

## US06DCHE27: SELECTED TOPICS IN CHEMISTRY-2

### UNIT – 3 : CHEMISTRY OF $\beta$ -DICARBONYL COMPOUNDS

Introduction, synthesis of ethyl acetoacetate (EAA) and diethylmalonate acidic and ketonic hydrolysis of  $\beta$ -dicarbonyl compounds, synthetic applications of  $\beta$ -dicarbonyl compounds, (i) crotonic acid from EAA (ii) Valeric acid from diethyl malonate.

#### ❖ $\beta$ -DICARBONYL COMPOUNDS :



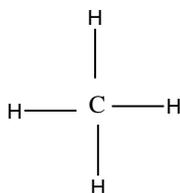
$\beta$ -dicarbonyl compound

A compound containing two carbonyl group and this two carbonyl group are separated by an intervening  $-\text{CH}_2-$  group is known  **$\beta$ -dicarbonyl compound**.

#### ❖ Active Methylene Compounds:

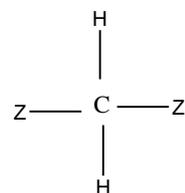
Two hydrogen of methane are replaced by two electron withdrawing group than the rest of the two hydrogen becoming acidic in nature and this ( $-\text{CH}_2-$ ) group is known as **active methylene group**.

Compound which containing active methylene group is known as **active methylene compound**.



Methane

Hydrogen have no acidic character



Two hydrogen of methane replaced by two

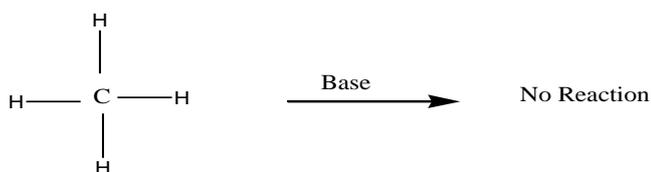
electron withdrawing group Z and Z'

Z and Z' may be same or different

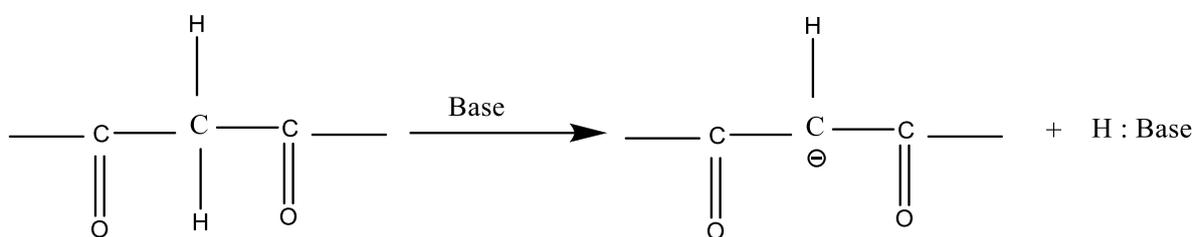
hydrogen have acidic character

Methane not giving any reaction with base because hydrogen of methane has no acidic character.

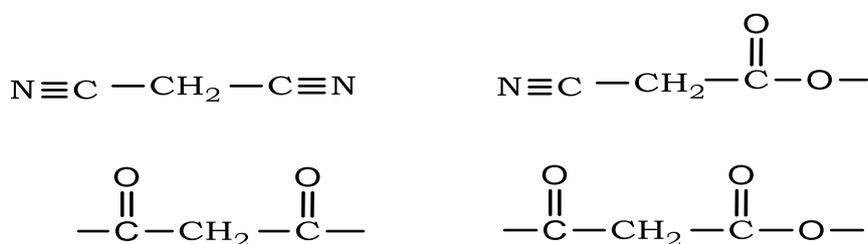
In methane molecule carbon containing four hydrogen atom and this all hydrogen have no acidic character.



When two hydrogen of methane are replaced by two electron withdrawing group like Z and Z' (Z and Z' may be  $-\text{C}=\text{O}$ ,  $>\text{C}\equiv\text{N}$ ,  $>\text{C}=\text{S}$  or others) (Z and Z' may be same or different) then the rest of the two hydrogen in molecule have shown acidic character. When this type of compound reacted with base, Base abstracted hydrogen as given below.

