

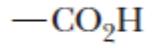
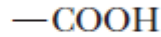
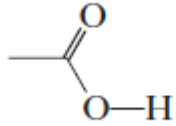
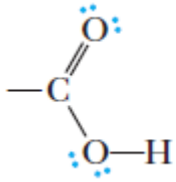
Acidi carbossilici

Francesca Anna Scaramuzzo, PhD

Dipartimento di Scienze di Base e Applicate per l'Ingegneria - Centro di Nanotecnologie Applicate all'Ingegneria

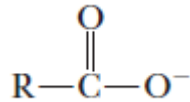
francesca.scaramuzzo@uniroma1.it

Definizione e struttura

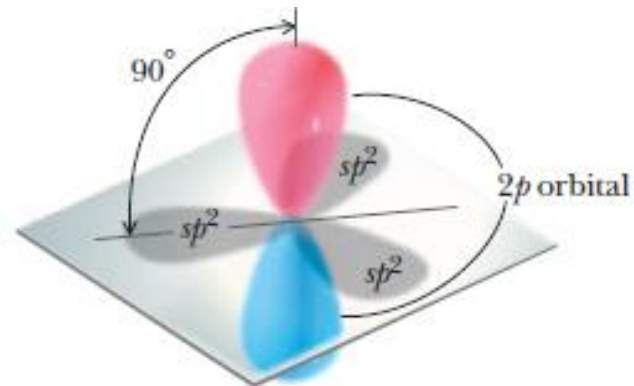
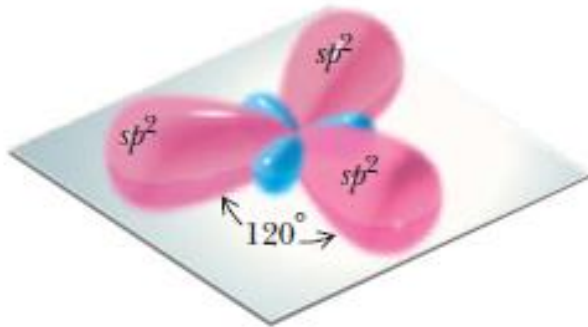


Gruppo carbossile: gruppo funzionale composto da un gruppo *carbonile* + un gruppo *idrossile*

Acidi carbossilici: composti organici contenenti un gruppo carbossile



Gruppo carbossilato: gruppo carbossilico deprotonato

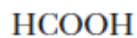


Nomenclatura IUPAC

Acido + *Prefisso* → Numero di atomi di C
Infisso → Tipo di catena idrocarburica
Suffisso → **-ico** o **-oico**

- **Nome base:** catena più lunga di atomi di C contenente il gruppo carbossile
- **Direzione della catena:** acido sempre sul C 1 (non c'è bisogno di numero)
- **Priorità:** il gruppo carbossile è il gruppo a maggiore priorità, perciò tutti gli altri gruppi vanno nominati come sostituenti
- **Composti con 2 gruppi carbossilici:** suffisso -dioico
- **Composti ciclici con -COOH legati direttamente:** acido + nome composto + suffisso -oico

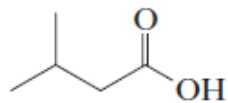
Esempi



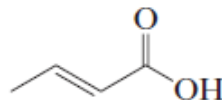
Methanoic acid
(Formic acid)



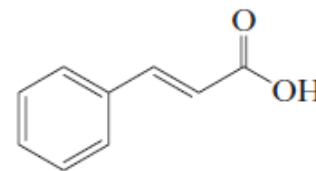
Ethanoic acid
(Acetic acid)



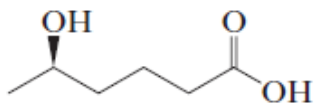
3-Methylbutanoic acid
(Isovaleric acid)



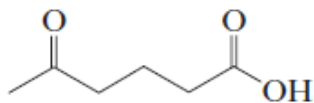
trans-2-Butenoic acid
(Crotonic acid)



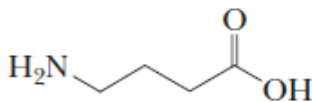
trans-3-Phenylpropenoic acid
(Cinnamic acid)



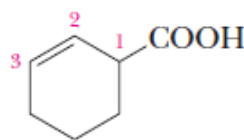
(*R*)-5-Hydroxyhexanoic acid



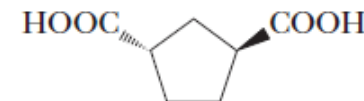
5-Oxohexanoic acid



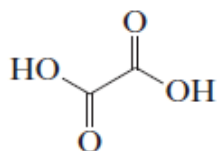
4-Aminobutanoic acid



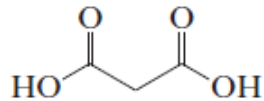
2-Cyclohexenecarboxylic acid



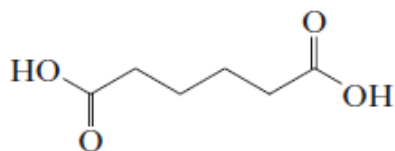
trans-1,3-Cyclopentanedicarboxylic acid



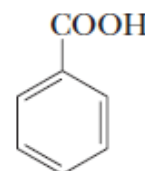
Ethanedioic acid
(Oxalic acid)



