Nucleophilic Reactivity of Zinc-Bound Thiolates: Subtle Interplay between Coordination Set and Conformational Flexibility

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Supplementary Information

Experimental Section

Materials and Methods: N-α-Fmoc-protected amino acids, PyBOP and resins were obtained from Novabiochem. Other reagents for peptide synthesis, solvents, buffers and metal salts were purchased from Sigma-Aldrich. HPLC analyses and purifications were performed on a VWR LaPrep system. ESI-MS analyses were performed on a Thermo LXQ spectrometer. UV-Vis spectra were recorded on a Perkin-Elmer Lambda 35 spectrophotometer or on a Cary 50 spectrophotometer. CD spectra were recorded on an Applied Photophysics Chirascan spectropolarimeter or on a Biologic MOS-450 AF-CD spectropolarimeter. Fluorescence emission spectra were recorded on Perkin-Elmer LS-50B or Cary Eclipse fluorescence spectrometers. UV-Vis, CD and fluorescence spectrometers are equipped with a thermo-regulated cell holder. All buffer or metal solutions were prepared with MilliQ water (Millipore) and purged with argon. Buffer solutions were treated with Chelex 100 resin (Biorad) to remove metal traces. $CoSO_4$, $Zn(ClO_4)_2$ and $ZnCl_2$ (99.999%) stock solutions were prepared by dissolving the metal salt in water. Their precise concentration was determined by colorimetric EDTA titration.[1]

Peptide synthesis: L_{HSP} and CP1 variants were assembled manually by solid-phase peptide synthesis on 2-chlorotrityl chloride and NovaPeG Rink Amide resins, respectively, using Fmoc chemistry with PyBOP activation as previously described.[2, 3] The peptides were purified by RP-HPLC (PurospherStar RP18e 5µm C18 particles, 50 mm × 25 mm, solvent A = H_2O/TFA 99.9:0.1, solvent B = CH_3CN/H_2O/TFA 90:10:0.1, flow rate 30 mL/min, gradient 5 to 70% B in 28 min). Analytical RP-HPLC (PurospherStar RP18e 5µm C18 particles, 150 mm × 4.6 mm, gradient 5 to 50% B in 28 min) were performed at 1.0 mL/min with UV monitoring at 214 nm. L_{HSP}(HCCC): t_R(analytical) = 16.7 min; ESI-MS m/z = 1171.6 $[M+2H]^{2+}$, 781.4 $[M+3H]^{3+}$, 586.3 $[M+4H]^{4+}$ (calculated: 1171.55 $[M+2H]^{2+}$, 781.36

$[M+3H]^{3+}$, 586.27 $[M+4H]^{4+}$). L_{HSP}(CHCC): t_R(analytical) = 16.5 min; ESI-MS m/z = 1171.6 $[M+2H]^{2+}$, 781.4 $[M+3H]^{3+}$, 586.3 $[M+4H]^{4+}$ (calculated: 1171.55 $[M+2H]^{2+}$, 781.36 $[M+3H]^{3+}$, 586.27 $[M+4H]^{4+}$). L_{HSP}(HHCC): t_R(analytical) = 16.2 min; ESI-MS m/z = 1188.7 $[M+2H]^{2+}$, 792.8 $[M+3H]^{3+}$, 594.8 $[M+4H]^{4+}$ (calculated: 1188.59 $[M+2H]^{2+}$, 792.72 $[M+3H]^{3+}$, 594.79 $[M+4H]^{4+}$).

Absorbance, CD and fluorescence titrations: The peptides were dissolved in the buffer under an argon atmosphere. The concentration of the peptide was determined by measuring cysteine free thiol concentration using Ellman's reagent.[4] TCEP was added to the peptide solution (0.25-1.0 mM) to prevent the formation of disulfide during long titrations. Titrations were performed at 298 K under argon by adding aliquots of a degassed metal stock solution to a rubber-sealed quartz cell (0.4 cm or 1 cm path length) containing the peptide solution. UV-Vis spectra were recorded every 1 nm at a scan rate of 240 nm/min. The CD signal was recorded every 1 nm with a 2 s signal averaging for each point. Each spectrum was recorded twice and averaged. Fluorescence emission spectra were recorded at 298 K from 290 nm to 480 nm (1 nm step) with excitation of the tyrosine chromophore at 280 nm. For L_{HSP}(HCCC) and L_{HSP}(CHCC) which form only 1:1 complexes, the Zn^{2+} binding constants were derived from competition experiments as previously described.[3, 5] For L_{HSP}(HHCC), both SPECFIT[6] and HySS2009[7] were used to determine the formation constant of the 1:1 and 1:2 complex. SPECFIT/32 was used to analyze the direct titration and the EDTA competition independently. This yielded allowed to estimate $K_{1:1}$ from the competition with EDTA and $K_{1:2}$ was estimated from the direct titration. These constants were further refined by simulating the two titrations with the same set of parameters with HySS2009.

NMR Spectroscopy and structure calculations: All of the NMR experiments were performed as previously described.[2, 5] The structures of Zn·L_{HSP}(CHCC) and Zn·L_{HSP}(HCCC) were calculated as described previously[5] using the program XPLOR 3.851[8] with H-H distance constraints derived from NOESY spectra (300 ms mixing time) and ϕ and χ^1 dihedral restraints derived from 1D ^{1}H spectra or from 2D soft-COSY experiments. In house modifications were incorporated in the topology and parameter files for zinc binding to cysteines and histidines in a tetrahedral geometry with 2.33 Å and 2.00 Zn-S and Zn-N bonds, respectively, 109.4°, 109.4°, 105° and 125° S-Zn-S and S-Zn-N, Zn-S-C and Zn-N-C angles, respectively. Structures selected for analysis had no NOE violations greater than 0.3 Å and no dihedral angle violations greater than 5°.

Kinetic measurements: Rate constants for the oxidation of the zinc complexes were obtained according to the procedure described previously. A solution of the zinc complex (≈1

mM) was prepared by dissolving the peptide in H_2O (the precise concentration was determined using DTNB assay[4]), adding 1.1 eq. of $ZnCl_2$ and adjusting the pH to 7.0 with NaOH. The complex was diluted to 5-10 µM in phosphate buffer 100 mM pH 8.0, with EGTA (0.5 mM) for the $Zn(Cys)_4$ models. Excess H_2O_2 was added and the time dependence of the UV (220 nm) or fluorescence (λ_{em} = 305 nm, λ_{ex} =280 nm) signal was recorded. The kinetic traces were fitted with a single exponential, except for Zn·CP1(CCHC) for which bi-exponential fit was required, as stated above in the text. Plots of the observed first order rate constant k^{obs} against $[H_2O_2]$ yielded the second order rate constant k, which was determined at nine different temperatures in the range 287-331 K (the same cell holder, whose temperature was set using a Peltier apparatus, was used for fluorescence and UV-Vis measurements). The activation parameters $\Delta H^{\neq}$ and $\Delta S^{\neq}$ were drawn from Eyring plots.

