No. 101

SEPARATION REPORT

Ultraspeed GPC Semi-micro Column TSKgel SuperHZ Series

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TOSOH CORPORATION

1. Introduction

Ever since its emergence, gel permeation chromatography (GPC) has developed to a high-precision, high-reproducibility system with higher functions of the device, columns and packing materials. Tosoh Corporation introduced a group of ultra-high-speed organic solvent GPC columns, "TSKgel SuperH series," to the market ahead of the world, and realized a short-time, high-resolution, and solvent-saving GPC. Since we have commercialized a group of organic solvent semi-micro GPC columns, "TSKgel SuperHZ series" with higher performance in addition, this article introduces its basic features as well as application data.

2. Features of TSKgel SuperHZ Series

The SuperHZ series consists of SuperHZ1000 - 4000 in which a packing material of a different pore size is packed for each grade, and SuperHZM-N, M-M, and M-H in which packing materials with different pore sizes were mixed and the range of measurable molecular weights is extended (**Table-1**).
SuperHZ1000 - 4000 are capable of measuring from monomers, polymer additives, and oligomers to polymers up to molecular weight of several hundred thousands by selecting the grade. Since the resolution of the column is essential in this range of molecular weight (especially in the low molecular weight range), fine particles (3μm) are used for packing.
On the other hand, the mixed grades (SuperHZM-N, M-M, and M-H) are capable of measuring from oligomers to polymers with molecular weights up to tens of millions by selecting the grade. Packing materials of appropriate particle sizes are used for packing, in order to place focus on resolution in the low-molecular weight range and to avoid shear degradation of polymer in the high-molecular weight region. The features of SuperHZ series are shown in **Table-2**. In addition, calibration curves of SuperHZ series are shown in **Figures-1** and **-2**.

Table-1 List of TSKgel SuperHZ Series

Grade	Exclusion limit (polystyrene)	Particle size (μm)	Theoretical plates (TP/15cm)	Column size (mm I.D × cm)
TSKgel SuperHZ1000	1×10^3	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZ2000	1×10^4	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZ2500	2×10^4	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZ3000	6×10^4	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZ4000	4×10^5	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZM-N	7×10^5	3	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZM-M	4×10^6	3&5	16,000	4.6 × 15
				6.0 × 15
TSKgel SuperHZM-H	4×10^8 (Estimate)	10	9,000	4.6 × 15
				6.0 × 15

Table-2

Feature	Advantage
1) Adoption of fine particles for packing material	• Short measurement time is achieved. Resolution equivalent to conventional columns (30cm) can be obtained in 1/2 measurement time. • Resolution does not deteriorate even under a high flow rate.
2) Semi-micro column	• Reduction in solvent consumption (running costs, effluent processing costs) 1/6 to 1/3 solvent consumption compared to conventional columns.
3) Optimization of particle size in the packing material	• Shear degradation in polymers with high molecular weight can be prevented.
4) Adoption of low-absorption packing materials	• Applicable to wide range of samples.

3. Basic Properties

3-1. Resolution

As shown in **Table-1**, columns for separation of low-molecular weight substances such as oligomers, TSKgel SuperHZ1000 - SuperHZ4000 and TSKgel SuperHZM-N that is required high resolution are packed with packing materials which particle size is 3μm, and have high theoretical plates values (per unit length) which are twice of those of the H_{XL} series. As a result, equal resolution can be obtained with half the measurement time of the conventional products as shown in **Figure-3**. To sufficiently deliver the performance of such high-performance columns, optimization in the detector, sample injector, tubing in the system, etc. (dead volume reduction) is inevitable in addition to optimization of measurement conditions. Please use due caution when using the semi-micro column with inner diameter of 4.6mm, in which the effect becomes significant (column performance can be sufficiently delivered by using HLC-8220GPC. In addition, micro flow cell is required for UV detector).

As shown in **Figure-2**, the advantage of TSKgel SuperHZM series (HZ mix series) is that it has a wide separation range of molecular weights with linearity in the calibration curve. That is, it has a wide range of measurable molecular weights with a column of 1 grade. Furthermore, similar to the SuperHZ series for oligomer measurement, TSKgel SuperHZM-N (molecular weight separation range 7×10^5 - 266), SuperHZM-M (molecular weight separation range 4×10^6 - 266), and SuperHZM-H (molecular weight separation range 1×10^8 - 1,000 (estimate)) are capable of measuring molecular weight and molecular weight distribution in half the measurement time of the conventional products.

Figure-4 shows a comparison of polyisobutylene chromatograms by GMH_{XL}, which is a packing material with particle size of 9μm, and SuperHZM-H with particle size of 10μm.

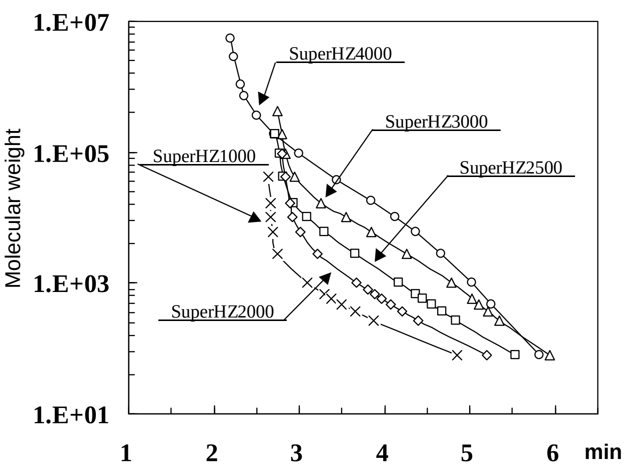


Figure-1 Calibration Curves of TSKgel SuperHZ Series

Column: TSKgel SuperHZ series (4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 25°C
Sample: standard polystyrene
Injection volume: 2μL

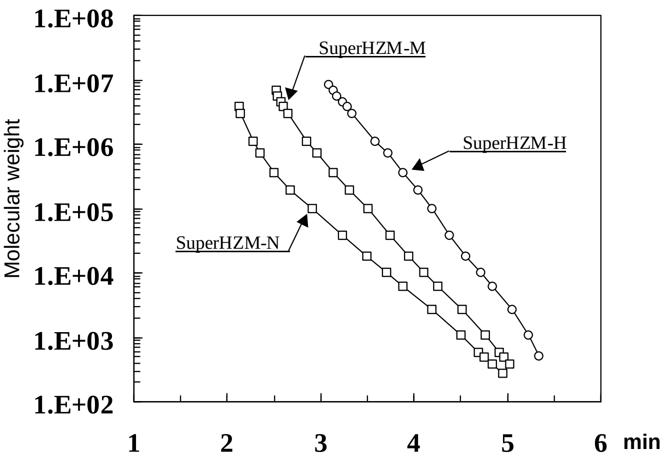


Figure-2 Calibration Curves of TSKgel SuperHZM Series

Column: TSKgel SuperHZM series (4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 25°C
Sample: standard polystyrene
Injection volume: 2μL

3-2. Dependence of Height Equivalent to a Theoretical Plate (HETP) on Flow Rate

Figure-5 shows the results of comparing the flow rate dependence of HETP in TSKgel G2500H_{XL} (particle size 5μm) and TSKgel SuperHZ2500 (particle size 3μm) using a low-molecular-weight compound as sample. While HETP gradually increases in the high flow rate region in G2500H_{XL} with larger particle size, little change in HETP is seen in the high flow rate region in SuperHZ2500 with small particle size, indicating that its column efficiency does not deteriorate even under a high flow rate. HETP flow rate dependency of each of SuperHZ2500, SuperHZM-N, SuperHZM-M, and SuperHZM-H (inner diameter 4.6mm and 6.0mm) columns is shown in **Figures-6**, **-7**, **-8**, and **-9**, respectively.
In actual measurement, HETP flow rate dependency will also depend on the sample's molecular size (molecular weight), eluent type (viscosity) and measurement temperature. Especially with high molecular weight polymers, HETP gradually increases as the flow rate increases and this tendency becomes more significant as the molecular weight becomes larger. Therefore, it can be generally said that low flow rate is desired when a high molecular weight polymer is measured.