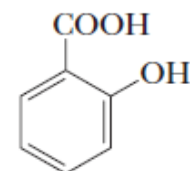
Propanedioic acid
(Malonic acid)



Hexanedioic acid
(Adipic acid)



Benzoic acid



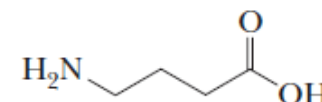
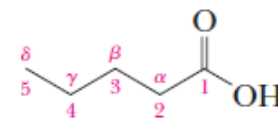
2-Hydroxybenzoic acid
(Salicylic acid)

Nomenclatura comune

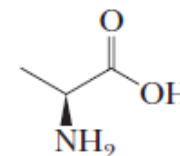
- **Nome base:** nomi di origine greca o latina, derivanti dalla fonte naturale in cui gli acidi carbossilici si trovano
- **Posizione dei sostituenti:** indicata con lettera greca (alternativa alla numerazione degli atomi di C)

Esempi

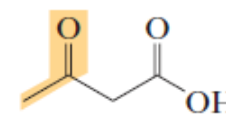
Structure	IUPAC Name	Common Name	Derivation
HCOOH	Methanoic acid	Formic acid	Latin: <i>formica</i> , ant
CH ₃ COOH	Ethanoic acid	Acetic acid	Latin: <i>acetum</i> , vinegar
CH ₃ CH ₂ COOH	Propanoic acid	Propionic acid	Greek: <i>propion</i> , first fat
CH ₃ (CH ₂) ₂ COOH	Butanoic acid	Butyric acid	Latin: <i>butyrum</i> , butter
CH ₃ (CH ₂) ₃ COOH	Pentanoic acid	Valeric acid	Latin: <i>valeriana</i> , a flowering plant
CH ₃ (CH ₂) ₄ COOH	Hexanoic acid	Caproic acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₆ COOH	Octanoic acid	Caprylic acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₈ COOH	Decanoic acid	Capric acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₁₀ COOH	Dodecanoic acid	Lauric acid	Latin: <i>laurus</i> , laurel
CH ₃ (CH ₂) ₁₂ COOH	Tetradecanoic acid	Myristic acid	Greek: <i>myristikos</i> , fragrant
CH ₃ (CH ₂) ₁₄ COOH	Hexadecanoic acid	Palmitic acid	Latin: <i>palma</i> , palm tree
CH ₃ (CH ₂) ₁₆ COOH	Octadecanoic acid	Stearic acid	Greek: <i>stear</i> , solid fat
CH ₃ (CH ₂) ₁₈ COOH	Eicosanoic acid	Arachidic acid	Greek: <i>arachis</i> , peanut



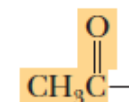
4-Aminobutanoic acid
(γ -Aminobutyric acid, GABA)



(*S*)-2-Aminopropanoic acid
[(*S*)- α -Aminopropionic acid;
L-Alanine]



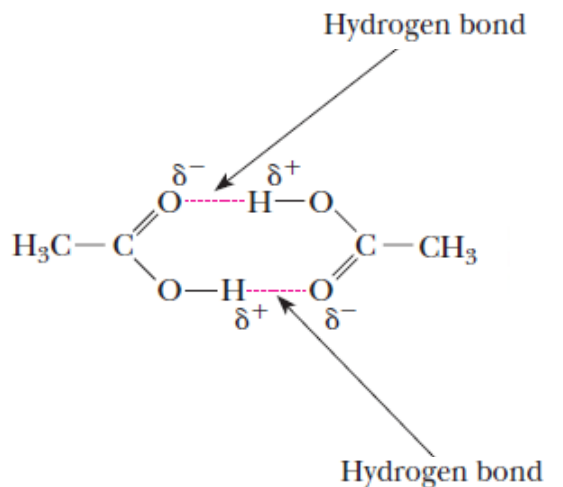
3-Oxobutanoic acid
(β -Ketobutyric acid;
Acetoacetic acid)



Acetyl group
(an aceto group)

Proprietà fisiche degli acidi carbossilici

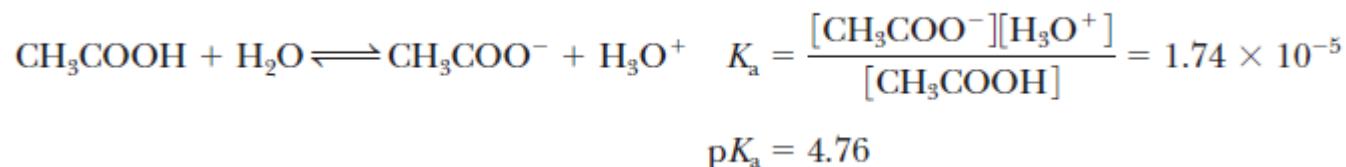
- Sono composti polari
- Le loro molecole interagiscono con legami dipolo-dipolo e legami idrogeno
- I legami idrogeno determinano la formazione di dimeri
- Hanno p.e. significativamente più alti di altri composti organici di peso molecolare paragonabile
- Sono più solubili in acqua di altri composti organici di peso molecolare paragonabile
- P.e. aumenta all'aumentare della lunghezza della catena
- La solubilità in acqua diminuisce all'aumentare della lunghezza della catena



