Characterization of High Molecular Weight Polyacrylamide Using Asymmetrical Flow Field-Flow Fractionation and Multi-Angle Light Scattering

General Information

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Applicaton Polymer Characterization
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Introduction

Polyacrylamide (PAM) is a water-soluble polymer which is widely used for industrial applications such as wastewater and sewage treatments, mining processes, and oil recovery. The physical and mechanical properties of PAM are sensitive to changes in their average molecular weight and degree of branching. Thorough characterization of PAM products is essential to tailor their physical and rheological properties.

Asymmetrical Flow Field-Flow Fractionation (AF4) coupled to Multi-Angle Light Scattering (MALS) is a powerful analytical technique for characterization of high molecular weight and branched PAM products where conventional techniques such as gel permeation chromatography lack the separation range needed to provide accurate mass and size measurements [1-2].

In this application note the use of AF4-MALS is demonstrated to characterize a high molecular weight PAM sample. A schematic for the AF4 channel is shown in figure 2. The combination of cross flow and channel flow causes size separation over the course of analysis, with smaller particles eluting to connected detectors before larger particles.

Figure 1: Experimental setup: Postnova AF2000 Asymmetrical Flow Field-Flow Fractionation system (left); Postnova MALS detector (right).

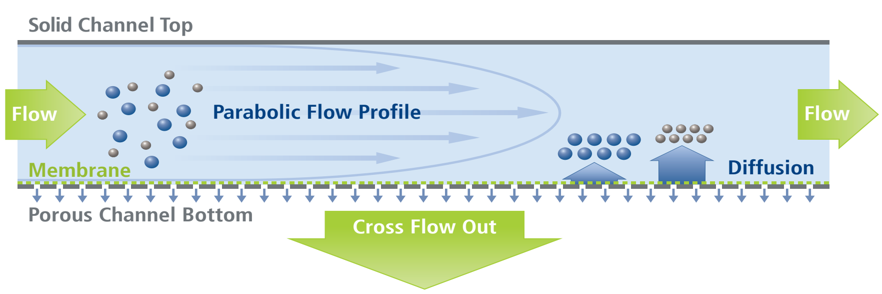

Figure 2: Schematic of the AF4 separation principle.

AF4-MALS Analysis of PAM Standard

Figures 3 illustrates the fractograms of two replicates of a high molecular weight PAM sample. The solid lines represent the response of the 92° angle LS signal. The results show good reproducibility for retention time and peak height. The radius of gyration and molecular weight profiles are also shown in the graphs represented by solid circles. The radius and molecular weight profiles increase steadily across the distribution. The radius varies from 100 nm to 180 nm which corresponds to a molecular weight range of 3 MDa to 20 MDa.

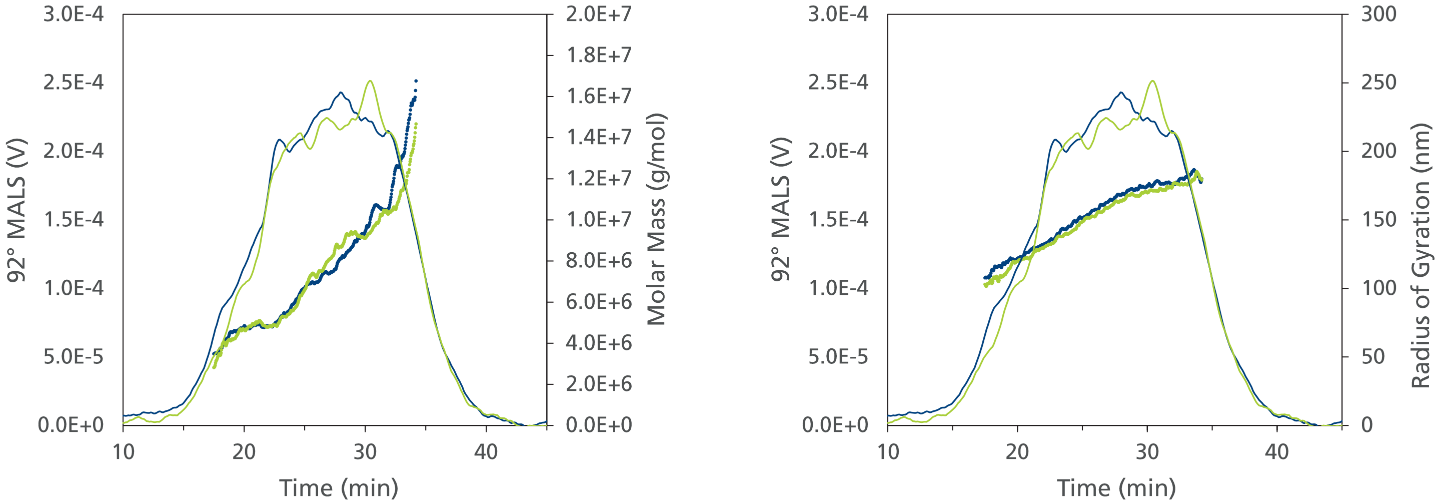

Figure 3: Molar mass (left) and radius of gyration (right) distributions of the PAM standard obtained from AF4-MALS analysis.

Zimm and Stockmayer introduced a mathematical formulation to detect and quantify polymer branching [3]. The branching of polymers can be recognized from the slope of the conformation plot (log of radius of gyration versus log of molecular weight). The slope of the confirmation plot for a linear polymer is ≈ 0.58, and a branched structure exhibits a lower value (the value for a compact sphere is 0.33). The conformation plots of the PAM standard replicates are given in figure 4. The average slope of the plots is measured as 0.36, which is indicative of a highly branched or compact structure.

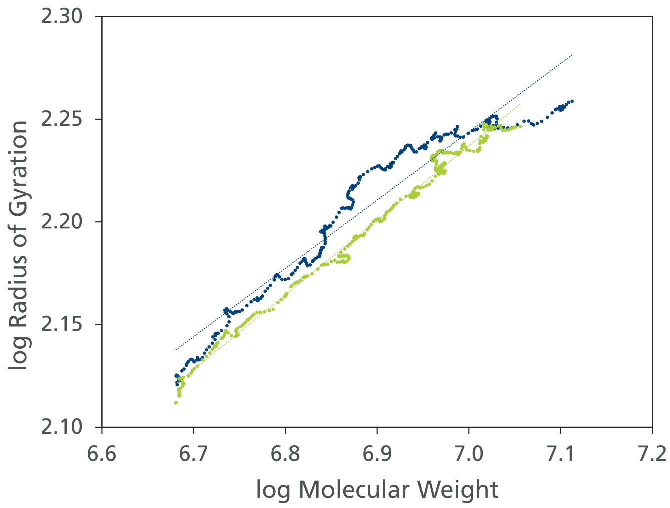

Figure 4: Conformation plot of the PAM sample.

Conclusion

A high molecular weight PAM standard was characterized by AF4-MALS for molecular weight, size and branching. The weight average molecular weight of the polymer was measured as 7.6 MDa with a weight average radius of gyration of 154 nm. The conformation plot suggested high order of branching in the polymer structure. The data demonstrates the capability of the methodology in the accurate characterization of high molecular weight and branched PAM products.

References

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