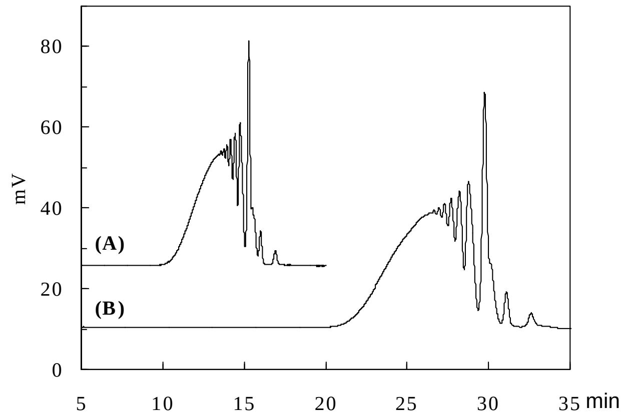


Figure-3 Comparison between SuperHZ and GMH$_{XL}$

Column: (A) TSKgel SuperHZ (4000 + 3000 + 2500) (4.6mmI.D. × 15cm × 3)
(B) TSKgel Super G (4000 + 3000 + 2500) H_{XL} (7.8mmI.D. × 30cm × 3)
Eluent: THF
Flow rate: (A) 0.35mL/min
(B) 1.0mL/min
Temperature: 40°C
Detection: RI
Sample: phenolic resin
Injection volume: (A) 5μL, (B) 30μL

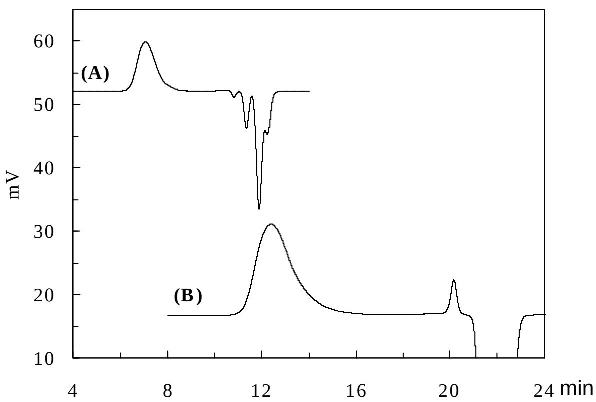


Figure-4 Comparison between SuperHZM-H and GMH$_{XL}$

Column: (A) TSKgel SuperHZM-H (4.6mmI.D. × 15cm × 2)
(B) TSKgel GMH$_{XL}$ (7.8mmI.D. × 30cm × 2)
Eluent: THF
Flow rate: (A) 0.35mL/min
(B) 1.0mL/min
Temperature: 40°C
Detection: RI
Sample: phenolic resin
Injection volume: (A) 10μL, (B) 100μL

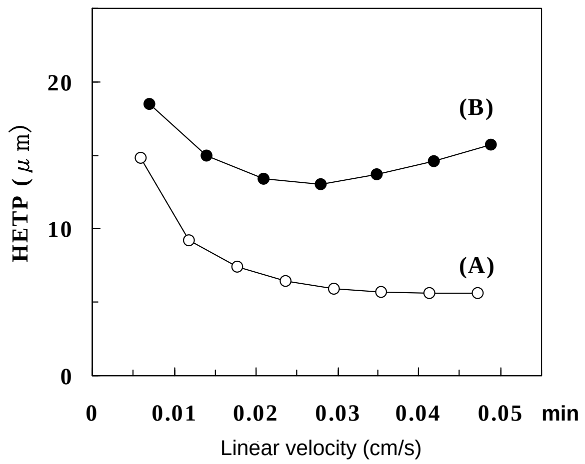


Figure-5 Comparison of the Effect of Linear Velocity on HETP in SuperHZ2500 and G2500H$_{XL}$

Column: (A) TSKgel SuperHZ2500 (6.0mmI.D. × 15cm)
(B) TSKgel G2500H$_{XL}$ (7.8mmI.D. × 30cm)
Eluent: THF
Temperature: 25°C
Sample: (A) dicyclohexyl phthalate (DCHP), (B) benzene
Injection volume: (A) 2μL
(B) 20μL

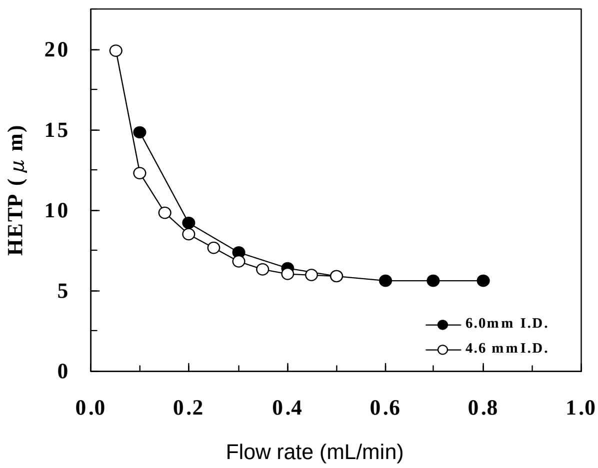


Figure-6 Relationship between HETP and Flow Rate in SuperHZ2500

Column: TSKgel SuperHZ2500
(6.0mmI.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Temperature: 25°C
Sample: DCHP
Injection volume: 2μL (6.0mmI.D. × 15cm)
1μL (4.6mm I.D. × 15cm)

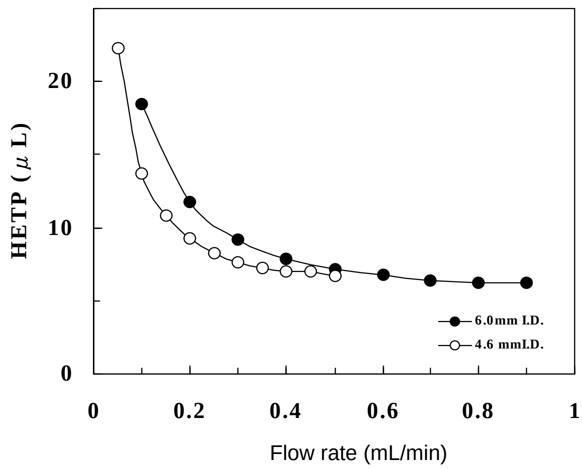


Figure-7 Relationship between HETP and Flow Rate in SuperHZM-N

Column: TSKgel SuperHZM-N
(6.0mmI.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Temperature: 25°C
Sample: DCHP
Injection volume: 2μL (6.0mmI.D. × 15cm)
1μL (4.6mm I.D. × 15cm)

