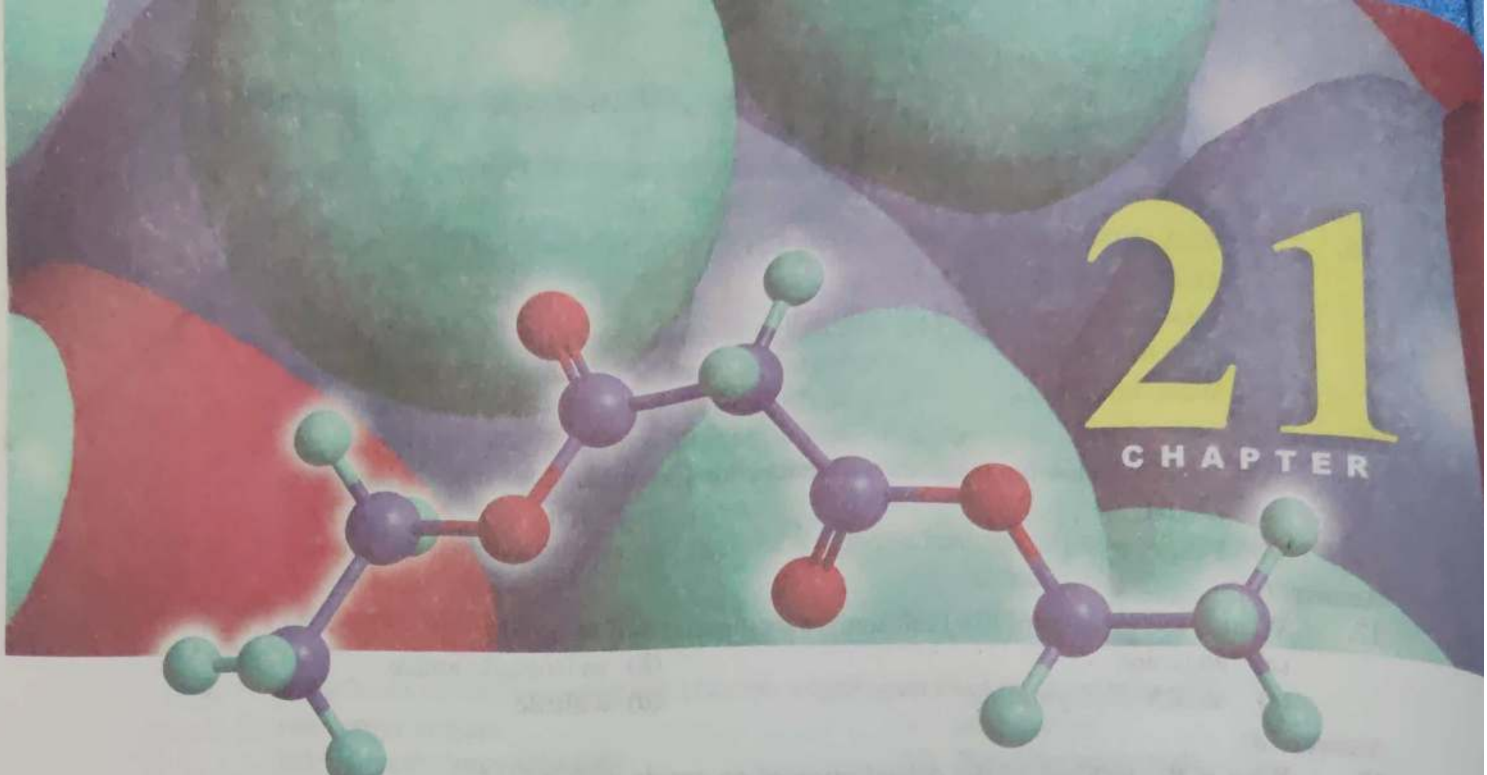
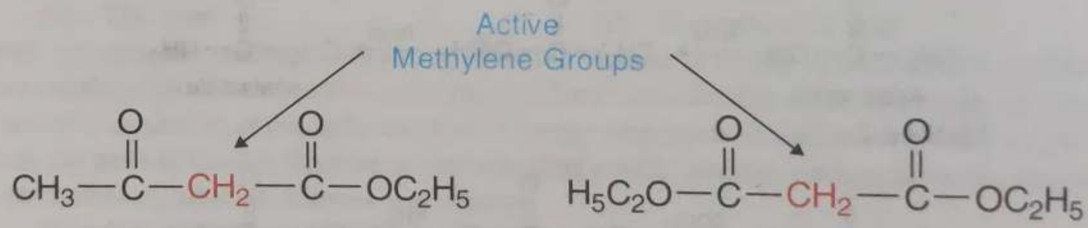


Active Methylene Compounds

The class of compounds which contain a methylene group ($-CH_2-$) directly bonded to two electron withdrawing groups such as $-COCH_3$, $-COOC_2H_5$, $-CN$, are called **Active Methylene Compounds**. This is so because the $-CH_2-$ group in them is acidic and reactive. Ethyl acetoacetate (*Acetoacetic ester*) and Diethyl malonate (*Malonic ester*) belong to this class.

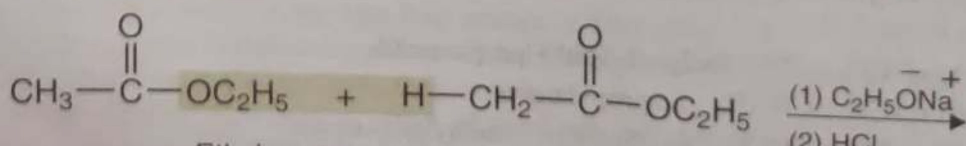


Ethyl acetoacetate (Acetoacetic ester) — Diethyl malonate (Malonic ester)

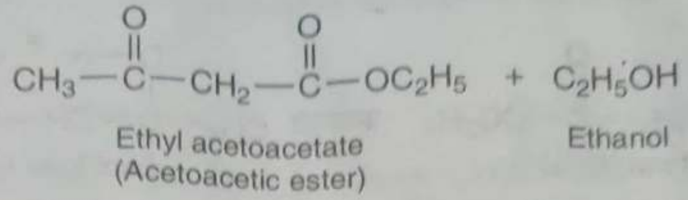
ETHYL ACETOACETATE, $CH_3COCH_2COOC_2H_5$

Ethyl acetoacetate is also called **Acetoacetic ester**. Its IUPAC name is **Ethyl 3-oxobutanoate**.

Preparation. Ethyl acetoacetate is prepared by heating ethyl acetate with sodium ethoxide in ethanol, followed by acidification.



Ethyl acetate (2 molecules)

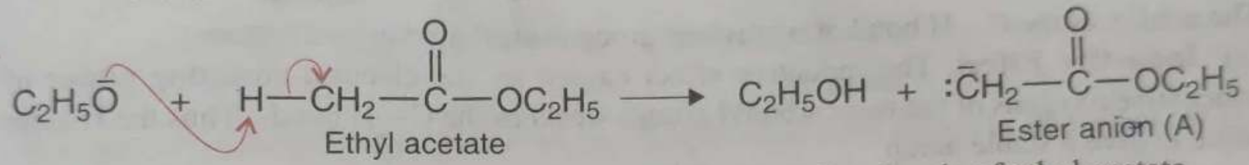


Laboratory Method A mixture of ethyl acetate and sodium ethoxide ($C_2H_5OH + Na \rightarrow C_2H_5ONa$) is heated at 78°C for 8 hours. The mixture is then cooled and HCl or acetic acid is slowly added. The oily layer is separated, dried, and distilled. The fraction passing between 178-181°C is ethyl acetoacetate.

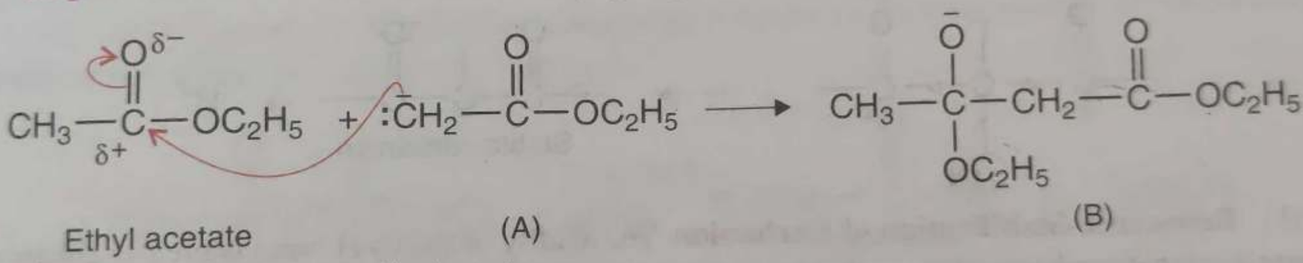
This reaction is an example of a general reaction known as **Claisen Condensation**. It involves base-catalyzed condensation of two ester molecules to form an alcohol and a β-keto ester. Ethyl acetoacetate is a β-keto ester.

MECHANISM. The mechanism of the above reaction involves three steps :

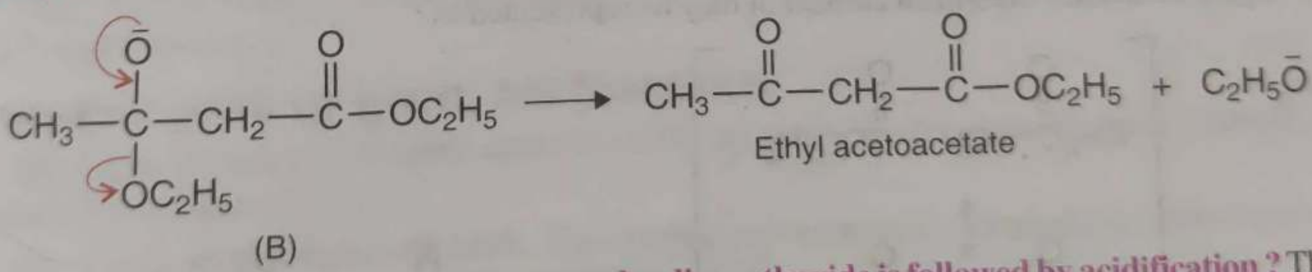
Step 1. Ethoxide ion (from $C_2H_5O^-Na^+$) attacks ethyl acetate to give ethyl alcohol and the ester anion.



