



## REFERENCES

- Atkins, T. W., Peacock, S. J., and Yates, D.J. 1998. J. Microcapsule. 15: 31-44.
- Bakan, J.A. and Doshi, A.M. 1991. Coacervation /phase separation. Encyclopedia of Pharmaceutical Technology 3:21-29.
- Bakan, J.A., and Sloan, F.D. 1972. Microencapsulation of drugs. Drug and Cosmetic Ind. 110: 34-38, 117-120.
- Becher, P. 1983. Encyclopedia of Emulsion Technology. New York : Marcel Dekker.
- Chang, T.S., Macintosh, F.C., and Mason, S.G. 1966. Semipermeable aqueous microcapsules. Can. J. Physiol. Pharmacol. 44: 115-128.
- Cohen.S, and Bernstein, H. 1996. Microparticulate systems for the delivery of proteins and vaccines. New York : Marcel Dekker.
- Deasy, P.B. 1984. Microencapsulation and related drug processes. Drugs and the Pharmaceutical Sciences Vol. 20. New York : Marcel Dekker.
- Idson, B. 1993. Vitamin and the skin . Cosmetic & Toiletries 108:79-94.
- Ishizaka, T. 1981. Preparation of egg albumin microcapsules and microspheres. J.Pharm. Sci. 70: 358-363.
- Kondo, T. 1978. Microcapsules: Their preparation and properties. In L. Matijevic (ed.), Surface and Colloid Science vol. 10 :13.
- Koishi, M., Fukuhara, N. and Kondo, T. 1969. Microcapsule 2: Preparation of polyphthalamide microcapsules. Chem Phrm Bull 17: 804-809.
- Kondo, A. 1979. History and Classification of microencapsulation.
- Levy, M.-C. and Andry, M.-C. 1992. Microcapsules with wall made of cross-linked starch derivatives. In T.L. Whatley (ed.), Microencapsulation of Drugs. pp 7-16. Switzerland: Harwood Academic.
- Levy, M.-C., and Andry, M.-C. 1990. Microcapsules prepared through interfacial cross-linking of starch derivatives, Int. J. Pharm. 62:27-35.
- Modena, T. et.al. 1998. J. Microencapsul. 15: 85-92.
- Mathiowitz, E. 1999. Microencapsulation, Encyclopedia of Controlled Drug Delivery vol 2, pp 493-500. New York: Wiley Interscience.
- Mathiowitz, E. and Langer, R. 1987. J. Controlled Release. 5: 13-22.

- Mathiowitz, E. et al. 1988. J Appl Polym Sci. 35: 755-774.
- Morgan, P.W. 1965. Condensation polymers: Interfacial and solution methods, Polymers Reviews Series No. 10. New York: Interscience.
- Pekarek, K., Jacob, J. and Mathiowitz, E. 1994. Nature (London) 367: 258-260.
- Rambourg, P., Levy, J., and Levy, M.C. 1982. Microcapsulation IV: Cross-linked hemoglobin microcapsules. J.Pharm. Sci. 71. 759-762.
- Vanichtanukul, D. 1997. Microencapsulation of ascorbic acid by coacervation and solvent evaporation techniques. Master's Thesis, Department of Pharmacy, Graduate School, Chulalongkorn University.
- Wakamatsu, Y., Koishi, M. and Kondo, T. 1974. Microcapsule 17, Effect of chemical structure of acid chloride and biphenols on the formation of polyphenyl ester microcapsules. Chem Pharm Bull 22: 1319-1325.
- Whateley, L., T. 1996. Microcapsules: Preparation by interfacial polymerization and interfacial complexation and their application. In S. Benita (ed.), Microencapsulation Methods and Industrial Applications, pp 349-363. New York: Marcel.

## APPENDICES

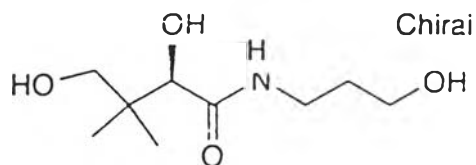
APPENDIX I  
DATA OF INGREDIENTS USED IN D-PANTHENOL MICROCAPSULES

## Albumin Fraction V Powder

|                          |   |
|--------------------------|---|
| CAP                      | 9048468   |
| Appearance               | white to yellow with a tan to green cast powder                   |
| Solubility               | Clear to slightly hazy faint yellow to yellow<br>soluble in water |
| Loss of Drying           | NMT 5%  |
| Nitrogen                 | 14.5-16,5%  |
| Identity                 | of Bovine origin  |
| pH                       | 6.8 to 7.2 (1% in 0.15 M Sodium chloride)                         |
| Agarose Electrophoresis  | NLT 98%   |
| Storage Temp             | Store at 2-8°C  |
| Shelf life sup QC-12-006 | 5 years   |

## D-Panthenol

Chemical structure  $C_9H_{19}NO_4$



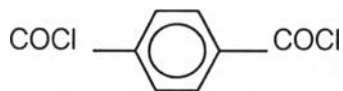
$C_9H_{19}NO_4$

$M_r$  205.25

|                |   |
|----------------|---|
| Mw.            | 205.25  |
| CAS NO:        | 81-13-0   |
| INCI Name      | Panthenol   |
| Chemical names | (R)-2, 4-dihydroxy-N-(3-hydroxy propyl) -3, 3-dimethylbutyramide;<br>D(+)- $\alpha$ , $\gamma$ -dihydroxy-N-(3-hydroxy propyl)- $\beta$ - $\beta$ -<br>dimethylbutanamide |
| Solubility     | Soluble in water freely soluble in ethanol, slightly soluble in ether<br>and in insoluble in fats and oils  |
| pH             | max 9.0-10.5 (5% w/v in water)  |
| Water max      | 1.0%  |
| Sulphated max  | max 0.1%  |
| Heavy metal    | max 10 ppm  |
| Assay          | 98.0-101.0%   |

## Terephthaloyl Chloride (TC)

p-Phthaloyl Chloride



|                 |   |
|-----------------|---|
| Description     | white crystalline solid at room temperature |
| MW              | 203.  |
| Soluble         | organic solvents, methylene chloide, ether  |
| Boiling point°C | 265   |

## Span 85

Sorbitan trioleate

Sorbitan, ester, tri-9-octadecanoate

Empirical formula  $C_{60}H_{108}O_8$ 

Molecular weight 958

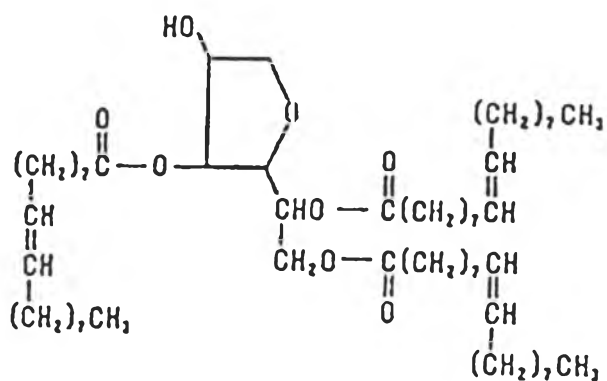
HLB 1.8

Melting point range liquid

Functional category Wetting and/or solubilizing agent

Emulsifying and/or solubilizing agent

Structure formula





APPENDIX II  
VALIDATION OF THE HPLC ANALYSIS

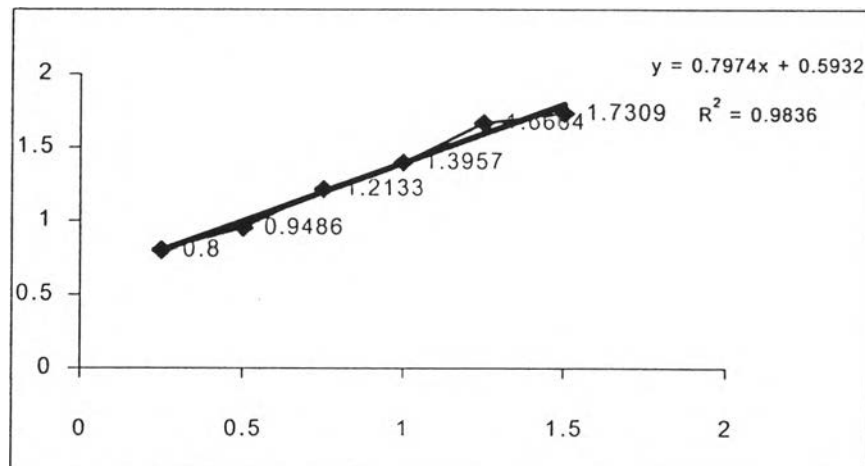
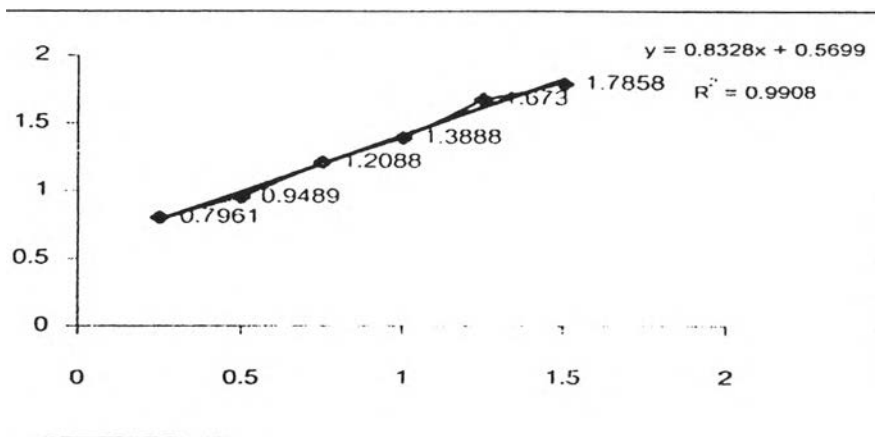
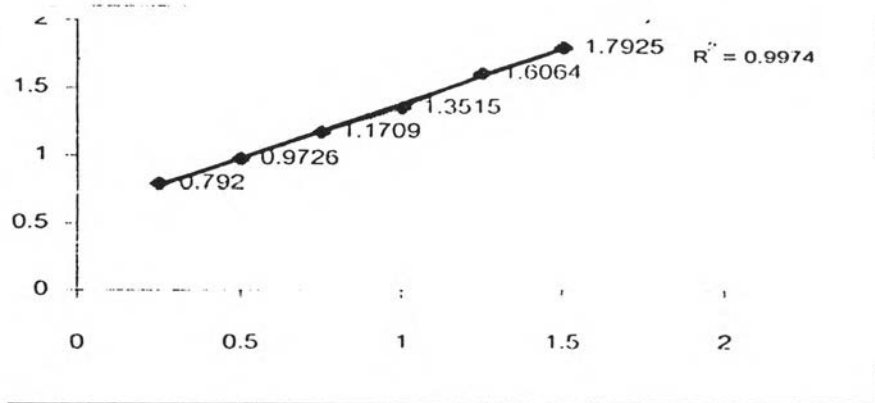


Figure 45 The calibration curve of D-pantanol for within run precision. No1, No2, No3.

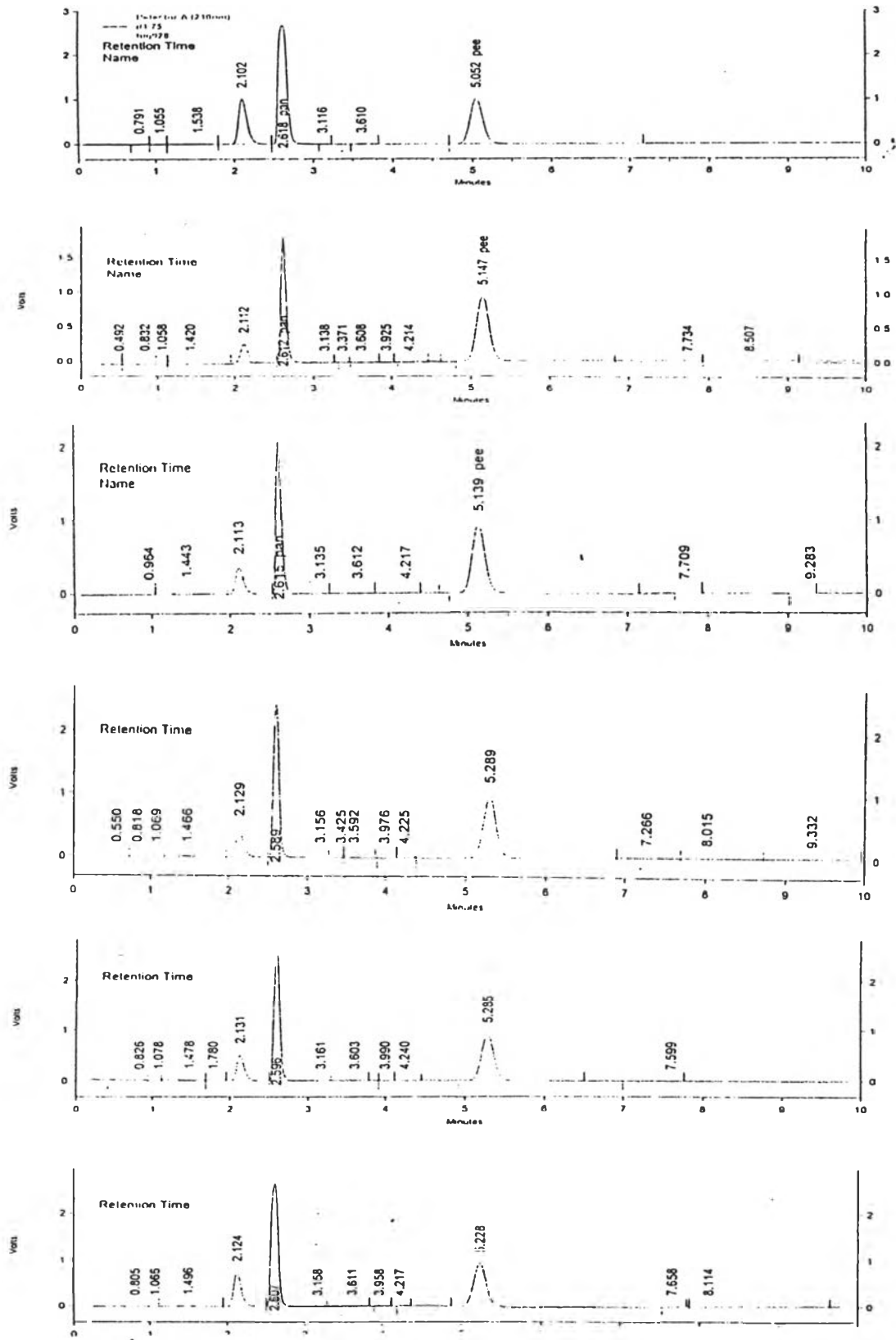


Figure 46 The chromatogram of D-panthenol standard solution within run precision (No.1).