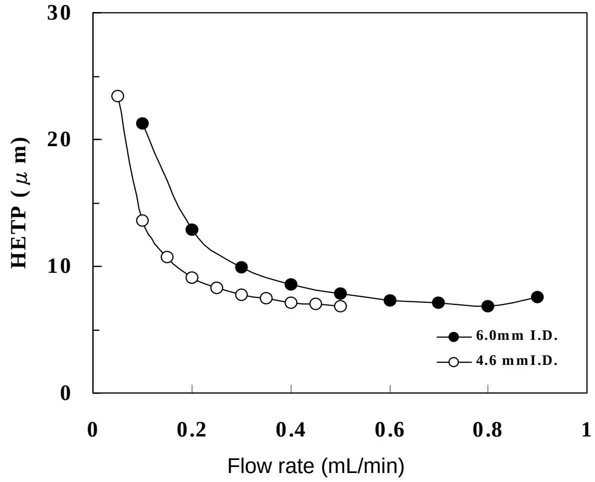


Figure-8 Relationship between HETP and Flow Rate in SuperHZM-M

Column: TSKgel SuperHZM-M
(6.0mmI.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Temperature: 25°C
Sample: DCHP
Injection volume: 2μL (6.0mmI.D. × 15cm)
1μL (4.6mm I.D. × 15cm)

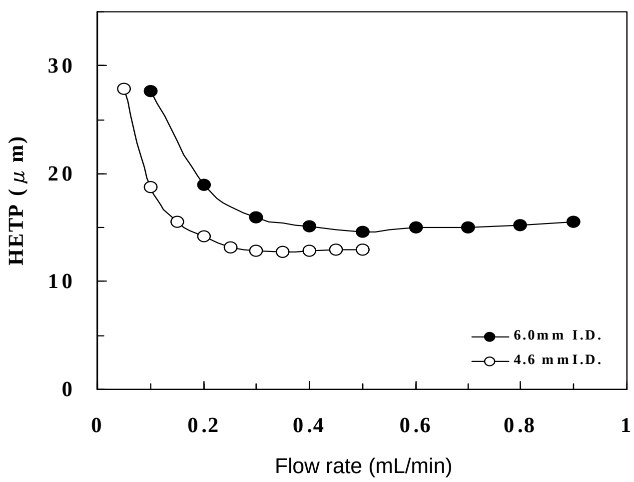


Figure-9 Relationship between HETP and Flow Rate in SuperHZM-H

Column: TSKgel SuperHZM-H
(6.0mmI.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Temperature: 25°C
Sample: DCHP
Injection volume: 2μL (6.0mmI.D. × 15cm)
1μL (4.6mm I.D. × 15cm)

3-3. Effect of Sample Injection Volume

Since TSKGEL SuperHZ series has small packing material particle size as well as small column size, sample injection volume becomes an important factor for obtaining sufficient column performance. As shown in the case of SuperHZ2500 in **Figure-10**, HETP value grows larger and the column performance deteriorates as the sample injection volume increases. This HETP deterioration due to increase in the sample injection volume is seen with more significance in high-performance columns with small packing material particle sizes. As shown in **Figures-10**, **-11**, **-12**, and **-13**, the maximum sample injection volume of each column is 2μL (inner diameter 4.6mm I.D.) and 4μL (inner diameter 6.0mm I.D.) for SuperHZ2500 and SuperHZM-N for oligomer measurement, 2μL (inner diameter 4.6mm I.D.) and 5μL (inner diameter 6.0mm I.D.) for Super HZM-M for synthetic polymer measurement, and 5μL (inner diameter 4.6mm I.D.) and 10μL (inner diameter 6.0mm I.D.) for SuperHZM-H.

In measurement of polymers including oligomers in which high resolution is most important, it is necessary that measurement is taken with high sample concentration so that the sample injection volume is less than the maximum volume. On the other hand, for synthetic polymers that do not contain oligomers and have relatively large molecular weights, measurement should be taken with low concentration and large injection volume because the dependency of measured molecular weight on the sample injection volume is small. At this time, sample injection volume should be optimized with consideration of overloading, detection sensitivity, etc.

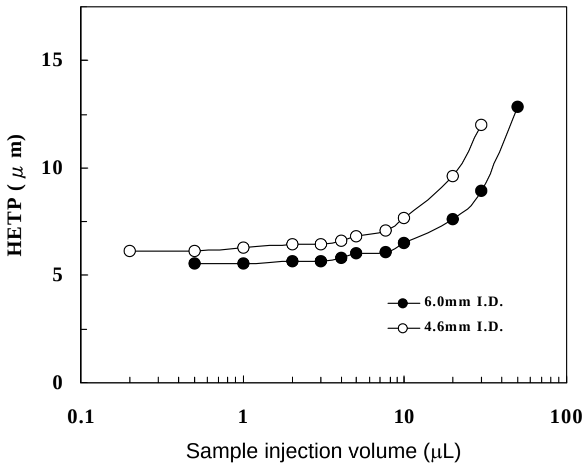


Figure-10 Relationship between HETP and Sample Injection Volume in SuperHZ2500

Column: TSKgel SuperHZ2500
(6.0mm I.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.6mL/min (6.0mm I.D. × 15cm)
0.35mL/min (4.6mm I.D. × 15cm)
Temperature: 25°C
Sample: DCHP

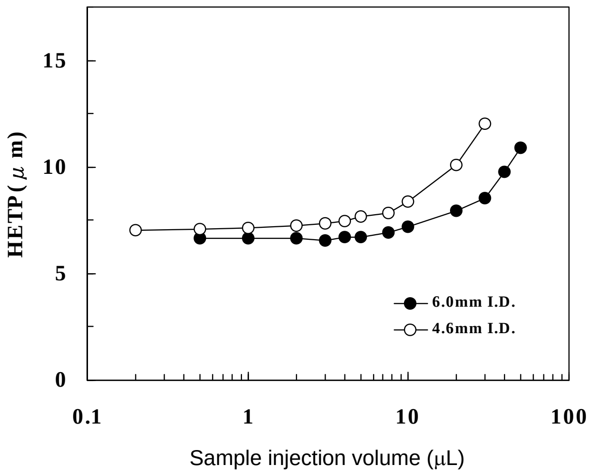
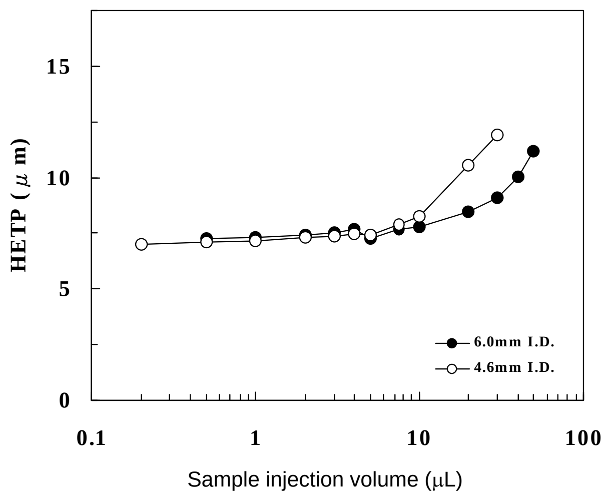


Figure-11 Relationship between HETP and Sample Injection Volume in SuperHZM-N

Column: TSKgel SuperHZM-N
(6.0mm I.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.6mL/min (6.0mm I.D. × 15cm)
0.35mL/min (4.6mm I.D. × 15cm)
Temperature: 25°C
Sample: DCHP



