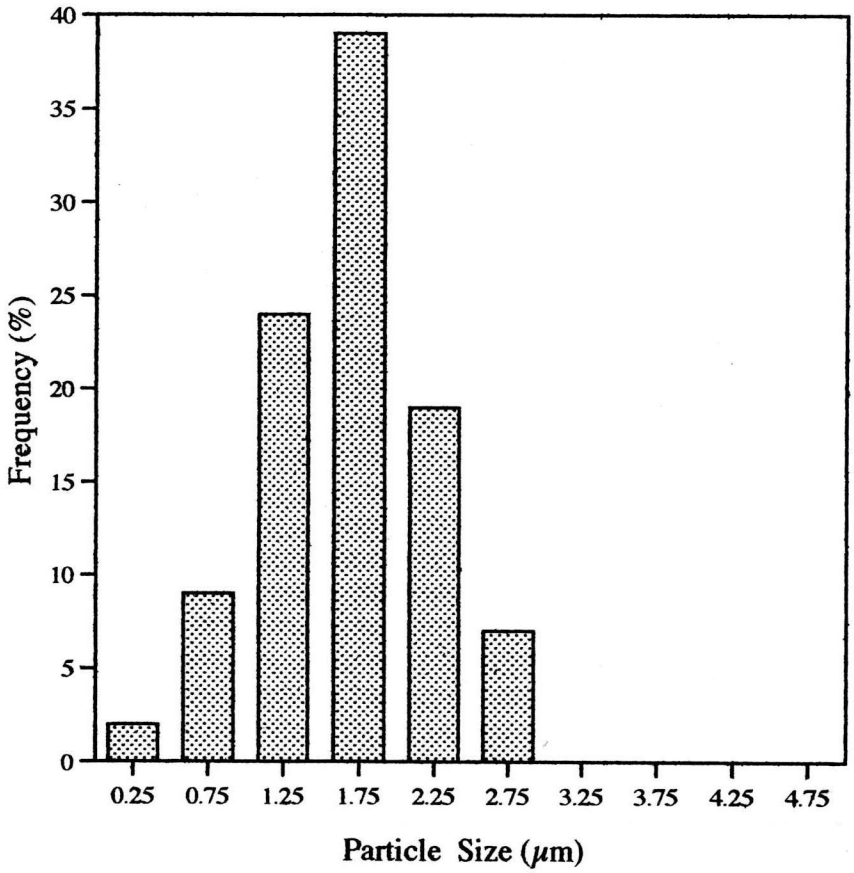



Figure B-b7 Particle size distribution of the dispersion copolymer in the feed content of 25:75 mole% St/MMA in homogeneous system (EtOH 100 weight%)

Temperature 50°C

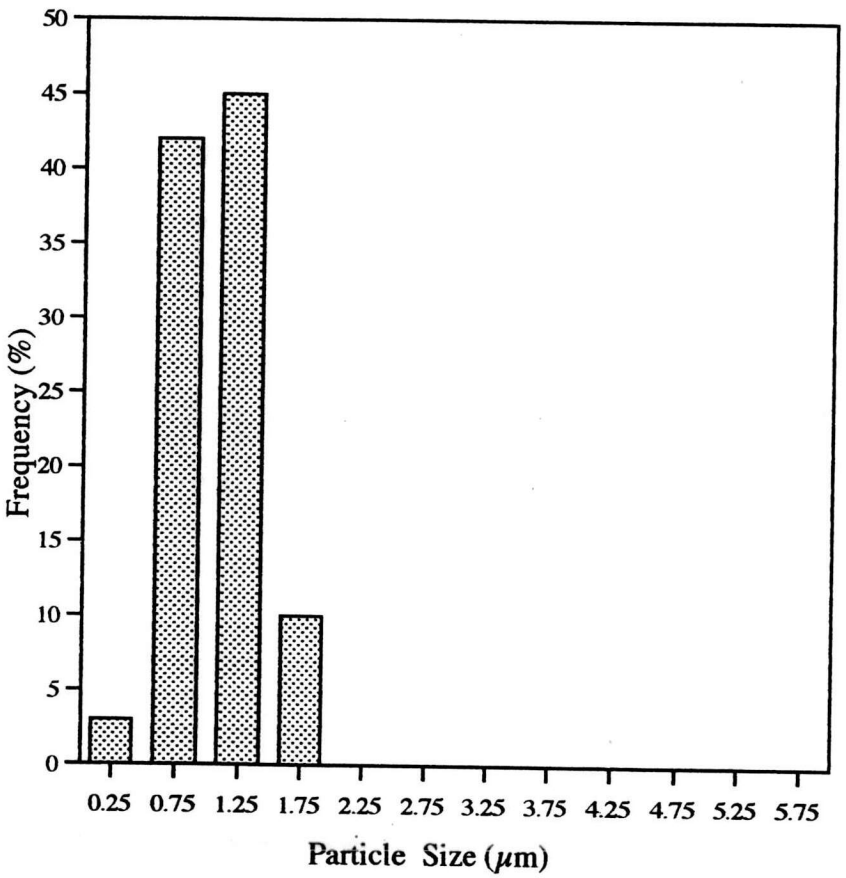



Figure D-c1 Particle size distribution of the dispersion copolymer in the feed of 75:25 mole% St/MMA and mixed solvent content of 80:20 weight% ethanol/n-hexane at 50° C of the reaction temperature

Temperature 55°C

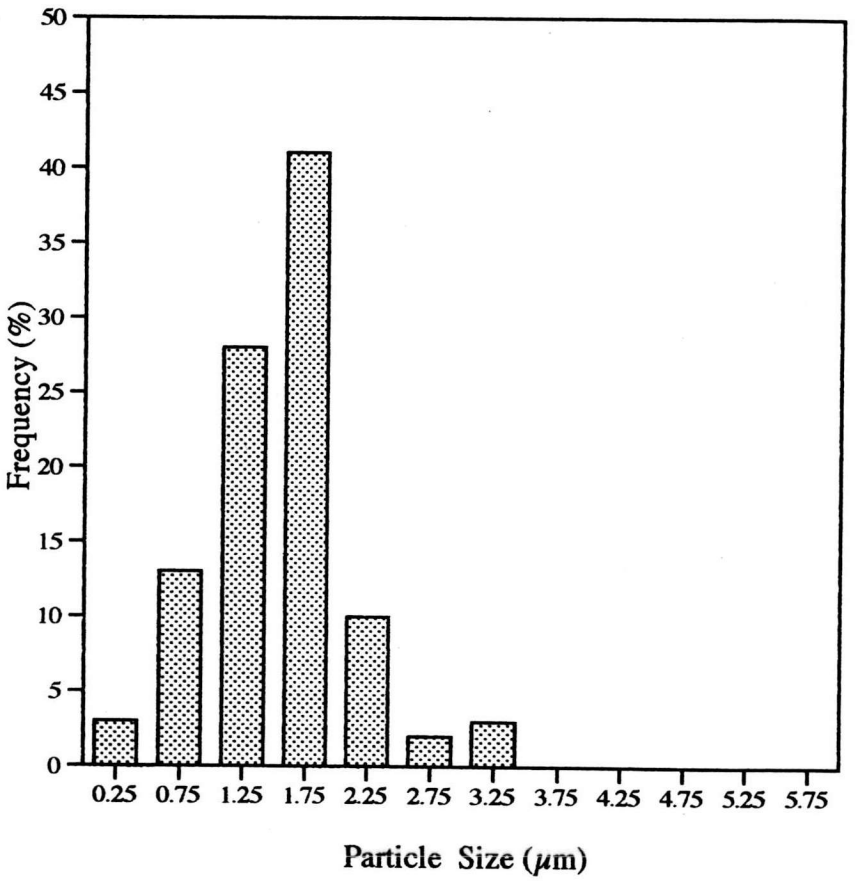



Figure D-c2 Particle size distribution of the dispersion copolymer in the feed of 75:25 mole% St/MMA and mixed solvent content of 80:20 weight% ethanol/n-hexane at 55°C of the reaction temperature

Temperature 64°C

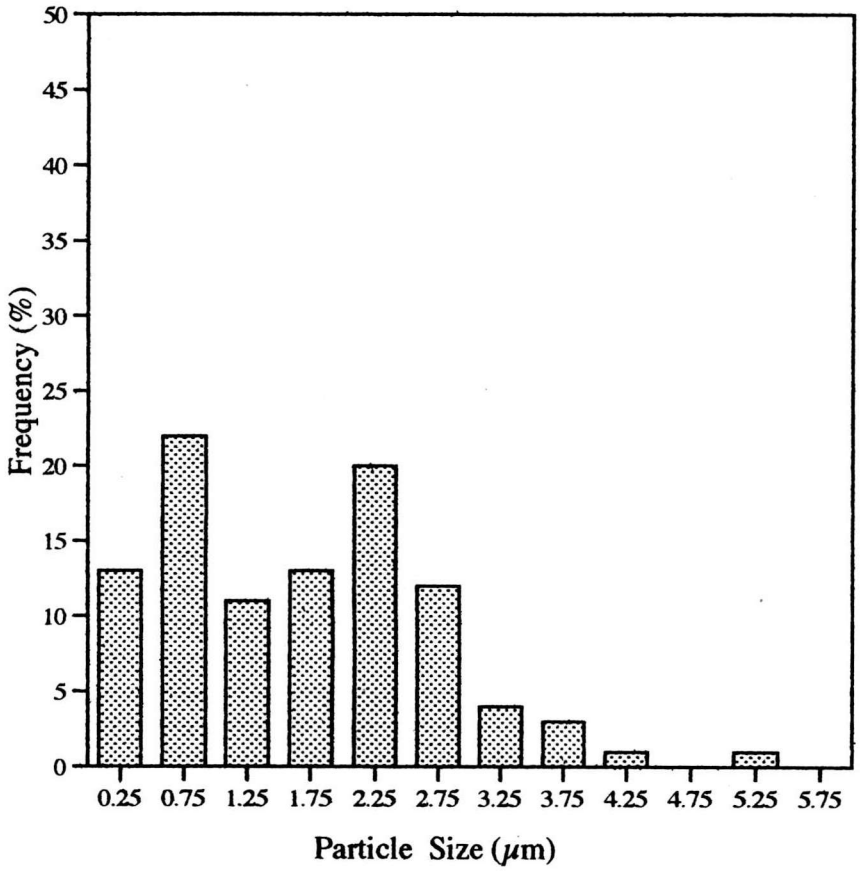



Figure D-c3 Particle size distribution of the dispersion copolymer in the feed of 25:75 mole% St/MMA and mixed solvent content of 80:20 weight% ethanol/n-hexane at 64°C of the reaction temperature

# Appendix E

## Calculated-Glass Transition Temperature

Tg of the copolymer was calculated from the following (1):

$$T_g = (w_1T_{g1}+Kw_2T_{g2})/(w_1+Kw_2) \qquad E(1)$$

$T_{g1}$ and $T_{g2}$ are the glass transition temperatures of homopolymers 1 and 2
$w_1$ and $w_2$ are the weight fractions of constituents 1 and 2 in the copolymer.
K is calculated from the ratio of $\alpha_r$-$\alpha_g$ of homopolymer 1 to homopolymer 2
when $\alpha_r$ is the thermal expansion coefficient of the rubber state.
$\alpha_g$ is the thermal expansion coefficient of the glass state.
$\alpha_r$-$\alpha_g$ is about $2x10^5$ for polystyrene and poly(methyl methacrylate).

The relation between Tg of the homopolymer and the copolymer is therefore transformed into

$$T_g = (w_1T_{g1}+w_2T_{g2})/(w_1+w_2) = w_1T_{g1}+w_2T_{g2} \qquad E(2)$$

as $w_1+w_2 = 1$

An example of calculation

Dispersion copolymerization of 25:75 mole% styrene/methyl methacrylate feed and 80:20 weigt % ethanol/n-hexane in in mixed solvent.

Let styrene be the constituent 1,
$w_1$ be the weight fraction of styrene in copolymer = 35.9%,
$w_2$ be the weight fraction of methyl methacrylate in copolymer = 64.1%,
$T_{g1}$ be the glass transition temperature of homopolystyrene = 96°C,
$T_{g2}$ be the glass transition temperature of homopoly(methyl methacrylate) = 111°C.

$T_g$ of the 25 mole% styrene feed copolymer = (0.359x96)+(0.641x111)
= 105.2°C

Reference

1. Billmeyer, F.W. Textbook of Polymer Science. 3rd ed. New York: John Wiley & Sons., 1984:337-339.

# APPENDIX F

## Gel Permeation Chromatography

The GPC chromatograms were obtained on a Shimadzu (LC-10A) with a Showa Denko (KF-80M) chromato column at the maximum temperature of 60°C. Both of refractive index (RI) and ultraviolet (UV) spectrophotometer were used as detectors. UV detector was used at 277 nm for PS and copolymers and at 246 nm for PMMA. The GPC column was packed with poly(styrene-co-divinylbenzene) with the minimum number of theoretical plates 10,000. Tetrahydrofuran (THF) was used as a solvent and carrier.

For GPC analysis, 2 mg of dried sample was dissolved into 2 ml of THF. The solution was then filtered by using 0.45 $\mu$m syringe filter. 10 microliter of the filtered polymer solution was injected into the GPC (using THF as the carrier fluid) for each analysis.

| | |
|---|---|
| Figures F-a1 to F-a7 | show the GPC chromatograms of solution copolymers |
| Figures F-b1 to F-b5 | show the GPC chromatograms of bulk copolymer |
| Figures F-cs1 to F-cs7 | show the GPC chromatograms of dispersion copolymers at various styrene feeds |
| Figures F-ce1 to F-ce7 | show the GPC chromatograms of dispersion copolymers at various ethanol contents |
| Figures F-ct1 to F-ct4 | show the GPC chromatograms of dispersion copolymers at various reaction temperatures |

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 15.167 | 567932 | 3 |
| top | 19.075 | 17873 | 5632 |
| end | 21.833 | 1556 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 17482 | Weight-A.M.W. | MW= | 27336 |
| Z-A.M.W. | MZ= | 56759 | Visc-A.M.W. | MV= | 25090 |
| Dispersity | MW/MN= | 1.56367 | Dispersity | MZ/MN= | 3.24669 |
| Dispersity | MV/MN= | 1.43516 | I.Viscosity | I.VISC= | 0.20425 |

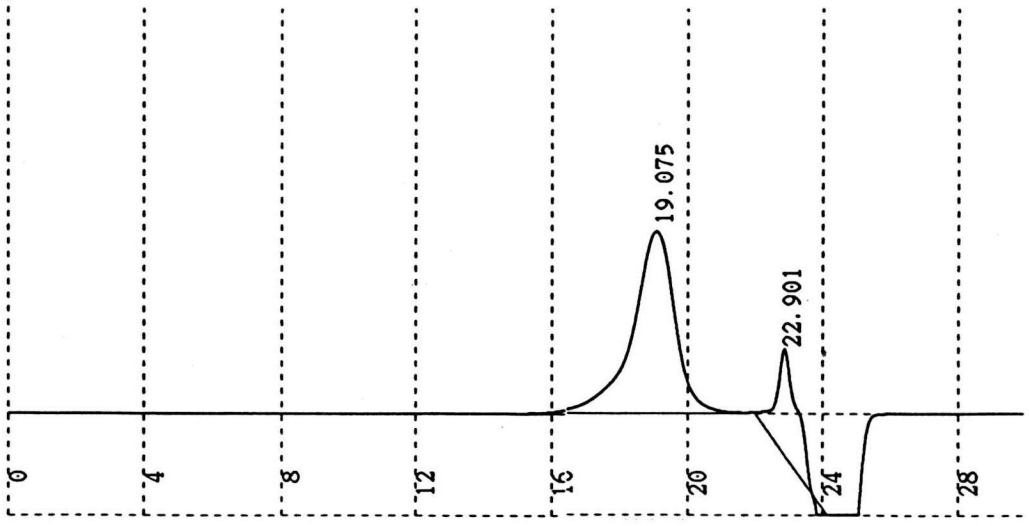



Figure F-a1 GPC chart of solution homopolymer: St feed 0 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16.333 | 202258 | 69 |
| top | 18.512 | 29406 | 5100 |
| end | 21 | 3253 | 47 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 21388 | Weight-A.M.W. | MW= | 35213 |
| Z-A.M.W. | MZ= | 55068 | Visc-A.M.W. | MV= | 32785 |
| Dispersity | MW/MN= | 1.64638 | Dispersity | MZ/MN= | 2.5747 |
| Dispersity | MV/MN= | 1.53285 | I.Viscosity | I.VISC= | 0.24671 |

