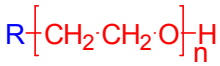
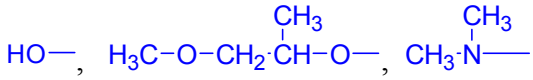
# Polymer Reference Materials-Polyethylene Oxide

## Introduction

Reference materials are used for calibration and performance evaluation of instruments used as part of overall quality assurance programs of polymer. These materials support the development of new measurement methods and characterize new materials. The synthesis and characterization of our polymer reference materials are achieved meticulously. Above all, the user can be assured of receiving a well-characterized and quality product.

## Chemical structure of the polyethylene oxide:



R could be  depending on the initiator used for anionic polymerization.

## Molecular weight based reference polymers

Polymer Source offers a wide range of reference polymeric materials (RM) for both organic and aqueous phase applications. New reference polymers are added regularly. A wide range of polymers with number average molecular masses ($M_n$) (oligomers ***to 10 million***) have been covered.

Molecular weight values are characterized by various analytical techniques. Interfacing chromatographic methods with other analytical techniques can significantly increase the amount of information available for polymer characterization. The techniques used for characterization are: size exclusion chromatography (SEC), nuclear magnetic resonance (NMR), intrinsic viscosity, thermal analysis, and Matrix Assisted Laser Desorption Ionization-Time of Flight-Mass Spectrometry (MALDI-TOF-MS).

| | | | | |
|---|---|---|---|---|
| **Organic phase soluble** | Polystyrene | Polymethyl methacrylate | Polybutadiene | Polyethylene oxide (PEO) |
| **Aqueous phase** | Polyethylene | Polyacrylic | Polystyrene | Polystyrene |

| | | | | |
|---|---|---|---|---|
| **soluble** | oxide (PEO) | acid | sulfonic acid | sodium sulfonate |

The polymer standards are available either *individually* (in the widest range of molecular weights) or *as kits* containing wide range of $M_n$. Care has been taken to develop standards with the narrowest molecular weight distribution to ensure reliable calibrations of the instruments or for basic research. A *Certificate of analysis* that accompanies each product provides the characterization information indicating the type of end groups and microstructure of the polymer.

## Purification of Polymer samples:

Purification of the polyethylene oxide was carried out rigorously to ensure the removal of the catalyst by following steps:

1. Dissolved the polymer in de-ionized distilled water to remove the any insoluble organic catalyst side product.
2. Polymer extracted from water with dichloromethane.
3. Polymer solution in dichloromethane was dried over anhydrous sodium sulfate.
4. Solution filtered and then passed through a column packed with basic $Al_2O_3$.
5. Solution concentrated on rota-evaporator.
6. Solution precipitated in cold diethyl ether.
7. Dried under vacuum for 48h at 38 $^{o}$C.

## Gel Permeation or Size Exclusion Chromatography

Gel permeation chromatography (GPC) also known as size exclusion chromatography (SEC) is employed to obtain number average molecular masses ($M_n$) and weight average molecular weight ($M_w$). Both these values result to obtain polydispersity index (PDI) ($PDI=M_w/M_n$). It guides the application level of reference polymers.

SEC analysis was performed on a Varian liquid chromatograph equipped with refractive index detector at 60 °C with DMF as eluent.

Average molecular weight by weight:

$$M_w = \frac{\sum w_i M_i}{\sum w_i}$$

Average molecular weight by number:

$$M_n = \frac{\sum n_i M_i}{\sum n_i}$$

where: $w_i$ is the weight in fraction i; $n_i$ is the molecular number in fraction i. $M_i$ is the molecular weight of fraction i.

$$M_i = \frac{w_i}{n_i}$$

Due to some polymer chains distribution in polymer sample, weight average molecular weights (Mw) is always greater than number average molecular weights (Mn). The index of Mw/Mn determine the molecular distribution (polydispersity: PDI) is introduced.

$$PI = \frac{M_w}{M_n}$$

If PDI=1, all the chain lengths are same. Usually, the sample prepared by living process is of narrow distribution character, the PI should be less than 1.15.

Mp is the molecular weight at peak maximum.

