

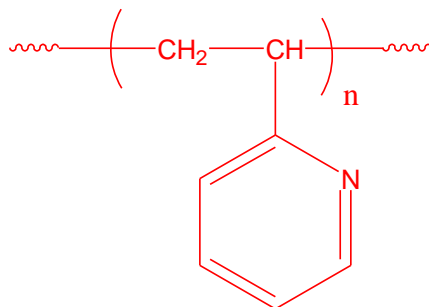


Polymer Reference Materials-Poly(2-Vinyl Pyridine)

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 polymer showing end groups:



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 Poly(2-vinylpyridine)	Polymethyl methacrylate	Polybutadiene	Polyisoprene
Aqueous phase soluble	Polyethylene oxide (PEO)	Polyacrylic acid	Polystyrene sulfonic acid	Polystyrene 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 polystyrene was carried out rigorously to ensure the removal of the catalyst by following steps:

1. Dissolved the polymer in CHCl_3 and washed with water to remove insoluble organic catalyst as side product.
2. Polymer solution in chloroform filtered and passed through a column packed with basic Al_2O_3 .
3. Solution was concentrated on rota-evaporator
4. Concentrated solution precipitated in cold methanol.
5. Dried under vacuum for 48h at 38 °C. Further, dissolved in dioxane; filter, and freeze dried under vacuum.
6. Polymer was packed in a clean vial in dust free environment.

Characterization techniques

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 and UV light scattering detectors. Three SEC columns from Supelco (G6000-4000-2000 HXL) were used with a dual detector model 270 from Viscotek Co connected on line in series with columns. Low angle and at 90° light scattering were used to determine absolute molecular weights of the polymer.

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 (M_w) is always greater than number average molecular weights (M_n). The index of M_w/M_n determine the molecular distribution (polydispersity: PDI) is introduced.

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

If $PI=1$, 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.

M_p is the molecular weight at peak maximum.

Intrinsic viscosity $[\eta]$ is the related viscosity exploited to concentration = 0, which is related to solvent and temperature. The molecular shape is important to the intrinsic viscosity. When molecular weight is same, the $[\eta]$ of multi-arm (four- or six-arm) polymer is much lower than that of linear one.

Radius of Gyration (R_g): the size of macromolecule.

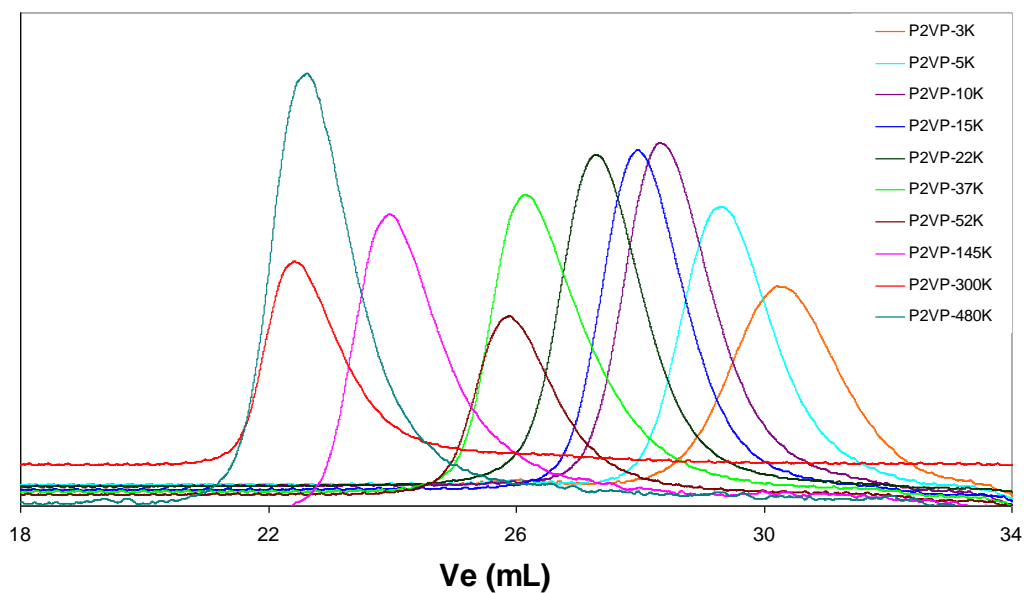
Infrared spectrum will give us the difference in the samples qualitatively, due to the sensibility to impurities. The three samples are chemical identical, as well as the functionality range.

