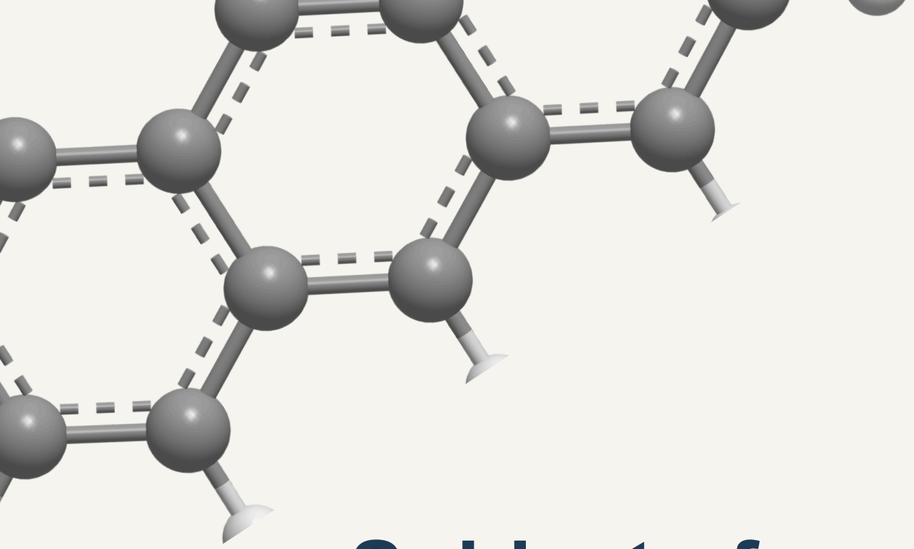
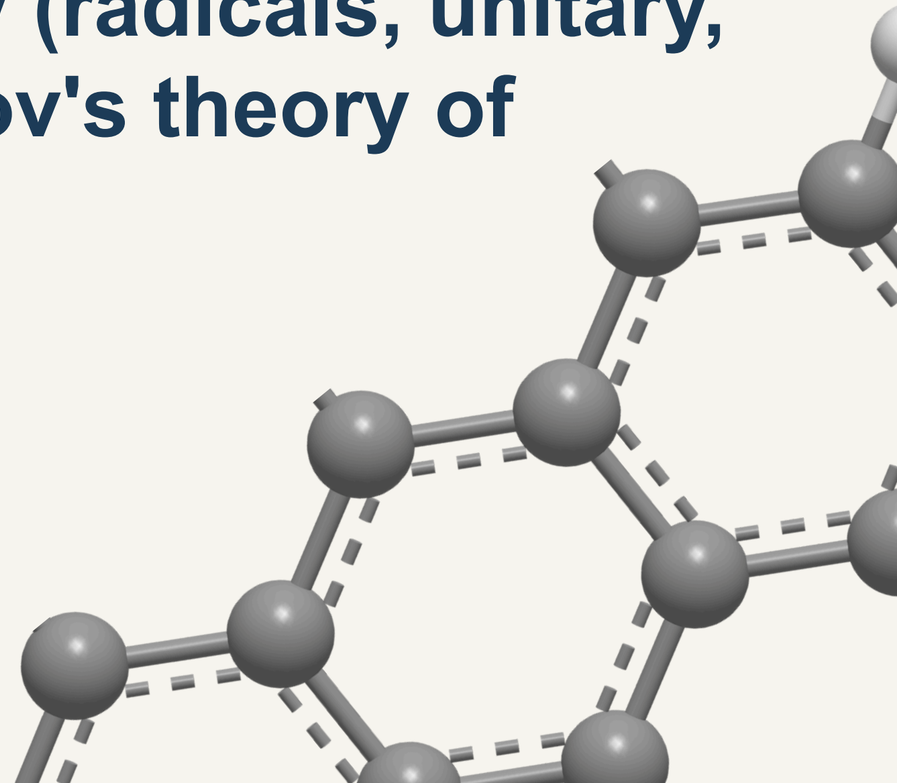


lecture 1

Subject of organic chemistry. A brief history of the development of organic chemistry (radicals, unitary, theory of types, etc.). Butlerov's theory of construction.



Lecture: PhD, acc. professor: Kudaibergenova B.M

1.Aim

To study the subject of organic chemistry, the history of its development, the main early theories, and A. M. Butlerov’s theory of chemical structure.

2. Objectives

- To examine the subject and main principles of organic chemistry.
- To study the historical development of organic chemistry.
- To describe the Radical Theory, Unitary Theory, and Theory of Types.
- To explain the main principles of Butlerov’s Theory of Chemical Structure.
- To study the concept of structural isomerism.
- To determine the importance of Butlerov’s theory in modern organic chemistry.