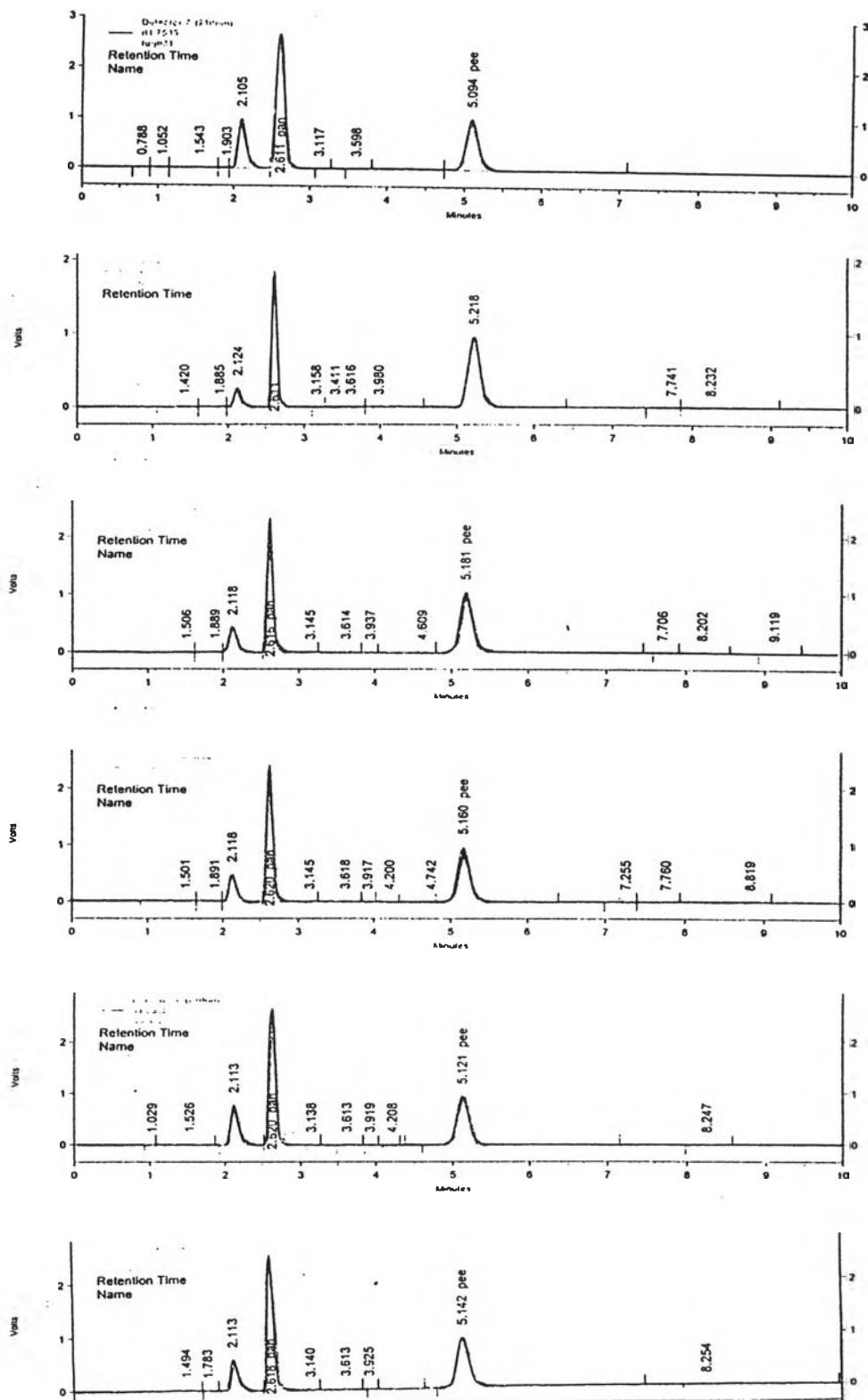


Figure 48 The chromatogram of D-panthenol standard solution within run precision (No.3).

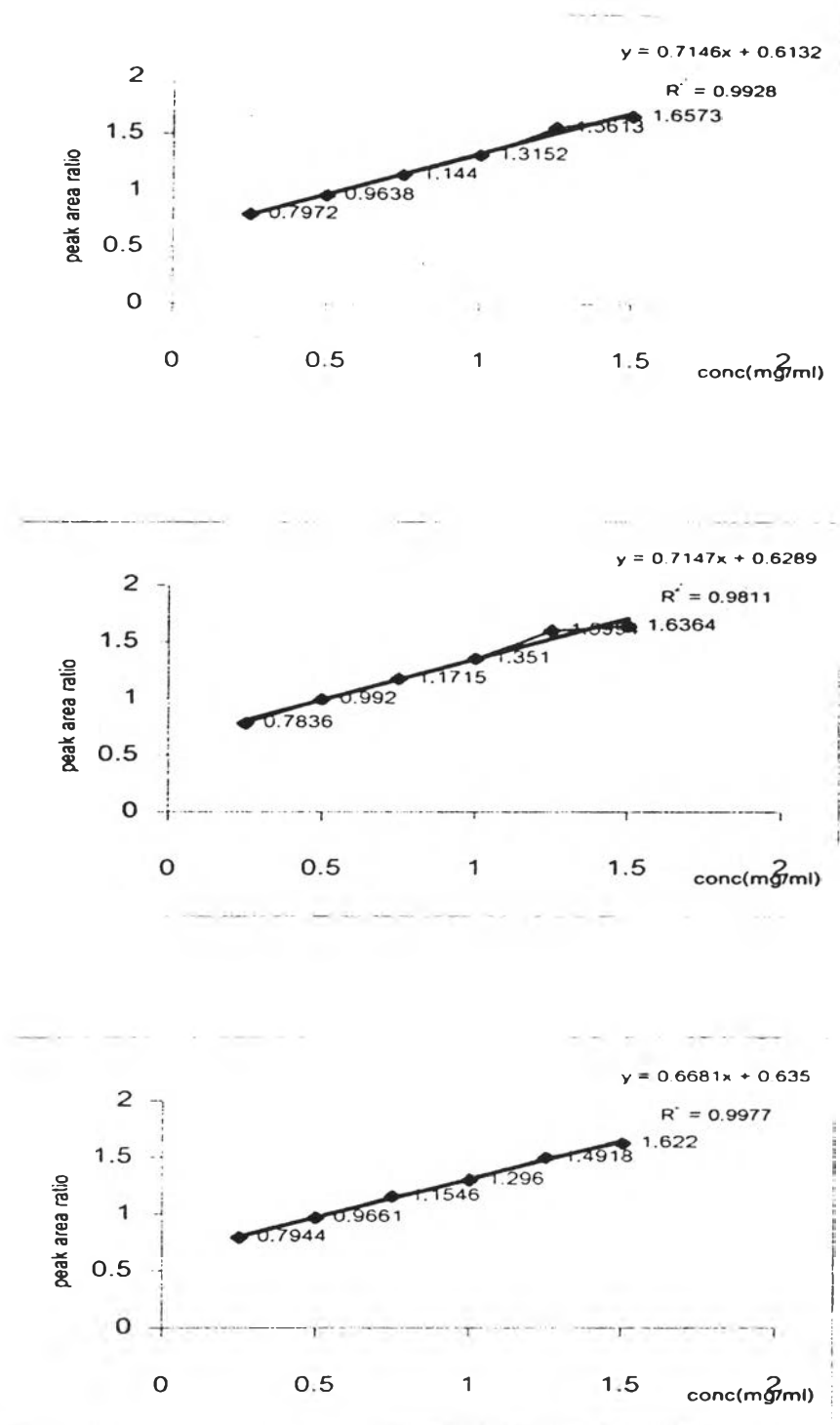


Figure 49 The calibration curve of D-panthenol between run precision day1, day2, day3.

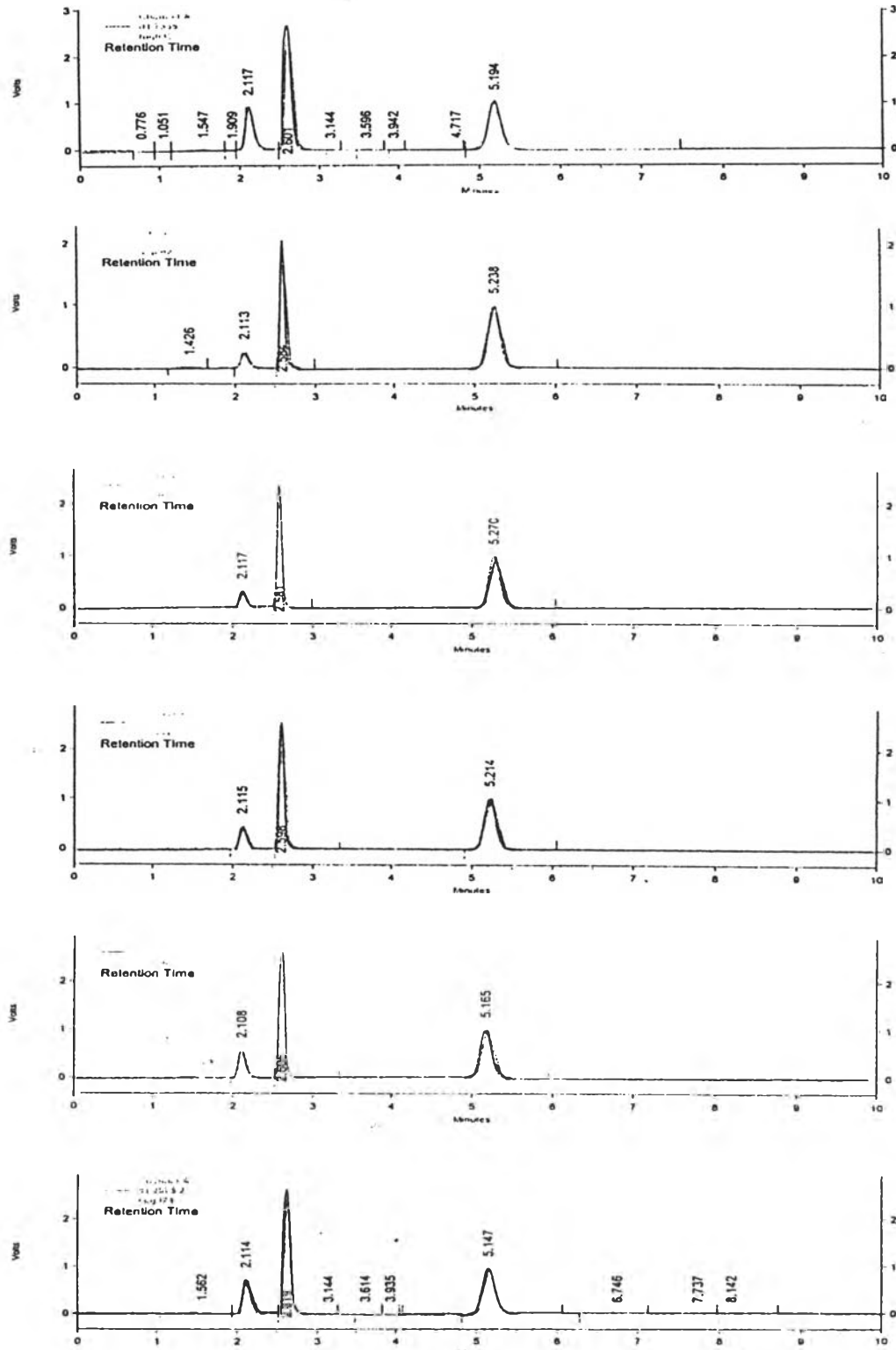


Figure 50 The chromatogram of D-panthenol standard solution between run precision (Day 1).