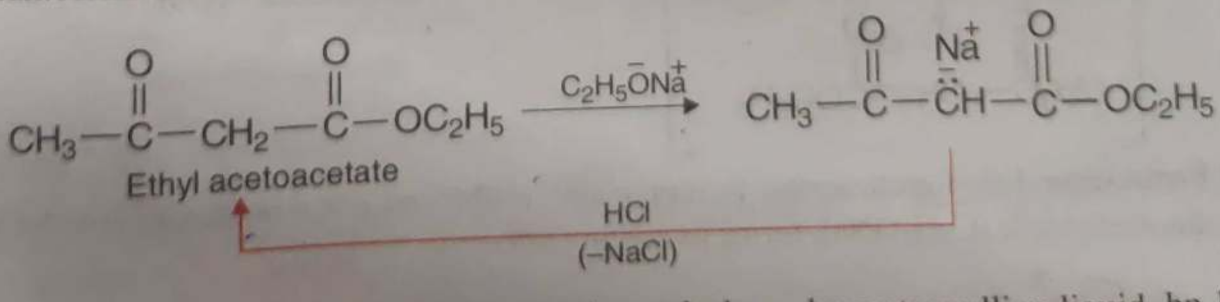
Step 2. Ester anion attacks the carbonyl group of a second molecule of ethyl acetate.



Step 3. Ethoxide ion is eliminated.

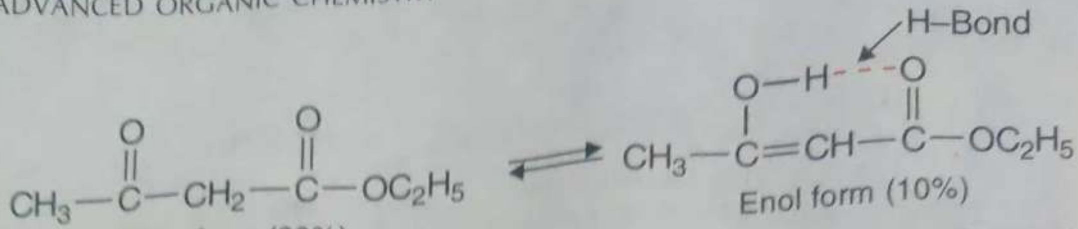


Why the reaction between ethyl acetate and sodium ethoxide is followed by acidification ? This is because the α-hydrogens of ethyl acetoacetate are acidic. It further reacts with sodium ethoxide to form a salt. Acidification of the salt gives back ethyl acetoacetate.



Properties (Physical). Ethyl acetoacetate is a colorless pleasant-smelling liquid, bp 180.4°C, density 1.0282. It is sparingly soluble in water but freely so in organic solvents. Refractive index of ordinary ethyl acetoacetate is $n_D = 1.4194$. It is neutral to litmus.

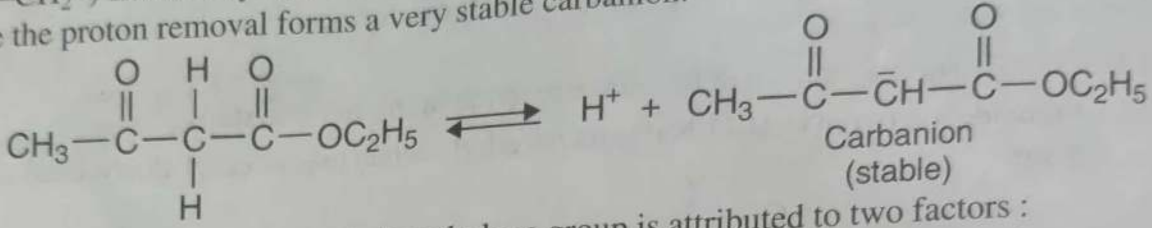
(Chemical). Ethyl acetoacetate, is in fact a tautomeric mixture of *keto* and *enol* forms.



Keto form (90%) Enol form (10%)

Thus it gives the reactions of the various functional groups present in the two forms. Here we will discuss only those reactions which make ethyl acetoacetate a useful synthetic reagent.

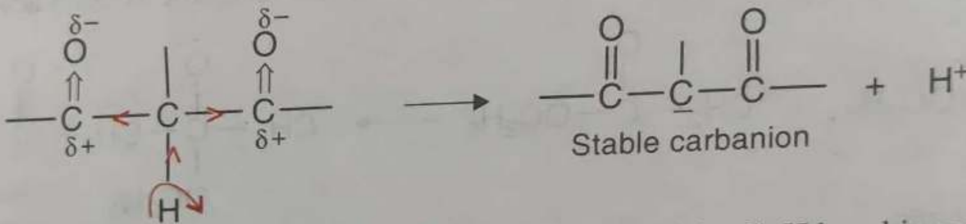
(1) **Acidity of Methylene hydrogens ; Formation of salts.** Ethyl acetoacetate contains a methylene group (–CH_2–) flanked by two carbonyl groups. The C–H bond in CH_2 group is readily ionizable because the proton removal forms a very stable carbanion.



Carbanion (stable)

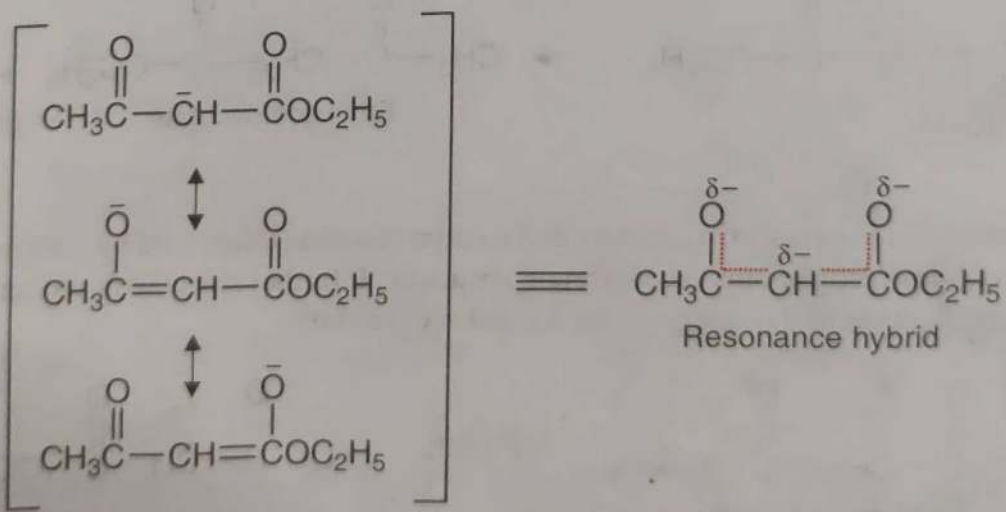
The acidity of the C—H bond of methylene group is attributed to two factors :

(*a*) **Inductive Effect.** The inductive effect caused by the electron attracting power of the electronegative oxygens of the two carbonyl groups weakens the C—H bonds. Thus the H atom can dissociate to give a stable anion.



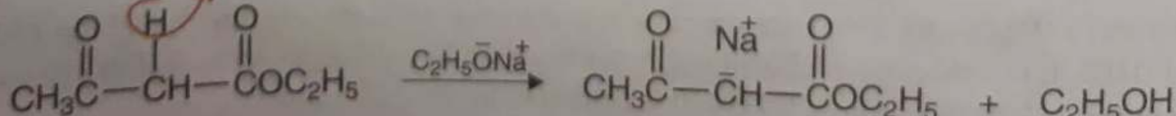
Stable carbanion

(*b*) **Resonance-Stabilization of Carbanion.** The acidity of the C–H bond is greatly enhanced because the negative charge in the carbanion is delocalized into the two carbonyl groups by resonance. The highly resonance-stabilized carbanion may be represented as :



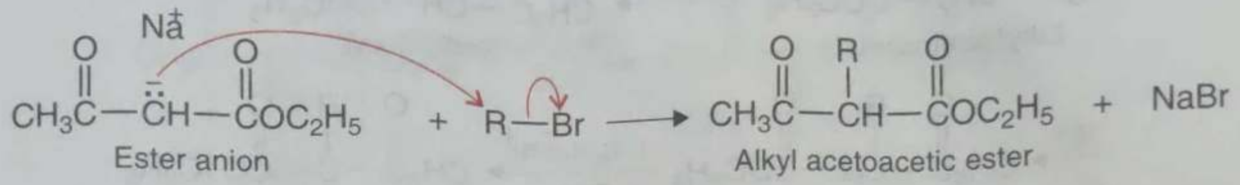
Resonance hybrid

Salt Formation. Ethyl acetoacetate is appreciably acidic and when treated with a strong base such as sodium ethoxide (C_2H_5ONa), forms its sodium salt.

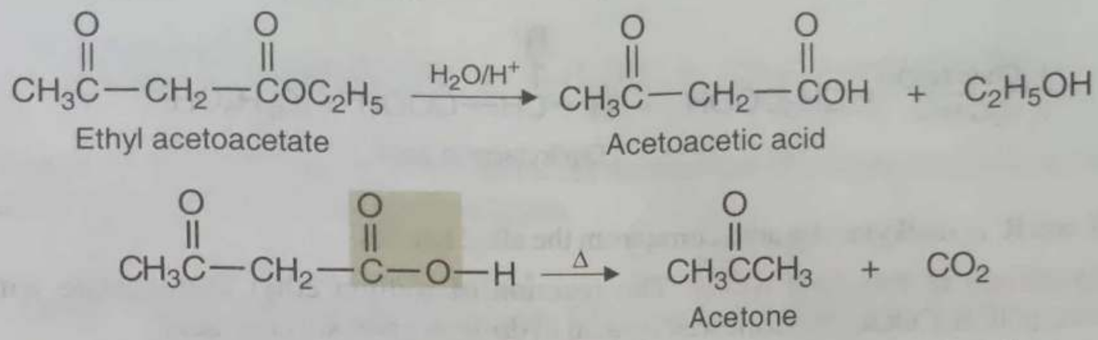


Ethyl acetoacetate Sodium ethyl acetoacetate

(2) **Alkylation**. Ethyl acetoacetate anion is nucleophilic and reacts with alkyl halides to give alkyl acetoacetic ester.

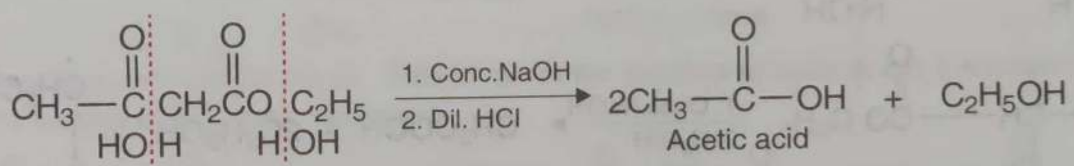


(3) **Ketonic Hydrolysis**. When ethyl acetoacetate is hydrolysed with dilute HCl, acetoacetic acid is formed. Acetoacetic acid undergoes decarboxylation on heating.



