DPT SCIENCE ET GENIE MATERIAUX
MATERIALS SCIENCE AND ENGINEERING
INSA Campus LyonTech - 7-9 Avenue Jean Capelle
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Polymers

PHYSICAL PROPERTIES OF POLYMERS

IDENTIFICATION

CODE : SGM-4-S2-POLYPHYS
ECTS : 2.0

HOURS

Lectures :	20.0 h
Seminars :	10.0 h
Laboratory :	0.0 h
Project :	0.0 h
Teacher-student contact :	30.0 h
Personal work :	20.0 h
Total :	50.0 h

ASSESSMENT METHOD

1.30 hour written exam without course documents

TEACHING AIDS

- Course support slides (in English and French)
- Handout of tutorial exercises (in English and French)

TEACHING LANGUAGE

French

CONTACT

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AIMS

The aims of this teaching module are to introduce the main concepts relating to the physical properties of polymers in the solid state (and molten state for thermoplastics) in order to be able to associate them with architectures on the macromolecular scale and with morphologies by emphasizing the specificity of polymers, which is molecular mobility. For this type of material, physical behavior is highly dependent on the temperature and/or speed of stress (or time or frequency). The important concepts for describing physical behavior (viscoelastic in the molten and solid state, mechanical at large deformations and electrical/dielectric), including in terms of models, will be presented.

CONTENT

A.- VISCOELASTIC BEHAVIOUR OF POLYMERS
1 - INTRODUCTION
2.- PHENOMENOLOGICAL APPROACH
2.1 Definitions
Hooke's solid and Newton's liquid: Moduli and viscosity
2.2 Viscoelastic behavior
Creep and relaxation experiments
2.3 Boltzmann's Superimposition Principle
2.4 Viscoelastic Models
2.5 Dynamic Mechanical Behavior
2.6 - Time(frequency)-temperature relationship
3.- VISCOELASTIC BEHAVIOUR OF POLYMERS: RELATIONSHIPS WITH THEIR MICROSTRUCTURE AND MORPHOLOGY
3.1 - Viscoelastic spectra
Main transition a and secondary relaxations / Examples
Molecular relaxation map
Analogy with other spectroscopies /
Molecular mobility in the solid state
3.2.- Illustrations of the influence of the main molecular parameters
Amorphous polymers
Microstructure, molar mass, networks (cross-linking density)
Polymer blends and copolymers
Semi-crystalline polymers
Filled polymers

B.- RHEOLOGICAL BEHAVIOUR OF POLYMERS IN THE MOLTEN STATE
1.- INTRODUCTION
1.1. - Definition
1.2. - Rheological phenomena
2 - NON-NEWTONIAN FLUIDS
2.1. - Definitions and Applications
Newtonian fluids, shear-thinning fluids, shear-thickening fluids, threshold fluids
2.2. - Classification and viscosity models
3 - LINEAR VISCOELASTICITY
3.1. - Definitions and principles
3.2. - Linear models
3.3. - Measurement Systems - Steady State Rheometry
3.4. ¿ Influence of macromolecular parameters

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C.- MECHANICAL BEHAVIOUR OF POLYMERS UNDER LARGE DEFORMATIONS
1.- MOLECULAR MECHANISMS OF POLYMER DEFORMATION AND FRACTURE
1.1 - Experimental approach
Bond extension and deformation
Bond breakage
Creation of microvoids
1.2 - Polymer behavior
Amorphous thermoplastic polymers
Semi-crystalline polymers
Cross-linked polymers (networks)
1.3 Theoretical approaches
2 - CRAZING AND SHEAR
2.1 - Shear and cracking - Demonstration
2.2 Plasticity and cracking criteria
2.3 Interactions between shear and cracking
3 - FRACTURE
3.1 Fatigue fracture
3.2 - Fracture mechanics of polymers

D.- ELECTRICAL AND DIELECTRICAL BEHAVIOUR OF POLYMERS
1 - INTRODUCTION
1.1 - Electrical stresses
1.2 Type of polarization
2 - STUDY OF THE RESPONSE OF POLYMERS TO AN ELECTRIC FIELD
2.1 Resistance and resistivity
2.2 Dielectric strength
3. STUDY OF THE RESPONSE OF POLYMERS TO AN ALTERNATING ELECTRIC FIELD
3.1 - Dielectric constant
3.2 - Dissipation or loss factor
3.3 - Cole-Cole diagram
3.4 - Behavior of polymers
3.5 Electrical measurement techniques
4.- FACTORS INFLUENCING ELECTRICAL BEHAVIOUR

BIBLIOGRAPHY

- Viscoelastic Properties of Polymers. 3rd Edition. J.D. Ferry. ¿ Wiley¿Blackwell (1980)

- De la macromolécule au matériau polymère - Synthèse et propriétés des chaînes. J.L. Halary, F. Lauprêtre. Belin Education Echelles (2006)

- Mécanique des matériaux polymères. J.L. Halary, F. Lauprêtre. Belin Education Echelles (2008)

- ¿ Polymer Rheology. LE. Nielsen. Marcel Dekker (1977)

- Rheology: Principles, Measurements, and Applications. C.W. Macosko. Wiley VCH (1994)

- Electrical Properties of Polymers 2nd Edition. T. Blythe, D. Bloor. Cambridge Edtions (1987)

- Electrical Properties of Polymers. E. Riande, R. Diaz-Calleja. CRC Press (2004)

PRE-REQUISITE

The concepts of stresses and strains in the different modes as well as those of modulus of elasticity, viscosity, etc. will need to be assimilated.
Knowledge of the quantities and parameters associated with the main families of polymers (amorphous and semi-crystalline thermoplastics, networks - or thermosets) is required.
Formalizing behavior and its dependence on parameters such as temperature, time, state of stress, etc. requires the ability to handle differential equations, complex calculations and tensor calculations