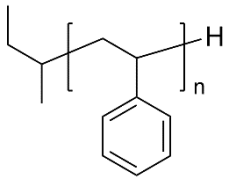
CERTIFICATE OF ANALYSIS

Product name and structure: **POLYSTYRENE**

Certified Reference Material



PS standards kit number: **R12-08k6m-PS**

Part numbers:

1-PS-0.8k_R8093-S,	5-PS-11k_R8575-S,	9-PS-250k_R5712-S,
2-PS-1.8k_R1772-S,	6-PS-25k_R1507-S,	10-PS-650k_R2814-S,
3-PS-2.5k_R2275-S,	7-PS-60k_R4249-S,	11-PS-900k_R5654-S,
4-PS-5.5k_R4246-S,	8-PS-105k_R10518-S,	12-PS-6M_R106p-S.

PS Certified Reference Material:

Polymer:	Polystyrene (PS)
Linear formula:	$[CH_2CH(C_6H_5)]_n$
CAS number:	9003-53-6
Purity:	99.9 %
Appearance:	White powder, solid, or fluffy material (except PS with MW<1,000: viscous material)
Production:	Polystyrene was synthesized by living anionic technique, and regressively purified by column chromatography to remove inorganic side-products followed by freeze-drying of the obtained polymer solution from benzene.
Quality Control:	Polymer Source is **ISO 9001:2015** certified company, and our Testing and Calibration Laboratory is complying with **ISO 17025** international standard for laboratory quality system.

GPC/SEC Instrument Details and Analysis Conditions:

Instrument:	Agilent Technologies 1260 Infinity II GPC/SEC System
Detectors:	Triple detector (RI, Viscometer, LS 90° and LS 15°)
Columns:	Three columns 300×7.5 mm, Agilent Technologies: • PLgel 5µm 10E3Å (MW range: 500 to 60,000) • PLgel 10µm 10E5Å (MW range: 60,000 to 2,000,000) • PLgel 10µm 10E6Å (MW range: 600,000 to 10,000,000)
Solvent (mobile phase):	THF (Tetrahydrofuran with 1% triethylamine)
Temperature:	30 °C
Flow rate:	1 mL/min
Injection volume:	100 µL
Column calibration:	Polystyrene analytical standards (M_p: 580 – 6,035,000 g/mol)
System calibration:	Polystyrene analytical standard (M_p: 217,000 g/mol)
Data acquisition software:	Agilent GPC/SEC Software
Sample concentration:	0.5–2 mg/mL
dn/dc (mL/g)	0.185
*Abbreviations used in Results:	M_p, M_n, M_w, M_z and M_v are the respective peak, number, weight, Z and viscosity molecular weight averages. M_w/M_n is the polydispersity ratio. [η] is the intrinsic viscosity (THF, 30 °C).

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^{1}H NMR Instrument Details and Analysis Conditions:

Instrument:	Bruker Avance III 500 NMR spectrometer
Solvent:	Chloroform-d_3

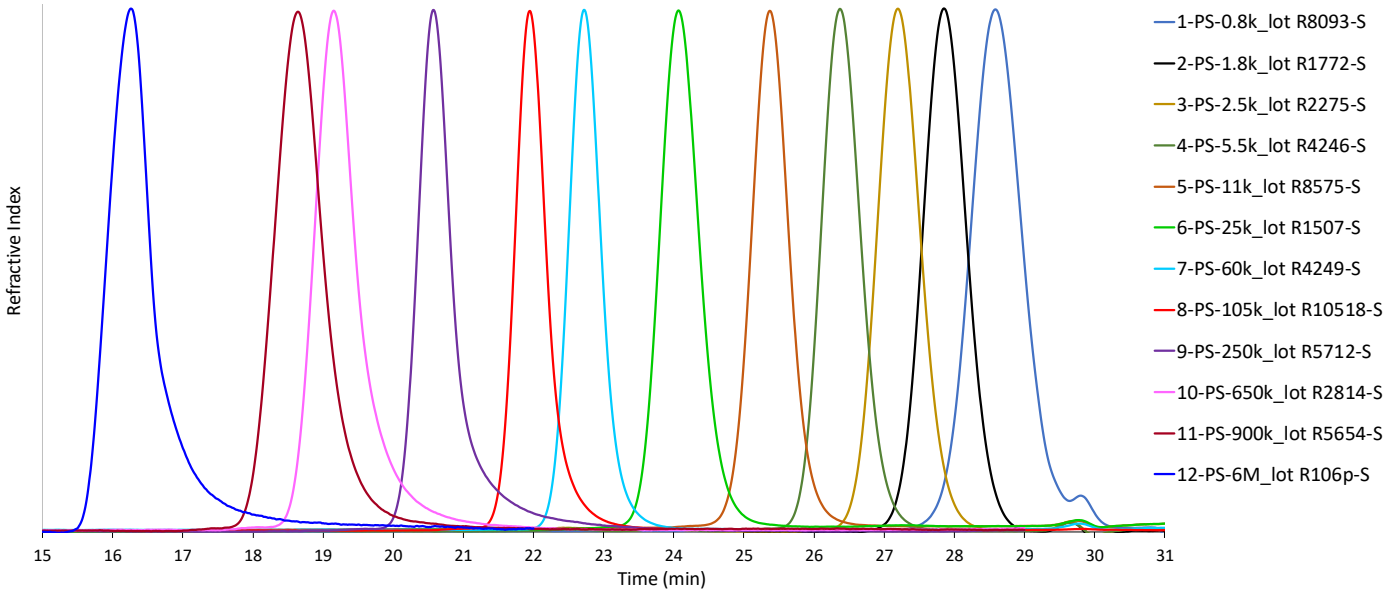
DSC Instrument Details and Analysis Conditions:

Instrument:	TA Instruments DSC Q100
Gas:	Nitrogen
Thermal analysis:	Glass transition temperature (T_g) was measured at a scan rate of 10°C/min.

RESULTS:

Sample #	GPC/SEC Results							Mol.Wt. calculated from ^{1}H NMR	T_g (°C)
	Molecular weight averages (g/mol)					Mw/Mn	$[\eta]_w$ (dL/g)		
	Mp	Mn	Mw	Mz	Mv				
1-PS-0.8k	790	725	820	930	880	1.13	0.03	790	–4
2-PS-1.8k	1,870	1,820	1,890	1,950	1,930	1.04	0.04	1,410	49
3-PS-2.5k	2,500	2,430	2,500	2,550	2,500	1.03	0.05	2,660	68
4-PS-5.5k	5,500	5,300	5,450	5,500	5,450	1.03	0.07	4,850	84
5-PS-11k	11,000	10,800	11,000	11,050	11,000	1.02	0.10		90
6-PS-25k	25,700	25,000	25,500	25,800	25,750	1.02	0.18		100
7-PS-60k	60,500	60,000	61,000	61,200	61,100	1.02	0.32		100
8-PS-105k	105,000	103,000	105,000	104,000	104,000	1.02	0.46		100
9-PS-250k	249,000	235,000	240,000	245,000	244,000	1.02	0.83		102
10-PS-650k	690,000	615,000	658,000	690,000	680,000	1.07	1.79		106
11-PS-900k	900,000	857,000	881,000	901,000	899,000	1.03	2.16		106
12-PS-6M	6,500,000	5,570,000	6,260,000	6,750,000	6,550,000	1.12	6.34		106

