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Phenol and its medical uses

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Abstract

In organic chemistry, phenols, sometimes called phenolic, are a class of chemical compounds consisting of one or more hydroxyl groups ($—OH$) bonded directly to an aromatic hydrocarbon group. The simplest is phenol, C_6H_5OH. Sorption of phenolic compounds is a very complex process and many factors influence it. At the beginning, detailed chemical structure of phenols is presented with its consequence for physical properties, for example, values of melting and boiling points, solubility in water, pKa and $Log\ P$. Also influence of activating and deactivating substituents on the properties is explained. On this basis, interaction with the most frequently used sorbents, for example, chemically modified silica's, polymers and porous carbons, is described. Phenol is a type of organic compound. It has a mildly sugary scent that might remind you of somewhere that's sterile, such as a hospital room. In limited quantities, it's available for several medical and health-related uses.

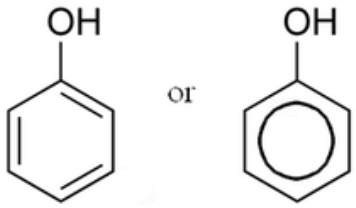
Key words

Phenol, Acid, boiling point, oxidation, natural source

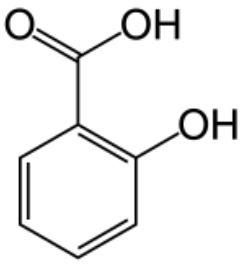
1. Introduction

There is a huge variety of phenolic compounds in our natural environment. Some like eugenol, thymol, pyrogallol, guaiacol or pyrocatechol are formed in natural way, but a vast majority of them are introduced as a consequence of industrial, agricultural and communal activities of humans. While the former are neutralized as the result of natural processes, the latter pose a serious risk to the environment.

Phenolic compounds are classified as simple phenols or polyphenols based on the number of phenol units in the molecule.

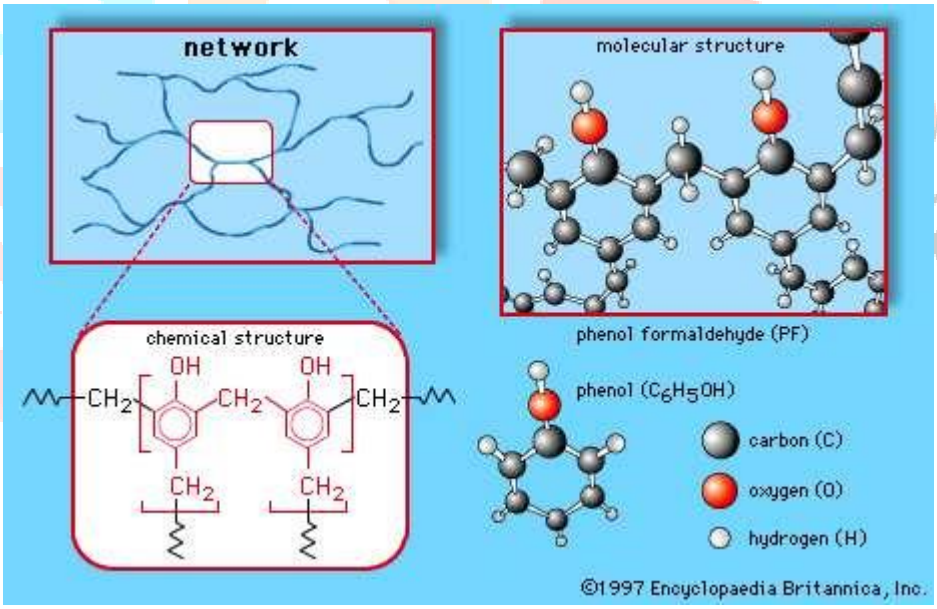


Phenol – the simplest of the phenols.

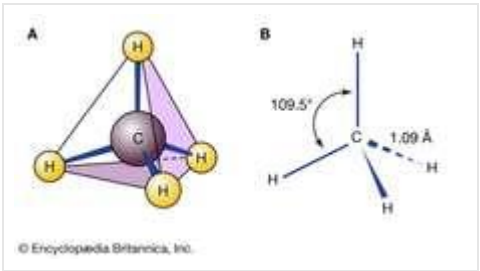


Chemical structure of salicylic acid, the active metabolite of aspirin.

any of a family of organic compounds characterized by a hydroxyl (—OH) group attached to a carbon atom that is part of an aromatic ring. Besides serving as the generic name for the entire family, the term *phenol* is also the specific name for its simplest member, monohydroxybenzene (C_6H_5OH), also known as benzenol, or carbolic acid.



Phenol-formaldehyde resins are heat-resistant and waterproof, though somewhat brittle. They are formed through the reaction of phenol with formaldehyde, followed by cross-linking of the polymeric chains.



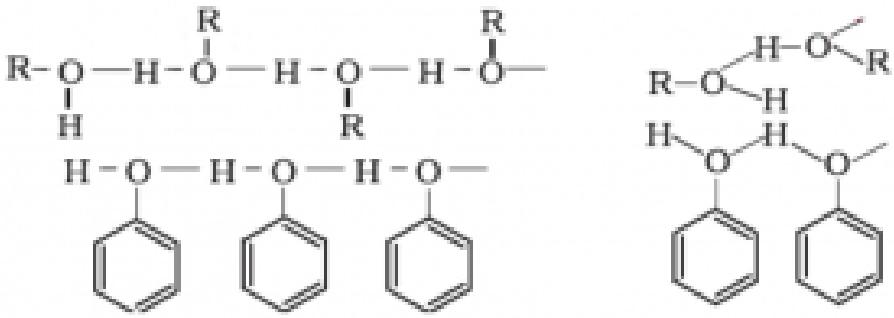
Pure phenol is used in certain medical procedures and as an ingredient in numerous treatments and laboratory applications.

2. Physical and chemical Properties of Phenols

Phenols are the organic compounds containing benzene ring bonded to a hydroxyl group. They are also known as carbolic acids. They exhibit unique physical and chemical properties in comparison to alcohol. These physical and chemical properties of phenols are mainly due to the presence of the hydroxyl group. Some prominent physical and chemical properties of phenols are given below.

2.1. Boiling Point of Phenols

Phenols generally have higher boiling points in comparison to other hydrocarbons having equal molecular masses. This is due to the presence of intermolecular hydrogen bonding between hydroxyl groups of phenol molecules. In general, the boiling point of phenols increases with an increase in the number of carbon atoms.

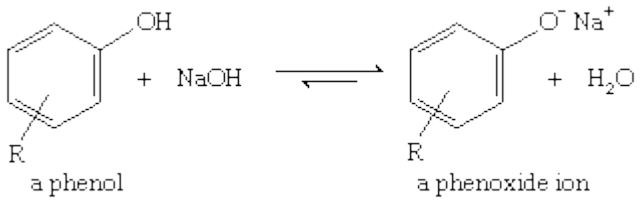


2.2. Solubility of Phenols

- The solubility of phenol in water is governed by the hydroxyl group present.
- The hydroxyl group in phenol is involved in the formation of intermolecular hydrogen bonding.
- Thus, hydrogen bonds are formed between water and phenol molecules which make phenol soluble in water.
- However, the aryl group attached to the hydroxyl group is hydrophobic in nature.
- Thus, the solubility of phenol decreases with the increase in the size of the aryl group.

2.3. Acidity of Phenols

Although phenols are often considered simply as aromatic alcohols, they do have somewhat different properties. The most obvious difference is the enhanced acidity of phenols. Phenols are not as acidic as carboxylic acids, but they are much more acidic than aliphatic alcohols, and they are more acidic than water. Unlike simple alcohols, most phenols are completely deprotonated by sodium hydroxide (NaOH).

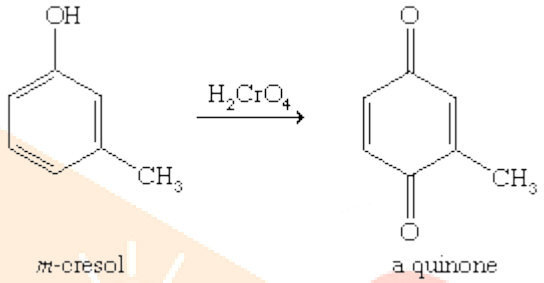


2.4. Chirality of Phenols

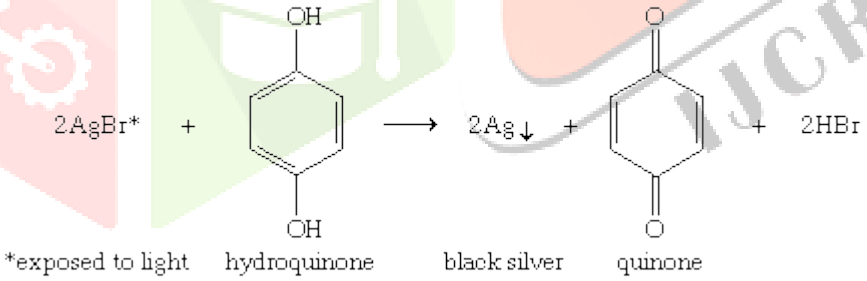
Phenols exhibit chirality within their molecules, for example, catechin. This chirality is due to the absence of planar and axial symmetry in the phenol molecule.

2.5. Oxidation

Like other alcohols, phenols undergo oxidation, but they give different types of products from those seen with aliphatic alcohols. For example, chromic acid oxidizes most phenols to conjugate 1,4-diketones called quinones. In the presence of oxygen in the air, many phenols slowly oxidize to give dark mixtures containing quinones.

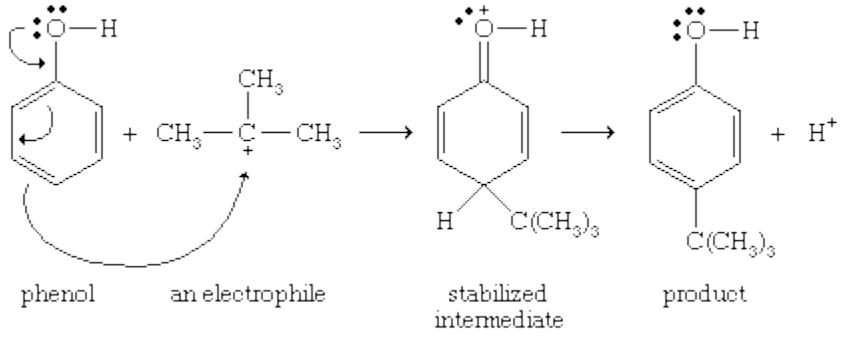


Hydroquinone ($1,4-benzenediol$) is a particularly easy compound to oxidize, because it has two hydroxyl groups in the proper relationship to give up hydrogen atoms to form a quinone. Hydroquinone is used in developing photographic film by reducing activated (exposed to light) silver bromide ($AgBr$) to black metallic silver ($Ag\downarrow$). Unexposed grains of silver bromide react more slowly than the exposed grains.

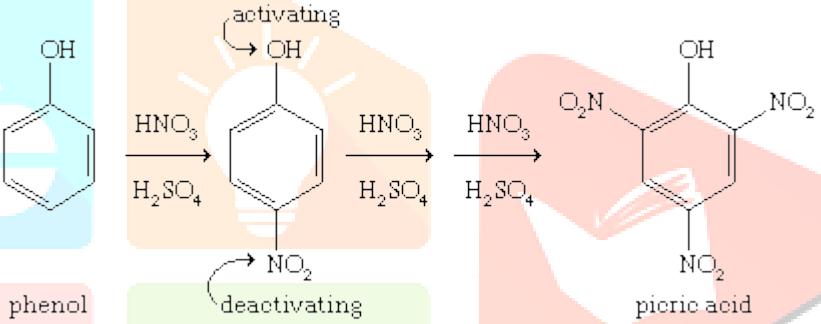


2.6. Electrophilic aromatic substitution

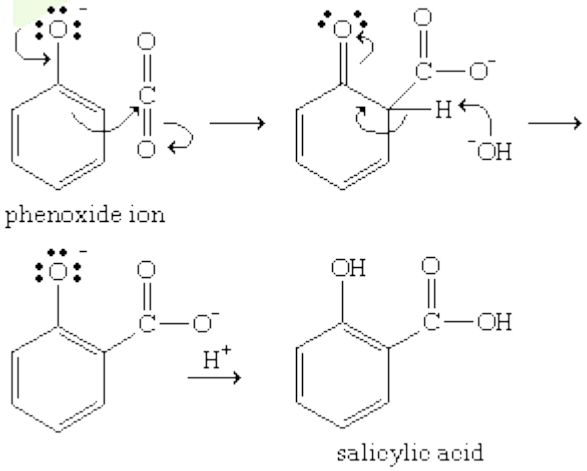
Phenols are highly reactive toward electrophilic aromatic substitution, because the nonbonding electrons on oxygen stabilize the intermediate cation. This stabilization is most effective for attack at the *ortho* or *para* position of the ring; therefore, the hydroxyl group of a phenol is considered to be activating (i.e., its presence causes the aromatic ring to be more reactive than benzene) and *ortho*- or *para*-directing.