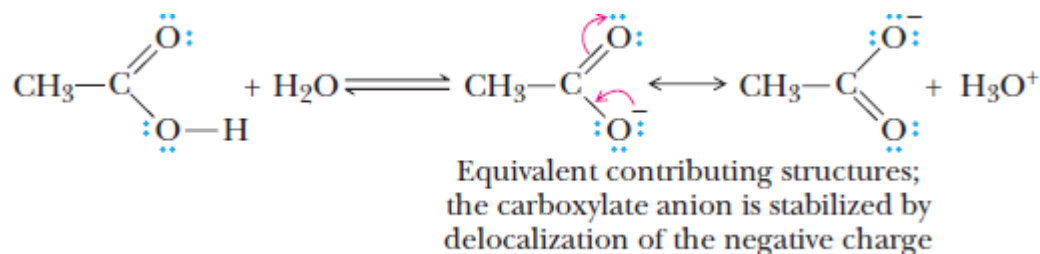
Structure	Name	Molecular Weight (g/mol)	Boiling Point (°C)	Solubility (g/100 g H ₂ O)
CH ₃ COOH	Acetic acid	60.1	118	Infinite
CH ₃ CH ₂ CH ₂ OH	1-Propanol	60.1	97	Infinite
CH ₃ CH ₂ CHO	Propanal	58.1	48	16.0
CH ₃ (CH ₂) ₂ COOH	Butanoic acid	88.1	163	Infinite
CH ₃ (CH ₂) ₃ CH ₂ OH	1-Pentanol	88.1	137	2.3
CH ₃ (CH ₂) ₃ CHO	Pentanal	86.1	103	Slight
CH ₃ (CH ₂) ₄ COOH	Hexanoic acid	116.2	205	1.0
CH ₃ (CH ₂) ₅ CH ₂ OH	1-Heptanol	116.2	176	0.2
CH ₃ (CH ₂) ₅ CHO	Heptanal	114.1	153	0.1

Acidità degli acidi carbossilici

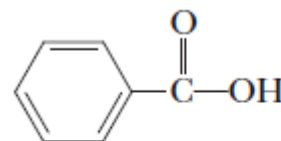
- Acidi deboli, $4 < pK_a < 5$



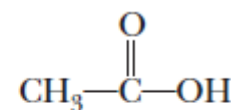
- Acidità favorita dalla delocalizzazione della carica sull'anione



- Acidità maggiore in caso di sostituito più elettronegativo sul C α (effetto induttivo)



Benzoic acid
 pK_a 4.19



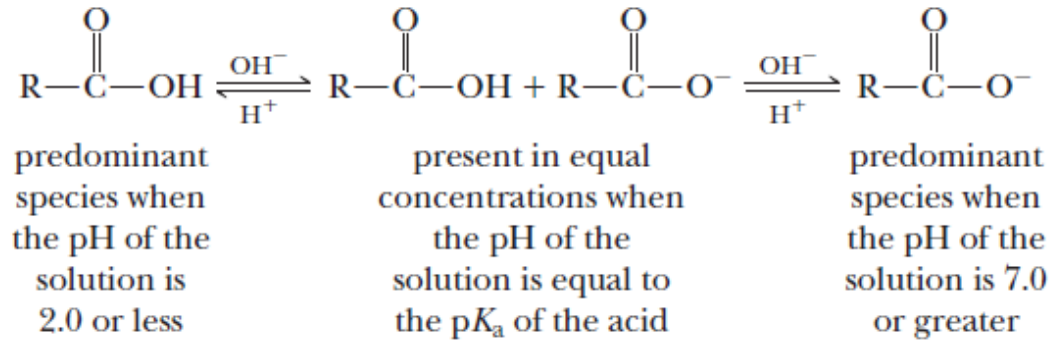
Acetic acid
 pK_a 4.76

Formula:	CH_3COOH	ClCH_2COOH	Cl_2CHCOOH	Cl_3CCOOH
Name:	Acetic acid	Chloroacetic acid	Dichloroacetic acid	Trichloroacetic acid
pK_a :	4.76	2.86	1.48	0.70

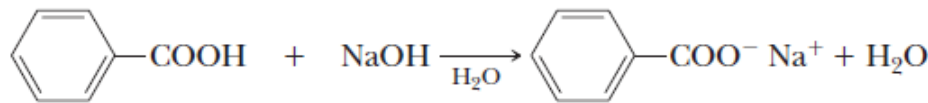
Increasing acid strength

Acidità degli acidi carbossilici

Comportamento degli acidi carbossilici in soluzione acquosa

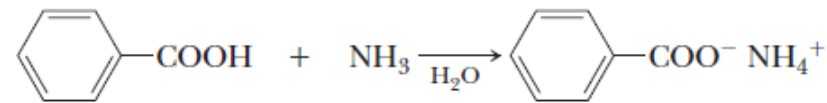


Comportamento degli acidi carbossilici in soluzione acquosa in presenza di basi



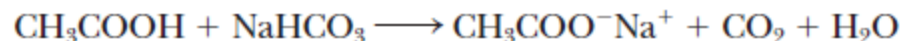
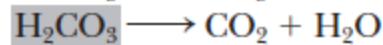
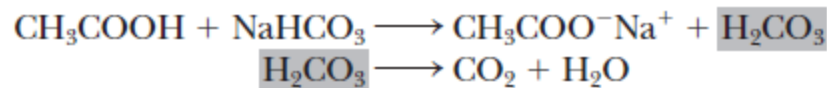
Benzoic acid
(slightly soluble in water)