Chromatograms Overlay



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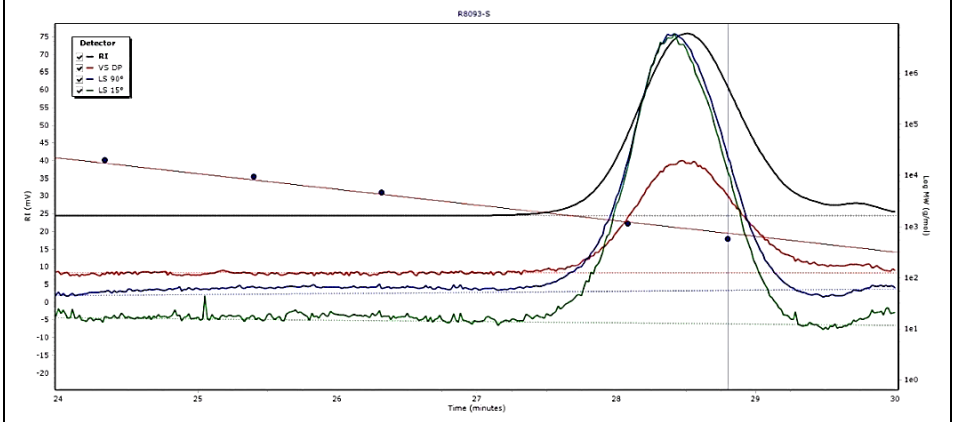
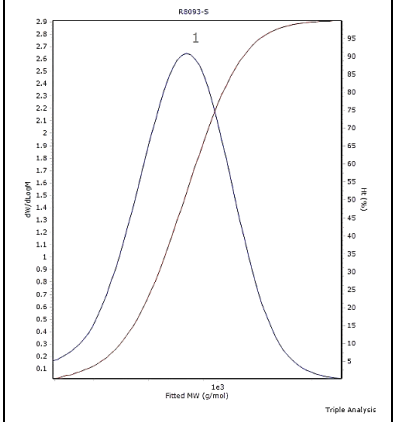
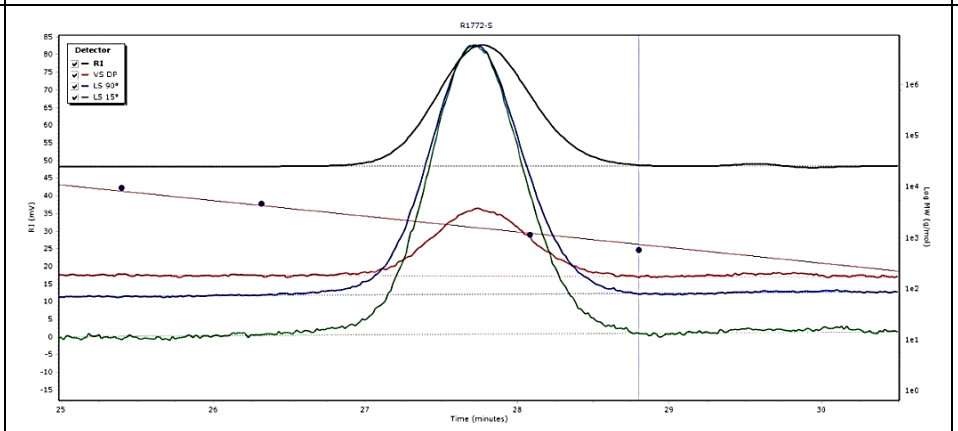
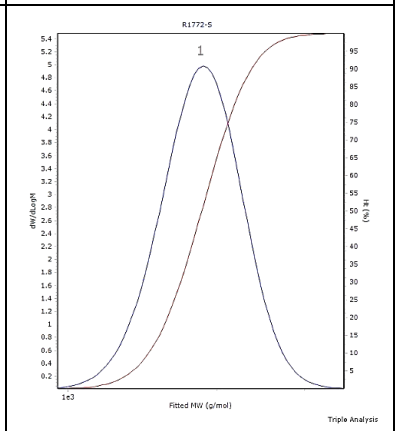