Picric acid ($2,4,6-trinitrophenol$) is an important explosive that was used in World War I. An effective explosive needs a high proportion of oxidizing groups such as nitro groups. Nitro groups are strongly deactivating (i.e., make the aromatic ring less reactive), however, and it is often difficult to add a second or third nitro group to an aromatic compound. Three nitro groups are more easily substituted onto phenol, because the strong activation of the hydroxyl group helps to counteract the deactivation of the first and second nitro groups.

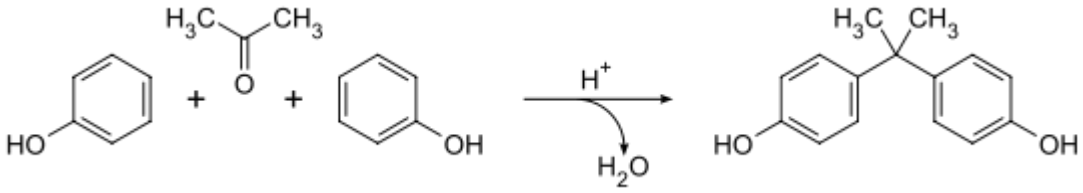


Phenoxide ions, generated by treating a phenol with sodium hydroxide, are so strongly activated that they undergo electrophilic aromatic substitution even with very weak electrophiles such as carbon dioxide (CO_2). This reaction is used commercially to make salicylic acid for conversion to aspirin and methyl salicylate.



2.7 Condensation with aldehydes and ketones

Phenols are susceptible to Electrophilic aromatic substitutions. Condensation with formaldehyde gives resinous materials, famously Bakelite. Another industrial-scale electrophilic aromatic substitution is the production of bisphenol A, which is produced by the condensation with acetone.



2.8 Alkylation with alkenes

Phenol is readily alkylated at the ortho positions using alkenes in the presence of a Lewis acid such as aluminium phenoxide:

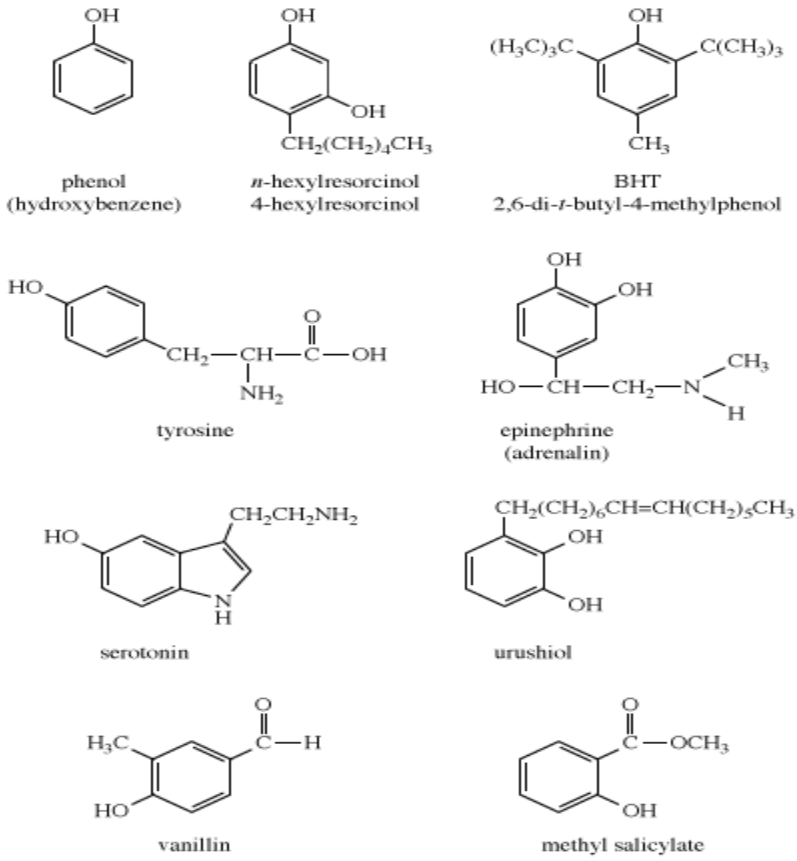
$$CH_2 = CR_2 + C_6H_5OH \rightarrow R_2CHCH_2 - 2 - C_6H_4OH$$

More than 100,000 tons of tert-butyl phenols are produced annually (year: 2000) in this way, using isobutylene ($CH_2 = CMe_2$) as the alkylating agent. Especially important is $2{,}6 - ditert - butylphenol$, a versatile antioxidant.