Co^{2+} titrations

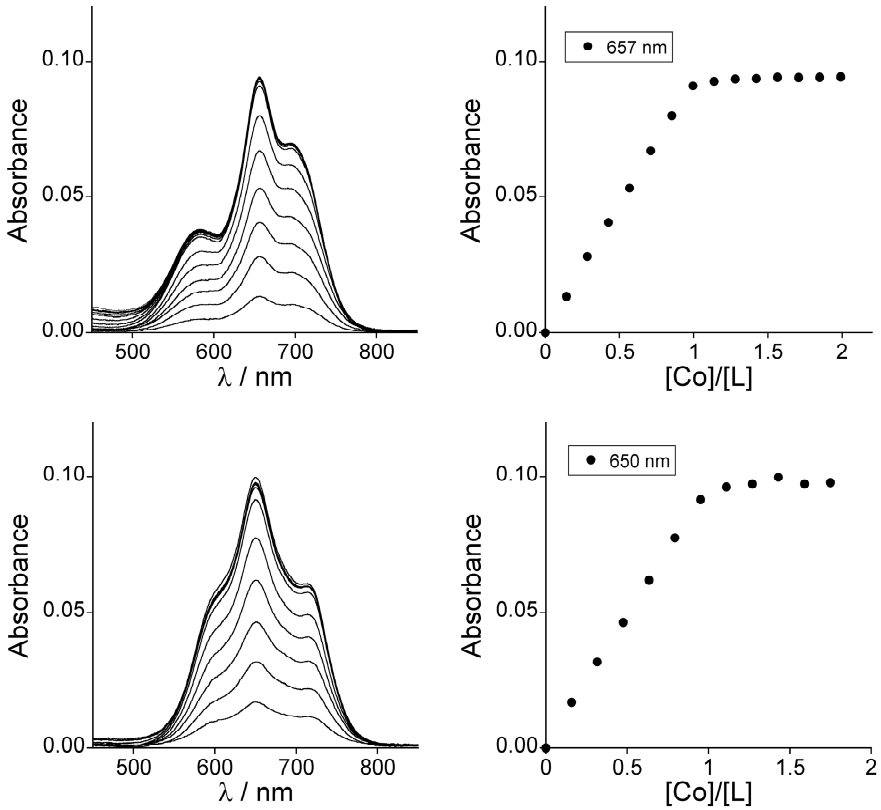


Fig. S1. UV-Vis Titration of L_{HSP}(HCCC) 135 µM (top) and L_{HSP}(CHCC) 138 µM (bottom) by $CoSO_4$, BisTris 100 mM / KCl 100 mM pH 7.0, TCEP 270 µM, 298K. Spectra were corrected for dilution.

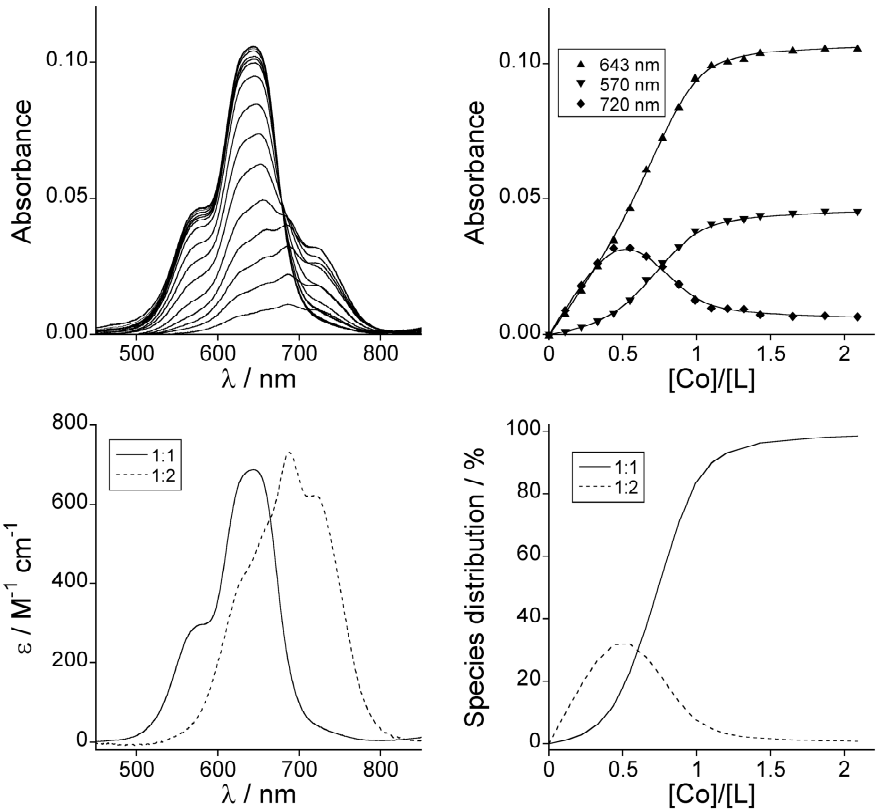


Fig. S2. UV-Vis Titration of L_{HSP}(HHCC) 155 µM (bottom) by $CoSO_4$, BisTris 100 mM / KCl 100 mM pH 7.0, TCEP 270µM, 298K. Spectra were corrected for dilution. The fit obtained with SPECFIT/32[6] is displayed as solid lines on top-right panel. The spectra of the 1:2 and 1:1 complexes derived from the fit are displayed on bottom-left panel and the species distribution during the titration is on bottom-right panel. The fit yields log $K_{1:1}$ = 7.6 (2) and log $K_{1:2}$ = 12.4 (2).

Zn^{2+} titrations

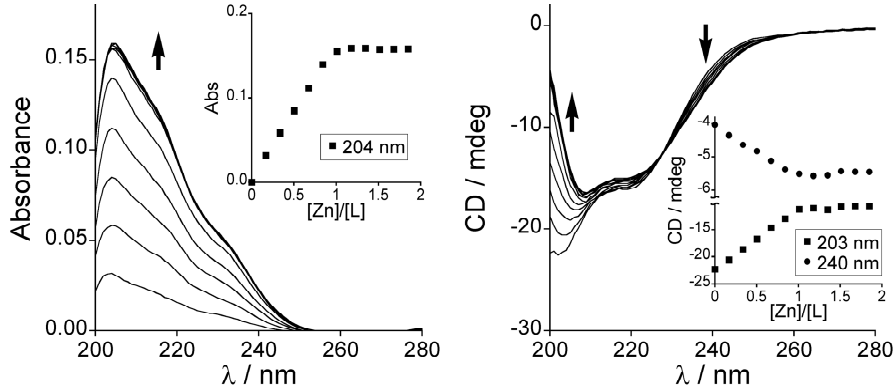


Fig. S3. UV-Vis (left) and CD (right) titrations of L_{HSP}(CHCC) (21 µM) by Zn^{2+} in phosphate buffer 20 mM pH 7.0, TCEP 250 µM, 298 K (path length = 0.4 cm). (Insets) Evolution of the UV or CD signal against metal/peptide ratio. For UV-Vis, the spectrum of the free peptide was subtracted from each spectrum. All spectra were corrected for dilution.

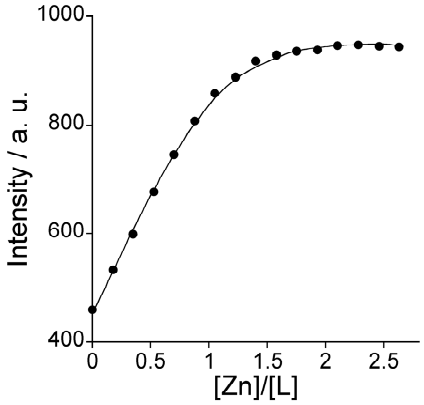


Fig. S4. Fluorescence titration of L_{HSP}(HCCC) (17 µM) and EDTA (17 µM) by Zn^{2+} in phosphate buffer 100 mM pH 7.0, TCEP 250 µM, 298 K. Excitation and emission wavelength were 280 nm and 305 nm, respectively. Data were corrected for dilution. The solid line corresponds to the fit obtained with SPECFIT/32[6] which yielded log $K_{1:1}$ = 14.2 (2) using log K_{ZnEDTA} = 13.1.

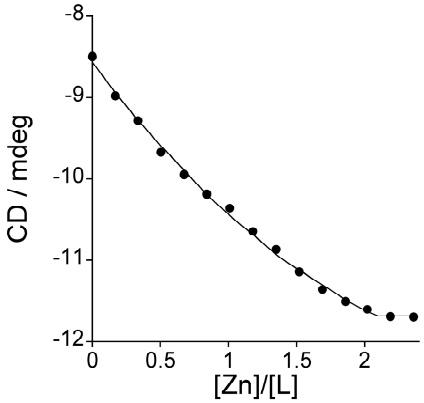


Fig. S5. CD titration of L_{HSP}(CHCC) (42 µM) and EDTA (46 µM) by Zn^{2+} in phosphate buffer 100 mM pH 7.0, TCEP 250 µM, 298 K. The evolution of CD signal at 238 nm is presented. Data were corrected for dilution. The solid line corresponds to the fit obtained that yielded log $K_{1:1}$ = 13.5 (2) using log K_{ZnEDTA} = 13.1.