Sodium benzoate
(60 g/100 mL water)



Benzoic acid
(slightly soluble in water)

Ammonium benzoate
(20 g/100 mL water)

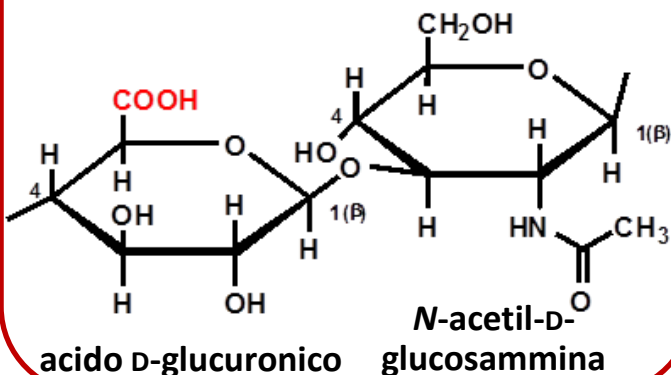


Nomenclatura degli anioni degli acidi: Nome gruppo alchilico/arilico + *ato*

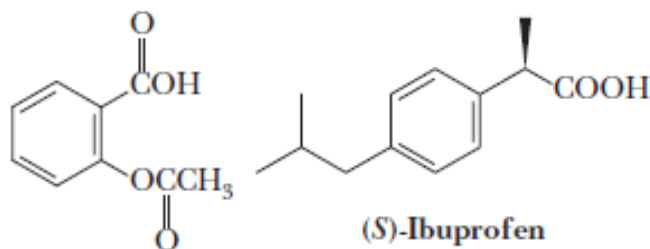
Nomenclatura dei sali degli acidi: Nome anione + di + nome del catione

Gli acidi carbossilici in natura e in chimica farmaceutica

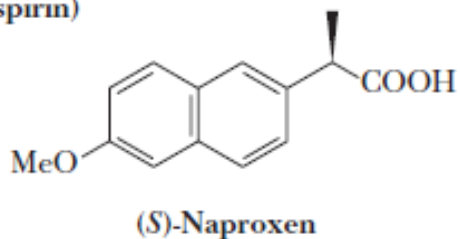
Derivati dei carboidrati acido ialuronico



Farmaci



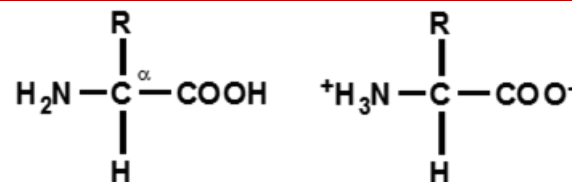
Acetylsalicylic acid
(Aspirin)



Acidi grassi

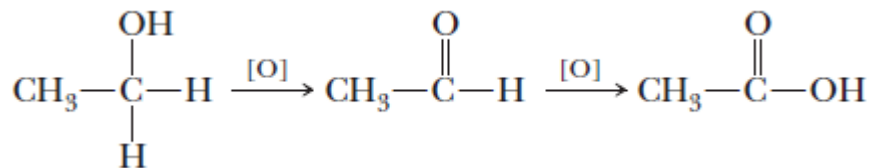
Structure	IUPAC Name	Common Name	Derivation
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CH ₃ COOH	Ethanoic acid	Acetic acid	Latin: <i>acetum</i> , vinegar
CH ₃ CH ₂ COOH	Propanoic acid	Propionic acid	Greek: <i>propion</i> , first fat
CH ₃ (CH ₂) ₂ COOH	Butanoic acid	Butyric acid	Latin: <i>butyrum</i> , butter
CH ₃ (CH ₂) ₃ COOH	Pentanoic acid	Valeric acid	Latin: <i>valeriana</i> , a flowering plant
CH ₃ (CH ₂) ₄ COOH	Hexanoic acid	Caproic acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₆ COOH	Octanoic acid	Caprylic acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₈ COOH	Decanoic acid	Capric acid	Latin: <i>caper</i> , goat
CH ₃ (CH ₂) ₁₀ COOH	Dodecanoic acid	Lauric acid	Latin: <i>laurus</i> , laurel
CH ₃ (CH ₂) ₁₂ COOH	Tetradecanoic acid	Myristic acid	Greek: <i>myristikos</i> , fragrant
CH ₃ (CH ₂) ₁₄ COOH	Hexadecanoic acid	Palmitic acid	Latin: <i>palma</i> , palm tree
CH ₃ (CH ₂) ₁₆ COOH	Octadecanoic acid	Stearic acid	Greek: <i>stear</i> , solid fat
CH ₃ (CH ₂) ₁₈ COOH	Eicosanoic acid	Arachidic acid	Greek: <i>arachis</i> , peanut
CH ₃ (CH ₂) ₅ CH=CH(CH ₂) ₇ COOH	9-Hexadecanoic acid	Palmitoleic acid	
CH ₃ (CH ₂) ₇ CH=CH(CH ₂) ₇ COOH	9-Octadecanoic acid	Oleic acid	
CH ₃ (CH ₂) ₄ (CH=CHCH ₂) ₂ (CH ₂) ₆ COOH	9,12-Octadecadienoic acid	Linoleic acid	
CH ₃ CH ₂ (CH=CHCH ₂) ₃ (CH ₂) ₆ COOH	9,12,15-Octadecatrienoic acid	α-Linolenic acid	
CH ₃ (CH ₂) ₄ (CH=CHCH ₂) ₃ (CH ₂) ₃ COOH	6,9,12-Octadecatrienoic acid	γ-Linolenic acid	
CH ₃ (CH ₂) ₄ (CH=CHCH ₂) ₄ (CH ₂) ₂ COOH	5,8,11,14-Eicosatetraenoic acid	Arachidonic acid	