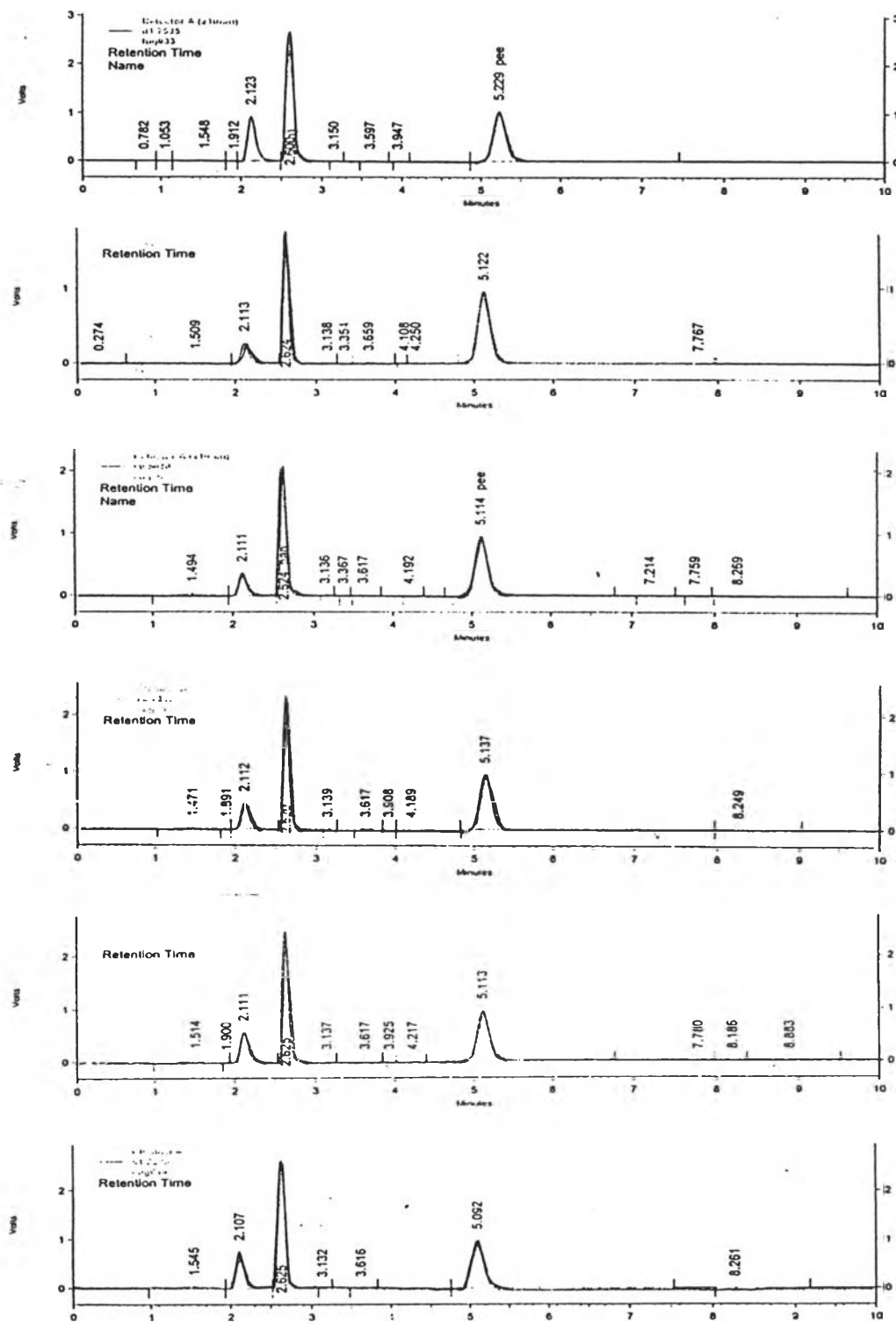


Figure 51 The chromatogram of D-pantethol standard solution between run precision (Day 2).



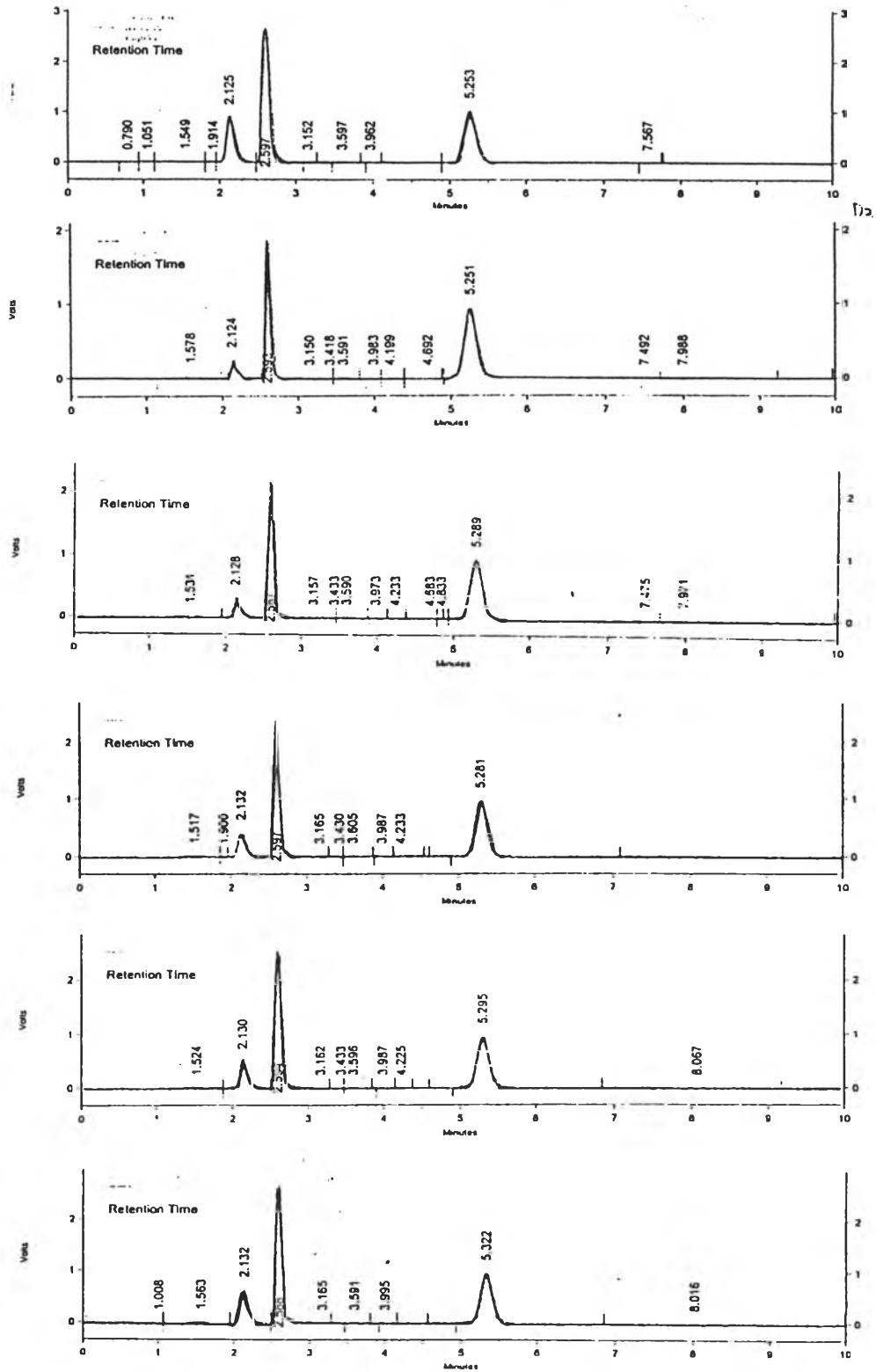


Figure 52 The chromatogram of D-panthenol standard solution between run precision (Day 3).

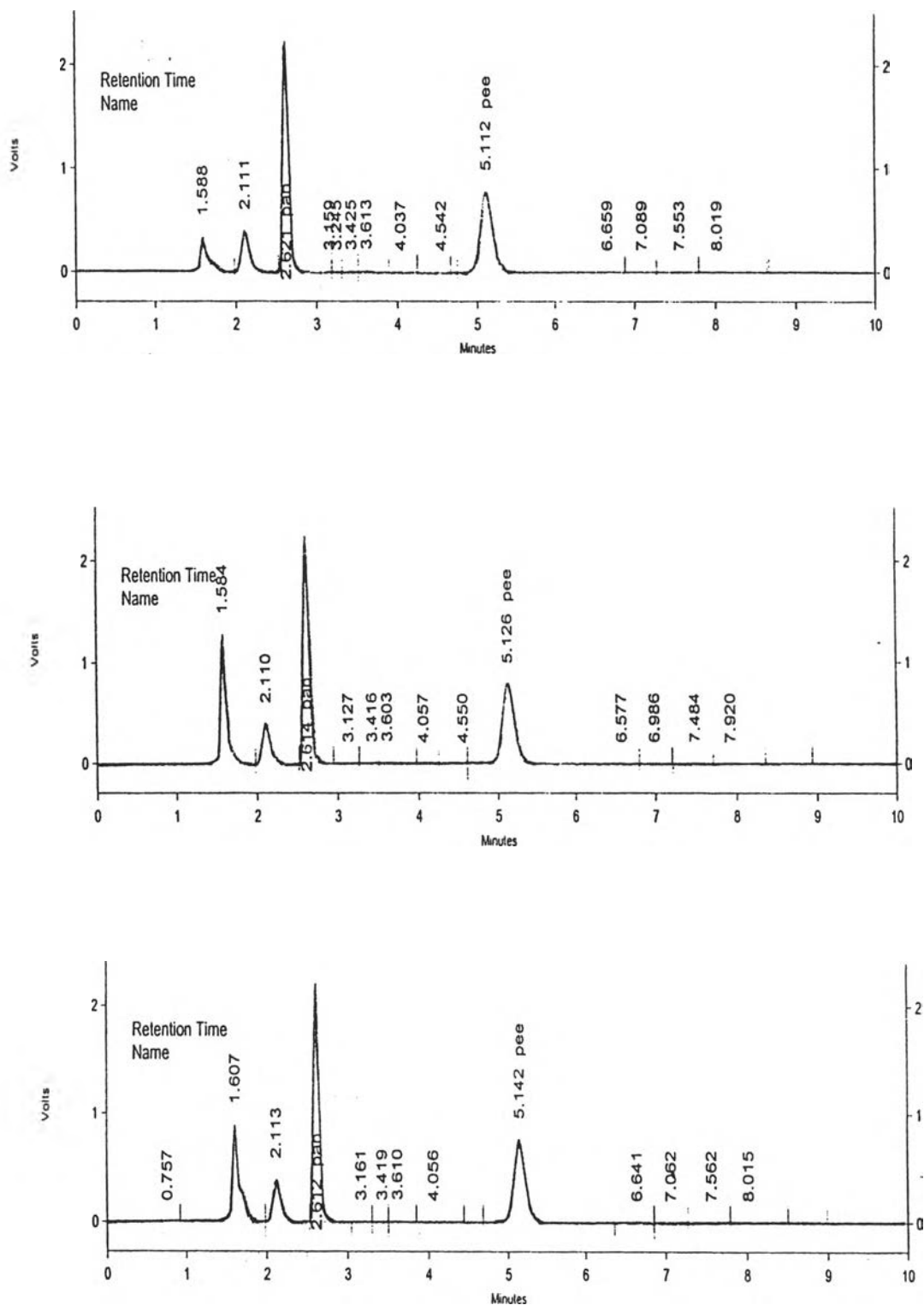


Figure 53 The chromatogram of D-panthenol microcapsules D3 (13.3% w/v BSA, 16.6%w/v D-panthenol).

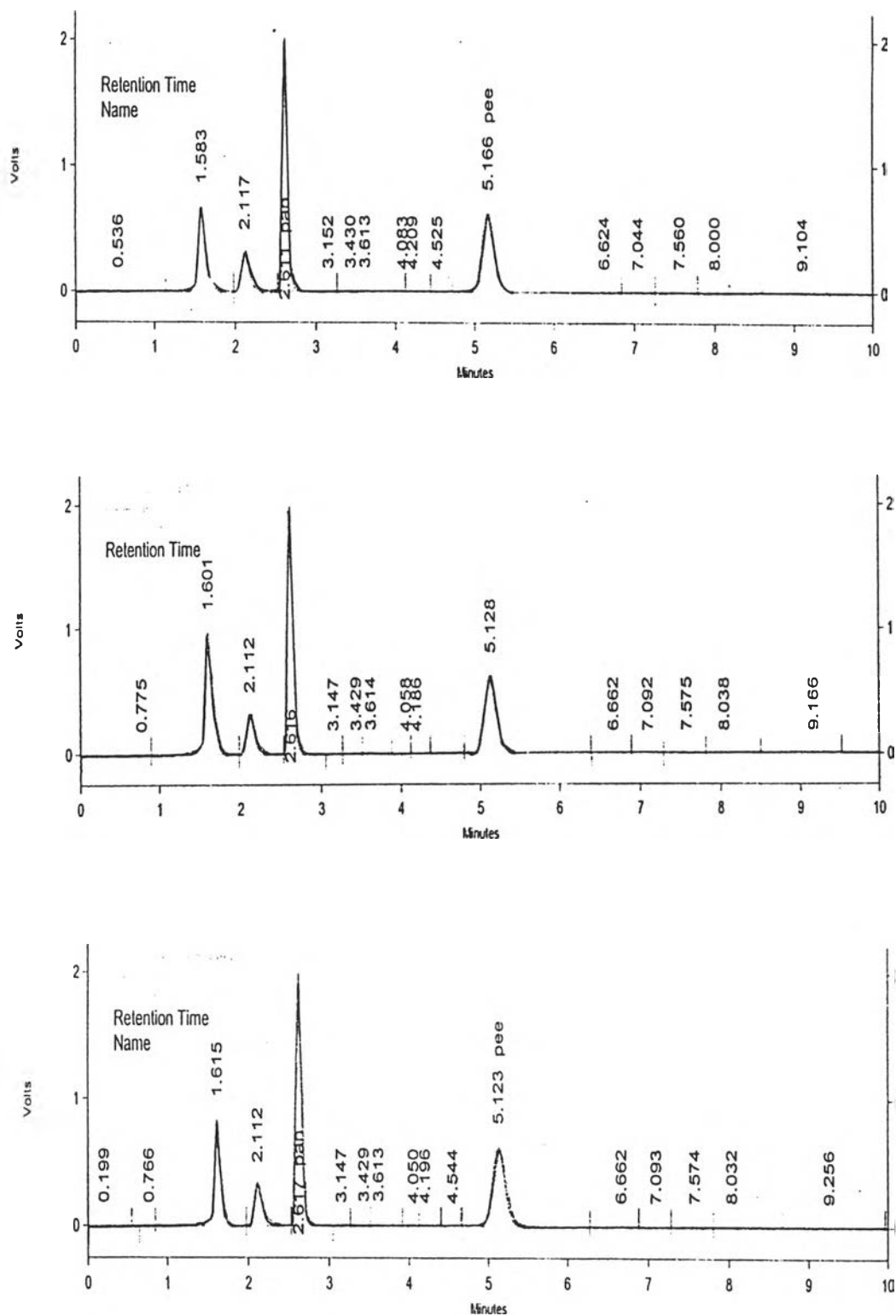


Figure 54 The chromatogram of D-panthenol microcapsules D5 (20%w/v BSA, 13.3%w/v D-panthenol).