This type of hydrolysis of ethyl acetoacetate (or its alkyl derivatives) to give a ketone is called *ketonic hydrolysis*.

(4) **Acid Hydrolysis**. When ethyl acetoacetate is hydrolysed with concentrated NaOH and then acidified with dilute HCl, acetic acid is formed.

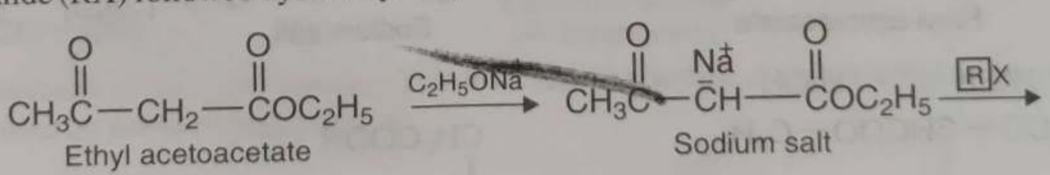


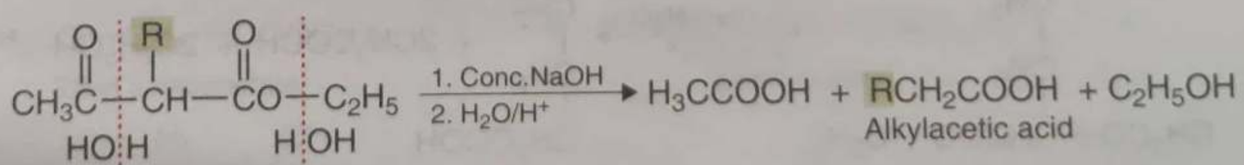
This type of hydrolysis of ethyl acetoacetate (or its alkyl derivatives) to give a carboxylic acid is called *acid hydrolysis*.

SYNTHETIC USES OF ETHYL ACETOACETATE

Ethyl acetoacetate (Acetoacetic ester) is used in the synthesis of carboxylic acids, ketones, and heterocyclic compounds.

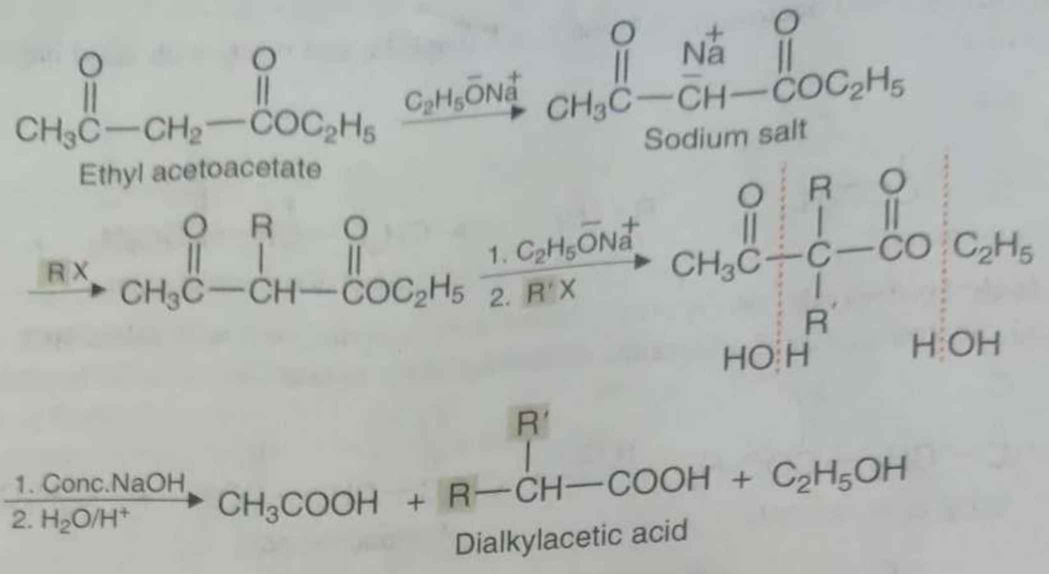
(1) **Synthesis of Alkylacetic Acids**. This involves the reaction of sodium ethyl acetoacetate with an alkyl halide (RX) followed by acid hydrolysis.





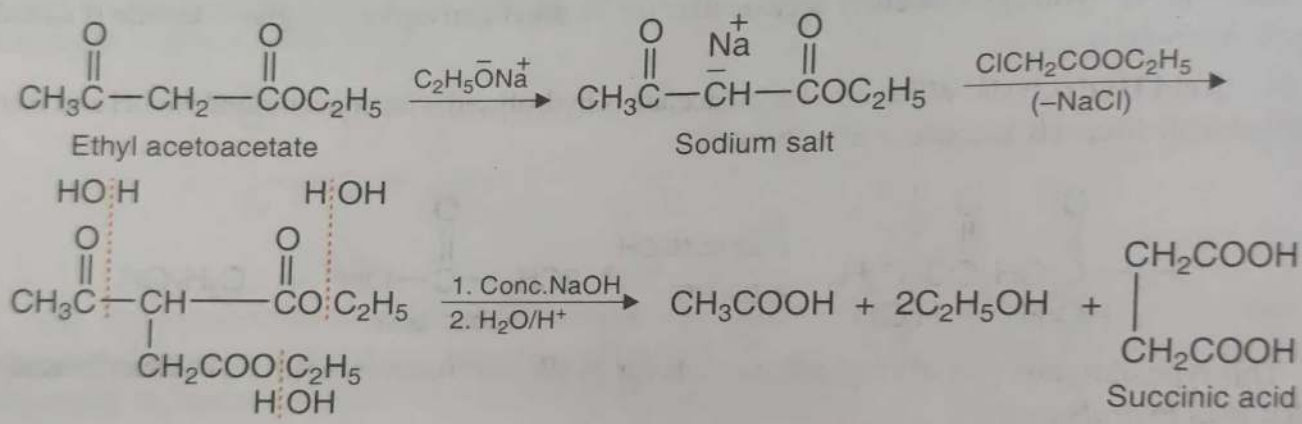
The R in alkylacetic acid comes from the alkyl halide.

(2) **Synthesis of Dialkylacetic Acids**. Alkylation of sodium ethyl acetoacetate is first done with RX and then with R′X followed by acid hydrolysis.



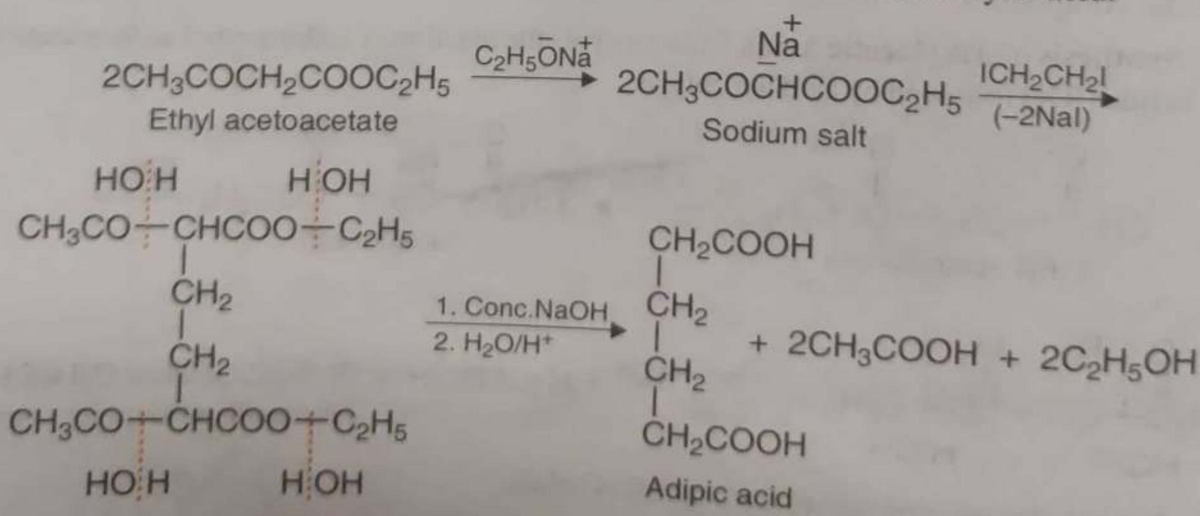
The R and R′ in dialkylacetic acid come from the alkyl halides.

(3) **Synthesis of Succinic Acids**. The reaction of sodium ethyl acetoacetate with ethyl chloroacetate ($ClCH_2COOC_2H_5$) followed by acid hydrolysis gives succinic acid.

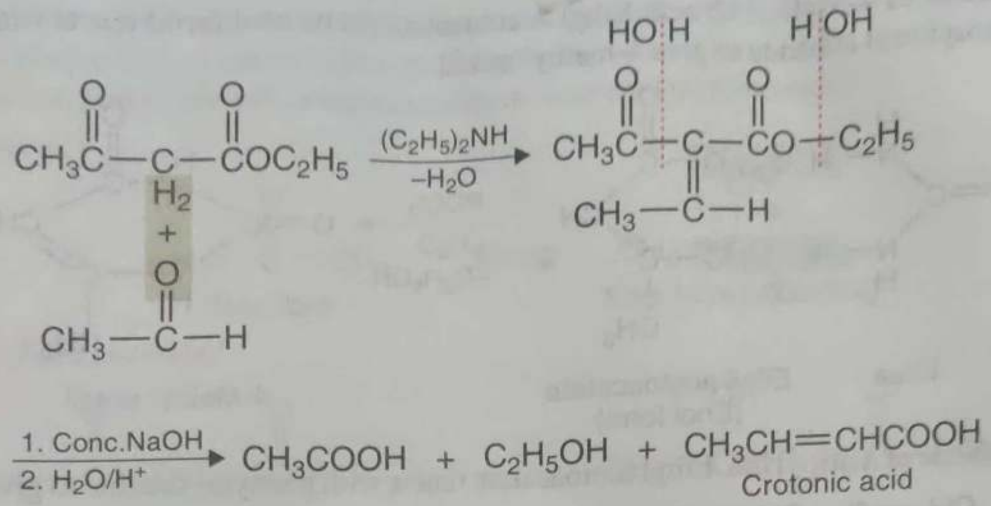


If we start with sodium alkylacetoacetic esters, alkylsuccinic acids are formed.