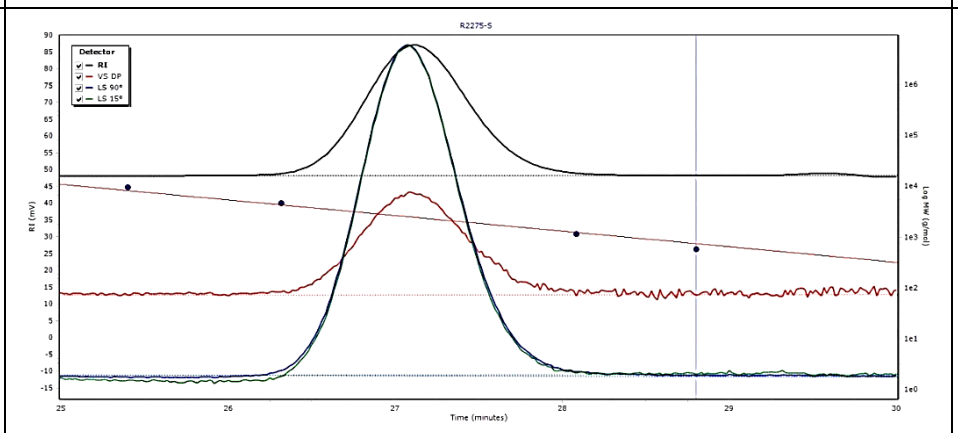
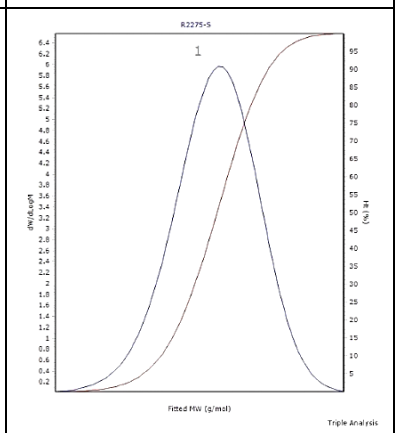
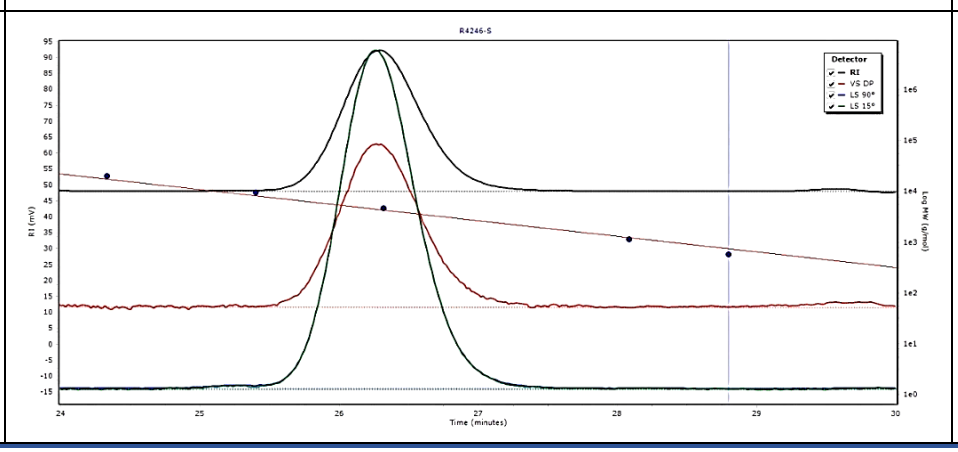
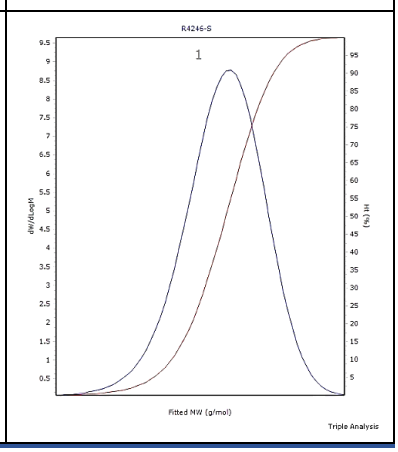
1-PS-0.8k:		
2-PS-1.8k:		
3-PS-2.5k:		
4-PS-5.5k:		