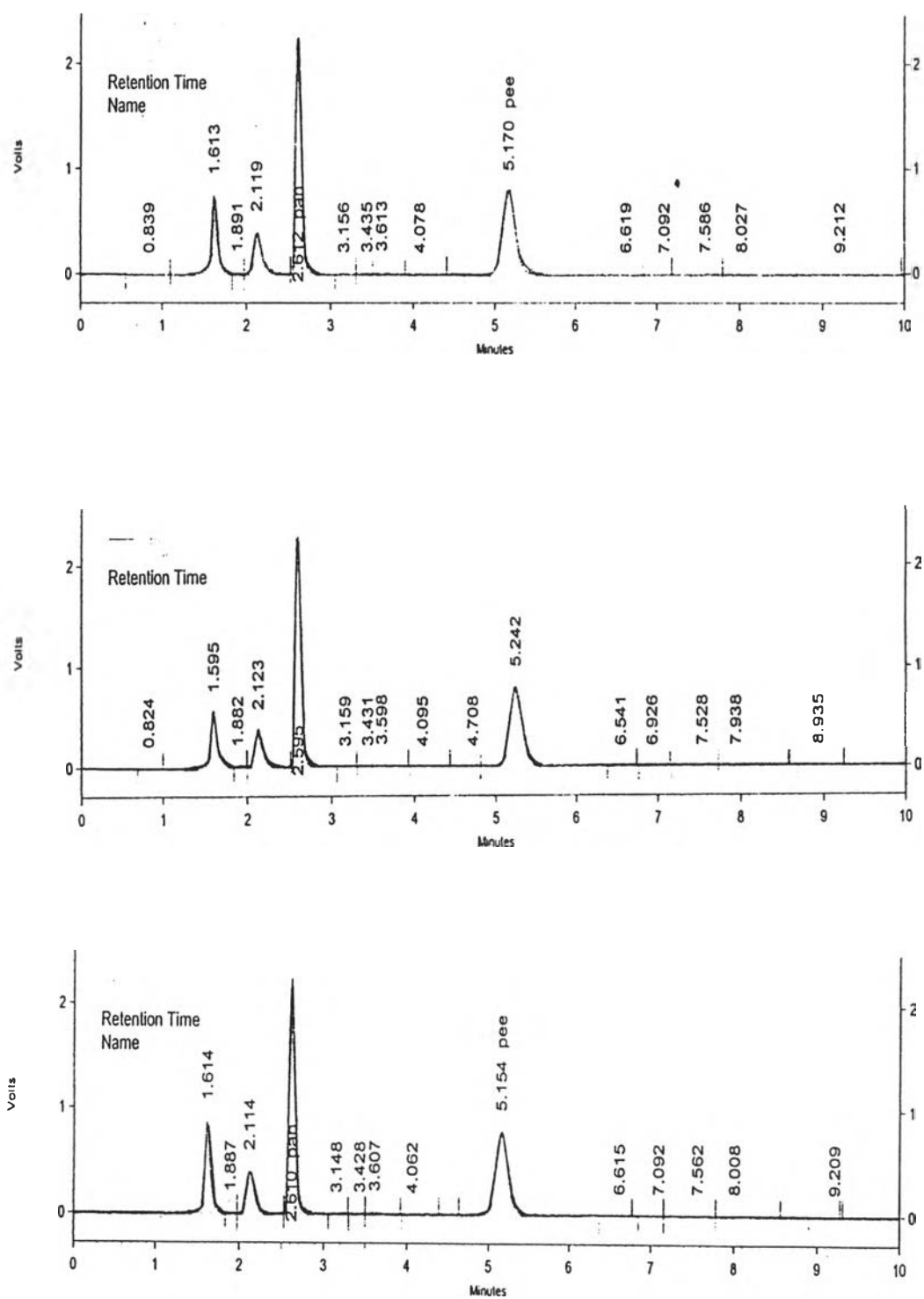


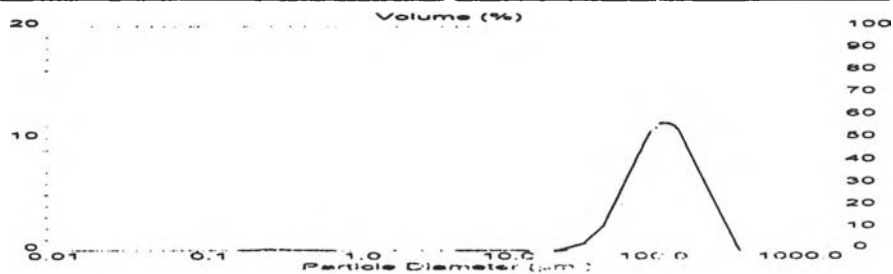
Figure 55 The chromatogram of D-panthenol microcapsules D6 (20%w/v BSA, 16.6% w/v D-panthenol).

APPENDIX III  
DATA OF PARTICLE SIZE AND SIZE DISTRIBUTION

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 300RF mm         | Beam Length: 2.40 mm                | Sampler: MS1              | Obscuration: 15.7 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] |                     |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.593 %   |
| Modifications: Active -      | Killed Data Channels: Low 0; High 2 |                           |                     |

| Result Statistics        |                             |                             |                                  |
|--------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type/Volume | Concentration = 0.1045 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.2840 sq. m / g |
| Mean Diameters:          | D [v, 0.1] = 60.27 um       | D [v, 0.5] = 122.58 um      | D [v, 0.9] = 233.70 um           |
| D [4, 3] = 135.32 um     | D [3, 2] = 21.12 um         | Span = 1.415E+00            | Uniformity = 4.415E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 0.05          | 0.00 | 0.06           | 0.00   | 6.63          | 0.07  | 7.72           | 1.78   |
| 0.06          | 0.00 | 0.07           | 0.00   | 7.72          | 0.08  | 9.00           | 1.86   |
| 0.07          | 0.00 | 0.08           | 0.00   | 9.00          | 0.09  | 10.48          | 1.94   |
| 0.08          | 0.00 | 0.09           | 0.01   | 10.48         | 0.08  | 12.21          | 2.03   |
| 0.09          | 0.00 | 0.11           | 0.01   | 12.21         | 0.07  | 14.22          | 2.10   |
| 0.11          | 0.01 | 0.13           | 0.02   | 14.22         | 0.05  | 16.57          | 2.15   |
| 0.13          | 0.01 | 0.15           | 0.03   | 16.57         | 0.04  | 19.31          | 2.19   |
| 0.15          | 0.02 | 0.17           | 0.05   | 19.31         | 0.03  | 22.49          | 2.22   |
| 0.17          | 0.04 | 0.20           | 0.09   | 22.49         | 0.07  | 26.20          | 2.29   |
| 0.20          | 0.08 | 0.23           | 0.16   | 26.20         | 0.18  | 30.53          | 2.47   |
| 0.23          | 0.13 | 0.27           | 0.29   | 30.53         | 0.41  | 35.56          | 2.88   |
| 0.27          | 0.17 | 0.31           | 0.45   | 35.56         | 0.86  | 41.43          | 3.74   |
| 0.31          | 0.16 | 0.36           | 0.61   | 41.43         | 1.63  | 48.27          | 5.37   |
| 0.36          | 0.13 | 0.42           | 0.75   | 48.27         | 2.82  | 56.23          | 8.18   |
| 0.42          | 0.11 | 0.49           | 0.86   | 56.23         | 4.50  | 65.51          | 12.68  |
| 0.49          | 0.10 | 0.58           | 0.96   | 65.51         | 6.51  | 76.32          | 19.20  |
| 0.58          | 0.07 | 0.67           | 1.03   | 76.32         | 8.51  | 88.91          | 27.71  |
| 0.67          | 0.06 | 0.78           | 1.09   | 88.91         | 10.11 | 103.58         | 37.82  |
| 0.78          | 0.05 | 0.91           | 1.13   | 103.58        | 11.03 | 120.67         | 48.85  |
| 0.91          | 0.04 | 1.06           | 1.18   | 120.67        | 11.23 | 140.58         | 60.08  |
| 1.06          | 0.04 | 1.24           | 1.22   | 140.58        | 10.95 | 163.77         | 71.03  |
| 1.24          | 0.04 | 1.44           | 1.26   | 163.77        | 9.37  | 190.80         | 80.40  |
| 1.44          | 0.04 | 1.68           | 1.30   | 190.80        | 7.54  | 222.28         | 87.93  |
| 1.68          | 0.04 | 1.95           | 1.34   | 222.28        | 5.68  | 258.95         | 93.61  |
| 1.95          | 0.04 | 2.28           | 1.38   | 258.95        | 3.90  | 301.68         | 97.52  |
| 2.28          | 0.04 | 2.65           | 1.43   | 301.68        | 2.13  | 351.46         | 99.65  |
| 2.65          | 0.04 | 3.09           | 1.47   | 351.46        | 0.35  | 409.45         | 100.00 |
| 3.09          | 0.04 | 3.60           | 1.51   | 409.45        | 0.00  | 477.01         | 100.00 |
| 3.60          | 0.04 | 4.19           | 1.55   | 477.01        | 0.00  | 555.71         | 100.00 |
| 4.19          | 0.04 | 4.88           | 1.60   | 555.71        | 0.00  | 647.41         | 100.00 |
| 4.88          | 0.05 | 5.69           | 1.64   | 647.41        | 0.00  | 754.23         | 100.00 |
| 5.69          | 0.06 | 6.63           | 1.70   | 754.23        | 0.00  | 878.67         | 100.00 |



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Table 22 The data of particle size distribution for BSA-TC microcapsules prepared by 20% BSA, 2.5% TC, formulation B1

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 300RF mm         | Beam Length: 2.40 mm                | Sampler: MS1              | Obscuration: 15.9 % |
| Presentation: 30HD           | [Particle R.I. = 1.5295, 0.1000];   | Dispersant R.I. = 1.3300] |                     |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.457 %   |
| Modifications: Active --     | Killed Data Channels: Low 0; High 2 |                           |                     |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.1215 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.2254 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 74.37 um       | D (v, 0.5) = 127.60 um      | D (v, 0.9) = 222.04 um           |
| D [4, 3] = 138.31 um      | D [3, 2] = 26.62 um         | Span = 1.157E+00            | Uniformity = 3.596E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 0.05          | 0.00 | 0.06           | 0.00   | 6.63          | 0.03  | 7.72           | 1.42   |
| 0.06          | 0.00 | 0.07           | 0.00   | 7.72          | 0.05  | 9.00           | 1.47   |
| 0.07          | 0.00 | 0.08           | 0.00   | 9.00          | 0.06  | 10.48          | 1.53   |
| 0.08          | 0.00 | 0.09           | 0.00   | 10.48         | 0.07  | 12.21          | 1.60   |
| 0.09          | 0.00 | 0.11           | 0.00   | 12.21         | 0.08  | 14.22          | 1.68   |
| 0.11          | 0.00 | 0.13           | 0.00   | 14.22         | 0.07  | 16.57          | 1.75   |
| 0.13          | 0.00 | 0.15           | 0.00   | 16.57         | 0.06  | 19.31          | 1.81   |
| 0.15          | 0.00 | 0.17           | 0.00   | 19.31         | 0.04  | 22.49          | 1.86   |
| 0.17          | 0.01 | 0.20           | 0.01   | 22.49         | 0.03  | 26.20          | 1.89   |
| 0.20          | 0.04 | 0.23           | 0.05   | 26.20         | 0.04  | 30.53          | 1.93   |
| 0.23          | 0.10 | 0.27           | 0.15   | 30.53         | 0.10  | 35.56          | 2.03   |
| 0.27          | 0.18 | 0.31           | 0.33   | 35.56         | 0.27  | 41.43          | 2.30   |
| 0.31          | 0.17 | 0.36           | 0.50   | 41.43         | 0.60  | 48.27          | 2.89   |
| 0.36          | 0.12 | 0.42           | 0.62   | 48.27         | 1.22  | 56.23          | 4.12   |
| 0.42          | 0.10 | 0.49           | 0.72   | 56.23         | 2.38  | 65.51          | 6.50   |
| 0.49          | 0.09 | 0.58           | 0.81   | 65.51         | 4.45  | 76.32          | 10.94  |
| 0.58          | 0.06 | 0.67           | 0.86   | 76.32         | 7.66  | 88.91          | 18.60  |
| 0.67          | 0.04 | 0.78           | 0.91   | 88.91         | 11.45 | 103.58         | 30.05  |
| 0.78          | 0.03 | 0.91           | 0.94   | 103.58        | 14.28 | 120.67         | 44.34  |
| 0.91          | 0.03 | 1.06           | 0.97   | 120.67        | 15.32 | 140.58         | 59.65  |
| 1.06          | 0.04 | 1.24           | 1.01   | 140.58        | 13.00 | 163.77         | 72.66  |
| 1.24          | 0.04 | 1.44           | 1.06   | 163.77        | 10.07 | 190.80         | 82.72  |
| 1.44          | 0.05 | 1.68           | 1.10   | 190.80        | 7.32  | 222.28         | 90.04  |
| 1.68          | 0.04 | 1.95           | 1.15   | 222.28        | 5.02  | 258.95         | 95.06  |
| 1.95          | 0.04 | 2.28           | 1.19   | 258.95        | 3.12  | 301.68         | 98.18  |
| 2.28          | 0.04 | 2.65           | 1.23   | 301.68        | 1.65  | 351.46         | 99.83  |
| 2.65          | 0.04 | 3.09           | 1.28   | 351.46        | 0.17  | 409.45         | 100.00 |
| 3.09          | 0.04 | 3.60           | 1.31   | 409.45        | 0.00  | 477.01         | 100.00 |
| 3.60          | 0.03 | 4.19           | 1.34   | 477.01        | 0.00  | 555.71         | 100.00 |
| 4.19          | 0.02 | 4.88           | 1.36   | 555.71        | 0.00  | 647.41         | 100.00 |
| 4.88          | 0.01 | 5.69           | 1.37   | 647.41        | 0.00  | 754.23         | 100.00 |
| 5.69          | 0.02 | 6.63           | 1.39   | 754.23        | 0.00  | 878.67         | 100.00 |