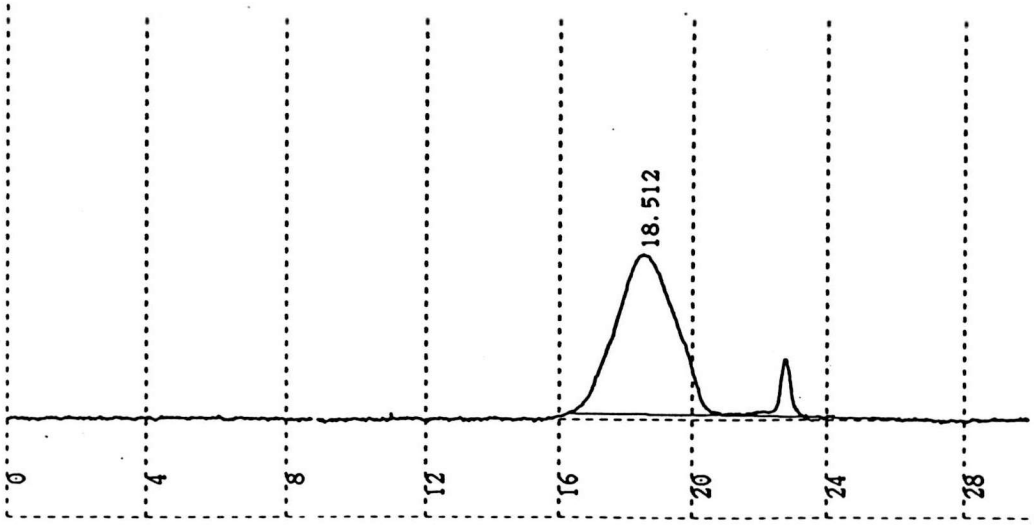



Figure F-a2 GPC chart of solution copolymer: St feed 25 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16.5 | 174522 | 128 |
| top | 19.052 | 18235 | 8774 |
| end | 21.167 | 2807 | 115 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 16112 | Weight-A.M.W. | MW= | 26519 |
| Z-A.M.W. | MZ= | 43528 | Visc-A.M.W. | MV= | 24569 |
| Dispersity | MW/MN= | 1.64595 | Dispersity | MZ/MN= | 2.70163 |
| Dispersity | MV/MN= | 1.52488 | I.Viscosity | I.VISC= | 0.20125 |

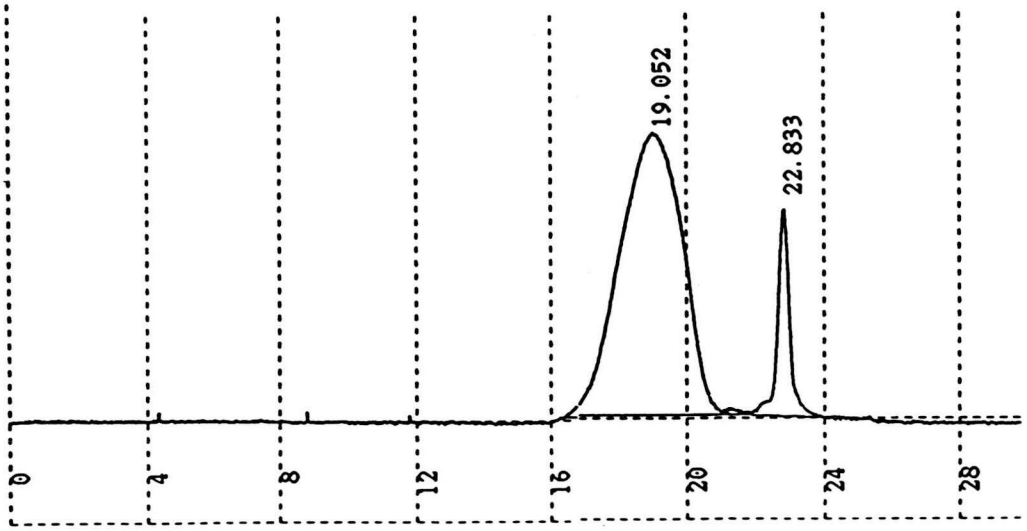



Figure F-a3 GPC chart of solution copolymer: St feed 38 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16 | 271655 | 87 |
| top | 18.417 | 32004 | 9387 |
| end | 21.167 | 2807 | 102 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 23524 | Weight-A.M.W. | MW= | 38540 |
| Z-A.M.W. | MZ= | 61346 | Visc-A.M.W. | MV= | 35926 |
| Dispersity | MW/MN= | 1.63835 | Dispersity | MZ/MN= | 2.60783 |
| Dispersity | MV/MN= | 1.52719 | I.Viscosity | I.VISC= | 0.26317 |

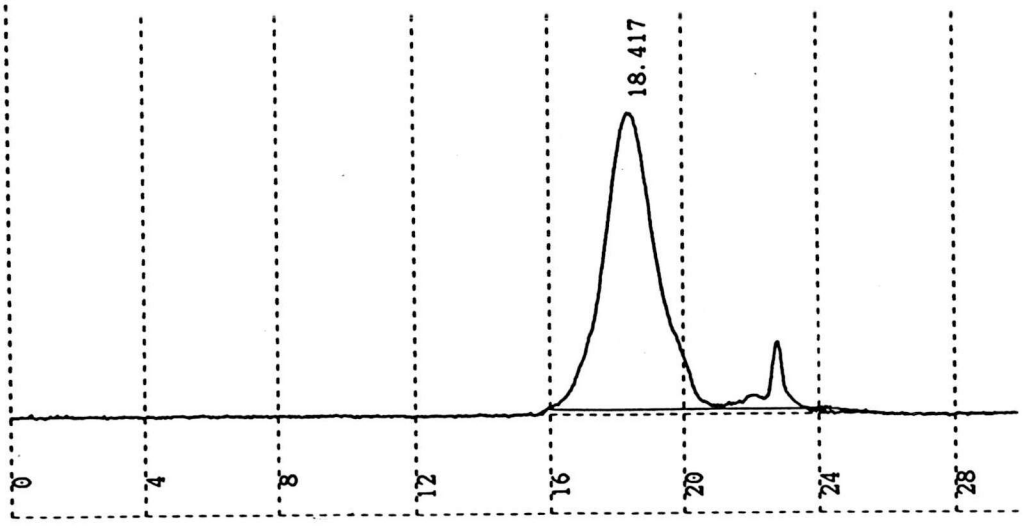



Figure F-a4 GPC chart of solution copolymer: St feed 50 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16.5 | 174522 | 149 |
| top | 18.721 | 24448 | 11473 |
| end | 21.667 | 1804 | 115 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 16268 | Weight-A.M.W. | MW= | 27256 |
| Z-A.M.W. | MZ= | 43498 | Visc-A.M.W. | MV= | 25330 |
| Dispersity | MW/MN= | 1.67543 | Dispersity | MZ/MN= | 2.67385 |
| Dispersity | MV/MN= | 1.55707 | I.Viscosity | I.VISC= | 0.20563 |

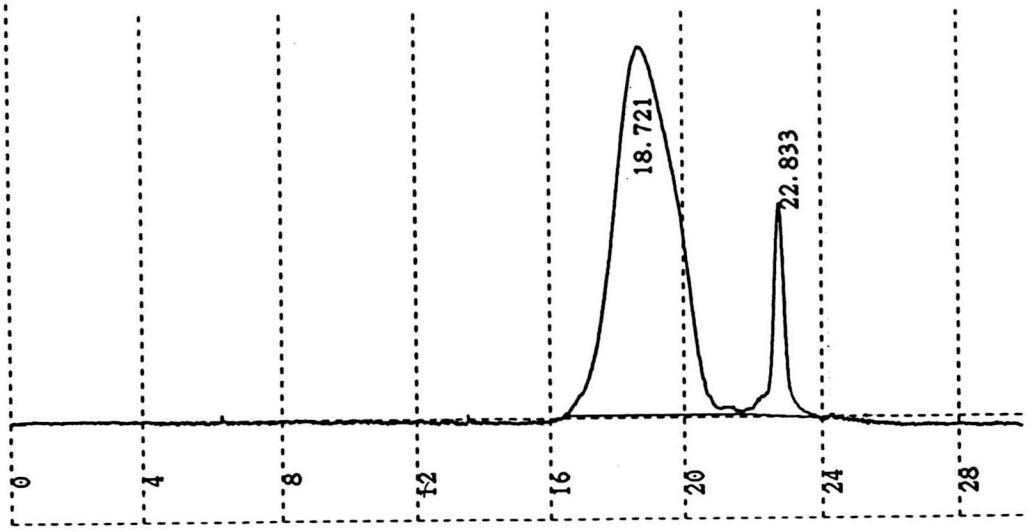



Figure F-a5 GPC chart of solution copolymer: St feed 62 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16.5 | 174522 | 77 |
| top | 19.108 | 17358 | 10755 |
| end | 21.667 | 1804 | 414 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 11894 | Weight-A.M.W. | MW= | 21063 |
| Z-A.M.W. | MZ= | 36687 | Visc-A.M.W. | MV= | 19328 |
| Dispersity | MW/MN= | 1.77089 | Dispersity | MZ/MN= | 3.08453 |
| Dispersity | MV/MN= | 1.62507 | I.Viscosity | I.VISC= | 0.16989 |

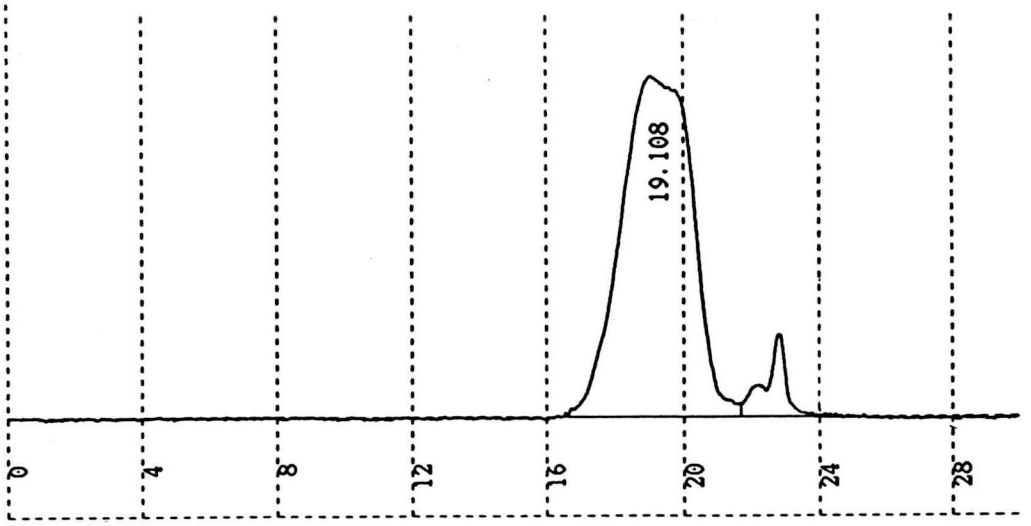



Figure F-a6 GPC chart of solution copolymer: St feed 75 mole%

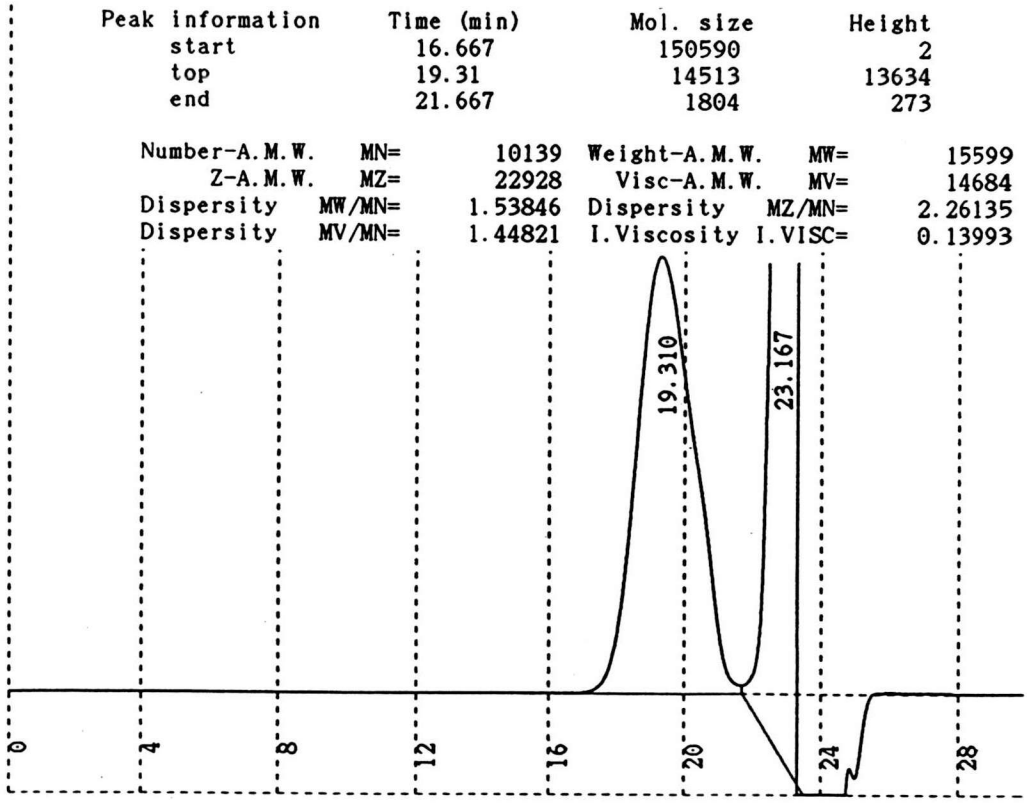



Figure F-a7 GPC chart of solution homopolymer: St feed 100 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 12.333 | 6970163 | 53 |
| top | 15.416 | 455614 | 6560 |
| end | 20.333 | 5869 | 20 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 186719 | Weight-A.M.W. | MW= | 717828 |
| Z-A.M.W. | MZ= | 1631229 | Visc-A.M.W. | MV= | 619726 |
| Dispersity | MW/MN= | 3.84442 | Dispersity | MZ/MN= | 8.73626 |
| Dispersity | MV/MN= | 3.31902 | I.Viscosity | I.VISC= | 1.96523 |

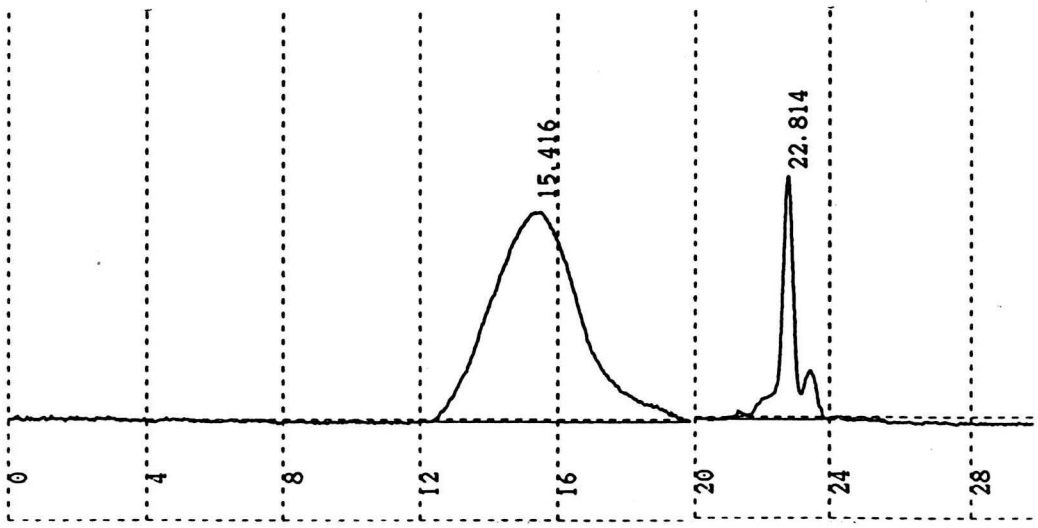



Figure F-b1 GPC chart of bulk comopolymer: St feed 25 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 13.333 | 2876792 | 55 |
| top | 15.661 | 366589 | 5860 |
| end | 19 | 19099 | 339 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 195366 | Weight-A.M.W. | MW= | 418973 |
| Z-A.M.W. | MZ= | 692992 | Visc-A.M.W. | MV= | 384437 |
| Dispersity | MW/MN= | 2.14455 | Dispersity | MZ/MN= | 3.54714 |
| Dispersity | MV/MN= | 1.96778 | I.Viscosity | I.VISC= | 1.40283 |

