Analysis of Biodegradable Polymers by GPC

Application Note

Materials Testing & Research

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Introduction

Polymers have a wide range of uses in society because of their durability and resistance. This durability, however, has its drawbacks, especially when it comes to the disposal of polymers once they are no longer useful. An accumulation of degradation resistant polymers in landfill sites has become a serious problem. The solution is a polymer that can be degraded by natural means without losing the functional properties that make the polymer so useful.

A biodegradable polymer can be broken down into simpler substances by the activities of living organisms and is, therefore, unlikely to persist in the environment. Biodegradable polymers are also used in medicine, for such things as drug and gene delivery or bio-absorbable stents. Polycaprolactones and polylactides are good examples of biodegradable polymers with a wide range of industrial and biomedical applications. Polycaprolactones are fully biodegradable thermoplastic polymers, though they are derived from the chemical synthesis of non-renewable crude oil. Polylactides (PLA) are biodegradable polymers derived from lactic acid. Gel permeation chromatography is an ideal method for the analysis of biodegradable polymers. The approach adopted here employs refractive index and viscometry detection.

Conditions

Sample: Polylactide, polycaprolactone and polylactide-glycolide
Columns: 2× Agilent ResiPore, 7.5 × 300 mm (p/n PL1113-630)
Eluent: THF
Flow Rate: 1 mL/min
Temp: 40 °C
Detector: Agilent PL-GPC 50 (DRI and Agilent PL-BV 400RT)

Results and Discussion

Figures 1 to 3 show examples of dual detection chromatograms for some biodegradable polymers. Figure 1 shows a polylactide sample, Figure 2 is a polycaprolactone sample and Figure 3 is a polylactide-glycolide.

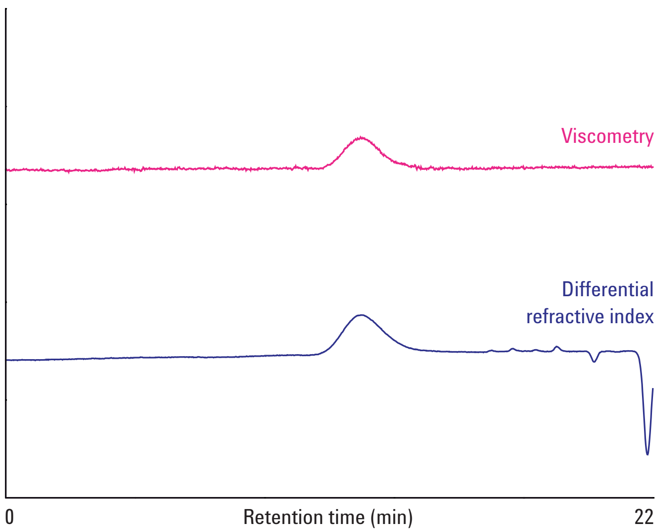

Figure 1. Dual detection chromatograms of a sample of polylactide

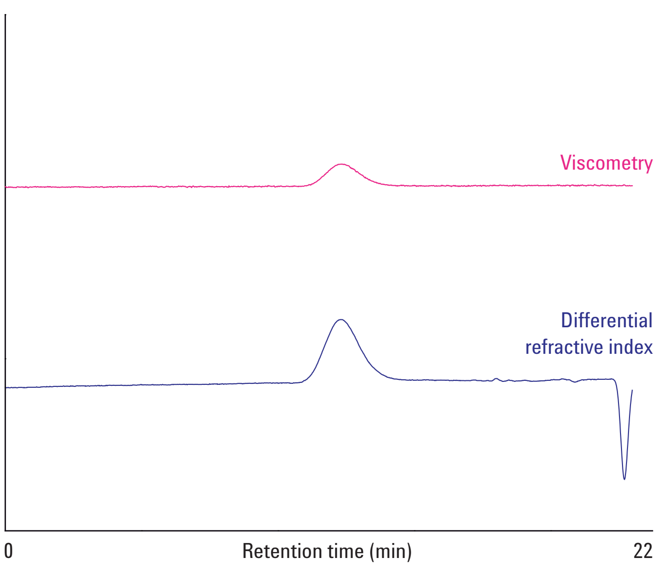

Figure 2. Dual detection chromatograms of a sample of polycaprolactone

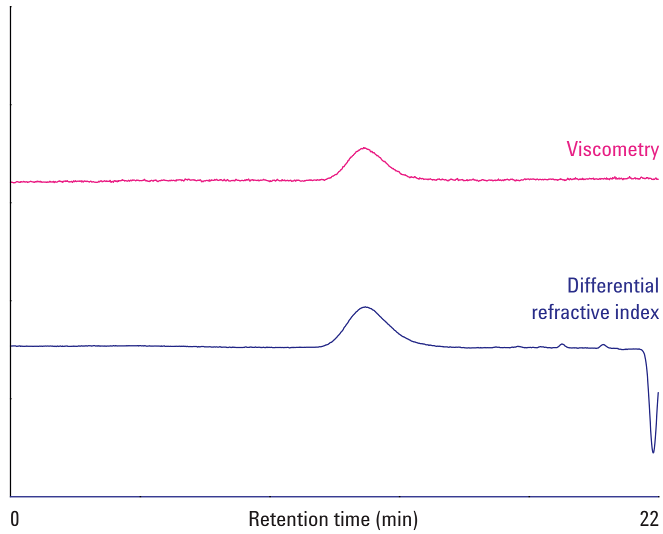

Figure 3. Dual detection chromatograms of a sample of polylactide-glycolide

The overlaid molecular weight distribution plots are shown in Figure 4.

