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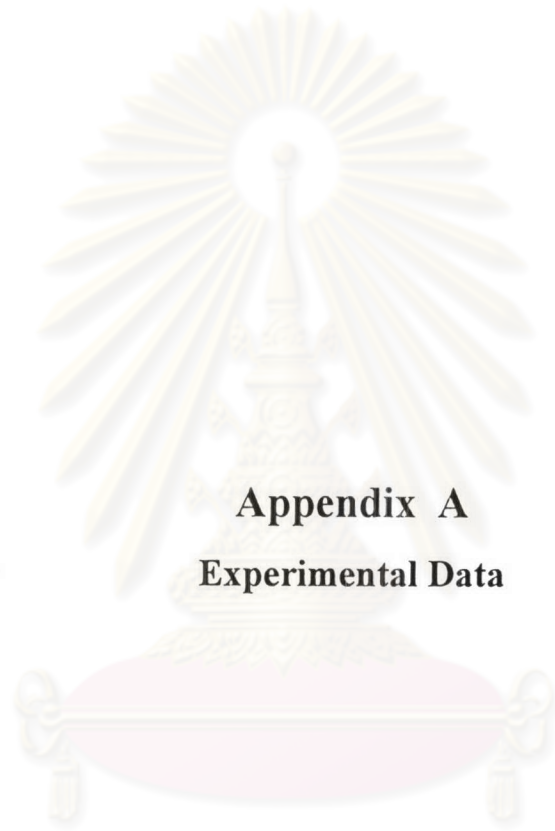
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**APPENDICES**

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย



**Appendix A**  
**Experimental Data**

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย

**Table A1 Experimental data of formula 2.5,7.5,0.01**

(2.5 g of cassava starch, 7.5 g of MMA monomer, and 0.01 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 4.11  | 4.37  | 4.34  | 4.88  | 4.71  |
| Weight of product obtained after Soxhlet extraction (g)    | 3.31  | 3.59  | 3.69  | 4.12  | 3.89  |
| Weight loss after Soxhlet extraction (g)                   | 0.80  | 0.78  | 0.65  | 0.76  | 0.82  |
| Weight obtained after acid hydrolysis (g)                  | 0.85  | 1.16  | 1.28  | 1.67  | 1.46  |
| Percent yield  | 41.06 | 43.66 | 43.36 | 48.75 | 47.05 |
| Percent monomer conversion                                 | 22.00 | 25.87 | 25.73 | 32.40 | 30.40 |
| Percent homopolymer formation                              | 48.48 | 40.21 | 33.68 | 31.28 | 35.96 |
| Percent Grafting Efficiency                                | 51.52 | 59.79 | 66.32 | 68.72 | 64.04 |
| Percent Grafting Ratio                                     | 34.00 | 46.40 | 51.20 | 66.80 | 58.40 |
| Percent Add-on   | 25.68 | 32.31 | 34.69 | 40.53 | 37.53 |

**Table A2 Experimental data of formula 2.5,7.5,0.1**

(2.5 g of cassava starch, 7.5 g of MMA monomer, and 0.1 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 5.68  | 6.16  | 6.28  | 5.83  | 5.95  |
| Weight of product obtained after Soxhlet extraction (g)    | 4.23  | 4.77  | 4.99  | 4.49  | 4.41  |
| Weight loss after Soxhlet extraction (g)                   | 1.45  | 1.39  | 1.29  | 1.34  | 1.54  |
| Weight obtained after acid hydrolysis (g)                  | 1.7   | 2.31  | 2.44  | 2.03  | 1.98  |
| Percent yield  | 56.24 | 60.99 | 62.18 | 57.72 | 58.91 |
| Percent monomer conversion                                 | 43.07 | 49.33 | 49.73 | 44.93 | 46.93 |
| Percent homopolymer formation                              | 44.89 | 37.57 | 34.58 | 39.76 | 43.75 |
| Percent Grafting Efficiency                                | 55.11 | 62.43 | 65.42 | 60.24 | 56.25 |
| Percent Grafting Ratio                                     | 71.21 | 92.40 | 97.60 | 81.20 | 79.20 |
| Percent Add-on   | 42.08 | 48.43 | 48.90 | 45.21 | 44.90 |



**Table A3 Experimental data of formula 2.5,7.5,1.0**

(2.5 g of cassava starch, 7.5 g of MMA monomer, and 1.0 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 7.47  | 7.82  | 7.88  | 7.73  | 7.64  |
| Weight of product obtained after Soxhlet extraction (g)    | 3.56  | 3.98  | 4.06  | 3.77  | 3.65  |
| Weight loss after Soxhlet extraction (g)                   | 3.91  | 3.84  | 3.82  | 3.96  | 3.99  |
| Weight obtained after acid hydrolysis (g)                  | 1.18  | 1.55  | 1.71  | 1.37  | 1.26  |
| Percent yield  | 67.91 | 71.09 | 71.64 | 70.27 | 69.45 |
| Percent monomer conversion                                 | 67.87 | 71.87 | 73.73 | 71.07 | 70.00 |
| Percent homopolymer formation                              | 76.82 | 71.24 | 69.08 | 74.30 | 76.00 |
| Percent Grafting Efficiency                                | 23.18 | 28.76 | 30.92 | 25.70 | 24.00 |
| Percent Grafting Ratio                                     | 47.20 | 62.00 | 68.40 | 54.80 | 50.40 |
| Percent Add-on   | 33.15 | 38.94 | 42.12 | 36.34 | 34.52 |

