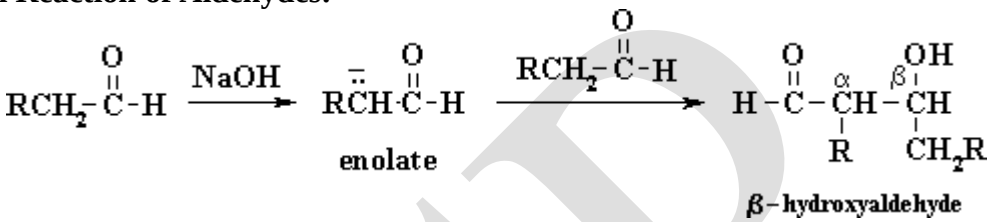
ALDOL CONDENSATION REACTION

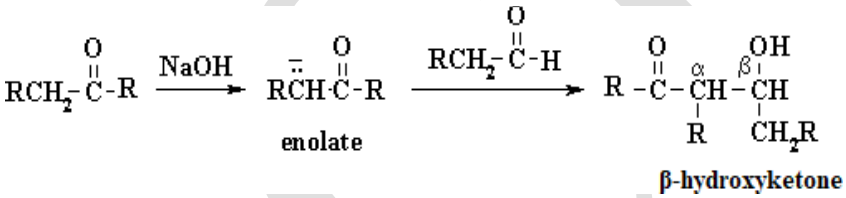
An Aldol Condensation is a condensation reaction in organic chemistry in which an enol or an enolate ion reacts with a carbonyl compound to form a β-hydroxyaldehyde or β-hydroxyketone, followed by dehydration to give aconjugated enone.

Discovered independently by the Russian chemist *Alexander Borodin* in 1869 and by the French chemist *Charles-Adolphe Wurtz* in 1872,

The Aldol Reaction of Aldehydes:



The Aldol Reaction of Ketones:



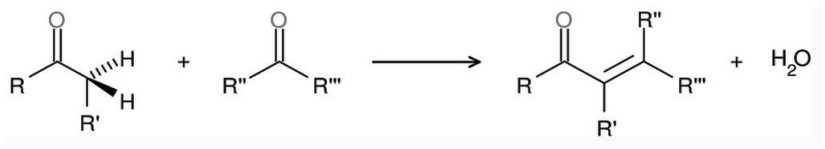
Reaction type: Nucleophilic addition.

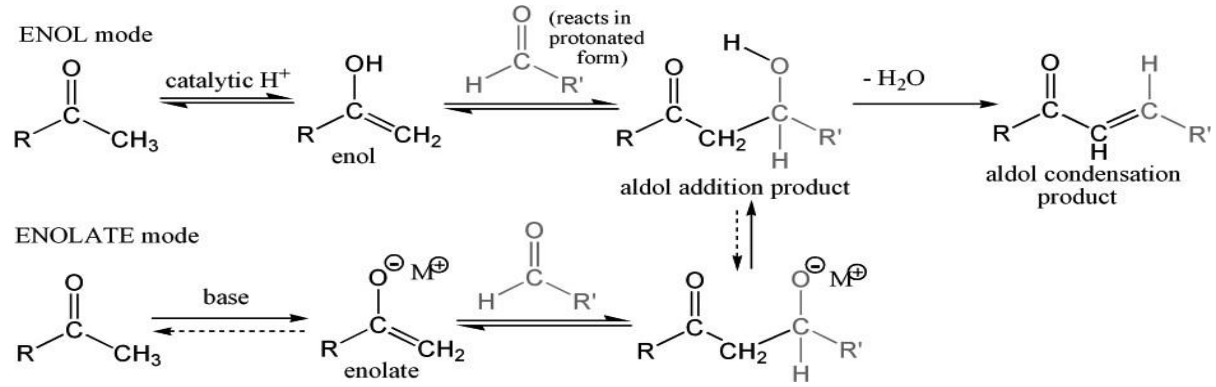
Reagents: commonly a base such as NaOH or KOH is added to the aldehyde.