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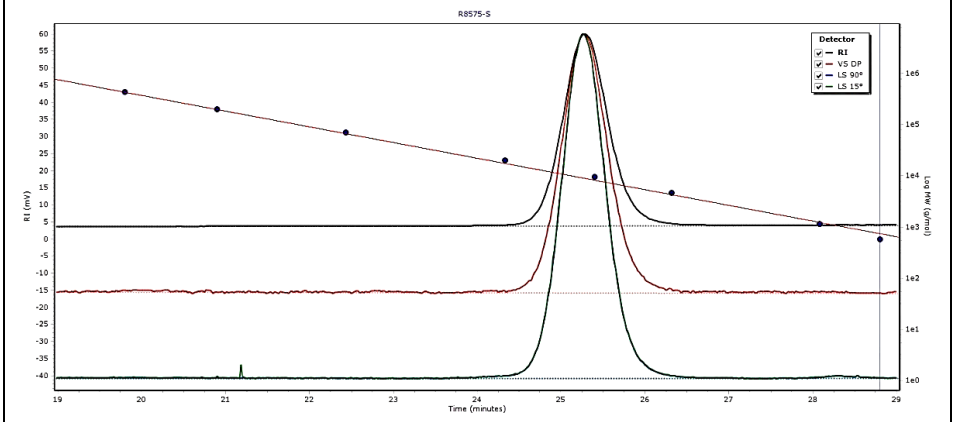
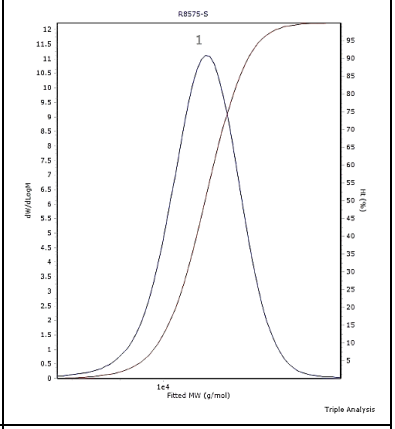
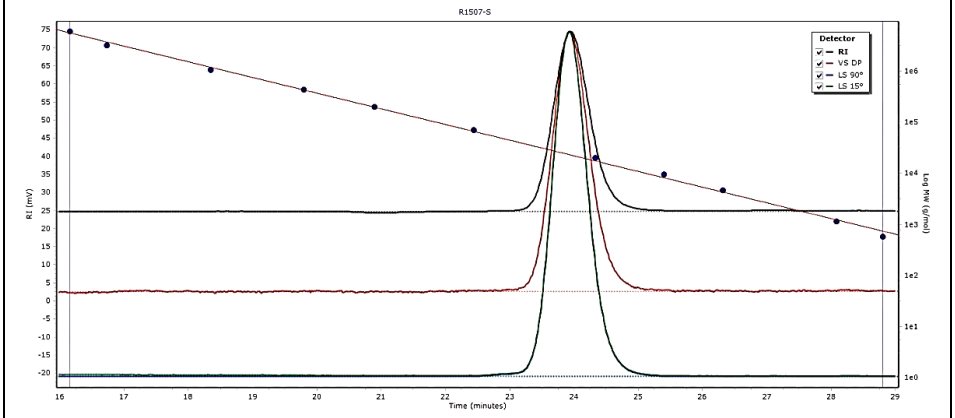
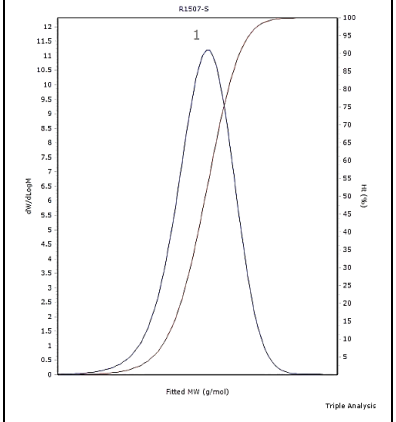