**Table A4 Experimental data of formula 5,5,0.01**

(5 g of cassava starch, 5 g of MMA monomer, and 0.01 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 7.98  | 8.05  | 8.14  | 8.06  | 8.13  |
| Weight of product obtained after Soxhlet extraction (g)    | 6.54  | 6.69  | 6.78  | 6.93  | 7.02  |
| Weight loss after Soxhlet extraction (g)                   | 1.44  | 1.36  | 1.36  | 1.13  | 1.11  |
| Weight obtained after acid hydrolysis (g)                  | 1.44  | 1.28  | 1.54  | 1.86  | 1.69  |
| Percent yield  | 79.72 | 80.42 | 81.32 | 80.52 | 81.22 |
| Percent monomer conversion                                 | 57.60 | 52.80 | 58.00 | 59.80 | 56.00 |
| Percent homopolymer formation                              | 50.00 | 51.52 | 46.90 | 37.79 | 39.64 |
| Percent Grafting Efficiency                                | 50.00 | 48.48 | 53.10 | 62.21 | 60.36 |
| Percent Grafting Ratio                                     | 28.80 | 25.60 | 30.80 | 37.20 | 33.80 |
| Percent Add-on   | 22.02 | 19.13 | 22.71 | 26.84 | 24.07 |

**Table A5 Experimental data of formula 5,5,0.1**

(5 g of cassava starch, 5 g of MMA monomer, and 0.1 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 8.69  | 9.24  | 9.65  | 9.71  | 9.59  |
| Weight of product obtained after Soxhlet extraction (g)    | 7.22  | 7.01  | 7.44  | 6.89  | 7.23  |
| Weight loss after Soxhlet extraction (g)                   | 1.47  | 2.23  | 2.21  | 2.82  | 2.36  |
| Weight obtained after acid hydrolysis (g)                  | 1.71  | 1.57  | 1.86  | 1.98  | 1.83  |
| Percent yield  | 86.04 | 91.49 | 95.54 | 96.14 | 94.95 |
| Percent monomer conversion                                 | 63.60 | 76.00 | 81.40 | 96.00 | 83.80 |
| Percent homopolymer formation                              | 46.23 | 58.68 | 54.30 | 58.75 | 56.32 |
| Percent Grafting Efficiency                                | 53.77 | 41.32 | 45.70 | 41.25 | 43.68 |
| Percent Grafting Ratio                                     | 34.20 | 41.40 | 37.20 | 39.60 | 36.0  |
| Percent Add-on   | 23.68 | 22.40 | 25.00 | 28.74 | 25.31 |

**Table A6 Experimental data of formula 5,5,1.0**

(5 g of cassava starch, 5 g of MMA monomer, and 1.0 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 9.32  | 9.39  | 9.57  | 9.78  | 9.89  |
| Weight of product obtained after Soxhlet extraction (g)    | 5.18  | 5.26  | 5.47  | 5.44  | 5.29  |
| Weight loss after Soxhlet extraction (g)                   | 4.14  | 4.13  | 4.10  | 4.34  | 4.60  |
| Weight obtained after acid hydrolysis (g)                  | 0.29  | 0.35  | 0.27  | 0.19  | 0.18  |
| Percent yield  | 84.73 | 85.36 | 87.00 | 88.91 | 89.91 |
| Percent monomer conversion                                 | 88.60 | 89.60 | 87.40 | 90.60 | 95.60 |
| Percent homopolymer formation                              | 93.45 | 92.19 | 93.82 | 96.51 | 96.23 |
| Percent Grafting Efficiency                                | 6.55  | 7.81  | 6.18  | 4.19  | 3.77  |
| Percent Grafting Ratio                                     | 5.80  | 7.00  | 5.40  | 3.80  | 3.60  |
| Percent Add-on   | 5.60  | 6.65  | 4.94  | 3.49  | 3.40  |

**Table A7 Experimental data of formula 7.5,2.5,0.01**

(7.5 g of cassava starch, 2.5 g of MMA monomer, and 0.01 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 8.01  | 8.19  | 7.89  | 7.84  | 7.88  |
| Weight of product obtained after Soxhlet extraction (g)    | 7.87  | 7.95  | 7.72  | 7.68  | 7.64  |
| Weight loss after Soxhlet extraction (g)                   | 0.14  | 0.24  | 0.26  | 0.16  | 0.24  |
| Weight obtained after acid hydrolysis (g)                  | 0.58  | 0.69  | 0.48  | 0.27  | 0.28  |
| Percent yield  | 80.02 | 81.82 | 79.72 | 78.32 | 78.72 |
| Percent monomer conversion                                 | 28.80 | 37.20 | 29.60 | 17.20 | 20.80 |
| Percent homopolymer formation                              | 19.44 | 25.81 | 35.14 | 37.21 | 46.15 |
| Percent Grafting Efficiency                                | 80.56 | 74.19 | 64.86 | 62.79 | 53.85 |
| Percent Grafting Ratio                                     | 7.73  | 9.20  | 6.40  | 3.60  | 3.73  |
| Percent Add-on   | 7.37  | 8.68  | 6.22  | 3.52  | 3.66  |

**Table A8 Experimental data of formula 7.5,2.5,0.1**

(7.5 g of cassava starch, 2.5 g of MMA monomer, and 0.1 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 8.16  | 8.78  | 8.75  | 8.67  | 8.18  |
| Weight of product obtained after Soxhlet extraction (g)    | 7.69  | 8.25  | 8.08  | 7.96  | 7.67  |
| Weight loss after Soxhlet extraction (g)                   | 0.47  | 0.53  | 0.67  | 0.71  | 0.51  |
| Weight obtained after acid hydrolysis (g)                  | 0.59  | 0.88  | 0.96  | 0.79  | 0.57  |
| Percent yield  | 80.79 | 86.93 | 86.63 | 85.84 | 80.99 |
| Percent monomer conversion                                 | 42.40 | 56.40 | 65.20 | 60.00 | 43.20 |
| Percent homopolymer formation                              | 44.34 | 37.59 | 41.10 | 47.33 | 47.22 |
| Percent Grafting Efficiency                                | 55.66 | 62.41 | 58.90 | 52.67 | 52.78 |
| Percent Grafting Ratio                                     | 7.87  | 11.73 | 12.80 | 10.53 | 7.60  |
| Percent Add-on   | 7.67  | 10.67 | 11.88 | 9.92  | 7.43  |