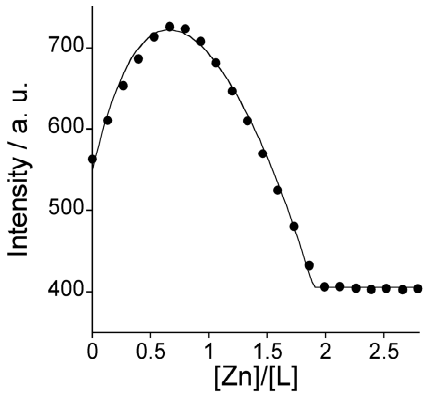


Fig. S6. Fluorescence titration of L_{HSP}(HHCC) (27 µM) and EDTA (24 µM) by Zn^{2+} in phosphate buffer 100 mM pH 7.0, TCEP 250 µM, 298 K. Excitation and emission wavelength were 280 nm and 308 nm, respectively. Data were corrected for dilution. The solid line corresponds to the fit obtained by using SPECFIT/32[6] and HySS2009[7] which yielded log $K_{1:1}$ = 13.4 (1) and log $K_{1:2}$ = 17.6 (2). The binding constant of the Zn·EDTA complex at pH 7.0 ($10^{13.1}$) was introduced in the fit.

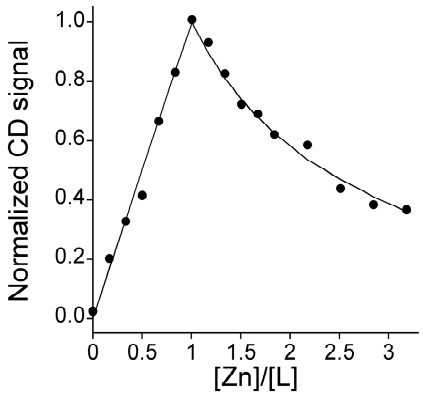


Fig. S7. CD titration of $L_{HSP}(CCCC)^{lin}$ (28 µM) by Zn^{2+} in 20 mM phosphate buffer pH 7.0, TCEP 250 µM, 298 K. The solid line correspond to the fit obtained with SPECFIT/32 with formation of 1:1 and 3:2 zinc/peptide complexes (the data could also be satisfactorily fitted with 4:3, 5:4, … complexes instead of the 3:2 complex). The 1:1 binding constant $K_{1:1}$ was set to $10^{13.5}$. This value was derived from competition with EDTA. The normalized evolution of CD signal at 230 nm is presented. Data were corrected for dilution.

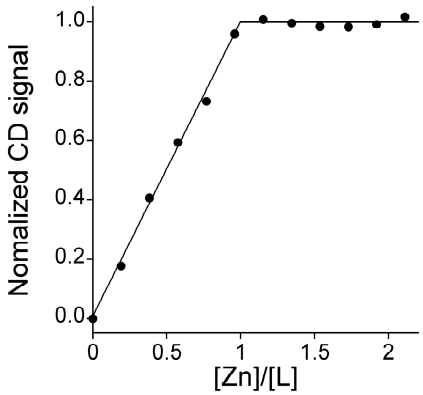


Fig. S8. CD titration of $L_{HSP}(CCCC)^{lin}$ (25 µM) and EGTA (100 µM) by Zn^{2+} in phosphate buffer 100 mM pH 7.0, TCEP 250 µM, 298 K. The normalized evolution of CD signal at 230 nm is presented. Data were corrected for dilution.

ESI/MS monitoring of the oxidation of Zn·CP1(CCHC) by H_2O_2

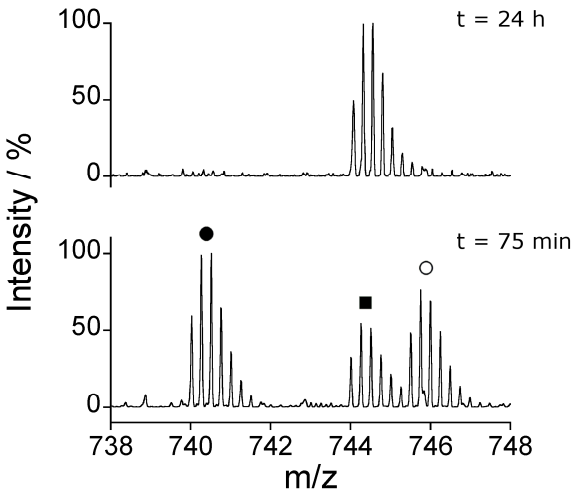


Fig. S9. ESI/MS monitoring of the oxidation of Zn·CP1(CCHC) by H_2O_2 20 mM in phosphate buffer pH 8.0. The region corresponding to the tetra-charged sulfinic and sulfonic acid peptide is shown. ● and ○: $[M+4H]^{4+}$ and $[M+3H+Na]^{4+}$ peaks correspondin to CP1(CCHC)(-SS-, $-SO_2H$) (disulfide + silfinic acid). ■: $[M+4H]^{4+}$ peak corresponding to CP1(CCHC)(-SS-, $-SO_3H$) (disulfide + sulfonic acid).

NMR spectra of the Zn·CP1 complexes

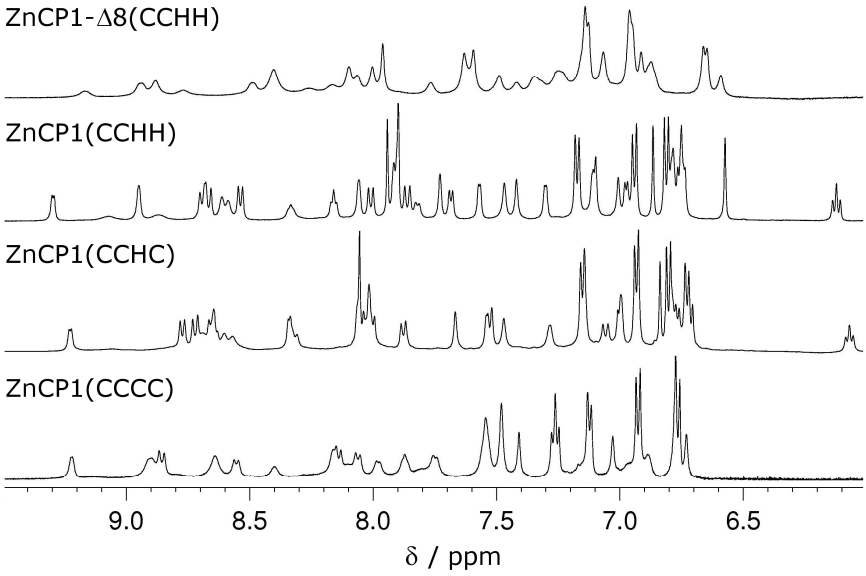
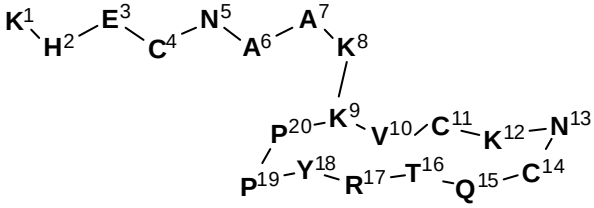


Fig. S10. NH and aromatic region of the ^1H NMR spectra (500 MHz) of the the Zn·CP1 complexes (≈ 2 mM in H_2O/D_2O 9:1 pH 6.5 at 298 K).