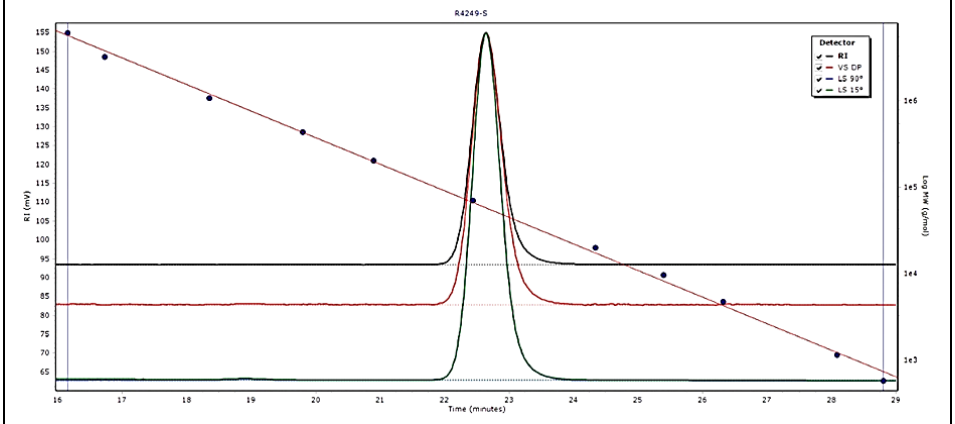
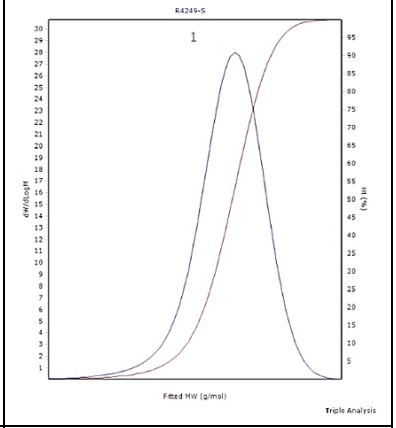
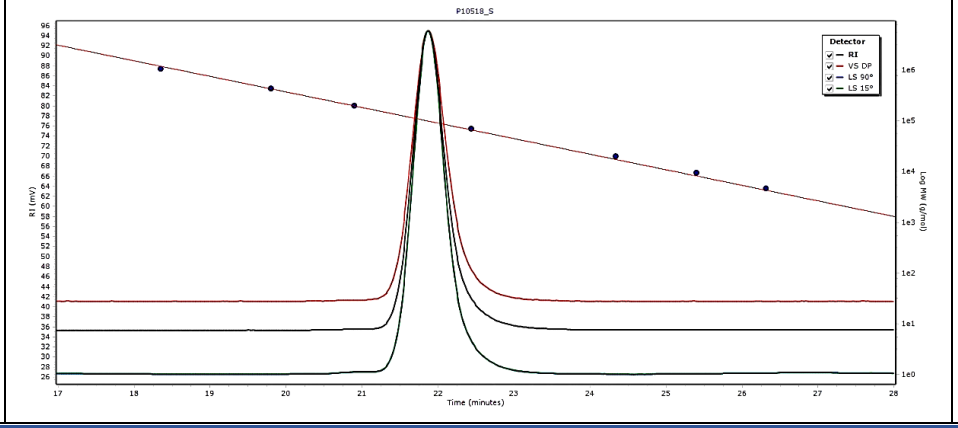
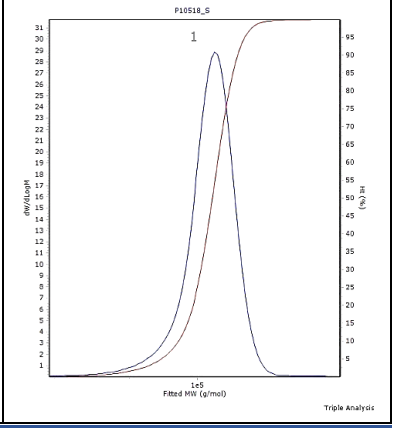
#	Chromatogram plot:	Distribution plot:
5-PS-11k:		
6-PS-25k:		
7-PS-60k:		
8-PS-105k:		