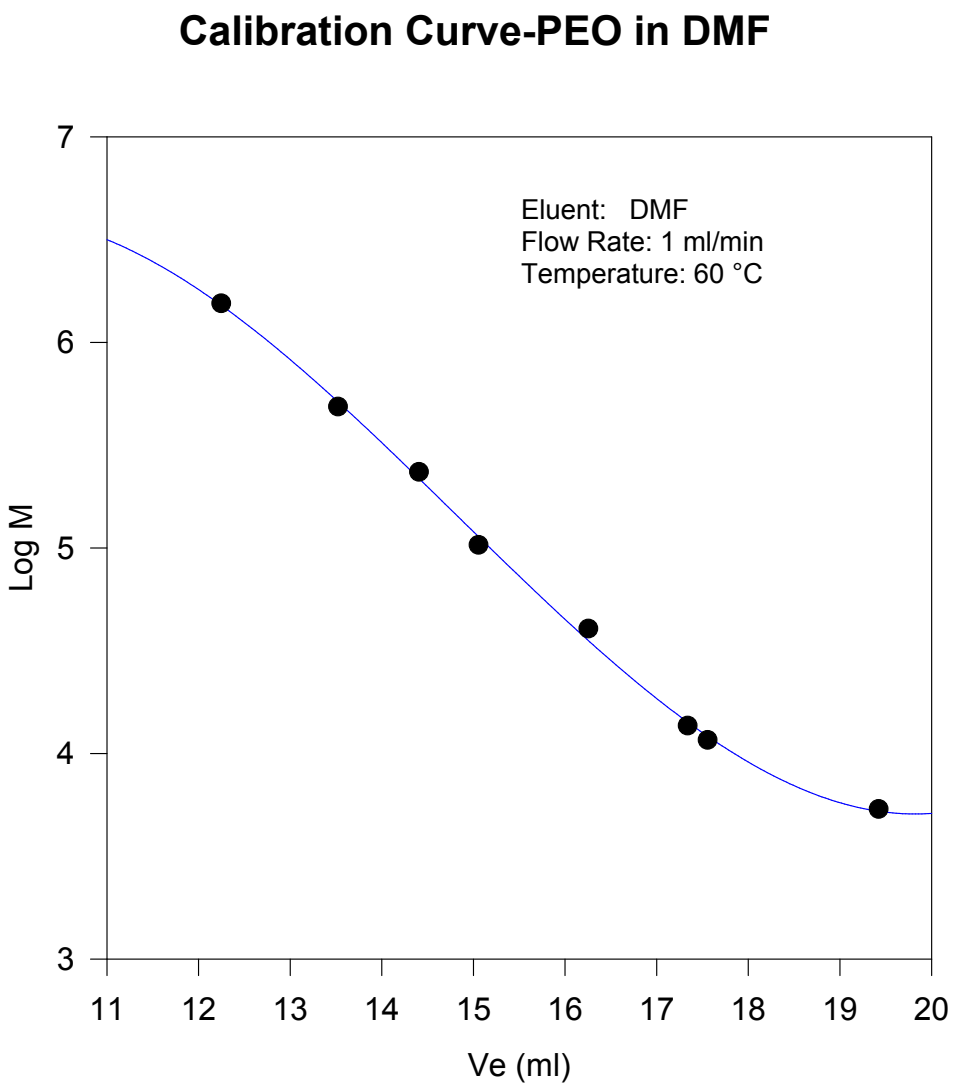
It is worth to note that all the results listed here might have about ±5% deviation.

## Typical SEC of PEO Reference Materials

Polyethylene oxide standard samples

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 5K | P9236 | 5,100 | 5,200 | 5,100 | 1.02 |
| PEO 11K | P3755 | 11,500 | 12,600 | 13,200 | 1.09 |
| PEO 13K | P3771 | 13,200 | 14,700 | 15,500 | 1.12 |
| PEO 35K | P2359A | 34,500 | 39,000 | 40,400 | 1.14 |
| PEO 100K | P1893 | 107,000 | 122,000 | 125,000 | 1.14 |
| PEO 180K | P1904 | 171,000 | 202,000 | 219,000 | 1.18 |
| PEO 420K | P5617 | 415,000 | 493,000 | 505,500 | 1.18 |