NMR characterization of the Zn·L_{HSP} complexes



Scheme S1. Numbering of amino-acids for the NMR data of L_{HSP}(HCCC).

Table S1. ^{1}H NMR (500 MHz) chemical shifts δ (ppm) for Zn·L_{HSP}(HCCC) in H_2O/D_2O 9:1 (pH 6.2) at 298 K.[a]

Residue	HN	Hα	Hβ	Others
Ac		2.03		
LYS 1	8.34	4.30	1.76	CH_2(γ): 1.41; CH_2(δ): 1.68; CH_2(ε): 2.98
HIS 2	8.51	4.69	3.13	ImH(2), 6.81; ImH(4): 7.95
GLU 3	8.44	4.24	1.82	CH_2(γ): 2.04, 2.15
CYS 4	8.32	4.41	2.37 (*pro-S*), 2.90 (*pro-R*)	
ASN 5	7.73	4.25	2.76, 3.02	NH_2(δ), 6.77, 7.49
ALA 6	8.25	3.26	1.20	
ALA 7	7.86	4.08	1.34	
LYS 8	7.67	4.21	1.96	CH_2(γ): 1.38, 1.45; CH_2(δ): 1.64; CH_2(ε): 2.96
LYS 9	7.71	4.41	1.97	CH_2(γ): 1.15; CH_2(δ): 1.52; CH_2(ε): 2.94, 3.40; NH(ζ): 7.35
VAL 10	8.42	4.48	1.82	CH_3(γ): 0.69, 0.79
CYS 11	8.80	4.46	2.94 (*pro-S*), 3.27 (*pro-R*)	
LYS 12	9.07	4.11	1.88	CH_2(γ): 1.55; CH_2(δ): 1.74; CH_2(ε): 3.06
ASN 13	8.86	4.57	2.00, 2.20	NH_2(δ), 6.91, 7.81
CYS 14	8.08	4.89	3.36 (*pro-S*), 2.63 (*pro-R*)	
GLN 15	8.01	4.00	2.26, 2.37	CH_2(γ): 2.19, 2.26; NH_2(ε), 6.52, 7.22
THR 16	8.14	3.96	3.76	CH_3(γ): 0.73, OH(γ): 4.46
ARG 17	8.26	4.85	1.66	CH_2(γ): 1.44; CH_2(δ): 3.13, 3.23; NH(ε): 7.30
TYR 18	9.16	4.90	2.84, 2.90	CH(δ): 6.90; CH(ε): 6.67
^{D}PRO 19	-	4.76	1.93 (*pro-S*), 2.26 (*pro-R*)	CH_2(γ): 1.99, 2.11; CH_2(δ): 3.39, 3.78
PRO 20	-	4.42	1.98 (*pro-R*), 2.26 (*pro-S*)	CH_2(γ): 2.07; CH_2(δ): 3.74, 4.07

[a] Chemical shifts are measured relative to internal DSS.

Table S2. $^{3}J_{HN,H\alpha}$ coupling constants (Hz) for Zn·L_{HSP}(HCCC) in H_2O/D_2O 9:1 (pH 6.2) at 298 K.

LYS 1	HIS 2	GLU 3	CYS 4	ASN 5	ALA 6	ALA 7	LYS 8	LYS 9
6.7	5.9	-	7.4	<6	<4	5.9	7.7	8.4
VAL 10	CYS 11	LYS 12	ASN 13	CYS 14	GLN 15	THR 16	ARG 17	TYR 18
9.9	5.3	4.4	8.4	9.7	7.4	5.4	8.2	9.9

Table S3. $^{3}J_{H\alpha,H\beta}$ coupling constants (Hz) for Zn·L_{HSP}(HCCC) in D_2O at 298 K.

CYS 4		CYS 11		CYS 14	
pro-R	*pro-S*	*pro-R*	*pro-S*	*pro-R*	*pro-S*
9.1	4.5	12.4	4.9	3.0	4.9

Table S4. NOE-derived distances (Å) used for calculations with XPLOR for Zn·L_{HSP}(HCCC).

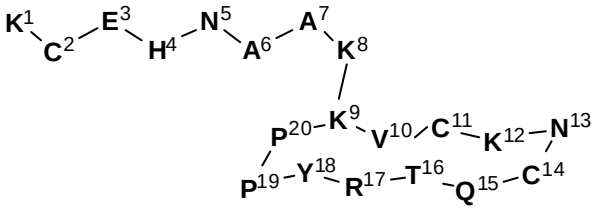
LYS	1	HN	LYS	1	HA	3.30	CYS	11	HB2	CYS	11	HA	2.35
LYS	1	HN	LYS	1	HB*	3.45	CYS	11	HN	CYS	11	HA	3.87
LYS	1	HN	HIS	2	HA	3.30	CYS	11	HN	CYS	11	HB1	2.37
HIS	2	HD2	LYS	1	HA	3.79	CYS	11	HN	CYS	11	HB2	2.47
HIS	2	HN	LYS	1	HA	2.71	CYS	11	HB1	GLN	15	HA	3.07
HIS	2	HB*	HIS	2	HA	2.54	CYS	11	HN	GLN	15	HA	3.42
HIS	2	HD2	HIS	2	HA	3.51	CYS	11	HN	GLN	15	HN	3.34
HIS	2	HD2	HIS	2	HB*	2.86	CYS	11	HN	THR	16	HB	4.00
HIS	2	HE1	HIS	2	HB*	4.81	CYS	11	HN	THR	16	HN	3.38
HIS	2	HN	HIS	2	HA	3.19	CYS	11	HN	ARG	17	HA	2.98
HIS	2	HN	HIS	2	HB*	3.42	CYS	11	HN	TYR	18	HD*	3.85
HIS	2	HD2	CYS	4	HA	3.10	CYS	11	HN	TYR	18	HE*	3.91
HIS	2	HD2	CYS	4	HB2	3.39	LYS	12	HN	CYS	11	HA	2.20
HIS	2	HD2	CYS	4	HB1	3.49	LYS	12	HN	CYS	11	HB1	3.99
HIS	2	HE1	CYS	4	HA	3.82	LYS	12	HN	CYS	11	HB2	3.37
HIS	2	HD2	ASN	13	HB*	3.64	LYS	12	HN	LYS	12	HA	2.92
HIS	2	HE1	ASN	13	HB*	3.26	LYS	12	HN	LYS	12	HB*	2.86
HIS	2	HD2	CYS	14	HB1	3.50	LYS	12	HN	LYS	12	HD*	6.27
HIS	2	HE1	CYS	14	HA	4.24	LYS	12	HN	LYS	12	HG*	3.31
HIS	2	HE1	CYS	14	HB1	2.63	LYS	12	HN	ASN	13	HA	3.79
GLU	3	HN	HIS	2	HA	2.90	LYS	12	HN	ASN	13	HN	2.81
GLU	3	HN	HIS	2	HB*	3.78	ASN	13	HN	CYS	11	HA	3.64
GLU	3	HB*	GLU	3	HA	3.20	ASN	13	HN	CYS	11	HB1	3.57
GLU	3	HN	GLU	3	HA	3.32	ASN	13	HN	CYS	11	HB2	3.32
GLU	3	HN	GLU	3	HB*	3.96	ASN	13	HN	LYS	12	HA	3.27
CYS	4	HN	HIS	2	HD2	4.61	ASN	13	HN	LYS	12	HB*	3.55
CYS	4	HN	GLU	3	HA	2.21	ASN	13	HN	LYS	12	HG*	4.14
CYS	4	HN	GLU	3	HB*	3.72	ASN	13	HB*	ASN	13	HA	2.64
CYS	4	HN	GLU	3	HG*	4.18	ASN	13	HN	ASN	13	HA	2.69
CYS	4	HB2	CYS	4	HA	2.97	ASN	13	HN	ASN	13	HB*	2.70
CYS	4	HB1	CYS	4	HA	2.52	ASN	13	HD22	ASN	13	HA	3.87
CYS	4	HN	CYS	4	HA	2.98	ASN	13	HD22	ASN	13	HB*	4.21
CYS	4	HN	CYS	4	HB2	3.14	ASN	13	HN	CYS	14	HN	2.46
CYS	4	HN	CYS	4	HB1	2.96	ASN	13	HN	GLN	15	HN	3.53
CYS	4	HB1	ASN	5	HA	4.00	CYS	14	HN	CYS	11	HB1	2.85
CYS	4	HN	ASN	5	HN	3.44	CYS	14	HN	CYS	11	HB2	3.54
CYS	4	HB1	THR	16	HB	3.37	CYS	14	HN	ASN	13	HA	3.46
ASN	5	HN	CYS	4	HA	2.30	CYS	14	HN	ASN	13	HB*	2.84
ASN	5	HN	CYS	4	HB2	3.39	CYS	14	HB2	CYS	14	HA	2.17
ASN	5	HN	CYS	4	HB1	3.33	CYS	14	HB1	CYS	14	HA	2.49
ASN	5	HB*	ASN	5	HA	2.61	CYS	14	HN	CYS	14	HA	2.86
ASN	5	HN	ASN	5	HA	3.08	CYS	14	HN	CYS	14	HB2	3.09
ASN	5	HN	ASN	5	HB*	3.96	CYS	14	HN	CYS	14	HB1	2.80
ASN	5	HD21	ASN	5	HB*	3.37	CYS	14	HN	GLN	15	HB*	4.03
ASN	5	HD22	ASN	5	HA	4.04	GLN	15	HN	VAL	10	HG*	4.65
ASN	5	HD22	ASN	5	HB*	2.90	GLN	15	HN	CYS	11	HB1	2.84
ASN	5	HD21	ALA	7	HB*	4.69	GLN	15	HN	CYS	11	HB2	3.65
ASN	5	HD22	ALA	7	HB*	5.30	GLN	15	HN	LYS	12	HA	3.56
ASN	5	HD21	LYS	8	HD*	4.98	GLN	15	HE22	LYS	12	HA	3.94
ASN	5	HD21	LYS	8	HG*	4.41	GLN	15	HE21	LYS	12	HA	4.27
ALA	6	HB*	ASN	5	HA	4.41	GLN	15	HN	ASN	13	HB*	5.87
ALA	6	HN	ASN	5	HA	2.50	GLN	15	HB*	CYS	14	HA	3.61
ALA	6	HN	ASN	5	HB*	2.74	GLN	15	HN	CYS	14	HA	3.12
ALA	6	HN	ALA	6	HA	2.86	GLN	15	HN	CYS	14	HB2	3.21
ALA	6	HN	ALA	6	HB*	3.04	GLN	15	HN	CYS	14	HB1	3.07
ALA	7	HB*	ALA	7	HA	2.82	GLN	15	HB*	GLN	15	HA	2.40
ALA	6	HB*	ALA	7	HA	4.57	GLN	15	HG*	GLN	15	HA	3.15
ALA	6	HN	ALA	7	HB*	5.64	GLN	15	HN	GLN	15	HA	2.08
ALA	6	HN	ALA	7	HN	3.19	GLN	15	HN	GLN	15	HB*	3.14