**Table A9 Experimental data of formula 7.5,2.5,1.0**  
(7.5 g of cassava starch, 2.5 g of MMA monomer, and 1.0 g of BPO were used)

| Reaction time<br>Data                                      | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| Weight of product obtained from graft copolymerization (g) | 8.64  | 9.55  | 9.61  | 9.32  | 9.39  |
| Weight of product obtained after Soxhlet extraction (g)    | 7.80  | 8.35  | 8.33  | 8.17  | 8.23  |
| Weight loss after Soxhlet extraction (g)                   | 0.84  | 1.20  | 1.28  | 1.15  | 1.16  |
| Weight obtained after acid hydrolysis (g)                  | 0.83  | 1.06  | 1.07  | 0.93  | 0.94  |
| Percent yield  | 78.55 | 86.82 | 87.36 | 84.73 | 85.36 |
| Percent monomer conversion                                 | 66.80 | 90.40 | 94.00 | 83.20 | 84.00 |
| Percent homopolymer formation                              | 50.30 | 53.10 | 54.47 | 55.29 | 55.24 |
| Percent Grafting Efficiency                                | 49.70 | 46.90 | 45.53 | 44.71 | 44.76 |
| Percent Grafting Ratio                                     | 11.07 | 14.13 | 14.27 | 12.40 | 12.53 |
| Percent Add-on   | 10.64 | 12.69 | 12.85 | 11.38 | 11.42 |

## Appendix B

### GPC Data

**Table B1 Explanation of sample names of GPC samples**

| Sample name | Formula*              | Type of PMMA |
|-------------|-----------------------|--------------|
| 1           | <b>PMMA reference</b> |              |
| 2           | 2.5,7.5,0.1,3         | grafted PMMA |
| 3           | 2.5,7.5,0.1,3         | homoPMMA     |
| 4           | 5,5,0.1,3             | grafted PMMA |
| 5           | 5,5,0.1,3             | homoPMMA     |
| 6           | 5,5,1,3               | grafted PMMA |
| 7           | 5,5,1,3               | homoPMMA     |
| 8           | 7.5,2.5,0.1,3         | grafted PMMA |
| 9           | 7.5,2.5,0.1,3         | homoPMMA     |

\* Formula a,b,c,d

Where

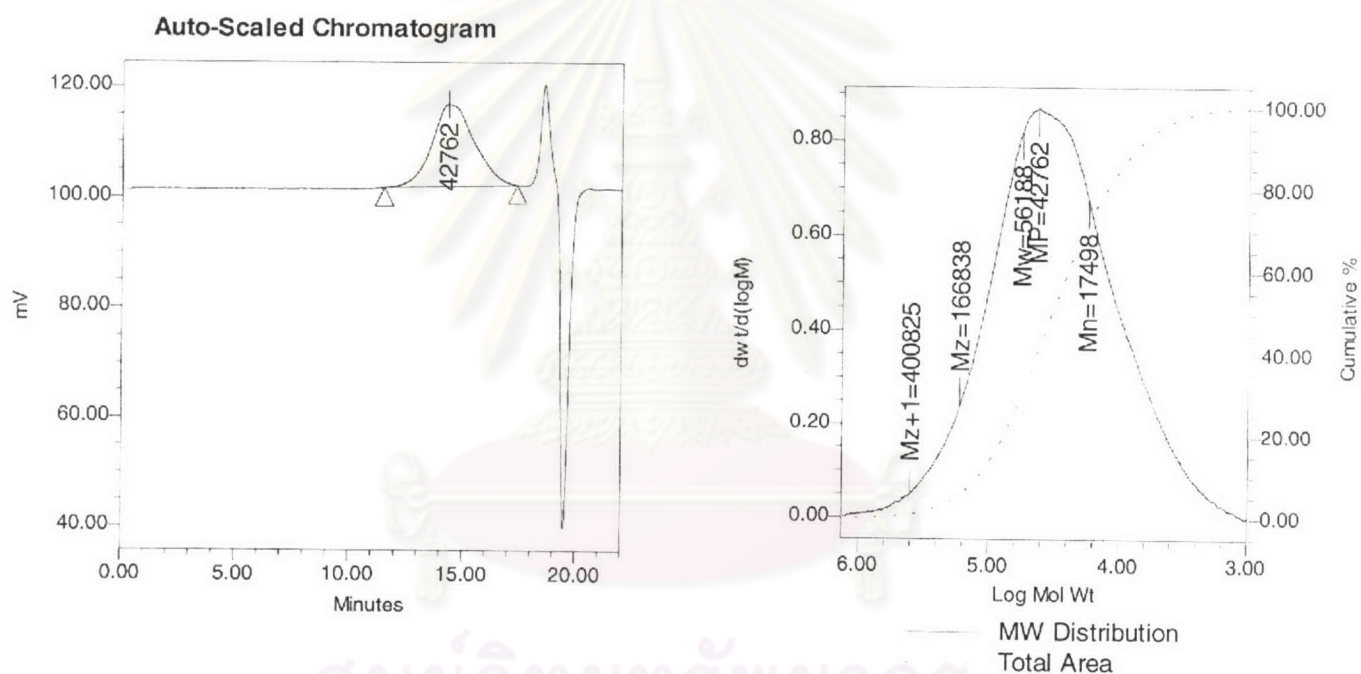
- a = the amount of cassava starch
- b = the amount of MMA monomer
- c = the amount of BPO
- d = the reaction time



Current Date 3/9/04

## Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 1            | Sample Type       | Broad Unknown           |
| Vial             | 1            | Date Acquired     | 3/9/04 2:39:13 PM       |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 3:55:22 PM       |
| Run Time         | 22.0 Minutes |                   |                         |



