Kolbe Reaction

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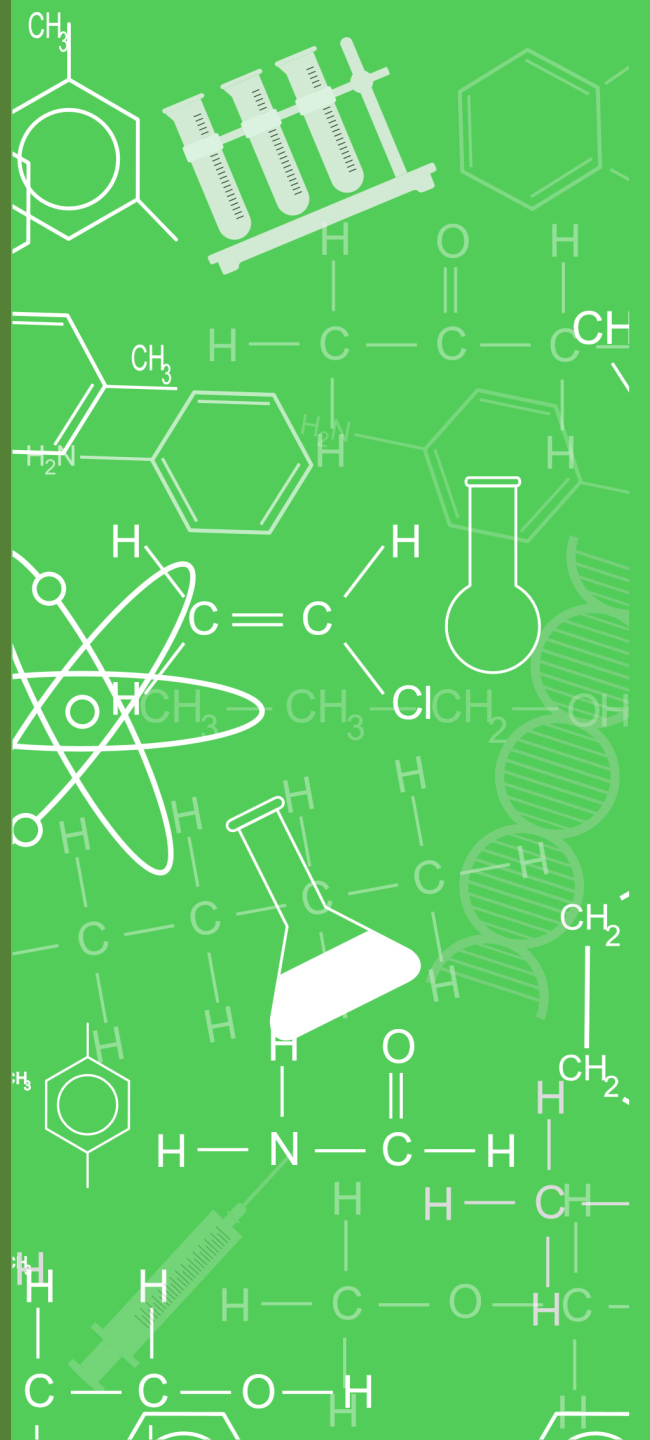
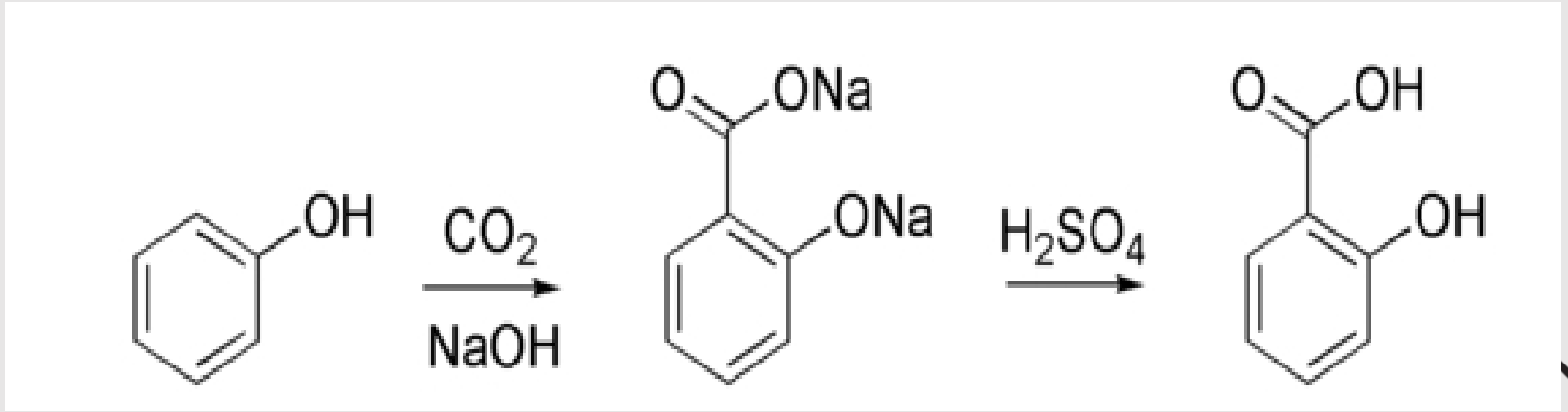