Amminoacidi e proteine

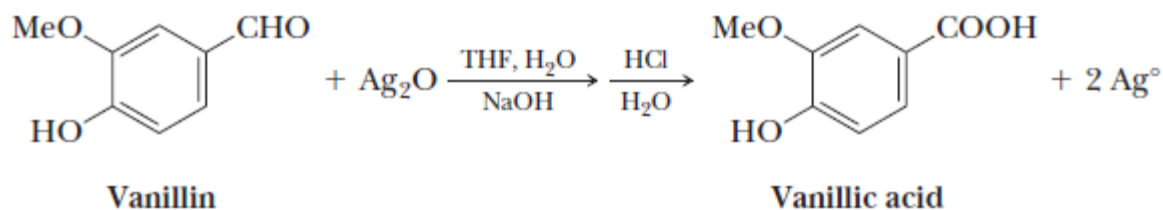
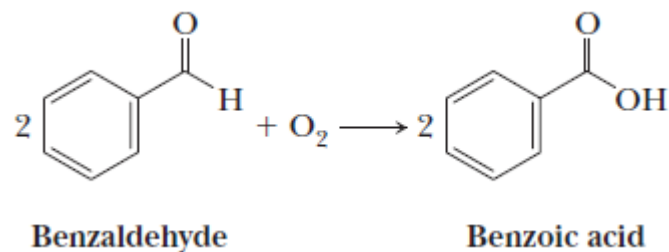
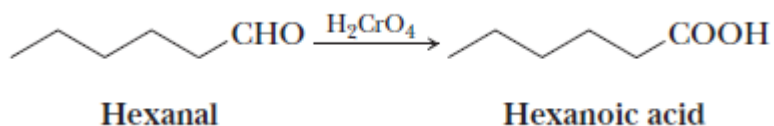


Preparazione degli acidi carbossilici

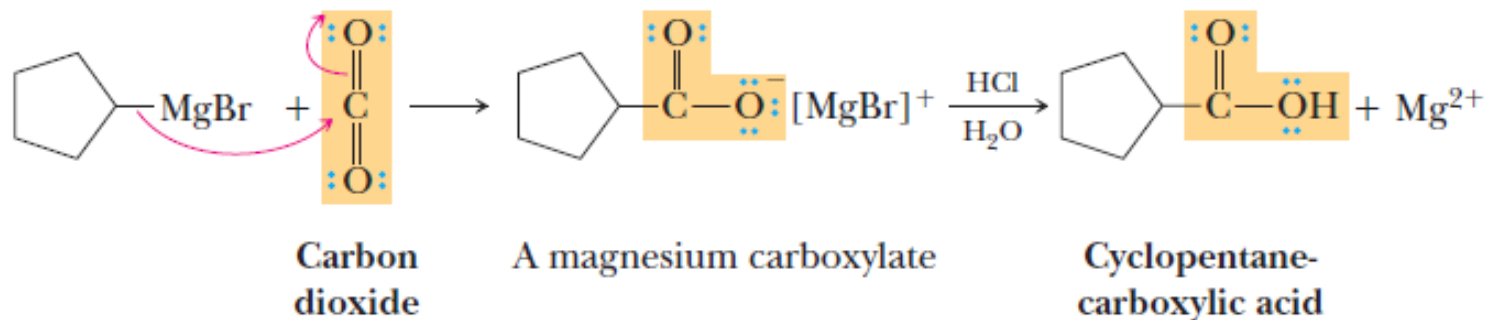
Ossidazione di alcoli primari con acido cromico (reattivo di Jones)



