CH3F6-15 Polymer and Colloid Science

21/22

Department
Chemistry
Level
Undergraduate Level 3
Module leader
Stefan Bon
Credit value
15
Module duration
12 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

N/A

Module web page

Module aims

The principle module aims are to give students some deeper understanding in key concepts of polymer chemistry, polymer physics, and colloid science. A choice have been made to discuss the chemistry and physics of polyethylene and polypropylene (global dominant polymer products), to elaborate on living (radical) polymerization and how this has lead to a renaissance in the fabrication of copolymers with control of monomer sequence and chain architecture. The use of amphiphilic copolymers will be discussed by means of assembly in solution, and bulk. The underlying physics will be discussed. Moreover, thermodynamics of mixing will be discussed. Colloids will be introduced and an emphasis is made on emulsion and miniemulsion processes to fabricate colloidal particles. The mechanisms of these processes will be discussed indepth. Copolymerization and its kinetic modelling will be discussed in both homogeneous and heterogeneous polymerization systems. The basic physics of colloidal motion and colloidal stability will be discussed.

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.

This module consists of 6 individual blocks. Each block is 4 lectures and 1 associated workshop. An outline for the syllabus is given below:

BLOCK 1: ON POLYMERIZATION PROCESSES OF ALKENES: ZIEGLER NATTA METALLOCENE, ROMP, AND ADMET.
In this block we will discuss the importance of ethylene/propylene based polymers, their physical and mechanical properties (crystallization structures, moduli, processing) based on their monomer sequence and tacticity. The latter concepts will be discussed. Ziegler Natta polymerization (Nobel Prize) will be taught from a historical perspective, with comments on kinetics and mechanism of this polymerization. Metallocene polymerization will be touched upon (the mechanism will be discussed in the inorganic core module) Ring opening metathesis (Nobel prize) including acyclic diene metathesis polymerization will be discussed from a mechanistic viewpoint.

BLOCK 2: ON LIVING (RADICAL) POLYMERIZATION
In this block the concept of living polymerization and its characteristics will be discussed. How to achieve a living polymerization from a mechanistic viewpoint. Dormant and active chains. Activation through covalent bond cleavage vs. degenerative chain transfer. Side reactions like disproportionation/transfer and how to use this to your benefit CCTP. The concept of control of propagation; block and gradient copolymers. Introduce main concepts of Nitroxide mediated, ATRP-SET LRP and RAFT. Place all in historic context, discuss kinetics, opportunities and restrictions.

BLOCK 3: ON PHASE BEHAVIOR OF (BLOCK)COPOLYMERS
In this block we will discuss:
Assembly of amphiphilic macromolecules: lyophilic/lyophobic behavior, aggregation, critical aggregation concentration, cluster size, packing parameter, micelles, cylinders/rods, vesicles/polymersomes . Examples of interesting polymer micelles, cylinders, and polymersomes.
Thermodynamics of mixing: entropy of binary mixing, Helmholtz free energy of binary mixing, Flory interaction parameter, equilibrium and stability, phase diagrams of mixing, LCST/UCST behavior for polymer solutions and polymer melts.
Phase behavior of blockcopolymers in bulk and thin films. Phase diagram of blockcopolymer melts. Influence of addition of homopolymer on morphology. How does phase separation in thin films differ?

BLOCK 4 : ON (MINI)EMULSION POLYMERIZATION
In this block we will discuss

- Introduction to colloids: what is a colloid? Phases and colloidal systems. Specific properties. Ancient colloids. The importance of surface area. Capillarity. Laplace pressure. Variety of shapes. Lyophilic vs. lyophobic colloids.
- Emulsion polymerization: what is an emulsion polymerization and how does it differ from a suspension polymerization, dispersion polymerization, precipitation polymerization, and

miniemulsion polymerization? A brief history of emulsion polymerization. Pro's and con's of emulsion polymerization vs. bulk/solution polymerization. A typical recipe. · Mechanistic understanding of Emulsion Polymerization: rate of polymerization, particle formation (micellar and homogeneous nucleation), particle growth, particle swelling, diffusion limitation/starved conditions, compartmentalization, zero-one vs. pseudo bulk polymerization kinetics, Trommsdorf effect. · Miniemulsion polymerization: What is miniemulsion polymerization? Ostwald ripening, how to retard/arrest Ostwald ripening.
BLOCK 5 ON COLLOID MOTION AND INTRO TO COLLOID STABILITY In this block we will discuss: Motion of colloids: gravity, buoyancy, drag force (Newton/Rayleigh/Stokes), terminal velocity, Brownian motion, Osmotic pressure, Stokes Einstein (Smoluchowski/Langevin), Barometric height, Ballistic velocity, Propulsion on the microscale (Purcell) Colloidal stability: How to prolong the lifetime of a lyophobic colloid. Electrostatic stabilization. DLVO theory. Steric stabilization. Bridging and depletion flocculation. Kinetics of coagulation.

