Supplementary Material (ESI) for Faraday Discussions

Reductive Cleavage of the O-O bond in Multicopper Oxidases: QM/MM and QM Study. *Supplementary Material*

Martin Srnec, Ulf Ryde, Lubomír Rulíšek

Table S1: For every system shown in this table, two different QM/MM structures with comparable total energies but significantly different individual energetic contributions were optimized. The energies of one of two structures are always set to zero. All values are in $kJ.mol^{-1}$.

System	$\Delta E_{QM/vac}$	ΔE_{MM}	$\Delta E_{QM/MM}$
NI{-;O^{2-};O^{2-} }	-20.7	12.5	0.1
NI{H_2O;O^{2-};O^{2-}}	36.6	25.5	3.9
NI{OH^-;O^{2-};O^{2-}}	-39.4	-30.6	6.1
NI'{H_2O;O_2^{2-}}	-17.7	63.2	17.6

Table S2. Vibrational terms of activation and reaction entropies, enthalpies and Gibbs free energies calculated at RI-PBE/DZP level. The total energies of the reactants (NI') are set to zero. All values are in $kJ.mol^{-1}$.

Cu-T2 ligand	Central ligand	Charge of QM cluster	$\Delta H_{vib}^{\neq}$	$-T\Delta S_{vib}^{\neq}$	$\Delta G_{vib}^{\neq}$	ΔH_{vib}	$-T\Delta S_{vib}$	ΔG_{vib}
H_2O	O_2H^-	3	-3.1	1.0	-2.1	1.2	14.1	15.2
OH^-	O_2H^-	2	-	-	-	2.0	11.5	13.5
–	O_2H^-	3	-3.5	2.5	-1.0	0.9	17.3	18.2
H_2O	O_2^{2-}	2	-4.3	5.7	1.4	1.0	11.2	12.2
OH^-	O_2^{2-}	1	-4.8	10.1	5.3	-0.4	28.7	28.3
–	O_2^{2-}	2	-4.0	8.7	4.7	1.1	14.8	15.9

$$H_{vib} = E_{ZPE} + \tfrac{1}{2}\sum_i h\nu_i \frac{1+\exp(-h\nu_i/kT)}{1-\exp(-h\nu_i/kT)};\ S = \tfrac{1}{2T}\sum_i h\nu_i \frac{1+\exp(-h\nu_i/kT)}{1-\exp(-h\nu_i/kT)} + R\ln q_{vib}$$

Table S3. The solvation effect on the energetics of O-O cleavage in the QM clusters is represented by polarized continuum model (COSMO) with relative permittivity typical for proteins ε = 4 or 20. The level of approximation is B3LYP/def2-TZVP/COSMO,ε//RI-PBE/DZP. The total energies of the reactants (NI') are set to zero. All values are in kJ.mol^{-1}.

Cu-T2 ligand	**Central ligand**	**Charge of QM cluster**	**$\Delta E_{QM}^{\neq}$** (ε_r=0)	**$\Delta E_{QM}^{\neq}$** (ε_r=4)	**$\Delta E_{QM}^{\neq}$** (ε_r=20)	**ΔE_{QM}** (ε_r=0)	**ΔE_{QM}** (ε_r=4)	**ΔE_{QM}** (ε_r=20)
H_2O	O_2H^-	3	50.4	48.2	50.4	-113.6	-118.6	-120.4
OH^-	O_2H^-	2	-	-	-	-141.7	-156.2	-162.0
–	O_2H^-	3	33.4	37.6	39.4	-118.5	-122.7	-124.1
H_2O	O^{2-}	2	39.7	39.5	39.6	-41.7	-47.0	-49.2
OH^-	O^{2-}	1	79.4	78.7	79.1	-95.9	-99.9	-101.3
–	O^{2-}	2	39.8	42.1	43.6	-42.7	-47.9	-50.1