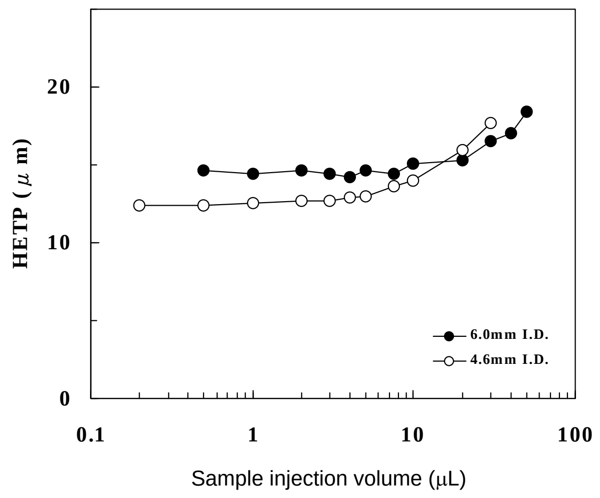


Figure-12 Relationship between HETP and Sample Injection Volume in SuperHZM-M

Column: TSKgel SuperHZM-M
(6.0mm I.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.6mL/min (6.0mm I.D. × 15cm)
0.35mL/min (4.6mm I.D. × 15cm)
Temperature: 25°C
Sample: DCHP

Figure-13 Relationship between HETP and Sample Injection Volume in SuperHZM-H

Column: TSKgel SuperHZM-H
(6.0mm I.D. × 15cm)
(4.6mm I.D. × 15cm)
Eluent: THF
Flow rate: 0.6mL/min (6.0mm I.D. × 15cm)
0.35mL/min (4.6mm I.D. × 15cm)
Temperature: 25°C
Sample: DCHP

3-4. Effect of Sample Concentration

Since the apparent sample molecule size becomes small when the sample concentration increases, the overload phenomenon in which elution volume becomes slow starts to appear. As shown in **Figure-14**, the overload phenomenon is similar to the effect of sample injection volume. It becomes more significant as the particle size of the packing material becomes smaller and slowing in elution volume is observed from lower concentrations as the molecular weight of the measured sample is larger. Caution is required since the calibration curve will appear as shown in **Figure-15** and the molecular weight of the measured sample will be calculated larger when calibration curve is obtained under such circumstances. Proper molecular weight measurement will be difficult when overload phenomenon occurs in either of the molecular weight standard for calibration curve or in the measured sample.

The relationship between the standard polystyrene sample concentration and elution time in TSKGEL SuperHZ mix grade (4.6mm I.D.) is shown in **Figures-16**, **-17** and **-18**. When actual polymers are measured, optimal sample concentration varies depending on the molecular weight distribution and the column to be used in the molecular weight measurement. However, when epoxy resin is measured using SuperHZM-N (4.6mm I.D.) as shown in **Figure-19**, little change is seen in various average molecular weights and resolutions as long as the sample concentration stays below 20g/L (load 100μg), which is relatively high, since the molecular weight of the measured sample is small and the effect of overloading is not seen. **Figure-20** shows the chromatograms of epoxy resin under different sample concentrations. With concentration of 100g/L (load 500μg), slowing in elution position due to overloading is seen.

Figures-21, and **-22** show the relationship between the sample concentration and molecular weight. Measurement needs to be performed with load of 20μg or less when polystyrene SRM706 (Mw257000) is used as the measured sample in SuperHZM-M (4.6mm I.D.), because deterioration in molecular weight value due to overloading is seen at sample concentration of 2g/L (load 20μg) or higher. On the other hand, when polyisobutylene is measured in SuperHZM-H (4.6mm I.D.), deterioration in the molecular weight value is seen from the sample concentration of 1g/L (load 10μg) because the molecular weight of the sample is large. Thus it is necessary that measurement must be taken under a sufficiently low concentration when a sample with large molecular weight is measured.

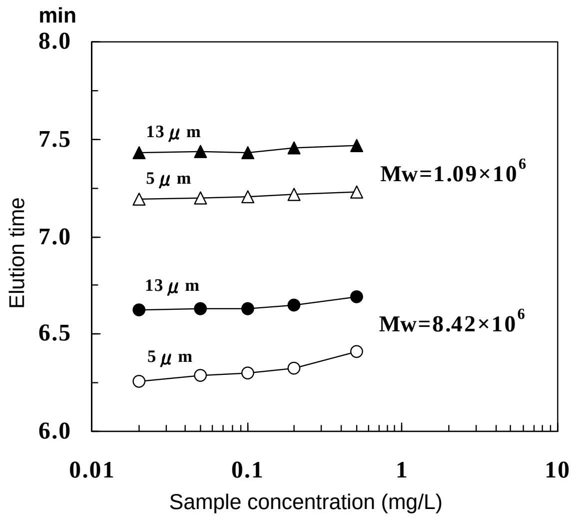


Figure-14 Effect of Sample Concentration on Elution Time

Column: TSKgel SuperHZM-H × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C
Detection: RI
Sample: standard polystyrene
Injection volume: 10μL

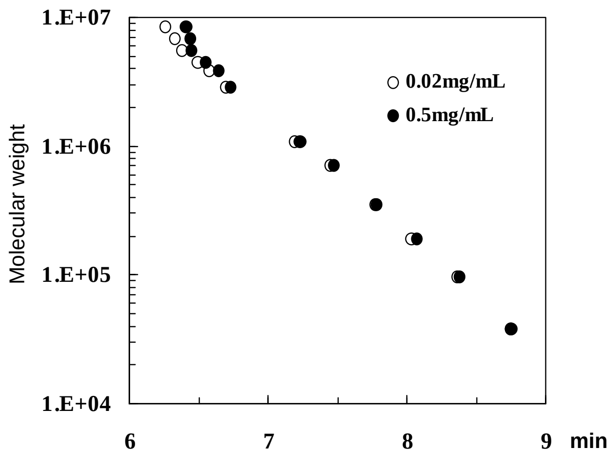


Figure-15 Effect of Sample Concentration on Elution Time (Calibration Curve)

Column: TSKgel SuperHZM-H × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C
Detection: RI
Sample: standard polystyrene
Injection volume: 10μL