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

Poly (2-Vinyl Pyridine) standard samples

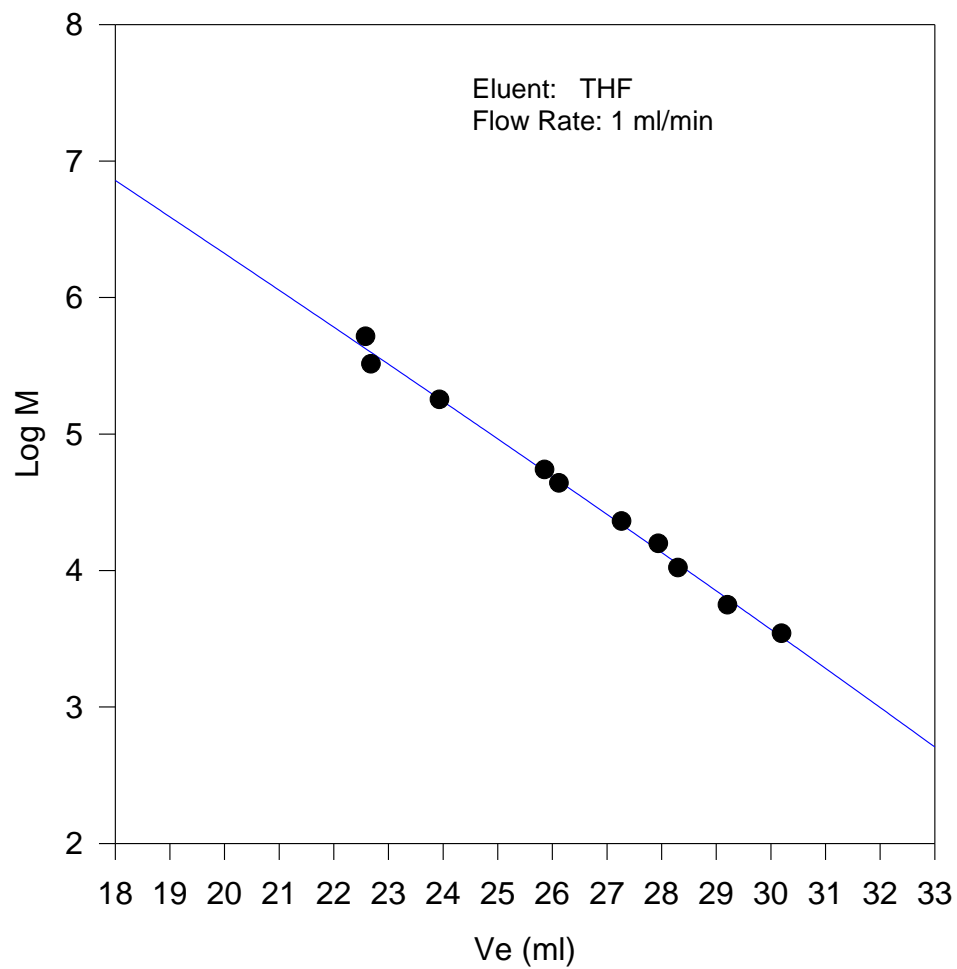
Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 3K	P1565	3300	3700	3400	0.0674	1.13
P2VP 5K	P7543	5300	5600	5500	0.0907	1.06
P2VP 10K	P4846A	9800	10500	10300	0.1215	1.08
P2VP 15K	P18194	15000	16000	15500	0.1532	1.06
P2VP 22K	P18148	22400	24400	22600	0.1919	1.09
P2VP 37K	P7536	37400	41100	43600	0.2709	1.10
P2VP 52K	P15017	52,400	55400	54100	0.3209	1.06
P2VP 145K	P18295	145000	164700	176000	0.6871	1.13
P2VP 300K	P18426	300000	317000	320400	0.9273	1.06
P2VP 480K	P8431	480400	505800	510100	1.4031	1.06

Gel permeation chromatography (GPC) of poly(2-vinyl pyridine) M_w ranging from 3K to 500K are shown below.