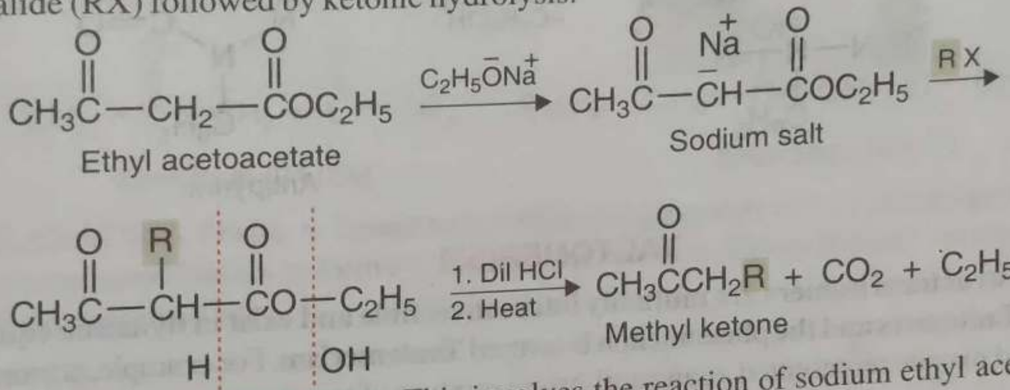
(4) **Synthesis of Higher Normal Diacids**. The reaction of sodium ethyl acetoacetate (2 molecules) with an alkylene diiodide followed by acid hydrolysis gives a normal dicarboxylic acid.



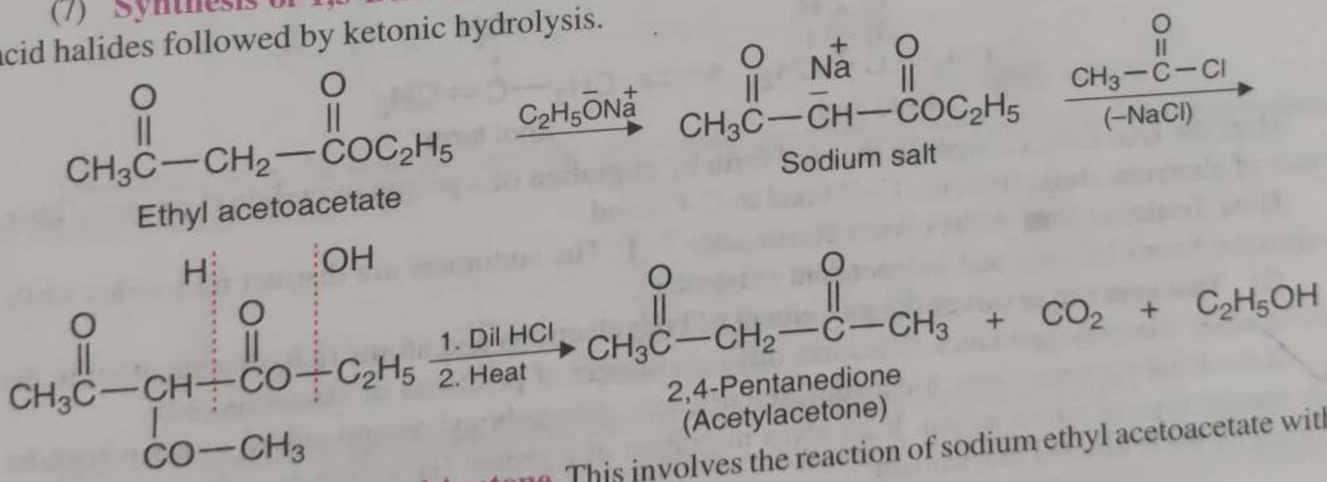
(5) **Synthesis of α,β-Unsaturated Acids**. This involves base catalyzed reaction of ethyl acetoacetate with an aldehyde or a ketone followed by acid hydrolysis.



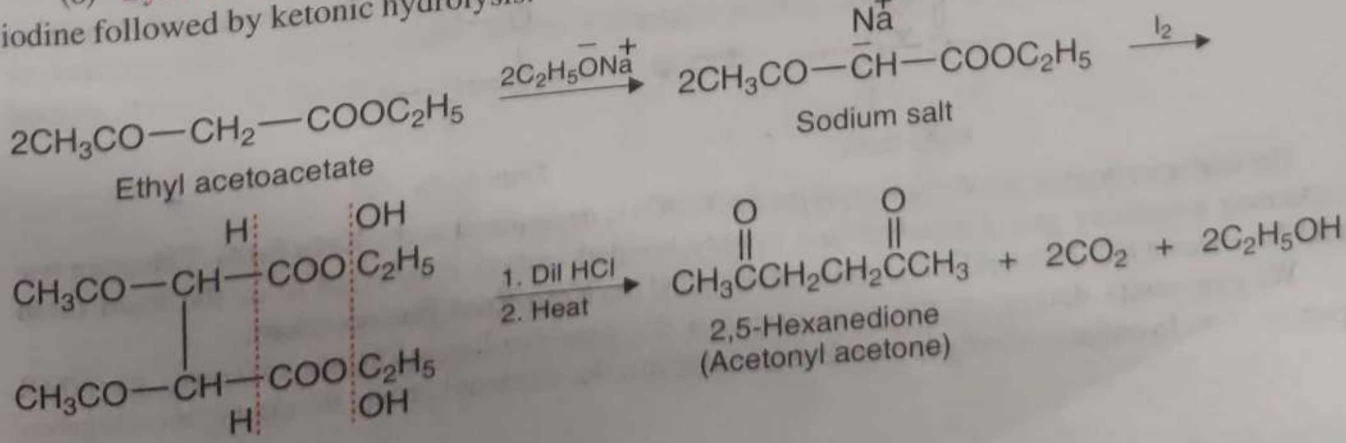
(6) **Synthesis of Methyl Ketones**. This involves the reaction of sodium ethyl acetoacetate with an alkyl halide (RX) followed by ketonic hydrolysis.



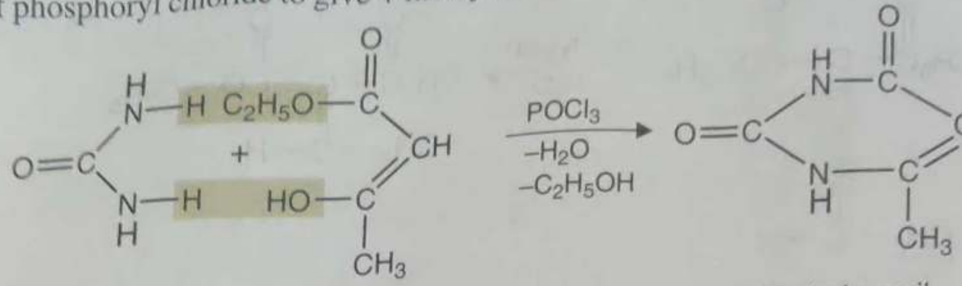
(7) **Synthesis of 1,3-Diketones**. This involves the reaction of sodium ethyl acetoacetate with acid halides followed by ketonic hydrolysis.



(8) **Synthesis of Acetonyl Acetone**. This involves the reaction of sodium ethyl acetoacetate with iodine followed by ketonic hydrolysis.

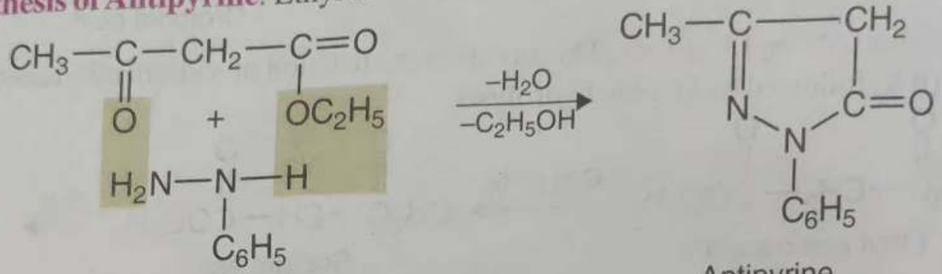


(9) **Synthesis of 4-Methyl Uracil.** Ethyl acetoacetate (in its *enol* form) reacts with urea in the presence of phosphoryl chloride to give 4-methyl uracil.



Urea Ethyl acetoacetate (Enol form) 4-Methyl uracil

(10) **Synthesis of Antipyrine.** Ethyl acetoacetate reacts with phenylhydrazine to give antipyrine.



Antipyrine

TAUTOMERISM

When two structural isomers are mutually interconvertible and exist in dynamic equilibrium, they are called Tautomers and the phenomenon is termed Tautomerism. For example, acetone exhibits tautomerism and may be represented as an equilibrium mixture of two isomers.

Keto form Enol form

Here the *keto* form changes to the *enol* form by migration of a proton to carbonyl oxygen. Then a pair of electrons shifts from the C–H bond to C–C bond.

How Tautomerism differs from Resonance ? (1) The tautomers are distinct molecules while resonance forms have no real independent existence.

(2) Tautomerism involves the movement of both electrons and atoms (a hydrogen atom in the above case) whereas resonance structures differ in respect of positions of electrons only.

Keto-Enol Tautomerism. Aldehydes, ketones, and other carbonyl compounds (*e.g.*, esters) exhibit this special type of tautomerism. It involves migration of a proton (H^+) from α-carbon to carbonyl oxygen by the following mechanism.

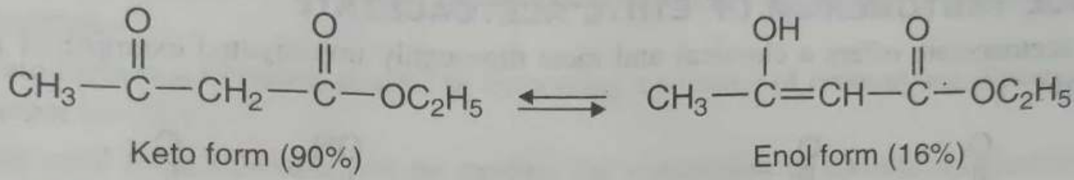
Keto form Enol form

The tautomer containing the carbonyl group (C=O) is designated as the **Keto form**. The other one containing a hydroxy group attached to a doubly bonded carbon is referred to as the **Enol form** (alkENe + alcohOL). This kind of tautomerism is called the **Keto-Enol Tautomerism**.

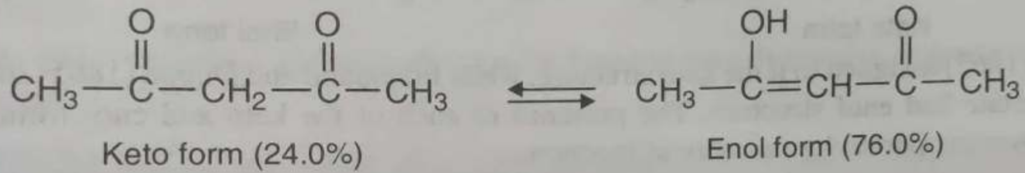
We can easily determine the percentage of the keto-enol equilibrium mixtures by NMR spectroscopy. In ordinary aldehydes and ketones with just one carbonyl group, the enol form comprises less than 1% of the equilibrium mixture. However, compounds with two carbonyl groups separated by a methylene group ($-CH_2-$) can exist to a great degree in the enol form under equilibrium conditions. This will be illustrated by the following examples of keto-enol tautomerism.