ALA	6	HN	LYS	8	HN	3.07
ALA	6	HB*	TYR	18	HA	4.52
ALA	6	HB*	TYR	18	HB*	3.73
ALA	6	HN	TYR	18	HD*	4.40
ALA	6	HN	TYR	18	HE*	4.83
ALA	7	HN	ASN	5	HA	3.72
ALA	7	HN	ASN	5	HB*	3.60
ALA	7	HN	ALA	6	HA	3.26
ALA	7	HN	ALA	6	HB*	3.55
ALA	7	HN	ALA	7	HA	2.82
ALA	7	HN	ALA	7	HB*	2.95
ALA	7	HN	LYS	8	HN	2.40
ALA	7	HN	LYS	9	HZ1	4.11
LYS	8	HN	ALA	6	HA	4.10
LYS	8	HN	ALA	6	HB*	4.89
LYS	8	HN	ALA	7	HA	3.10
LYS	8	HN	ALA	7	HB*	3.63
LYS	8	HB*	LYS	8	HA	3.14
LYS	8	HD*	LYS	8	HA	3.02
LYS	8	HG*	LYS	8	HA	2.76
LYS	8	HN	LYS	8	HA	2.88
LYS	8	HN	LYS	8	HB*	3.12
LYS	8	HN	LYS	8	HD*	3.04
LYS	8	HN	LYS	8	HG*	3.05
LYS	8	HN	LYS	9	HZ1	2.66
LYS	9	HZ1	ALA	6	HA	4.02
LYS	9	HZ1	ALA	7	HA	4.94
LYS	9	HZ1	LYS	8	HA	3.14
LYS	9	HZ1	LYS	8	HB*	4.20
LYS	9	HZ1	LYS	8	HD*	3.93
LYS	9	HD*	LYS	9	HA	3.05
LYS	9	HG*	LYS	9	HA	3.22
LYS	9	HN	LYS	9	HA	3.61
LYS	9	HN	LYS	9	HB*	2.39
LYS	9	HN	LYS	9	HD*	3.64
LYS	9	HN	LYS	9	HG*	3.96
LYS	9	HZ1	LYS	9	HD*	2.85
LYS	9	HZ1	LYS	9	HE*	2.77
LYS	9	HZ1	LYS	9	HG*	4.36
LYS	9	HN	TYR	18	HB*	3.83
LYS	9	HN	PRO	20	HB*	4.44
LYS	9	HN	PRO	20	HD*	3.01
VAL	10	HG*	LYS	9	HA	4.85
VAL	10	HN	LYS	9	HA	2.10
VAL	10	HN	LYS	9	HB*	3.70
VAL	10	HN	LYS	9	HD*	3.38
VAL	10	HN	LYS	9	HG*	3.41
VAL	10	HN	LYS	9	HN	4.20
VAL	10	HB	VAL	10	HA	2.86
VAL	10	HG*	VAL	10	HA	3.17
VAL	10	HG*	VAL	10	HB	2.76
VAL	10	HN	VAL	10	HA	2.83
VAL	10	HN	VAL	10	HB	2.55
VAL	10	HN	VAL	10	HG*	3.73
VAL	10	HG*	LYS	12	HA	5.34
VAL	10	HG*	GLN	15	HA	3.33
VAL	10	HG*	ARG	17	HA	3.99
CYS	11	HN	LYS	9	HD*	4.15
CYS	11	HN	LYS	9	HG*	5.45
CYS	11	HN	VAL	10	HA	2.06
GLN	15	HN	GLN	15	HG*	3.66
GLN	15	HN	GLN	15	HE21	4.86
GLN	15	HN	GLN	15	HE22	4.51
GLN	15	HE22	GLN	15	HG*	4.76
GLN	15	HN	THR	16	HB	4.97
THR	16	HN	CYS	11	HB1	2.55
THR	16	HN	CYS	11	HB2	3.13
THR	16	HN	CYS	14	HA	4.42
THR	16	HN	CYS	14	HB2	3.50
THR	16	HN	CYS	14	HB1	3.53
THR	16	HN	GLN	15	HB*	3.92
THR	16	HG2*	THR	16	HA	3.20
THR	16	HG2*	THR	16	HB	3.18
THR	16	HN	THR	16	HA	2.55
THR	16	HN	THR	16	HB	2.48
THR	16	HN	THR	16	HG2*	4.04
ARG	17	HN	THR	16	HA	2.07
ARG	17	HN	THR	16	HB	3.67
ARG	17	HN	THR	16	HG2*	3.14
ARG	17	HB*	ARG	17	HA	2.57
ARG	17	HE	ARG	17	HD*	3.95
ARG	17	HG*	ARG	17	HA	3.59
ARG	17	HN	ARG	17	HA	2.69
ARG	17	HN	ARG	17	HB*	2.52
ARG	17	HN	ARG	17	HG*	3.77
TYR	18	HD*	LYS	9	HA	4.12
TYR	18	HE*	CYS	4	HA	4.43
TYR	18	HE*	CYS	4	HB*	4.33
ASN	5	HD21	ASN	5	HA	4.85
TYR	18	HE*	ASN	5	HA	4.83
TYR	18	HE*	ASN	5	HA	3.51
TYR	18	HD*	ALA	6	HA	3.40
TYR	18	HD*	ALA	6	HB*	3.72
TYR	18	HE*	ALA	6	HB*	4.81
TYR	18	HD*	LYS	9	HB*	3.83
TYR	18	HD*	LYS	9	HD*	3.41
TYR	18	HN	LYS	9	HB*	3.62
TYR	18	HN	LYS	9	HN	3.25
TYR	18	HD*	VAL	10	HA	3.65
TYR	18	HE*	VAL	10	HA	4.24
TYR	18	HN	VAL	10	HA	2.99
TYR	18	HN	VAL	10	HG*	5.10
TYR	18	HE*	CYS	11	HB1	3.44
TYR	18	HE*	CYS	11	HB2	2.81
TYR	18	HD*	THR	16	HG2*	4.63
TYR	18	HE*	THR	16	HB	3.24
TYR	18	HE*	THR	16	HG2*	4.03
TYR	18	HN	ARG	17	HA	2.12
TYR	18	HN	ARG	17	HB*	3.20
TYR	18	HN	ARG	17	HG*	3.85
TYR	18	HN	ARG	17	HN	3.72
TYR	18	HB*	TYR	18	HA	2.55
TYR	18	HD*	TYR	18	HA	2.81
TYR	18	HD*	TYR	18	HB*	2.54
TYR	18	HN	TYR	18	HA	3.20
TYR	18	HN	TYR	18	HB*	2.88
TYR	18	HN	TYR	18	HD*	3.15
TYR	18	HN	TYR	18	HE*	4.31
TYR	18	HN	PRO	19	HA	3.68
TYR	18	HN	PRO	19	HD*	3.62