BLOCK 6: FREE RADICAL COPOLYMERIZATION, EMULSION COPOLYMERIZATION, PARTICLE MORPHOLOGY In this block we will discuss: · Free radical copolymerization. Bernouillian process (zero order Markov process). First order Markov process. Copolymer composition. Rate of (co) polymerization. How to measure the rate coefficient of propagation. · The terminal/ultimate and penultimate models. Mayo-Lewis. Conditional probabilities. Copolymer composition and monomer sequence distribution. Implicit vs. explicit penultimate model. The average rate of polymerization. · Determination of reactivity ratios. Planning of experiments (Tidwell and Mortimer). Various examples. · Monomer partitioning and partial monomer conversion in emulsion polymerization · Control of particle morphology: phase separation, core shell, salami, acorn structures.

Each block will have an associated 1 h workshop. Total contact hours 30

Learning outcomes

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

- Provide students with a solid in depth basis of several (industrially) relevant key topics in polymer and colloid science
- Interlinks with other areas of science will be demonstrated (thermodynamics, kinetics, physics)

Indicative reading list

1. Principles of Polymerization by George Odian, 4th Edition. Publisher: Wiley-Blackwell; 4th Edition edition (5 Mar 2004) ISBN-10: 0471274003 ISBN-13: 978-0471274001
2. Polymer Chemistry, second edition by Paul C. Hiemenz and Timothy P. Lodge. Publisher: CRC Press; 2 edition (15 Feb 2007) ISBN-10: 1574447793 ISBN-13: 978-1574447798
3. Polymer Chemistry: an introduction by Malcolm P. Stevens. Publisher: OUP USA; 3 edition (11 Feb 1999) ISBN-10: 0195124448 ISBN-13: 978-0195124446
4. Polymer Physics by Michael Rubinstein and Ralph H. Colby. Publisher: OUP Oxford (26 Jun
5. ISBN-10: 019852059X ISBN-13: 978-0198520597

6. Polymer Colloids: a comprehensive introduction by Robert M. Fitch Publisher: Academic Press (22 April 1997) ISBN-10: 0122577450 ISBN-13: 978-0122577451
7. Chemistry and Technology of Emulsion Polymerisation, second edition. Edited by Alex M. van Herk. Publisher: Wiley-Blackwell; 2nd Edition edition (12 July 2013) ISBN-10: 1119953723 ISBN-13: 978-1119953722
8. Intermolecular and Surface Forces: revised third edition by Jacob N. Israelachvili Publisher: Academic Press; 3 edition (22 July 2011) ISBN-10: 0123919274 ISBN-13: 978-0123919274

Interdisciplinary

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

Subject specific skills

Numeracy
Problem solving
Critical thinking

Transferable skills

Numeracy
Problem solving
Critical thinking

Study

Study time

Type	Required
Lectures	24 sessions of 1 hour (16%)
Practical classes	12 sessions of 1 hour (8%)
Private study	114 hours (76%)
Total	150 hours

Private study description

Module has 6 blocks, runs over 12 weeks, each week 3 contact hours (mix of lectures and workshops). Private study material does include e-book for colloid science part.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group B2

	Weighting	Study time	Eligible for self-certification
Assessment component			
Online Examination ~Platforms - AEP	100%		No

- Periodic Tables
- Students may use a calculator
- Answerbook Pink (12 page)

Reassessment component is the same

Feedback on assessment

Cohort level examination feedback provided via Moodle.

Past exam papers for CH3F6

Availability

Pre-requisites

To take this module, you must have passed:

- All of
  - CH272-15 Materials and Polymers

Post-requisite modules

If you pass this module, you can take:

- CH415-15 Colloid Science II

Courses

This module is Optional for:

- Year 1 of TCHA-F1PB MSc in Chemistry with Scientific Writing
- Year 4 of UCHA-F107 Undergraduate Master of Chemistry (with Intercalated Year)
- UCHA-F109 Undergraduate Master of Chemistry (with International Placement)
    - Year 3 of F109 MChem Chemistry (with International Placement)
    - Year 3 of F111 MChem Chemistry with Medicinal Chemistry (with International Placement)
- UCHA-4M Undergraduate Master of Chemistry Variants
    - Year 3 of F105 Chemistry
    - Year 3 of F109 MChem Chemistry (with International Placement)
    - Year 3 of F126 MChem Chemistry with Med Chem (with Prof Exp)
    - Year 3 of F125 MChem Chemistry with Medicinal Chemistry
    - Year 3 of F106 MChem Chemistry with Professional Experience
- Year 4 of UCHA-F127 Undergraduate Master of Chemistry with Medicinal Chemistry(with Intercalated Year)

This module is Option list A for:

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