UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Organic Chemistry I

2324-1-E2702Q085

Aims

This course provides students with the basic principles of organic chemistry: the nomenclature of the main classes of organic compounds, their structure, and stereochemistry, reactivity. The course is the first of a homogeneous didactic path consisting of the courses of Organic Chemistry 1, 2 and 3 and of Organic Chemistry.

The teaching objectives are as follows:

KNOWLEDGE AND UNDERSTANDING

At the end of this training activity, the student must know the basic principles of organic chemistry in terms of compound nomenclature, stereochemistry, fundamental reactivity. To reach a good level of basic knowledge, lectures are integrated by many examples and exercises are foreseen in order to make the student acquire some familiarity with the organic compounds, with the reaction mechanisms written graphically, and with the graphic symbols used for reactivity and resonance (arrows for moving a pair of electrons). The study of the nomenclature and stereochemistry will be based on a series of references to molecules of everyday life that make their understanding easier and more stimulating (natural molecules present in food, plants, synthetic molecules present in various products including the drugs). The student's ability to understand the course of a certain chemical reaction will instead be stimulated and induced by reasoning on the "push-pull" nature of the displacements of electron pairs and consequent arrangements of chemical bonds leading to product formation. The deep knowledge of the basic rules regulating these mechanisms makes the student independent from a purely mnemonic study of the subject and enables him / her to write correctly, even during the examination, mechanisms and products of new reactions.

ABILITY TO APPLY KNOWLEDGE AND UNDERSTANDING

At the end of this training activity, the student must demonstrate to be able to:

1 write the IUPAC nomenclature of an organic compound starting from its structure and *vice versa*, including stereochemistry notations

2 Write the lower energy conformations and critically discuss about the conformational energy of the organic molecules presented during the course

3 write the mechanism of a reaction, imagine the products of a reaction not yet studied

4 understand the role of molecular orbitals and their influence in chemical reactivity

5 use the fundamental reactions learned during the course as tools to understand the more advanced reactivity presented in the following courses of: Organic Chemistry 2 and 3, Superior Organic Chemistry.

AUTONOMY OF JUDGMENT

At the end of this training activity, the student will have to demonstrate that he is able to critically analyse the course of a chemical reaction and its mechanism, even if the reaction has not been specifically presented in the course. The teachers stimulate the critical discussion on a series of topics through exercises.

LEARNING ABILITY

Expected results:

Knowing how to solve exercises of general reactivity, knowledge of all the classes of most important organic compounds and of the fundamental reactions, reaction mechanisms, discussing the prevalence of one mechanism compared to the other (thermodynamics: substitution on elimination, kinetics: monomolecular mechanism vs bimolecular).

Contents

The structure of organic molecules; nomenclature, stereochemistry, conformational isomers, molecular orbitals, the main classes of organic compounds with special focus on natural molecules (amino acids, proteins and peptides, sugars and polysaccharides, lipids, nucleotides and nucleic acids, terpenes, secondary metabolites of plants), synthetic molecules of everyday's life (molecules in food, plants, drugs, cosmetics, commercial products).

Reactivity: mechanisms and reactions. Thermodynamics and kinetics of a reaction among organic compounds.

The main reactions of organic chemistry by classes of compounds, the formation of the carbon-carbon bond, the main condensation reactions, mention of the use of organometallic compounds in organic synthesis, hints on synthetic strategies.

Detailed program

General aspects of Organic Chemistry.

Atoms involved in Organic molecules and their electrons. Hybridation of carbon atoms. Molecular orbitals, and hybrid orbitals. Representation of a structure of organic compound. Molecular orbital delocalization, properties of aromatic compounds. Polarised bonds and dipolar interactions. Intermolecular bounds.

Fundaments of chemical reactivity.

Symbols and definitions. Thermodynamic and kinetic of a reaction. Reaction coordinates, activation energy,

transition state, reaction intermediates. Reaction mechanisms, electrophiles, nucleophiles, radicals.

Alkanes and cycloalkanes.

Definition, structure, isomeric forms, nomenclature. Conformations of alkanes and cycloalkanes. Reactivity of alkanes, oxidation, halogenation. Radical reactions.

Stereoisomery.

Bases of stereoisomery. Stereogenic center. Enantiomers. Diastereoisomers. R and S configurations. Mesoforms. Stereogenic axis. Stereoisomers cis and trans, E e Z.

Alkenes.