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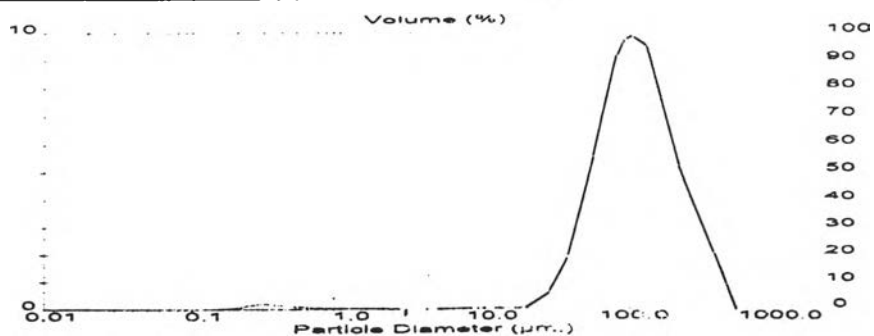
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Table 23 The data of particle size distribution for BSA-TA microcapsules prepared by 15% BSA, 2.5% TC, formulation B2

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 300RF mm         | Beam Length: 2.40 mm                | Sampler: MS1              | Obscuration: 10.4 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] |                     |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.515 %   |
| Modifications: Active -      | Killed Data Channels: Low 0; High 2 |                           |                     |

| Result Statistics        |                             |                             |                                  |
|--------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type/Volume | Concentration = 0.0560 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.3653 sq. m / g |
| Mean Diameters:          | D (v, 0.1) = 48.12 um       | D (v, 0.5) = 105.82 um      | D (v, 0.9) = 243.13 um           |
| D [4, 3] = 127.48 um     | D [3, 2] = 16.42 um         | Span = 1.843E-00            | Uniformity = 5.672E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In % | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|------|----------------|--------|
| 0.05          | 0.00 | 0.06           | 0.00   | 6.63          | 0.06 | 7.72           | 2.03   |
| 0.06          | 0.00 | 0.07           | 0.00   | 7.72          | 0.08 | 9.00           | 2.11   |
| 0.07          | 0.00 | 0.08           | 0.01   | 9.00          | 0.08 | 10.48          | 2.19   |
| 0.08          | 0.00 | 0.09           | 0.01   | 10.48         | 0.07 | 12.21          | 2.26   |
| 0.09          | 0.01 | 0.11           | 0.02   | 12.21         | 0.06 | 14.22          | 2.32   |
| 0.11          | 0.01 | 0.13           | 0.03   | 14.22         | 0.05 | 16.57          | 2.37   |
| 0.13          | 0.02 | 0.15           | 0.05   | 16.57         | 0.07 | 19.31          | 2.43   |
| 0.15          | 0.03 | 0.17           | 0.08   | 19.31         | 0.14 | 22.49          | 2.57   |
| 0.17          | 0.06 | 0.20           | 0.14   | 22.49         | 0.32 | 26.20          | 2.89   |
| 0.20          | 0.10 | 0.23           | 0.25   | 26.20         | 0.65 | 30.53          | 3.55   |
| 0.23          | 0.16 | 0.27           | 0.41   | 30.53         | 1.21 | 35.56          | 4.76   |
| 0.27          | 0.21 | 0.31           | 0.62   | 35.56         | 2.06 | 41.43          | 6.81   |
| 0.31          | 0.20 | 0.36           | 0.81   | 41.43         | 3.26 | 48.27          | 10.08  |
| 0.36          | 0.16 | 0.42           | 0.98   | 48.27         | 4.80 | 56.23          | 14.88  |
| 0.42          | 0.14 | 0.49           | 1.11   | 56.23         | 6.54 | 65.51          | 21.42  |
| 0.49          | 0.12 | 0.58           | 1.23   | 65.51         | 8.14 | 76.32          | 29.56  |
| 0.58          | 0.09 | 0.67           | 1.32   | 76.32         | 9.28 | 88.91          | 38.84  |
| 0.67          | 0.07 | 0.78           | 1.39   | 86.91         | 9.79 | 103.58         | 48.63  |
| 0.78          | 0.07 | 0.91           | 1.46   | 103.58        | 9.70 | 120.67         | 58.32  |
| 0.91          | 0.06 | 1.06           | 1.52   | 120.67        | 9.28 | 140.58         | 67.61  |
| 1.06          | 0.06 | 1.24           | 1.58   | 140.58        | 7.92 | 163.77         | 75.52  |
| 1.24          | 0.06 | 1.44           | 1.65   | 163.77        | 6.55 | 190.80         | 82.07  |
| 1.44          | 0.06 | 1.68           | 1.71   | 190.80        | 5.31 | 222.28         | 87.38  |
| 1.68          | 0.05 | 1.95           | 1.75   | 222.28        | 4.26 | 258.95         | 91.65  |
| 1.95          | 0.04 | 2.28           | 1.79   | 258.95        | 3.35 | 301.68         | 94.99  |
| 2.28          | 0.03 | 2.65           | 1.82   | 301.68        | 2.51 | 351.46         | 97.50  |
| 2.65          | 0.02 | 3.09           | 1.84   | 351.46        | 1.67 | 409.45         | 99.17  |
| 3.09          | 0.01 | 3.60           | 1.85   | 409.45        | 0.83 | 477.01         | 100.00 |
| 3.60          | 0.01 | 4.19           | 1.87   | 477.01        | 0.00 | 555.71         | 100.00 |
| 4.19          | 0.02 | 4.88           | 1.89   | 555.71        | 0.00 | 647.41         | 100.00 |
| 4.88          | 0.03 | 5.69           | 1.92   | 647.41        | 0.00 | 754.23         | 100.00 |
| 5.69          | 0.05 | 6.63           | 1.97   | 754.23        | 0.00 | 878.67         | 100.00 |



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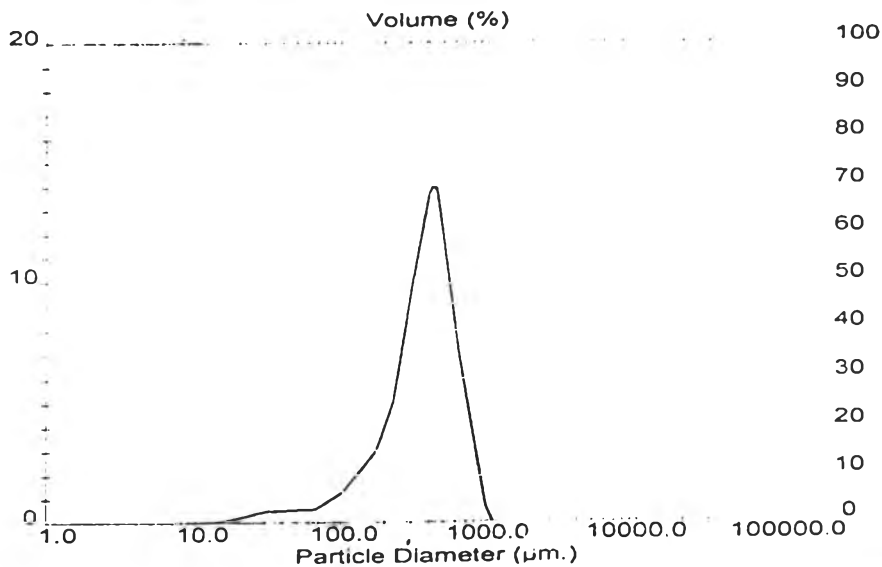
Table 24 The data of particle size distribution for BSA-TC microcapsules prepared by 10% BSA, 2.5% TC, formulation B3



| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 13.4 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] | Residual: 0.698 %   |
| Analysis Model: Polydisperse |                                     |                           |                     |
| Modifications: None          |                                     |                           |                     |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.1070 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0266 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 138.16 um      | D (v, 0.5) = 377.27 um      | D (v, 0.9) = 640.04 um           |
| D [4, 3] = 386.34 um      | D [3, 2] = 225.20 um        | Span = 1.330E+00            | Uniformity = 3.977E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 2.00  | 140.58         | 10.25  |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 2.50  | 163.77         | 12.75  |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 3.13  | 190.80         | 15.88  |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 4.10  | 222.28         | 19.98  |
| 7.72          | 0.02 | 9.00           | 0.02   | 222.28        | 5.63  | 258.95         | 25.61  |
| 9.00          | 0.03 | 10.48          | 0.05   | 258.95        | 7.92  | 301.68         | 33.52  |
| 10.48         | 0.04 | 12.21          | 0.09   | 301.68        | 10.69 | 351.46         | 44.22  |
| 12.21         | 0.06 | 14.22          | 0.16   | 351.46        | 12.97 | 409.45         | 57.19  |
| 14.22         | 0.10 | 16.57          | 0.25   | 409.45        | 13.86 | 477.01         | 71.05  |
| 16.57         | 0.15 | 19.31          | 0.41   | 477.01        | 11.30 | 555.71         | 82.35  |
| 19.31         | 0.25 | 22.49          | 0.66   | 555.71        | 8.17  | 647.41         | 90.52  |
| 22.49         | 0.36 | 26.20          | 1.02   | 647.41        | 5.33  | 754.23         | 95.85  |
| 26.20         | 0.46 | 30.53          | 1.48   | 754.23        | 3.16  | 878.67         | 99.01  |
| 30.53         | 0.51 | 35.56          | 1.99   | 878.67        | 0.99  | 1023.66        | 100.00 |
| 35.56         | 0.52 | 41.43          | 2.50   | 1023.66       | 0.00  | 1192.56        | 100.00 |
| 41.43         | 0.50 | 48.27          | 3.00   | 1192.56       | 0.00  | 1389.33        | 100.00 |
| 48.27         | 0.50 | 56.23          | 3.50   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.54 | 65.51          | 4.05   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.65 | 76.32          | 4.70   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.95 | 88.91          | 5.55   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 1.15 | 103.58         | 6.71   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 1.55 | 120.67         | 8.25   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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Table 25 The data of particle size distribution for BSA-TC microcapsules prepared by 20% BSA, 1.25% TC, formulation B4

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 300RF mm         | Beam Length: 2.40 mm                | Sampler: MS1              | Obscuration: 14.8 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] | Residual: 0.541 %   |
| Analysis Model: Polydisperse | Killed Data Channels: Low 0; High 2 |                           |                     |
| Modifications: Active -      |                                     |                           |                     |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0750 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.3270 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 46.30 um       | D (v, 0.5) = 90.85 um       | D (v, 0.9) = 179.05 um           |
| D [4, 3] = 103.31 um      | D [3, 2] = 18.35 um         | Span = 1.461E+00            | Uniformity = 4.662E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 0.05          | 0.00 | 0.06           | 0.00   | 6.63          | 0.14  | 7.72           | 2.42   |
| 0.06          | 0.00 | 0.07           | 0.00   | 7.72          | 0.16  | 9.00           | 2.57   |
| 0.07          | 0.00 | 0.08           | 0.00   | 9.00          | 0.15  | 10.48          | 2.73   |
| 0.08          | 0.00 | 0.09           | 0.00   | 10.48         | 0.13  | 12.21          | 2.86   |
| 0.09          | 0.00 | 0.11           | 0.00   | 12.21         | 0.10  | 14.22          | 2.95   |
| 0.11          | 0.00 | 0.13           | 0.01   | 14.22         | 0.06  | 16.57          | 3.02   |
| 0.13          | 0.01 | 0.15           | 0.01   | 16.57         | 0.06  | 19.31          | 3.08   |
| 0.15          | 0.01 | 0.17           | 0.03   | 19.31         | 0.11  | 22.49          | 3.19   |
| 0.17          | 0.03 | 0.20           | 0.06   | 22.49         | 0.27  | 26.20          | 3.46   |
| 0.20          | 0.07 | 0.23           | 0.13   | 26.20         | 0.59  | 30.53          | 4.05   |
| 0.23          | 0.14 | 0.27           | 0.26   | 30.53         | 1.18  | 35.56          | 5.24   |
| 0.27          | 0.20 | 0.31           | 0.46   | 35.56         | 2.19  | 41.43          | 7.43   |
| 0.31          | 0.19 | 0.36           | 0.66   | 41.43         | 3.80  | 48.27          | 11.22  |
| 0.36          | 0.15 | 0.42           | 0.81   | 48.27         | 5.99  | 56.23          | 17.21  |
| 0.42          | 0.13 | 0.49           | 0.93   | 56.23         | 8.54  | 65.51          | 25.75  |
| 0.49          | 0.11 | 0.58           | 1.05   | 65.51         | 10.70 | 76.32          | 36.45  |
| 0.58          | 0.09 | 0.67           | 1.13   | 76.32         | 11.85 | 88.91          | 48.30  |
| 0.67          | 0.08 | 0.78           | 1.21   | 88.91         | 11.88 | 103.58         | 60.18  |
| 0.78          | 0.07 | 0.91           | 1.28   | 103.58        | 11.19 | 120.67         | 71.37  |
| 0.91          | 0.08 | 1.06           | 1.36   | 120.67        | 8.93  | 140.58         | 80.31  |
| 1.06          | 0.09 | 1.24           | 1.46   | 140.58        | 6.69  | 163.77         | 86.99  |
| 1.24          | 0.10 | 1.44           | 1.55   | 163.77        | 4.81  | 190.80         | 91.81  |
| 1.44          | 0.10 | 1.68           | 1.65   | 190.80        | 3.35  | 222.28         | 95.16  |
| 1.68          | 0.09 | 1.95           | 1.74   | 222.28        | 2.27  | 258.95         | 97.43  |
| 1.95          | 0.07 | 2.29           | 1.81   | 258.95        | 1.47  | 301.68         | 98.90  |
| 2.29          | 0.06 | 2.65           | 1.87   | 301.68        | 0.86  | 351.46         | 99.76  |
| 2.65          | 0.05 | 3.09           | 1.92   | 351.46        | 0.24  | 409.45         | 100.00 |
| 3.09          | 0.04 | 3.60           | 1.96   | 409.45        | 0.00  | 477.01         | 100.00 |
| 3.60          | 0.04 | 4.19           | 2.00   | 477.01        | 0.00  | 555.71         | 100.00 |
| 4.19          | 0.06 | 4.88           | 2.07   | 555.71        | 0.00  | 647.41         | 100.00 |
| 4.88          | 0.09 | 5.69           | 2.15   | 647.41        | 0.00  | 754.23         | 100.00 |
| 5.69          | 0.12 | 6.63           | 2.27   | 754.23        | 0.00  | 878.67         | 100.00 |

