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BETA OXIDATION OF FATTY ACID

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Respiratory oxidation of fatty acid is known as beta (β) oxidation which occurs in liver and adipose tissues. It is an catabolic process and produce great amount of ATP and it was first discovered by Franz. Knoop. In this process, the fatty acids are oxidized at the β carbon i.e., the second carbon atom from the carboxyl group. The process is completed in five steps and the enzymes required occur in the mitochondria. These steps are as follows -

1) Activation of fatty acid
2) Dehydrogenation of activated fatty acid.
3) Hydration
4) Oxidation of β hydroxyl - acyl CoA.
5) Reaction of β Keto acyl CoA with CoA (Thiolysis).

1) Activation of fatty acid :-

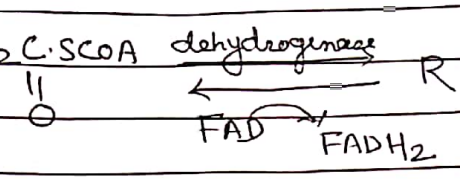
In the first step of oxidation, fatty acids are activated by their conversion to thioesters with the help of coenzyme A. The energy for this process is derived from ATP and the enzyme involved is thiokinase.

$$RCH_2CH_2COOH + COASH \xrightarrow[\text{thiokinase, } Mg^{++}]{ATP \rightarrow AMP + PP_i} RCH_2CH_2C(=O)SCoA + H_2O$$

2) Dehydrogenation -

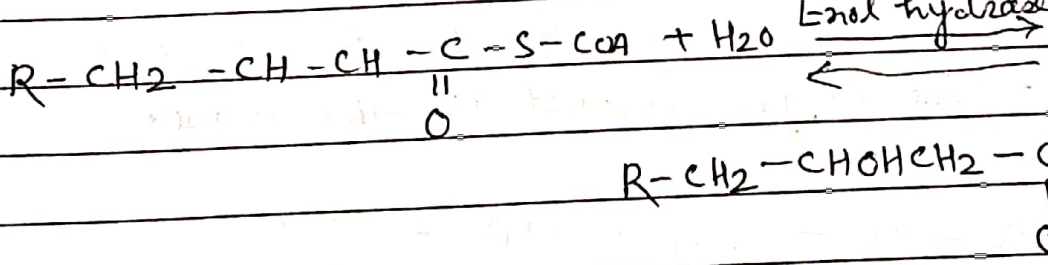
This reaction is a dehydrogenation, removing two hydrogen atoms from α and β carbon atoms of the fatty acids. This reaction is catalysed

by FAD containing enzymes, acyl CoA dehydrogenase.



Three types of dehydrogenases have been identified from liver tissues. They differ according to their specificity to the substrate. The first prefers to act on long chain fatty acid (C_{14}, C_{16}, C_{18}) while the other two act on medium or short chains.

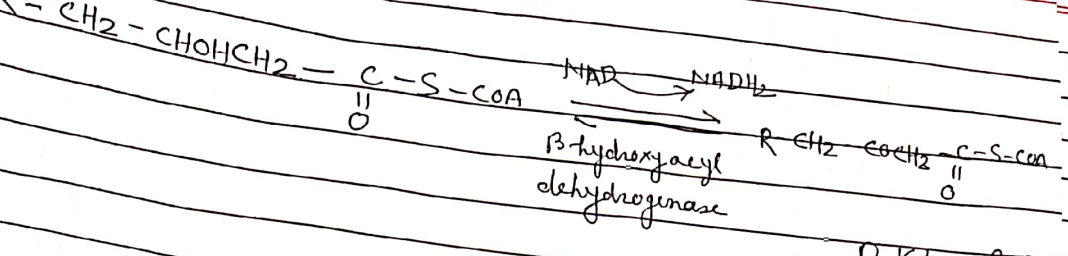
3) Hydration :- In this third step a molecule of water is added across the double bond in the presence of enzyme enol hydrase producing an alcoholic group on the β-carbon. The product is β-hydroxy-acyl CoA.



