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Question

Describe the three (3) stages of beta oxidation. (Show pathways where necessary)

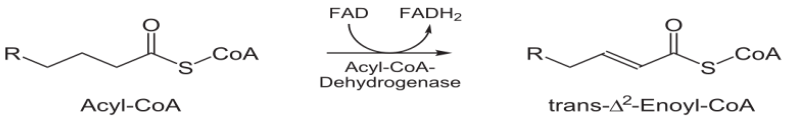
Answer
The three stages of beta oxidation are:
1. The activation of fatty acids
2. Transport of fatty acyl CoA into the mitochondria
3. The Reactions of beta oxidation

Activation of fatty acids: In this stage, fatty acids are converted to CoA thioesters by acyl-CoA synthetase. The PPi released is then hydrolyzed by a pyrophosphatase to 2 Pi. Two phosphoanhydride bonds are consumed to activate one fatty acid to a thioester

Transport of Fatty Acyl CoA into Mitochondria: Fatty acyl CoA is first converted to acylcarnitine in the presence of the enzyme - carnitine acyltransferase I that's bound to the outer mitochondrial membrane. Then the Acylcarnitine enters the mitochondria by a translocase. The acyl group is then transferred back to CoA. The enzyme in this reaction is carnitine acyltransferase II.

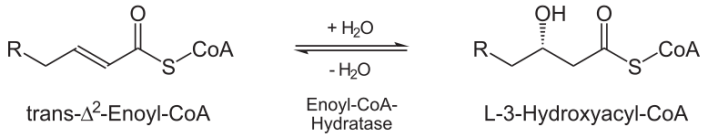
The Reactions of beta oxidation: This is the last stage where the beta oxidation pathway degrades fatty acids two carbons at a time.
Reactions of beta oxidation take place in four steps: dehydrogenation, hydration, oxidation and thyolisis. Each step is catalyzed by a specific enzyme.
Each cycle of this process begins with an acyl-CoA chain and ends with one acetyl-CoA, one FADH2, one NADH and water, and the acyl-CoA chain becomes two carbons shorter. The total energy yield per cycle is 17 ATP molecules. This cycle is repeated until two acetyl-CoA molecules are formed as opposed to one acyl-CoA and one acetyl-CoA.

Dehydrogenation: Acyl-CoA is oxidized by the enzyme acyl CoA dehydrogenase to give an enoyl CoA. A double bond is formed between the second and third carbons (C2 and C3) of the acyl-CoA chain entering the beta oxidation cycle; the end product of this reaction is trans-Δ2-enoyl-CoA (trans-delta 2-enoyl CoA). The coenzyme FAD and produces FADH2, which will enter the citric acid cycle and form ATP to be used as energy.

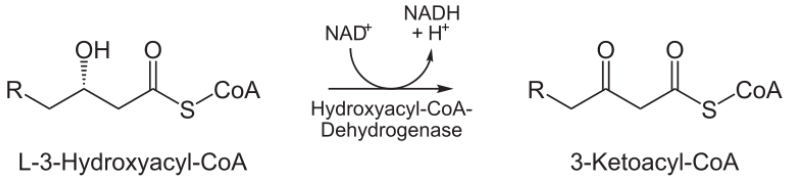


Acyl-CoA trans-Δ^2-Enoyl-CoA

Hydration: In the second step, the double bond between C2 and C3 of trans-Δ2-enoyl-CoA is hydrated, forming the end product L-β-hydroxyacyl CoA, which has a hydroxyl group (OH) in C2, in place of the double bond. This reaction is catalyzed by another enzyme: enoyl CoA hydratase. This step requires water.



Oxidation: In the third step, the hydroxyl group in C2 of L-β-hydroxyacyl CoA is oxidized by NAD+ in a reaction that is catalyzed by 3-hydroxyacyl-CoA dehydrogenase. The end products are β-ketoacyl CoA and NADH + H. NADH will enter the citric acid cycle and produce ATP that will be used as energy.



Thiolysis: in the fourth step, β-ketoacyl CoA is cleaved by a thiol group (SH) of another CoA molecule (CoA-SH). The enzyme that catalyzes this reaction is β-ketothiolase. The cleavage takes place between C2 and C3; therefore, the end products are an acetyl-CoA molecule with the original two first carbons (C1 and C2), and an acyl-CoA chain two carbons shorter than the original acyl-CoA chain that entered the beta oxidation cycle