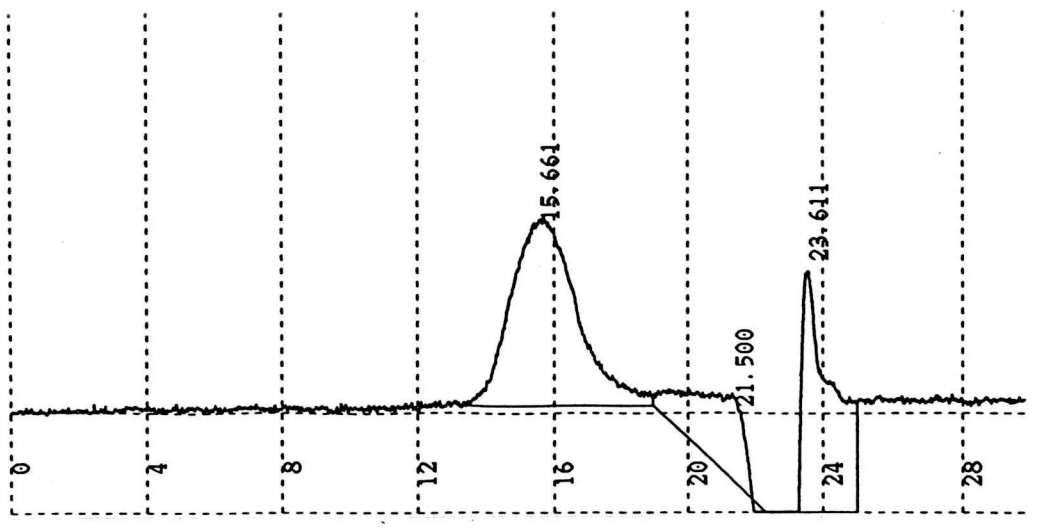



Figure F-b2 GPC chart of bulk comopolymer: St feed 38 mole%

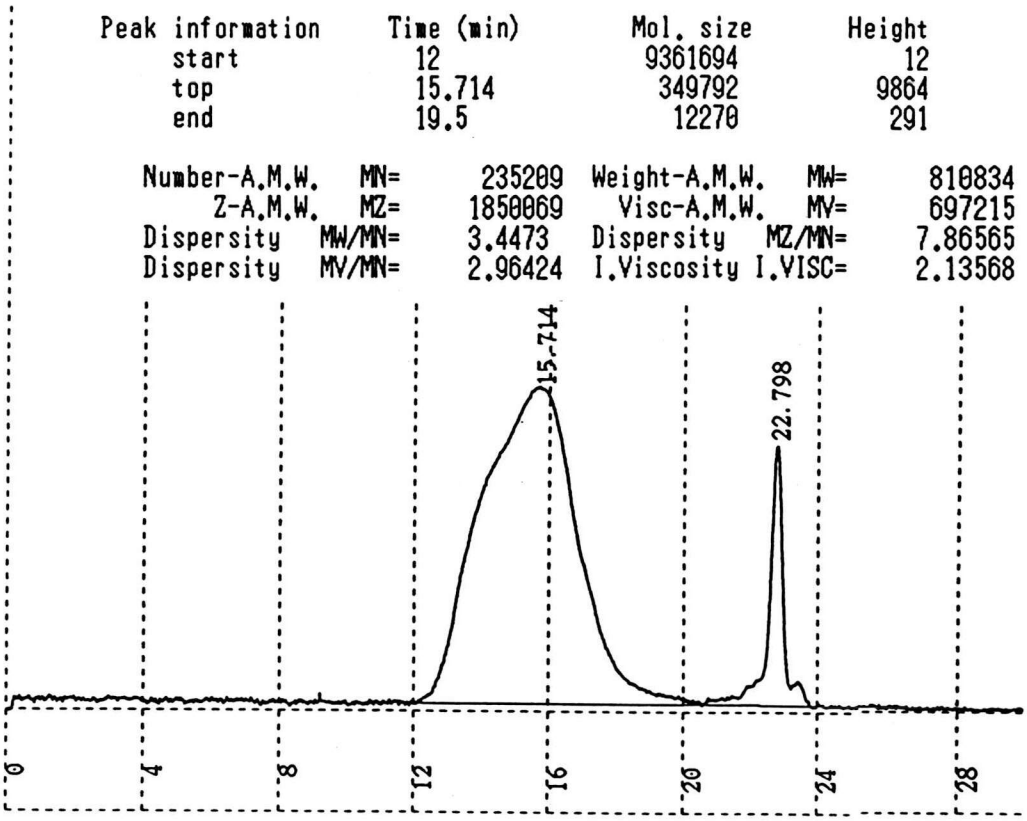



Figure F-b3 GPC chart of bulk comopolymer: St feed 50 mole%

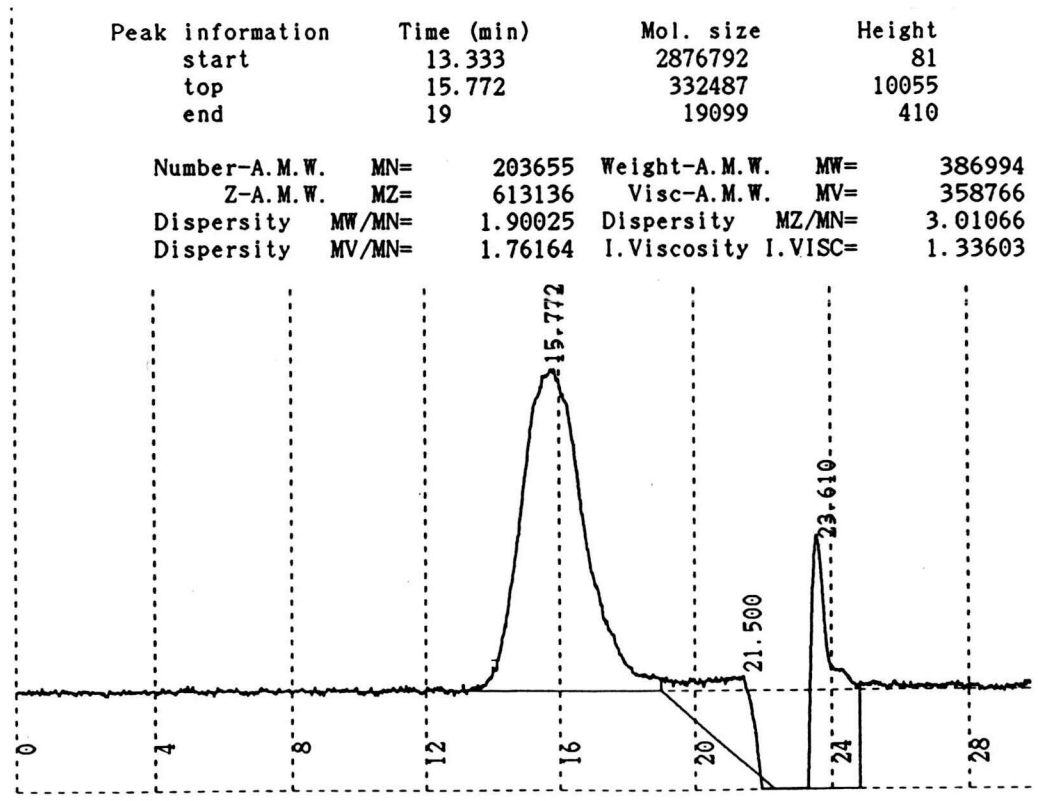



Figure F-b4 GPC chart of bulk comopolymer: St feed 62 mole%

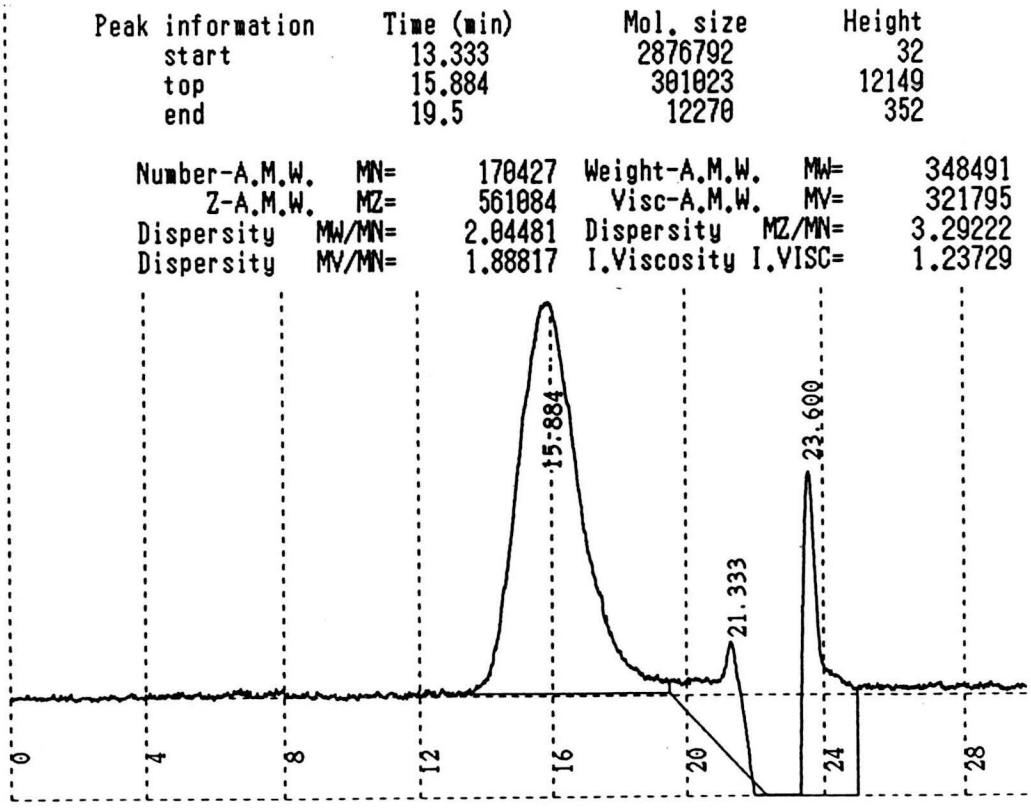



Figure F-b5 GPC chart of bulk comopolymer: St feed 75 mole%

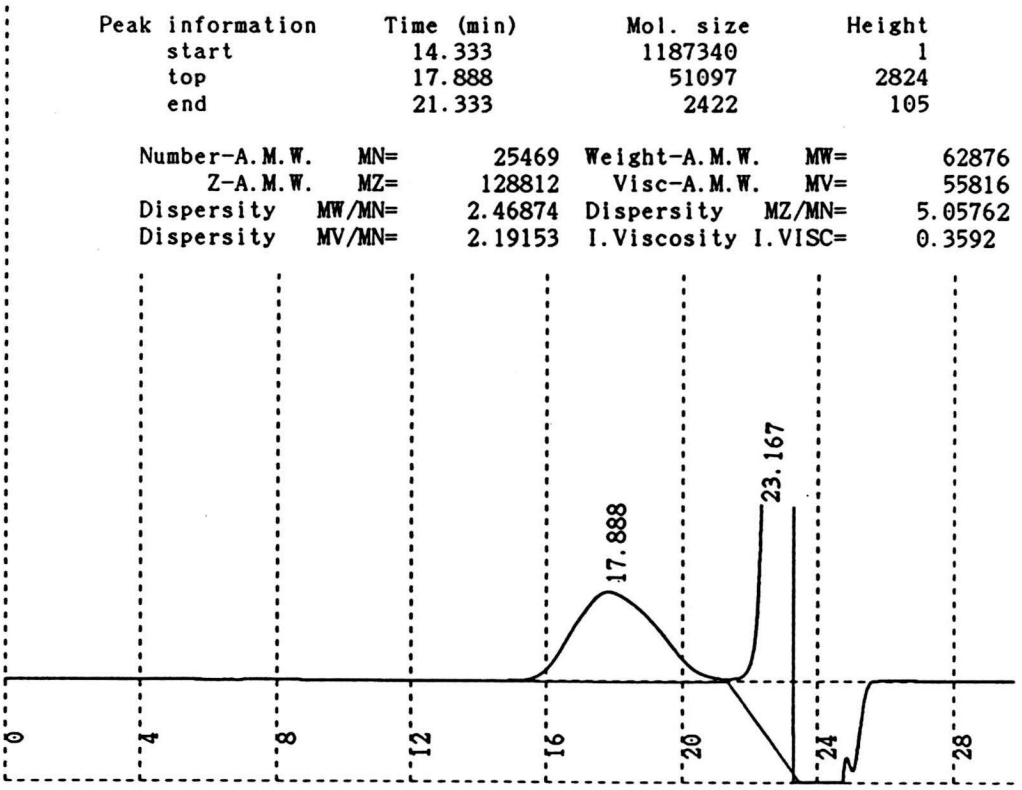



Figure F-cs1 GPC chart of dispersion homopolymer: St feed 0 mole%

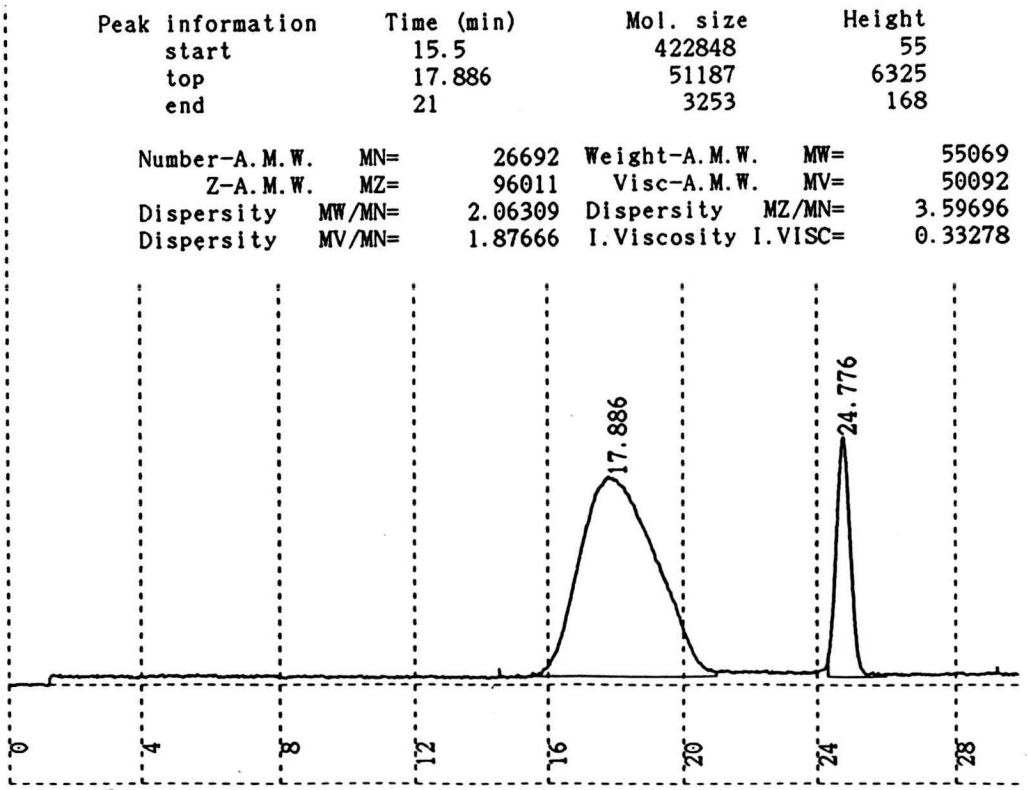



Figure F-cs2 GPC chart of dispersion copolymer: St feed 25 mole%,

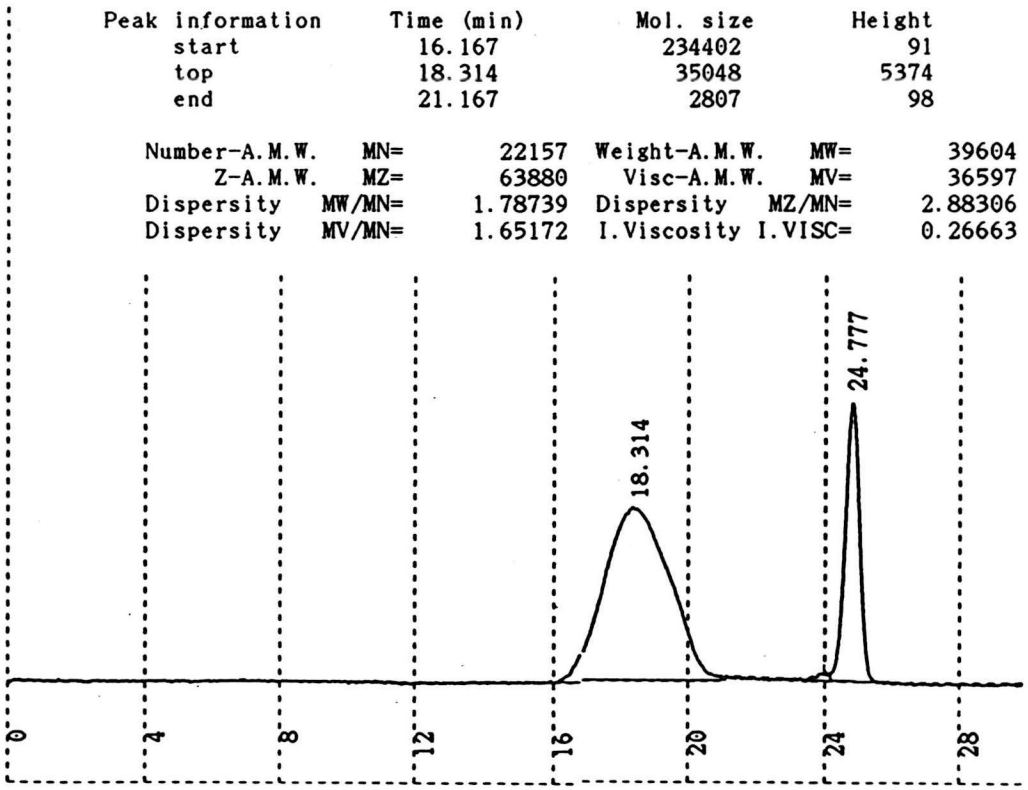



Figure F-cs3 GPC chart of dispersion copolymer: St feed 38 mole%,

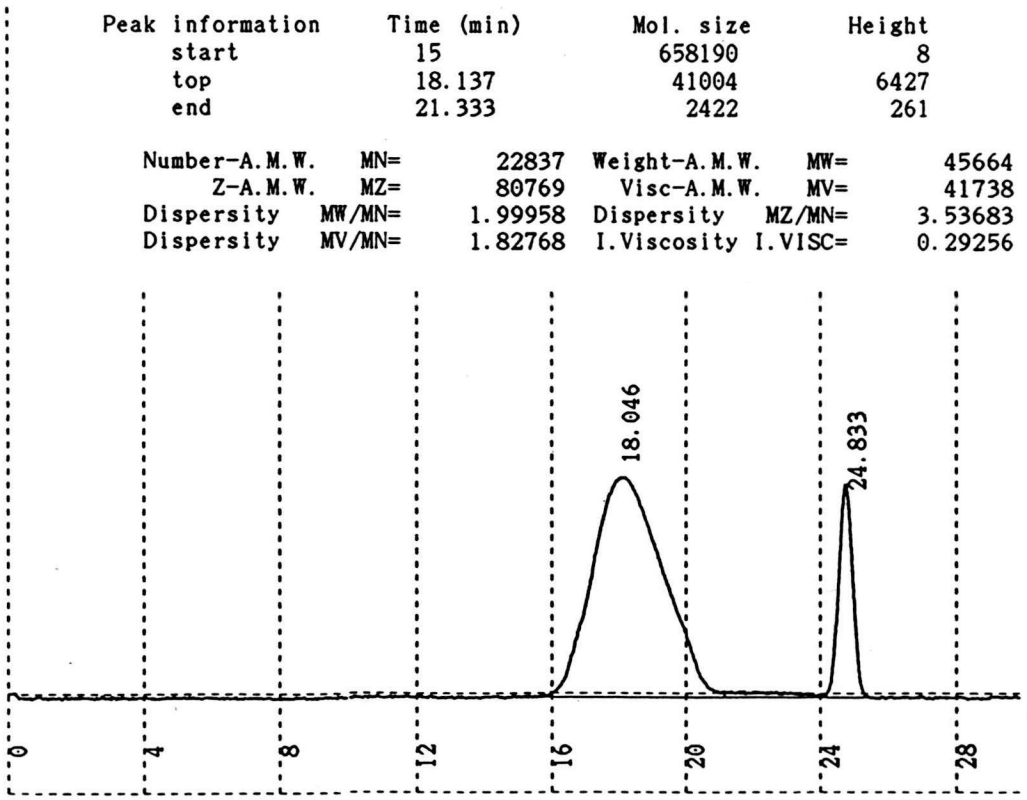



Figure F-cs4 GPC chart of dispersion copolymer: St feed 50 mole%,

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16.167 | 234402 | 60 |
| top | 18.548 | 28484 | 6557 |
| end | 21.667 | 1804 | 66 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 17633 | Weight-A.M.W. | MW= | 33821 |
| Z-A.M.W. | MZ= | 57637 | Visc-A.M.W. | MV= | 30951 |
| Dispersity | MW/MN= | 1.91809 | Dispersity | MZ/MN= | 3.26875 |
| Dispersity | MV/MN= | 1.75531 | I.Viscosity | I.VISC= | 0.23688 |

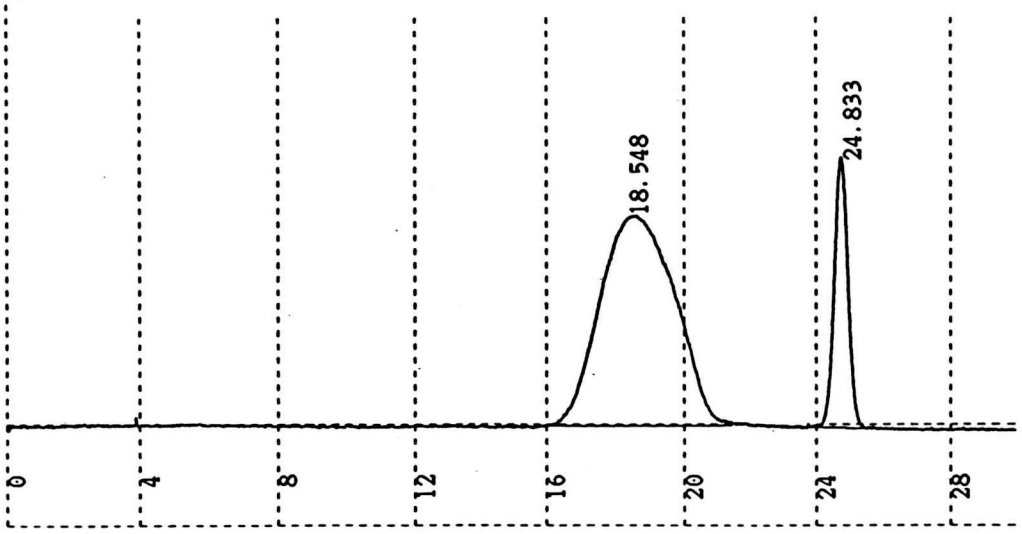



Figure F-cs5 GPC chart of dispersion copolymer: St feed 62 mole%,

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 15.167 | 567932 | 2 |
| top | 18.389 | 32788 | 7941 |