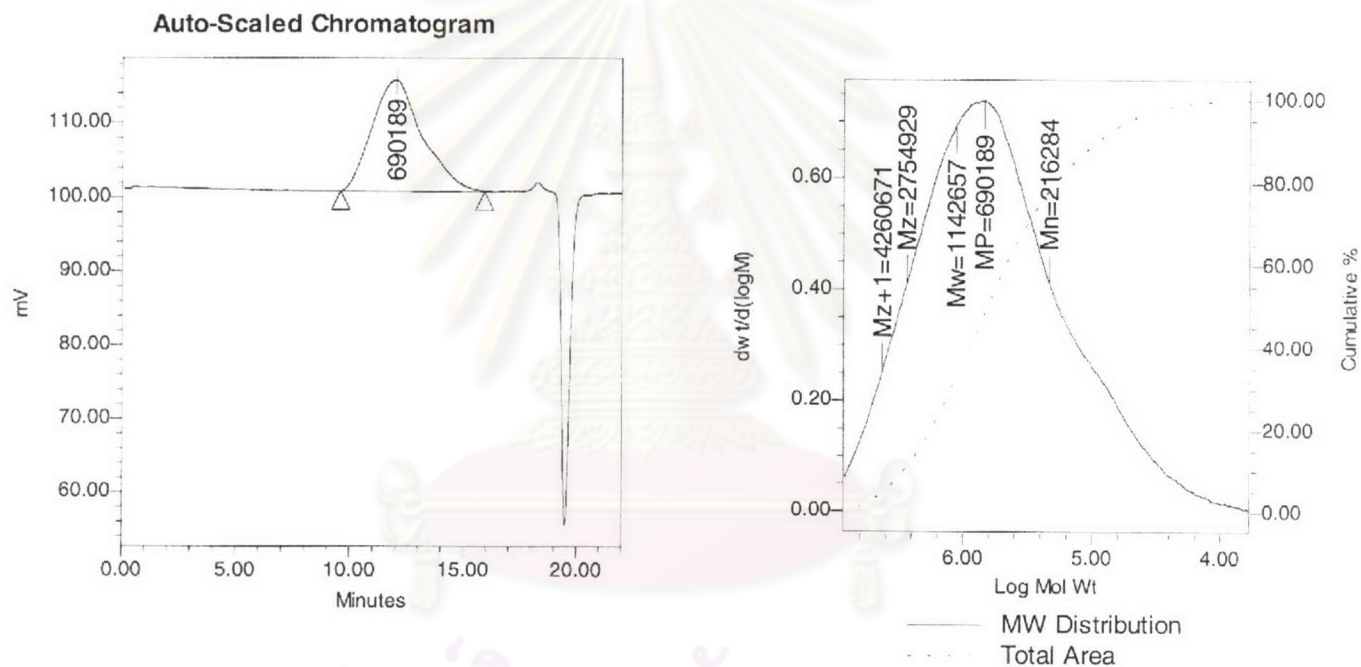
### Peak Results

|   | Name  | Mn    | Mw    | MP    | Mz     | Mz+1   | Polydispersity |
|---|-------|-------|-------|-------|--------|--------|----------------|
| 1 | Peak1 | 17498 | 56188 | 42762 | 166838 | 400825 | 3.211093       |
| 2 | Peak  |       |       |       |        |        |                |

Current Date 3/9/04

## Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 2            | Sample Type       | Broad Unknown           |
| Vial             | 2            | Date Acquired     | 3/9/04 11:04:08 AM      |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:27:03 PM       |
| Run Time         | 22.0 Minutes |                   |                         |



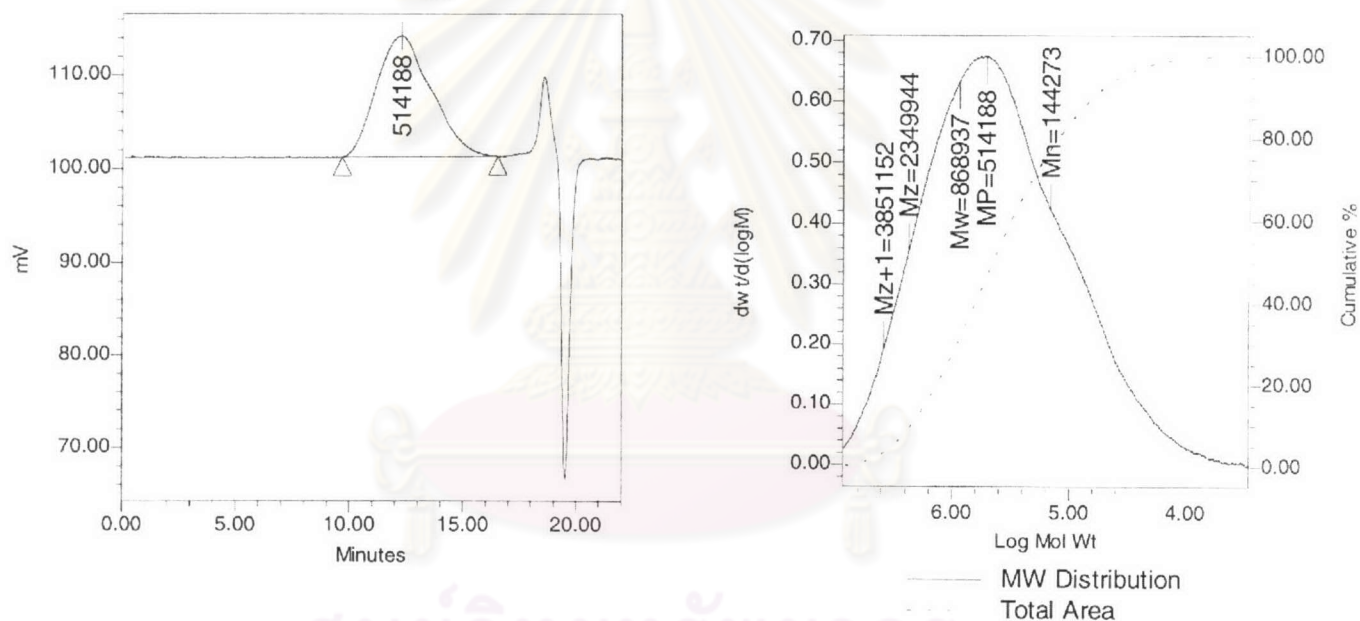
|   | Name  | Mn     | Mw      | MP     | Mz      | Mz+1    | Polydispersity |
|---|-------|--------|---------|--------|---------|---------|----------------|
| 1 | Peak1 | 216284 | 1142657 | 690189 | 2754929 | 4260671 | 5.283146       |
| 2 | Peak. |        |         |        |         |         |                |
| 3 | Peak  |        |         |        |         |         |                |