3. Natural Sources of Phenols

Phenols are common in nature; examples include tyrosine, one of the standard amino acids found in most proteins; epinephrine (adrenaline), a stimulant hormone produced by the adrenal medulla; serotonin, a neurotransmitter in the brain; and urushiol, an irritant secreted by poison ivy to prevent animals from eating its leaves. Many of the more complex phenols used as flavourings and aromas are obtained from essential oils of plants. For example, vanillin, the principal flavouring in vanilla, is isolated from vanilla beans, and methyl salicylate, which has a characteristic minty taste and odour, is isolated from wintergreen. Other phenols obtained from plants include thymol, isolated from thyme, and eugenol, isolated from cloves.

Poison ivy (Toxicodendron radicans) is a natural source of the phenol urushiol—an irritant that causes severe inflammation of the skin.Walter Chandoha



Phenol, the cresols (methyl phenols), and other simple alkylated phenols can be obtained from the distillation of coal tar or crude petroleum.

4. Medical Uses of Phenol

4.1 Phenol Injection

Phenol can be injected into your muscles to treat a condition known as muscle spasticity. This happens when your brain doesn't communicate properly with your spinal cord and nerves. It causes your muscles to become tight. Muscle spasticity can even interrupt your ability to walk or talk. It can be caused by conditions like Parkinson's disease, cerebral palsy, or brain trauma. A phenol injection helps limit the signals sent from your nerves to your muscles that cause contractions. This allows you to move more easily and feel less discomfort. This treatment is similar to getting a botulinum toxin A (Botox) shot. But phenol tends to be more useful for large muscles.

4.2. Chemical matrixectomy

Phenol is commonly used in surgeries for ingrown toenails. It's used on more severe ingrown toenails that don't respond to other treatments. The phenol, in the form of trichloroacetic acid, is used to stop the nail from growing back. A small 2001 study Trusted Source of 172 people found that 98.8 percent of those who received a chemical matrixectomy with phenol cauterization had successful results. However, phenol matrixectomy may be falling out of favor. A 2014 paper Trusted Source in the Journal of the American Podiatric Medical Association found that sodium hydroxide had fewer complications than phenol as an ingrown toenail treatment.

4.3. Vaccine preservative

Phenol is used as a preservative Trusted Source in at least four vaccines. It helps keep bacteria from growing in and contaminating the vaccine solutions.

- Pneumovax 23 for conditions like pneumonia and meningitis
- Typhim Vi for typhoid fever
- ACAM2000 for smallpox
- a phenol compound called 2-Phenoxyethanol is used in the vaccine Ipol, for polio

4.5. Sore throat spray

Phenol is used in some throat sprays that can help numb your throat and relieve symptoms caused by a sore throat, or irritation in the mouth caused by canker sores. You can buy over-the-counter phenol spray almost anywhere. The most common brand is Chloraseptic. It contains about 1.4 percent phenol. Phenol spray is safe to use at the recommend dose for a short time. But using too much or giving it to children younger than 3-years old can be unsafe. Read the ingredients label carefully to make sure you're not allergic to any other components of the spray. And if your sore throat is accompanied by a fever, nausea, and vomiting, see a doctor as soon as possible before using phenol for throat soreness.

4.6. Oral analgesics

Many phenol-based products that help relieve pain or irritation in or around your mouth can also be bought over-the-counter to numb tissues in the mouth and lips. These products are used as a short-term treatment for the symptoms of pharyngitis. This happens when your throat gets inflamed from a bacterial or viral infection. Phenol-based products for mouth and throat pain are widely available and safe to use in small doses. But throat sprays and antiseptic liquids shouldn't be used for more than a couple days at a time. And if you're having symptoms like fever and vomiting, see a doctor. Phenols are widely used as antiseptics (substances that kill microorganisms on living tissue) and as disinfectants (substances intended to kill microorganisms on inanimate objects such as furniture or floors). The first widely used antiseptic was phenol. Joseph Lister used it for antiseptic surgery in 1867. Phenol is toxic to humans, however, and

can cause severe burns when applied to the skin. In the bloodstream, it is a systemic poison—that is, one that is carried to and affects all parts of the body. Its severe side effects led to searches for safer antiseptics, a number of which have been found.

5. Conclusion

In this paper we are study the phenol and it's physical and chemical properties. Also from this paper we know how we obtain phenol from natural source and this research work able us to know the application of phenol in medical. Phenol is a type of organic compound. While toxic to consume on its own, it's available in tiny doses in many household products like mouthwash and spray cleaners. In its pure form, it may be colorless or white

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