## Calibration Curve of PEO in DMF:

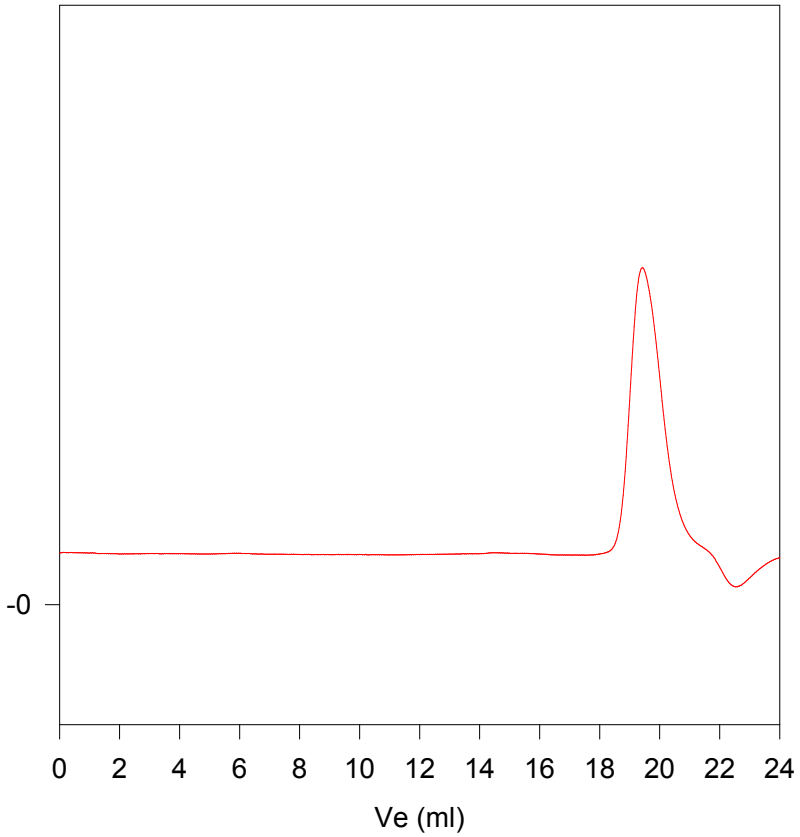


## Characterization report for the each sample analysis:

### PEO: 5K lot P9236

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 5K | P9236-S | 5,100 | 5,200 | 5,100 | 1.02 |

**P9236-EO**



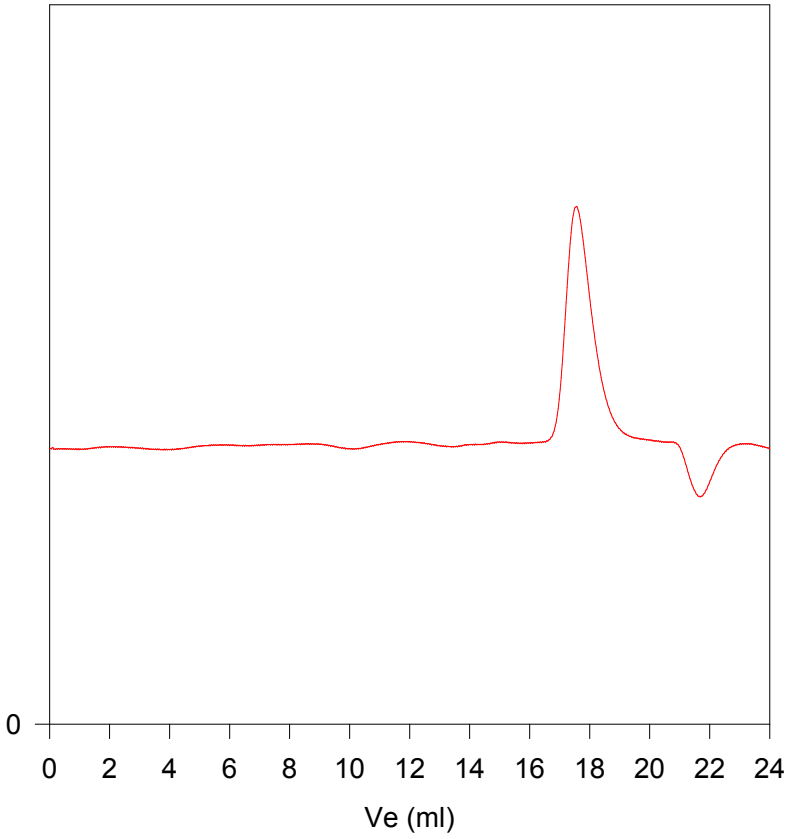

Size exclusion chromatography of polyethylene oxide:

$M_n$=5,100 $M_w$=5,200, PDI=1.02

## PEO: 11K lot P3755

| | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 11K | P3755 | 11,500 | 12,600 | 13,200 | 1.09 |

**P3755-EO**



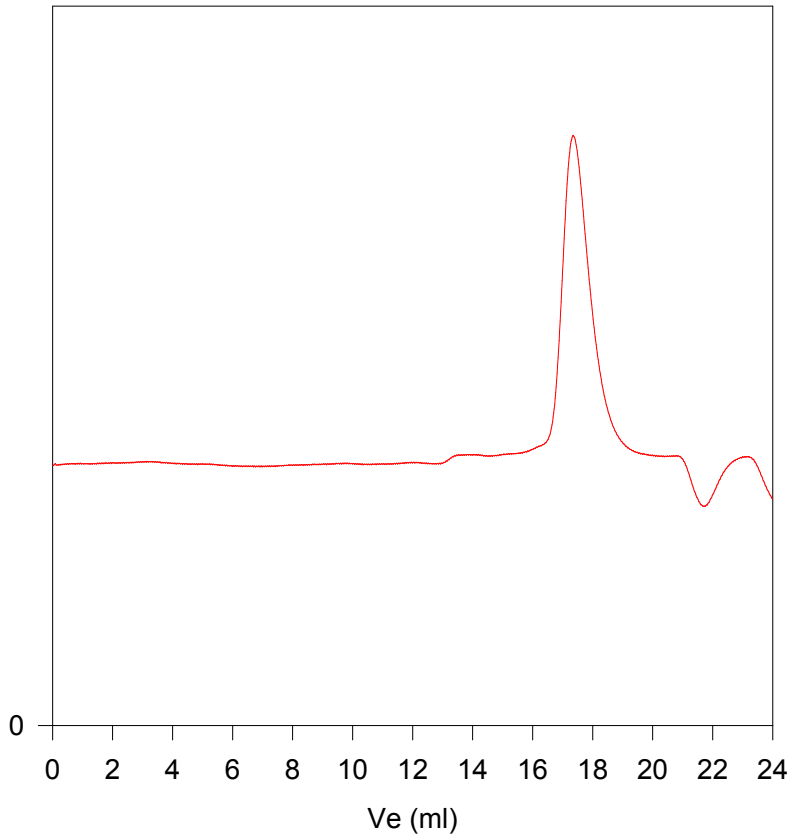

Size exclusion chromatography of polyethylene oxide:

$M_n$=11,500 $M_w$=12,600, PDI=1.09

## PEO: 13K lot P3771

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 13K | P3771 | 13,200 | 14,700 | 15,500 | 1.12 |