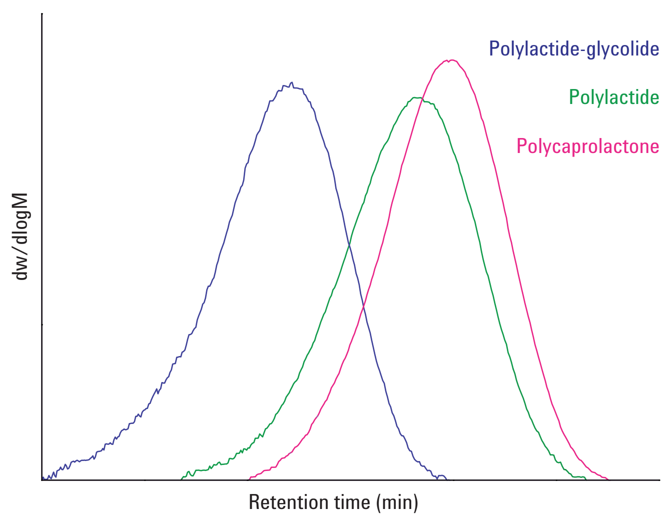

Figure 4. Molecular weight distibutions of three biodegradable polymers

The universal calibration curve was generated using linear PS standards with narrow polydispersity (Figure 5).

Based on this calibration, the molecular weight averages and weight average, intrinsic viscosity (IVw) was calculated for the biodegradable polymers. The table shows the molecular weight averages for a selection of such polymers.

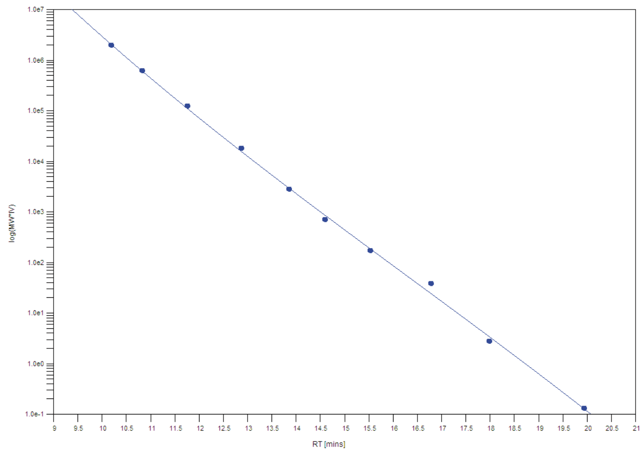

Figure 5. Universal calibration curve

Conclusion

The GPC system successfully characterized some biodegradable polymers. Using RI and viscometer detection, and universal calibration, it was possible to derive the molecular weight distributions of the samples, and calculate several of their characterization parameters.

Table 1. Molecular weight averages for a selection of biodegradable polymers

Sample	Molecular Weight Averages $gmol^{-1}$						PD
	Mp	Mn	Mw	Mz	Mz+1	Mv	
Poly(dl-lactide)	70,863	42,039	73,904	115,032	160,338	68,604	1.758
	69,596	41,967	74,148	114,767	158,539	68,860	1.7668
Poly(dl-lactide)-glycolide	72,153	44,926	77,077	118,849	164,761	71,687	1.7156
	70,863	43,821	76,555	118,849	164,761	71,687	1.747
50:50 d,l-PLGA	43,010	24,729	42,860	63,021	84,231	40,121	1.7332
	42,259	24,183	41,822	62,163	83,542	390,774	1.7294
65:35 d,l-PLGA	64,762	36,471	63,183	96,758	133,397	58,812	1.7324
	59,209	33,999	61,212	96,217	135,076	56,698	1.8004
75:25 d,l-PLGA	72,153	43,984	75,487	116,184	160,925	70,231	1.7162
	72,153	42,852	74,164	114,689	158,620	68,914	1.7307
95:5 d,l-PLGA	16,447	9,114	16,488	24,968	33,641	15,339	1.8091
	16,447	9,231	16,280	24,477	32,753	15,167	1.7636
Polycaprolactone	100,091	67,340	105,978	153,033	203,984	99,736	1.5738
	100,091	67,310	105,871	154,173	206,777	99,514	1.5729

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