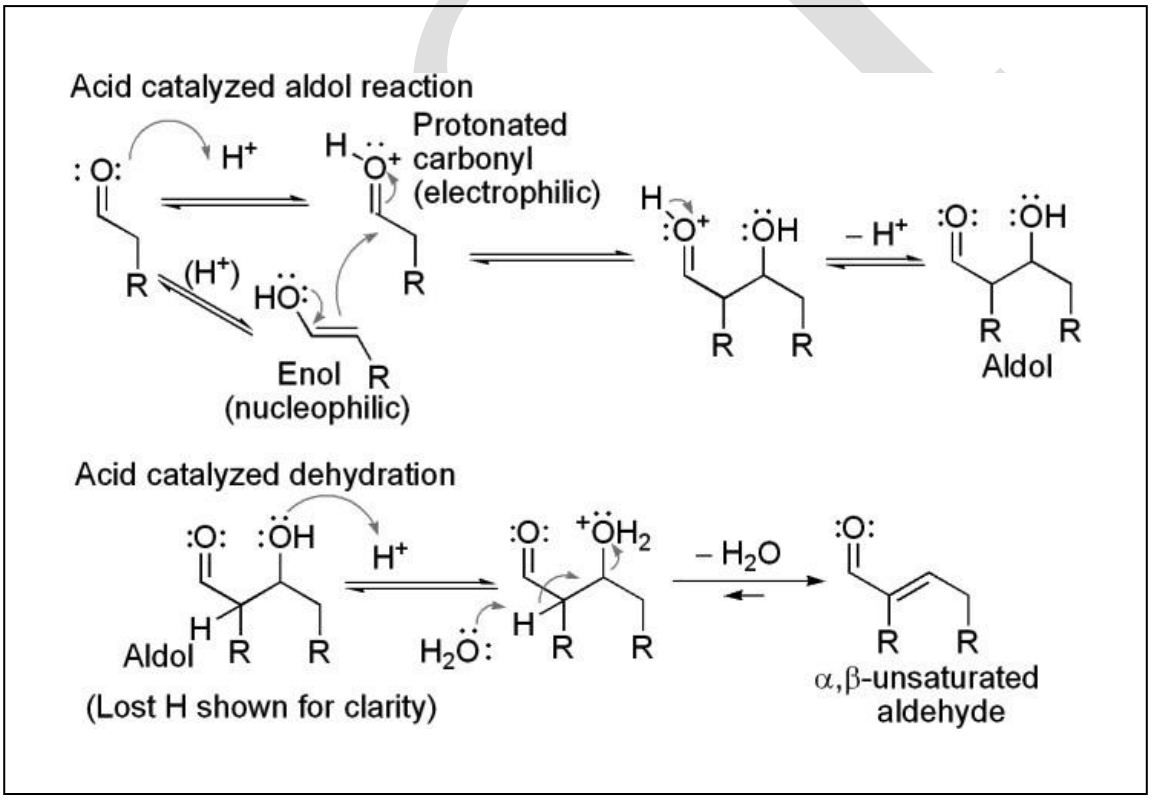
The reaction involves an aldehyde enolate reacting with another molecule of the aldehyde. Remember enolates are good nucleophiles and carbonyl carbon is good electrophiles.

Since the pK_a of an aldehyde is close to that of NaOH, both enolate and aldehyde are present simultaneously. The products of these reactions are β-hydroxyaldehydes or aldehyde-alcohols = aldols.

