▶ Video explanation (YouTube Short)

Reduction and Decarboxylation of Carboxylic Acids

Reactions in which the –COOH group itself changes (NCERT 8.9.3).

1. Decarboxylation with soda lime

Sodium salts of carboxylic acids, heated with soda lime (NaOH and CaO in the ratio 3 : 1), lose carbon dioxide and give alkanes with **one carbon less**: RCOONa + NaOH → (CaO, heat) → R–H + Na_2CO_3. Example: $CH_3COONa \rightarrow CH_4$ (methane).

A simple picture with curved arrows: the O^- lone pair forms C=O while the C–C bond pair moves onto the alkyl carbon (a carbanion) and CO_2 separates; the carbanion takes up a hydrogen to give the alkane.

2. Kolbe electrolysis

Electrolysis of an aqueous solution of a sodium or potassium carboxylate gives an alkane with **twice the carbons of the alkyl group**. At the anode: $RCOO^- - e^- \rightarrow RCOO\cdot \rightarrow R\cdot + CO_2$; then $R\cdot + \cdot R \rightarrow R–R$. Example: $2CH_3COO^- \rightarrow CH_3–CH_3$ (ethane) + $2CO_2$ + $2e^-$.

3. Reduction

$LiAlH_4$ (or diborane, B_2H_6), followed by H_3O^+, reduces RCOOH to the primary alcohol RCH_2OH. $NaBH_4$ does not reduce the carboxyl group.

Reagent	Product from CH_3COOH / CH_3COONa	Carbons
soda lime, heat (on CH_3COONa)	CH_4	2 → 1
Kolbe electrolysis (CH_3COONa, aq)	C_2H_6	2 CH_3 joined
$LiAlH_4$, then H_3O^+	CH_3CH_2OH	2 → 2

Solved example

Q. Which alkane is obtained by (i) heating sodium propanoate with soda lime (ii) Kolbe electrolysis of sodium propanoate?
A. (i) CH_3CH_3, ethane (one carbon less). (ii) $CH_3CH_2–CH_2CH_3$, butane (two ethyl groups joined).

Key takeaways

- Soda lime: $-CO_2$, alkane with one carbon less.
- Kolbe: two alkyl groups join, R–R.
- $LiAlH_4$ or B_2H_6: RCOOH → RCH_2OH; $NaBH_4$ does not work.

Practice questions

1. (MCQ) Sodium acetate heated with soda lime gives: (a) ethane (b) methane (c) ethene (d) acetone

2. (MCQ) Kolbe electrolysis of sodium acetate gives: (a) methane (b) ethane (c) propane (d) butane
3. (MCQ) Which reagent reduces RCOOH to RCH_2OH? (a) $NaBH_4$ (b) $LiAlH_4$ (c) Zn–Hg/HCl (d) H_2O
4. (Very short) What is soda lime?
5. (Very short) At which electrode does the Kolbe reaction produce the alkane?
6. (Short) Why does decarboxylation reduce the number of carbon atoms by one?
7. (Short) Write the steps at the anode in the Kolbe electrolysis of sodium acetate.
8. (Application) Give the products of soda-lime decarboxylation and Kolbe electrolysis of sodium butanoate.

Answer key

1. (b) methane.
2. (b) ethane.
3. (b) $LiAlH_4$.
4. A mixture of NaOH and CaO (3 : 1).
5. At the anode.
6. The carboxyl carbon leaves as CO_2 (trapped as Na_2CO_3).
7. $CH_3COO^- - e^- \rightarrow CH_3COO\cdot$; $CH_3COO\cdot \rightarrow CH_3\cdot + CO_2$; $2CH_3\cdot \rightarrow C_2H_6$.
8. Soda lime: propane ($CH_3CH_2CH_3$). Kolbe: hexane ($CH_3CH_2CH_2–CH_2CH_2CH_3$).

▶ Watch the video explanation