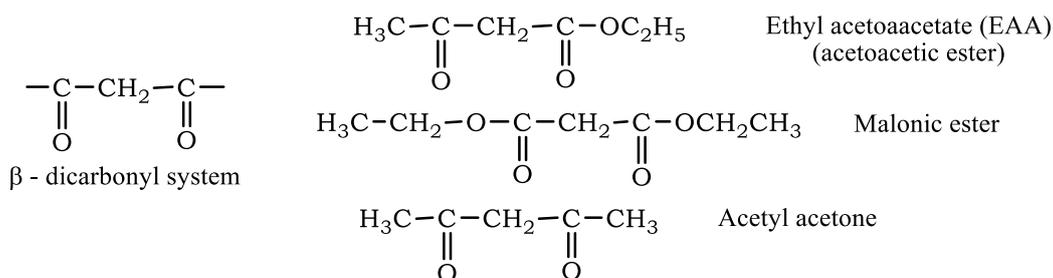


Hydrogen of methylene group ( $-\text{CH}_2-$ ) of  $\beta$ -dicarbonyl compound is abstracted by base because of having an acidic character. A methylene group ( $-\text{CH}_2-$ ) is attached with two electron withdrawing groups like  $\text{C}=\text{O}$ ,  $>\text{C}\equiv\text{N}$ ,  $>\text{C}=\text{S}$  etc. then, those hydrogens are unusually acidic, called active methylene group. e.g.

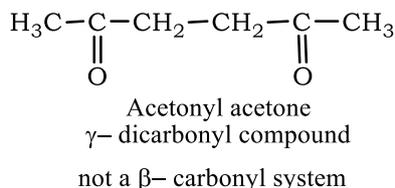


These types of compounds are known as active methylene compounds.

Compounds having two carbonyl groups separated by an intervening  $\text{CH}_2$  group are called  $\beta$ -dicarbonyl compounds and these compounds are highly versatile reagents for organic synthesis e.g.



These types of compounds are known as active methylene compounds.



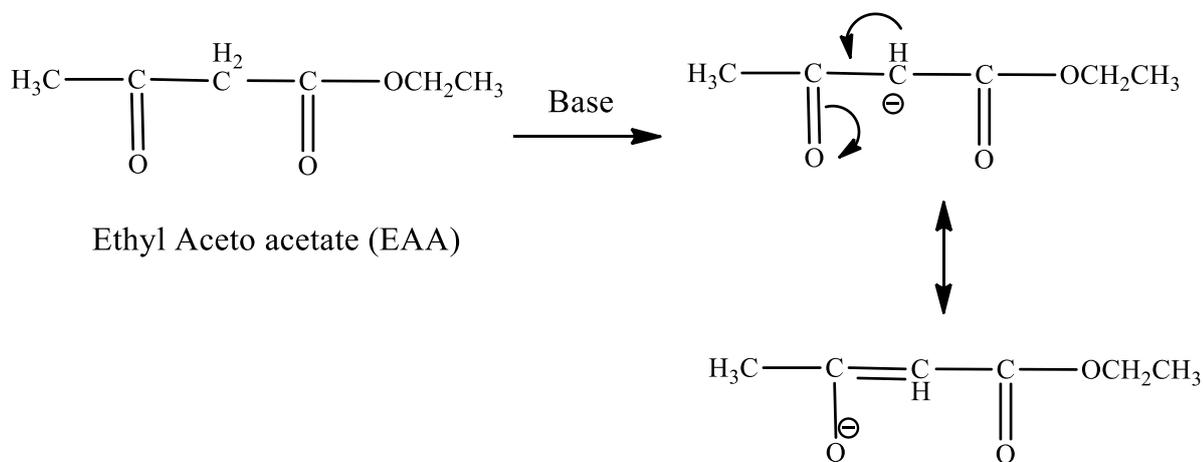
A compound containing two carbonyl group and this two carbonyl group are separated by two -CH<sub>2</sub>- group is known **γ-dicarbonyl compound**.

Because of the acidity of their methylene hydrogens, malonic ester, aceto acetic ester and similar compounds are often called active methylene compounds. Generally speaking active hydrogen compounds have two electron-withdrawing groups attached to the same carbon.