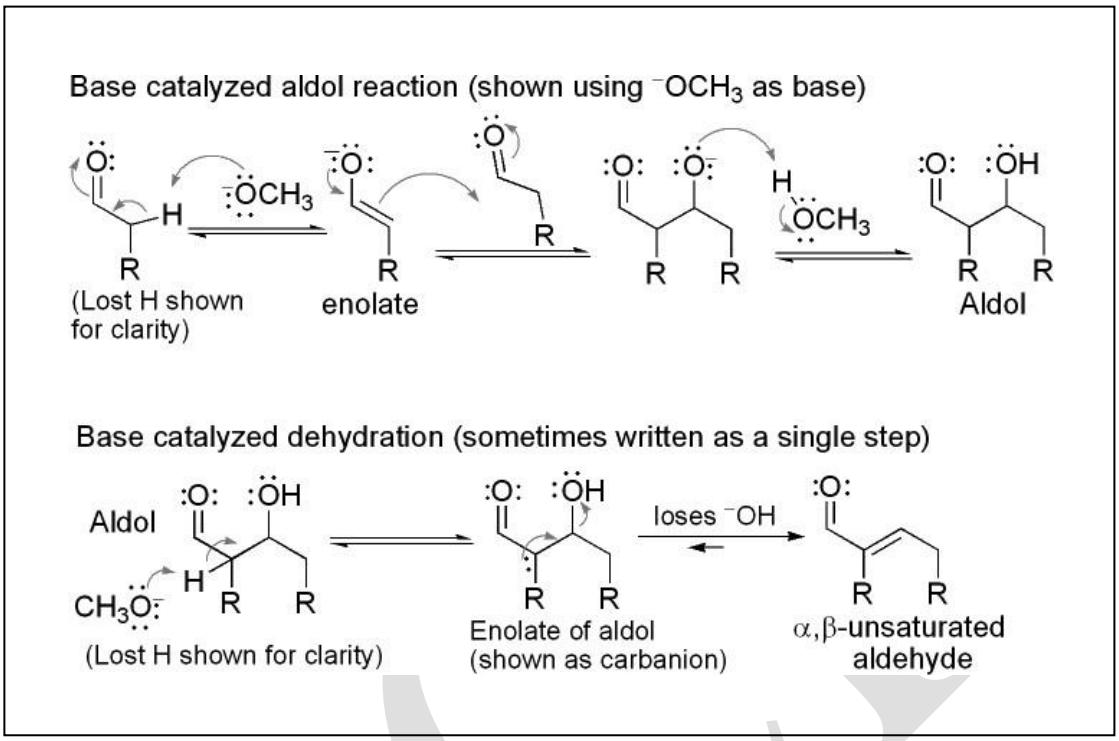
General Aldol Condensation Reaction







The Mechanism of Aldol Condensation Reaction Of A ALDEHYDE:



The Mechanism of Aldol Condensation Reaction of A KETONE:

Step 1:

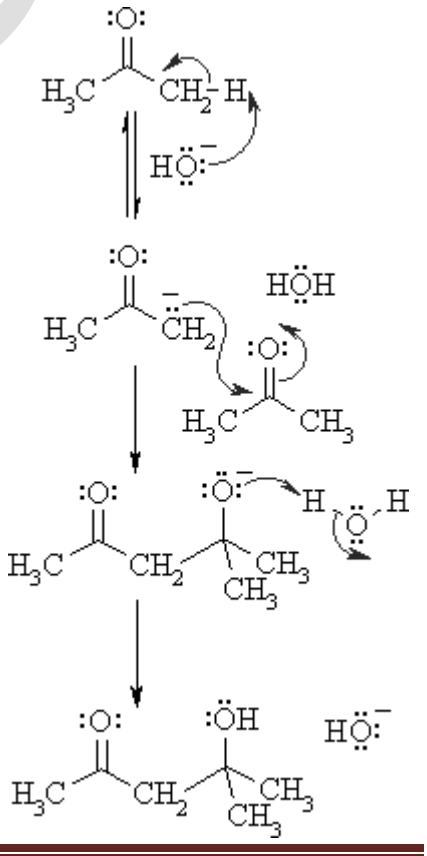
First, an acid-base reaction. Hydroxide functions as a base and removes the acidic α-hydrogen giving the reactive enolate.

Step 2:

The nucleophilic enolate attacks the ketone at the electrophilic carbonyl **C** in a nucleophilic addition type process giving an intermediate alkoxide.