Calibration Curve of P2VP in THF

Calibration Curve-P2VP in THF



Prices

10 P2VP reference material 500mg each US\$ 2000.00

10 P2VP reference material 1,000mg each US\$ 2800.00

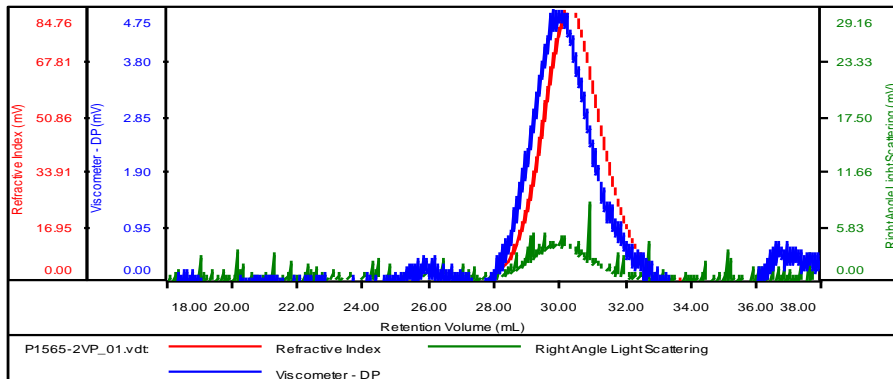
Characterization report for the each sample analysis:

P2VP: 3K lot P1565

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 3K	P1565	3300	3700	3400	0.0674	1.13

Sample ID: P2VP-3K

Concentration (mg/mL)	2.9617
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



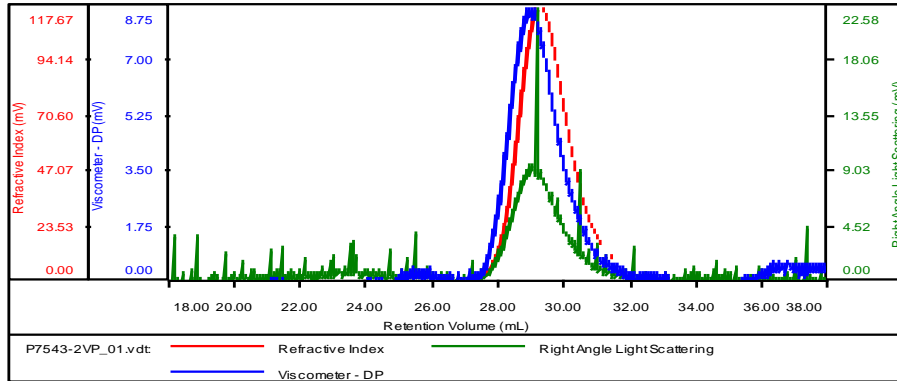
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P1565-2VP_01.vdt	3,300	3,730	3,408	1.130	0.0674

P2VP: 5K lot 7543

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 5K	P7543	5300	5600	5500	0.0907	1.06

Sample ID: P2VP-5K

Concentration (mg/mL)	3.4468
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