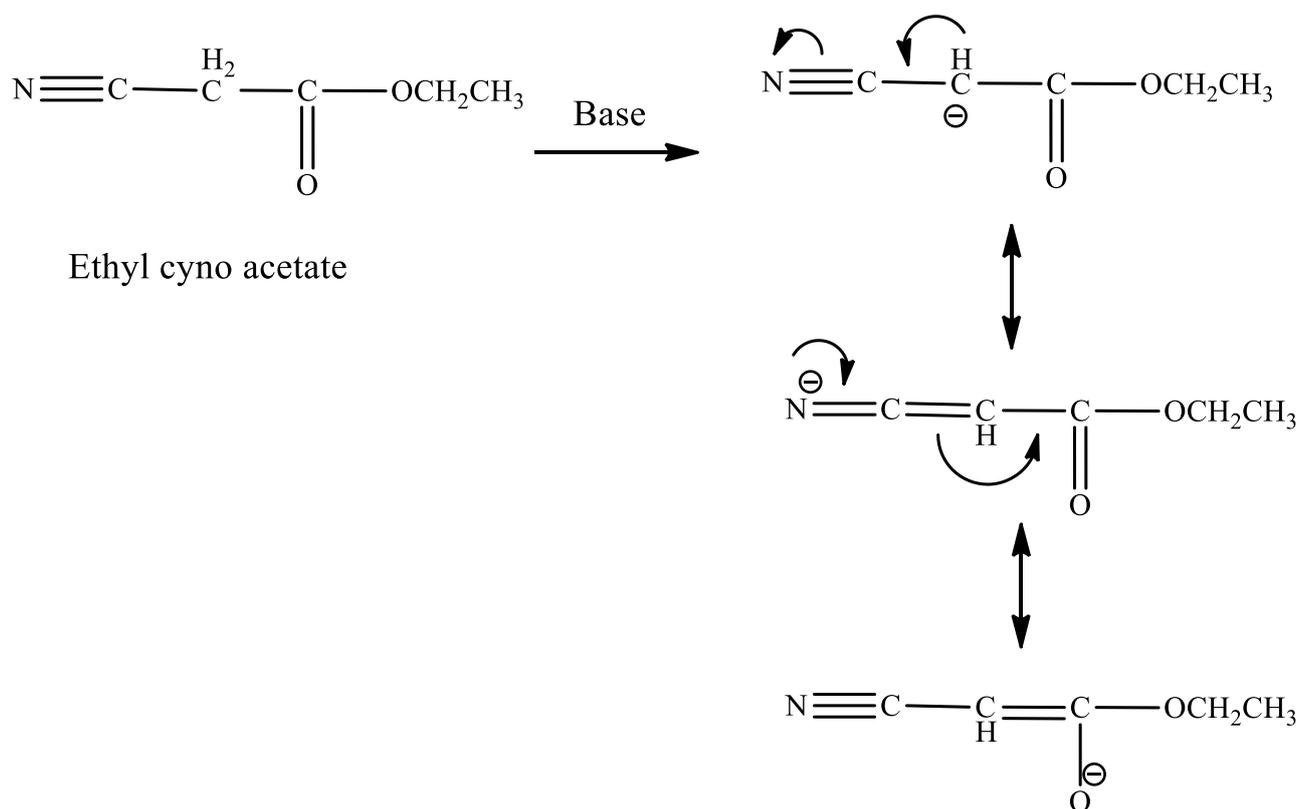


These compounds lose a proton to a base giving resonance stabilized anion proving the acidic nature of hydrogen e.g.