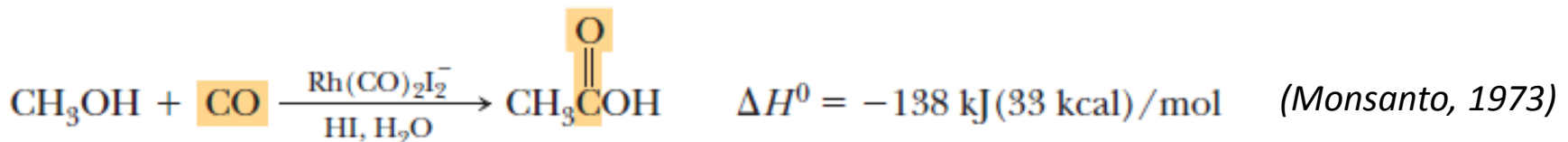
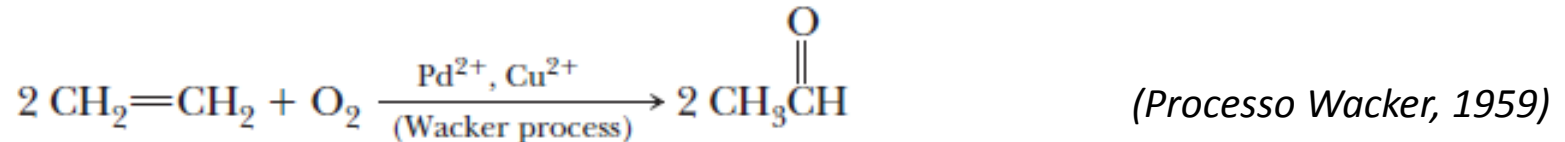
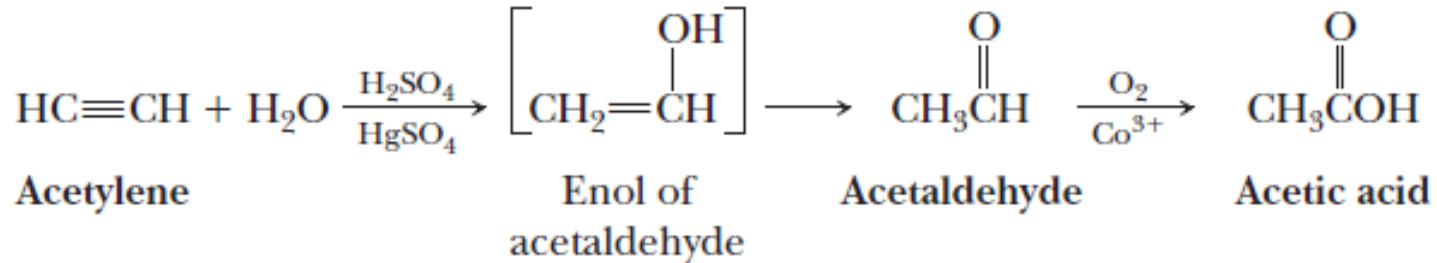
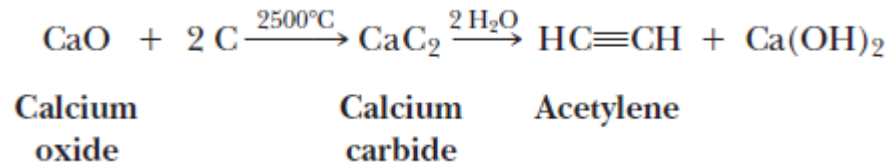
Ossidazione di aldeidi (reattivo di Jones, O₂, Ag⁺)



Reazione di un reattivo di Grignard con CO₂ (carbonatazione)

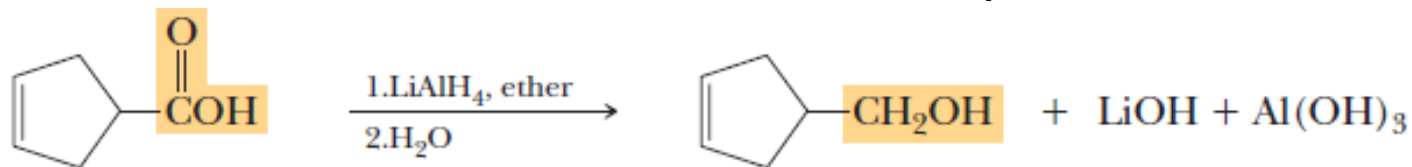


Processi di produzione industriale dell'acido acetico



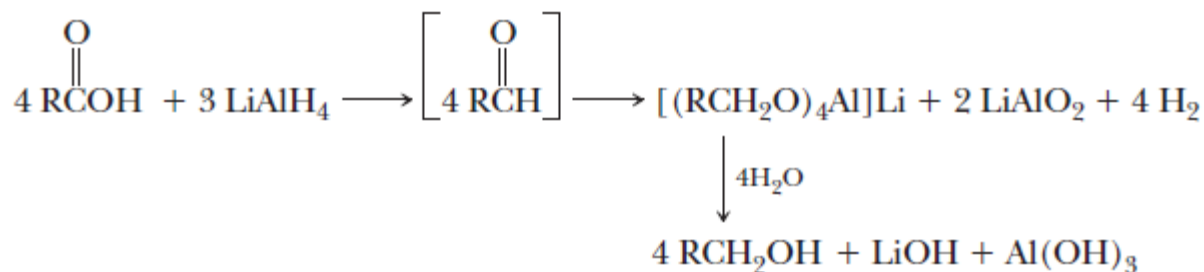
Riduzione di acidi carbossilici

Riduzione con LiAlH_4



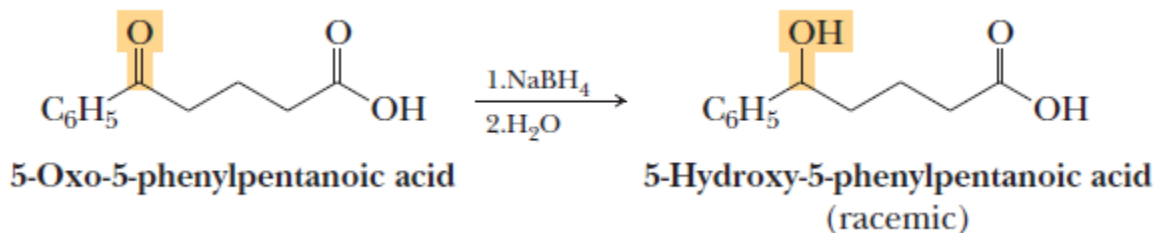
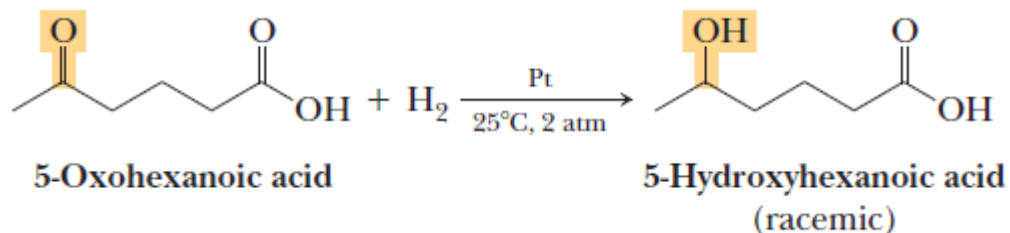
3-Cyclopentene-carboxylic acid

4-Hydroxymethylcyclopentene



(per il meccanismo vedi reazioni dei derivati degli acidi carbossilici)

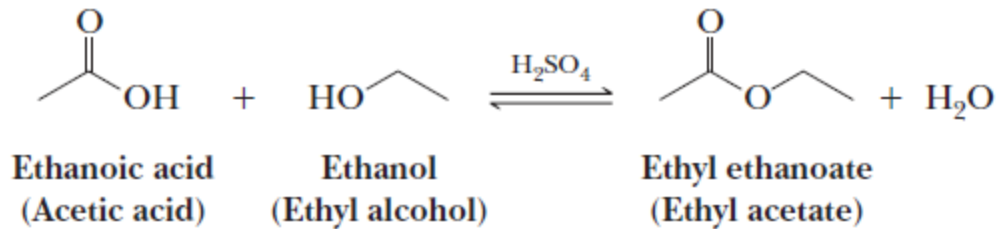
Riduzione di altri gruppi funzionali in presenza di $-\text{COOH}$



Esterificazione di acidi carbossilici

Esterificazione di Fisher

Reazione di formazione di un estere a partire da acido carbossilico e alcol portati a riflusso in presenza di un catalizzatore acido (es. HCl, H₂SO₄)

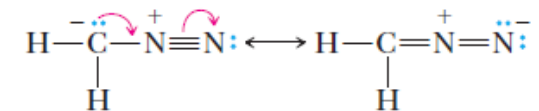
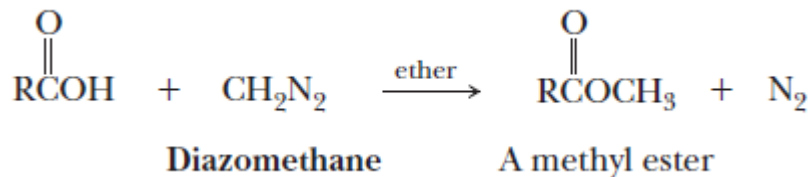


Reazione reversibile

(per il meccanismo vedi reazioni dei derivati degli acidi carbossilici)

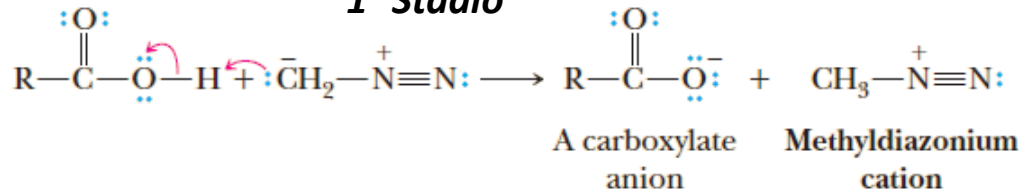
Reazione con diazometano

Reazione di formazione di un estere metilico

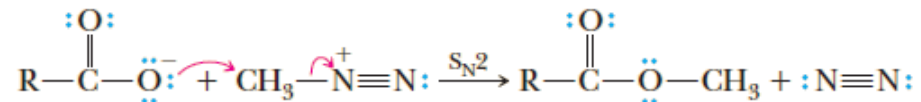


Diazomethane
(a resonance hybrid of two important contributing structures)