Structure, nomenclature, physical properties. Addition of electrophiles. Carbocations, order of stability, addition of nucleophiles, transposition, elimination. Radical additions. Concerted additions, epoxidation, catalytic hydrogenation.

Alkynes.

Structure, nomenclature, physical properties. Acidity of terminal alkynes. Electrophile addition. Hydration and tautomery. Hydrogenation.

Alkyl halides.

Structure, nomenclature, physical properties. Nucleophilic substitution and elimination reactions. Mono and bimolecular mechanisms.

Alcohols and thiols.

Structure, nomenclature, physical properties. Acidity. Nucleophilic substitution and elimination reactions. Esters and ethers formation. Oxidation. Thiols and thioethers. Phenols.

Ethers.

Structure, nomenclature, physical properties and reactivity.

Epoxides.

Structure, nomenclature, physical properties and reactivity.

Amines.

Structure, nomenclature, physical properties. Basicity and nucleophilic character. Synthesis of amines. Hofmann and Cope elimination. Diazonium slats.

Aldehydes and Ketones.

Structure, nomenclature, physical properties. Nucleophilic addition reactions with strong nucleophiles or acid catalysed. Addition of carbon nucleophiles: cyanide, organometallic compounds, acetylures, Wittig reagents. Acid catalysed addition of water, alcohols, thiols, ammonia, amines and ammonia derivatives. Tautomery. Aldol reaction. Oxidation reactions, Bayer-Villiger. Reduction to alcohols and hydrocarbons.

Carboxylic acids and derivatives.

Structure, nomenclature, physical properties. Acidity. Influence of the structure on the pKa. Reactivity of carboxylic acids, acyl chlorides, anhydrides, esters, amines, nitriles. Differences in their reactivity, including reduction and reaction with organometallic reagents.

?-halogenation. Claisen condensation. Acetacetic and malonic synthesis.

Conjugate systems.

Reactivity of conjugated dienes and ?,?-unsaturated carbonyl compounds.

Polyfunctional compounds.

Intramolecular reactions, concepts of protection and activation.

Formation of the C-C bond, organometallic compounds and synthetic strategies

Reactions that allow the formation of the C-C bond, organic synthesis. The most important organometallic compounds and their reactivity.

Biomolecules.

Carbohydrates: structure of monosaccharides, D e L, cyclic forms, anomers, glycosidic bond, disaccharides, polysaccharides. Amino acids: structure, behaviour at different pH. Peptidic bond. Peptide synthesis. Nucleic acids: structure and bases complementarity. Lipids: fatty acids, triglycerides, glycol-and phospholipids, terpens, steroids.

Organic molecules in everyday life

During the course we will see a series of examples of synthetic and natural molecules that play a fundamental role in food, drugs, and commercial products

Prerequisites

A good knowledge of the principles of general and inorganic chemistry, in particular: atomic properties, covalent bond, theory of atomic and molecular orbitals, concept of acid and base (Broenstred, Lewis), salts, redox reactions, oxidation numbers, basic concepts of thermodynamics and kinetics, supramolecular bonds (hydrogen bonding, dipole-dipole interactions, van Der Waals forces).

Teaching form

Class lessons (F. Peri), class exercises (M. Sassi), tutoring on request (dedicated student).

The teaching material will still be available online on the Moodle platform: slides of lessons, exercises. Use of online exercise platforms, with correction by teachers.

Textbook and teaching resource

Textbooks: All organic chemistry books 1 may in principle go well, for example:

P. Bruice, Organic Chemistry

Brown, Iverson, Anslyn, Foote, Novak, Organic Chemistry

Molecular models that can be found with textbooks or purchased separately are very important

On the Moodle platform the slides of the lessons, the recordings of the lessons will be uploaded, together with scientific articles related to several course topics.

In addition, exercises will be uploaded and a forum for the correction of the exercises and online tutoring will be created.

Semester

second semester

Assessment method

Written exam (or two intermediate written exams during the year) + oral exam.

Two intermediate exams during the year, same structure than the written exam, which can replace the written exam if the outcome of both intermediates is positive.

Oral exam with verification of basic knowledge and ability to use the basic concepts in reasoning on reactivity and mechanisms of organic reactions.

It is very important to note that the final oral exam has a decisive weight in the composition of the final mark, the written exam and the partials during the year provide teachers with an important but not decisive indication on the student's preparation.

Office hours

The office hours of the teacher (F. Peri) and exerciser (M. Sassi) to receive students will be communicated the first lesson of the course.

Sustainable Development Goals

ZERO HUNGER | GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION