

THE ROLE OF PHENOLS IN THE STRUCTURE OF BIOLOGICALLY ACTIVE
COMPOUNDS AND THEIR MEDICINAL PROPERTIES

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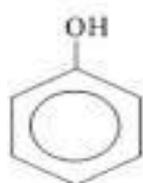
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Abstract: Furthermore, phenolic compounds act as natural antioxidants, protecting plant tissues from oxidative stress caused by environmental factors such as UV radiation, temperature fluctuations, and pathogen attacks. Their ability to neutralize free radicals contributes not only to plant health but also enhances the nutritional value of phenol-rich foods for humans. These antioxidant properties are also beneficial for human health, as they help prevent chronic diseases, reduce inflammation, support cardiovascular health, and may lower the risk of certain cancers.[1]

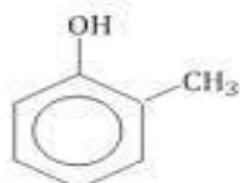
In addition, phenols participate in the formation of pigments, flavors, and aromas, which determine the sensory qualities of many fruits and vegetables. They also influence the plant's defense signaling pathways, helping it adapt to biotic and abiotic stress conditions. In the human body, phenolic compounds contribute to immune system support, promote detoxification processes, and protect cells from oxidative damage.

Keywords: phenols, phenolic compounds, antioxidant properties vitamins, hormones, enzymes

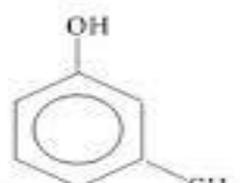
Phenols are mainly crystalline substances, and only a few of them (such as m-cresol) exist in liquid form. Most phenols have a strong, characteristic odor. They dissolve poorly in water but dissolve well in alkaline solutions. Phenol (C_6H_5OH), also known as carboic acid, is used as an antiseptic; it is toxic, therefore it is applied only externally. A separate class of organic compounds is called phenols; these include substances that differ in properties from aromatic alcohols and consist of a phenyl radical C_6H_5 connected to a hydroxyl group.[1,2]



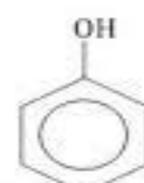
Фенол



орто-Крезол,
2-метилфенол

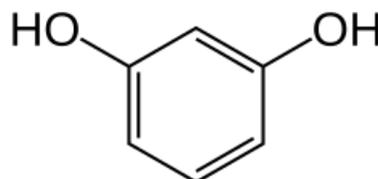
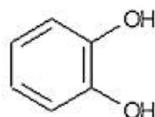


мета-Крезол,
3-метилфенол



пара-Крезол,
4-метилфенол

Monatomic phenols (such as the phenol and cresols mentioned above) and polyatomic phenols are distinguished. Among phenols that contain more than one $-OH$ group, the most common are diatomic phenols.[3]



Based on the examples given above, it can be stated that phenols exhibit structural isomerism depending on the position of the hydroxyl group.

Phenol — C_6H_5OH , is a colorless crystalline substance with a sharp odor, and it takes on a pinkish tint when exposed to air. An aqueous solution of phenol at a concentration of 0.5–3% (carbolic acid) kills microorganisms. It is used to disinfect surgical instruments. In industry, phenol is utilized to obtain phenol-formaldehyde resins and dyes through polycondensation reactions.[3,4]

Hydroquinone (1,4-dihydroxybenzene) is a crystalline substance that naturally occurs in plants (such as bearberry) in a bound form. In industrial practice, it is obtained from quinone. Hydroquinone oxidizes easily and is used in photography as a developer. With iron (III) chloride, it produces a green color, which then turns yellow.[5,6,7]

Pyrocatechol (1,2-dihydroxybenzene) is a crystalline substance found in many plants. It is used in the synthesis of an important hormone produced by the adrenal glands — adrenaline. Adrenaline is one of the key regulators of vital physiological processes in the body.[8,9]

Resorcinol (1,3-dihydroxybenzene) is a colorless crystalline substance that turns brownish when exposed to air. It is used in the treatment of skin diseases as an antiseptic in aqueous and alcoholic solutions. Resorcinol produces a violet color with $FeCl_3$ (iron III chloride).[7,9]

Picric acid (2,4,6-trinitrophenol) is a yellow crystalline, toxic compound. Its ammonium and potassium salts — picrates — are powerful explosives and are also used as dyes. Picric acid is also applied in the treatment of burns.

Phenols in the Composition of Vitamins

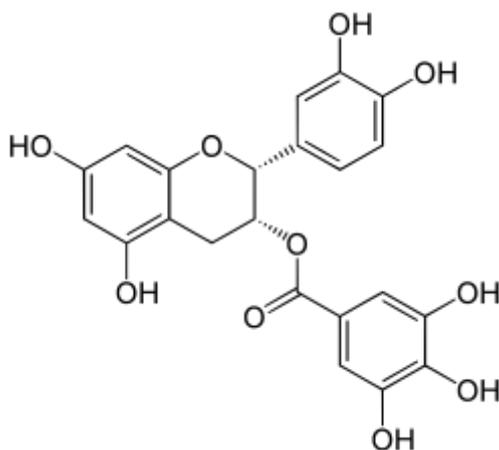
Vitamins are low-molecular-weight organic compounds with diverse chemical structures that are essential for organisms even in very small amounts. Their biological role lies in the fact that many vitamins function as coenzymes within the active sites of numerous enzymes, and without them biochemical processes cannot proceed normally. Phenols may also be present in the structure of such biologically active substances.[10,11]

1) Tocopherol (Vitamin E) Tocopherols are a group of vitamins that are derivatives of hydroquinone and contain a phytol alcohol residue as a side radical. Among them, the most active form is α -tocopherol. Tocopherol and related compounds act as antioxidants for the unsaturated lipids in cell membranes, protecting membrane lipids from free radicals formed

during lipid peroxidation. Tocopherols may also participate in oxidation-reduction reactions. A deficiency of Vitamin E disrupts the function of cell membranes, causes muscle tissue degeneration, leads to liver necrosis, and may even result in infertility. The main dietary sources of this vitamin are vegetable oils and the green parts of plants.[10,11]

2) Citrin (Vitamin P) In the treatment of scurvy, ascorbic acid alone is not sufficient; for this purpose, other substances known as Vitamin P are needed. These substances are closely associated with ascorbic acid in the organism's biochemical processes. The Vitamin P complex includes two groups of flavonoids:

— free flavonoid compounds — flavonoid glycosides bound to carbohydrates. One of the substances with the strongest P-activity is catechins, which are found in plants in free form.



Epicatechin

Epicatechin is found in tea leaves (a flavanol derivative).

Eriodictyol is found in the peel of citrus fruits (a flavanone derivative).

Quercetin is found in the fruits of black chokeberry (aronia) and in the buds of the Japanese sophora (a flavonol derivative).

Phenols in the Structure of Enzymes

Both simple (in the form of polypeptide chains) and complex enzymes exist in nature. Simple enzymes break down into amino acids during hydrolysis. However, most natural enzymes are complex proteins that, in addition to polypeptide chains, contain a non-protein component — a coenzyme or a cofactor. A coenzyme is an organic compound, while a cofactor is an inorganic substance.[12]

Metal ions often serve as cofactors: iron (Fe), copper (Cu), zinc (Zn), and others. They are required for the catalytic activity of many enzymes.

Most coenzymes are derivatives of water-soluble vitamins (Table 1).

Table 1. Coenzymes Derived From Vitamins

Vitamins	Coenzymes
PP (nicotinic acid)	NAD ⁺ , NADF
B ₂ (riboflavin)	FAD, FMN
B ₆ (pyridoxal)	Pyridoxal phosphate
B ₁ (thiamine)	Thiamine pyrophosphate
B ₉ (folic acid)	Tetrahydrofolic acid
B ₁₂ (cyanocobalamin)	Cobalamins

Three groups of coenzymes are distinguished:

1. **Coenzymes participating in oxidation–reduction reactions:**

- NAD⁺/NADH₂
- NADF⁺/NADFH₂
- FAD/FADH₂
- Coenzyme Q (CoQ)

2. **Coenzymes that carry atomic groups:**

- Pyridoxal phosphate — carries amino groups
- Biotin — carries carbon dioxide (CO₂)
- Tetrahydrofolic acid — carries methyl and other one-carbon groups

3. **Coenzymes involved in synthesis, isomerization, and decomposition processes:**

- Thiamine pyrophosphate — decarboxylation of keto acids
- Coenzyme A (CoA) — activation of fatty acids

Coenzymes such as FMN, FAD, and pyridoxal phosphate are directly bound to the enzyme, and therefore they are considered part of the enzyme's active site.

