CH272-15 Materials and Polymers

20/21

Department
: Chemistry

Level
: Undergraduate Level 2

Module leader
: David Haddleton

Credit value
: 15

Module duration
: 10 weeks

Assessment
: 20% coursework, 80% exam

Study location
: University of Warwick main campus, Coventry

Description

Introductory description

N/A.

[Module web page]

Module aims

Materials and Polymers are used in all applications from functional to structural applications. They turn molecules into useful devices and items, or are extended arrays of connected atoms that have unique properties as solids. This module will give students an appreciation of how materials can be made, how they need to be characterised and how macroscopic properties can be designed for use in energy, healthcare, electronics, personal care and other applications.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Here follows an illustrative syllabus for each section of the module.
Part 1. Polymers (16 lectures + 4 workshops)

BLOCK 1: Polymer Physics
LECTURE 1: Introduction to the fascinating material features of polymers in the liquid state. Polymer solutions and polymer melts. Introduce the concept of viscosity (and visco-elasticity: the latter by means of a movie to watch as homework).
LECTURE 2: Understand the conformation of a polymer chain in the liquid state. The concepts of end-to-end distance, radius of gyration. A recap of molar mass distributions and the introduction of size exclusion chromatography.
LECTURE 3: Understand the structure of polymers in the solid state. Amorphous and crystalline states. The solid-liquid phase transition. The concept of a glass transition, the concept of crystalline polymers. Note that elastomers/gels/rubbers will only be addressed briefly.
LECTURE 4: Concepts and details of Tg, crystallinity, XRay (SAXS and WAXS), DSC, DMA
WORKSHOP 1
BLOCK 2: Step-growth/Condensation Polymerization
LECTURE 5: The underlying chemistry: polyesters, polyamides and polyaramids, polyurethanes, polycarbonates, etc.
LECTURE 6: Conducting polymers and polymers for OPV applications
LECTURE 7: Polymers from renewable sources, problems associated with replacing oil based chemistry, use of carbon dioxide
LECTURE 8: Hyperbranched polymers, dendrimers and gels
WORKSHOP 2
BLOCK 3: Chain-growth/Addition Polymers I
LECTURE 9: The concept of chain-growth/addition polymerization. Free radical, or ionic. Number degree of polymerization. Molar mass distributions in chain-growth polymerizations. The concept of tacticity, NMR.
LECTURE 10: The mechanism of free radical polymerization: initiation (radical generation and first monomer addition), propagation, bimolecular termination, and chain-transfer. Kinetic chain-length. Mayo-Equation
LECTURE 11: Case study: A closer look at a commercially important addition polymer.
LECTURE 12: Free radical copolymerisation
WORKSHOP 3
BLOCK 4: Living Polymerization
LECTURE 13: The concept of living polymerization: control of chain-growth. Its effect on the molar mass distribution and ability to control monomer sequence. Living ionic polymerization.
LECTURE 14: Living ionic ring opening polymerization of ethylene oxide, caprolactone, caprolactam. Group transfer polymerization
LECTURE 15: Case study: a closer look at a commercially important polymer made via living polymerization.
LECTURE 16: Biodegradable polymers for ring opening polymerisation and from fermentation including polymers from lactides, glycolides, etc
WORKSHOP 4

Part 2: Inorganic Materials and Structure Determination (12 lectures + 2 workshops)

Block 5:

Lecture 1: Introduction to Inorganic Materials
Classification of extended structures: ionic, covalent, molecular, polymeric.
Structure-property relationships (examples): nanomaterials, energy, biomaterials, electronics.

Revision of simple ionic structures (from CH160): packing of spheres and radius ratios

Lecture 2: Transition-metal oxides and polymorphism
Binary and ternary oxides: rutiles, perovskites and spinels.
Prediction of structure type: tolerance factor and CFSE
Polymorphism and crystal structure: introduction to phase transitions

Lecture 3: Synthesis of Oxide Materials
Solid-state, sol-gel hydrothermal and topochemical methods
Nanostructured metal oxides

Lecture 4: Crystallography
The unit cell and Bravais Lattice: crystallographic notation
Basic crystal symmetry
Miller planes and distances between planes

Lecture 5: Diffraction
Basic diffraction theory and the Bragg equation
Measurement of a diffraction pattern and indexing
Systematic absences and introduction to the structure factor

Lecture 6: Experimental aspects of diffraction
Powder vs single crystal
Neutrons vs X-rays
Synchrotron vs laboratory X-rays

Workshop 1: Analysis of powder X-ray diffraction
Worked examples (provided in advance) of indexing, determination of unit cell parameter of cubic materials and calculation of distances within a unit cell.