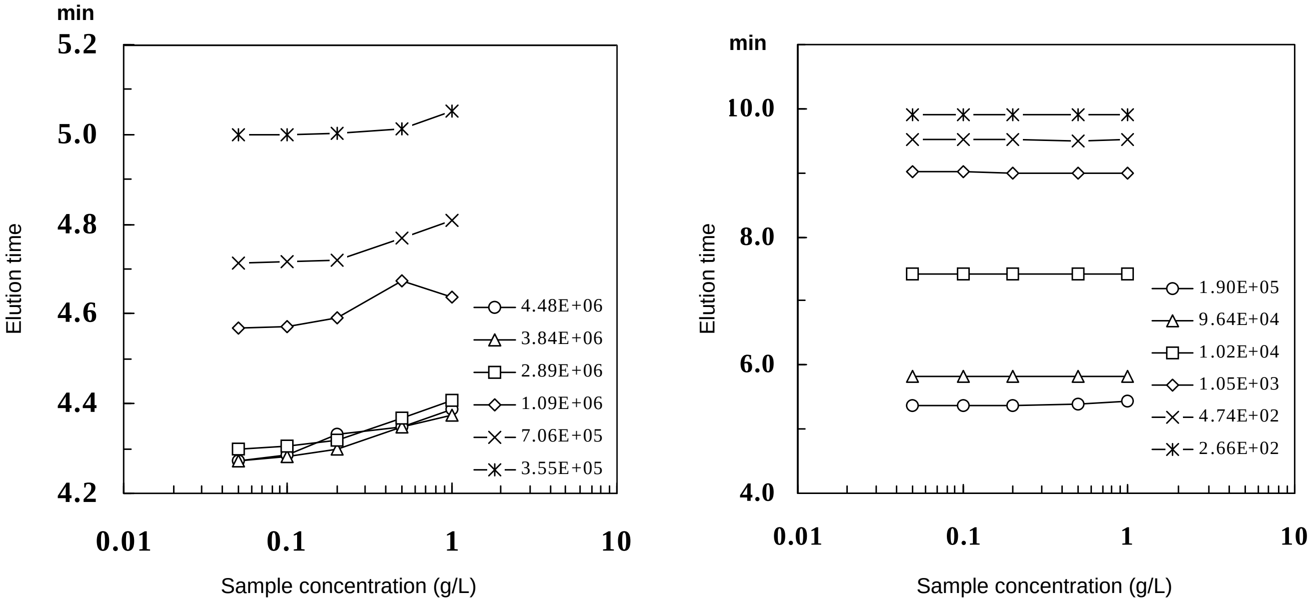


Figure-16 Effect of Sample Concentration on Elution Time

Column:	TSKgel SuperHZM-N × 2 (4.6mm I.D. × 15cm × 2)
Eluent:	THF
Flow rate:	0.35mL/min
Temperature:	40°C
Detection:	RI
Sample:	standard polystyrene
Injection volume:	5μL

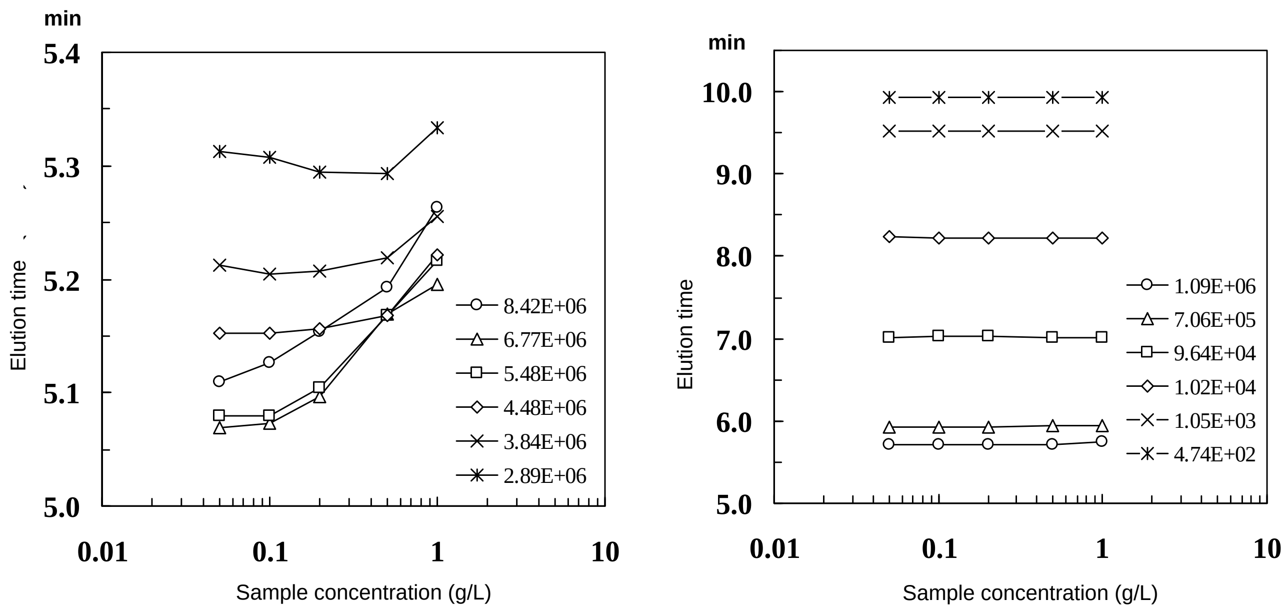


Figure-17 Effect of Sample Concentration on Elution Time

Column:	TSKgel SuperHZM-M × 2 (4.6mm I.D. × 15cm × 2)
Eluent:	THF
Flow rate:	0.35mL/min
Temperature:	40°C
Detection:	RI
Sample:	standard polystyrene
Injection volume:	10μL

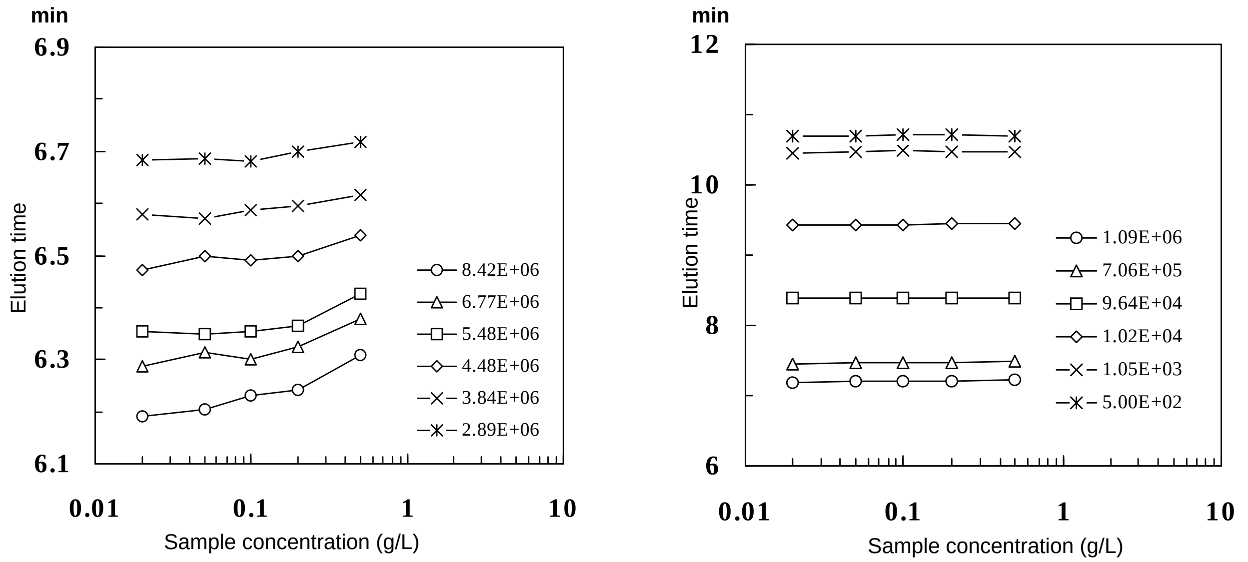


Figure-18 Effect of Sample Concentration on Elution Time

Column: TSKgel SuperHZM-H × 2
(4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C
Detection: RI
Sample: standard polystyrene
Injection volume: 5μL