SUBJECT OF ORGANIC CHEMISTRY

Introduction to Organic Chemistry

Organic chemistry studies carbon-containing compounds: their structure, properties, reactions, and methods of synthesis. They mainly contain carbon and hydrogen, and may also include oxygen, nitrogen, sulfur, phosphorus, and halogens.

1. Study the structure and properties of organic substances.
2. Investigate chemical reactions and their mechanisms.
3. Develop methods for synthesizing new compounds.
4. Study how molecular structure relates to chemical properties.

Applications: medicine, pharmacy, agriculture, food production, cosmetics, polymer manufacturing.

Why Carbon?

Carbon atoms have unique ability to bond with each other and with other elements, which creates an enormous variety of organic compounds.

Tetravalent

Carbon forms four covalent bonds.

Chains and rings

C–C bonds build chains, branches, and rings.

Multiple bonds

Single, double, and triple bonds are possible.

Simple examples

Methane CH_4, ethane C_2H_6, ethene C_2H_4, ethyne C_2H_2.

Historical Development

Organic chemistry became an independent science in the late 18th and early 19th centuries.

Scientists first believed organic substances could only be produced by living organisms: the theory of **vitalism**.

1828

Friedrich Wöhler synthesized urea from ammonium cyanate, an inorganic substance.

Challenged vitalism

The idea of a “vital force” lost its basis.

Artificial synthesis

Organic compounds can be made in the laboratory.

Modern science

Opened the way to modern organic chemistry.

Timeline of Key Ideas

From vitalism to the structural theory in about three decades.



1828

Wöhler synthesizes urea; vitalism is challenged.

1830s

Liebig and Wöhler develop the radical theory.

1830s–40s

Dumas and Laurent propose the unitary theory.

1850s

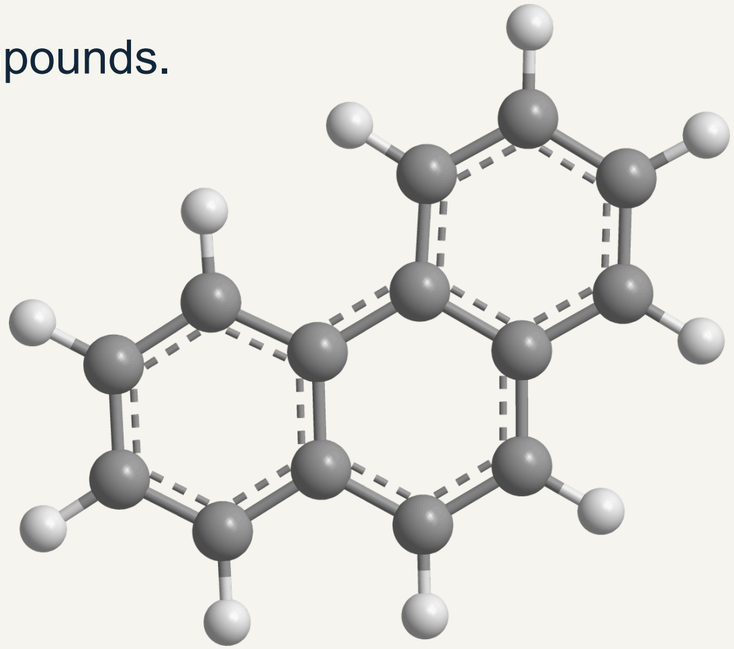
Gerhardt develops the theory of types.

1861

Butlerov establishes the theory of chemical structure.

Early Theories

Before Butlerov, several theories explained the composition of organic compounds.



Radical Theory

J. Liebig and F. Wöhler. Compounds contain groups of atoms (radicals) that stay unchanged in some reactions, e.g. the benzoyl radical (1830s).

Unitary Theory

J.-B. Dumas and A. Laurent. A compound is a unified molecular system; composition and overall arrangement matter more than permanent radicals.

Theory of Types

C. Gerhardt, 1850s. Compounds are classified by type: water H–O–H, hydrogen H–H, ammonia NH_3.

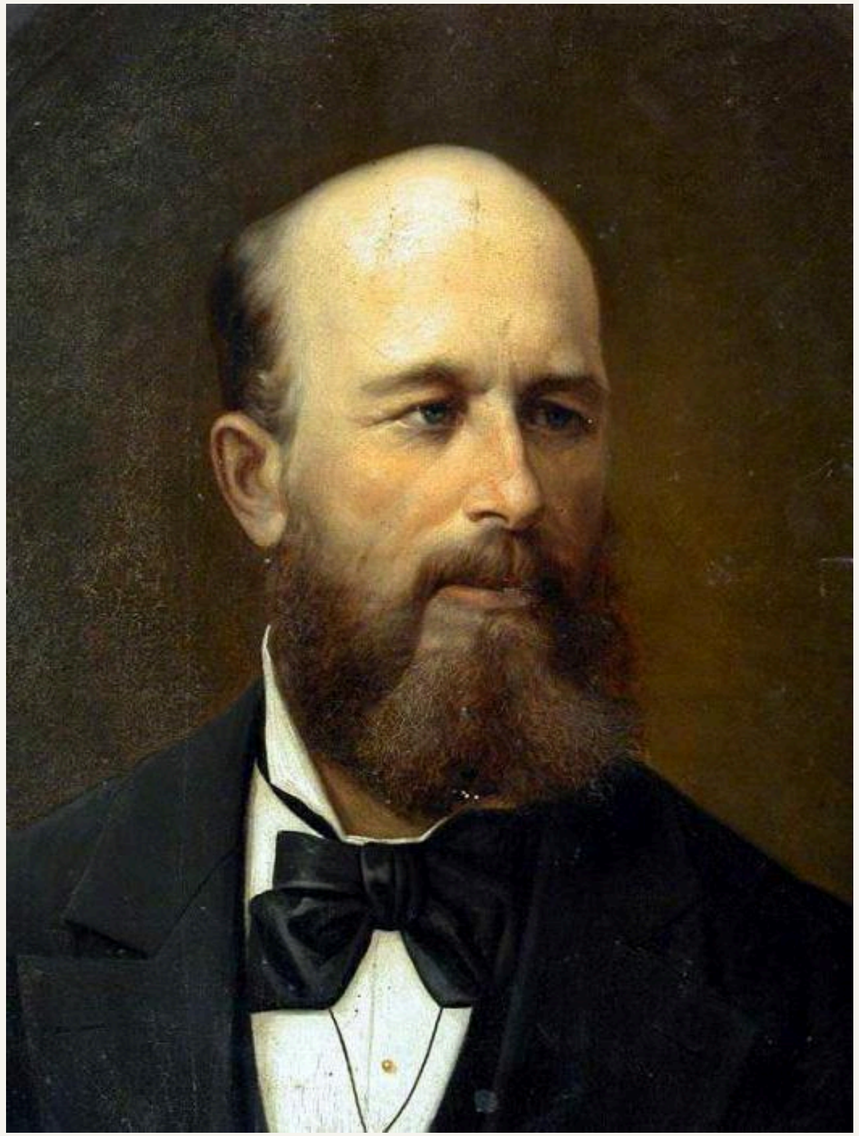
Comparing the Theories

Theory	Scientists	Main idea	Limitation
Radical	Liebig, Wöhler	Stable groups of atoms (radicals)	No picture of atomic order
Unitary	Dumas, Laurent	Molecule as a unified system	Atom connectivity unclear
Types	Gerhardt	Classification by chemical types	Classifies, but not structure
Structure	Butlerov	Order of atoms defines properties	Explains isomerism

Butlerov’s Theory of Chemical Structure

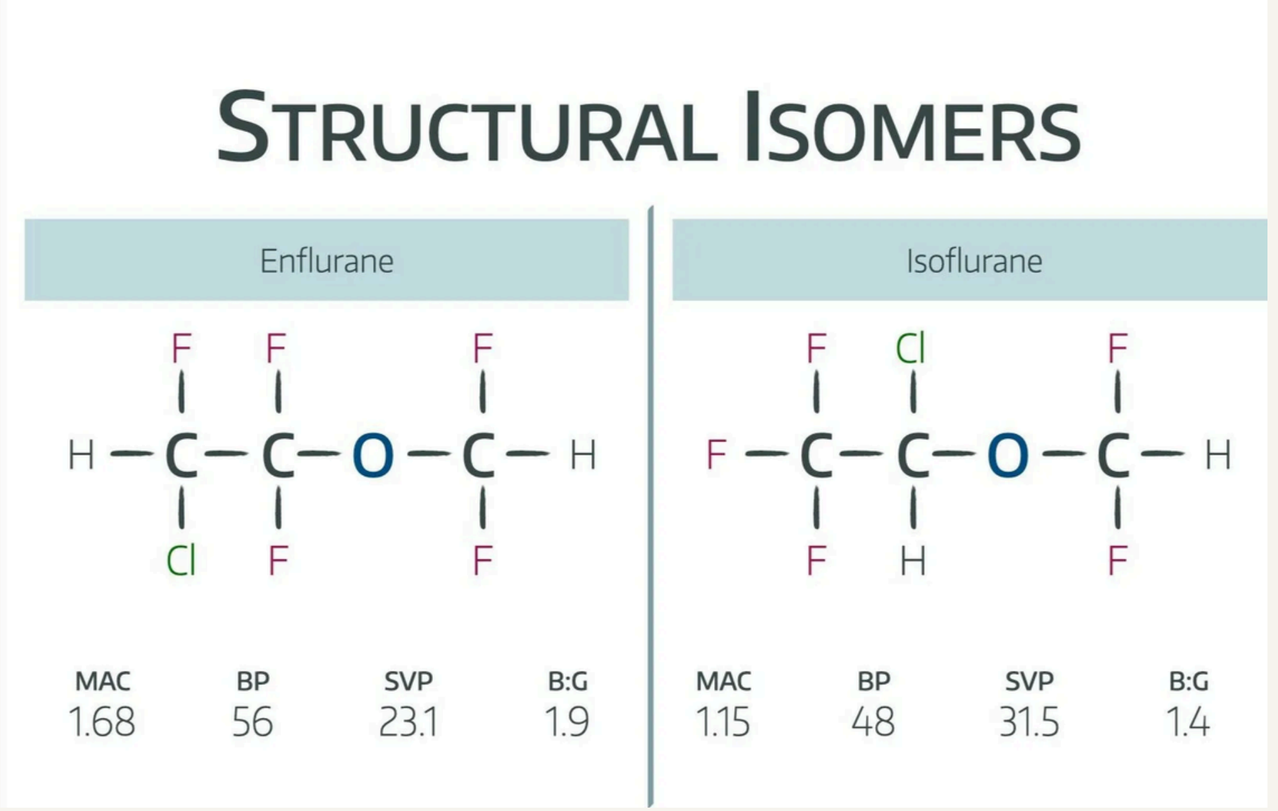
Alexander M. Butlerov (1828–1886) established the theory in 1861. Properties depend not only on composition but on the order in which atoms are connected.

1. Atoms are connected in a definite order according to their valency.
2. Properties depend on molecular structure.
3. Atoms and groups of atoms influence one another.
4. Structure can be determined through chemical reactions.
5. One molecular formula can correspond to different structures.



Structural Isomerism

Isomers have the same molecular formula but different structures and properties. Butlerov’s theory explained this.



n-Butane

$CH_3–CH_2–CH_2–CH_3$

C_4H_{10}, straight carbon chain

Isobutane

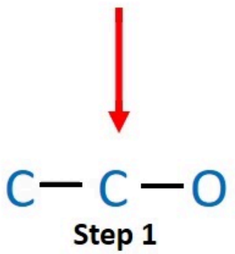
$(CH_3)_3CH$

C_4H_{10}, branched carbon skeleton

Both have 4 carbon and 10 hydrogen atoms, yet different skeletons give different physical properties, such as boiling points. Structure determines properties.

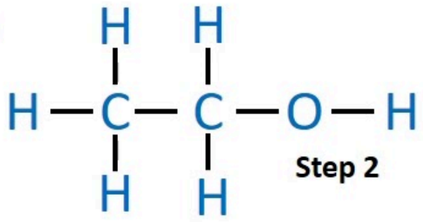
Isomers in Practice: C_2H_6O

Build the structure of molecule



Complete the structure by connecting H atoms to carbon atoms and oxygen atom

Isomer 1



- There should be four bonds around carbon atom to complete its octal.
- There should be two bonds around oxygen atom to complete its octal.

$CH_3—CH_2—OH$

Ethanol (alcohol)

Ethanol

$CH_3–CH_2–OH$

Liquid, boils at about 78 °C; reacts with sodium.

Dimethyl ether

$CH_3–O–CH_3$

Gas at room temperature, boils at about −24 °C; does not react with sodium.

Different connection of the same atoms gives different properties: the core of Butlerov’s theory.

Importance in Modern Chemistry

Contributions

- Links structure and chemical properties
- Explains structural isomerism
- Predicts unknown compounds
- Guides synthesis of new substances
- Basis for reaction mechanisms

Modern applications

- Pharmaceuticals: medicines and active ingredients
- Polymers: plastics, fibers, rubber
- Petrochemicals: processing hydrocarbons
- Biotechnology: bioactive substances

Key Terms

Valency
The number of bonds an atom can form.

Radical
A group of atoms passing unchanged through reactions.

Isomers
Compounds with the same formula but different structure.

Structural formula
Shows the order in which atoms are connected.

Vitalism
The belief that organic substances need a “vital force”.

Carbon skeleton
The chain or ring of carbon atoms in a molecule.

Conclusion

Organic chemistry grew from the study of natural substances into an independent branch of modern science.

The radical theory, unitary theory, and theory of types helped explain composition and properties.

The key breakthrough was Butlerov’s theory of chemical structure (1861): properties depend on the arrangement and mutual influence of atoms.

Today it remains a fundamental principle for understanding, predicting, and synthesizing organic compounds.

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1. Butlerov, A. M. (1861). *Introduction to the Complete Study of Organic Chemistry.*
2. Morrison, R. T., Boyd, R. N. *Organic Chemistry.*
3. Clayden, J., Greeves, N., Warren, S. *Organic Chemistry.*
4. McMurry, J. *Organic Chemistry.*