# 1. Acyloin Condensation

Principle

The carboxylic acid esters undergoes bimolecular reductive coupling upon refluxing with aprotic solvents such as ether, benzene, toluene or xylene to afford α-hydroxy ketone is known as acyloin condensation. Symmetrical *α*-hydroxy ketones (aliphatic analogs of benzoins) are commonly known as acyloin; the name is derived by adding the suffix '*-oin*' to the name of corresponding acid.

   The reaction is more favored when R is an alkyl group. With longer alkyl chains, higher boiling solvents can be used. Di-esters are used to prepare cyclic acyloins. When the acyloin condensation is carried out in the presence of chlorotrimethylsilane, the enediolate intermediate is trapped as bis-silyl derivative which is hydrolysed in acidic condition to the acyloin. Reaction occurs between two moles of ester (intermolecular condensation) or one mole of di-ester (intramolecular condensation). Rearrangement is promoted by either acid or base; the thermal acyloin rearrangement can be accelerated by high pressure.

General Reaction
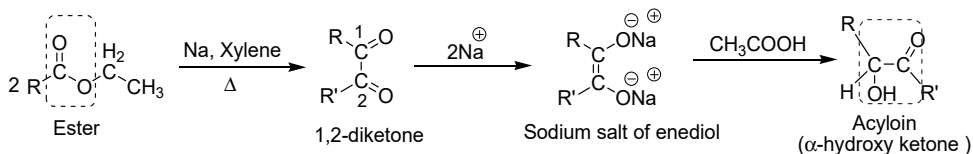
Mechanism

Step 1: Reaction proceeds through free radical mechanism.
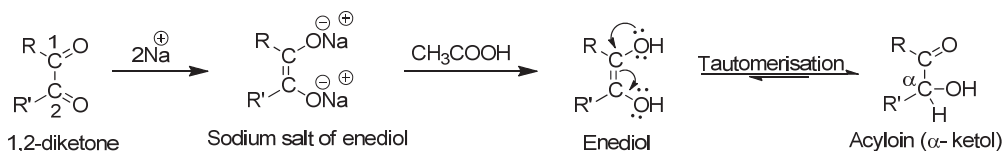
A reaction occurs in presence of metallic sodium; a direct transfer of electron towards carbonyl carbon atom takes place to give an intermediate (**I**) which rapidly dimerize to produce unstable intermediate product (**II**). Rapid loss of both alkoxy groups from intermediate (**II**) gives 1,2-diketone.

OC_2H_5
R—C—ONa$^{\oplus}$
R'—C—ONa$^{\oplus}$
OC_2H_5
(II)

$-2C_2H_5ONa$

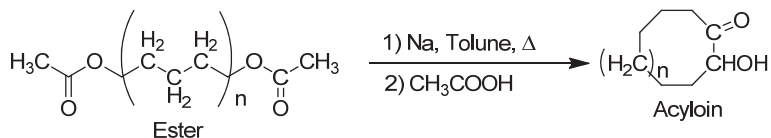$R\ _1C=O$
$R'\ _2C=O$
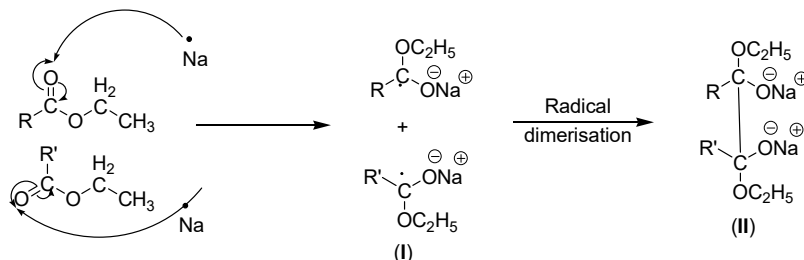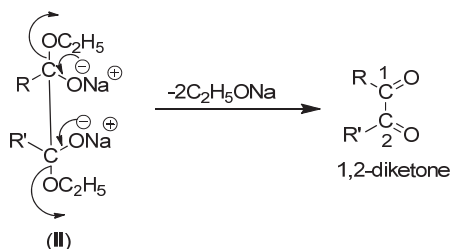
1,2-diketone

Step 2: 1,2-diketone is highly reactive, undergoes reduction with metallic sodium to give sodium salt of enediol. Finally addition of carboxylic acid affords 1,2-diol which after tautomerization resulted into the stable product acyloin (α-ketol or α-hydroxy ketone).

$R\ _1C=O$
$R'\ _2C=O$
1,2-diketone

2Na $\rightarrow$

$R—C—ONa$
$R'—C—ONa$
Sodium salt of enediol

CH_3COOH $\rightarrow$

$R—C—OH$
$R'—C—OH$
Enediol

Tautomerisation

$R—C=O$
$R'—\overset{\alpha}{C}—OH$
$\quad\quad H$
Acyloin (α-ketol)

Applications

Intramolecular acyloin condensations of diesters have been widely used for synthesis of medium and large ring compounds with better yield.

a) Preparation of cyclic acyloins.

$H_3C—C(O)—O—C(H_2)—C(H_2)—C(H_2)—(\ )_n—O—C(O)—CH_3$
Ester

1) Na, Tolune, Δ
2) CH_3COOH

$(H_2C)_n$ $C=O$ / CHOH
Acyloin

b) Preparation of catenane.

$H_3C—C(O)—O—C(H_2)—C(H_2)—C(H_2)—(\ )_n—O—C(O)—CH_3$
Ester

1) Na, Tolune, Δ
2) CH_3COOH

$O=C$ $(H_2C)_{32}$ CH ... $(CH_2)_{32}$ $HC—OH$ $C=O$
HO—CH
Catenane

+ $(H_2C)_n$ $C=O$ / CHOH
Acyloin