SYNOPSIS

Organic Chemistry, 2 year Pharmacy students

2016-2017

1. Introduction. Subject and historical development of Organic Chemistry. Structural theory. Natural sources of organic compounds. Natural gas, petroleum, coal tar, compounds from plant and animal origin.
2. Chemical bond. Atomic orbitals, hybridization, σ- and π – bonds. Parameters and polarity of the bonds. Electro negativity, dipole moments. Types of chemical bonds (ionic, covalent, donor-acceptor, coordinative, semi polar). Inductive effect.
3. Aromatism. Hückel's rule. Structure of [4]-, [8]-, [10]-, [14]-anulenes and coronenes (Hückel's criterium). Non benzoic aromatic compounds (aromatic ions, azulene).
4. Classification and nomenclature of organic compounds. Basic principles of the IUPAC nomenclature. Main chain, principal group, locants, priority of the substituents. Substitutive and radicofunctional nomenclature.
5. Physical and chemical methods for structure elucidation. UV-spectroscopy, IR-spectroscopy. Nuclear magnetic resonance (NMR). Mass spectrometry (MS). Element analysis and calculation of the molecular formula.
6. Alkanes and cycloalkanes. Preparation, Wurtz synthesis. Properties. Halogenation – radical substitution mechanism (S_R). Reactive ability and selectivity. Nitration, sulfonation and sulfo-oxidation. Petroleum products. Cracking (meaning).
7. Principles of stereochemistry(I). Conformations and conformational analysis. Perspective and Newman projection formulae. Ethane and Butane. Cyclohexane – chair and bath conformations, equatorial and axial substituents. Conformational balance at methylcyclohexane. Decalins, adamantane, spiranes (spiro compounds).
8. Alkenes and Cycloalkenes. Preparation – mechanism of the β-elimination reaction (E1 and E2), Zaitsev's rule, Hofmann's rule, examples. Properties – mechanism of the electrophilic (A_E), nucleophilic (A_N) and radical (A_R) addition reactions; Markovnikov's rule, examples. Oxidation of alkenes. Polymerization of alkenes (polyethylene, polypropylene, polystyrene, polyvinylchloride).
9. Alkines and dienes. Preparation and properties of the alkines. Kucherov reaction, acidity of alkines. Types of dienes; preparation of 1,3-dienes. Addition to conjugated dienes. Pericyclic reactions (definition). 1,4-Cycloaddition – mechanism and stereochemistry of the Diels-Alder reaction (diene synthesis). Electrocyclic reactions, sigmatropic rearrangements (examples). Polymerization of dienes.
10. Arenes (Aromatic hydrocarbons). Classification, nomenclature, preparation. UV, IR and NMR characteristics. Representatives (benzene homologues, styrene, biphenyl, multinuclear arenes with condensed rings). Chemical properties. Mechanism of the electrophilic substitution reactions (S_E), π- and σ-complexes. Energy profile of the reaction. Sulfonation, sulfochlorination, nitration, halogenations, alkylation, acylation, Friedel-Krafts reaction –examples.