Current Date 3/9/04

## Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 3            | Sample Type       | Broad Unknown           |
| Vial             | 3            | Date Acquired     | 3/9/04 11:29:51 AM      |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:27:17 PM       |
| Run Time         | 22.0 Minutes |                   |                         |

### Auto-Scaled Chromatogram



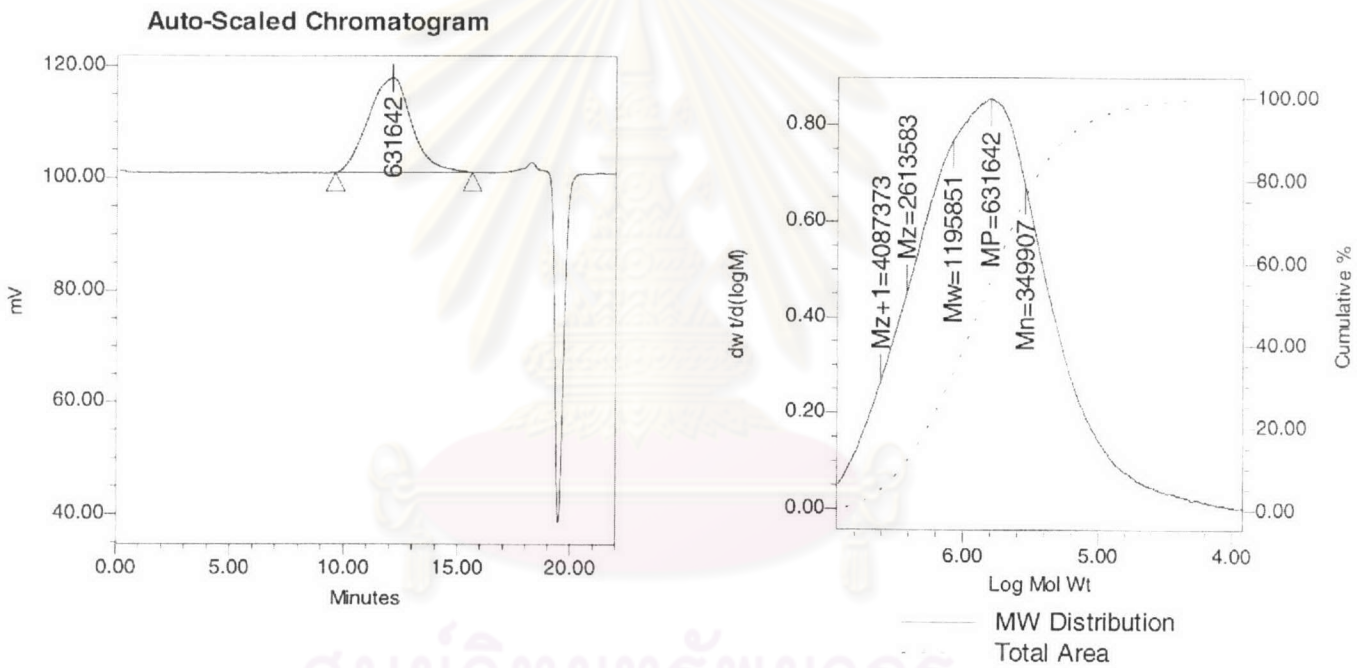
### Peak Results

|   | Name  | Mn     | Mw     | MP     | Mz      | Mz+1    | Polydispersity |
|---|-------|--------|--------|--------|---------|---------|----------------|
| 1 | Peak1 | 144273 | 868937 | 514188 | 2349944 | 3851152 | 6.022881       |
| 2 | Peak. |        |        |        |         |         |                |
| 3 | Peak. |        |        |        |         |         |                |

Current Date 3/9/04

### Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 4            | Sample Type       | Broad Unknown           |
| Vial             | 4            | Date Acquired     | 3/9/04 11:55:35 AM      |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:27:30 PM       |
| Run Time         | 22.0 Minutes |                   |                         |