1° Stadio

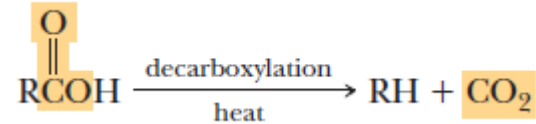


2° Stadio

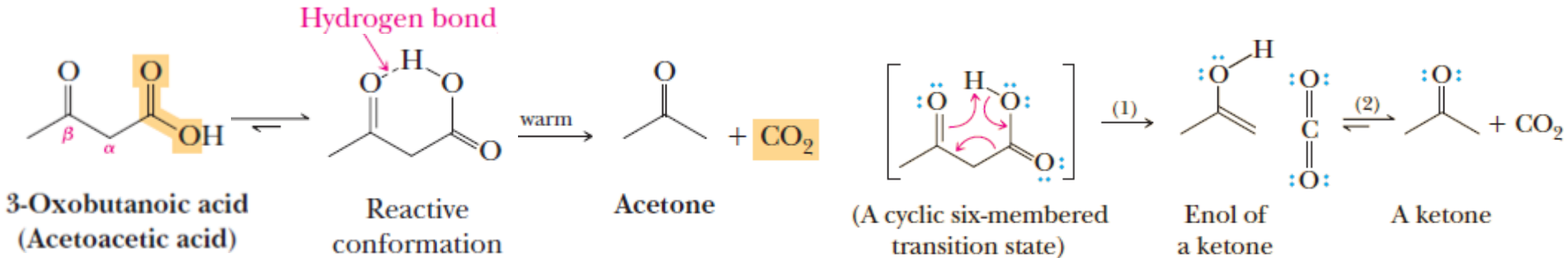


Decarbossilazione

Perdita di CO₂ da un gruppo carbossilico



Formazione di chetoni da β-chetoacidi

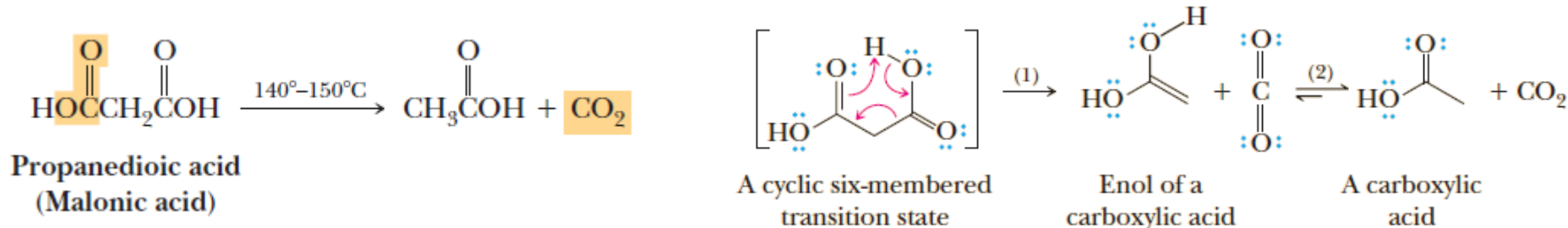


3-Oxobutanoic acid (Acetoacetic acid) 3-Hydroxybutanoic acid (β-Hydroxybutyric acid)

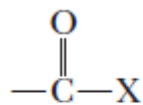
Corpi chetonici

- Sintetizzati nel fegato da acetil-CoA (metabolismo acidi grassi e amminoacidi)
- [corpi chetonici] aumenta per malnutrizione o diabete mellito
- Formazione di CO₂ e escrezione di acetone da reni e polmoni

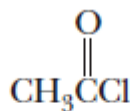
Decarbossilazione di acido malonico e suoi derivati



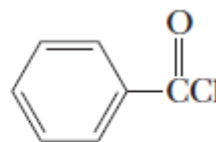
Conversione in cloruri acilici



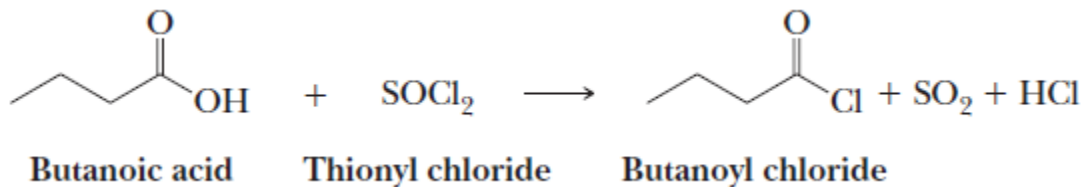
Functional group
of an acid halide



Acetyl chloride



Benzoyl chloride



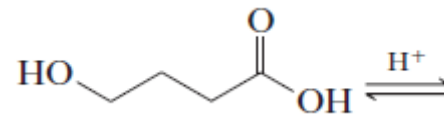
(per il meccanismo vedi reazione di formazione dei cloruri alchilici da alcol con SOCl_2)

Esercizio: Completare la seguente reazione acido-base e scrivere i nomi di reagenti e prodotti.



Esercizio: Completare la seguente esterificazione di Fischer e scrivere i nomi di reagente e prodotto.

Suggerimento: il prodotto è un estere ciclico



Esercizio: Scrivere gli enoli intermedi e i prodotti finali ottenuti nella reazione di decarbossilazione dei seguenti composti. Scrivere il nome di reagente e prodotto finale.