(*a*) **Acetone :**

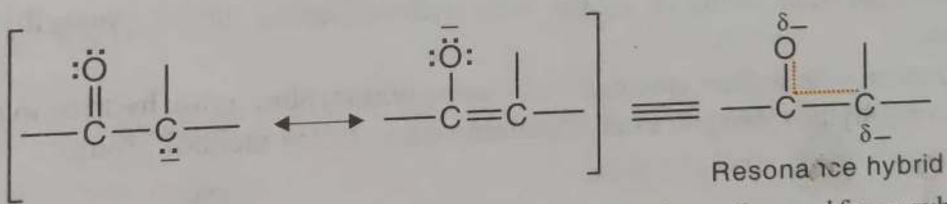
(*b*) **Ethyl acetoacetate :**



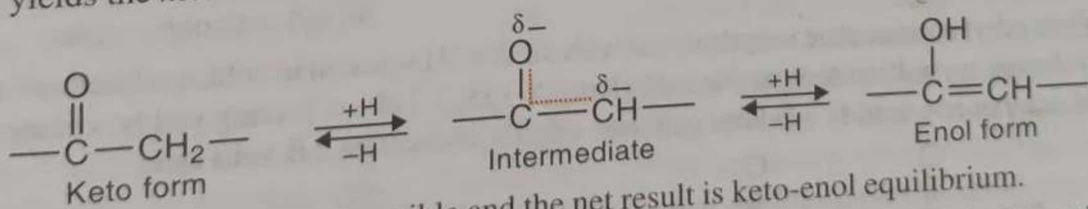
(*c*) **Acetylacetone :**



EXPLANATION. Owing to the electron-withdrawing capacity of the carbonyl group, α-hydrogen of the keto compound ionizes to form a carbanion (enolate ion). The carbanion is resonance-stabilized and may be represented as

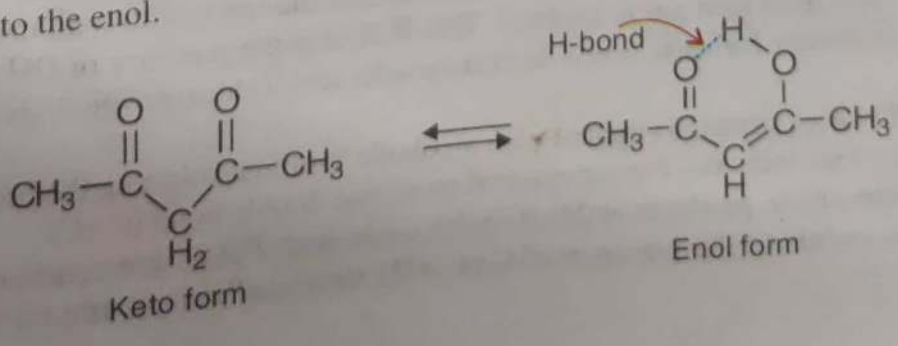


On acidification, the protonation of the cation at oxygen produces the *enol* form, while protonation at carbon yields the *keto* form.

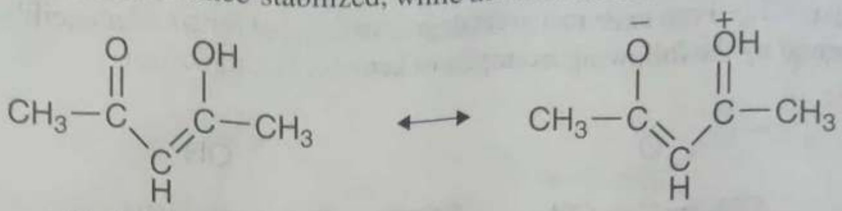


Both of these reactions are reversible and the net result is keto-enol equilibrium.

The proportion of the enol present in equilibrium mixture is determined by its stability. The existence of an appreciable amount of enol in a 1,3-dicarbonyl compound *e.g.*, acetylacetone (72%) is on two accounts : (1) Formation of intramolecular hydrogen bonds to give a six-membered ring, lending stability to the enol.



(2) The enol form is resonance-stabilized, while the keto form is not.



Acetylacetone
(Enol form)

KETO-ENOL TAUTOMERISM OF ETHYL ACETOACETATE

Ethyl acetoacetate offers a classical and most thoroughly investigated example of keto-enol tautomerism.

Keto form — Enol form

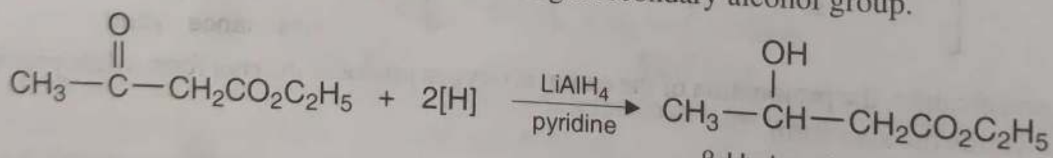
Geuther (1863) assigned to it the keto structure, while Frankland and Duppa (1865) showed that ethyl acetoacetate had enol structure. The presence of each of the keto and enol forms in ethyl acetoacetate was supported by two sets of reactions.

Reactions Supporting the Keto form. (1) Ethyl acetoacetate forms a bisulfite compound with sodium hydrogen sulphite.

(2) Ethyl acetoacetate forms a cyanohydrin with hydrogen cyanide.

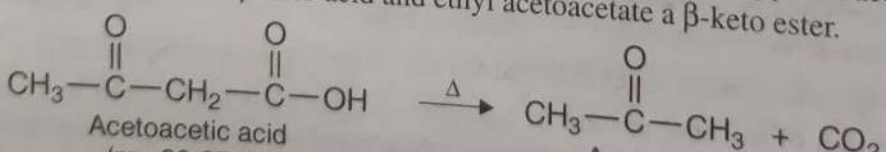
(3) Ethyl acetoacetate forms an oxime with hydroxylamine, and a phenylhydrazone with phenylhydrazine.

(4) On reduction with sodium amalgam or by using lithium aluminium hydride in pyridine, ethyl acetoacetate gives β-hydroxybutyric ester containing a secondary alcohol group.



β-Hydroxybutyric ester

(5) When ethyl acetoacetate is hydrolysed with dil. NaOH solution in cold, acidified and extracted with ether, it forms crystalline acetoacetic acid (Kruger, 1952). This on heating yields acetone showing thereby that acetoacetic acid is a β-keto acid and ethyl acetoacetate a β-keto ester.



Acetoacetic acid
(mp 36-37°C)

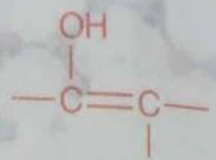
Acetone

Reactions Supporting the Enol form. (1) Ethyl acetoacetate reacts with sodium metal to form the sodium derivative and hydrogen gas is evolved. This indicates the presence of OH group.

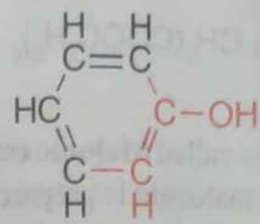
(2) Ethyl acetoacetate forms an acetyl derivative with acetyl chloride which shows the presence of OH group.

(3) When ethyl acetoacetate is treated with alcoholic bromine solution, the brown color of the latter is discharged. This indicates the presence of an alkene double bond (C=C).

(4) Ethyl acetoacetate produces reddish-violet color with $FeCl_3$, a reaction characteristic of phenolic OH. This points to the presence of C=C–OH structural unit in ethyl acetoacetate as in phenols.



Enolic OH



Phenol

Separation of Keto and Enol forms. Ludwing Knorr (1911) isolated the two tautomeric forms of ethyl acetoacetate.

(1) Keto form was obtained as crystals by cooling a solution of ordinary ethyl acetoacetate in petroleum ether to –78°C.

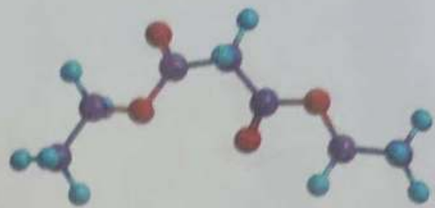
(2) The enol form was obtained by treating the suspension of sodium acetoacetic ester in petroleum ether cooled to –78°C with just enough HCl gas to decompose the sodium salt. The product was an oily liquid.

The keto and enol forms isolated as above were found to have distinctive properties conforming to their structure.

Table 21.1 PROPERTIES OF KETO AND ENOL FORMS

Keto form	Enol form
1. Long colorless needles, mp –39°C	1. Colorless oily liquid, at –78°C
2. Refractive Index, $n_D^{20} = 1.4171$	2. $n_D^{20} = 1.4432$
3. Density 1.0368^{10}	3. 1.0119^{10}
4. No coloration with $FeCl_3$	4. Intense coloration (red-violet)
5. Decolorizes bromine solution	5. Does not decolorize bromine solution

DIETHYL MALONATE, $CH_2(COOC_2H_5)_2$



Diethyl malonate is also called **Malonic ester**.

Preparation. Diethyl malonate is prepared very conveniently by boiling sodium or potassium cyanoacetate with alcohol and concentrated hydrochloric acid.

$$\underset{\text{Pot. cyanoacetate}}{H_2C(CN)(COOK)} + 2H_2O + 2HCl \longrightarrow \underset{\text{Malonic acid}}{H_2C(COOH)(COOH)} + KCl + NH_4Cl$$

$$H_2C(COOH)(COOH) + C_2H_5OH \xrightarrow{HCl} \underset{\substack{\text{Diethyl malonate}\\ \text{(Malonic ester)}}}{H_2C(COOC_2H_5)(COOC_2H_5)} + 2H_2O$$

The cyanoacetate required for the process is obtained from acetic acid by the following steps :

$$\underset{\text{Acetic acid}}{CH_3COOH} \xrightarrow[\text{(HVZ reaction)}]{Cl_2/P} Cl-CH_2COOH \xrightarrow{K_2CO_3} H_2C(Cl)(COOK) \xrightarrow{KCN} \underset{\text{Pot. cyanoacetate}}{H_2C(CN)(COOK)}$$

Properties (Physical). Diethyl malonate is a colorless, pleasant-smelling liquid, bp 199.2°C. It is sparingly soluble in water, freely soluble in alcohol and ether.