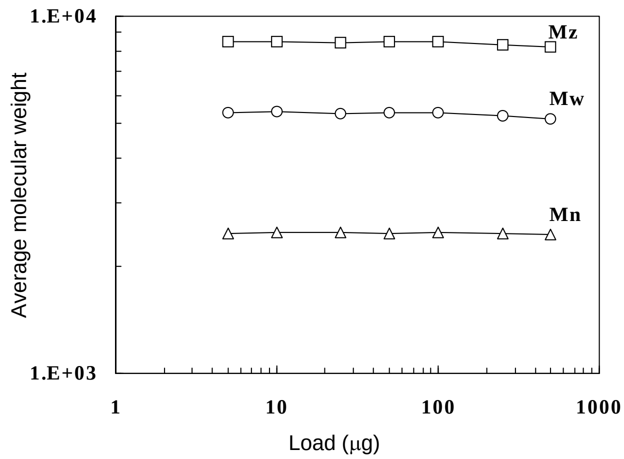


Figure-19 Effect of Sample Injection Volume on Average Molecular Weight

Column: TSKgel SuperHZM-N
(4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C
Detection: RI
Sample: epoxy resin
Injection volume: 5μL

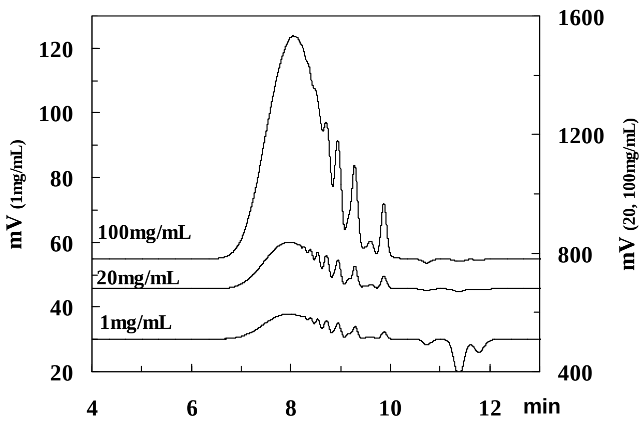


Figure-20 Effect of Sample Load on Chromatogram

Column: TSKgel SuperHZM-N
(4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C
Detection: RI
Sample: epoxy resin
Injection volume: 5μL

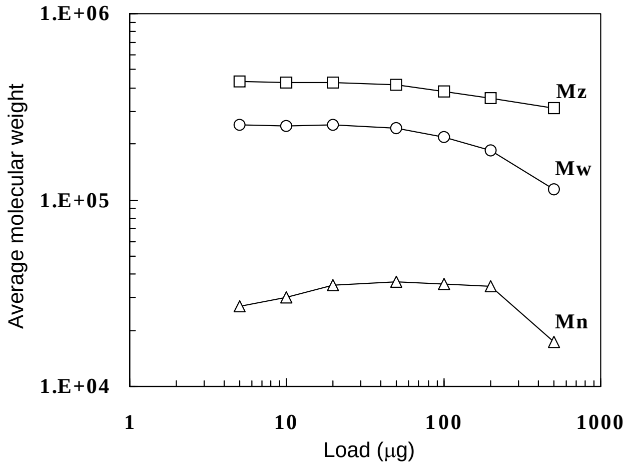


Figure-21 Effect of Sample Injection Volume on Average Molecular Weight

Column:	TSKgel SuperHZM-M (4.6mm I.D. × 15cm × 2)
Eluent:	THF
Flow rate:	0.35mL/min
Temperature:	40°C
Detection:	RI
Sample:	polystyrene SRM706
Injection volume:	10μL

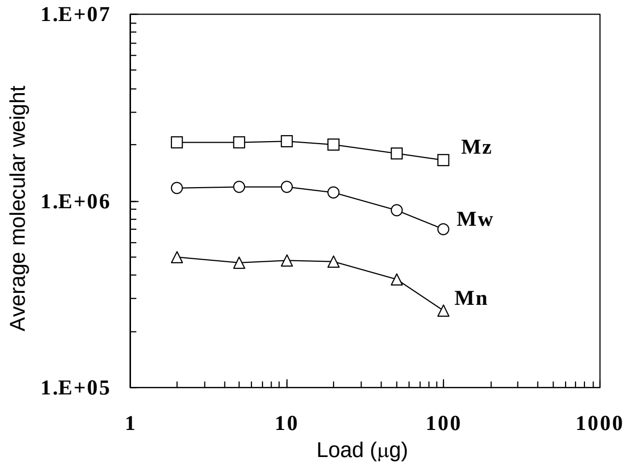


Figure-22 Effect of Sample Injection Volume on Average Molecular Weight

Column:	TSKgel SuperHZM-H (4.6mm I.D. × 15cm × 2)
Eluent:	THF
Flow rate:	0.35mL/min
Temperature:	40°C
Detection:	RI
Sample:	polyisobutylene
Injection volume:	10μL

3-5. Optimization of Packing Material Particle Size

When measurement is taken using a column packed with fine-particle packing materials or under a high flow rate, it becomes more likely that chain breaking in polymers occur. Therefore, in TSKGEL SuperHZ series, optimal particle size that corresponds to the range of molecular weight fractionation is adopted in each of TSKgel SuperHZM-M and SuperHZM-H, which are the columns for polymers.

Figure-23 shows the calibration curve obtained by measuring the standard polystyrene using packing materials of different particle sizes and different measurement flow rates. When a packing material with particle size of 3µm is used for samples with molecular weight of 1 million or higher, delay in elution due to breaking in branched chains is seen at 0.35mL/min. Furthermore, delay in elution can also be seen for samples with molecular weight of several hundred thousands or larger. This phenomenon appears more drastically as the particle size becomes smaller and the measurement flow rate becomes higher. On the other hand, when a packing material with particle size of 13µm is used, delay in sample elution is not seen throughout the molecular weight range under any flow rate. Based on this fact, SuperHZM-H, which targets measurement of average molecular weight of several millions to several hundred thousands, has been packed with a packing material of particle size 10µm and SuperHZM-M, which targets measurement of average molecular weight of several hundred thousands to several ten thousands, has been packed with a packing material of particle size 5 or 3µm. In addition, a packing material with particle size of 3µm has been used for SuperHZM-N, in which high resolution is focused to target samples that include oligomers and have average molecular weight of several ten thousands. As you can see, SuperHZM series has been packed with packing materials with optimal particle sizes that correspond to the molecular weights of the target samples.