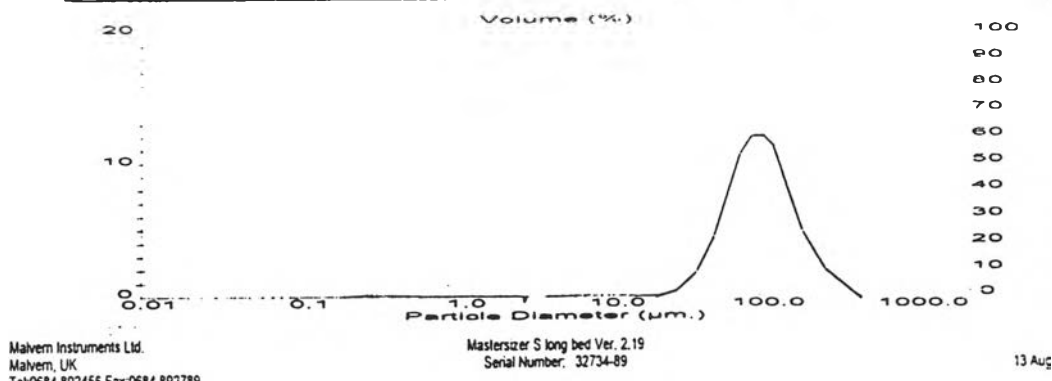


Table 26 The data of particle size distribution for BSA-TC microcapsules prepared by 20% BSA, 5% TC, formulation B5

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 300RF mm         | Beam Length: 2.40 mm                | Sampler: MS1              | Obscuration: 18.8 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] |                     |
| Analysis Model: Polydisperse |                                     |                           | Residual: 1.093 %   |
| Modifications: Active -      | Killed Data Channels: Low 0; High 2 |                           |                     |

| Result Statistics        |                             |                             |                                  |
|--------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type/Volume | Concentration = 0.0242 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 1.8299 sq. m / g |
| Mean Diameters:          | D (v, 0.1) = 3.56 um        | D (v, 0.5) = 30.26 um       | D (v, 0.9) = 136.06 um           |
| D [4, 3] = 52.51 um      | D [3, 2] = 3.28 um          | Span = 4.379E+00            | Uniformity = 1.312E+00           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In % | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|------|----------------|--------|
| 0.05          | 0.03 | 0.06           | 0.03   | 6.63          | 1.95 | 7.72           | 16.85  |
| 0.06          | 0.05 | 0.07           | 0.08   | 7.72          | 2.32 | 9.00           | 19.17  |
| 0.07          | 0.08 | 0.09           | 0.16   | 9.00          | 2.72 | 10.48          | 21.89  |
| 0.08          | 0.11 | 0.09           | 0.27   | 10.48         | 3.12 | 12.21          | 25.01  |
| 0.09          | 0.15 | 0.11           | 0.41   | 12.21         | 3.50 | 14.22          | 28.51  |
| 0.11          | 0.18 | 0.13           | 0.60   | 14.22         | 3.86 | 16.57          | 32.36  |
| 0.13          | 0.23 | 0.15           | 0.83   | 16.57         | 4.16 | 19.31          | 36.53  |
| 0.15          | 0.29 | 0.17           | 1.12   | 19.31         | 4.41 | 22.49          | 40.94  |
| 0.17          | 0.36 | 0.20           | 1.48   | 22.49         | 4.60 | 26.20          | 45.54  |
| 0.20          | 0.44 | 0.23           | 1.92   | 26.20         | 4.74 | 30.53          | 50.27  |
| 0.23          | 0.51 | 0.27           | 2.43   | 30.53         | 4.81 | 35.56          | 55.08  |
| 0.27          | 0.54 | 0.31           | 2.96   | 35.56         | 4.81 | 41.43          | 59.89  |
| 0.31          | 0.51 | 0.36           | 3.48   | 41.43         | 4.74 | 48.27          | 64.63  |
| 0.36          | 0.47 | 0.42           | 3.94   | 48.27         | 4.60 | 56.23          | 69.23  |
| 0.42          | 0.42 | 0.49           | 4.36   | 56.23         | 4.39 | 65.51          | 73.62  |
| 0.49          | 0.38 | 0.58           | 4.75   | 65.51         | 4.14 | 76.32          | 77.76  |
| 0.58          | 0.34 | 0.67           | 5.09   | 76.32         | 3.75 | 88.91          | 81.51  |
| 0.67          | 0.32 | 0.78           | 5.41   | 88.91         | 3.36 | 103.58         | 84.88  |
| 0.78          | 0.33 | 0.91           | 5.74   | 103.58        | 2.99 | 120.67         | 87.87  |
| 0.91          | 0.35 | 1.06           | 6.08   | 120.67        | 2.68 | 140.58         | 90.55  |
| 1.06          | 0.37 | 1.24           | 6.45   | 140.58        | 2.41 | 163.77         | 92.96  |
| 1.24          | 0.40 | 1.44           | 6.85   | 163.77        | 2.17 | 190.90         | 95.13  |
| 1.44          | 0.42 | 1.68           | 7.27   | 190.80        | 1.89 | 222.28         | 97.02  |
| 1.68          | 0.45 | 1.95           | 7.72   | 222.28        | 1.51 | 256.95         | 98.53  |
| 1.95          | 0.49 | 2.28           | 8.21   | 258.95        | 0.99 | 301.68         | 99.52  |
| 2.28          | 0.53 | 2.65           | 8.74   | 301.68        | 0.48 | 351.46         | 100.00 |
| 2.65          | 0.61 | 3.09           | 9.35   | 351.46        | 0.00 | 409.45         | 100.00 |
| 3.09          | 0.71 | 3.60           | 10.06  | 409.45        | 0.00 | 477.01         | 100.00 |
| 3.60          | 0.86 | 4.19           | 10.92  | 477.01        | 0.00 | 555.71         | 100.00 |
| 4.19          | 1.06 | 4.88           | 11.98  | 555.71        | 0.00 | 647.41         | 100.00 |
| 4.88          | 1.31 | 5.69           | 13.29  | 647.41        | 0.00 | 754.23         | 100.00 |
| 5.69          | 1.61 | 6.63           | 14.90  | 754.23        | 0.00 | 878.67         | 100.00 |

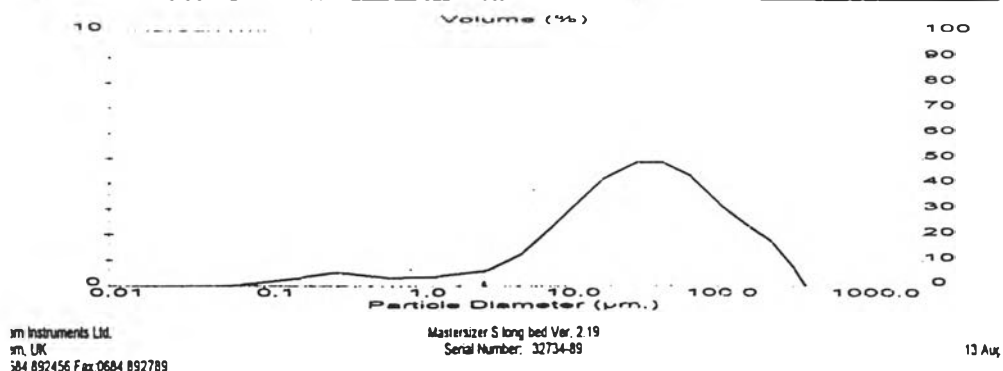
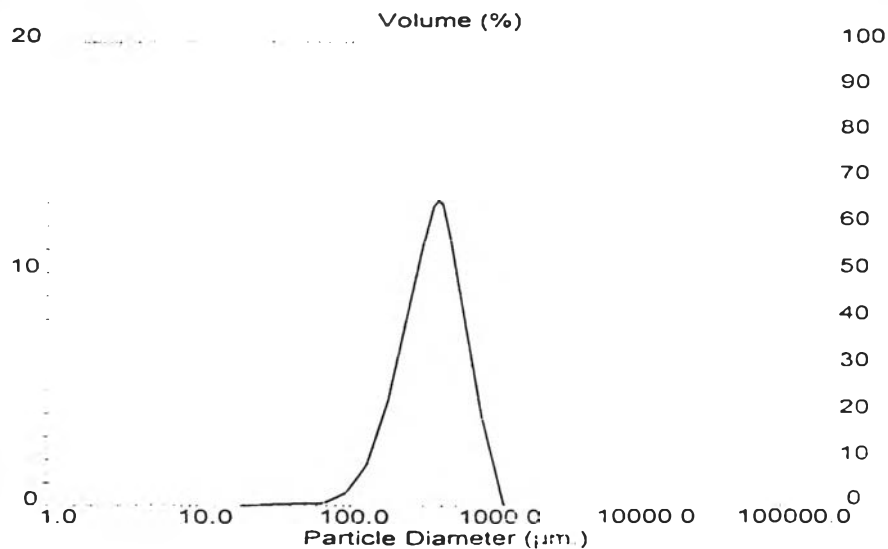


Table 27 The data of particle size distribution for BSA-TC microcapsules prepared by 20% BSA, 5% TC, formulation B6

| System Details               |                                     |                           |                    |
|------------------------------|-------------------------------------|---------------------------|--------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 7.5 % |
| Presentation: 30HD           | (Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300) |                    |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.738 %  |
| Modifications: None          |                                     |                           |                    |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0745 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0211 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 174.14 um      | D (v, 0.5) = 348.56 um      | D (v, 0.9) = 625.35 um           |
| D [4, 3] = 376.92 um      | D [3, 2] = 285.02 um        | Span = 1.295E+00            | Uniformity = 3.998E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 2.00  | 140.58         | 5.21   |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 3.13  | 163.77         | 8.34   |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 4.63  | 190.80         | 12.96  |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 6.47  | 222.28         | 19.44  |
| 7.72          | 0.00 | 9.00           | 0.00   | 222.28        | 8.55  | 258.95         | 27.99  |
| 9.00          | 0.00 | 10.48          | 0.00   | 258.95        | 10.57 | 301.68         | 38.56  |
| 10.48         | 0.00 | 12.21          | 0.00   | 301.68        | 12.13 | 351.46         | 50.69  |
| 12.21         | 0.00 | 14.22          | 0.00   | 351.46        | 13.05 | 409.45         | 63.74  |
| 14.22         | 0.00 | 16.57          | 0.00   | 409.45        | 11.59 | 477.01         | 75.34  |
| 16.57         | 0.02 | 19.31          | 0.02   | 477.01        | 9.24  | 555.71         | 84.57  |
| 19.31         | 0.03 | 22.49          | 0.05   | 555.71        | 6.76  | 647.41         | 91.34  |
| 22.49         | 0.05 | 26.20          | 0.10   | 647.41        | 4.58  | 754.23         | 95.92  |
| 26.20         | 0.07 | 30.53          | 0.18   | 754.23        | 2.89  | 878.67         | 98.80  |
| 30.53         | 0.09 | 35.56          | 0.26   | 878.67        | 1.20  | 1023.66        | 100.00 |
| 35.56         | 0.11 | 41.43          | 0.37   | 1023.66       | 0.00  | 1192.56        | 100.00 |
| 41.43         | 0.12 | 48.27          | 0.49   | 1192.56       | 0.00  | 1389.33        | 100.00 |
| 48.27         | 0.12 | 56.23          | 0.61   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.14 | 65.51          | 0.75   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.21 | 76.32          | 0.96   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.37 | 88.91          | 1.33   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.68 | 103.58         | 2.00   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 1.20 | 120.67         | 3.21   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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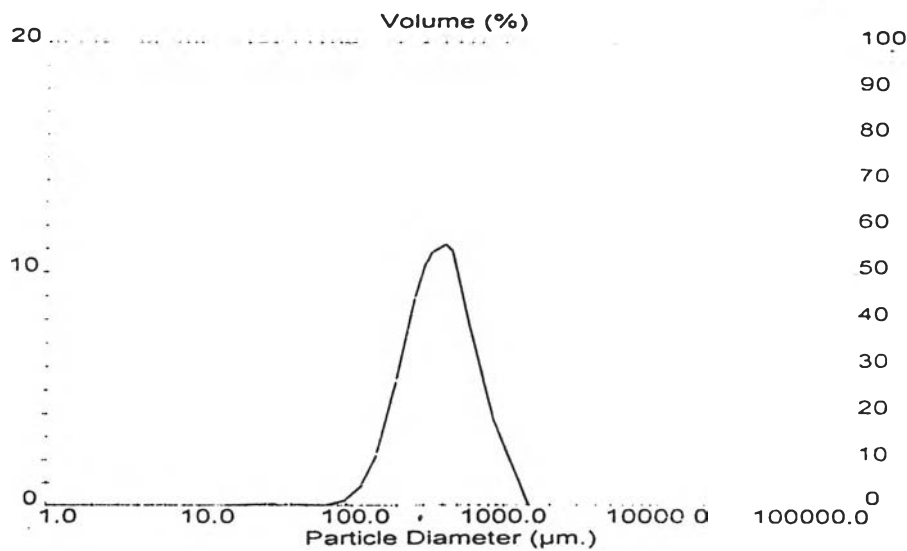
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Table 28 The data of particle size distribution for D-panthenol microcapsules prepared by 13.3% BSA, 10% D-panthenol and 5% TC, formulation D1

