PS 712
Advanced Polymer Analysis

Course outline

Prof. Peter Mallon (Course Convener)

Polymer Science 712
Advanced Polymer Analysis
2012

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Aim of this course:

This course will introduce many routine and advanced techniques used to analyze and characterize polymers. It will also focus on the interpretation of analysis results, as well as the planning and execution of practical assignments. The aim is for you to become familiar with the techniques, instruments and experimental approaches that are available, so that you are able to apply this knowledge to solving real research or practical problems.

Rationale for the course:

Knowledge of the various techniques and instruments needed to analyze and characterize polymers is extremely important as these techniques form the foundation of the investigation of polymers in both a research and industrial environment. You need to know the types of techniques that are available, and the types of information that you can get from each technique. There will be a strong emphasis on the analysis and interpretation of results.

What you should be able to do after this course:

1) you need to know and be able to describe the analytical techniques including the principles behind these techniques
2) you need to be able to interpret the results of the various techniques.
3) You need to be able to read, interpret and provide critical analysis of scientific papers
4) you need to be able to plan an approach to solve a particular problem, including what technique you will need to use to get the required information, what information you will need and a strategy for getting the required information.
5) you should have a basic understanding and knowledge of how to operate the various instruments available in the Division of Polymer Science.

How the course will work:

This course will be based on lectures, practical work and assignments. We will also be reading and analysis scientific papers to get a better idea of how the various

techniques can be used. You will also be asked to prepare and present mini-lectures in class on some techniques and report back on your work.

Assessment:

Your mark for this module will be composed of the marks for the various assignments and tasks as well as written tests and exam. The exam counts 60% and the class mark 40%. The class mark is made up of 70% class test and 30% marks from other assignments.

Resources:

The "Encyclopedia of Polymer Science" is available in the reference area of the J.S. Gericke library (location R 668.903 ENC). This can serve as an excellent resource for addition information and background on the work we will cover in the course.

The "Encyclopedia of Analytical Chemistry" (location R 543.03 ENC) also has some excellent reviews of the various techniques we will be discussing in this course.

In addition there is a polymer science resource centre located next to the polymer science tea room in the division of polymer science building. The resource centre has a large collection of books on polymers. You have access to this centre during normal university hours, but may not remove any books.

Course Content:

1) Introduction and overview (Prof Mallon)
    - The role of polymer characterization and analysis
        - Research at the fundamental level
        - Industrial
            - Role in the product development cycle
    - The "philosophy" of analysis
    - Distributive properties of polymers.
    - What technique and when?
    - The "big picture"
    - Analytical approaches
        - Sample preparation and handling
        - Preparative fractionation
        - "Depth profiling"
        - Time dependent studies
        - Comparative analysis
        - Does size matter?
    - Polymer molecules in solution
    - Review of molecular weight determination
        - Introduction and overview of techniques
        - Measurement of Number Average Molecular Weight
        - Measurement of Weight Average Molecular Weight
        - Viscometry
        - Molecular Weight Distributions (SEC, MALDI-TOF)

2) Characterisation and analysis of polymer surfaces and microscopy (Prof Mallon)
    - Introduction
        - When and why surface characterisation is important
    - Scanning Electron Microscopy (SEM)

- Attenuated Total Reflectance Spectroscopy (ATR)
- Photoacoustic Spectroscopy (PAS)
- Electron Spectroscopy for Chemical Analysis (ESCA) and Augér Electron Spectroscopy (AES)
- Secondary-Ion Mass Spectroscopy (SIMS) and Ion Scattering Spectroscopy (ISS)
- Scanning Probe Microscopy
    - Introduction
    - The Scanning Probe Microscope (SPM)
    - Atomic Force Microscope (AFM)
    - Near Field Scanning Optical Microscope (SNOM)
    - Special Scanning Techniques
    - Applications of AFM for Polymers
- Measurement of contact angle and surface energy
- Positron annihilation spectroscopy (Slow Positron Beam).

3) Chromatography as a tool for polymer analysis (Prof Pasch)
    - Size exclusion chromatography (SEC)
    - Liquid absorption chromatography (LAC)
    - Gradient elution chromatography
    - Critical chromatography
    - Hyphenated techniques
        - LC transform and FTIR,
        - 2-D chromatography
        - SEC-MALDI-TOF
    - Examples of analysis of complex polymer systems

4) Mass Spectrometry of Polymers (Prof Pasch)
    - Different ionization methods
    - Ion sources and mass analyzers
    - MALDI-TOF mass spectrometry: fundamentals and technical details
    - MALDI-TOF applications: molar mass, chemical composition, functional groups
    - Collision induced dissociation (CID) for microstructure analysis

5) Thermal analysis (Prof Mallon)
    - Introduction
        - What information can we get and why this information is important.
    - Review of common thermal analysis techniques, DSC, TGA, DMA, DEA
    - Modulated DSC (MDSC)
    - Thermal analysis of polymer blends, DSC and TGA
    - Novel thermal analysis techniques
        - Using AFM as a thermal analysis tool

6) ` Spectroscopic analysis (Prof Mallon)
    - ^{1}H-NMR examples of application in polymer studies
    - ^{13}C-NMR for structural analysis, tacticity, comomer content etc.
    - Infra-red spectroscopy

7) Analysis of polyolefins (Prof Mallon)
    - Molecular heterogeneity of polyolefins
    - High temperature GPC
    - Separation by crystallisability

    - Temperature Rising Elution Fractionation (TREF)
    - Crystallisation Analysis Fractionation (CRYSTAF)
  - Analysis of polyolefin blends
  - Determination of morphology and crystallinity

8) Morphology and physical properties (Prof Mallon)
  - Introduction
  - Determination of amount of crystallinity and crystal structure in semi-crystalline polymers.
  - Physical testing of polymers

Below is the tentative schedule for the course this semester:

Lectures: Tuesday 08:30 – 10:30 (Sanderson Seminar Room)
Thursday 10:30 – 13:00 (Lecture Room)
Friday 14:00 – 17:00 Seminars (Lecture Room)
