Vibrational Spectroscopy (Raman, Near-/Mid-/Far-Infrared) of Polymers: Theory, Instrumentation and Applications

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Course Description

Polymers have become an integral part of our everyday life and this short course will demonstrate that the vibrational spectroscopic techniques are extremely important characterization and control tools for the whole life cycle of a polymeric product. The course will give an overview on the theoretical principles and state-of-the-art instrumentation (including imaging and hand-held systems) of the vibrational spectroscopic techniques (Raman, mid-infrared (IR), near-infrared (NIR) and far-infrared (FIR) spectroscopy) and it will provide a broad range of application examples with reference to the chemical and physical analysis of polymers. Sample preparation and possible artifacts originating thereof will be discussed in detail and qualitative and quantitative analysis will be treated in terms of univariate as well as multivariate, chemometric evaluation procedures. Real-life applications will illustrate the relevance of these spectroscopic techniques for polymer research, reaction monitoring and quality/process control and will facilitate their implementation as industrial routine tools. The course will not only help to more efficiently evaluate vibrational spectroscopic data but will also enable participants to assess the pros and cons of the vibrational spectroscopies relative to other techniques.

Course Outline

Key Topics:

Introduction to the basic theory and instrumentation of Raman, NIR/IR/FIR spectroscopy.

Sample preparation of polymers (including possible pitfalls and artifacts).

Qualitative and quantitative analysis (univariate and condensed overview on multivariate chemometric procedures).

Special instrumental techniques: reflection (attenuated total reflection (ATR), diffuse reflection, reflection absorption); photoacoustic spectroscopy (PAS); polarization measurements, step-scan spectroscopy, resonance-Raman spectroscopy, surface-enhanced Raman and IR spectroscopy (SERS/SEIRS).

Application of Raman, NIR/IR/FIR spectroscopy to chemical quality/process control and reaction monitoring.

IR/NIR and Raman spectroscopic analysis of the state of order and orientation in polymers.

Raman and IR imaging spectroscopy of polymers.

Coupling of vibrational spectroscopy with thermal analysis (TGA, DTA) and with mechanical and rheological measurements of polymers.

Short overview on the latest developments in handheld Raman and IR/NIR spectrometers and presentation of application examples to assess their performance in comparison to benchtop instruments.

Target Audience

Chemists, physicists, chemical engineers (also graduate students in these disciplines), working in the field of polymer research, quality assurance and process control will benefit from this course.

Heinz W. Siesler

Heinz Siesler is a Professor of Physical Chemistry at the University of Duisburg-Essen, Germany, since 1987. His main research interests focus on the application of vibrational spectroscopy to chemical and polymer research, analysis and quality control. He has written more than 240 publications (including four monographs) in this field of research and presented more than 275 lectures worldwide. He received the 1994 EAS Award, the 2000 Tomas Hirschfeld Award and the 2003 Buechi Award in near-infrared spectroscopy and is a Fellow of the Society for Applied Spectroscopy since 2012. He held guest professorships in France (1992), Japan (2000, 2008, 2010) and Austria (2008-2015). Prior to his present academic position he gained extensive industrial experience as section head in molecular spectroscopy and thermal analysis from 1974 to 1987 in the Corporate R&D Department of Bayer AG, Germany. He also worked as lecturer at the University of the Witwatersrand, Johannesburg, South Africa (1972-1974) and as Post-Doc at the University of Cologne (1970-1972), Germany, after receiving his PhD in Chemistry from the University of Vienna, Austria (1970).