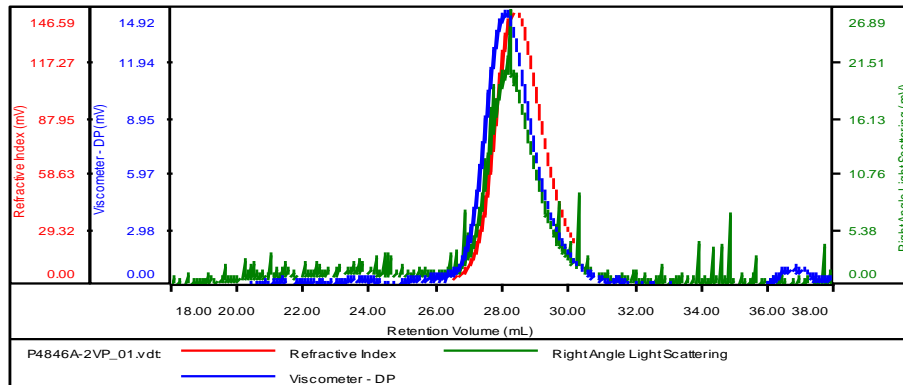
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P7543-2VP_01.vdt	5,298	5,627	5,496	1.062	0.0907

P2VP: 10K lot 4846A

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 6K	P4846A	9800	10500	10300	0.1215	1.08

Sample ID: P2VP-10K

Concentration (mg/mL)	4.3083
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



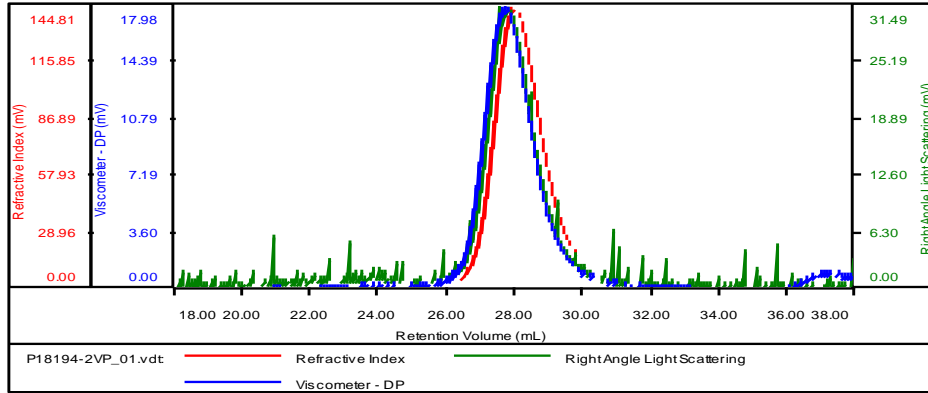
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P4846A-2VP_01.vdt	9,787	10,541	10,263	1.077	0.1215

P2VP: 15K lot 18194

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 15K	P18194	15000	16000	15500	0.1532	1.06

Sample ID: P2VP-15K

Concentration (mg/mL)	4.0141
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



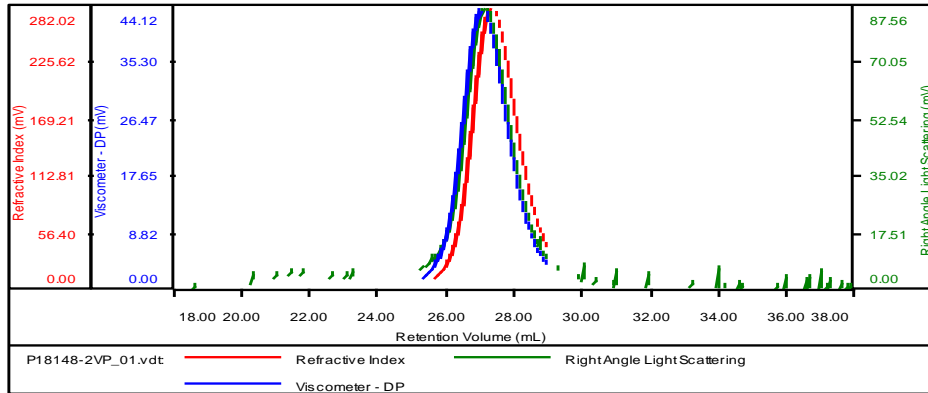
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P18194-2VP_01.vdt	15,014	15,958	15,551	1.063	0.1532

P2VP: 22K lot 18148

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 22K	P18148	22400	24400	22600	0.1919	1.09

Sample ID: P2VP-22K

Concentration (mg/mL)	7.8562
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



