Preface

Polyolefins are the most widely used synthetic polymers and their production capacities are rapidly increasing. Polyolefins are produced from very simple monomers containing only carbon and hydrogen, yet they exhibit very complex molecular structures. As all other synthetic polymers, polyolefins are distributed regarding various molecular properties, including molar mass, chemical composition, microstructure and molecular topology.

One consequence of the complex structure of polyolefins is the need for advanced analytical methods that provide accurate and quantitative information on the different parameters of molecular heterogeneity. In addition to analysis of bulk properties by spectroscopic methods, emphasis is on the analysis of property distributions that require suitable fractionation methods. If the material is distributed in more than one molecular property, multidimensional fractionations or the combination of fractionation and spectroscopic analysis might be required. High temperature fractionation methods must be used because most polyolefins are semi-crystalline and do not dissolve in common solvents at ambient temperatures. Powerful and well established methods include high temperature size exclusion chromatography (HT-SEC) for molar mass analysis, temperature rising elution fractionation (TREF) and crystallization analysis fractionation (CRYSTAF) for the analysis of chemical composition and branching. Recently, a number of more advanced methods including high temperature two-dimensional liquid chromatography (HT-2D-LC), temperature gradient interaction chromatography (TGIC) and crystallization elution fractionation (CEF) have been developed.

The fractionation of polyolefins has been addressed in numerous original publications and review articles. The most recent reviews were published by Monrabal (Adv. Polym. Sci., 2013, 257:203–51) and the authors of this book (Adv. Polym. Sci., 2013, 251:77–140) in 2013. These reviews provide an excellent overview on the current status of polyolefin characterization. They do not, however, give any detailed information on experimental protocols and procedures. To date, no textbook has been published that addresses the experimental background of different polyolefin fractionation techniques in great detail. This challenge is now addressed in the present textbook.

Similar to the previous textbooks in the Springer Laboratory Series, this laboratory manual is written for beginners as well as for experienced scientists. The subject of the book is the description of the experimental approach for the analysis of complex polyolefins. It summarizes important applications in all major fractionation methods with emphasis on multidimensional analytical approaches. The theoretical background, equipment, experimental procedures and applications are discussed for each fractionation technique. It will enable polymer chemists, physicists and material scientists, as well as students of polymer and analytical sciences, to optimize experimental conditions for specific fractionation problems. The main benefit for the reader is that a great variety in instrumentation, separation procedures and applications is given, making it possible to solve simple as well as sophisticated separation tasks.

The book is structured in a similar fashion to the review article of the authors. It commences with a short introduction to the molecular complexity of polyolefins. This is followed by a discussion of crystallization-based fractionation techniques, including TREF, CRYSTAF and CEF. The major part addresses column chromatographic techniques for molar mass, chemical composition and microstructure, and the combination of different fractionations in multidimensional experimental set-ups. Finally, some first information on the application of field-flow fractionation is presented.

This textbook is dedicated to friends and colleagues that contributed (directly or indirectly) to this book by pioneering high temperature fractionation using HPLC, TREF, CRYSTAF, CEF and multidimensional chromatography, most prominently Tibor Macko (Germany) and, among others, Benjamin Monrabal (Spain), Freddy van Damme (The Netherlands), Yefim Brun, Colin Li Pi Shan and Rongjuan Cong (USA), Wolf Hiller, Robert Bruell, Dieter Lilge, Volker Dolle and Peter Montag (Germany), Joao Soares (Canada), Albert van Reenen (South Africa) and a number of former graduate students including Lars-Christian Heinz, Andreas Albrecht, Nyambeni Luruli, Pritish Sinha, Tino Otte, Anton Ginzburg, Stefan de Goede, Elana de Goede and Sadiqali Cheruthazhekatt.

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