Lecture 7: Advanced scattering theory
Scattering vectors, momentum transfer, periodicity and phase.
The reciprocal relationship between object and scattered image
Miller indices, scattering vectors and reciprocal space

Lecture 8: A visual introduction to the mathematics of scattering theory
Sampling of periodic structures – another way to understand the Bragg equation
Fourier transforms explained visually.
Mathematics behind FTs.
Properties of periodic waves: amplitude, frequency and phase

Lecture 9: Structure factors - a special case of Fourier transforms
Fourier transforms and Fourier synthesis
The phase problem
Lensing and reconstructing the diffracted image.
Understanding systematic absences

Lecture 10: Small Angle Scattering
Scattering from non-periodic systems
Analysing small angle scattering patterns, determining particle size and shape.
Applications to polymer and soft matter science.

Lecture 11: Electronic Properties of Transition-Metal Oxides
Revision of band structure
Examples of semiconductors, metals and insulators

Lecture 12: Magnetic Properties of Transition-Metal Oxides
Classification of cooperative magnetic behaviour
Examples of ferromagnetic, antiferromagnets and ferrimagnets

Workshop 2: Applications of Fourier transforms to scattering theory
Worked examples that will allow students to explore the relationship between an object and its scattering pattern.

Learning outcomes

By the end of the module, students should be able to:

- Students should have a conceptual understanding of and be familiar with fundamental principles and approaches to solid-state materials, characterisation methods, and polymer chemistry, as laid out in the syllabus.

Indicative reading list

Reading lists can be found in Talis

Interdisciplinary

e.g. co taught with another department or with an industry perspective, bridges two or more disciplinary concepts, ideas, etc.

International

e.g. includes mobility opportunities, explores concepts and ideas in a global context, fosters a global mindset and awareness of diversity, etc.

Subject specific skills

Numeracy
Problem solving
Critical thinking
Teamwork

Transferable skills

Numeracy
Problem solving
Critical thinking
Teamwork

Study

Study time

Type	Required
Lectures	28 sessions of 1 hour (19%)
Practical classes	6 sessions of 1 hour (4%)
Private study	116 hours (77%)
Total	150 hours

Private study description

Self-Study.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group D1

	Weighting	Study time	Eligible for self-certification
Assessment component			
Powerpoint presentation & Team business proposal 4 page Team Business Proposal	20%		Yes (extension)
Reassessment component is the same			
Assessment component			
Online Examination	80%		No

	Weighting	Study time	Eligible for self-certification

Reassessment component is the same

Feedback on assessment

Oral and written feedback on assessed work and tutorials from module leader/ tutors. Cohort level examination feedback provided via Moodle.

Past exam papers for CH272

Availability

Pre-requisites

To take this module, you must have passed:

- All of
  - CH160-30 Introduction to Inorganic Chemistry

Post-requisite modules

If you pass this module, you can take:

- CH3G3-30 Advanced Chemistry (Organic, Inorganic and Physical) Industrial Placement
- CH3F6-15 Polymer and Colloid Science
- CH404-15 Synthetic Chemistry III (Macromolecular Chemistry)
- CH3F3-30 Advanced Chemistry (Organic, Inorganic and Physical)

Courses

This module is Core for:

- UCHA-4 Undergraduate Chemistry (with Intercalated Year) Variants
  - Year 2 of F101 Chemistry (with Intercalated Year)
  - Year 2 of F122 Chemistry with Medicinal Chemistry (with Intercalated Year)
- UCHA-3 Undergraduate Chemistry 3 Year Variants
  - Year 2 of F100 Chemistry
  - Year 2 of F121 Chemistry with Medicinal Chemistry
- UCHA-F110 Undergraduate Master of Chemistry (with Industrial Placement)
  - Year 2 of F100 Chemistry
  - Year 2 of F110 MChem Chemistry (with Industrial Placement)
  - Year 2 of F112 MChem Chemistry with Medicinal Chemistry with Industrial Placement

- Year 2 of UCHA-F107 Undergraduate Master of Chemistry (with Intercalated Year)
- UCHA-F109 Undergraduate Master of Chemistry (with International Placement)
    - Year 2 of F109 MChem Chemistry (with International Placement)
    - Year 2 of F111 MChem Chemistry with Medicinal Chemistry (with International Placement)
- UCHA-4M Undergraduate Master of Chemistry Variants
    - Year 2 of F100 Chemistry
    - Year 2 of F105 Chemistry
    - Year 2 of F110 MChem Chemistry (with Industrial Placement)
    - Year 2 of F109 MChem Chemistry (with International Placement)
    - Year 2 of F125 MChem Chemistry with Medicinal Chemistry
- Year 2 of UCHA-F127 Undergraduate Master of Chemistry with Medicinal Chemistry(with Intercalated Year)