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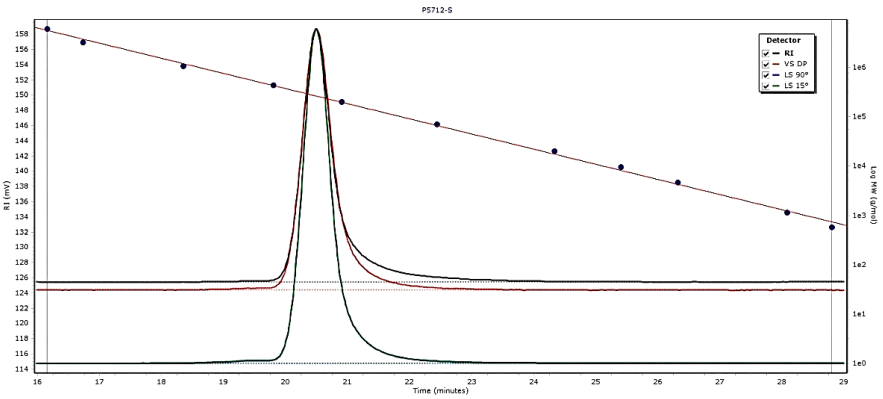
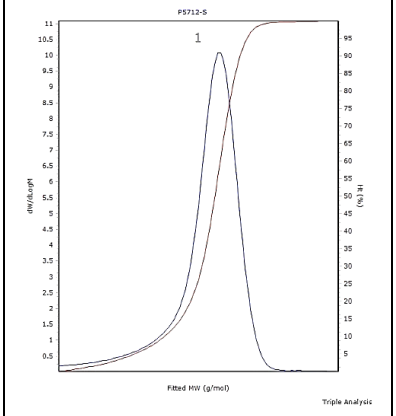
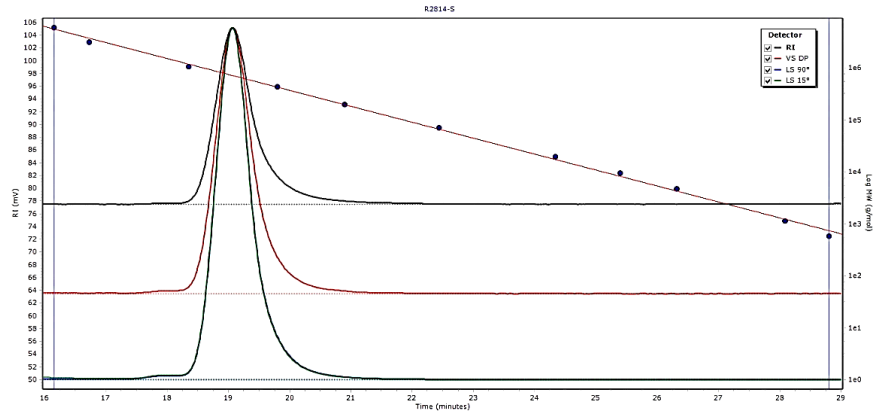
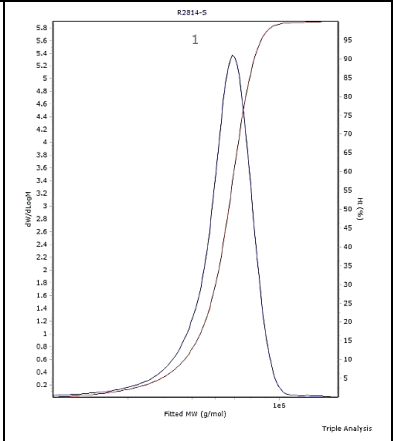
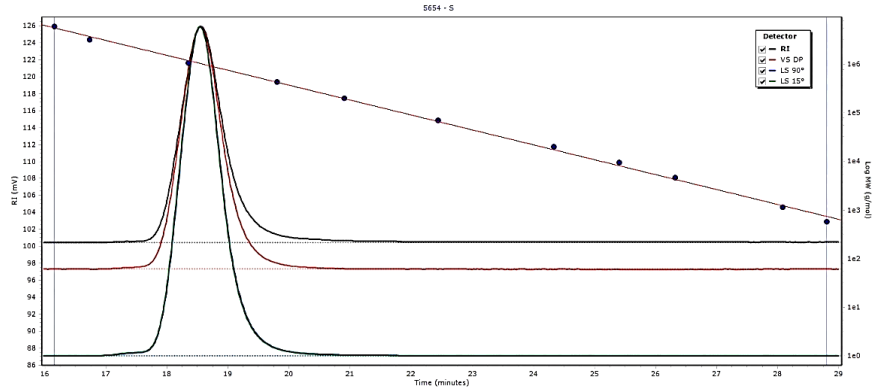
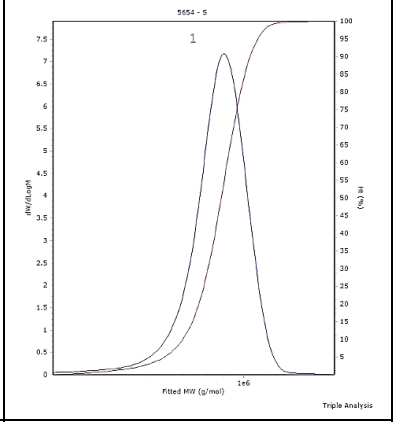
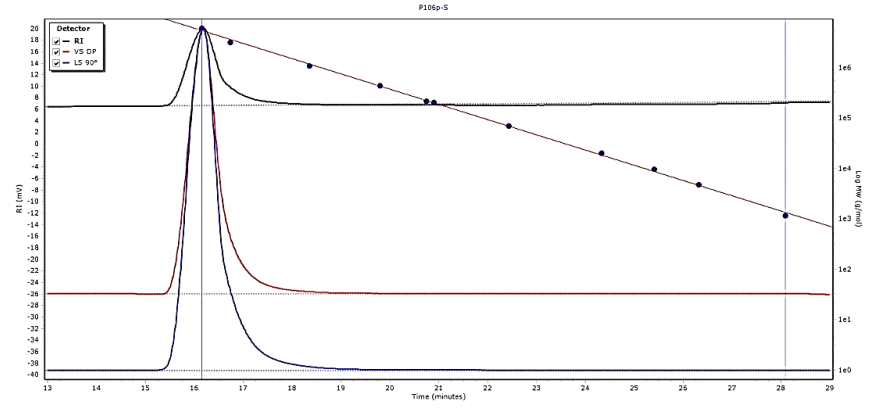
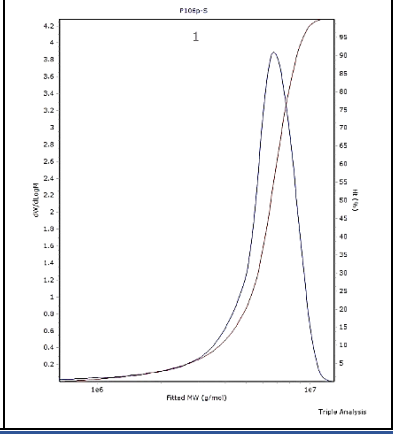
#	Chromatogram plot:	Distribution plot:
9-PS-250k:		
10-PS-650k:		
11-PS-900k:		
12-PS-6M:		