1. Ethylacetoacetate (EAA): When Ethylacetoacetate (EAA) is reacted with base, base abstracts hydrogen from active methylene group and gives resonance stabilized anion structure as given below;

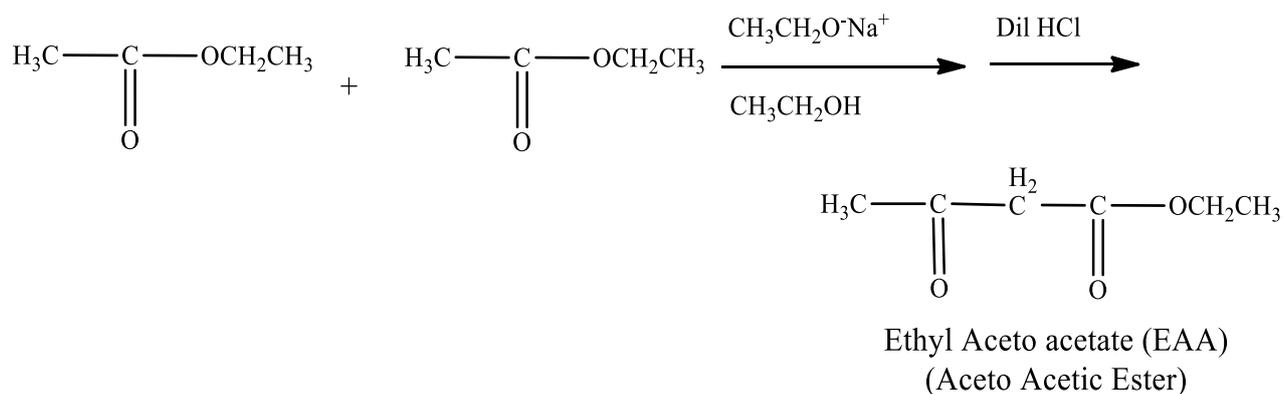


2. Ethylcynoacetate: When Ethylcynoacetate is reacted with base, base abstracts hydrogen from active methylene group and gives resonance stabilized anion as given below;



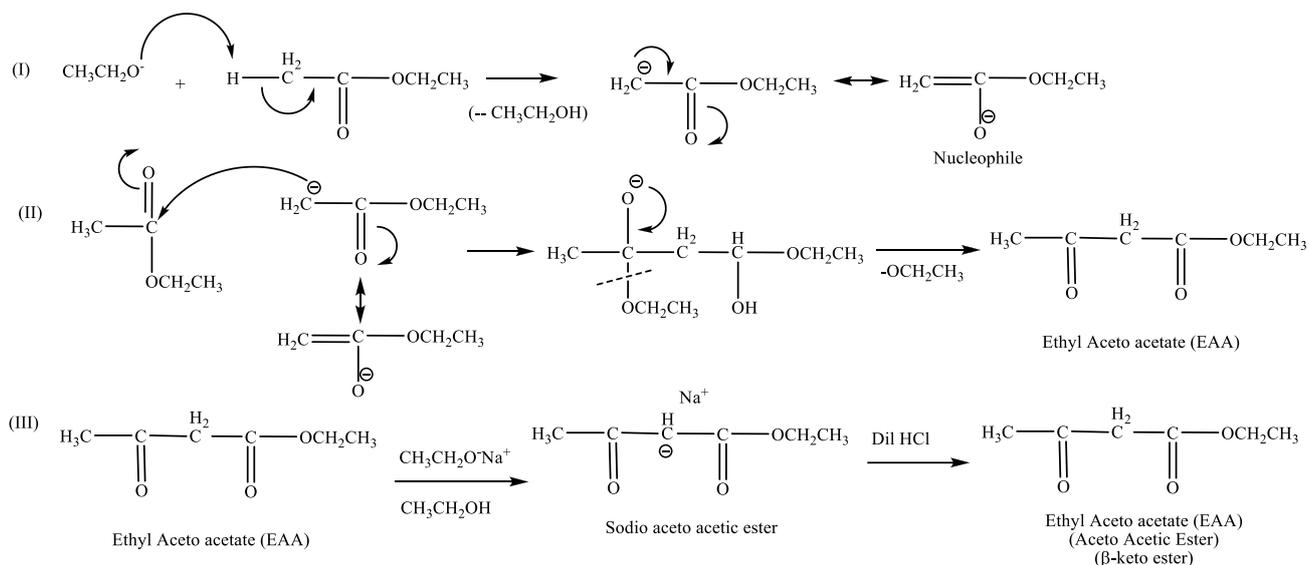
❖ **Preparation of Ethyl Aceto Acetate (Aceto Acetic Ester):  
(Claisen Condensation)**

Ethylaceto acetate (also called Acetoacetic ester) is prepared by the base induced self-condensation of ethyl acetate.