**P3771-EO**



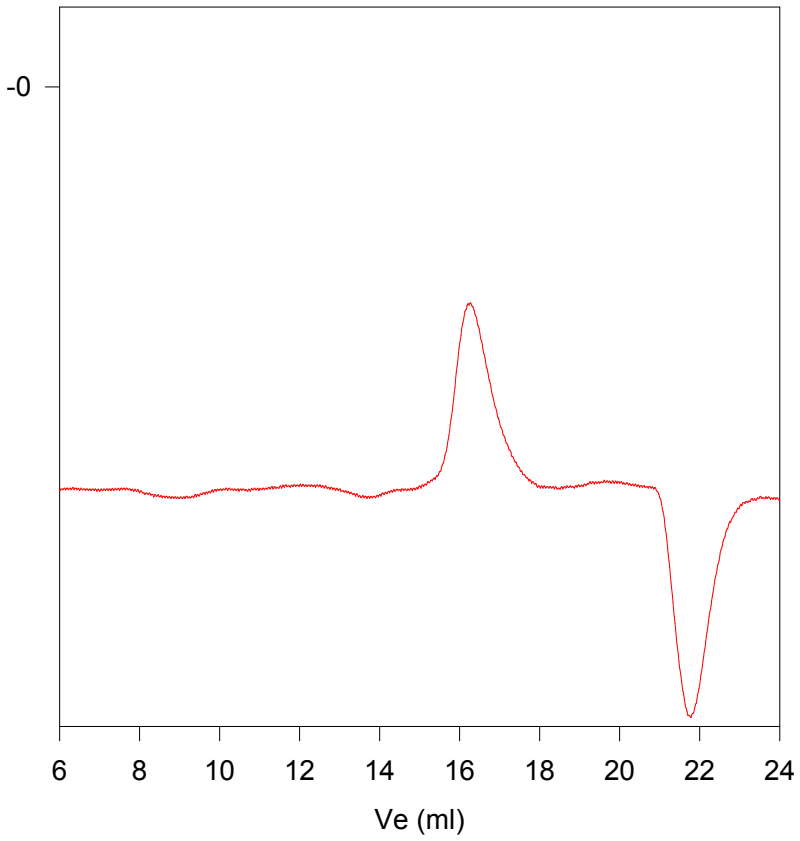

Size exclusion chromatography of polyethylene oxide:

$M_n$=13,200 $M_w$=14,700, PDI=1.12

## PEO: 35K lot P2359A

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 35k | P2359A | 34,500 | 39,000 | 40,400 | 1.14 |

**P2359A-EO**



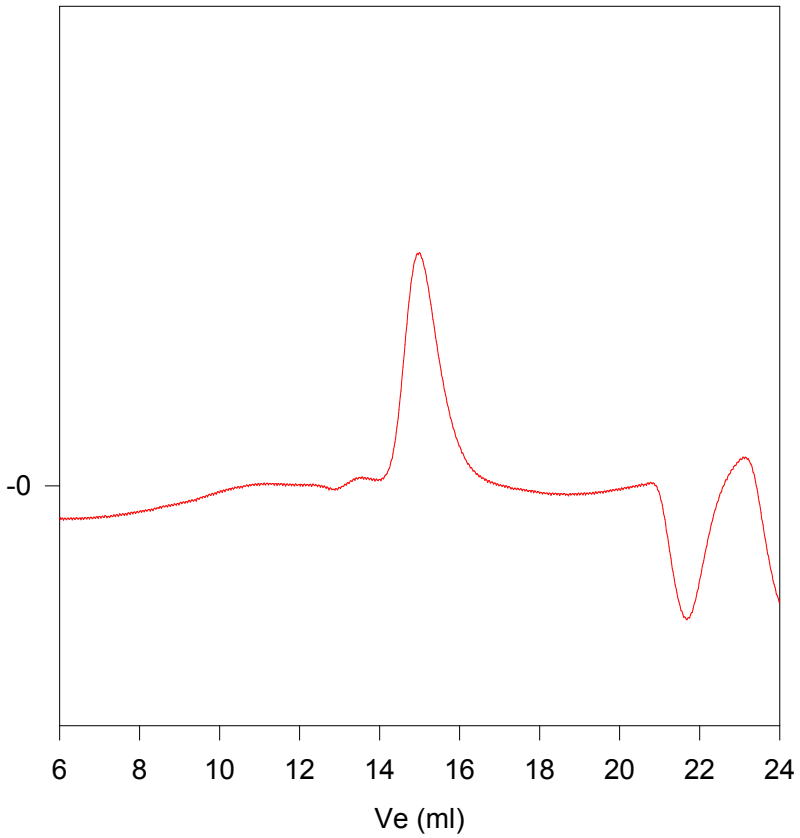

Size exclusion chromatography of polyethylene oxide:

$M_n$=34,500 $M_w$=39,000, PDI=1.14

## PEO: 100K lot P1893

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 100k | P1893 | 105,000 | 121,000 | 125,000 | 1.15 |