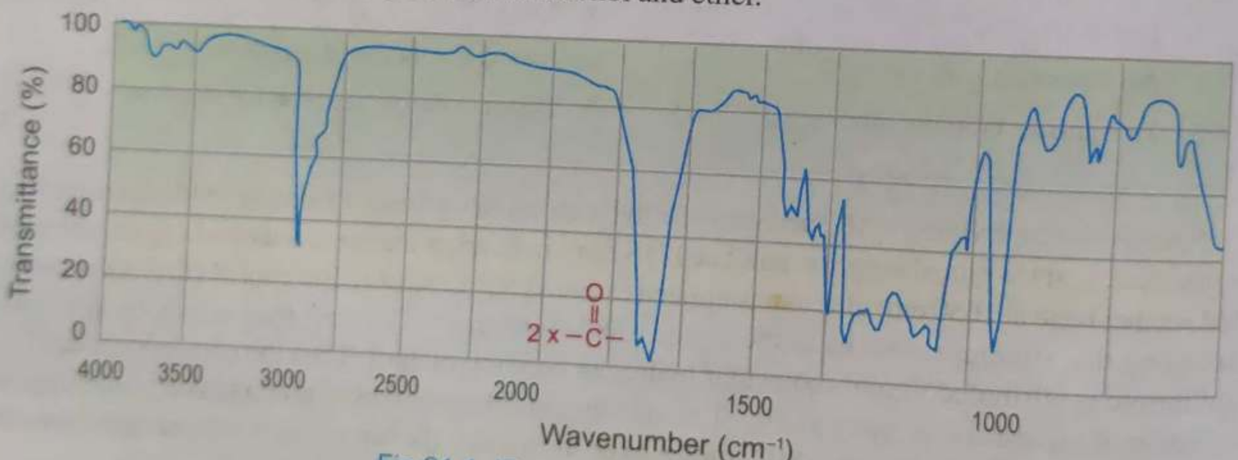
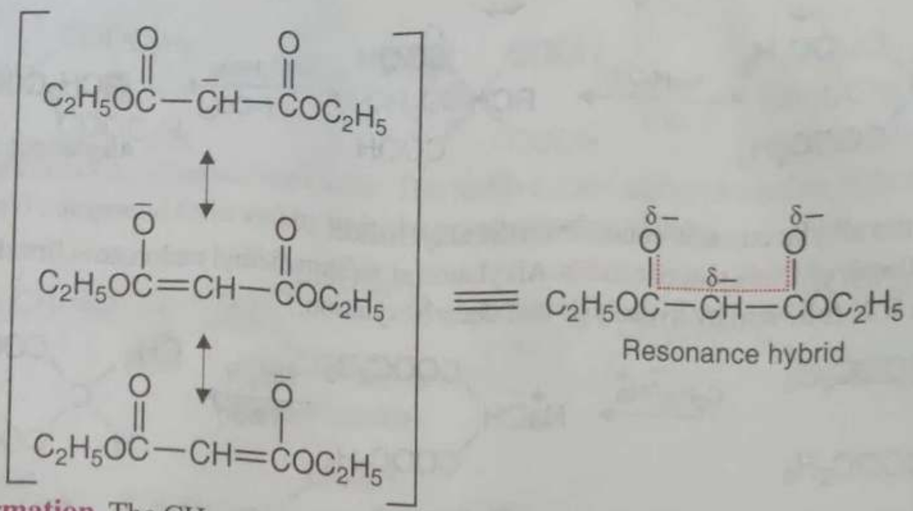


Fig.21.1. IR spectrum of diethyl malonate.

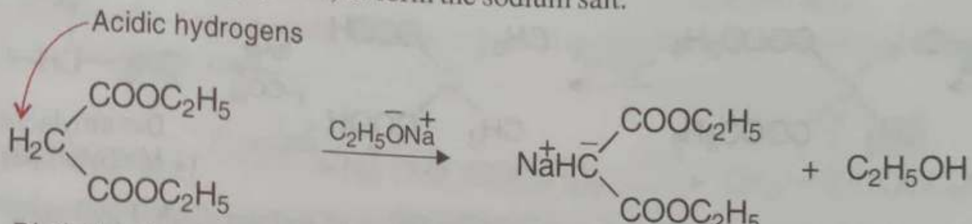
(Chemical). (1) Acidity of CH_2 group ; Formation of Salts. Like ethyl acetoacetate, diethyl malonate contains a methylene group joined to two carbonyl groups. The H atoms of the CH_2 group are acidic. This is attributed to two factors : (*a*) the electron-attracting power of the electronegative oxygen of the carbonyl group (*inductive effect*) ; and (*b*) the resonance-stabilization of the resultant cation (diethyl malonate anion). Thus,

$$\underset{\text{Diethyl malonate}}{C_2H_5O\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{C}H}-\overset{O}{\overset{\|}{C}}OC_2H_5} \rightleftharpoons H^+ + \underset{\text{Diethyl malonate anion}}{C_2H_5O\overset{O}{\overset{\|}{C}}-\bar{C}H-\overset{O}{\overset{\|}{C}}OC_2H_5}$$

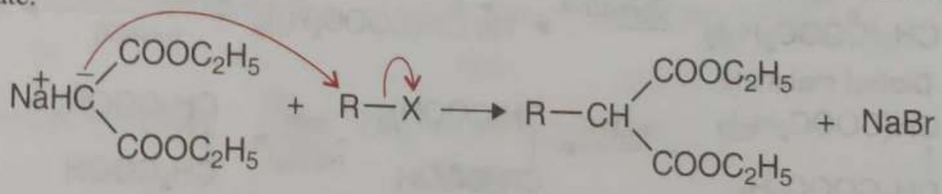
The diethyl malonate anion is highly resonance-stabilized so that its negative charge is delocalized into the two carbonyl groups.


Resonance hybrid

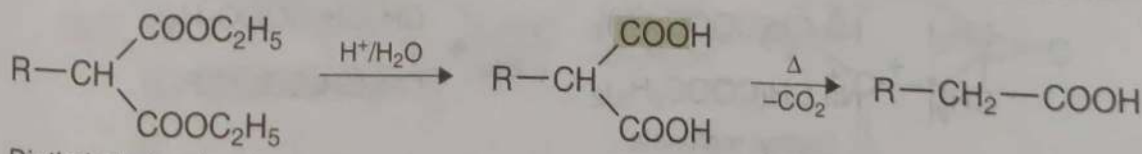
Salt Formation. The CH_2 group being sufficiently acidic, diethyl malonate reacts with a strong base like sodium ethoxide (C_2H_5ONa) to form the sodium salt.


Diethyl malonate   Sodium diethyl malonate

(2) **Alkylation.** Diethyl malonate anion is nucleophilic and reacts with halides to give diethyl alkylmalonate.


Diethyl alkylmalonate

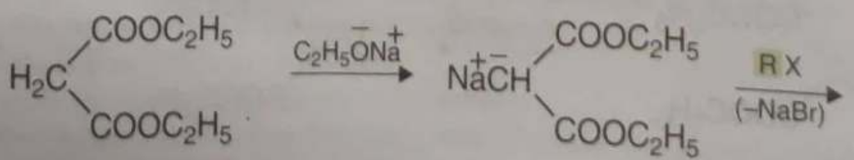
(3) **Hydrolysis and Decarboxylation.** Diethyl malonate undergoes hydrolysis with dilute HCl to give malonic acid. Similarly, diethyl alkylmalonate gives alkyl malonic acids. Such acids that have two –COOH groups separated by a carbon, on heating (at about 150°C) split out a molecule of CO_2 to give the monocarboxylic acid.

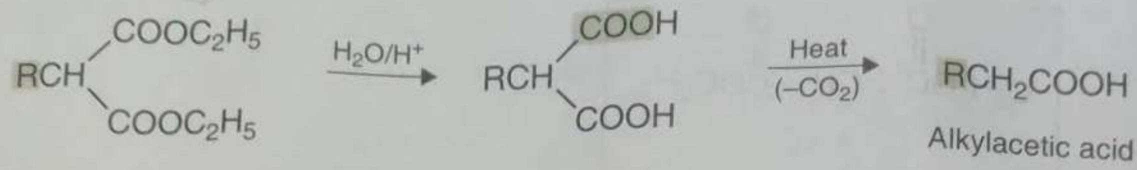

Diethyl alkylmalonate   Alkylacetic acid

SYNTHETIC USES OF DIETHYL MALONATE

Diethyl malonate is used in the synthesis of carboxylic acids, keto acids, α-amino acids, and barbituric acid.

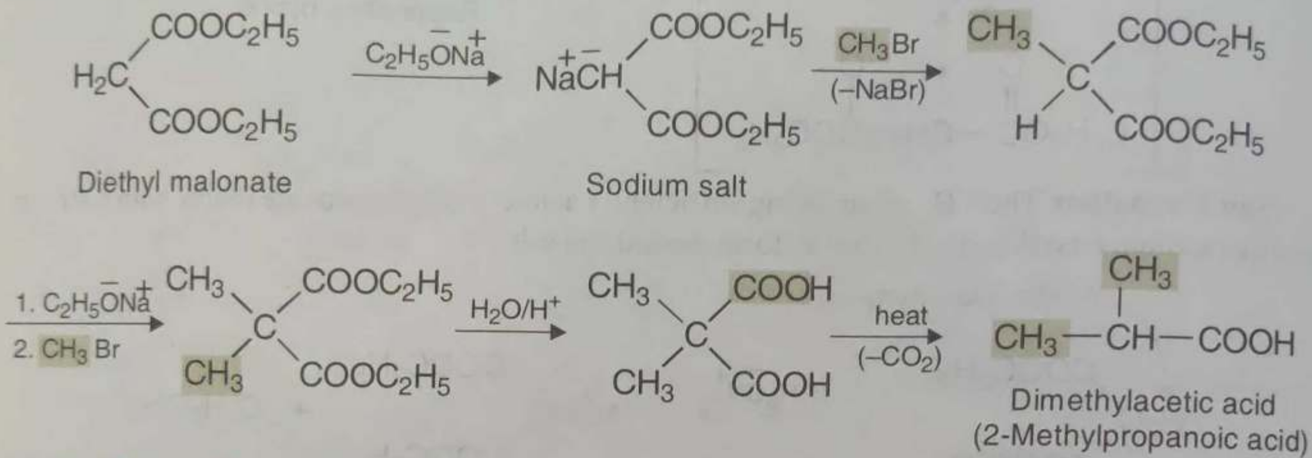
(1) **Synthesis of Alkylacetic Acids.** This involves the reaction of sodium diethyl malonate with an alkyl halide followed by hydrolysis and decarboxylation.


