Electronic Supplementary Information for Dalton Transactions

ELECTRONIC SUPPLEMENTARY INFORMATION

BINDING OF Ni^{2+} AND Cu^{2+} IONS TO PEPTIDES WITH CYS-HIS MOTIF

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Table 1S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **Ac-nW** Ac-GGKPDLRPCHP-NH_2. Metal to ligand ratio = 1:1.1; [Ni^{2+}] = 0.001 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	10.60(1)	$logK_{NH2\text{-}Lys}$ = 10.60				
H_2L	19.32(1)	$logK_{Cys}$ = 8.72				
H_3L	25.60(1)	$logK_{Nim}$ = 6.28				
H_4L	29.15(1)	$logK_{Asp}$ = 3.55				
NiHL	15.17(6)		minor			
NiL	8.60(1)	6.57	494	469	569	-0.598
			374	1528	487	+3.699
			286	2867	381	-2.917
					330	+0.509
					308_{sh}	-2.192
					282	-4.235
					237	-3.172
					219	-4.559
$NiH_{-1}L$	-1.36(3)	9.96	495	455	542	-1.473
			374	1474	482	+4.654
			286	2869	382	-3.740
					337	+0.553
					305_{sh}	-9.205
					285	-11.786
					246	-4.391
					223	+12.217
$NiH_{-2}L$	-11.99(2)	10.64	493	406	544	-0.968
			374	1257	484	+3.536
			285	2867	381	-3.012
					338	+0.213
					305_{sh}	-6.690
					285	-8.818
					246	-4.643
					222	+9.707

Table 2S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **Ac-cW** Ac-PCHYIPRPKPR-NH_2. Metal to ligand ratio = 1:1; [Ni^{2+}] = 0.001 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	11.30(2)	$logK_{NH2\text{-}Lys}$ = 11.30				
H_2L	21.14(2)	$logK_{O\text{-}Tyr}$ = 9.84				
H_3L	29.85(3)	$logK_{Cys}$ = 8.70				
H_4L	36.07(3)	$logK_{Nim}$ = 6.22				
NiHL	19.28(1)		500	455	547	-1.904
			374	1277	486	+4.801
			282	2693	380	-3.163
					340	+0.837
					303	-11.734
					284	-12.751
					226	+4.858
NiL	9.09(4)	10.19	500	455	547	-2.011
			376	1189	486	+4.340
			282	2690	382	-2.397
					338	+0.926
					304	-8.301
					281	-9.244
					234	+3.239
$NiH_{-1}L$	-1.59(4)	10.69	500	386	556	-0,727
			377	958	494	+2,402
			280	2690	435	-1,450
					375_{sh}	-1,105
					308	-1,183
					293	+0,884
					271	-2,077
					251	+1,823

Table 3S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **Ac-sW** Ac-PCHPPCHYIPR-NH_2. Metal to ligand ratio = 1:1; [Ni^{2+}] = 0.001 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	9.65(1)	$logK_{O\text{-}Tyr}$ = 9.65				
H_2L	16.33(1)	$logK_{Nim}$ = 6.68				
H_3L	22.16(1)	$logK_{Nim}$ = 5.83				
NiH_2L	19.01(9)		minor			
NiHL	12.75(4)	6.26	minor			
NiL	4.13(6)	8.62	minor			
$NiH_{-1}L$	-4.25(2)	8.38	-		788	+0.071
					277_{sh}	-0.467
					233	-4.829
$NiH_{-2}L$	-14.31(2)	10.06	-		526	-0.264
					293	-0.533
					261	+0.640
					226	-8.373