| System Details               |                                     |                           |                     |
|------------------------------|-------------------------------------|---------------------------|---------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 10.3 % |
| Presentation: 30HD           | (Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] |                     |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.624 %   |
| Modifications: None          |                                     |                           |                     |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.1105 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0196 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 187.07 um      | D (v, 0.5) = 375.49 um      | D (v, 0.9) = 752.44 um           |
| D [4, 3] = 428.37 um      | D [3, 2] = 305.57 um        | Span = 1.506E+00            | Uniformity = 4.639E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 1.54  | 140.58         | 3.75   |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 2.66  | 163.77         | 6.41   |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 4.23  | 190.80         | 10.64  |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 6.13  | 222.28         | 16.78  |
| 7.72          | 0.00 | 9.00           | 0.00   | 222.28        | 8.07  | 258.95         | 24.85  |
| 9.00          | 0.00 | 10.48          | 0.00   | 258.95        | 9.69  | 301.68         | 34.53  |
| 10.48         | 0.00 | 12.21          | 0.00   | 301.68        | 10.70 | 351.46         | 45.24  |
| 12.21         | 0.00 | 14.22          | 0.00   | 351.46        | 11.07 | 409.45         | 56.31  |
| 14.22         | 0.04 | 16.57          | 0.04   | 409.45        | 10.98 | 477.01         | 67.29  |
| 16.57         | 0.05 | 19.31          | 0.08   | 477.01        | 9.40  | 555.71         | 76.69  |
| 19.31         | 0.06 | 22.49          | 0.15   | 555.71        | 7.59  | 647.41         | 84.28  |
| 22.49         | 0.08 | 26.20          | 0.23   | 647.41        | 5.80  | 754.23         | 90.08  |
| 26.20         | 0.10 | 30.53          | 0.32   | 754.23        | 4.25  | 878.67         | 94.33  |
| 30.53         | 0.10 | 35.56          | 0.42   | 878.67        | 2.94  | 1023.66        | 97.27  |
| 35.56         | 0.10 | 41.43          | 0.52   | 1023.66       | 1.89  | 1192.56        | 99.16  |
| 41.43         | 0.08 | 48.27          | 0.60   | 1192.56       | 0.84  | 1389.33        | 100.00 |
| 48.27         | 0.06 | 56.23          | 0.66   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.05 | 65.51          | 0.71   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.08 | 76.32          | 0.79   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.18 | 88.91          | 0.97   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.41 | 103.58         | 1.38   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 0.83 | 120.67         | 2.21   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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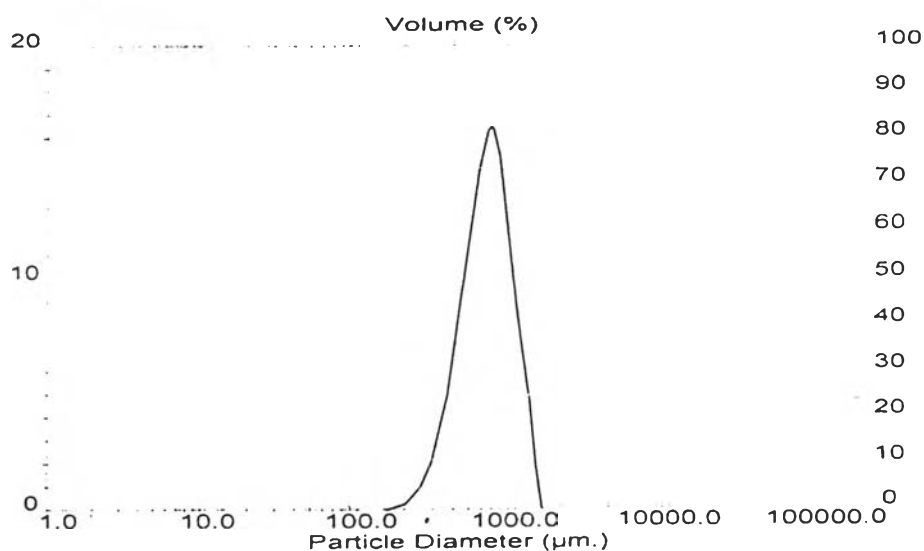
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Table 29 The data of particle size distribution for D-parthenol microcapsules prepared by 13.3% BSA, 13.3% D-parthenol and 5% TC, formulation D2

| System Details               |                                     |                           |                    |
|------------------------------|-------------------------------------|---------------------------|--------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 4.5 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] |                    |
| Analysis Model: Polydisperse |                                     |                           | Residual: 1.168 %  |
| Modifications: None          |                                     |                           |                    |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0914 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0100 sq. m : g |
| Mean Diameters:           | D [v, 0.1] = 392.16 um      | D [v, 0.5] = 657.91 um      | D [v, 0.9] = 1027.10 um          |
| D [4, 3] = 685.53 um      | D [3, 2] = 597.02 um        | Span = 9.651E-01            | Uniformity = 2.987E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 0.00  | 140.58         | 0.00   |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 0.04  | 163.77         | 0.04   |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 0.12  | 190.80         | 0.16   |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 0.33  | 222.28         | 0.49   |
| 7.72          | 0.00 | 9.00           | 0.00   | 222.28        | 0.78  | 258.95         | 1.28   |
| 9.00          | 0.00 | 10.48          | 0.00   | 258.95        | 1.67  | 301.68         | 2.95   |
| 10.48         | 0.00 | 12.21          | 0.00   | 301.68        | 3.24  | 351.46         | 6.19   |
| 12.21         | 0.00 | 14.22          | 0.00   | 351.46        | 5.72  | 409.45         | 11.91  |
| 14.22         | 0.00 | 16.57          | 0.00   | 409.45        | 8.99  | 477.01         | 20.91  |
| 16.57         | 0.00 | 19.31          | 0.00   | 477.01        | 12.37 | 555.71         | 33.28  |
| 19.31         | 0.00 | 22.49          | 0.00   | 555.71        | 15.00 | 647.41         | 48.28  |
| 22.49         | 0.00 | 26.20          | 0.00   | 647.41        | 16.41 | 754.23         | 64.69  |
| 26.20         | 0.00 | 30.53          | 0.00   | 754.23        | 14.35 | 878.67         | 79.04  |
| 30.53         | 0.00 | 35.56          | 0.00   | 878.67        | 10.77 | 1023.66        | 89.82  |
| 35.56         | 0.00 | 41.43          | 0.00   | 1023.66       | 6.82  | 1192.56        | 96.64  |
| 41.43         | 0.00 | 48.27          | 0.00   | 1192.56       | 3.36  | 1389.33        | 100.00 |
| 48.27         | 0.00 | 56.23          | 0.00   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.00 | 65.51          | 0.00   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.00 | 76.32          | 0.00   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.00 | 88.91          | 0.00   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.00 | 103.58         | 0.00   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 0.00 | 120.67         | 0.00   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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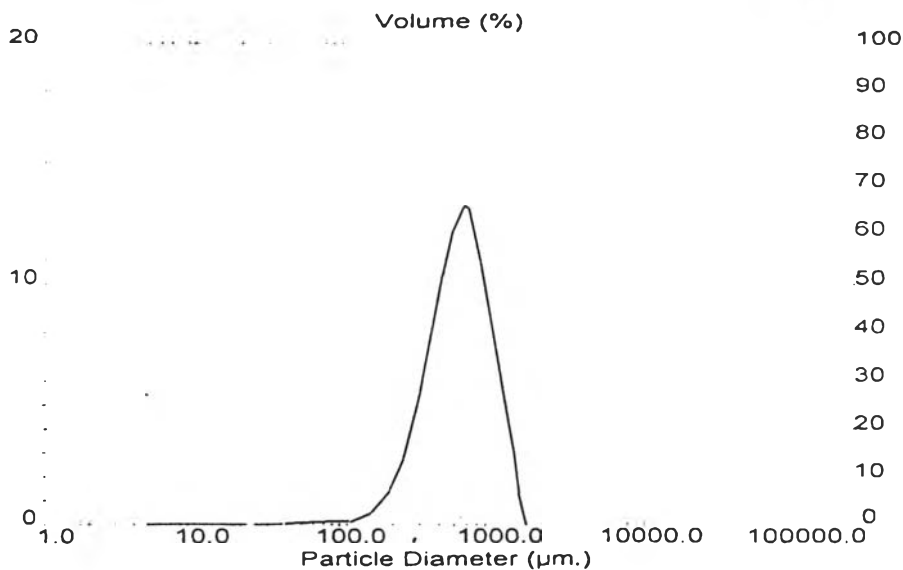
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Table 30 The data of particle size distribution for D-panthenol microcapsules prepared by 13.3% BSA, 16.6% D-panthenol and 5% TC, formulation D3

| System Details               |                                     |                           |                    |
|------------------------------|-------------------------------------|---------------------------|--------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 5.2 % |
| Presentation: 30HD           | (Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300) |                    |
| Analysis Model: Polydisperse |                                     |                           | Residual: 0.726 %  |
| Modifications: None          |                                     |                           |                    |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0b25 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0168 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 272.50 um      | D (v, 0.5) = 537.04 um      | D (v, 0.9) = 939.32 um           |
| D [4, 3] = 572.78 um      | D [3, 2] = 356.23 um        | Span = 1.242E+00            | Uniformity = 3.837E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.02 | 4.88           | 0.02   | 120.67        | 0.34  | 140.58         | 2.07   |
| 4.88          | 0.03 | 5.69           | 0.05   | 140.58        | 0.63  | 163.77         | 2.70   |
| 5.69          | 0.04 | 6.53           | 0.09   | 163.77        | 1.12  | 190.80         | 3.82   |
| 6.53          | 0.05 | 7.72           | 0.15   | 190.80        | 1.87  | 222.28         | 5.70   |
| 7.72          | 0.06 | 9.00           | 0.20   | 222.28        | 2.98  | 258.95         | 8.68   |
| 9.00          | 0.06 | 10.48          | 0.26   | 258.95        | 4.59  | 301.68         | 13.26  |
| 10.48         | 0.06 | 12.21          | 0.32   | 301.68        | 6.72  | 351.46         | 19.98  |
| 12.21         | 0.05 | 14.22          | 0.37   | 351.46        | 9.14  | 409.45         | 29.12  |
| 14.22         | 0.04 | 16.57          | 0.41   | 409.45        | 11.24 | 477.01         | 40.36  |
| 16.57         | 0.03 | 19.31          | 0.45   | 477.01        | 12.54 | 555.71         | 52.90  |
| 19.31         | 0.03 | 22.49          | 0.47   | 555.71        | 13.11 | 647.41         | 66.00  |
| 22.49         | 0.03 | 26.20          | 0.50   | 647.41        | 11.49 | 754.23         | 77.50  |
| 26.20         | 0.03 | 30.53          | 0.53   | 754.23        | 9.24  | 878.67         | 86.74  |
| 30.53         | 0.05 | 35.56          | 0.58   | 878.67        | 6.77  | 1023.66        | 93.51  |
| 35.56         | 0.07 | 41.43          | 0.65   | 1023.66       | 4.42  | 1192.56        | 97.93  |
| 41.43         | 0.10 | 48.27          | 0.75   | 1192.56       | 2.07  | 1389.33        | 100.00 |
| 48.27         | 0.13 | 56.23          | 0.88   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.15 | 65.51          | 1.03   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.16 | 76.32          | 1.19   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.16 | 88.91          | 1.36   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.16 | 103.58         | 1.52   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 0.20 | 120.67         | 1.73   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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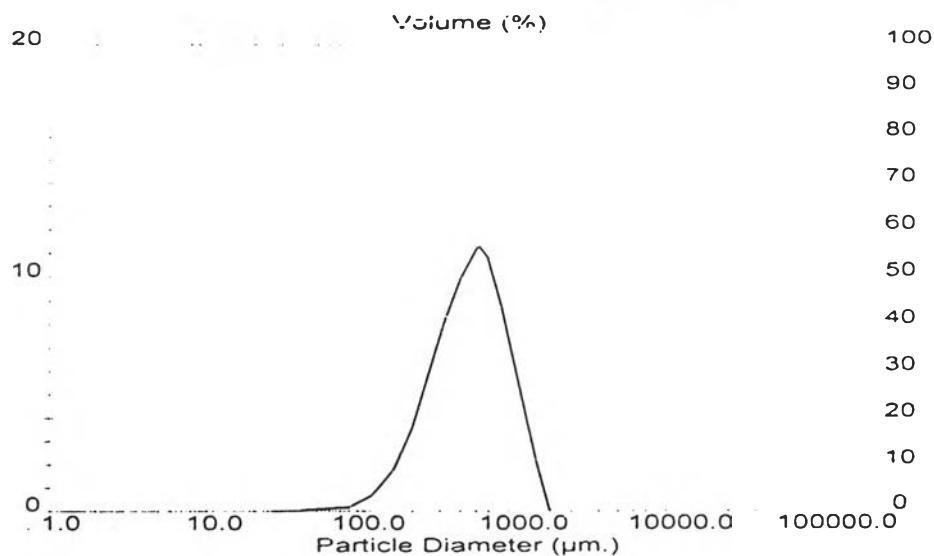
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Table 31 The data of particle size distribution for D-panthenol microcapsules prepared by 13.3% BSA, 20% D-panthenol and 5% TC, formulation D4

| System Details               |                                     |                           |                    |
|------------------------------|-------------------------------------|---------------------------|--------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 3.0 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] | Residual: 1.135 %  |
| Analysis Model: Polydisperse |                                     |                           |                    |
| Modifications: None          |                                     |                           |                    |