11. Theory for the orientation effect of the substituents in the aromatic ring in the electrophilic substitution reactions. Activating and deactivating substituents, electron effects. *O*-, *m*- and *p*-substitution and stability of the corresponding σ-complexes. (Delocalization of the positive charge). Sulfonation of naphthalene (specific features).
12. Halogen derivatives of Hydrocarbons. Preparation methods. Spectral characteristics. Chemical properties. Mobility of the halogen atom due to its nature and the structure of the hydrocarbon residue. Mechanism of the of nucleophilic substitution reaction (S_N) at unsaturated carbon atom. (Stereochemistry, Walden inversion, racemizaation. Neuclephility and alkalinity. Interphase catalysis in nucleophilic substitution reactions. Reactions of nucleophilic substitution in the aromatic ring ($S_N$arom.), examples. Elimination-addition reactions (benzene, dihydrobenzene). Organomagnesium compounds – Grignard reagents.
13. Alcohols and phenols. Classification and nomenclature. Electron and space structure – comparative study; UV, IR and NMR characteristics. Preparation methods. Reactive ability, acidity and alkalinity. Chemical properties of the alcohols (substitution, dehydratation, eterification, esterification, oxidation, dehydrogenation). More important alcohol representatives. Chemical properties of the phenols (alkylation, acylation, oxidation, electrophilic substitution). More important phenol representatives.
14. Ethers and epoxides. Chemical properties of the ethers and epoxides. More important representatives.
15. Aldehydes and ketones (I). Classification and nomenclature. Electron and space structure. IR and NMR spectral characteristics. Preparation methods. Direct formylation of aromatic compounds (mechanism of Gattermann-Koch reaction, Gatermann reaction, Reimer-Tiemann reaction, Vilsmeier-Haack reaction). Friedel-Krafts acylation to aromatic ketones.
16. Aldehydes and ketones (II). Chemical properties. Reactive ability. Mechanism of the electrophylic addition (A_N) and addition-elimination (A_N+E) reactions. Synthesis of enamines (A_N+E). Oxidation and reduction. Cannizzaro reaction (mechanism). Aldol reaction and crotonization (mechanism). Perkin synthesis (mechanism). Benzoin condensation (mechanism). More important aldehyde and ketone representatives. Quinones- structure, preparation and properties.
17. Carboxylic acids. Classification and nomenclature. Physical properties and spectral characteristics. Preparation methods. Kolbe-Schmitt reaction (mechanism). Chemical properties. Structure-acidity (*pKa*) relationship. More important representatives of the unsaturated, aromatic, halogen-, hydroxy,- oxo-, di- and polycarboxilic acids. Stereoisomerism (lactic, malic and tartaric acid). Decarbonilation and decarboxylation. Lactid, lacton and polyester preparation.
18. Functional derivatives of the carboxylic acids. Salts, esters, acylhalides, anhydrides, amides, hydrazides, azides, imidoesters, amidines, hydroxamic acids, nitriles, ketenes – structure, more important preparation methods, properties. Waxes and fats (lipids). Phospholipids. Surface active compounds – types, representatives.
19. Acetoacetic and malonic esters. Preparation of acetoacetic ester from ethyl acetate (mechanism). Preparation of malonic ester from ethyl cyanoacetate (mechanism).

Application of the acetoacedic and malonic ester into the organic synthesis. Knoevenagel reaction (mechanism) and Michael reaction (mechanism).

20. Principles of stereochemistry (II). Opitical activity and optical isomerism. Configuration (absolute and relative), chirality, chiral center, asymmetric atom (definition). Enantiomers and diastereomers. Perspective and Fischer projection formulae. Cahn-Ingold-Prelog priority rule (R,S-rule). Stereochemistry of the elimination reactions, nucleophilic substitution and electrophilic addition reactions.
21. Carbohydrates (I). Classification and nomenclature. Monosaccharides. Proof of the structure and configuration of D-glucose. More important representatives of the trioses, pentoses and hexoses. Hemi acetal forms. Stereoisomerism (anomers, epimers, mutarotation). Chemical properties (oxidation, reduction, elongation and degradation of the hydrocarbon chain). Glycosides. Amino sugars (meaning).
22. Carbohydrates (II). Disaccharides and polysaccharides. Disaccharides- representatives (sucrose, maltose, celobiose, lactose), types of linkage between the monosaccharise residues. Polysaccharides – cellulose, starch, glycogen. Structure and biological properties. Cellulose derivatives with practical significance.
23. Aliphatic and aromatic amines. Classification and nomenclature. Structure, physical properties and spectral characteristic. Preparation methods (from ammonia and amines, through reduction, through molecular rearrangements, etc.) Chemical properties. Basicity (*pKb*) and acidity – comparison. Salts. N-alkylation and N-acylation. Comparison on terms of nitrous acid.
24. Diazonium salts. Hydrazo, azo and diazo compounds – structure, preparation, chemical properties (reaction with elimination of nitrogen, Sandmeyer reaction, coupling. Azo dyes (representatives). Preparation of hydrazobenzene, azoxybenzene, and azobenzene. Benzidine rearrangement (mechanism). Diazoalkanes- diazomethane (preparation and application).
25. Heterocyclic compounds. Classification and Hantsch-Widman nomenclature. Heterocyclic compounds with aromatic structure.
26. Pentaatomic heterocycles with one heteroatom: furan, thiophene and pyrrole. Preparation methods. Structure and reactive ability. Comparative study of their chemical properties.
27. Heterocyclic compounds. Indole. Preparation, Fischer synthesis. Chemical properties. Indoxyl and oxindole (tautomerism). Indigo. Representatives with biological activity (tryptophan, tryptamine, serotonin, indolylacetic acid). Porphyrins and porphines, hemin and chlorophyll. Indole alkaloids.
28. Heterocyclic compounds. Pyranes and benzopyranes – nomenclature, general characteristic, more important representatives (pyrones, pyrrylic salts, chromenes and chromanes, flavonoids, coumarines – Perkin synthesis, Pechmann synthesis).
29. Heterocyclic compounds. Pyridine. Synthesis and pyridine derivatives (Hantch method and others). Structure and reactive ability. Alkalinity, salts. Electrophilic and nucleophilic substitution reactions (Chichibabin reaction – mechanism), oxidation nd reduction. Reactive ability of pyridine-N-oxide (examples). Pyridinecarboxylic acids. Pyridine alkaloids (examples).

30. Heterocyclic compounds. Quinoline (Skraup synthesis) and Isoquinoline. (Doebner-Miller and Bishler-Napieralski synthesis). Structure and reactive ability. Quinoline and isoquinoline alkaloids (examples). Acridine. Benzazepines.
31. Heterocyclic compounds. Pentaatomic heterocycles with two heteroatoms: oxazoles, thiazoles and diazoles – nomenclature, general characteristic, preparation. Structure and reactive ability. Representatives with biological activity (penicillins, cefalosporins). Synthesis of Antipyrine. Pyrrazolone drugs.
32. Heterocyclic compounds. Hexa- and heptaatomic heterocycles with two heteroatoms. Oxazines, thiazines, diazines – nomenclature, general characteristic. Structure and reactive ability. Phenothiazine drugs. Synthesis of diazines and their derivatives (methods). Representatives with biological activity (barbiturates, uracil, thymine, cytosine). Chinazoline, diazepines.
33. Heterocyclic systems with condensed rings. Purine – nomenclature, general characteristic, structure. Traube synthesis (purine, xanthine, uric acid). Adenine and guanine preparation. Purine alkaloids.
34. Heterocyclic compounds. Pteridine – nomenclature, general characteristic, structure. Synthesis. Pteridine derivatives with biological activity (folic and folinic acid, aloksazine, isoaloksazine, riboflavin; triamterene).
35. Synthetic polymers. Basic terms in the polymer chemistry. Classification and nomenclature. Physicochemical characteristics. Polymerization and polycondensation reactions (examples). Representatives of the synthetic polymers – preparation, more important properties and application (polyalkenes, polyoxomethylene, polyethylene oxide, polyesters, polyamide, polyurethanes, polysiloxanes, polyvinylpyrrolidone, polyglycols). Natural and synthetic rubber.
36. Peptides. Biological (proteinogenic) α-amino acids. Principles of the polypeptide synthesis (example: carbobenzoxy method). Classification and structure of the proteins.

Summary time: 60 hours

Literature:

1. Solomons & Fryhle – Organic chemistry, 8th edition, 2004
2. R. Morrison & R. Boyd - Organic chemistry, 6th edition, 2002

Edited by: assoc. prof. R. Buyukliev