CYS	11	HN	VAL	10	HB	3.76		PRO	19	HD*	TYR	18	HA	2.45
CYS	11	HN	VAL	10	HG*	3.71		PRO	20	HD*	PRO	19	HA	2.32
CYS	11	HB1	CYS	11	HA	2.86								

Table S5. Dihedral angle restraints (°) used in calculations with XPLOR for Zn·L_{HSP}(HCCC).

CYS	2	C	GLU	3	N	GLU	3	CA	GLU	3	C	-120	-160	-80
GLU	3	C	CYS	4	N	CYS	4	CA	CYS	4	C	-120	-160	-80
ALA	6	C	ALA	7	N	ALA	7	CA	ALA	7	C	-65	-90	-40
ALA	7	C	LYS	8	N	LYS	8	CA	LYS	8	C	-120	-160	-80
PRO	20	C	LYS	9	N	LYS	9	CA	LYS	9	C	-120	-160	-80
VAL	10	C	CYS	11	N	CYS	11	CA	CYS	11	C	-65	-90	-40
CYS	11	C	LYS	12	N	LYS	12	CA	LYS	12	C	-65	-90	-40
LYS	12	C	ASN	13	N	ASN	13	CA	ASN	13	C	-120	-160	-80
ASN	13	C	CYS	14	N	CYS	14	CA	CYS	14	C	-120	-160	-80
THR	16	C	ARG	17	N	ARG	17	CA	ARG	17	C	-120	-160	-80
ARG	17	C	TYR	18	N	TYR	18	CA	TYR	18	C	-120	-160	-80
CYS	2	N	CYS	2	CA	CYS	2	CB	CYS	2	SG	-60	-90	-30
HIS	4	N	HIS	4	CA	HIS	4	CB	HIS	4	CG	-60	-90	-30
CYS	11	N	CYS	11	CA	CYS	11	CB	CYS	11	SG	180	150	210
CYS	14	N	CYS	14	CA	CYS	14	CB	CYS	14	SG	60	30	90
CYS	14	N	CYS	14	CA	CYS	14	CB	CYS	14	SG	60	30	90



Scheme S2. Numbering of amino-acids for the NMR data of L_{HSP}(CHCC).

Table S6. ^{1}H NMR (500 MHz) chemical shifts δ (ppm) for Zn·L_{HSP}(CHCC) in H_2O/D_2O 9:1 (pH 6.2) at 298 K.[a]

Residue	HN	Hα	Hβ	Others
Ac		2.00		
LYS 1	8.15	4.33	1.73	CH_2(γ): 1.35; CH_2(δ): 1.64; CH_2(ε): 2.95
CYS 2	8.30	4.13	2.45 (*pro-S*), 2.32 (*pro-R*)	ImH(2), 6.81; ImH(4): 7.95
GLU 3	8.45	4.13	1.83, 1.95	CH_2(γ): 2.05, 2.13
HIS 4	8.63	3.97	2.72 (*pro-S*), 1.93 (*pro-R*)	ImH(2), 6.61; ImH(4): 7.72
ASN 5	8.03	4.77	2.76, 2.88	NH_2(δ), 7.07, 7.77
ALA 6	9.16	4.18	1.55	
ALA 7	8.21	4.22	1.46	
LYS 8	7.61	4.34	1.80, 2.10	CH_2(γ): 1.37, 1.46; CH_2(δ): 1.71; CH_2(ε): 2.99
LYS 9	7.70	4.34	0.85	CH_2(γ): 1.16, 1.36; CH_2(δ): 1.71; CH_2(ε): 2.86, 3.49; NH(ζ): 7.41
VAL 10	8.15	4.29	1.73	CH_3(γ): 0.63, 0.73
CYS 11	8.68	4.58	2.76 (*pro-S*), 3.30 (*pro-R*)	
LYS 12	9.19	4.18	1.94	CH_2(γ): 1.57; CH_2(δ): 1.76; CH_2(ε): 3.08
ASN 13	9.12	4.75	2.74, 3.01	NH_2(δ), 7.00, 7.89
CYS 14	8.15	4.99	3.37 (*pro-S*), 2.60 (*pro-R*)	
GLN 15	8.01	4.02	2.32	CH_2(γ): 2.23; NH_2(ε), 6.59, 7.32
THR 16	8.11	4.25	3.84	CH_3(γ): 1.01
ARG 17	8.60	4.83	1.70, 1.80	CH_2(γ): 1.44, 1.61; CH_2(δ): 3.12, 3.18; NH(ε): 7.24
TYR 18	8.56	4.94	2.72	CH(δ): 6.64; CH(ε): 6.27
^{D}PRO 19	-	4.60	1.83 (*pro-S*), 2.31 (*pro-R*)	CH_2(γ): 2.01, 2.15; CH_2(δ): 3.55, 3.85
PRO 20	-	4.42	1.86 (*pro-R*), 2.13 (*pro-S*)	CH_2(γ): 2.09; CH_2(δ): 3.71, 3.86

[a] Chemical shifts are measured relative to internal DSS.

Table S7. $^{3}J_{HN,H\alpha}$ coupling constants (Hz) for Zn·L_{HSP}(CHCC) in H_2O/D_2O 9:1 (pH 6.2) at 298 K.

LYS 1	CYS 2	GLU 3	CYS 4	ASN 5	ALA 6	ALA 7	LYS 8	LYS 9
-	6.2	8.4	8.5	-	-	4.9	8.8	9.9
VAL 10	CYS 11	LYS 12	ASN 13	CYS 14	GLN 15	THR 16	ARG 17	TYR 18
-	5.0	3.5	8.2	9.5	7.5	-	8.2	9.0

Table S8. $^{3}J_{H\alpha,H\beta}$ coupling constants (Hz) for Zn·L_{HSP}(CHCC) in D_2O at 298 K.