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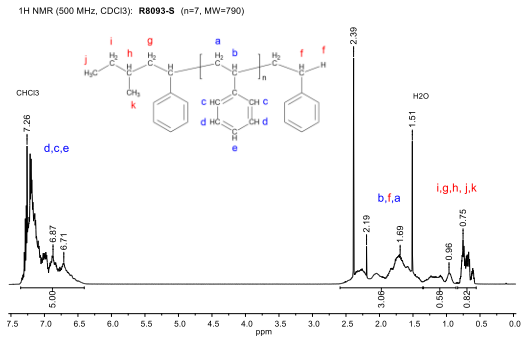
Polystyrene samples of low molecular weight were analyzed by proton NMR, and the calculated MW is in good correlation with GPC/SEC data. ^{1}H NMR spectra are presented below.

1-PS-0.8k:



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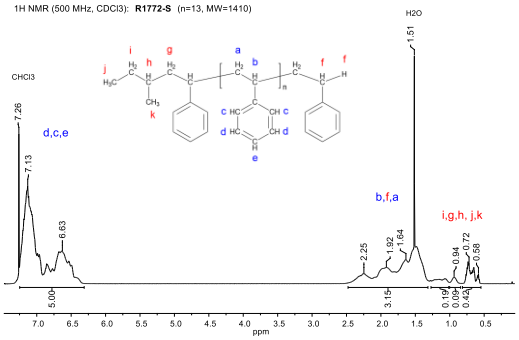

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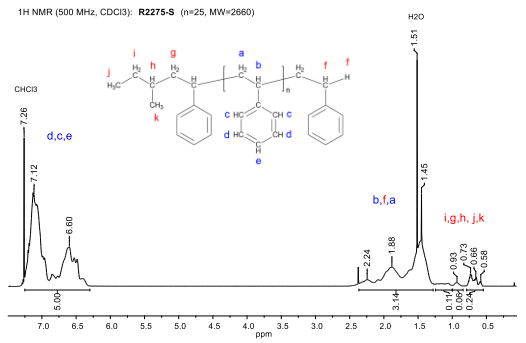
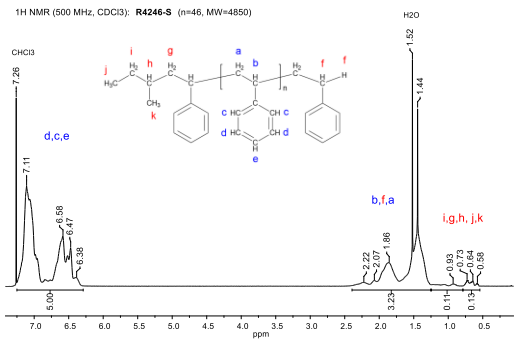
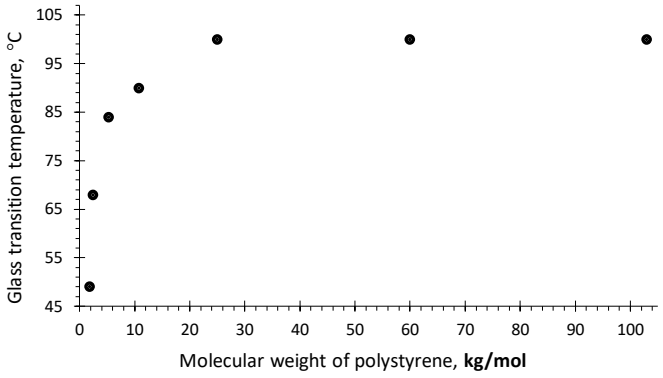
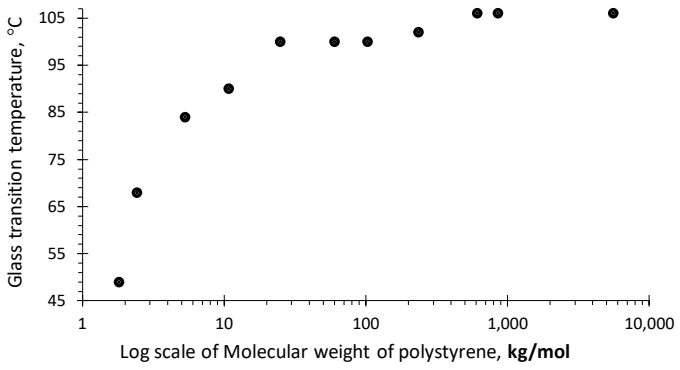


4-PS-5.5k:



Dependence of glass transition temperature (T_g) of polystyrene from its molecular weight:





The above analyses run according to international standard for laboratory quality systems.
Manufacture and quality control run according to *Polymer Source* methods of analysis.

Sunil K. Varshney, Ph.D.

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