| end | 21.667 | 1804 | 95 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 18168 | Weight-A.M.W. | MW= | 36780 |
| Z-A.M.W. | MZ= | 66901 | Visc-A.M.W. | MV= | 33411 |
| Dispersity | MW/MN= | 2.02445 | Dispersity | MZ/MN= | 3.68236 |
| Dispersity | MV/MN= | 1.83899 | I.Viscosity | I.VISC= | 0.25002 |

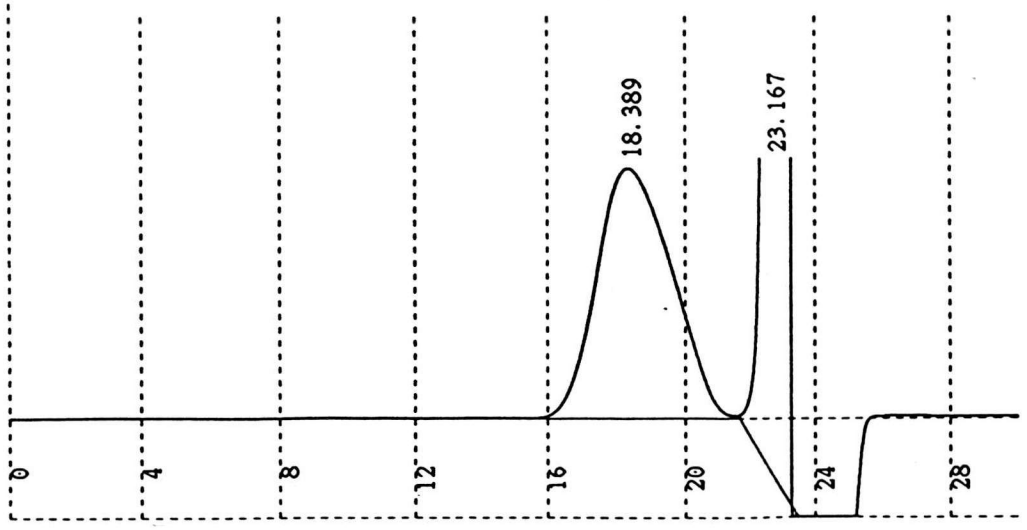



Figure F-cs6 GPC chart of dispersion copolymer: St feed 75 mole%,

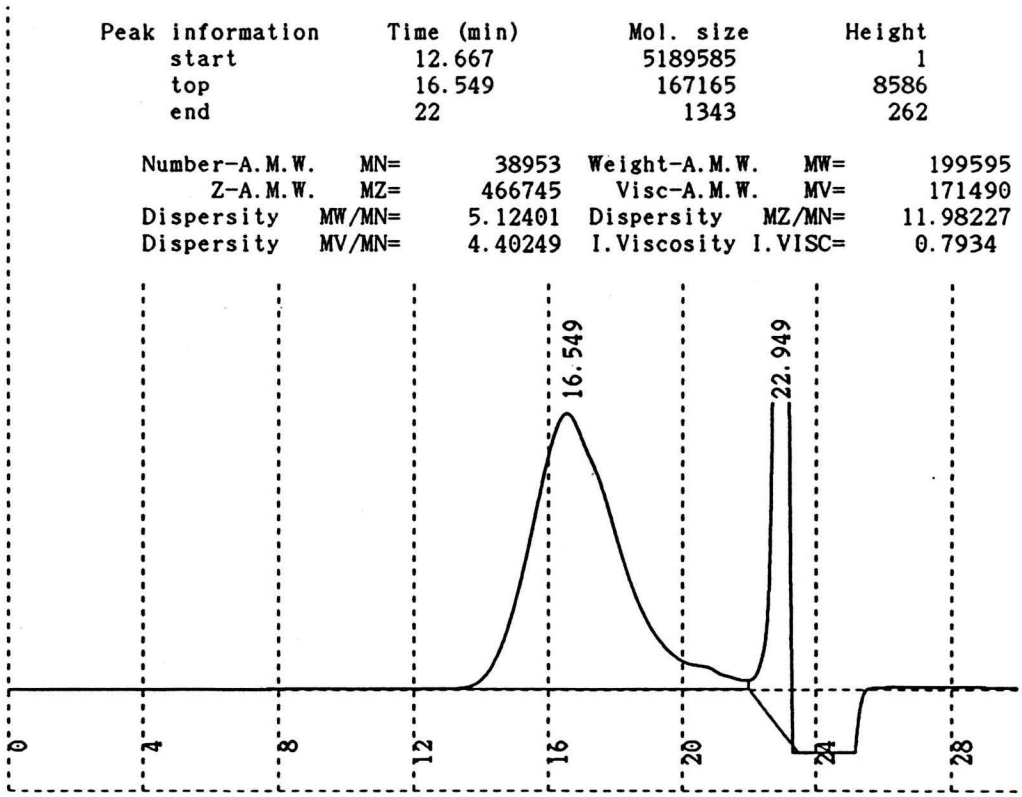



Figure F-cs7 GPC chart of dispersion homopolymer: St feed 100 mole%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 13.167 | 3333996 | 3 |
| top | 16.64 | 154231 | 2885 |
| end | 21.5 | 2090 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 62358 | Weight-A.M.W. | MW= | 203810 |
| Z-A.M.W. | MZ= | 462848 | Visc-A.M.W. | MV= | 177247 |
| Dispersity | MW/MN= | 3.26837 | Dispersity | MZ/MN= | 7.42241 |
| Dispersity | MV/MN= | 2.84241 | I.Viscosity | I.VISC= | 0.81211 |

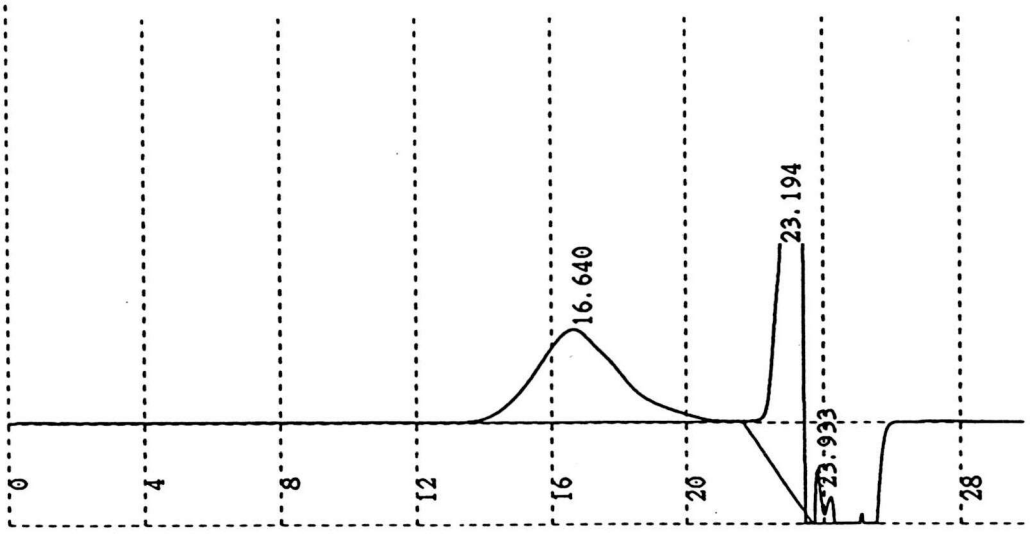



Figure F-ce1 GPC chart of dispersion copolymer: EtOH 0 weight%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 15.833 | 314828 | 62 |
| top | 17.996 | 46453 | 4393 |
| end | 21.333 | 2422 | 26 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 23496 | Weight-A.M.W. | MW= | 48808 |
| Z-A.M.W. | MZ= | 84270 | Visc-A.M.W. | MV= | 44388 |
| Dispersity | MW/MN= | 2.07728 | Dispersity | MZ/MN= | 3.58657 |
| Dispersity | MV/MN= | 1.88917 | I.Viscosity | I.VISC= | 0.30555 |

