

Polymer Molar Mass and Composition Elucidation Applying GPC/SEC and Multidimensional LC

Harald Pasch

Department of Multidimensional Polymer Characterization, Institute of Active Polymers,
Helmholtz-Zentrum Hereon, Kantstr. 55, 14513 Teltow, Germany

Complex polymers are multicomponent systems of macromolecules. These macromolecules are not uniform in their molecular structure but exhibit distributions in various molecular parameters including size, composition, types and numbers of functional groups, tacticity and molecular topology. To address these distributions, a number of liquid chromatographic techniques have been developed that fractionate complex polymers with regard to specific molecular parameters.

Until the end of the 1970s the major tool for fractionating complex polymers regarding molecular size was gel permeation chromatography (more accurately size exclusion chromatography, SEC) that, based on entropic interactions between the macromolecules and the stationary phase of a SEC system, separates the sample according to hydrodynamic size in solution. As the hydrodynamic size is directly related to molar mass, SEC was the primary method for molar mass analysis of polymers. In the early days of SEC, only a concentration-sensitive detector, mainly a differential refractometer (DRI) was used that measured the polymer concentration in the eluate as a function of elution volume. The correlation between elution volume and molar mass was obtained via a suitable calibration procedure. Later, molar mass sensitive detectors were developed that allowed for the direct reading of the molar mass. Information on chemical composition as a function of molar mass could be obtained by coupling SEC with information-rich detectors (FTIR, NMR, MS).

A milestone in fractionating polymers with regard to chemical composition was achieved when solvent and temperature gradient HPLC systems were developed. These techniques are based on influencing the enthalpic interactions between the macromolecules and the stationary phase by changing the composition/temperature of the mobile phase. The combination of different LC methods in two-dimensional HPLC setups was the ultimate approach for the comprehensive analysis of complex polymers. As per today, a toolbox of HPLC methods is in place that enables the fractionation of complex polymers according to all molecular parameters including tacticity and branching.

In the present talk, an overview on the different GPC/SEC and HPLC techniques is given and the coupling of different techniques is addressed. Some major applications are presented, including the analyses of thermoplastic polymers, polyolefins, bio-based and biodegradable polymers.

Biography

Harald Pasch

Pasch obtained his PhD and DSc in 1982 and 1987, respectively. From 1987 to 1989 he conducted research at the Kuwait Institute for Scientific Research followed by establishing an analytical department at the German Institute for Polymers (DKI), Darmstadt. At DKI, Pasch developed novel methods for polymer fractionation, most prominently in the field of multidimensional liquid chromatography. Working in polyolefin research for a long time and collaborating with SASOL, South Africa, he was appointed as SASOL Chair in Analytical Polymer Science at Stellenbosch University, South Africa in 2008. Pasch is the author or co-author of more than 350 scientific papers, he wrote 5 books and has promoted more than 50 postgraduate students. In 2021, he retired from Stellenbosch University. Currently, he is the head of the Department of Multidimensional Polymer Characterization at the Helmholtz Center Hereon in Teltow, Germany.