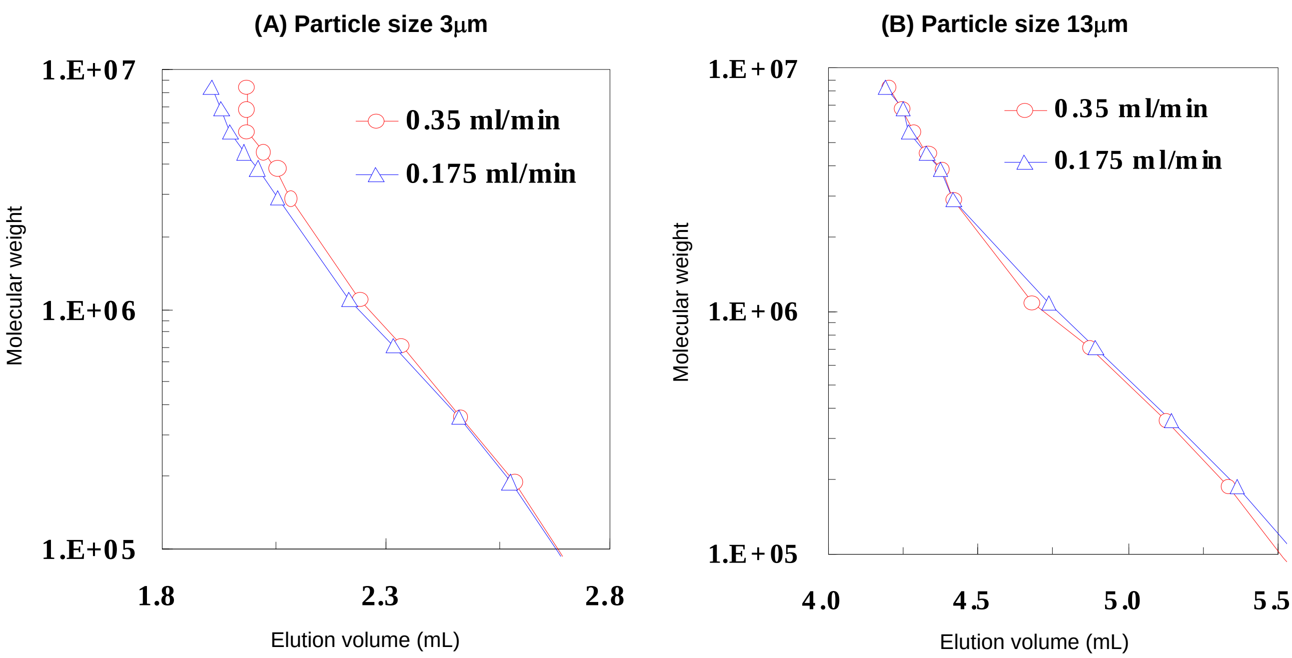


Figure-23 Effect of Measurement Flow Rate and Particle Size on Calibration Curve

Column:	styrene-divinylbenzene copolymerization gel (A): (4.6mm I.D. × 15cm) (B): (4.6mm I.D. × 30cm)
Eluent:	THF
Flow rate:	0.35mL/min
Temperature:	40°C
Detection:	RI
Sample:	standard polystyrene
Injection volume:	(A) 5µL, (B)10µL

4. Application

Figures-24 to **-35** show examples of analysis using various samples.

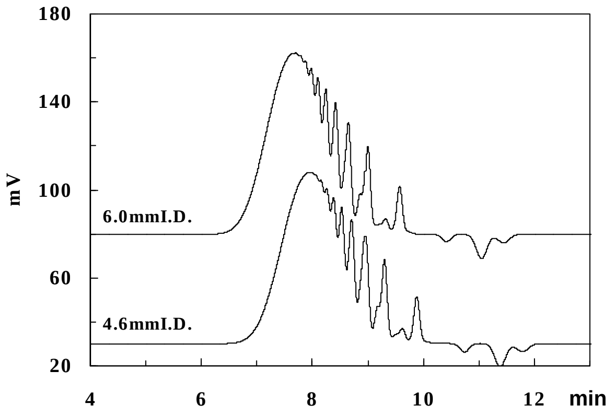


Figure-24 Chromatogram of Epoxy Resin

Column:	TSKgel SuperHZM-N × 2
Eluent:	THF
Flow rate:	0.35mL/min (4.6mm I.D.) 0.6mL/min (6.0mm I.D.)
Temperature:	40°C Detection: RI
Sample:	epoxy resin (10g/L)
Injection volume:	5μL (4.6mm I.D.) 9μL (6.0mm I.D.)

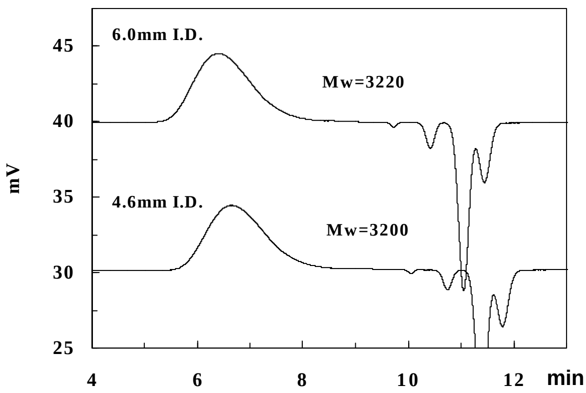


Figure-25 Chromatogram of Polymethyl Methacrylate

Column:	TSKgel SuperHZM-N × 2
Eluent:	THF
Flow rate:	0.35mL/min (4.6mm I.D.) 0.6mL/min (6mm I.D.)
Temperature:	40°C Detection: RI
Sample:	polymethyl metacrylate (1g/L)
Injection volume:	5μL (4.6mm I.D.) 9μ (6.0mm I.D.)

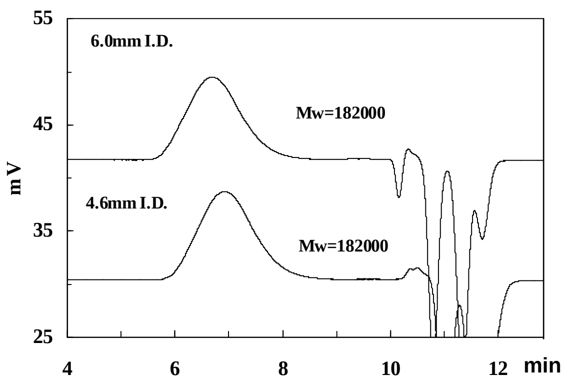


Figure-26 Chromatogram of Butylmethacrylate-Isobutylmethacrylate Copolymer

Column:	TSKgel SuperHZM-M × 2
Eluent:	THF
Flow rate:	0.35mL/min (4.6mm I.D.) 0.6mL/min (6mm I.D.)
Temperature:	40°C Detection: RI
Sample:	butylmethacrylate-isobutylmethacrylate copolymer (1g/L)
Injection volume:	10μL (4.6mm I.D.) 17μL (6.0mm I.D.)

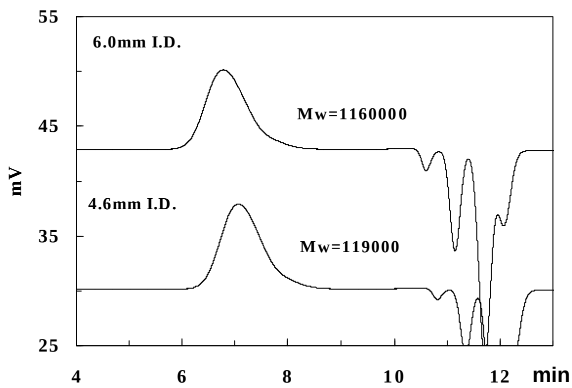


Figure-27 Chromatogram of Polyisobutylene

Column:	TSKgel SuperHZM-M × 2
Eluent:	THF
Flow rate:	0.35mL/min (4.6mm I.D.) 0.6mL/min (6.0mm I.D.)
Temperature:	40°C Detection: RI
Sample:	polyisobutylene (0.5g/L)
Injection volume:	10μL (4.6mm I.D.) 17μL (6.0mm I.D.)