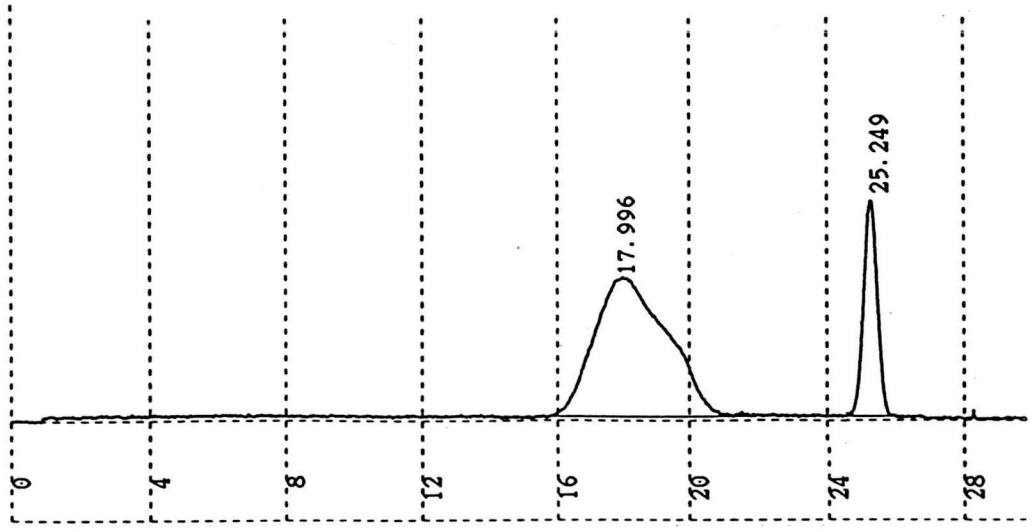



Figure F-ce2 GPC chart of dispersion copolymer: EtOH 20 weight%

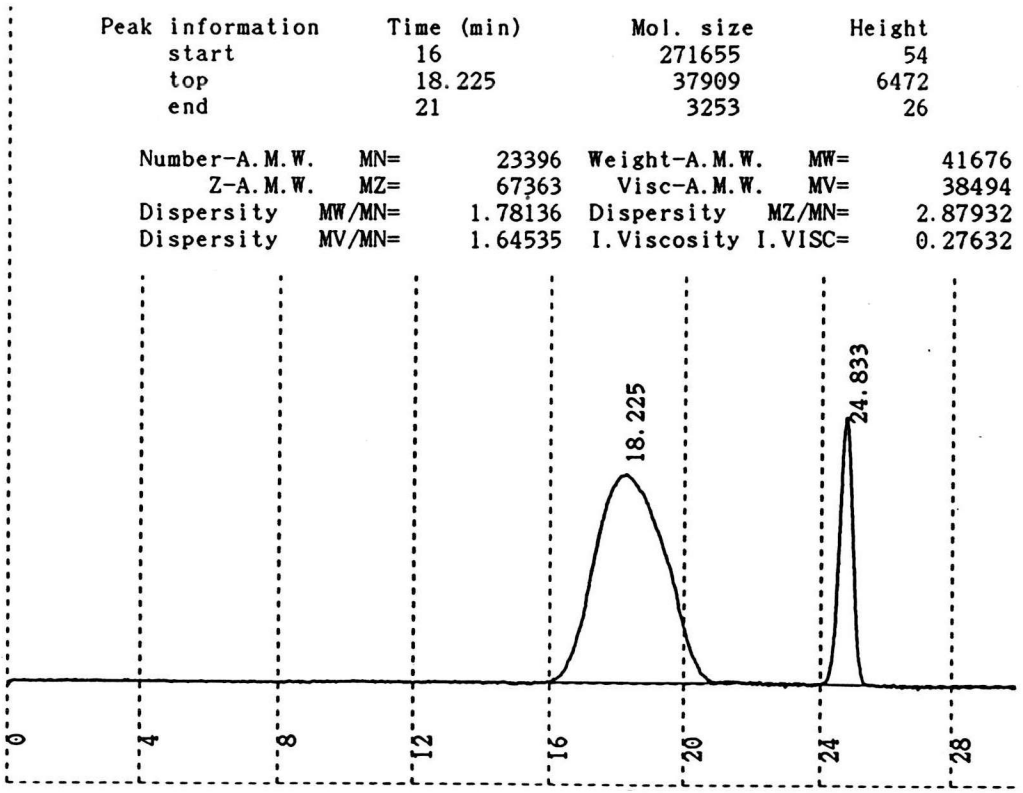



Figure F-ce3 GPC chart of dispersion copolymer: EtOH 35 weight%

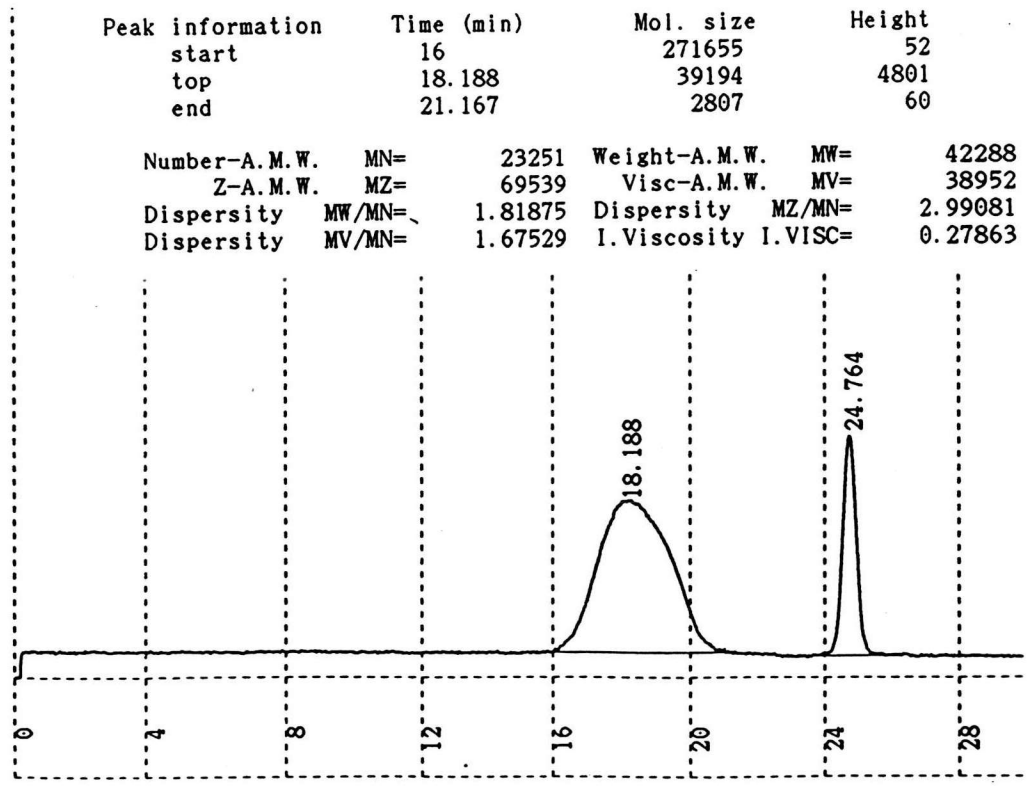



Figure F-ce4 GPC chart of dispersion copolymer: EtOH 50 weight%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 16 | 271655 | 74 |
| top | 18.163 | 40071 | 5792 |
| end | 21 | 3253 | 83 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 26325 | Weight-A.M.W. | MW= | 44243 |
| Z-A.M.W. | MZ= | 68969 | Visc-A.M.W. | MV= | 41196 |
| Dispersity | MW/MN= | 1.68062 | Dispersity | MZ/MN= | 2.61987 |
| Dispersity | MV/MN= | 1.56489 | I.Viscosity | I.VISC= | 0.28987 |

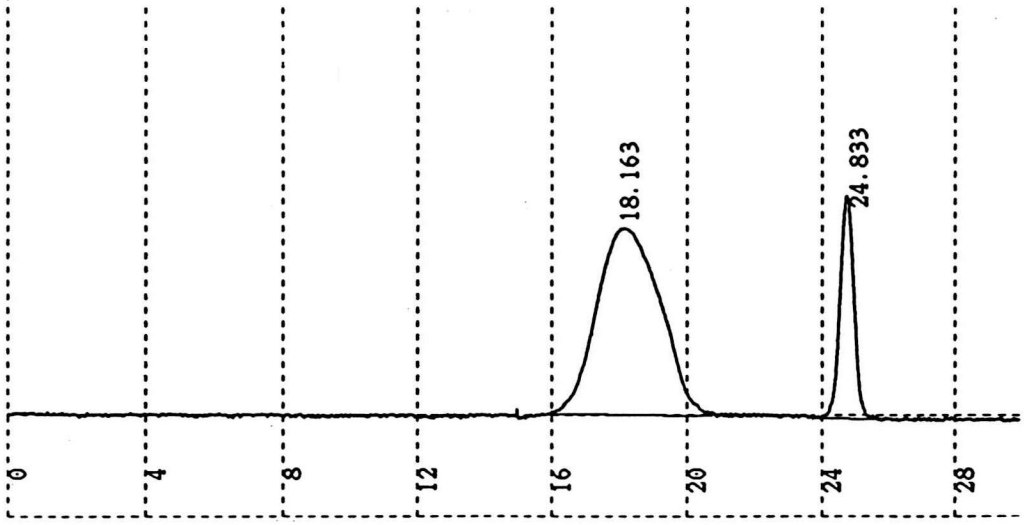



Figure F-ce5 GPC chart of dispersion copolymer: EtOH 65 weight%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 15.5 | 422848 | 55 |
| top | 17.886 | 51187 | 6325 |
| end | 21 | 3253 | 168 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 26692 | Weight-A.M.W. | MW= | 55069 |
| Z-A.M.W. | MZ= | 96011 | Visc-A.M.W. | MV= | 50092 |
| Dispersity | MW/MN= | 2.06309 | Dispersity | MZ/MN= | 3.59696 |
| Dispersity | MV/MN= | 1.87666 | I.Viscosity | I.VISC= | 0.33278 |

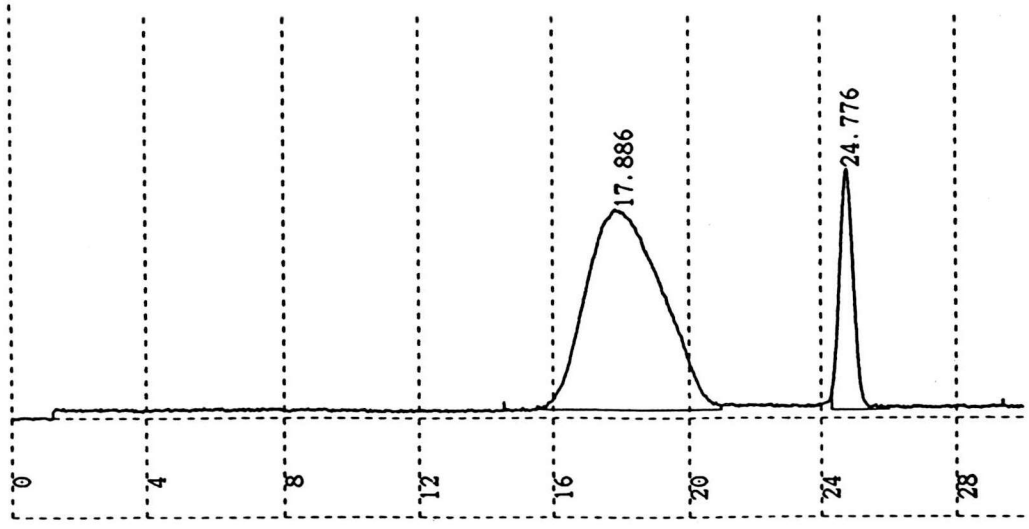



Figure F-ce6 GPC chart of dispersion copolymer: EtOH 80 weight%

| Peak information | Time (min) | Mol. size | Height |
|---|---|---|---|
| start | 15.667 | 364862 | 81 |
| top | 17.969 | 47548 | 4805 |
| end | 21.167 | 2807 | 57 |

| | | | | | |
|---|---|---|---|---|---|
| Number-A.M.W. | MN= | 26249 | Weight-A.M.W. | MW= | 53451 |
| Z-A.M.W. | MZ= | 93634 | Visc-A.M.W. | MV= | 48609 |
| Dispersity | MW/MN= | 2.03628 | Dispersity | MZ/MN= | 3.56714 |
| Dispersity | MV/MN= | 1.85184 | I.Viscosity | I.VISC= | 0.32579 |