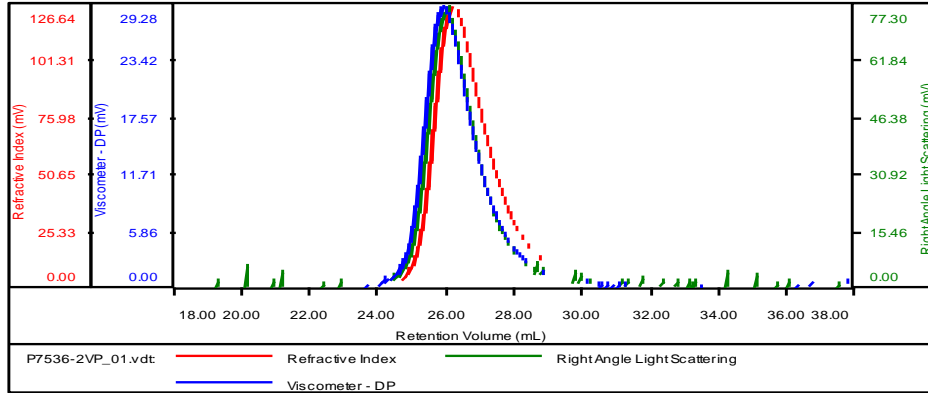
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P18148-2VP_01.vdt	22,417	24,384	22,656	1.088	0.1919

P2VP: 37K lot 7536

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 37K	P7536	37400	41000	43600	0.2709	1.10

Sample ID: P2VP-37K

Concentration (mg/mL)	3.9738
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



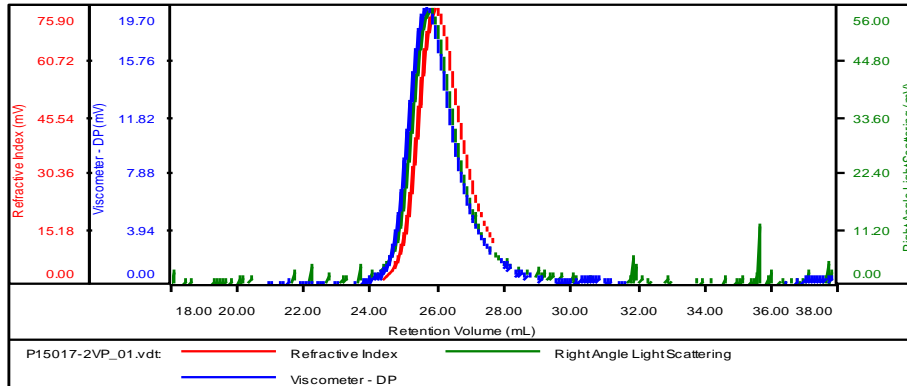
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P7536-2VP_01.vdt	37,422	41,065	43,646	1.097	0.2709

P2VP: 52K lot 15017

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 52K	P15017	52400	55400	54100	0.3209	1.06

Sample ID: P2VP-52K

Concentration (mg/mL)	2.0648
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



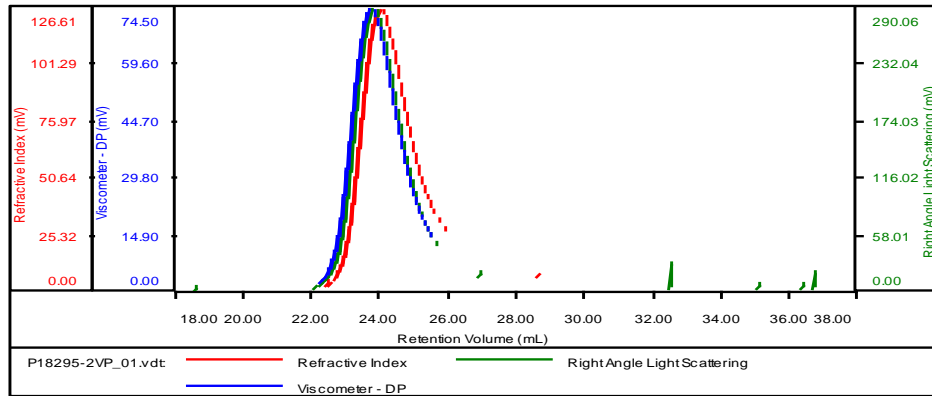
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P15017-2VP_01.vdt	52,415	55,411	54,110	1.057	0.3209