Diethyl malonate

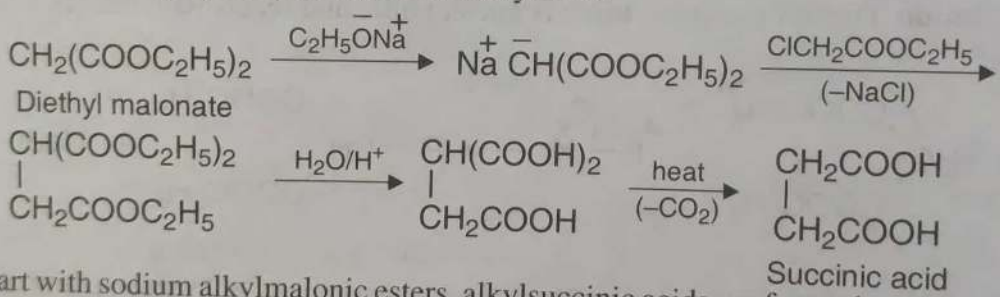


The R in the alkylacetic acid comes from the alkyl halide.

(2) **Synthesis of Dialkylacetic Acids.** Alkylation of sodium diethyl malonate is first done with RX and then with R'X followed by hydrolysis and decarboxylation.

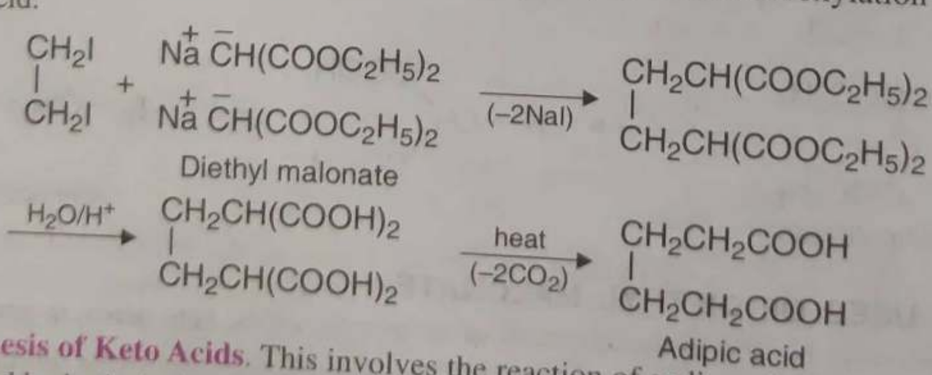


(3) **Synthesis of Succinic Acids.** This involves the reaction of sodium diethyl malonate with ethyl chloroacetate followed by hydrolysis and decarboxylation.

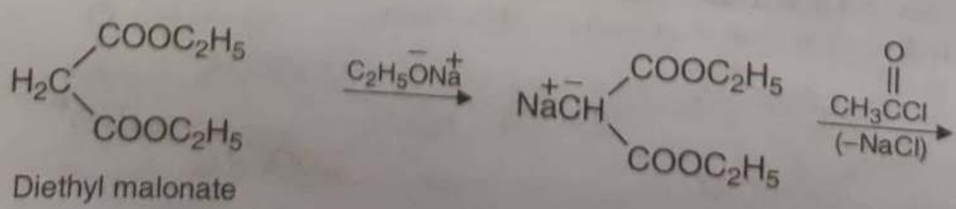


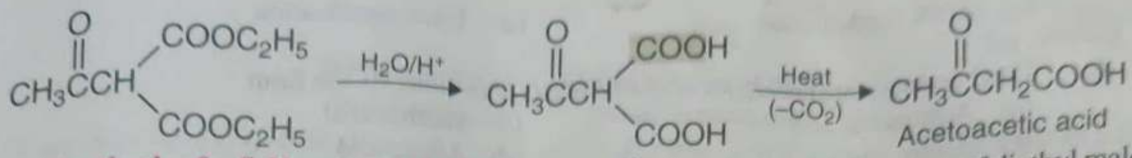
If we start with sodium alkylmalonic esters, alkylsuccinic acids are formed.

(4) **Synthesis of Higher Normal Diacids.** This involves the reaction of sodium diethyl malonate (2 molecules) with an alkylene diiodide followed by hydrolysis and decarboxylation gives a normal dicarboxylic acid.

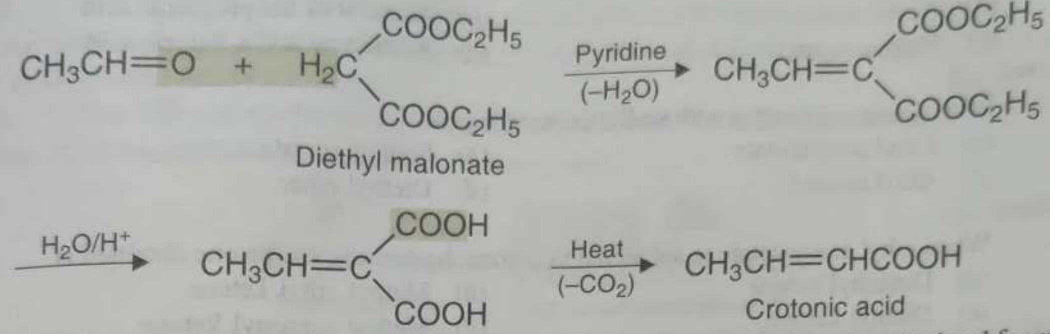


(5) **Synthesis of Keto Acids.** This involves the reaction of sodium diethyl malonate with acid halides followed by hydrolysis and decarboxylation.

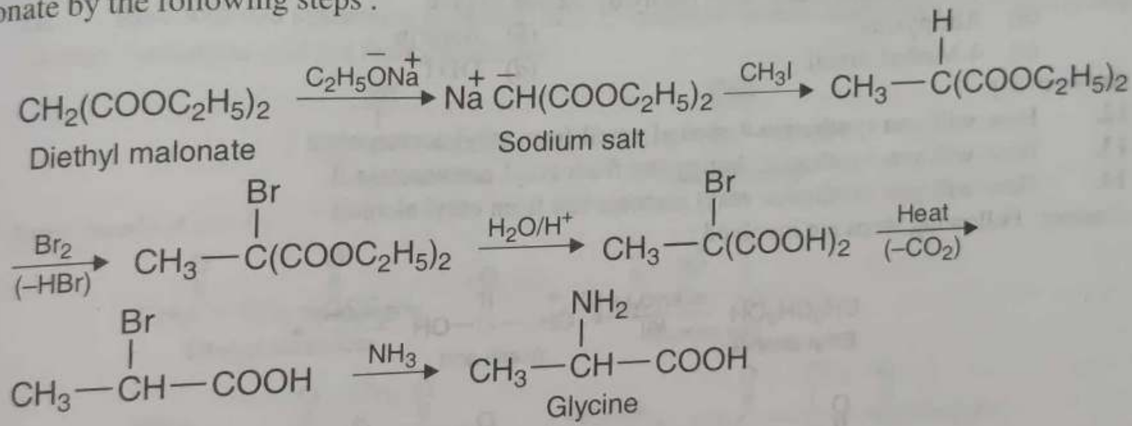




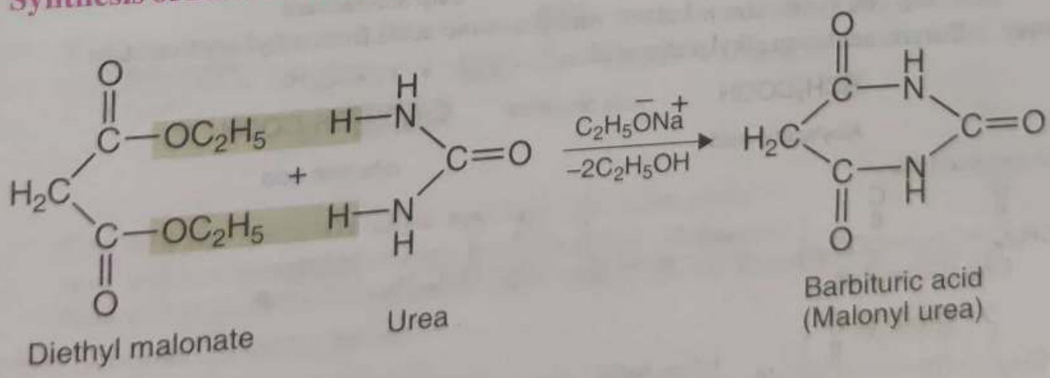
(6) **Synthesis of α,β-Unsaturated Acids.** This involves base catalyzed reaction of diethyl malonate with a carbonyl compound followed by hydrolysis and decarboxylation.



(7) **Synthesis of α-Amino acids.** Glycine (a typical α-amino acid) can be obtained from diethyl malonate by the following steps :



(8) **Synthesis of Barbituric Acid.** Diethyl malonate reacts with urea to give barbituric acid.



STUDY PROBLEMS

1. What is an active methylene group ? Give two examples.
2. How is ethyl acetoacetate prepared ? Discuss the mechanism of the reaction.
3. Discuss the mechanism of Claisen condensation.
4. Write a note on : Claisen condensation.
5. Describe the synthetic uses of ethyl acetoacetate.
6. Base-catalyzed condensation of two ester molecules to form an alcohol and β-keto ester is called
   (*a*) Claisen condensation (*b*) Corey-House reaction

(c) Aldol condensation
(d) Transesterification

Answer. (a)

7. Ethyl acetoacetate undergoes *acid-hydrolysis* with dilute HCl to form
(a) Acetoacetic acid
(b) Succinic acid
(c) Acetic acid
(d) Adipic acid

Answer. (a)

8. The ethyl derivative of acetoacetic ester on basic-hydrolysis gives
(a) Acetic acid
(b) Acetic acid and propionic acid
(c) Propionic acid
(d) Acetic acid and *n*-butyric acid

Answer. (a)

9. Ethyl acetate on heating with sodium ethoxide gives
(a) Ethyl acetoacetate
(b) Sodium acetate
(c) Ethyl alcohol
(d) Diethyl ether

Answer. (a)

10. When ethyl acetoacetate is subjected to ketonic hydrolysis, the ketone obtained is
(a) Dimethyl ketone
(b) Methyl ethyl ketone
(c) Diethyl ketone
(d) Methyl *n*-propyl ketone

Answer. (c)

11. Ethyl acetoacetate reacts with phenylhydrazine to give
(a) Antipyrine
(b) Aspirin
(c) 4-Methyl uracil
(d) DDT

Answer. (a)

12. How will you synthesize 4-methyl uracil from ethyl acetoacetate ?
13. How will you synthesize Antipyrine from ethyl acetoacetate ?
14. How will you synthesize ethyl acetoacetate from ethyl alcohol ?