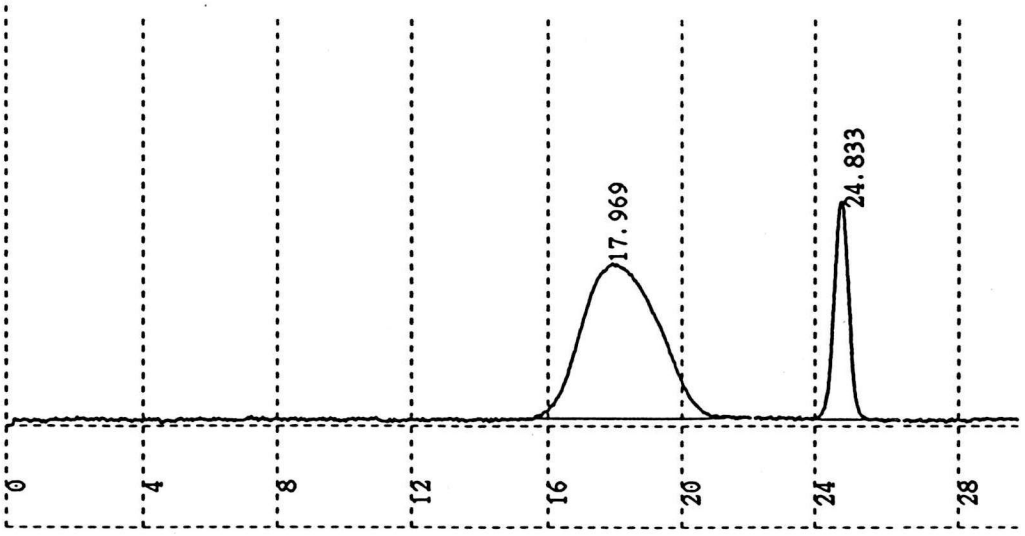



Figure F-ce7 GPC chart of dispersion copolymer: EtOH 100 weight%

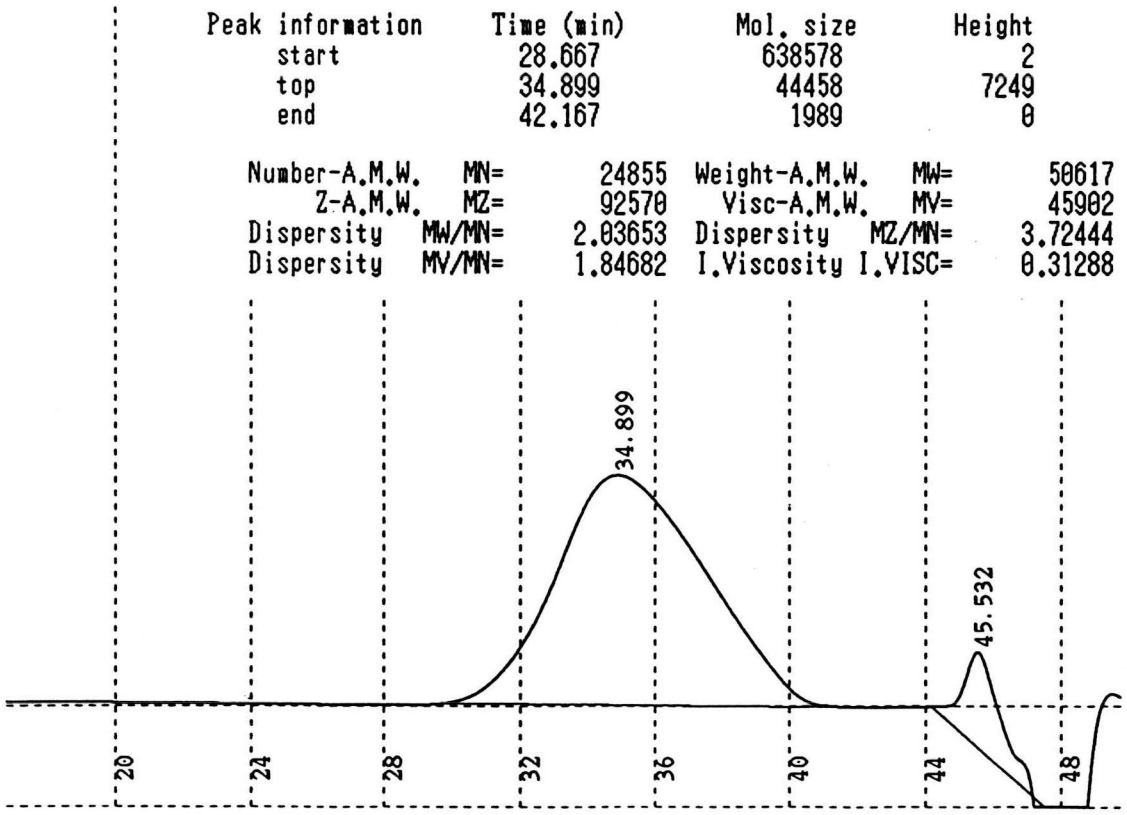



Figure F-ct1 GPC chart of dispersion copolymer: 50°C

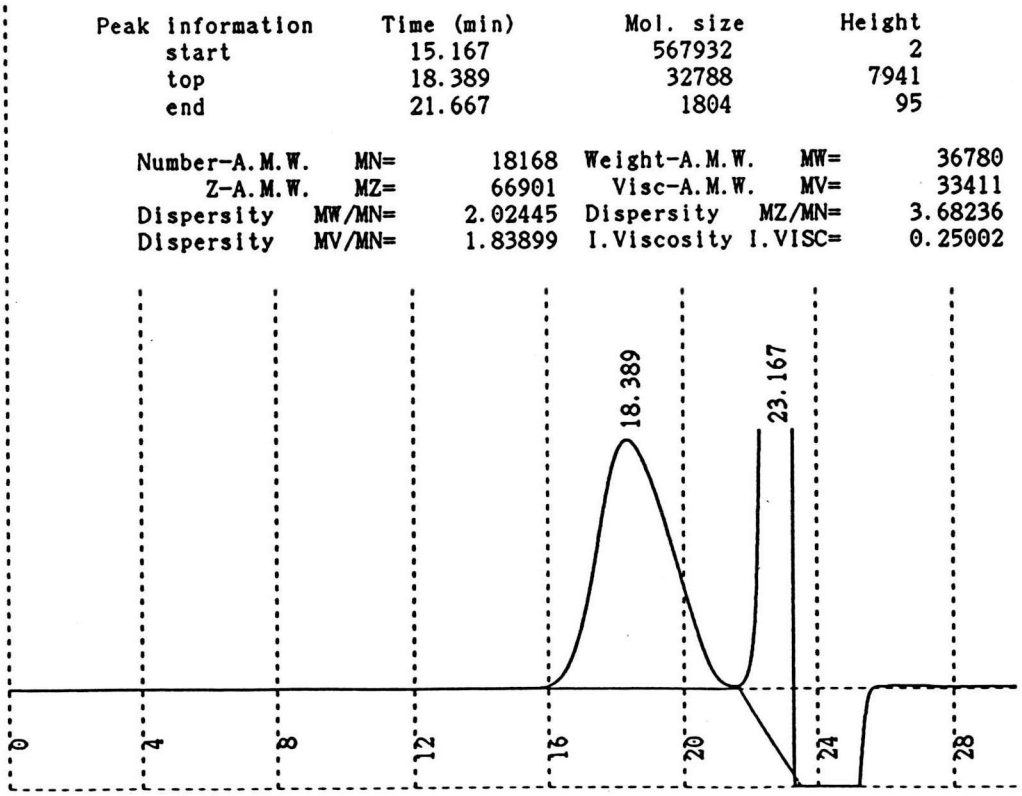



Figure F-ct2 GPC chart of dispersion copolymer: 55°C

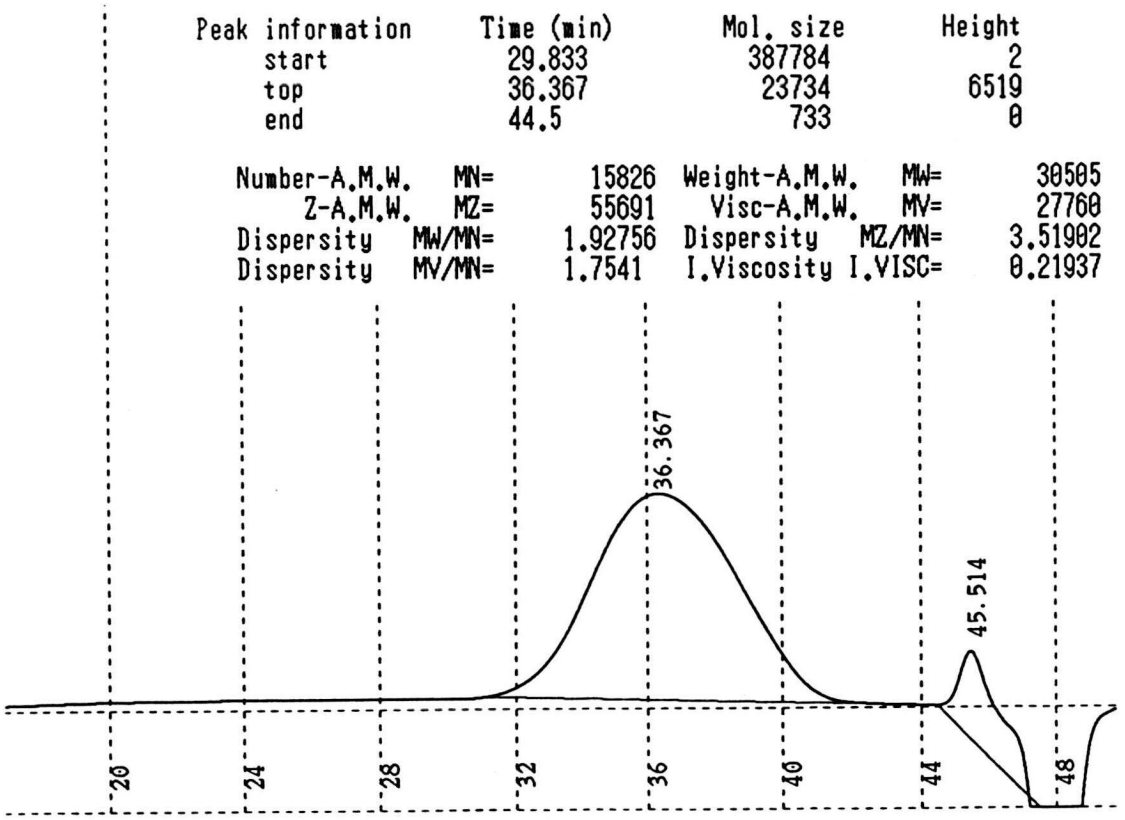



Figure F-ct3 GPC chart of dispersion copolymer: 64°C

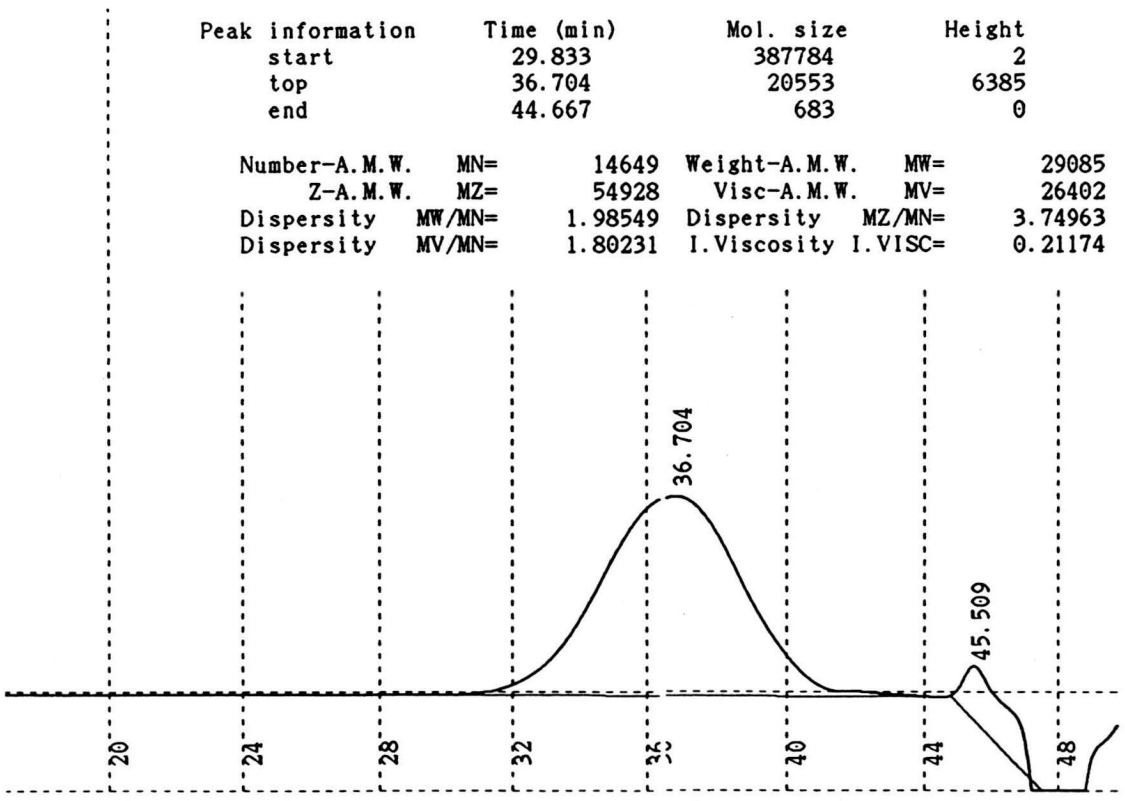



Figure F-ct4 GPC chart of dispersion copolymer: 73°C

# APPENDIX G

## Elemental Analysis

Elemental analysis was operated on a Perkin-Elmer model PE2400II. Analytical data showed %C, %H and %N. Percent carbon was used to calculate the styrene composition in the poly(styrene-co-methyl methacrylate).

### An example of calculation

| | | | |
|---|---|---|---|
| St | $C_8H_8$ | $M_W$ = 104.15 | %C = 12*8/104.15 = 92.17 |
| MMA | $C_5H_8O_2$ | $M_W$ = 100.12 | %C = 12*5/100.12 = 59.93 |

Dispersion copolymer ; 25 mole% St feed, 80 weight% EtOH in the mixed solvent

| | | |
|---|---|---|
| %C found (1st expt) | = | 71.15 |
| %C found (2nd expt) | = | 70.82 |
| Average %C found | = | (71.15+70.82)/2 = 70.985 |
| Ratio of MMA:St | = | (92.17-70.985) : (70.985-59.93) |
| | = | 21.185 : 11.055 |
| % St in copolymer | = | 11.055/(21.185+11.055) = 34 |

Table G-1 Analytical data of solution copolymers

| Copolymer (%St) | | %C | %H | %N |
|---|---|---|---|---|
| 25 | 1st | 70.86 | 8.05 | 2.05 |
| | 2nd | 70.87 | 8.09 | 2.07 |
| 38 | 1st | 74.83 | 8.09 | 0.84 |
| | 2nd | 74.81 | 8.10 | 0.65 |
| 50 | 1st | 77.38 | 8.01 | 0.66 |
| | 2nd | 77.20 | 7.99 | 0.96 |
| 62 | 1st | 80.42 | 8.14 | 0.92 |
| | 2nd | 79.95 | 8.09 | 0.47 |
| 75 | 1st | 83.70 | 8.15 | 1.45 |
| | 2nd | 83.20 | 8.08 | 1.60 |

Table G-2 Analytical data of dispersion copolymers

| Copolymer (%St) | | %C | %H | %N |
|---|---|---|---|---|
| PMMA (0) | 1st | 59.93 | 8.54 | 0 |
| | 2nd | 60.24 | 8.56 | 0 |
| 25 | 1st | 71.15 | 8.17 | 1.75 |
| | 2nd | 70.82 | 8.14 | 1.91 |
| 38 | 1st | 72.60 | 8.22 | 0.44 |
| | 2nd | 71.76 | 8.11 | 0.51 |
| 50 | 1st | 77.60 | 7.99 | 0.42 |
| | 2nd | 77.23 | 7.94 | 0.38 |
| 62 | 1st | 77.84 | 7.97 | 0.54 |
| | 2nd | 79.14 | 8.09 | 0.64 |
| 75 | 1st | 82.37 | 8.17 | 1.23 |
| | 2nd | 82.90 | 8.23 | 1.27 |
| PS (100), | 1st | 91.95 | 7.95 | 0.48 |
| | 2nd | 92.35 | 8.01 | 1.19 |

# APPENDIX H

## Differential Scanning Calorimeter

Glass transition temperatures ($T_g$) of the dispersion copolymers were measured on a differential scanning calorimeter model Seiko DSC 200-SSC5000. For each operation, a portion of dried copolymer (weight ca. 10 mg) was placed in the sample can that was sealed and weighed. The sample can was placed on the sensor at room temperature, together with an empty container to assist output balance. They were and rapaidly heated (heat rate 10°C/min) to the required temperature (400°C). The heating step was divided into 3 steps, from room temperature to 140°C then cooling by the use of liquid $N_2$ to -100°C and finaly, heated the sensor to 400°C. The $T_g$ was observed in the final heat step.

Figures H-1 to H-7 show the DSC curves of the PS, PMMA homopolymers and poly(St-co-MMA) copolymer.