- EAA is prepared by claisen condensation.
- It is similar to aldol condensation.

The mechanism of this reaction is similar to base catalyzed aldol condensation.



The reaction begins with the formation of carbanion stabilized by the adjacent ester group.

This carbanion acting as a nucleophile, adds to the carbon – oxygen double bond of a second molecule of ethyl acetate ester. The resulting intermediate then loses

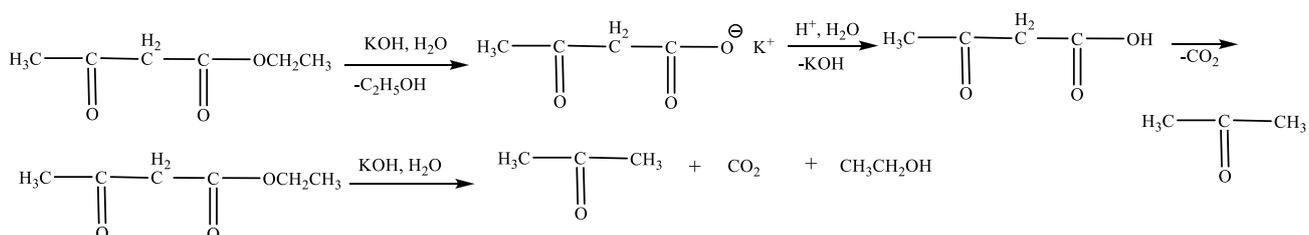
an ethoxide ion to form a β-ketoester  $\text{H}_3\text{C}-\text{C}(=\text{O})-\text{CH}_2-\text{C}(=\text{O})-\text{OC}_2\text{H}_5$ . It is relatively acidic because it forms a carbanion, which is stabilized by two C=O double bonds.

Here, basic solution is used to carry out the reaction, in which β-keto ester is converted into a sodium salt as shown in the reactions.

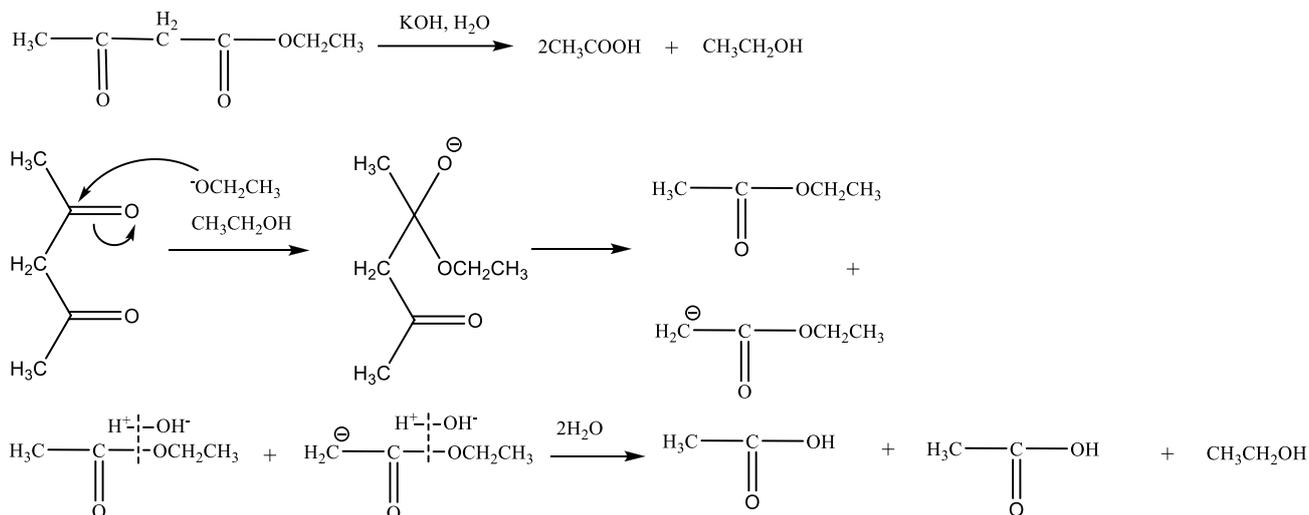
The sodium salt of aceto acetic ester is converted to the final product only after the addition of dilute acid. Ethyl alcohol which is produced during the reaction is continuously distilled to prevent reversible reaction.