| Result Statistics         |                              |                             |                                  |
|---------------------------|------------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0372 % Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0165 sq. m : g |
| Mean Diameters:           | D (v, 0.1) = 208.65 um       | D (v, 0.5) = 460.44 um      | D (v, 0.9) = 868.22 um           |
| D [4, 3] = 503.05 um      | D [3, 2] = 362.85 um         | Span = 1.432E+00            | Uniformity = 4.417E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 1.18  | 140.58         | 3.19   |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 1.86  | 163.77         | 5.04   |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 2.79  | 190.80         | 7.83   |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 3.97  | 222.28         | 11.80  |
| 7.72          | 0.00 | 9.00           | 0.00   | 222.28        | 5.36  | 258.95         | 17.15  |
| 9.00          | 0.00 | 10.48          | 0.00   | 258.95        | 6.87  | 301.68         | 24.02  |
| 10.48         | 0.00 | 12.21          | 0.00   | 301.68        | 8.34  | 351.46         | 32.37  |
| 12.21         | 0.00 | 14.22          | 0.00   | 351.46        | 9.61  | 409.45         | 41.98  |
| 14.22         | 0.00 | 16.57          | 0.00   | 409.45        | 10.55 | 477.01         | 52.52  |
| 16.57         | 0.00 | 19.31          | 0.00   | 477.01        | 11.23 | 555.71         | 63.75  |
| 19.31         | 0.02 | 22.49          | 0.02   | 555.71        | 10.49 | 647.41         | 74.24  |
| 22.49         | 0.02 | 26.20          | 0.04   | 647.41        | 9.05  | 754.23         | 83.30  |
| 26.20         | 0.03 | 30.53          | 0.07   | 754.23        | 7.20  | 878.67         | 90.50  |
| 30.53         | 0.04 | 35.56          | 0.12   | 878.67        | 5.18  | 1023.66        | 95.68  |
| 35.56         | 0.06 | 41.43          | 0.17   | 1023.66       | 3.17  | 1192.56        | 98.85  |
| 41.43         | 0.07 | 48.27          | 0.24   | 1192.56       | 1.15  | 1389.33        | 100.00 |
| 48.27         | 0.09 | 56.23          | 0.33   | 1389.33       | 0.00  | 1618.57        | 100.00 |
| 56.23         | 0.12 | 65.51          | 0.45   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.17 | 76.32          | 0.61   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.26 | 88.91          | 0.87   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.43 | 103.58         | 1.30   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 0.71 | 120.67         | 2.01   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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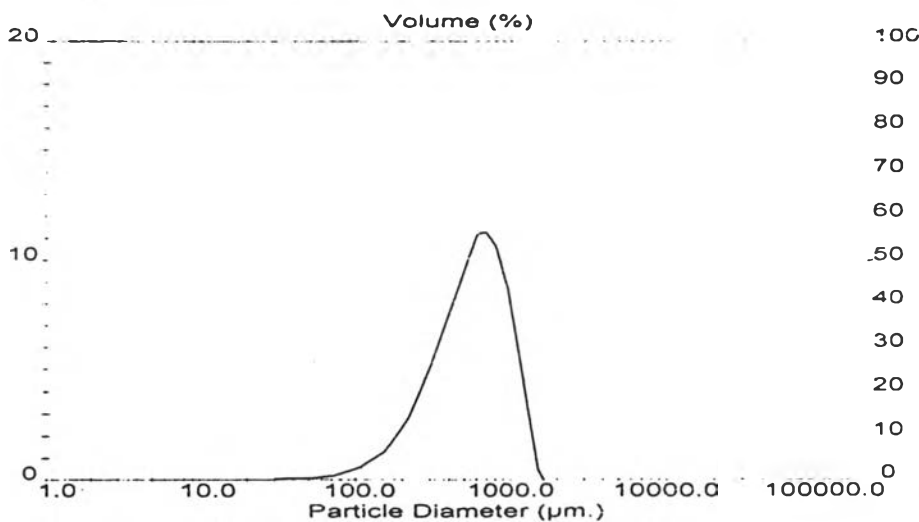
Table 32 The data of particle size distribution for D-panthenol microcapsules prepared by 20% BSA, 13.3% D-panthenol and 5% TC, Batch D5



| System Details               |                                     |                           |                    |
|------------------------------|-------------------------------------|---------------------------|--------------------|
| Range Lens: 1000 mm          | Beam Length: 10.00 mm               | Sampler: MS1              | Obscuration: 2.2 % |
| Presentation: 30HD           | [Particle R.I. = ( 1.5295, 0.1000); | Dispersant R.I. = 1.3300] | Residual: 1.999 %  |
| Analysis Model: Polydisperse |                                     |                           |                    |
| Modifications: None          |                                     |                           |                    |

| Result Statistics         |                             |                             |                                  |
|---------------------------|-----------------------------|-----------------------------|----------------------------------|
| Distribution Type: Volume | Concentration = 0.0313 %Vol | Density = 1.000 g / cub. cm | Specific S.A. = 0.0145 sq. m / g |
| Mean Diameters:           | D (v, 0.1) = 233.88 um      | D (v, 0.5) = 568.75 um      | D (v, 0.9) = 1029.00 um          |
| D [4, 3] = 603.16 um      | D [3, 2] = 414.68 um        | Span = 1.398E+00            | Uniformity = 4.321E-01           |

| Size Low (um) | In % | Size High (um) | Under% | Size Low (um) | In %  | Size High (um) | Under% |
|---------------|------|----------------|--------|---------------|-------|----------------|--------|
| 4.19          | 0.00 | 4.88           | 0.00   | 120.67        | 0.95  | 140.58         | 3.25   |
| 4.88          | 0.00 | 5.69           | 0.00   | 140.58        | 1.33  | 163.77         | 4.58   |
| 5.69          | 0.00 | 6.63           | 0.00   | 163.77        | 1.85  | 190.80         | 6.43   |
| 6.63          | 0.00 | 7.72           | 0.00   | 190.80        | 2.54  | 222.28         | 8.97   |
| 7.72          | 0.00 | 9.00           | 0.00   | 222.28        | 3.43  | 258.95         | 12.39  |
| 9.00          | 0.00 | 10.48          | 0.00   | 258.95        | 4.53  | 301.68         | 16.93  |
| 10.48         | 0.00 | 12.21          | 0.00   | 301.68        | 5.82  | 351.46         | 22.75  |
| 12.21         | 0.00 | 14.22          | 0.00   | 351.46        | 7.20  | 409.45         | 29.95  |
| 14.22         | 0.00 | 16.57          | 0.00   | 409.45        | 8.57  | 477.01         | 38.52  |
| 16.57         | 0.00 | 19.31          | 0.00   | 477.01        | 9.86  | 555.71         | 48.38  |
| 19.31         | 0.00 | 22.49          | 0.00   | 555.71        | 11.08 | 647.41         | 59.45  |
| 22.49         | 0.00 | 26.20          | 0.00   | 647.41        | 11.19 | 754.23         | 70.65  |
| 26.20         | 0.00 | 30.53          | 0.00   | 754.23        | 10.41 | 878.67         | 81.06  |
| 30.53         | 0.10 | 35.56          | 0.10   | 878.67        | 8.69  | 1023.66        | 89.75  |
| 35.56         | 0.10 | 41.43          | 0.20   | 1023.66       | 6.23  | 1192.56        | 95.98  |
| 41.43         | 0.10 | 48.27          | 0.30   | 1192.56       | 3.42  | 1389.33        | 99.40  |
| 48.27         | 0.12 | 56.23          | 0.42   | 1389.33       | 0.60  | 1618.57        | 100.00 |
| 56.23         | 0.17 | 65.51          | 0.59   | 1618.57       | 0.00  | 1885.64        | 100.00 |
| 65.51         | 0.23 | 76.32          | 0.82   | 1885.64       | 0.00  | 2196.77        | 100.00 |
| 76.32         | 0.33 | 88.91          | 1.16   | 2196.77       | 0.00  | 2559.23        | 100.00 |
| 88.91         | 0.47 | 103.58         | 1.63   | 2559.23       | 0.00  | 2981.51        | 100.00 |
| 103.58        | 0.67 | 120.67         | 2.30   | 2981.51       | 0.00  | 3473.45        | 100.00 |



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Table 33 The data of particle size distribution for D-panthenol microcapsules prepared by 20% BSA, 16.6% D-panthenol and 5% TC, formulation D6

APPENDIX IV  
CALCULATION OF % ENTRAPMENT

Calculation of the contents of D-panthenol in D-panthenol microcapsules (D3)

From the standard calibration curve  $y = 0.689X + 0.6227$

$$\begin{aligned} \text{When } y &= \text{peak area ratio} \\ x &= \text{concentration of D-panthenol (mg/ml)} \\ \text{If } y &= 1.2781 \\ \text{Then } x &= \frac{1.2781 - 0.6227}{0.689} \\ x &= 0.9512 \text{ mg/ml} \end{aligned}$$

This concentration was converted to the initial concentration by multiply with 100 as follows

$$X = 0.9512 \times 100 = 95.12 \text{ mg}$$

The content of D-panthenol in 100 ml volumetric flask

$$= 95.12 \text{ mg}$$

From 0.500 g of microcapsules, the content of D-panthenol was 93 mg

$$\begin{aligned} \text{For } 5.8010 \text{ g microcapsule} &= \frac{95.12 \times 5.8010}{0.5} = 1103.58 \text{ mg} \end{aligned}$$

$$\% \text{ Entrapment} = \frac{\% \text{ observed content} \times 100}{\% \text{ theoretical content}}$$

$$\% \text{ Observed content} = \frac{\text{Assay amount of D-panthenol(g)} \times 100}{\text{Amount of weighed microcapsules (g)}}$$

Where

$$\% \text{ Theoretical content} = \frac{\text{wt. of D-panthenol (g)} \times 100}{\text{wt. of BSA} + \text{wt of D-Panthenol} + \text{TC}}$$

Examples

$$\text{D3 \% observed} = \frac{1.1035}{5.8010} (\text{g}) \times 100 = 19.02$$

$$\text{Wt of microcapsules} = 5.8010 \text{ g}$$

$$\% \text{ Theoretical} = \frac{2.5}{(2.5+2+2)} \times 100 = 38.46$$

$$\% \text{ Entrapment} = \frac{19.02}{38.45} \times 100 = 49.45$$

$$\text{D5 \% observed} = \frac{1.0891}{6.414} \times 100 = 16.98$$

$$\text{Wt. of microcapsules} = 6.414 \text{ g}$$

$$\% \text{ Theoretical} = \frac{2.0}{(2+3+3)} = 25.0$$

$$\% \text{ Entrapment} = \frac{16.98}{25.0} \times 100 = 67.92$$

APPENDIX V  
STATISTIC FOR COMPARING PARTICLE SIZE, % ENTRAPMENT

Table 34 The statistic data of mean particle size of BSA microcapsules from various concentrations of BSA and TC

| Formulation | Mean particle size ( $\mu\text{m}$ ) |        |        |
|-------------|--------------------------------------|--------|--------|
|             | N1                                   | N2     | N3     |
| B1          | 122.58                               | 123.58 | 128.24 |
| B2          | 127.6                                | 127.8  | 131.41 |
| B3          | 105.82                               | 107.3  | 108.7  |

General Linear Models Procedure

Dependent Variable: SIZE

| Source          | DF | Sum of Squares | Mean Square  | F Value | Pr > F |
|-----------------|----|----------------|--------------|---------|--------|
| Model           | 2  | 793.59606667   | 396.79803333 | 75.35   | 0.0001 |
| Error           | 6  | 31.59473333    | 5.26578889   |         |        |
| Corrected Total | 8  | 825.19080000   |              |         |        |

| R-Square | C.V.     | Root MSE   | SIZE Mean    |
|----------|----------|------------|--------------|
| 0.961712 | 1.906926 | 2.29473068 | 120.33666667 |

| Source | DF | Type I SS    | Mean Square  | F Value | Pr > F |
|--------|----|--------------|--------------|---------|--------|
| BATCH  | 2  | 793.59606667 | 396.79803333 | 75.35   | 0.0001 |

| Source | DF | Type III SS  | Mean Square  | F Value | Pr > F |
|--------|----|--------------|--------------|---------|--------|
| BATCH  | 2  | 793.59606667 | 396.79803333 | 75.35   | 0.0001 |

Table 35 The statistic data of mean particle size of D-panthenol microcapsules from various concentrations of BSA and D-panthenol

| Formulation | Mean particle size ( $\mu\text{m}$ ) |        |        |
|-------------|--------------------------------------|--------|--------|
|             | N1                                   | N2     | N3     |
| D1          | 348.56                               | 354.9  | 344.54 |
| D2          | 375.49                               | 344.54 | 378.79 |
| D3          | 657.91                               | 678.99 | 644.32 |
| D4          | 537.04                               | 552.33 | 540.44 |

#### General Linear Models Procedure

Dependent Variable: SIZE

| Source          | DF | Sum of Squares  | Mean Square    | F Value | Pr > F |
|-----------------|----|-----------------|----------------|---------|--------|
| Model           | 3  | 190706.20029167 | 63568.73343056 | 597.99  | 0.0001 |
| Error           | 8  | 850.42513333    | 106.30314167   |         |        |
| Corrected Total | 11 | 191556.62542500 |                |         |        |

| R-Square | C.V.     | Root MSE    | SIZE Mean    |
|----------|----------|-------------|--------------|
| 0.995560 | 2.133465 | 10.31034149 | 483.26750000 |

| Source | DF | Type I SS       | Mean Square    | F Value | Pr > F |
|--------|----|-----------------|----------------|---------|--------|
| BATCH  | 3  | 190706.20029167 | 63568.73343056 | 597.99  | 0.0001 |

| Source | DF | Type III SS     | Mean Square    | F Value | Pr > F |
|--------|----|-----------------|----------------|---------|--------|
| BATCH  | 3  | 190706.20029167 | 63568.73343056 | 597.99  | 0.0001 |

Table 36 The statistical data of D-panthenol entrapment from D-panthenol microcapsules

| Formulation | % Entrapment |       |       |
|-------------|--------------|-------|-------|
|             | N1           | N2    | N3    |
| D3          | 51.07        | 46.98 | 49.17 |
| D5          | 69.24        | 67.92 | 68.19 |
| D6          | 44.47        | 45.60 | 46.28 |

#### General Linear Models Procedure

Dependent Variable: ENT

| Source          | DF | Sum of Squares | Mean Square  | F Value | Pr > F |
|-----------------|----|----------------|--------------|---------|--------|
| Model           | 2  | 917.58375556   | 458.79187778 | 249.74  | 0.0001 |
| Error           | 6  | 11.02246667    | 1.83707778   |         |        |
| Corrected Total | 8  | 928.60622222   |              |         |        |

| R-Square | C.V.     | Root MSE   | ENT Mean    |
|----------|----------|------------|-------------|
| 0.988130 | 2.494988 | 1.35538842 | 54.32444444 |

| Source | DF | Type I SS    | Mean Square  | F Value | Pr > F |
|--------|----|--------------|--------------|---------|--------|
| BATCH  | 2  | 917.58375556 | 458.79187778 | 249.74  | 0.0001 |

| Source | DF | Type III SS  | Mean Square  | F Value | Pr > F |
|--------|----|--------------|--------------|---------|--------|
| BATCH  | 2  | 917.58375556 | 458.79187778 | 249.74  | 0.0001 |



## VITA

Miss Naowarat Sananpanitchkul was born on April 6, 1963 in Bangkok, Thailand. She received her Bachelor Degree of Science in Pharmacy from faculty of Pharmaceutical Sciences, Chiang Mai University in 1986. She worked for cosmetic factory, Ceutic Co.Ltd. She was a manager for R&D department for 9 years then she joined to international program of Pharmaceutical Technology in Chulalongkorn University. For the future plan, she would like to carry on her career work as a researcher in her own cosmetic company and has her own cosmetic brand.