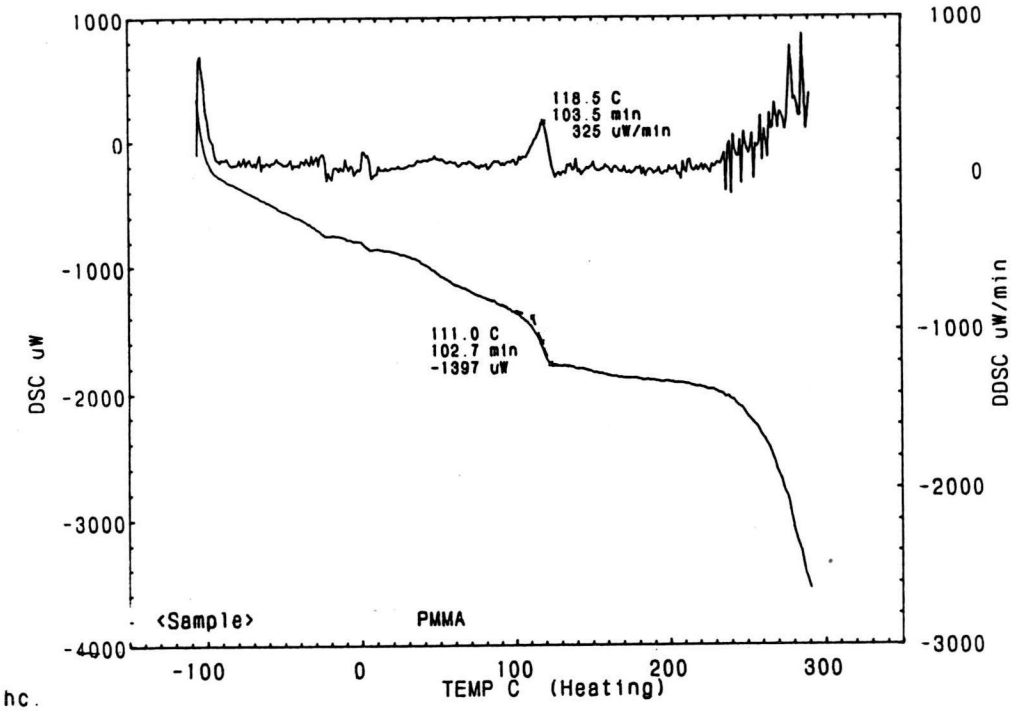



Figure H-1 DSC curve of dispersion PMMA homopolymer

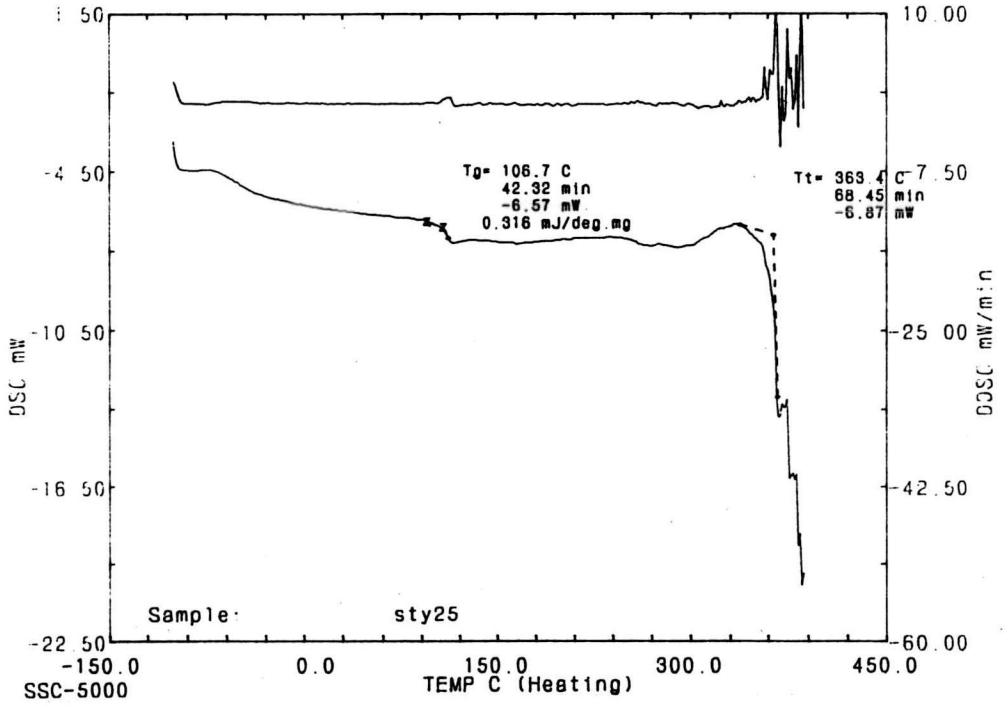



Figure H-2 DSC curve of dispersion poly(St-co-MMA): St feed 25 %

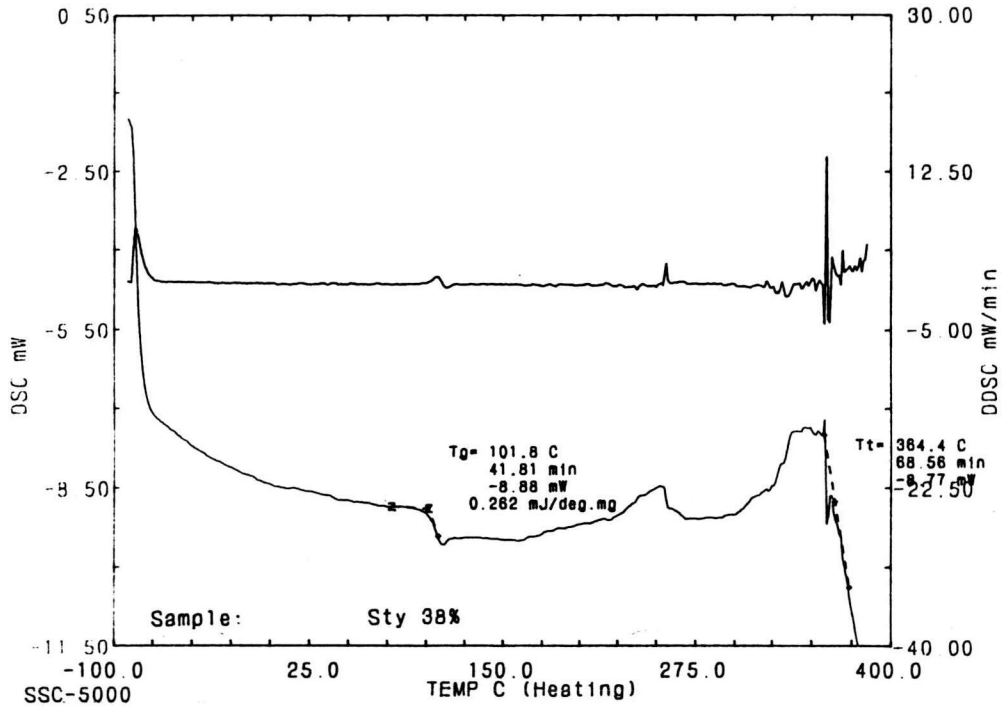



Figure H-3 DSC curve of dispersion poly(St-co-MMA): St feed 38 %

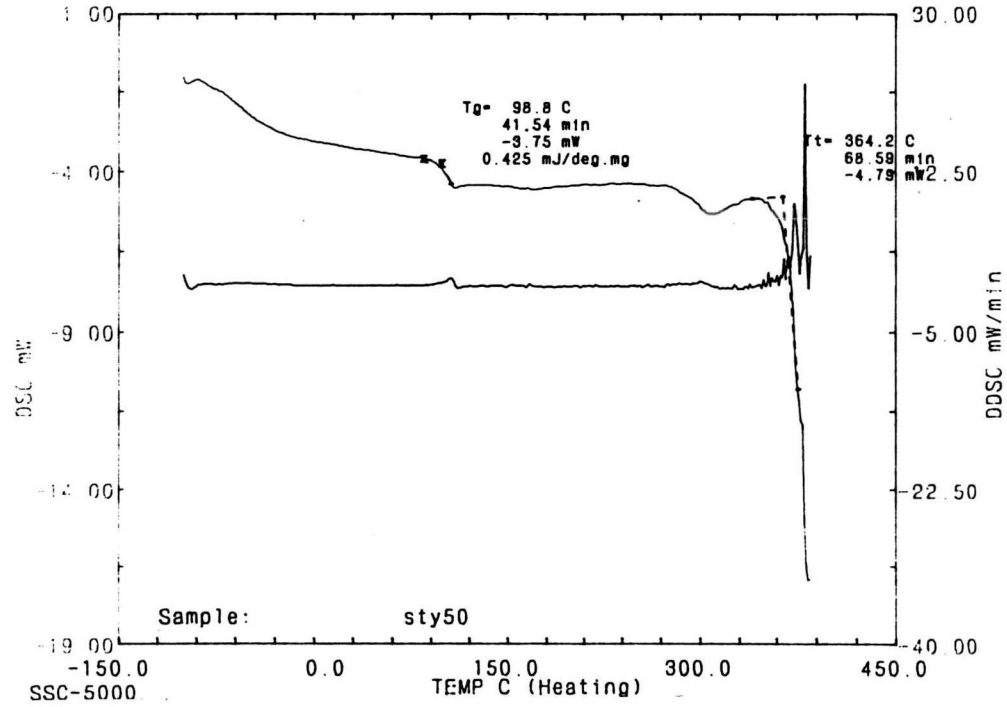



Figure H-4 DSC curve of dispersion poly(St-co-MMA): St feed 50 %

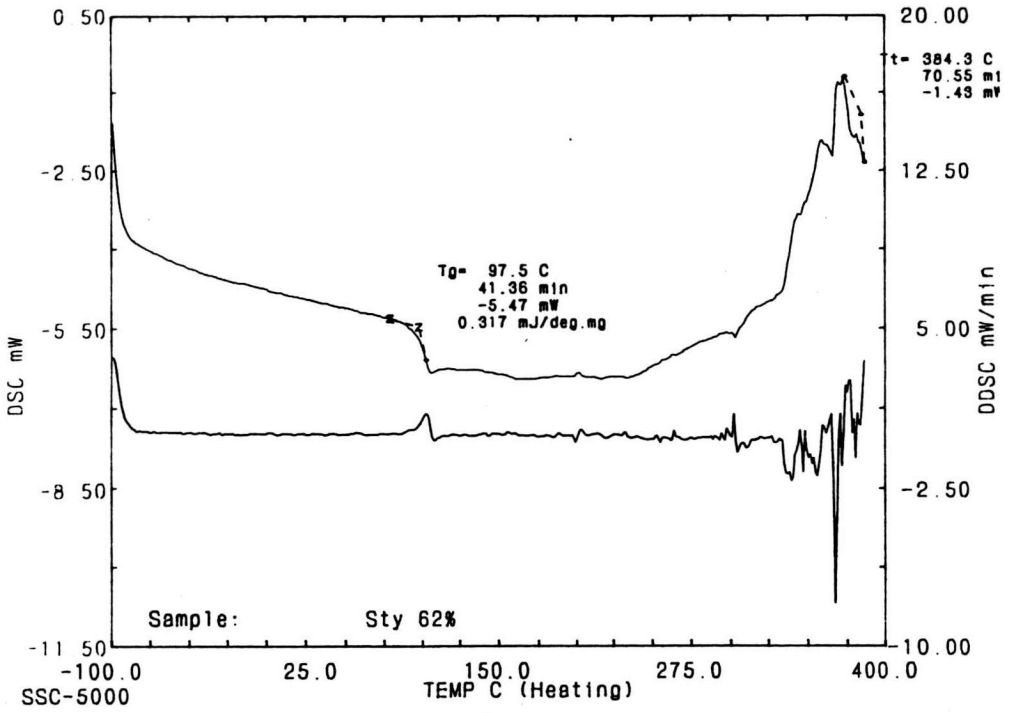



Figure H-5 DSC curve of dispersion poly(St-co-MMA): St feed 62 %

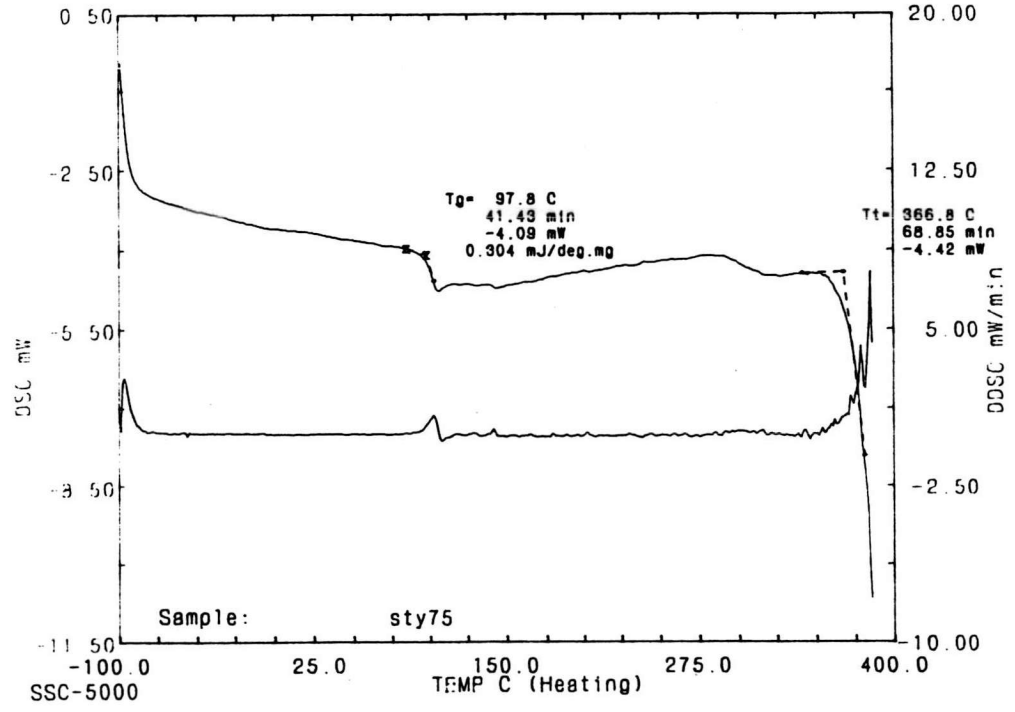



Figure H-6 DSC curve of dispersion poly(St-co-MMA): St feed 75 %

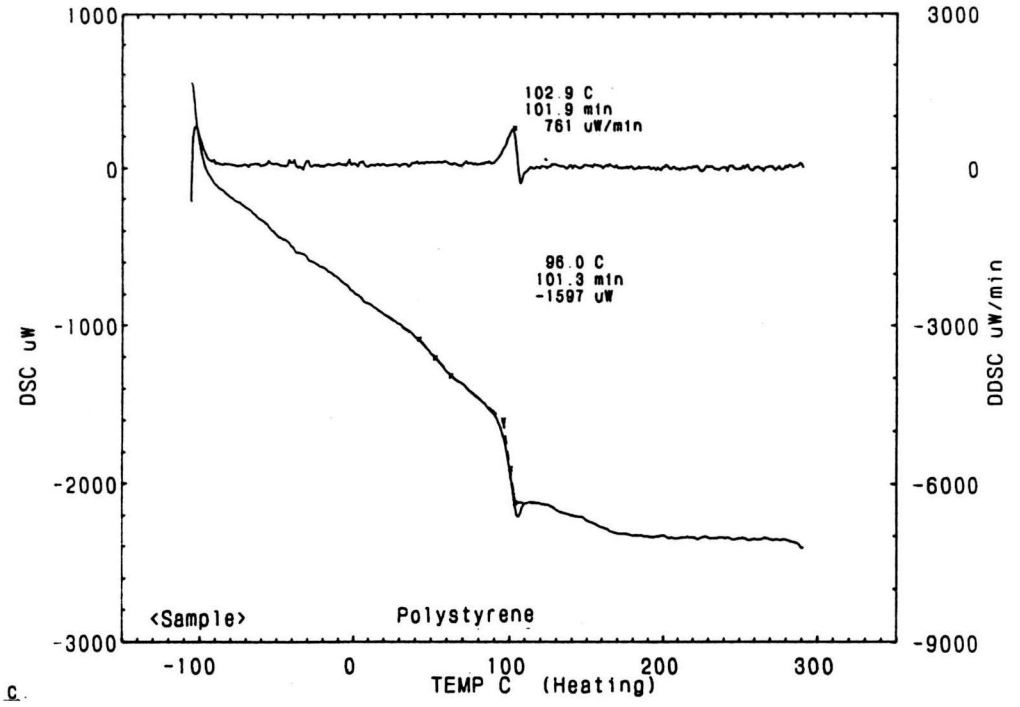



Figure H-7 DSC curve of dispersion PS homopolymer

# APPENDIX I

## Thermal Gravimetry/Differential Thermal Analysis

Decomposition temperatures ($T_d$) of the dispersion copolymers were measured on a thermal gravimetry/differential thermal analysis model Seiko TG/DTA 200-SSC5000). For each operation, a portion of dried copolymer (weight ca. 10 mg) was place in an aluminium pan and placed on the sensor at room temperature, together with an empty container to assist output balance. They were heated at the heat rate of 5°C/min to 500°C.

Figures I-1 to I-7 show the TG/DTA curves of the PS, PMMA homopolymers and poly(St-co-MMA) copolymer.