What is Kolbe Reaction?

Kolbe reaction, also known as Kolbe Schmitt Reaction is a type of addition reaction named after Hermann Kolbe and Rudolf Schmitt. When phenol is treated with sodium hydroxide, phenoxide ion is generated. The phenoxide ion generated is more reactive than phenol towards electrophilic aromatic substitution reaction. Hence, it undergoes electrophilic substitution reaction with carbon dioxide, which is a weak electrophile. Ortho-hydroxybenzoic acid (salicylic acid) is formed as the primary product. This reaction is popularly known as Kolbe's reaction.

Reaction

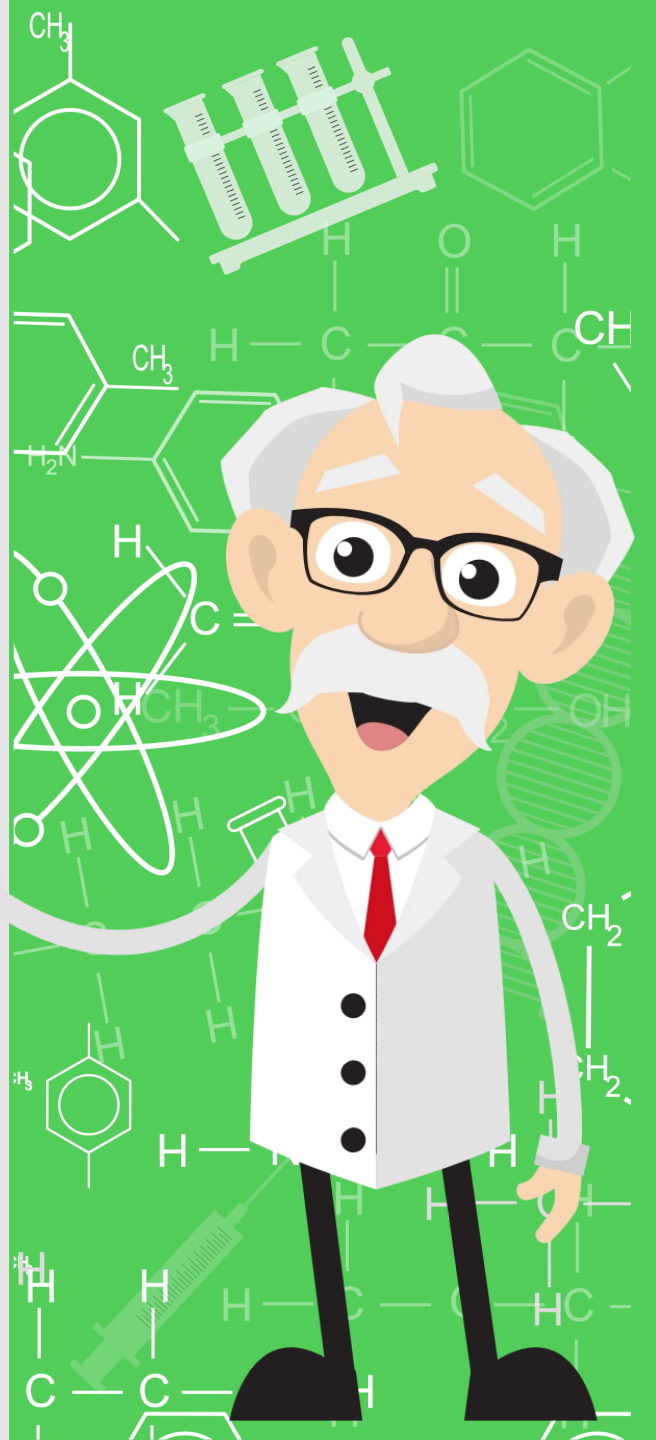
An example of the Kolbe reaction (Kolbe Schmitt Reaction) is given below:



Kolbe's Reaction – Treating phenol with sodium hydroxide generates phenoxide ion

The mechanism of Kolbe reaction proceeds through the nucleophilic addition of phenoxide to carbon dioxide, yielding the salicylate.

The salicylate formed further reacts with the acid to form salicylic acid. It is a carboxylation reaction where sodium phenoxide is heated with carbon dioxide under a pressure of 100 atmospheres and a temperature of 125 degrees Celsius, and the resulting product is treated with sulfuric acid to yield salicylic acid (an aromatic hydroxy acid).



Kolbe Reaction Mechanism

The Kolbe reaction can be classified as a carboxylation chemical reaction. The reaction occurs when sodium phenoxide is allowed to absorb carbon dioxide and the resulting product is heated at a temperature of a 125-degree celsius and a pressure of over a hundred atmospheres. An unstable intermediate is now formed.

This unstable intermediate goes through a proton shift, leading to the formation of sodium salicylate. Now, this mixture is treated with sulfuric acid. The acidification of the mixture yields the salicylic acid. The illustration for the Kolbe reaction mechanism is given below:Thus, the required aromatic hydroxy acid – salicylic acid is produced via the Kolbe reaction. It can be observed that there is a nucleophilic addition of sodium phenoxide to carbon dioxide gas to form the salicylate in the mechanism.

Kolbe Reaction Mechanism

1. Abstraction of Proton

deprotonation of phenol by hydroxide ion (a strong base) to give phenoxide (the conjugate base of phenol)