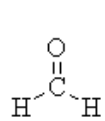
Step 3:

An acid-base reaction. The alkoxide deprotonates a water molecule creating hydroxide and the β-hydroxyketone, the **aldol** product.

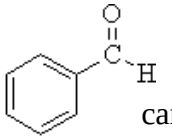


CROSSED ALDOL CONDENSATION REACTION

The process is also known as Mixed Aldol Condensation and occurs during the combination of two different molecules that contain carbonyl groups. Generally, such a reaction is only practical if **no α-hydrogens** are present in one of the compounds. This way, only one nucleophile is formed and only a single enol or enolate is generated.

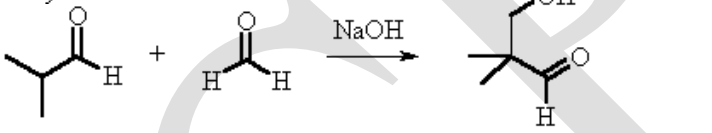


methanal



benzaldehyde

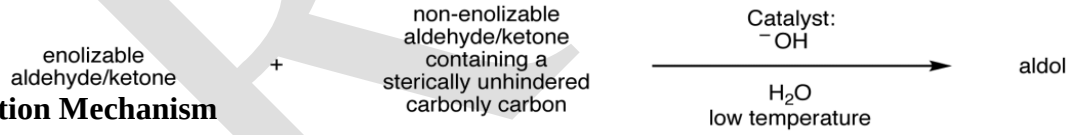
Neither of these aldehydes has α-hydrogens and therefore they cannot form an enolate.



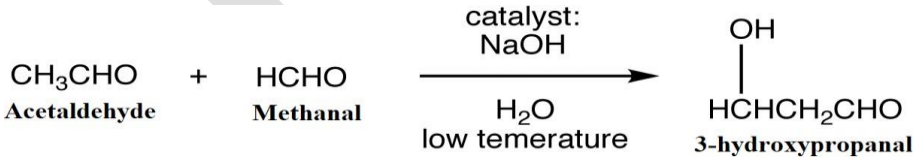
2-methylpropanal methanal 2,2-dimethyl-3-hydroxypropanal

Only one of this pair of aldehydes has an α-hydrogen (2-methyl propanal)

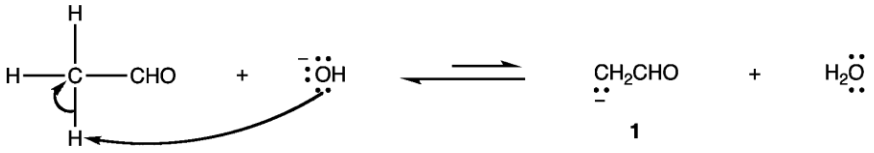
General representation of Aldol reaction:



Reaction Mechanism

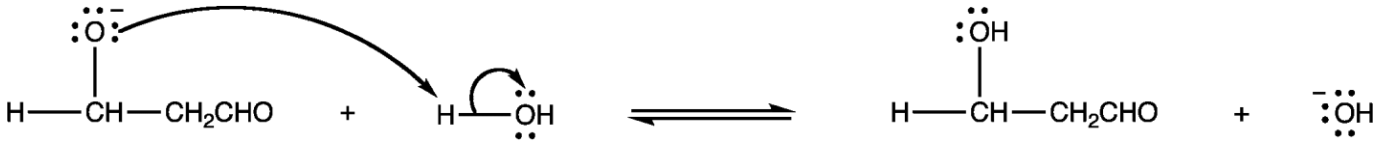


Step 1: *The hydroxide ion deprotanates the enolizable aldehyde reversibly.*



Step 2: Enolate ion 1 *preferentially adds to the non-enolizable aldehyde, which has the Sterically less hindered and,therefore, more accessible carbonyl carbon.*

Step 3: ***Alkoxide ion 2*** *is protonated by water.*



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