APPLICATION NOTE

AN1301: Characterization of PLGA using SEC-MALS-IV

Poly(lactic-co-glycolic acid) (PLGA) is a copolymer based on glycolic acid and lactic acid. The two monomer units are linked together by ester linkages and form linear polyester chains. The final product is biodegradable and biocompatible, and is approved by the Food and Drug Administration (FDA) for production of various therapeutic devices as well as for drug delivery applications. The properties of PLGA can be tuned by the ratio of the two monomers and by the overall molar mass distribution.

The characterization of PLGA by means of conventional size exclusion chromatography (SEC) is problematic because of the lack of suitable calibration standards. In addition, the linear polyester structure can be modified by the addition of small amounts of polyfunctional monomer to obtain branched chains of differing degrees of branching. The degree of branching becomes an additional parameter that can be used to adjust PLGA properties—all of which renders conventional column calibration an inadequate analytical technique.

In this application note, two commercially available samples were analyzed in the ASTRA® software by SEC coupled to a multi-angle light scattering (MALS) detector (DAWN®), a refractive index detector (Optilab®), and a differential viscosity detector (ViscoStar®). The MALS and RI signals were combined to determine absolute molecular weight, independently of elution time or column calibration. The ViscoStar was used in order to measure intrinsic viscosity (IV) and uncover additional information about the molecular structure of the analyzed polymers. In addition to molar mass distributions, the SEC-MALS-IV system yields the relationship between intrinsic viscosity and molar mass (Mark-Houwink-Sakurada plot) that can provide deep insight into the molecular structure of the polymers being analyzed.

In Figure 1 the molar mass distributions are given as differential distribution plots. As seen from the plots, the two samples span markedly different molar mass ranges. The Mark-Houwink-Sakurada plots of the two samples are shown in Figure 2 together with the plot of linear polystyrene that is shown simply for the sake of comparison. The slope of the Mark-Houwink-Sakurada plot of the linear polystyrene is 0.71, a typical value for linear random coils in thermodynamically good solvents. The slope of the red sample roughly corresponds to a linear structure as well. However, there is a slight indication of deviation from linearity at the region of high molar masses that may indicate the presence of branched molecules. The Mark-Houwink-Sakurada plot of the blue sample is curved. Curvature of the Mark-Houwink-Sakurada plot generally reveals branching.

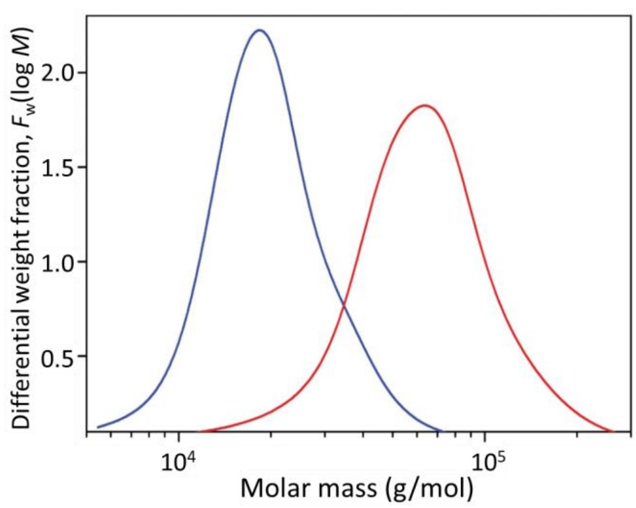


Figure 1. Differential molar mass distribution curves of two PLGA samples.

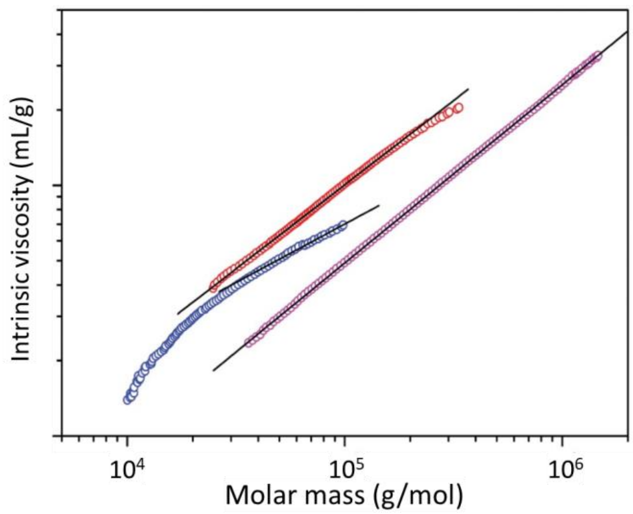
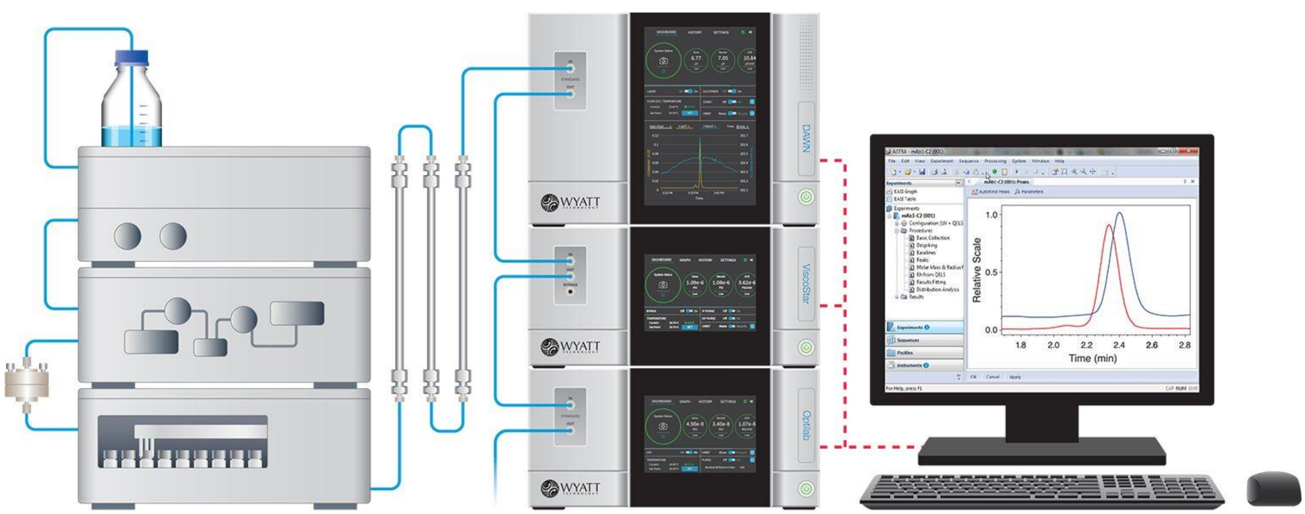


Figure 2. Mark-Houwink-Sakurada plots of two samples of PLGA (red and blue) and linear polystyrene (magenta). The lines are linear extrapolations of the data.

In addition, the slope of the higher molar mass portion of the Mark-Houwink-Sakurada plot of 0.48 suggests significant branching. SEC-MALS-IV is an excellent method for the characterization of PLGA polyesters as it has the ability to determine not only the absolute molar mass distribution, but to reveal subtle differences in PLGA's molecular structure.



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