4) Oxidation of β hydroxy-acyl CoA →

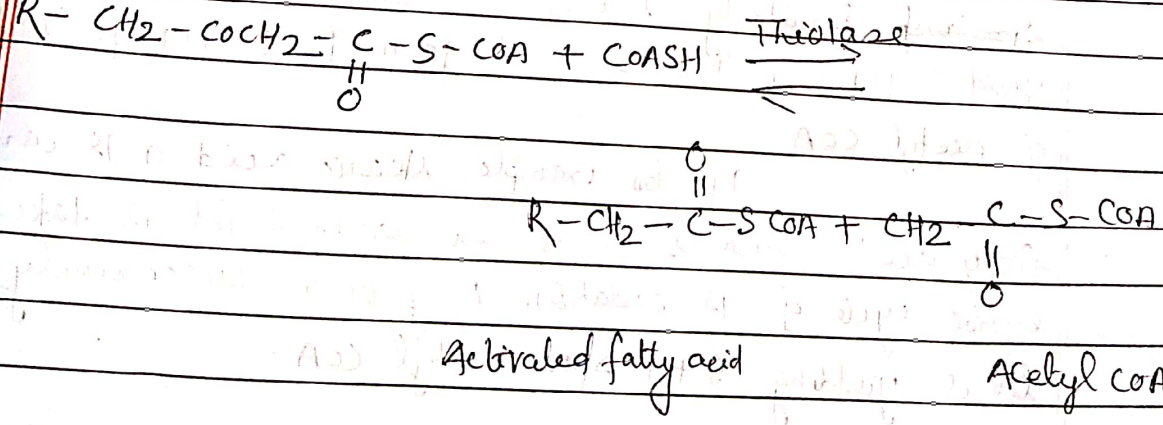
In this step, β hydroxy-acyl CoA is converted into β-Keto derivatives that's why it is called β oxidation. The reaction is catalysed by the enzyme - β hydroxyl-acyl dehydrogenase and NAD is

used as hydrogen acceptor.



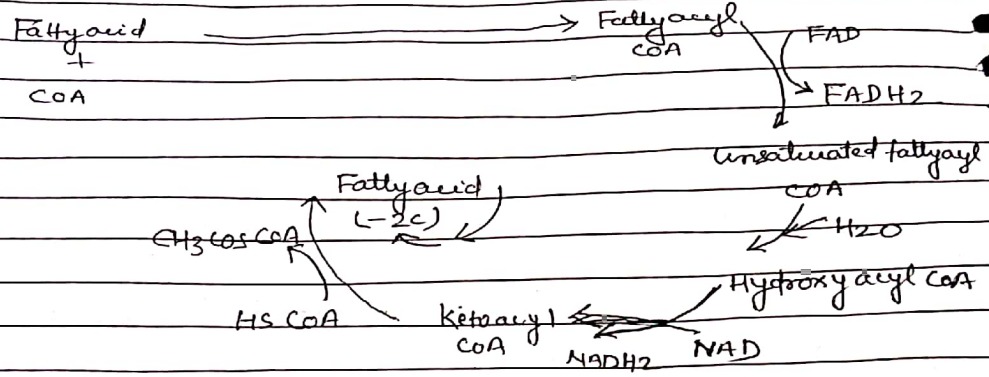
5) Reaction of β Ketoacyl CoA with CoA or Thiolysis

This is the final step and it involves the formation of acetyl CoA and an activated fatty acids. The reaction is catalyzed by the enzyme β-Keto acyl thiolase. It brings about hydrolysis of Sulphohydryl group CoA, hence known as thiolysis. Another molecule of CoA is added at the β carbon.



This process continues until the entire chain is cleaved into acetyl CoA units. The final cycle produces two separate acetyl CoA instead of one acyl CoA and one

acetyl CoA. For every cycle the acyl CoA unit is shortened by two carbon atoms. The acetyl CoA is oxidized to CO_2 and H_2O via Krebs cycle.



β - oxidation spiral

Energy produced during β-oxidation

1) Transfer of H_2 from FAD to $FADH_2$ yield 2 ATP and ~~similarly~~ Similarly transfer of H_2 from NAD to $NADH_2$ yield 3 ATP, so there is a net gain of 5 ATP per mole. of acetyl CoA.

If for example stearic acid a 18 carbon fatty acid which is common in animal fat is taken, the entire cycle of β-oxidation may occur successively eight times yielding 8+1 spare acetyl CoA.

2) A total of 40 ATP (5X8) are produced in 8 turns. Of these, a single ATP is used up in initial activation of fatty acid. As such the whole oxidation

process produce 39 ATP.

3) The acetyl CoA molecules produce 108 ATP molecules (9 X 12) in Kreb's cycle (one acetyl CoA produce 12 ATP mol.) So the total gain per mol. of fatty acid is 147 ATP.

The amount of energy produced by the oxidation of one molecule of fatty acid is almost four times the energy produced by one molecule of glucose (38 ATP). Thus fatty acids are evidently much richer source of energy than carbohydrates.

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FOR P.G IIND SEMESTER

BY

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