### ❖ Hydrolysis of EAA:

#### a) Ketonic hydrolysis:

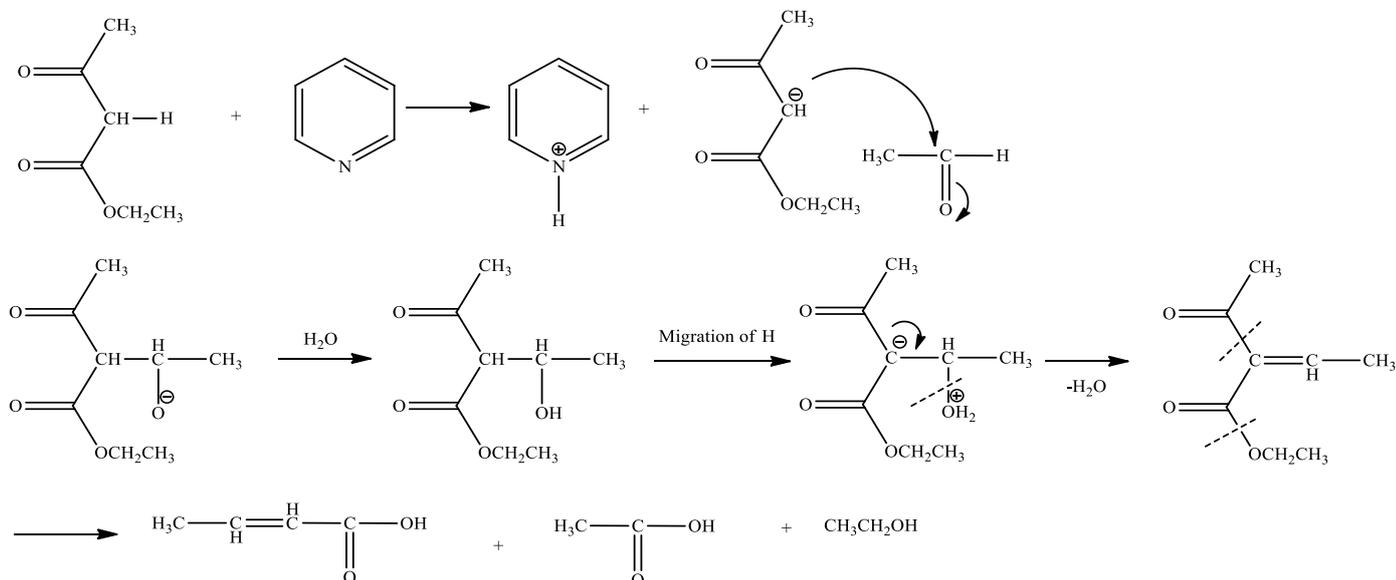
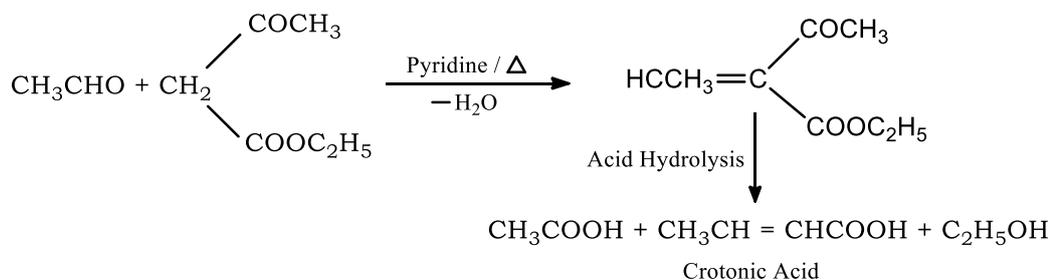


