UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Properties and Applications of Polymeric Materials

2526-3-ESM01Q018

Aims

The aims of the course is to familiarize students with relevant comcepts in polymer chemistry like characterization of polymers and molecular weight distributions; thermodynamics of polymer solutions; the crystalline and amorphous states; rubber elasticity; structure-property relationships. Special topics in polymer materials like block copolymers and natural polymers will be also introduced.

Application of knowledge:
• Acquisition of the ability to apply the notions learned during the course to the effective description of polymers of applicative and industrial interest

Communication skills:
• Acquisition of verbal and written communication skills in concepts related to the hierarchical structure of polymers from the molecular to the macroscopic level.

Elaboration of judgments:
• The student will acquire the ability to associate the main characteristics of a polymer (glass transition temperature, melting temperature, viscosity and elastic modulus) to its molecular architecture.

Learning skills
• The student is able to extend what has been learned in the lessons to case studies not covered during the course. In particular, he is able to
manage the datasheets of polymers of industrial interest

Contents

Thermodynamics of polymer solutions. Flory-Huggings theory. Chain conformation in solution: flexible and rigid polymers. Concept of random coil and radius of gyration. Polymeric mixtures and phase diagrams. Block

copolymers synthesis and properties. Emulsion Polymerization. T. The crystalline state of polymers: lamellae, spherulites, fibers. Semi-crystalline polymers: polyethylene, iso- and syndiotactic polypropylene. Crystalline liquid polymers. Cross-linked polymers and rubber elasticity. Mechanical behavior of polymers. Viscoelasticity and rheology of polymers: creep measurements, relaxation times. Polysaccharides and protein based materials

Detailed program

Conformations of Polymers, end-to-end distance, length of persistence, semi-flexible chains and rigid chains, radius of gyration, dendrimers, branched polymers

Thermodynamics of polymer solutions, entropy and mixing enthalpy, Flory-Huggings theory, parameter ?

Osmotic pressure of a polyme solution, osmometry, Flory Huggins theory for osmotic pressure, parameter B, comcept of ? solvent

Phase diagram of polymer solutions, binodal, spinodal and critical point (LCST and UCST)

Block copolymers and self-assembly in bulk and in solution

Dynamics of polymeric solutions, friction and viscosity, Newtonian and Non-Newtonian fluids, Stokes's law, viscosity of diluted polymeric solutions, Mark-Houwink's equation, diffusion and Stokes-Einstein relationship, emulsion polymerization

Elasticity of rubber, vulcanization of natural rubber, mechanical properties, thermodynamics of elasticity.

Mechanical properties: creep, relaxation, rubbery plateau, Maxwell element, Voigt element

Semicrystalline polymers, helical conformation, thermodynamics of crystallization, lamellae, spherulites,

Polymeric materials based on carbohydrates, cellulose, hemicellulose, cellulose acetate, starch, agar

Polymeric materials based on proteins, wool, silk, keratin, collagen

Prerequisites

Basic knowledge of polymer chemistry: definition of polymer, average molecular weight, simple polymerization methods

Teaching form

24 lectures of 2 hours each in classroom in italian language. In the case of incoming students, the course will be delivered in English.

Textbook and teaching resource

Textbooks

"Polymer Chemistry” (Second Edition) P.C. Hiemenz, T.P. Lodge, CRC Press.

“Introduction to Physical Polymer Science” (Fourth Edition), L.H. Sperling, Wiley”

Powerpoint presntation containing the lessons

Semester

Second semester

Assessment method

The exam consists of an oral exam in which the topics presented in the lessons are discussed. In addition to learning the fundamentals presented in the course, the student's skills and aptitudes are also assessed to adapt the theoretical foundations of polymer chemistry to particular operational and practical conditions (for example the differences in mechanical properties between a rubber and a thermoplastic, or the molecular origin of the elasticity of the rubber); the exhibition capacity and adequacy of the student's language is evaluated.

Two intermediate tests are also carried out (with the resolution of exercises and the answer to questions) at half of the course and at the end of the course; each test includes 10 questions and exercises; students who obtain a positive result in both the tests (for each exercise or question are assigned from 0 to 10 points, the achievement of 50 points is considered positive) can take a reduced oral exam, in which the questions and the exercises of the two intermediate tests are discussed.

Office hours

On tuedsay from 2:00 to 4:00 in instructor's office

Sustainable Development Goals

RESPONSIBLE CONSUMPTION AND PRODUCTION