**P1893-EO**



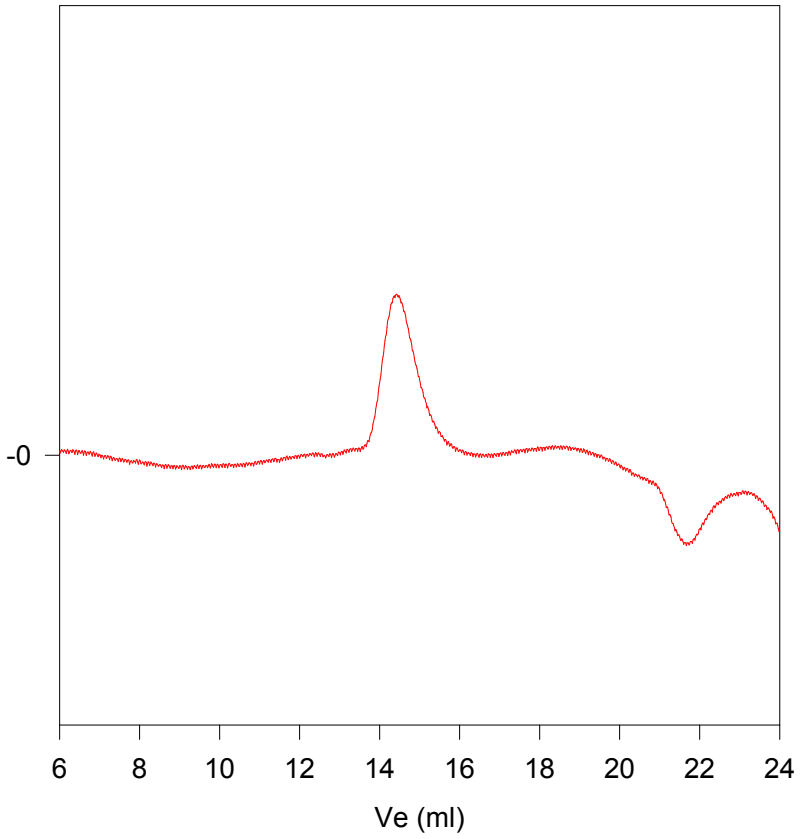

Size exclusion chromatography of polyethylene oxide:

$M_n$=107,000 $M_w$=122,000, PDI=1.14

## PEO: 180K lot P1904

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 180k | P1904 | 171,000 | 202,000 | 219,000 | 1.18 |

**P1904-EO**



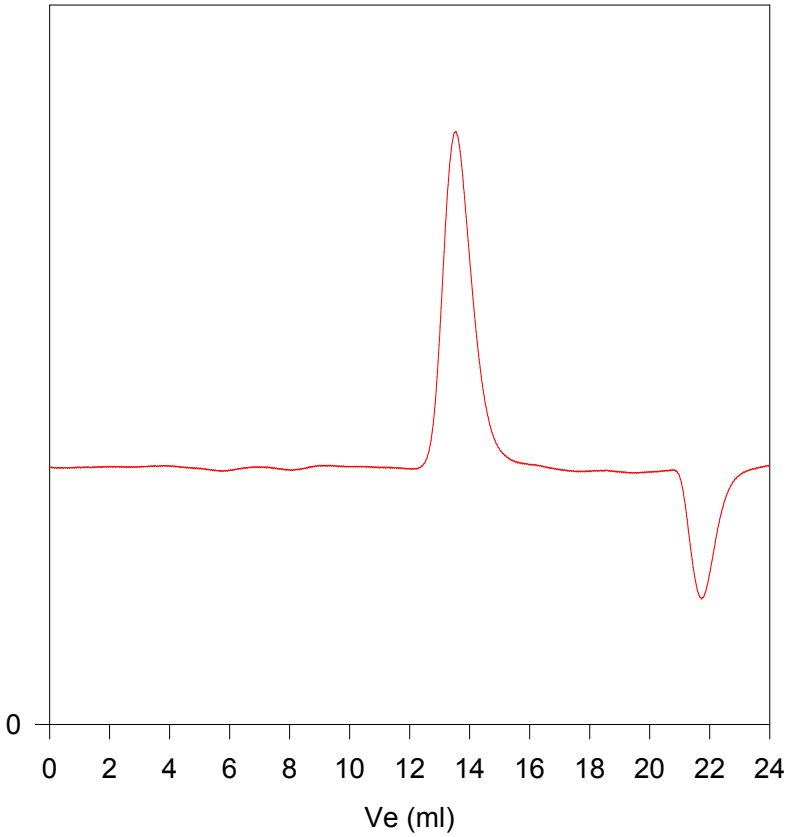

Size exclusion chromatography of polyethylene oxide:

$M_n$=171,000 $M_w$=202,000, PDI=1.18

## PEO: 420K lot P5617

| Part No. | Lot No. | $M_n$ | $M_w$ | $M_p$ | $M_w/M_n$ |
|---|---|---|---|---|---|
| PEO 420K | P5617 | 415,000 | 493.000 | 505,000 | 1.18 |

**P5617-EO**




Size exclusion chromatography of polyethylene oxide:

$M_n$=415,000 $M_w$=493,000, PDI=1.18