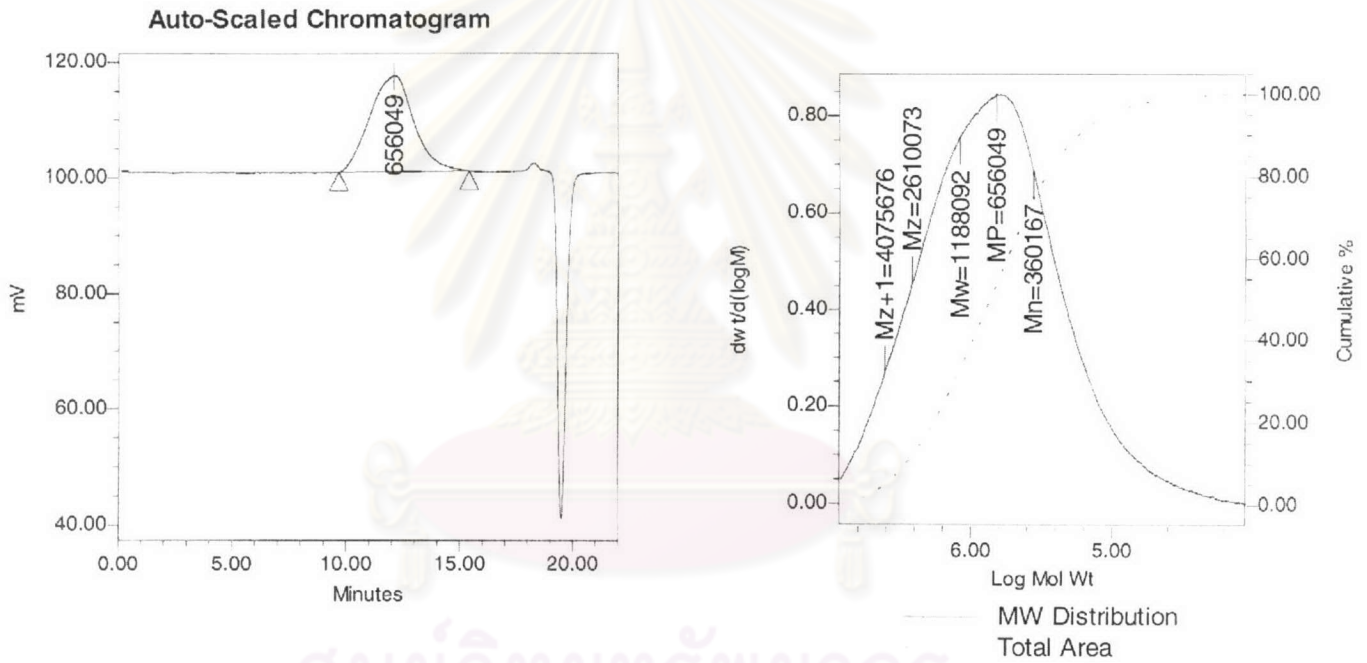
#### Peak Results

| Name    | Mn     | Mw      | MP     | Mz      | Mz+1    | Polydispersity |
|---------|--------|---------|--------|---------|---------|----------------|
| 1 Peak1 | 349907 | 1195851 | 631642 | 2613583 | 4087373 | 3.417629       |
| 2 Peak. |        |         |        |         |         |                |
| 3 Peak  |        |         |        |         |         |                |

Current Date 3/9/04

### Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 5            | Sample Type       | Broad Unknown           |
| Vial             | 5            | Date Acquired     | 3/9/04 12:21:17 PM      |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:27:40 PM       |
| Run Time         | 22.0 Minutes |                   |                         |



#### Peak Results

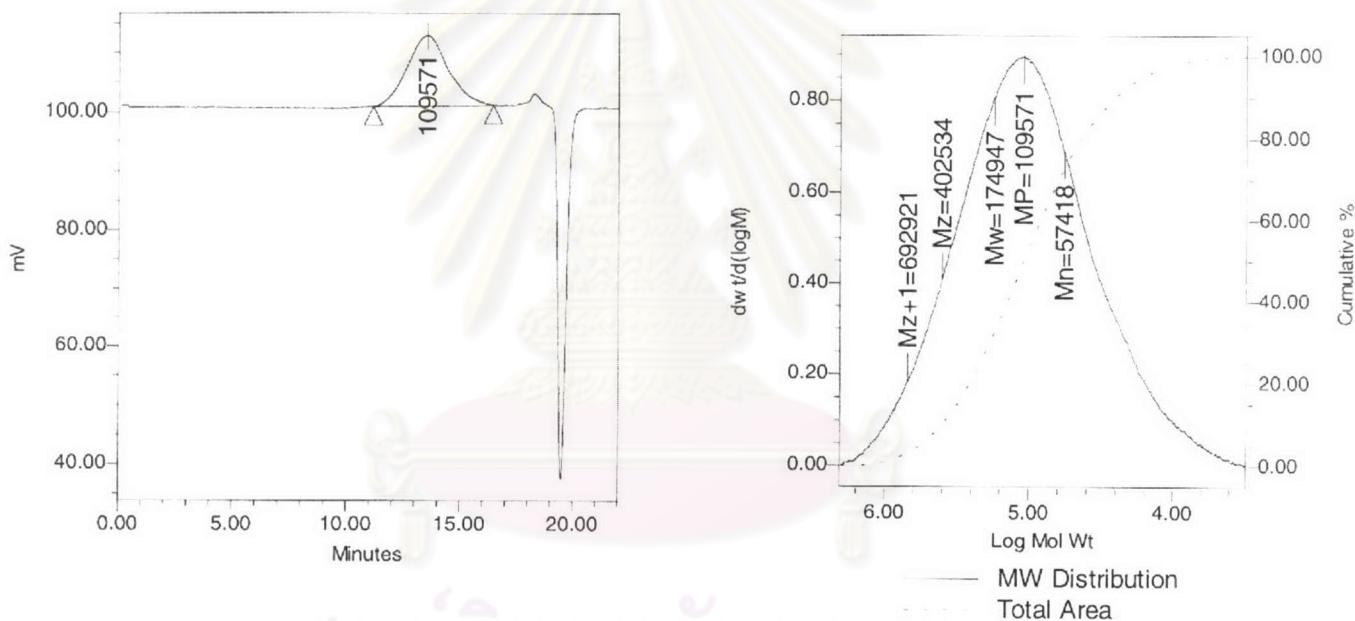
|   | Name  | Mn     | Mw      | MP     | Mz      | Mz+1    | Polydispersity |
|---|-------|--------|---------|--------|---------|---------|----------------|
| 1 | Peak1 | 360167 | 1188092 | 656049 | 2610073 | 4075676 | 3.298728       |
| 2 | Peak. |        |         |        |         |         |                |
| 3 | Peak. |        |         |        |         |         |                |

Current Date 3/9/04

### Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 6            | Sample Type       | Broad Unknown           |
| Vial             | 6            | Date Acquired     | 3/9/04 12:47:01 PM      |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:27:52 PM       |
| Run Time         | 22.0 Minutes |                   |                         |