P2VP: 145K lot 18295

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 145K	P18295	145000	164700	176000	0.6871	1.13

Sample ID: P2VP-145K

Concentration (mg/mL)	4.1072
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



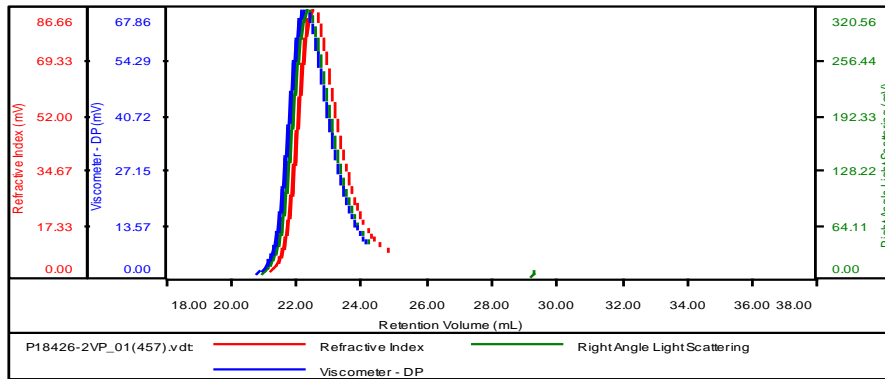
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersit	Intrinsic Viscosity (dL/g)
P18295-2VP_01.vdt	145,040	164,676	175,923	1.135	0.6871

P2VP: 300K lot 18426

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 300K	P18426	300000	317000	320400	0.9273	1.06

Sample ID: P2VP-300K

Concentration (mg/mL)	2.4479
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



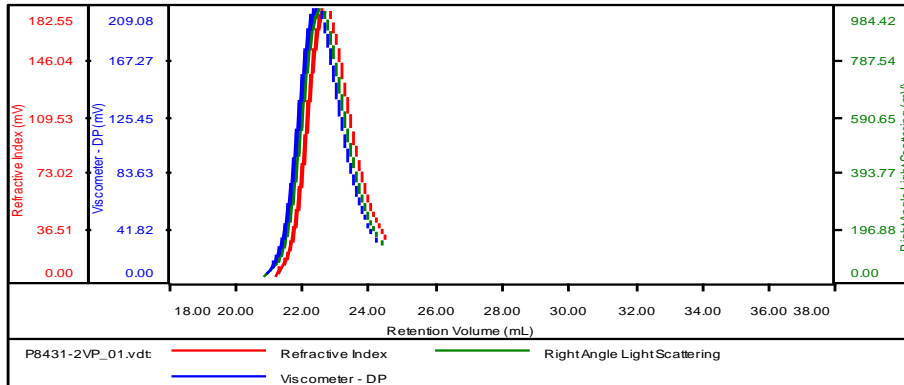
Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersity	Intrinsic Viscosity (dL/g)
P18426-2VP_01(457).vdt	299,813	317,028	320,443	1.057	0.9273

P2VP: 480K lot 8431

Part No.	Lot No.	M_n	M_w	M_p	$[\eta]$ in THF at 23°C (dl/g)	M_w/M_n
P2VP 480K	P8431	480400	505800	510100	1.4031	1.06

Sample ID: P2VP-480K

Concentration (mg/mL)	5.3537
Sample dn/dc (mL/g)	0.1670
Method File	PS80K-Jan22-2015-0000.vcm
Column Set	3x PL 1113-6300
Solvent	THF



Sample	MW Number Average (Da)	MW Weight Average (Da)	MW at Peak (Da)	Polydispersit	Intrinsic Viscosity (dL/g)
P8431-2VP_01.vdt	480,444	505,766	510,168	1.053	1.4031