CH272-15 Materials and Polymers

23/24

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.

Illustrative syllabus for each section of the module.

Part 1. Polymers (16 lectures + 4 workshops)

BLOCK 1: Radical Polymerisation
Thermal initiation, Photo initiation, Redox initiation. Propagation and termination including kinetic analysis. Chain transfer an inhibition. Case studies of photo3D printing and dental resin composites. statistical copolymerisation.

Block 2:Polymer Physics
Introduction to features of polymers in the liquid state. Polymer solutions and polymer melts. Introduce the concept of viscosity. Conformation of polymer chains in the liquid state, end-to-end distance, radius of gyration, molar mass distributions and the introduction of size exclusion chromatography.
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. Concepts and details of Tg, crystallinity, XRay (SAXS and WAXS), DSC, DMA

BLOCK 3: Step-growth/Condensation Polymerization
The underlying chemistry: polyesters, polyamides and polyaramids, polyurethanes, polycarbonates, etc., Conducting polymers and polymers for OPV applications, Polymers from renewable sources, problems associated with replacing oil based chemistry, use of carbon dioxide, Hyperbranched polymers, dendrimers and gels

BLOCK 4: Living Polymerization
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. Living ionic ring opening polymerization of ethylene oxide, caprolactone, caprolactam. Group transfer polymerization. Case study: a closer look at a commercially important polymer made via living polymerization. Biodegradable polymers for ring opening polymerisation and from fermentation including polymers from lactides, glycolides, etc

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 & 8 : Electronic Properties of Transition-Metal Oxides
Revision of band structure
Band narrowing
Effects of electron-electron repulsion and Jahn-Teller instabilities
Examples of semiconductors, metals and insulators

Lecture 8&9: Magnetic Properties of Transition-Metal Oxides
Macroscopic magnetism
Effective magnetic moment
Classification of cooperative magnetic behaviour
Direct and superexchange
Examples of ferromagnetic, antiferromagnets and ferrimagnets

Workshop 2: Electronic and Magnetic Properties
Worked examples that will allow students to explore the relationship structure, electronic configuration and electronic and magnetic properties .

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

1. Polymer Chemistry, 2nd Edition by Paul C. Hiemenz and Timothy P. Lodge
2. Polymer Chemistry by S Koltzenburg, M Maskos and O Nuyken
3. Principles of Polymerization, 4th Edition by George Odian
4. Polymer Physics by Michael Rubinstein and Ralph H. Colby
5. From Polymers to Plastics by A. K. van der Vegt
6. Inorganic Chemistry, Oxford University Press, Sixth Edition: Chapter 24
7. Weller, Inorganic Materials Chemistry
8. Solid State Chemistry: An Introduction, Fourth Edition, Smart and Moore, CRC Press

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 (18%)
Practical classes	6 sessions of 1 hour (4%)
Private study	116 hours (73%)
Assessment	8 hours (5%)
Total	158 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 D4

	Weighting	Study time
Powerpoint presentation & Team business proposal 4 page Team Business Proposal and presentation	20%	8 hours
In-person Examination	80%	

- Answerbook Green (8 page)
- Students may use a calculator
- Graph paper
- Periodic Tables

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
- 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 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)