3.3: Phenols

Learning Objectives

- Describe the structure and uses of some phenols.
- Generate the name of phenolic compounds.

Compounds in which an OH group is attached directly to an aromatic ring are designated ArOH and called **phenols**. Phenols differ from alcohols in that they are slightly acidic in water. They react with aqueous sodium hydroxide (NaOH) to form salts.

$$\mathrm{ArOH(aq) + NaOH(aq) \rightarrow ArONa(aq) + H_2O} \tag{3.3.1}$$

The parent compound, C_6H_5OH, is itself called phenol. (An old name, emphasizing its slight acidity, was *carbolic acid*.) Phenol is a white crystalline compound that has a distinctive ("hospital smell") odor.

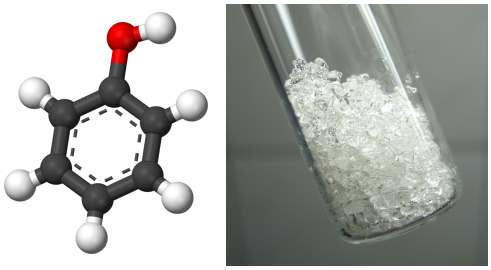


Figure 3.3.1: (Left) Structure of Phenol (right) Approximately two grams of phenol in glass vial. Image used with permisison from Wikipedia

To Your Health: Phenols and Us

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.

Figure 3.3.2: *An operation in 1753, painted by Gaspare Traversi, of a surgery before antiseptics were used.*

One safer phenolic antiseptic is 4-hexylresorcinol (4-hexyl-1,3-dihydroxybenzene; resorcinol is the common name for 1,3-dihydroxybenzene, and 4-hexylresorcinol has a hexyl group on the fourth carbon atom of the resorcinol ring). It is much more powerful than phenol as a germicide and has fewer undesirable side effects. Indeed, it is safe enough to be used as the active ingredient in some mouthwashes and throat lozenges.

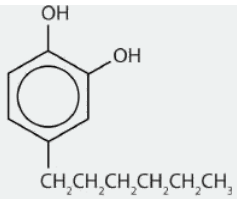


Figure 3.3.3:*The compound 4-hexylresorcinol is mild enough to be used as the active ingredient in antiseptic preparations for use on the skin.*

Naming Phenols

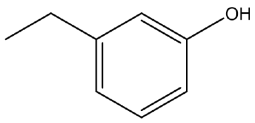
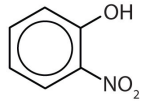


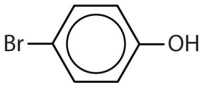
Figure 3.3.4: Structure of a substitued phenol.

In the International Union of Pure and Applied Chemistry (IUPAC) system, the rules for naming phenols are similar to naming substituted aromatics. When naming phenols, the **parent name is phenol**. This accounts for the benzene ring and the hydroxyl attached to it. The **carbon atom bearing the OH group is designated C1**, but the 1 is not used in the name. The **location of substituents** is then determined using the shortest path. The location of all substituents (even if only one is present) must be shown. The name is then determine by indicating the location and identity of the substituents followed by the word phenol. According to these rules, the name of the molecule shown in Figure 3.3.4 would be *3-ethylphenol*.

✔ Example 3.3.1

Name each compound.

a. 

b. 

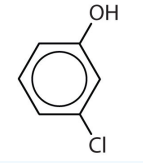
Solution

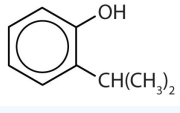
a. The parent chain is phenol and C1 would represent the carbon with the OH attached. There is one substituent present on the adjacent carbon, so the parent chain would be numbered clockwise to represent the shortest path. The substituent, which is identified as a nitro group, is on C2. Therefore, the name of the molecule is 2-nitrophenol (or o-nitrophenol).

b. The parent chain is phenol and C1 would represent the carbon with the OH attached. There is one substituent present on the carbon oppositie C1. In this position, the same number is obtained regardless of the chosen path. Therefore, the bromo substituent, is on C4. This indicates that the name of the molecule is 4-bromophenol (or p-bromophenol)

? Exercise 3.3.1

Name the following compounds.

a. 

b. 

Summary

- Phenols are compounds in which an OH group is attached directly to an aromatic ring. Many phenols are used as antiseptics.
- IUPAC nomenclature of phenols: location and identity of substituents + phenol