CYS 2		HIS 4		CYS 11		CYS 14	
pro-R	*pro-S*	*pro-R*	*pro-S*	*pro-R*	*pro-S*	*pro-R*	*Pro-S*
4.0	11.3	<4	14.5	12.5	4.1	<4	<4

Table S9. NOE-derived distances (Å) used for calculations with XPLOR for Zn·L_{HSP}(CHCC).

LYS	1	HB*	LYS	1	HA	3.64	CYS	11	HN	THR	16	HB	4.65
LYS	1	HN	LYS	1	HA	3.08	CYS	11	HN	THR	16	HG2*	5.12
LYS	1	HN	LYS	1	HB*	2.89	CYS	11	HN	THR	16	HN	3.11
LYS	1	HN	LYS	1	HD*	4.21	CYS	11	HN	ARG	17	HA	3.44
LYS	1	HN	LYS	1	HG*	3.01	CYS	11	HN	TYR	18	HD*	3.53
CYS	2	HN	LYS	1	HA	2.41	CYS	11	HN	TYR	18	HE*	3.47
CYS	2	HB1	CYS	2	HA	2.85	LYS	12	HN	CYS	11	HA	2.19
CYS	2	HB2	CYS	2	HA	3.10	LYS	12	HN	CYS	11	HB1	4.09
CYS	2	HN	CYS	2	HA	2.88	LYS	12	HN	CYS	11	HB2	4.36
CYS	2	HN	CYS	2	HB1	3.27	LYS	12	HB*	LYS	12	HA	2.80
CYS	2	HN	CYS	2	HB2	2.73	LYS	12	HN	LYS	12	HA	2.83
GLU	3	HN	CYS	2	HB1	3.53	LYS	12	HN	LYS	12	HB*	2.72
GLU	3	HN	CYS	2	HB2	3.51	LYS	12	HN	CYS	14	HN	3.54
GLU	3	HB*	GLU	3	HA	3.00	ASN	13	HB*	CYS	2	HA	3.72
GLU	3	HG*	GLU	3	HA	3.98	ASN	13	HD22	CYS	2	HA	4.31
GLU	3	HN	GLU	3	HA	2.23	ASN	13	HD22	CYS	2	HB2	4.75
GLU	3	HN	GLU	3	HB*	3.37	ASN	13	HD22	CYS	2	HN	3.95
GLU	3	HN	GLU	3	HG*	3.08	ASN	13	HN	CYS	11	HA	2.98
GLU	3	HN	HIS	4	HD2	3.44	ASN	13	HN	CYS	11	HB1	3.72
HIS	4	HD2	CYS	2	HA	3.28	ASN	13	HN	LYS	12	HA	3.11
HIS	4	HD2	CYS	2	HB1	3.36	ASN	13	HN	LYS	12	HB*	3.33
HIS	4	HD2	CYS	2	HB2	3.94	ASN	13	HB*	ASN	13	HA	3.04
HIS	4	HE1	CYS	2	HB1	3.53	ASN	13	HD21	ASN	13	HB*	3.66
HIS	4	HE1	CYS	2	HB2	4.93	ASN	13	HD22	ASN	13	HA	4.17
HIS	4	HN	GLU	3	HA	2.78	ASN	13	HD22	ASN	13	HB*	3.16
HIS	4	HB1	HIS	4	HA	2.71	ASN	13	HN	ASN	13	HA	2.81
HIS	4	HB2	HIS	4	HA	2.93	ASN	13	HN	ASN	13	HB*	2.64
HIS	4	HD2	HIS	4	HA	2.56	ASN	13	HD22	CYS	14	HB1	4.83
HIS	4	HD2	HIS	4	HB1	3.30	ASN	13	HN	CYS	14	HN	2.41
HIS	4	HE1	HIS	4	HB2	4.20	ASN	13	HN	GLN	15	HN	3.19
HIS	4	HN	HIS	4	HA	3.31	CYS	14	HN	CYS	11	HA	3.89
HIS	4	HN	HIS	4	HB1	3.44	CYS	14	HN	CYS	11	HB1	3.17
HIS	4	HN	HIS	4	HB2	3.12	CYS	14	HN	LYS	12	HA	4.21
HIS	4	HN	HIS	4	HD2	3.54	CYS	14	HN	ASN	13	HA	3.36
HIS	4	HD2	CYS	11	HA	3.74	CYS	14	HN	ASN	13	HB*	2.79
HIS	4	HD2	CYS	11	HB1	3.41	CYS	14	HB1	CYS	14	HA	2.47
HIS	4	HD2	CYS	11	HB2	2.51	CYS	14	HB2	CYS	14	HA	2.42
HIS	4	HE1	CYS	11	HB1	5.03	CYS	14	HN	CYS	14	HA	2.93
HIS	4	HE1	CYS	14	HB1	5.24	CYS	14	HN	CYS	14	HB1	2.96
HIS	4	HE1	CYS	14	HB2	4.97	CYS	14	HN	CYS	14	HB2	2.95
HIS	4	HE1	THR	16	HB	3.09	CYS	14	HN	GLN	15	HA	6.96
HIS	4	HE1	THR	16	HG2*	4.00	GLN	15	HN	VAL	10	HG*	5.11
HIS	4	HE1	TYR	18	HE*	4.73	GLN	15	HN	CYS	11	HB1	2.87
ASN	5	HN	HIS	4	HA	2.75	GLN	15	HE22	LYS	12	HA	4.29
ASN	5	HB*	ASN	5	HA	2.83	GLN	15	HN	LYS	12	HA	3.60
ASN	5	HD21	ASN	5	HB*	3.53	GLN	15	HN	ASN	13	HB*	5.36
ASN	5	HD22	ASN	5	HA	3.81	GLN	15	HN	CYS	14	HA	3.24
ASN	5	HD22	ASN	5	HB*	2.97	GLN	15	HN	CYS	14	HB1	4.25
ASN	5	HN	ASN	5	HA	2.87	GLN	15	HN	CYS	14	HB2	3.21
ASN	5	HN	ASN	5	HB*	3.11	GLN	15	HB*	GLN	15	HA	2.37
ASN	5	HD21	ALA	7	HB*	4.27	GLN	15	HG*	GLN	15	HA	3.91
ASN	5	HD22	ALA	7	HB*	5.01	GLN	15	HN	GLN	15	HA	2.13
ALA	6	HN	ASN	5	HA	2.35	GLN	15	HN	GLN	15	HB*	3.21
ALA	6	HN	ASN	5	HB*	3.53	GLN	15	HN	GLN	15	HG*	3.69
ALA	6	HB*	ALA	6	HA	2.99	GLN	15	HN	THR	16	HB	4.50
ALA	6	HN	ALA	6	HA	3.16	THR	16	HN	VAL	10	HG*	5.11
ALA	6	HN	ALA	6	HB*	3.51	THR	16	HN	CYS	11	HB1	2.47
ALA	6	HN	ALA	7	HN	3.58	THR	16	HN	CYS	11	HB2	3.32
ALA	7	HN	ASN	5	HA	3.52	THR	16	HN	GLN	15	HA	2.17