NAD⁺, NADF⁺, and CoA bind to the enzyme's active center only during the reaction, similar to a substrate.[12]

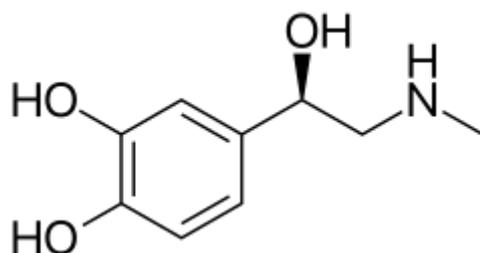
If, during a reaction, chemical changes occur in the coenzyme that correspond to changes in the substrate, such coenzymes are regarded as second substrates (cosubstrates). Sometimes the transformations involving the coenzyme itself have physiological significance — for example, the formation of NAD•H₂ in the citric acid cycle and its oxidation in the respiratory chain.

Phenols in the Structure of Hormones

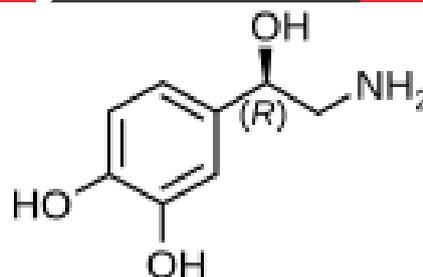
Hormones are derivatives of certain amino acids. For example:

- Adrenaline and noradrenaline — produced in the medulla of the adrenal gland,
 - Thyroxine and triiodothyronine — hormones of the thyroid gland,
- all of which are derivatives of the amino acid tyrosine.

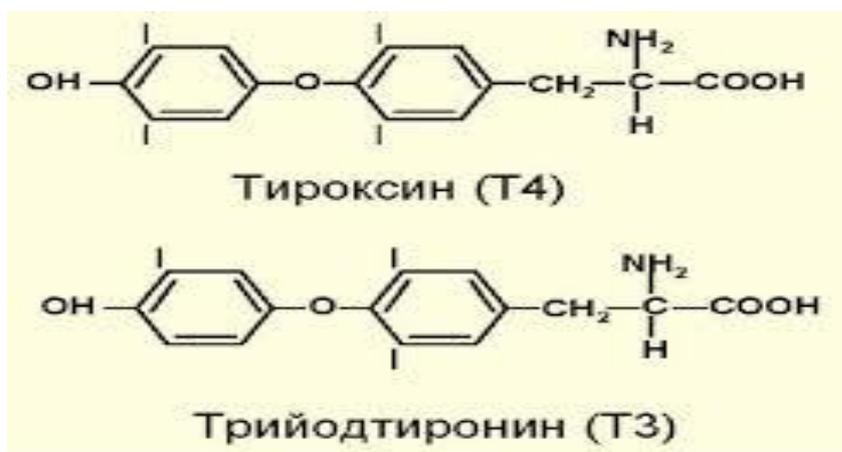
In the structure of the following hormones, the bonding of hydroxyl groups to the benzene ring also occurs.[10,11,12]



Adrenaline



noradrenaline



Conclusion

Thus, by studying the structure of the main substances essential for the organism, it can be concluded that phenolic compounds play an important role in the vital activity of the body and in ensuring physiological processes. [12] This is primarily evidenced by the fact that phenols are widespread in biologically active compounds, where they function as an integral part of the molecule. In addition, phenol is a structural component of the side chain of tyrosine, a standard amino acid, and therefore it is present in almost every protein molecule.

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