

A QM/MM study of nitric oxide reductase-catalyzed N₂O formation

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Abstract

Nitric oxide reductase (NOR) catalyzes the two-electron reduction of nitric oxide (NO) to nitrous oxide (N₂O). This reaction is the third step of the denitrification process in nature, converting nitrite (NO₃⁻) to dinitrogen (N₂), and it is also crucial for bacterial anaerobic respiration. Recent X-ray crystal structure of cytochrome *bc* complexes (cNOR) from *Pseudomonas aeruginosa* revealed that the active site is composed of binuclear metal center: one non-heme iron (Fe_B) and one heme *b*₃ iron (Fe_{b3})(Fig. 1). It was also found that cNOR exhibits many similarities to cytochrome oxidase (COX) in sequences, protein topology and the arrangement of metal centers.

The reaction mechanism of NOR is investigated by using quantum mechanical/molecular mechanical (QM/MM) calculations. We found that hyponitrous intermediate is formed at a two-NO binding state, and the highest activation barrier is 20 kcal/mol at the N-O bond cleavage step. Additional QM calculations for the active center show that the highest energy barrier increased up to 37 kcal/mol, where a five-membered ring is formed at the intermediate state. These results suggest that Glu211 coordination to Fe_B center is critically important to destabilize the hyponitrous intermediate and to decrease the highest energy barrier of the N-O bond cleavage step.

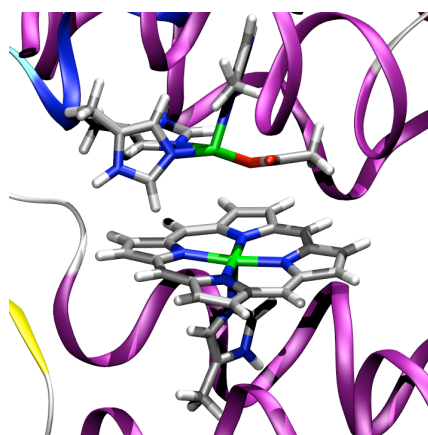


Fig 1. active site of NOR.