#### b) Acidic hydrolysis:



❖ **Crotonic acid from EAA:**

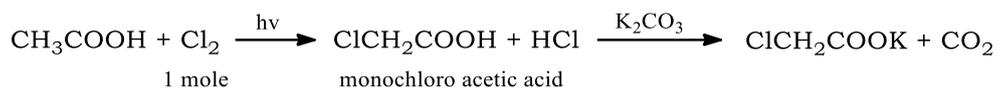
Crotonic acid:  $\text{CH}_3 \underset{\beta}{\text{CH}} = \underset{\alpha}{\text{CH}} \text{COOH}$  ( $\alpha, \beta$ -unsaturated)



❖ **Give Synthesis of Malonic Ester:**

It can be prepared from acetic acid by a series of reactions as under:

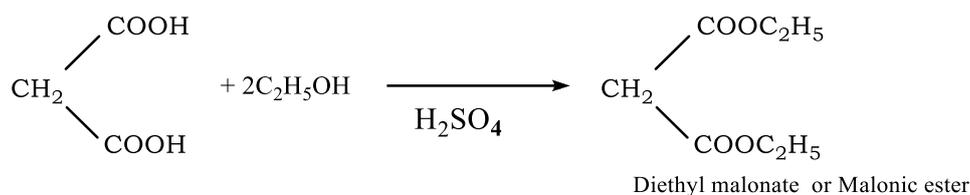
- First by action of limited supply of chlorine prepare monochloro acetic acid and prepare its K-salt by using  $\text{K}_2\text{CO}_3$ .



b) Now treat this salt with KCN and prepare cyano compound and hydrolyze it to get malonic acid.

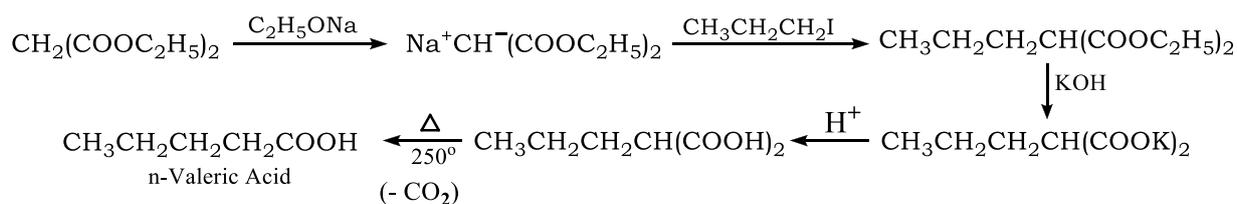


c) Finally diethyl ester was prepared by reaction of dicarboxylic acid with ethanol in presence of a dehydrating agent.



It is extracted with ester from aq. solution and ester is evaporated to obtain pure malonic ester. (b.p. 198°C) It is colourless liquid with sweet smell.

❖ **n-valeric acid from malonic ester:**



## EXERCISE

1. What are active methylene compounds?
2. Explain claisen condensation (synthesis of EAA)
3. Give synthesis of malonic ester.
4. Give conversions.
  - a) Crotonic acid from EAA
  - b) n-valeric acid from malonic ester.
  
5. Define  $\beta$ -dicarbonyl compound,  $\gamma$  - dicarbonyl compound, Active Methylene Compound
6. Differentiate between reaction of methane with base and reaction of  $\beta$ -dicarbonyl compound with base.
7. Give the structure of Ethyl Aceto Acetate (Aceto Acetic Ester) / Malonic ester / Acetyl acetone / Acetonyl acetone.
8. Differentiate between Acetyl acetone and Acetonyl acetone.
9. Differentiate between  $\beta$ -dicarbonyl compound and  $\gamma$  - dicarbonyl compound
10. Give the reaction of Ethyl aceto acetate with base.
11. Give the reaction of Ethyl cyano acetate with base.
12. Give the synthesis of Ethyl Aceto Acetate (Aceto Acetic Ester) with its mechanism. Explain claisen condensation (synthesis of EAA)
13. Discuss hydrolysis of Ethyl Aceto Acetate.
14. Give ketonic hydrolysis of Ethyl Aceto Acetate.
15. Give acedic hydrolysis of Ethyl Aceto Acetate.
16. Give the synthesis of Crotonic acid from Ethyl Aceto Acetate (Aceto Acetic Ester) with its mechanism.
17. Give the synthesis of Malonic ester
18. Give the synthesis of n-valeric acid from malonic ester.

**Reference books: Organic chemistry by I. L. FINAR**