Answer. Following steps are involved :

$$\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} \xrightarrow[\text{[O]}]{K_2Cr_2O_7/H^+} \underset{\text{Acetic acid}}{CH_3-\overset{O}{\overset{\|}{C}}-OH} \xrightarrow{C_2H_5OH/H^+}$$

$$\underset{\text{Ethyl acetate}}{CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5} \xrightarrow[\text{(2) HCl}]{\text{(1) } C_2H_5ONa} \underset{\text{Ethyl acetoacetate}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}-OC_2H_5}$$

15. How will you synthesize *n*-butyric acid (butanoic acid) from ethyl acetoacetate ?

Answer. *n*-Butyric acid is an alkylacetic acid.

$$\underset{\text{Alkylacetic acid}}{RCH_2COOH} \qquad \underset{n\text{-butyric acid}}{CH_3CH_2CH_2COOH}$$

Steps involved are :

$$\underset{\text{Ethyl acetoacetate}}{CH_3\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}OC_2H_5} \xrightarrow{C_2H_5\bar{O}\overset{+}{N}a} CH_3\overset{O}{\overset{\|}{C}}-\overset{\overset{+}{Na}}{\bar{C}H}-\overset{O}{\overset{\|}{C}}OC_2H_5 \xrightarrow{CH_3CH_2Br}$$

$$CH_3\overset{O}{\overset{\|}{C}}-\overset{CH_2CH_3}{\overset{|}{CH}}-\overset{O}{\overset{\|}{C}}OC_2H_5 \ (\text{HOH, HOH}) \xrightarrow[\text{2. } H_2O/H^+]{\text{1. Conc NaOH}} CH_3COOH + \underset{n\text{-Butyric acid}}{CH_3CH_2CH_2COOH} + C_2H_5OH$$

16. How will you synthesize propionic acid (propanoic acid) from ethyl acetoacetate ?

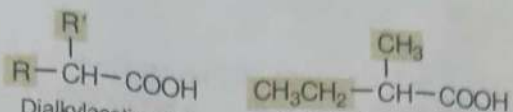
Clue. Propionic acid is an alkylacetic acid.

$$\underset{\text{Alkylacetic acid}}{RCH_2COOH} \qquad \underset{\text{Propionic acid}}{CH_3CH_2COOH}$$

Steps involved are : (*i*) C_2H_5ONa ; (*ii*) CH_3Br ; (*iii*) conc. NaOH followed by dil. HCl (acid hydrolysis).

17. How will you synthesize 2-methylbutanoic acid from ethyl acetoacetate ?

Clue. 2-Methylbutanoic acid is a dialkylacetic acid.



Dialkylacetic acid 2-Methylbutanoic acid

Steps involved are : (*i*) C_2H_5ONa ; (*ii*) CH_3Br ; (*iii*) C_2H_5ONa ; (*iv*) CH_3CH_2Br ; (*v*) conc. NaOH followed by dilute HCl (acid hydrolysis).

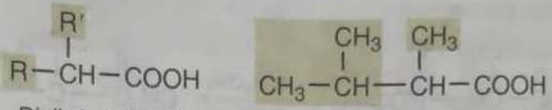
18. How will you synthesize succinic acid from ethyl acetoacetate ?

19. How will you synthesize methylsuccinic acid from ethyl acetoacetate ?

Clue. Steps are : (*i*) C_2H_5ONa ; (*ii*) $CH_3CH(Cl)COOC_2H_5$ = ethyl 2-chloropropanoate ; (*iii*) conc. NaOH followed by dilute HCl (acid-hydrolysis).

20. How will you synthesize 2,3-dimethylbutanoic acid from ethyl acetoacetate ?

Clue. 2,3-Dimethylbutanoic acid is a dialkylacetic acid.



Dialkylacetic acid 2,3-Dimethylbutanoic acid

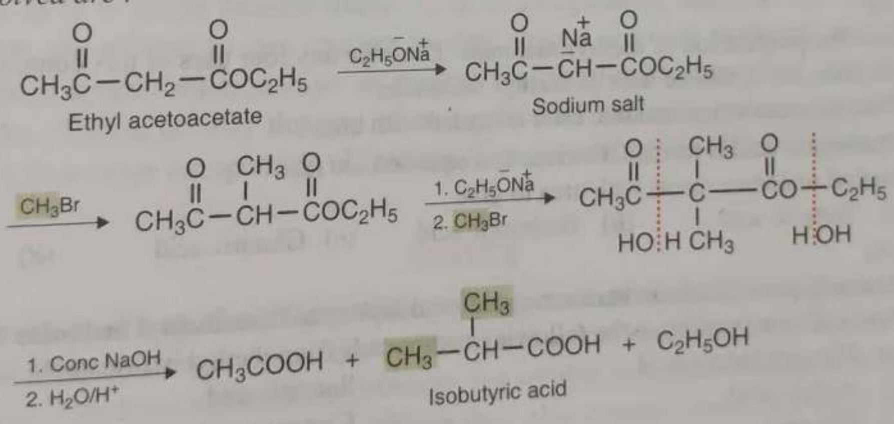
Steps involved are : (*i*) C_2H_5ONa ; (*ii*) CH_3Br ; (*iii*) C_2H_5ONa ; (*iv*) Isopropyl bromide = $(CH_3)_2CHBr$; (*v*) conc. NaOH followed by dilute HCl (acid hydrolysis).

21. How will you synthesize isobutyric acid (2-methylpropanoic acid) from ethyl acetoacetate ?

Answer. Isobutyric acid is a dialkylacetic acid.

Dialkylacetic acid Isobutyric acid

Steps involved are :

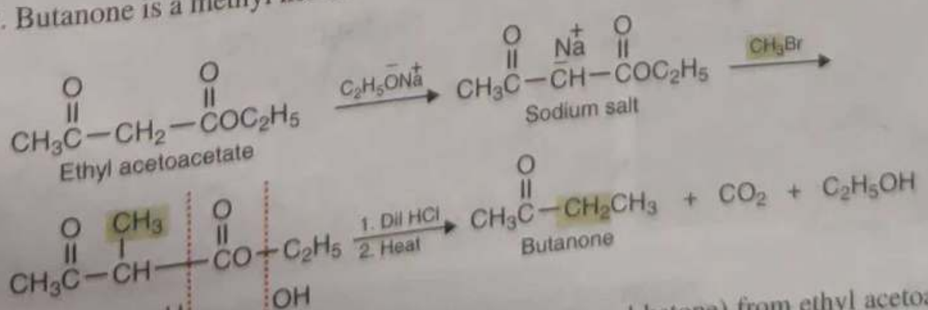


22. How will you synthesize adipic acid from ethyl acetoacetate ?

23. How will you synthesize crotonic acid from ethyl acetoacetate ?

24. How will you synthesize butanone (ethyl methyl ketone) from ethyl acetoacetate ?

Answer. Butanone is a methyl ketone.



25. How will you synthesize 2-pentanone (methyl propyl ketone) from ethyl acetoacetate ?

Clue. 2-Pentanone is a methyl ketone. *Steps involved are* : (*i*) C_2H_5ONa ; (*ii*) CH_3CH_2Br ; (*iii*) Dilute HCl followed by heat (ketonic hydrolysis).

26. How will you synthesize acetylacetone (2,4-pentanedione) from ethyl acetoacetate ?

27. How will you synthesize acetonyl acetone (2,5-hexanedione) from ethyl acetoacetate ?

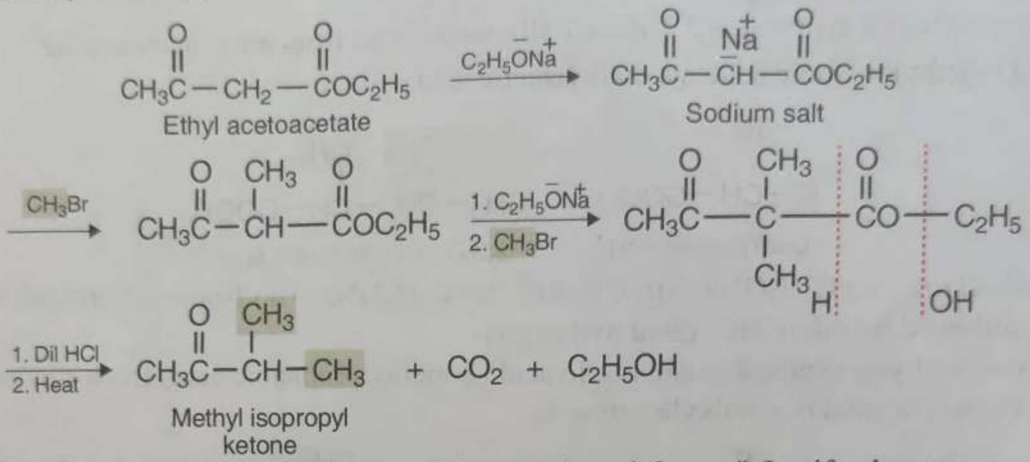
28. What is tautomerism ? How does it differ from resonance ?

29. Write a note on : Keto-enol tautomerism.

30. How it can be established that ethyl acetoacetate is a mixture of keto and enol forms ? How can the two forms be separated ?

31. How will you synthesize methyl isopropyl ketone from ethyl acetoacetate ?

Answer. Methyl isopropyl ketone is a methyl ketone.



32. "Ethyl acetoacetate is a mixture of keto and enol forms." Justify the statement with suitable experimental evidences.

33. Keto-enol tautomerism is shown by

(*a*) Benzaldehyde (*b*) Acetone (*c*) Benzophenone (*d*) Acetic acid

Answer. (*b*)

34. Give the preparation of diethyl malonate. Describe any four uses of this compound.

35. Describe the synthetic uses of diethyl malonate.

36. What happens when malonic ester is heated with urea ?

Answer. Barbituric acid is formed. For reaction equation see text.

37. Diethyl malonate reacts with urea to give

(*a*) Butyric acid (*b*) Barbituric acid (*c*) Glutaric acid (*d*) Mandelic acid

Answer. (*b*)

38. How will you synthesize barbituric acid (malonyl urea) from diethyl malonate ?

39. How will you synthesize the following compounds from diethyl malonate ?

(*a*) Dimethylacetic acid (*b*) Succinic acid

(*c*) Adipic acid (*d*) Crotonic acid

(*e*) Glycine

40. How will you synthesize acetic acid from diethyl malonate ?

Clue. Steps are : (*i*) H_2O/H^+ ; and (*ii*) heat

41. How will you synthesize *n*-butyric acid (butanoic acid) from diethyl malonate ?

Answer. *n*-Butyric acid is an alkylacetic acid.

RCH_2COOH — Alkylacetic acid $\quad$ $CH_3CH_2CH_2COOH$ — *n*-Butyric acid

Steps involved are :