2. Alkalimetal-Carbondioxide Complex formation

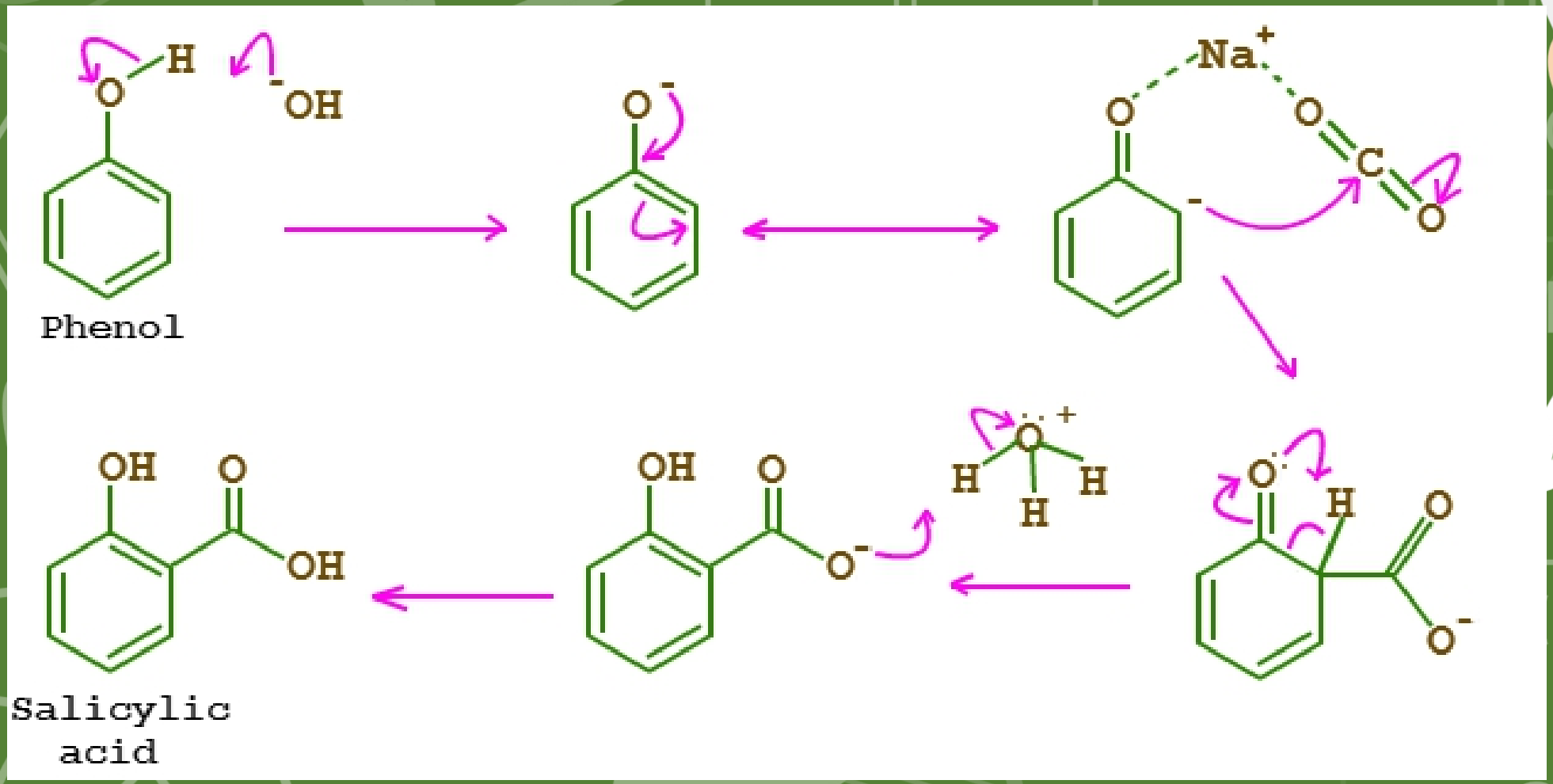
Phenoxide (an alkoxide and enolate nucleophile) adds to carbon dioxide to give a carboxylate.

3. Aromacity Restoration

4. Protonation

Aqueous sulfuric acid (a strong acid) protonates the carboxylate.
lons are water soluble, while addition of strong acid gives its heavy precipitates

Kolbe Reaction Mechanism



Applications of Kolbe Reaction

When Potassium Hydroxide is used in the Kolbe reaction, 4-Hydroxybenzoic acid can be accessed. This is an important precursor for parabens (parahydroxybenzoate or ester of para-hydroxy benzoic acid, used as a biocide in cosmetic products).

Kolbe reaction can also be used for the industrial synthesis of 3-hydroxy-2-naphthoic acid, which is a common precursor to azo dyes and pigments.

The salicylic acid can be used to make aspirin by reacting it with acetic anhydride. Aspirin is commonly used as a painkiller.

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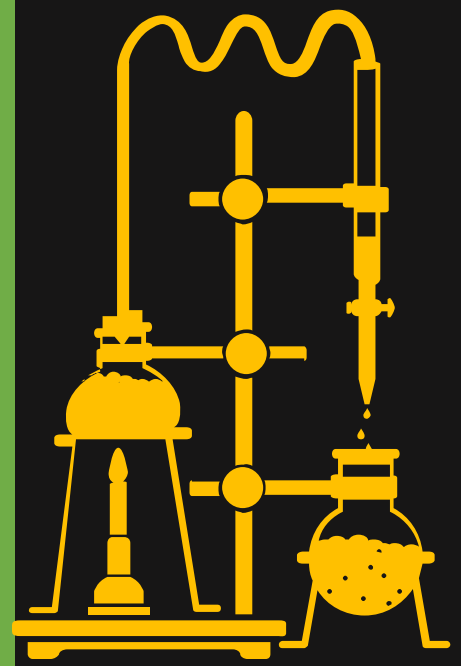

Thank You!

This Presentation is Prepared by

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