ALA	7	HN	ASN	5	HB*	4.58
ALA	7	HN	ALA	6	HA	5.27
ALA	7	HN	ALA	6	HB*	3.84
ALA	7	HB*	ALA	7	HA	2.82
ALA	7	HN	ALA	7	HA	2.69
ALA	7	HN	ALA	7	HB*	2.97
ALA	7	HN	LYS	8	HN	2.72
ALA	7	HN	LYS	9	HZ1	4.10
LYS	8	HN	ASN	5	HB*	3.78
LYS	8	HN	ALA	6	HB*	4.81
LYS	8	HN	ALA	7	HA	3.08
LYS	8	HB*	LYS	8	HA	2.63
LYS	8	HG*	LYS	8	HA	2.91
LYS	8	HN	LYS	8	HA	2.92
LYS	8	HN	LYS	8	HB*	2.82
LYS	8	HN	LYS	8	HG*	3.02
LYS	8	HN	LYS	9	HZ1	2.54
LYS	9	HZ1	ALA	6	HA	3.36
LYS	9	HZ1	LYS	8	HA	3.15
LYS	9	HZ1	LYS	8	HB*	3.54
LYS	9	HB*	LYS	9	HA	3.44
LYS	9	HD*	LYS	9	HE*	3.88
LYS	9	HG*	LYS	9	HE*	3.21
LYS	9	HG1	LYS	9	HA	2.75
LYS	9	HG2	LYS	9	HA	2.43
LYS	9	HN	LYS	9	HA	2.85
LYS	9	HN	LYS	9	HB*	2.83
LYS	9	HN	LYS	9	HD*	4.37
LYS	9	HN	LYS	9	HG*	2.81
LYS	9	HZ1	LYS	9	HD*	3.40
LYS	9	HZ1	LYS	9	HE*	2.71
LYS	9	HZ1	LYS	9	HG*	3.17
LYS	9	HN	PRO	20	HA	2.90
LYS	9	HN	PRO	20	HB1	3.31
LYS	9	HN	PRO	20	HB2	3.30
LYS	9	HN	PRO	20	HD1	3.71
LYS	9	HN	PRO	20	HD2	2.87
VAL	10	HN	LYS	9	HA	2.24
VAL	10	HN	LYS	9	HB*	3.80
VAL	10	HN	LYS	9	HG*	4.03
VAL	10	HB	VAL	10	HA	3.24
VAL	10	HG*	VAL	10	HA	3.28
VAL	10	HG*	VAL	10	HB	2.69
VAL	10	HN	VAL	10	HA	2.66
VAL	10	HN	VAL	10	HG*	3.88
VAL	10	HG*	GLN	15	HA	3.57
VAL	10	HA	ARG	17	HA	2.85
VAL	10	HG*	ARG	17	HA	4.28
CYS	11	HN	VAL	10	HA	2.13
CYS	11	HN	VAL	10	HB	3.67
CYS	11	HN	VAL	10	HG*	3.67
CYS	11	HB1	CYS	11	HA	3.14
CYS	11	HB2	CYS	11	HA	2.55
CYS	11	HN	CYS	11	HA	2.81
CYS	11	HN	CYS	11	HB1	2.38
CYS	11	HN	CYS	11	HB2	2.51
CYS	11	HB1	GLN	15	HA	3.50
CYS	11	HN	GLN	15	HA	3.72
CYS	11	HN	GLN	15	HN	4.05
CYS	11	HB1	THR	16	HB	4.31
THR	16	HN	GLN	15	HB*	3.98
THR	16	HG2*	THR	16	HA	3.30
THR	16	HG2*	THR	16	HB	3.18
THR	16	HN	THR	16	HA	2.95
THR	16	HN	THR	16	HB	2.54
THR	16	HN	THR	16	HG2*	4.26
THR	16	HG2*	TYR	18	HB*	4.34
ARG	17	HN	VAL	10	HG*	5.02
ARG	17	HN	THR	16	HA	2.15
ARG	17	HN	THR	16	HB	3.31
ARG	17	HN	THR	16	HG2*	3.32
ARG	17	HB*	ARG	17	HA	3.25
ARG	17	HB*	ARG	17	HA	3.59
ARG	17	HN	ARG	17	HB*	2.66
ARG	17	HN	ARG	17	HG*	3.31
TYR	18	HD*	HIS	4	HA	3.34
TYR	18	HD*	HIS	4	HB1	3.73
TYR	18	HE*	HIS	4	HA	3.67
TYR	18	HE*	HIS	4	HB1	4.27
TYR	18	HE*	ASN	5	HB*	3.23
TYR	18	HD*	ALA	6	HA	3.33
TYR	18	HD*	ALA	6	HB*	4.66
TYR	18	HE*	ALA	6	HA	3.15
TYR	18	HD*	LYS	9	HB*	4.70
TYR	18	HD*	LYS	9	HG*	4.61
TYR	18	HE*	LYS	9	HB*	4.27
TYR	18	HE*	LYS	9	HD*	3.88
TYR	18	HE*	LYS	9	HG*	3.61
TYR	18	HN	LYS	9	HB*	4.53
TYR	18	HN	LYS	9	HN	3.18
TYR	18	HD*	VAL	10	HA	3.65
TYR	18	HE*	VAL	10	HA	4.20
TYR	18	HN	VAL	10	HA	2.39
TYR	18	HN	VAL	10	HG*	4.83
TYR	18	HD*	CYS	11	HB1	3.62
TYR	18	HE*	CYS	11	HA	3.04
TYR	18	HE*	CYS	11	HB1	3.57
TYR	18	HD*	THR	16	HB	3.97
TYR	18	HD*	THR	16	HG2*	4.54
TYR	18	HE*	THR	16	HB	3.75
TYR	18	HE*	THR	16	HG2*	5.32
TYR	18	HD*	ARG	17	HA	3.80
TYR	18	HN	ARG	17	HA	2.25
TYR	18	HN	ARG	17	HB*	3.06
TYR	18	HN	ARG	17	HG*	3.40
TYR	18	HB*	TYR	18	HA	2.34
TYR	18	HD*	TYR	18	HA	3.36
TYR	18	HD*	TYR	18	HB*	2.61
TYR	18	HN	TYR	18	HA	3.17
TYR	18	HN	TYR	18	HB*	3.15
TYR	18	HN	TYR	18	HD*	3.04
TYR	18	HN	TYR	18	HE*	4.34
TYR	18	HB*	PRO	19	HD2	3.12
TYR	18	HD*	PRO	19	HA	4.08
TYR	18	HN	PRO	19	HD1	4.03
TYR	18	HN	PRO	19	HD2	4.15
PRO	19	HD1	TYR	18	HA	2.50
PRO	19	HD2	TYR	18	HA	2.32
PRO	20	HD1	PRO	19	HA	2.23
PRO	20	HD2	PRO	19	HA	2.19

Table S10. Dihedral angle restraints (°) used in calculations with XPLOR for Zn·L_{HSP}(CHCC).

CYS	2	C	GLU	3	N	GLU	3	CA	GLU	3	C	-120	-160	-80
GLU	3	C	CYS	4	N	CYS	4	CA	CYS	4	C	-120	-160	-80
ALA	6	C	ALA	7	N	ALA	7	CA	ALA	7	C	-65	-90	-40
ALA	7	C	LYS	8	N	LYS	8	CA	LYS	8	C	-120	-160	-80
PRO	20	C	LYS	9	N	LYS	9	CA	LYS	9	C	-120	-160	-80
VAL	10	C	CYS	11	N	CYS	11	CA	CYS	11	C	-65	-90	-40
CYS	11	C	LYS	12	N	LYS	12	CA	LYS	12	C	-65	-90	-40
LYS	12	C	ASN	13	N	ASN	13	CA	ASN	13	C	-120	-160	-80
ASN	13	C	CYS	14	N	CYS	14	CA	CYS	14	C	-120	-160	-80
THR	16	C	ARG	17	N	ARG	17	CA	ARG	17	C	-120	-160	-80
ARG	17	C	TYR	18	N	TYR	18	CA	TYR	18	C	-120	-160	-80
CYS	2	N	CYS	2	CA	CYS	2	CB	CYS	2	SG	-60	-90	-30
HIS	4	N	HIS	4	CA	HIS	4	CB	HIS	4	CG	-60	-90	-30
CYS	11	N	CYS	11	CA	CYS	11	CB	CYS	11	SG	180	150	210
CYS	14	N	CYS	14	CA	CYS	14	CB	CYS	14	SG	60	30	90

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