Effects of salts and minerals on SOD inhibition of ubiquinol oxidation

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Summary

Ubiquinone (CoQ_0 = 2,3-Dimethoxy-5-methyl-1,4-benzoquinone) and hydrogen peroxide (H_2O_2) were formed in the process of oxidation of ubiquinol (CoQ_0H_2 = 2,3-Dimethoxy-5-methyl-1,4-hydroquinone) in a phosphate buffer. Among eight mineral salts investigated, $FeSO_4$, $MnSO_4$ and $CuSO_4$ increased the ubiquinone formation. NaCl had no effect. Chelators such as DTPA (diethylenetriaminepentaacetic acid) decreased the amount of ubiquinone and H_2O_2. This suggests that trace amount of Fe ion in the buffer increased the ubiquinol oxidation. The amount of H_2O_2 was almost equal to that of CoQ_0, indicating that the H_2O_2 formation was coupled with the CoQ_0 formation. Copper-zinc superoxide dismutase (CuZn-SOD) and manganese superoxide dismutase (Mn-SOD), which accelerate the dismutation of superoxide ($2O_2^- + 2H^+ \rightarrow H_2O_2 + O_2$), inhibited both the CoQ_0 formation and the H_2O_2 formation in the presence of DTPA. We propose that CoQ_0H_2 oxidation occurs as a chain reaction with superoxide (O_2^-) as the chain carrier and that SOD inhibits this reaction by lowering the superoxide concentration.

$$CoQ_0H_2 + O_2^- \rightarrow CoQ_0^- \text{ (semiquinone radical)} + H_2O_2 \quad (1)$$

$$CoQ_0^- + O_2 \rightarrow CoQ_0 + O_2^- \quad (2)$$

The sum of (1) and (2) is: $CoQ_0H_2 + O_2 \rightarrow CoQ_0 + H_2O_2$

It is interesting that the active sites of SODs consist of the minerals which increased the ubiquinol oxidation. In animal cells, Mn-SOD is located in the mitochondria, and CuZn-SOD is located in the cytoplasm. Ubiquinols are also located in both the mitochondria and the cytoplasm. Similar inhibitory effects of Mn-SOD on the CoQ_0 formation and the H_2O_2 formation at the same enzymatic activity as in the case of CuZn-SOD imply that these enzymes have a common antioxidative role in different parts of the cells.