Auto-Scaled Chromatogram



Peak Results

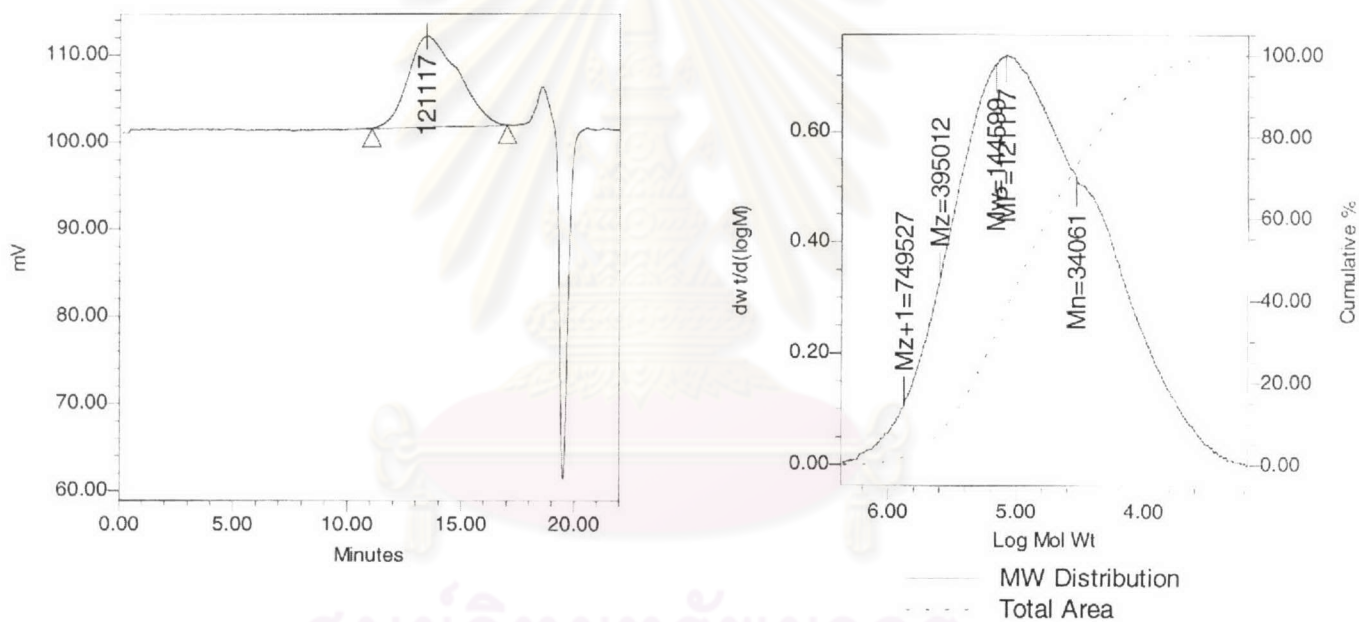
| Name    | Mn    | Mw     | MP     | Mz     | Mz+1   | Polydispersity |
|---------|-------|--------|--------|--------|--------|----------------|
| 1 Peak1 | 57418 | 174947 | 109571 | 402534 | 692921 | 3.046879       |
| 2 Peak. |       |        |        |        |        |                |

Current Date 3/9/04

## Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 7            | Sample Type       | Broad Unknown           |
| Vial             | 7            | Date Acquired     | 3/9/04 1:12:43 PM       |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:28:02 PM       |
| Run Time         | 22.0 Minutes |                   |                         |

### Auto-Scaled Chromatogram



### Peak Results

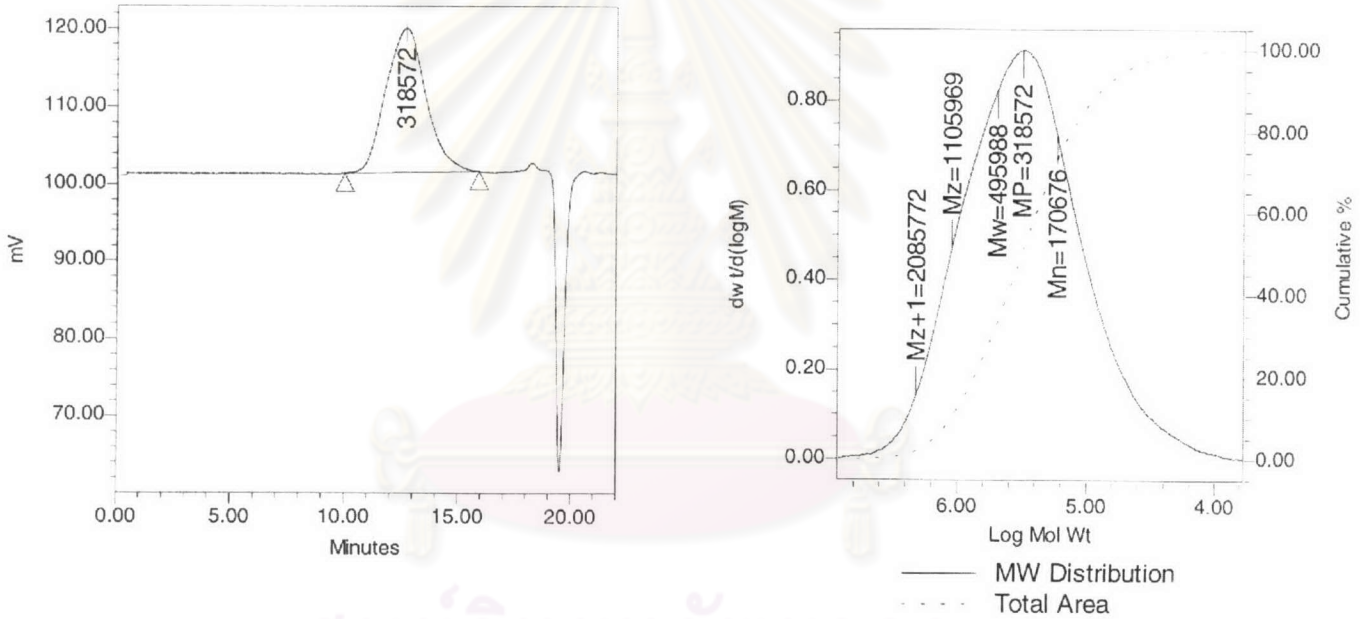
|   | Name  | Mn    | Mw     | MP     | Mz     | Mz+1   | Polydispersity |
|---|-------|-------|--------|--------|--------|--------|----------------|
| 1 | Peak1 | 34061 | 144599 | 121117 | 395012 | 749527 | 4.245339       |
| 2 | Peak  |       |        |        |        |        |                |

Current Date 3/9/04

### Sample Information

|                  |              |                   |                         |
|------------------|--------------|-------------------|-------------------------|
| SampleName       | 8            | Sample Type       | Broad Unknown           |
| Vial             | 8            | Date Acquired     | 3/9/04 1:38:27 PM       |
| Injection        | 1            | Acq Method Set    | Y2004_1_MethR_THF_30C_1 |
| Injection Volume | 100.00 ul    | Processing Method | Y2004_1_ProcR_THF_30C_1 |
| Channel          | SATIN        | Date Processed    | 3/9/04 2:28:13 PM       |
| Run Time         | 22.0 Minutes |                   |                         |

**Auto-Scaled Chromatogram**



**Peak Results**

|   | Name  | Mn     | Mw     | MP     | Mz      | Mz+1    | Polydispersity |
|---|-------|--------|--------|--------|---------|---------|----------------|
| 1 | Peak1 | 170676 | 495988 | 318572 | 1105969 | 2085772 | 2.906010       |
| 2 | Peak. |        |        |        |         |         |                |

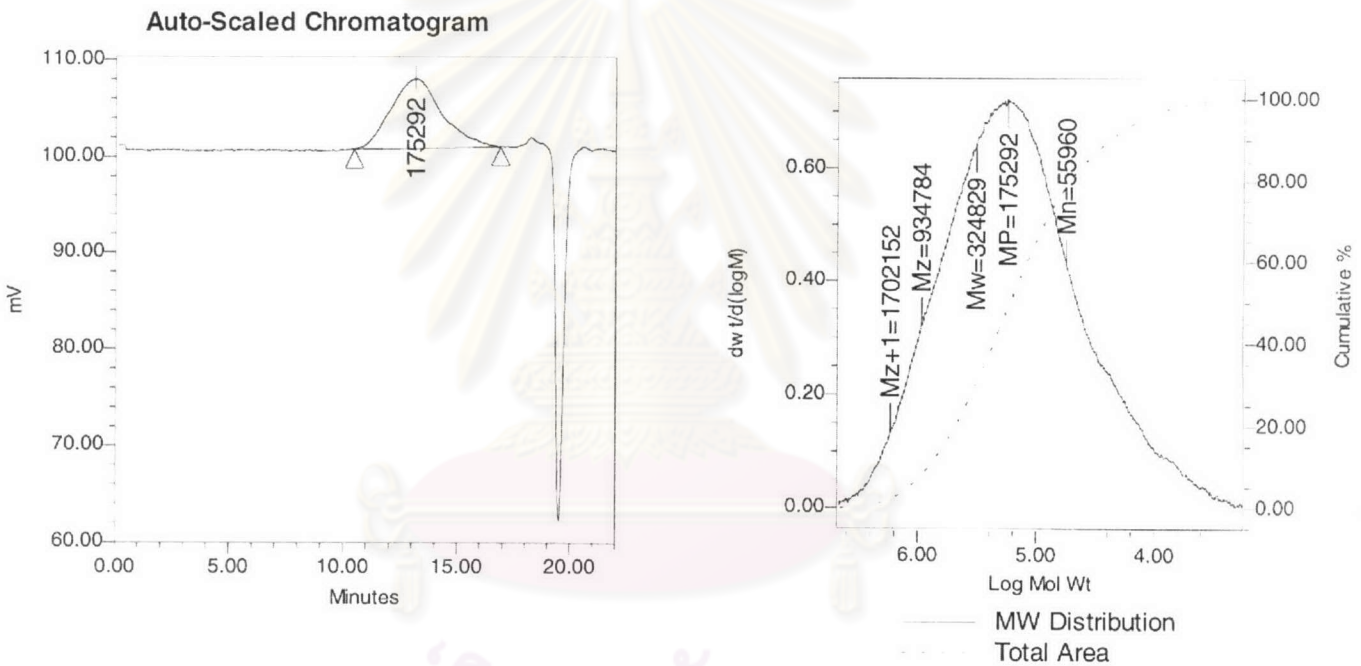


Current Date 3/9/04

### Sample Information

SampleName 9  
 Vial 9  
 Injection 1  
 Injection Volume 100.00 ul  
 Channel SATIN  
 Run Time 22.0 Minutes

Sample Type Broad Unknown  
 Date Acquired 3/9/04 2:04:09 PM  
 Acq Method Set Y2004\_1\_MethR\_THF\_30C\_1  
 Processing Method Y2004\_1\_ProcR\_THF\_30C\_1  
 Date Processed 3/9/04 2:28:21 PM



#### Peak Results

|   | Name  | Mn    | Mw     | MP     | Mz     | Mz+1    | Polydispersity |
|---|-------|-------|--------|--------|--------|---------|----------------|
| 1 | Peak1 | 55960 | 324829 | 175292 | 934784 | 1702152 | 5.804627       |
| 2 | Peak  |       |        |        |        |         |                |

## BIOGRAPHY

Miss Pranorm Thothong was born in Phranakhonsriayutthaya, Thailand, on August 17, 1975. She received the Degree of Bachelor of Science in Materials Science from the Department of Materials Science, Faculty of Science, Chulalongkorn University in 2001. Then, she continued her post graduate study in Applied Polymer Science and Textile Technology Major at the Department of Materials Science, Faculty of Science, Chulalongkorn University and ultimately completed the Degree of Master of Science in Applied Polymer Science and Textile Technology in May 2004.



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