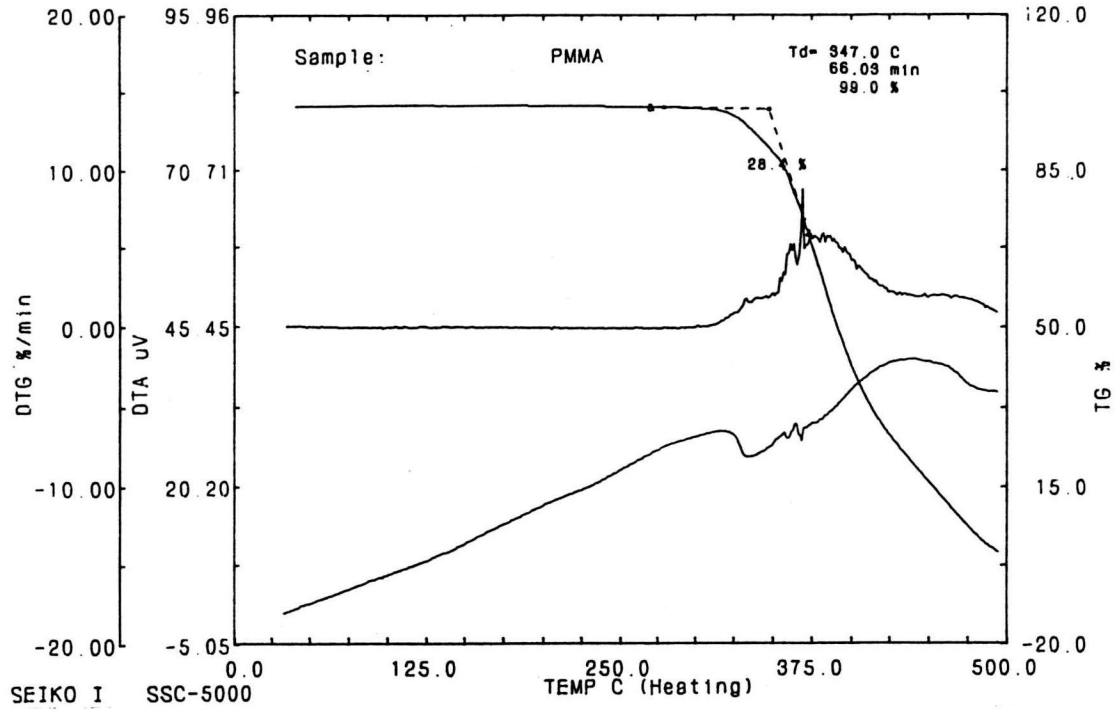



Figure I-1 TG/DTA curve of dispersion PMMA homopolymer

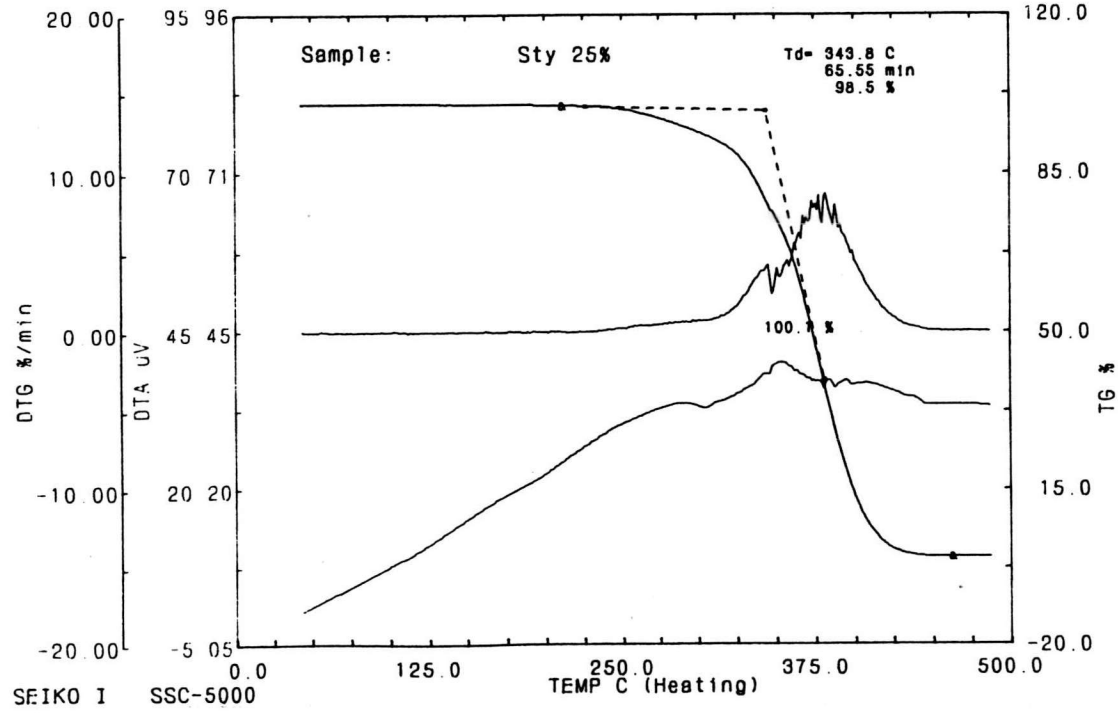



Figure I-2 TG/DTA curve of dispersion poly(St-co-MMA): St feed 25%

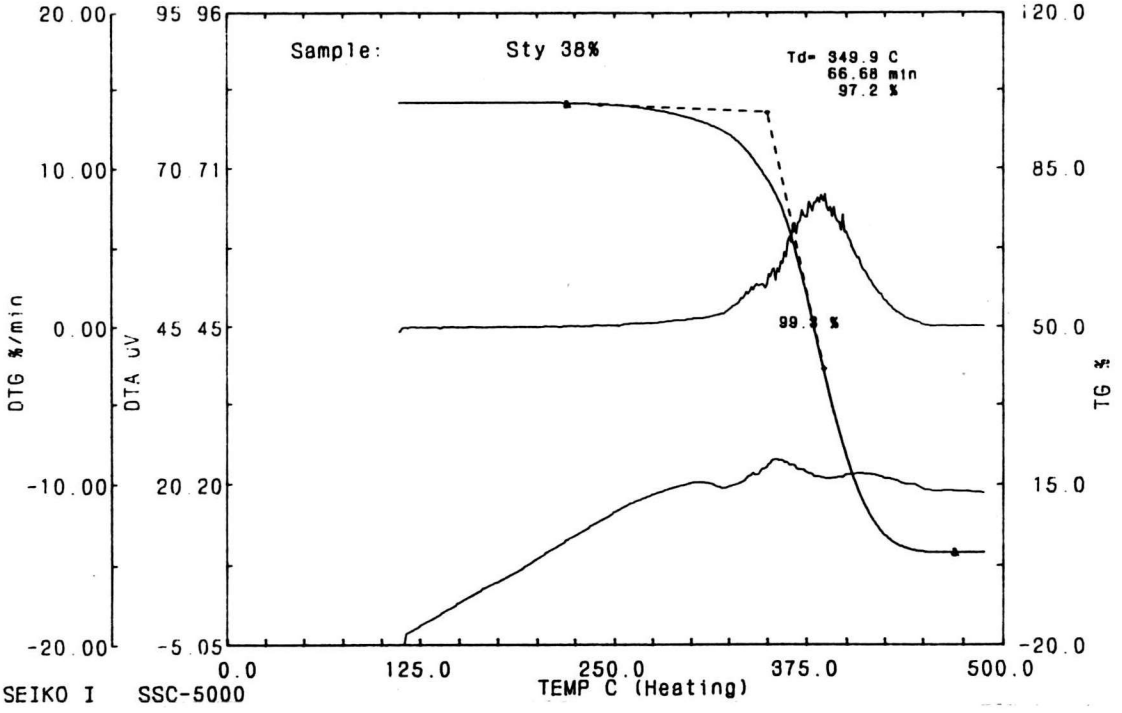



Figure I-3 TG/DTA curve of dispersion poly(St-co-MMA): St feed 38%

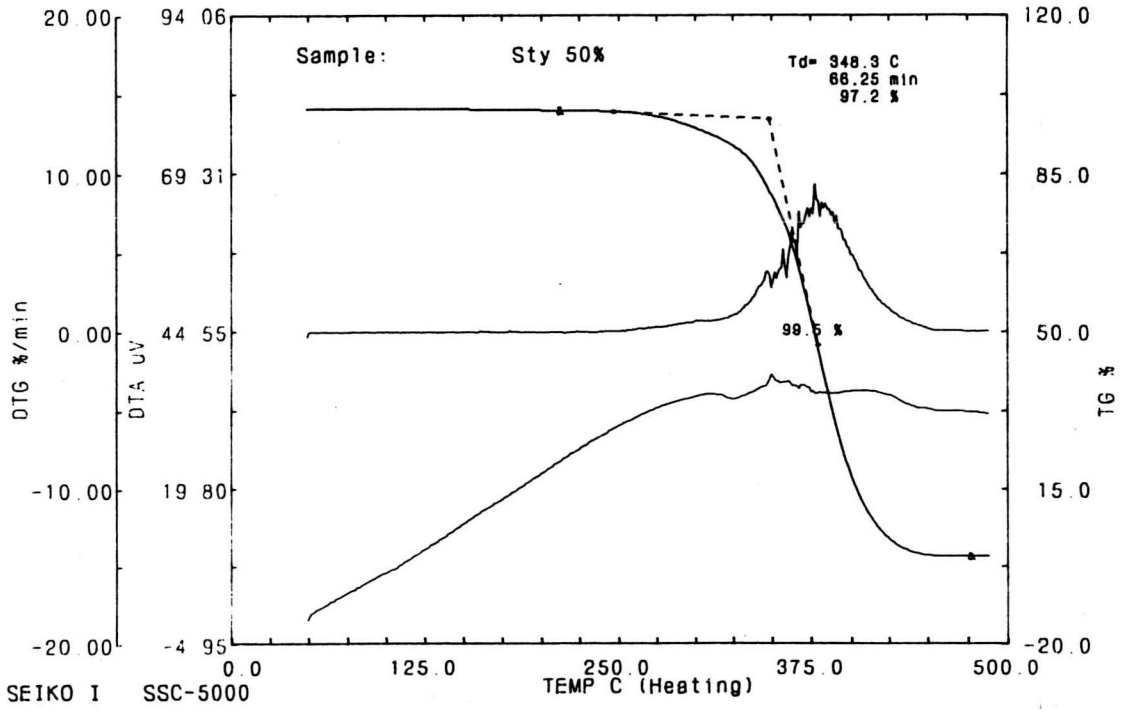



Figure I-4 TG/DTA curve of dispersion poly(St-co-MMA): St feed 50%

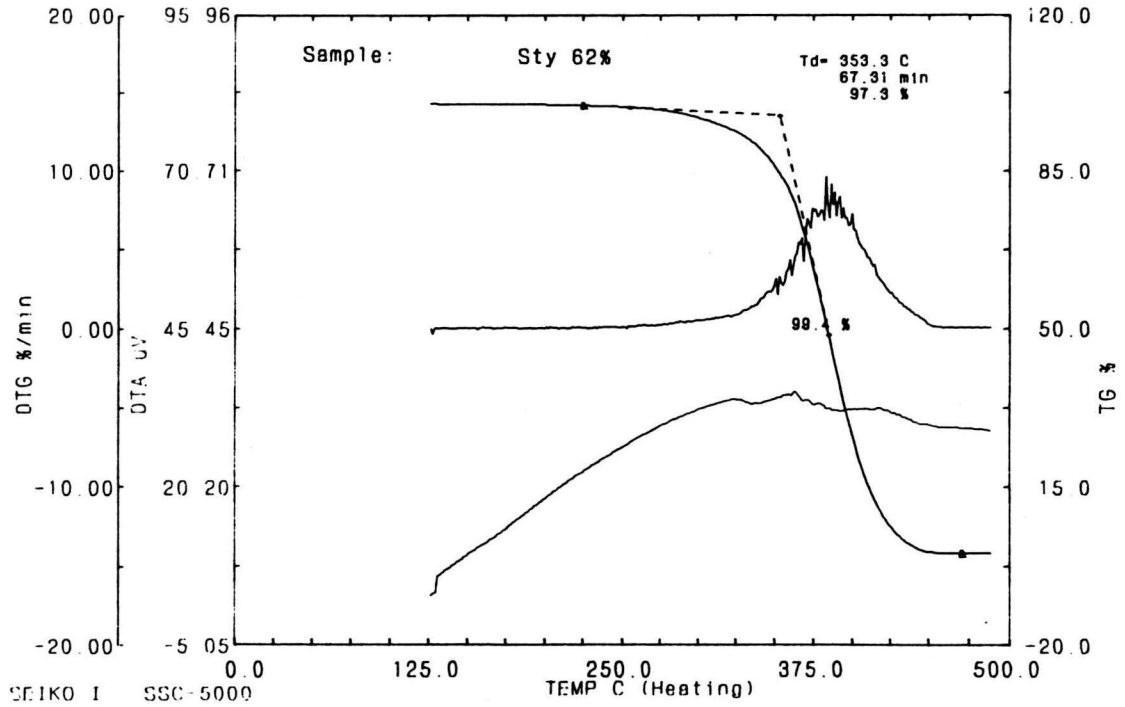



Figure I-5 TG/DTA curve of dispersion poly(St-co-MMA): St feed 62%

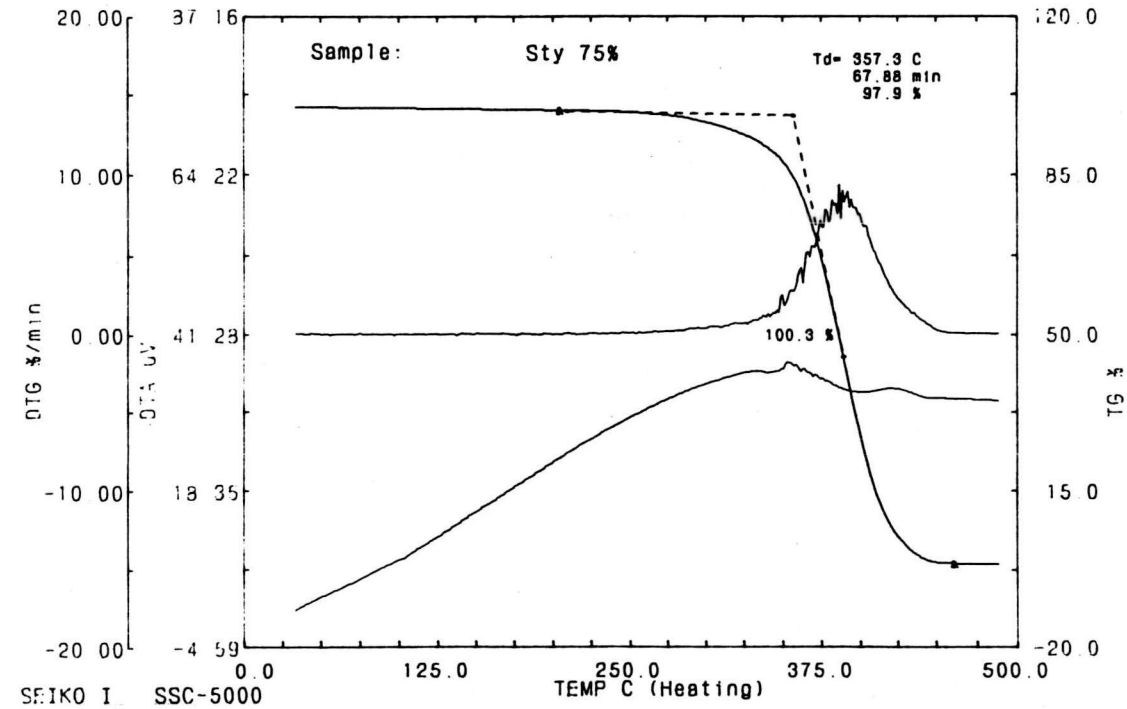



Figure I-6 TG/DTA curve of dispersion poly(St-co-MMA): St feed 75%

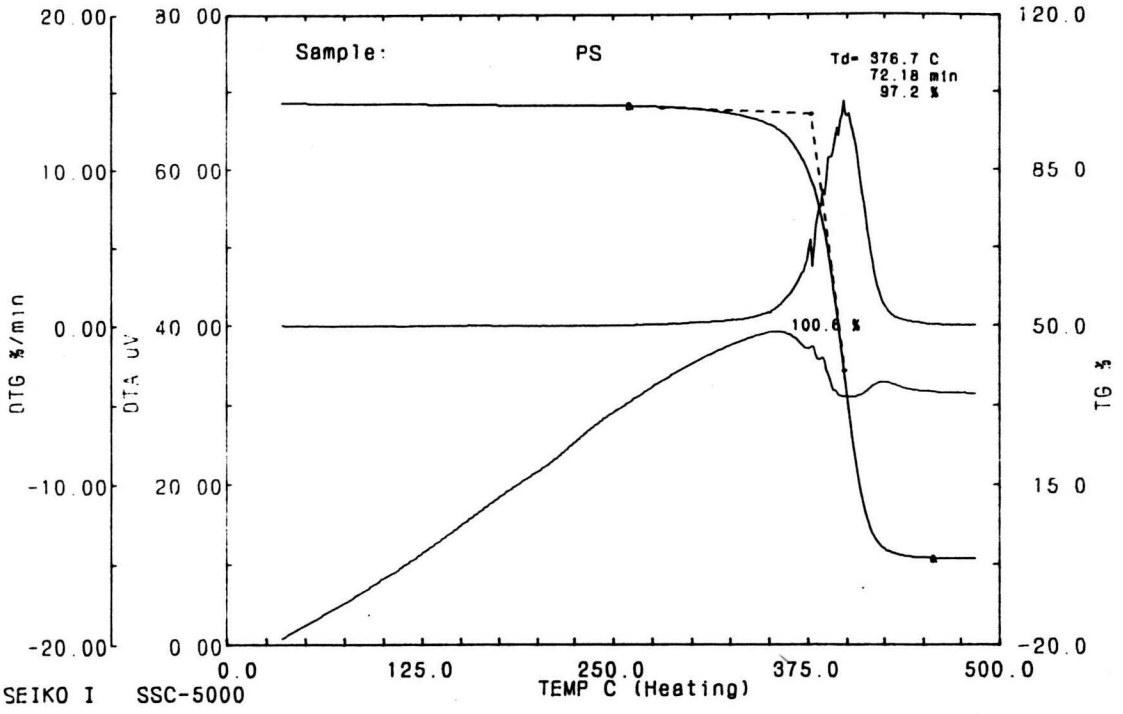



Figure I-7 TG/DTA curve of dispersion PS homopolymer

# VITA

Miss Saowaluk Apiwattananon was born on September 5, 1970 in Rayong, Thailand. She received her B.Sc. degree in Chemical Technology from the Faculty of Science, Chulalongkorn University in 1992 and she has been a graduate student in the Multidisciplinary Program of Petrochemistry-Polymer, Petrochemistry Division, Graduate School, Chulalongkorn University since 1992.