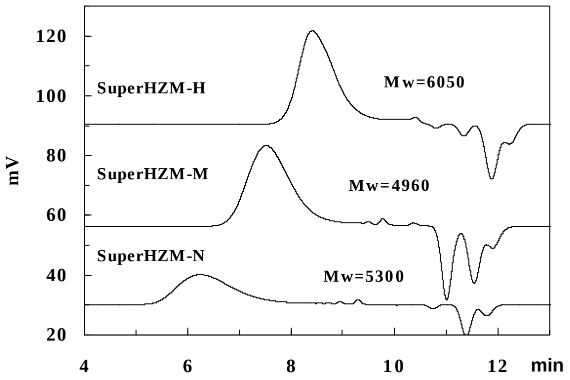


Figure-28 Chromatogram of Polysulfone

Column: TSKgel SuperHZM × 2 (4.6mm I.D.)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polysulfone (1g/L)
Injection volume: 5μL (SuperHZM-N), 10μL (SuperHZM-M, -H)

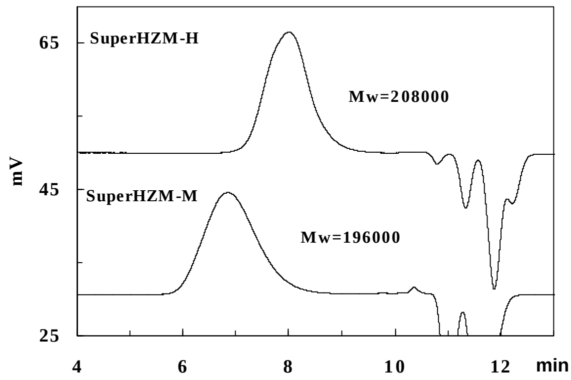


Figure-29 Chromatogram of 1, 2-Polybutadiene

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polybutadiene (1.0g/L)
Injection volume: 10μL

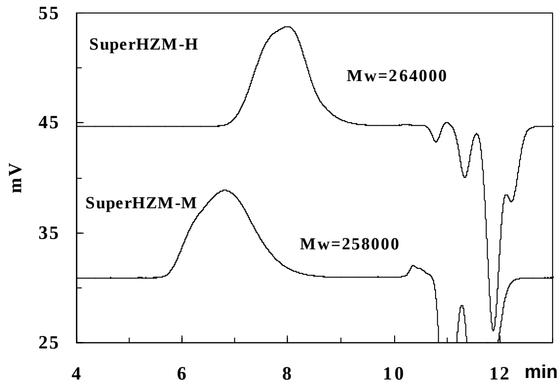


Figure-30 Chromatogram of Polyethylmethacrylate

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polyethylmethacrylate (1.0g/L)
Injection volume: 10μL

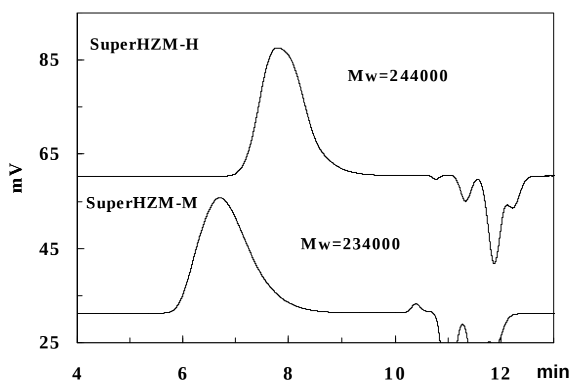


Figure-31 Chromatogram of Polystyrene

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polystyrene (1.0g/L)
Injection volume: 10μL

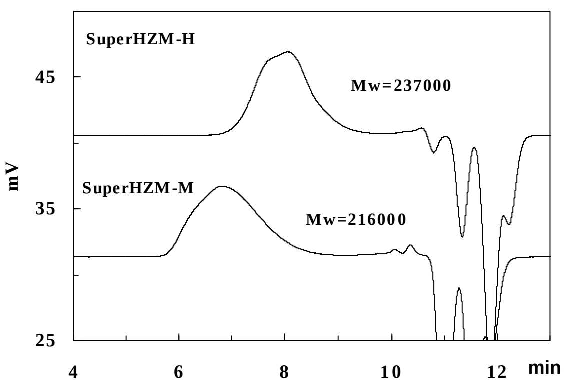


Figure-32 Chromatogram of Polyvinyl Acetate

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polyvinyl acetate (1.0g/L)
Injection volume: 10μL

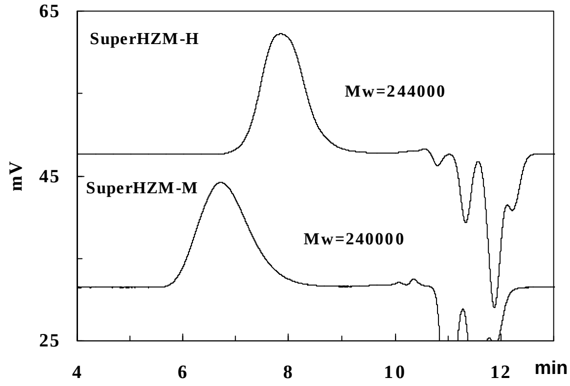


Figure-33 Chromatogram of Polyvinyl Chloride

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: polyvinyl chloride (1.0g/L)
Injection volume: 10μL

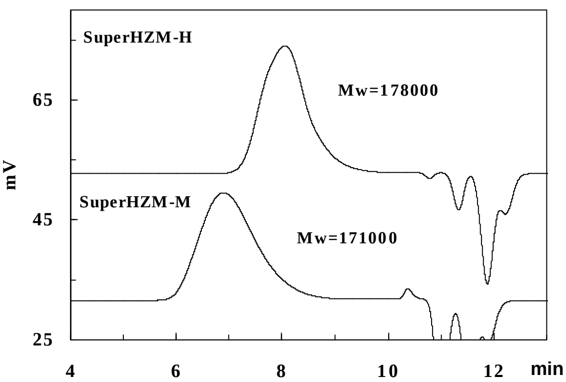


Figure-34 Chromatogram of Styrene-Acrylonitrile Copolymer

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: styrene-acrylonitrile copolymer (1.0g/L)
Injection volume: 10μL

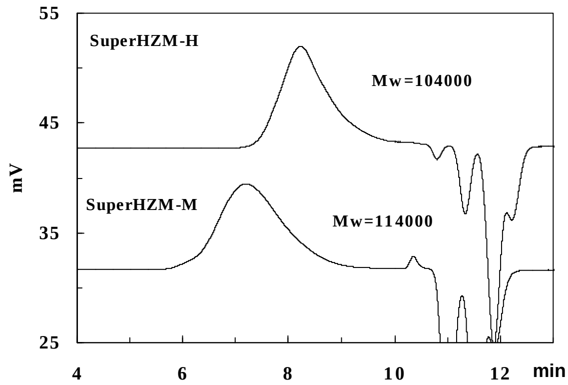


Figure-35 Chromatogram of Vinyl Alcohol-Vinyl Butyral Copolymer

Column: TSKgel SuperHZM × 2 (4.6mm I.D. × 15cm × 2)
Eluent: THF
Flow rate: 0.35mL/min
Temperature: 40°C Detection: RI
Sample: vinyl alcohol-vinyl butyral copolymer (1.0g/L)
Injection volume: 10μL

5. Conclusion

By optimizing the packing material particle size for each molecular weight measurement range, TSKGEL SuperHZ series is capable of performing measurement under the analysis time that is half of the conventional H_{XL} series while maintaining the high resolution in low-molecular weight range and for oligomers and eliminating the need to worry about chain breaking in the high-molecular weight range.

As described earlier in the main text, it is important that measurement is taken by an optimized system under the optimal measurement conditions in order to sufficiently deliver the performance of a high-performance column. While columns with inner diameters 4.6mm and 6.0mm are available, we recommend that measurement be taken in the high-speed GPC system, HLC-8220GPC, which is not influenced by 25C change, etc. and excels in liquid feeding repeatability, when columns with inner diameter of 4.6mm for low flow rate are used.