Table 4S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **nW** GKPDLRPCHP-NH_2. Metal to ligand ratio = 1:1.1; [Ni^{2+}] = 0.001 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	10.58(1)	$logK_{NH2\text{-}Lys}$ = 10.58				
H_2L	19.37(1)	$logK_{Cys}$ = 8.78				
H_3L	26.97(1)	$logK_{NH2}$ = 7.60				
H_4L	33.16(1)	$logK_{Nim}$ = 6.18				
H_5L	36.85(1)	$logK_{Asp}$ = 3.70				
NiH_3L	29.83(2)		398_{sh}	78	-	-
			340_{sh}	198		
			291_{sh}	451		
NiHL	16.42(1)	6.70 ($2H^+$)	496	349	556	-0.058
			374_{sh}	1200	485	+0.264
			336_{sh}	1783	382	-0.207
			285_{sh}	2681	305_{sh}	-0.327
					282	-0.535
					226_{sh}	-7.529
					215	-13.784
NiL	8.14(1)	8.28	495	371	547	-0.121
			374_{sh}	1174	484	+0.356
			284_{sh}	2767	384	-0.327
					338	+0.072
					305_{sh}	-0.770
					283	-1.079
					225_{sh}	-6.255
					215	-15.531
$NiH_{-1}L$	-1.61(1)	9.75	493	351	543	-0.104
			374_{sh}	1065	486	+0.228
			284_{sh}	2780	427_{sh}	-0.225
					386	-0.337
					338	+0.072
					306_{sh}	-0.663
					284	-1.284
					234	-3.927
					215	-5.612
$NiH_{-2}L$	-12.33(1)	10.72	477	286	507	+0.153
			374_{sh}	703	437	-0.533
			284_{sh}	2783	387_{sh}	-0.242
					233	-3.912
					217	-7.666

Table 5S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **cW** PCHYIPRPKPR-NH_2. Metal to ligand ratio = 1:3; [Ni^{2+}] = 0.0003 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	11.47(2)	$logK_{NH2\text{-}Lys}$ = 11.47				
H_2L	21.40(1)	$logK_{O\text{-}Tyr}$ = 9.93				
H_3L	30.46(2)	$logK_{Cys}$ = 9.06				
H_4L	38.40(2)	$logK_{NH}$ = 7.94				
H_5L	44.49(2)	$logK_{Nim}$ = 6.09				
NiHL	24.67(4)		457	445	495	-0.381
			331	2229	424	+0.669
					338	+0.433
					272	-1.788
					233_{sh}	-7.159
NiL	18.23(6)	6.44	454	421	506	-1.193
			334_{sh}	1309	428	+1.660
					337	+3.830
					276	-9.506
					235_{sh}	-8.613

Table 6S. Potentiometric and spectroscopic data for proton and Ni^{2+} complexes of **sW** PCHPPCHYIPR-NH_2. Metal to ligand ratio = 1:3; [Ni^{2+}] = 0.0003 M.

	log β	logK	UV-Vis		CD	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$
HL	9.75(1)	$logK_{O\text{-}Tyr}$ = 9.75				
H_2L	18.12(1)	$logK_{NH2}$ = 8.37				
H_3L	24.71(1)	$logK_{Nim}$ = 6.59				
H_4L	30.52(1)	$logK_{Nim}$ = 5.81				
$NiH_{-1}L$	0.48(3)		424	202	477	-2.510
					415	+2.135
					289_{sh}	+1.973
					257	+5.620
					234	-9.617
$NiH_{-2}L$	-8.62(7)	9.10	421	241	478	-2.593
			284_{sh}	5207	416	+2.296
					310	+0.483
					259	+6.753
					233	-14.732
$NiH_{-3}L$	-19.47(9)	10.85	minor			

Table 7S.[1]H Chemical shift of nW fragments 2.0 mM in D_2O at pH 7.8 and 298 K

	Hα	Hβ	Hγ	Others
Gly-1	3.59			
Gly-2	3.98			
Lys-3	4.65	1.85	1.47	Hδ 1.71 Hε 3.00
Pro-4*	4.41	2.27-2.02	1.87	Hδ 3.82-3.65
Asp-5	4.57	2.71-2.57		
Leu-6	4.35	1.61	1.61	Hδ 0.87
Arg-7	4.61	1.84-1.76	1.69	Hδ 3.21
Pro-8*	4.41	2.27-2.02	1.87	Hδ 3.82-3.65
Cys-9	4.38	2.86		
His-10	4.90	3.07		Hδ 7.70 Hε 7.00
Pro-11	4.38	2.26	1.94	Hδ 3.77-3.46

*The two proline were not distinguishable.

Table 8S.[1]H Chemical shift of Ac-nW fragments 2.0 mM in D_2O at pH 8.5 and 298 K

	Hα	Hβ	Hγ	Others
Gly-1	3.93			
Gly-2	3.93			
Lys-3	4.65	1.85	1.47	Hδ 1.71 Hε 3.00
Pro-4	4.41	2.27-2.02	1.87	Hδ 3.82-3.65
Asp-5	4.57	2.71-2.57		
Leu-6	4.35	1.61	1.61	Hδ 0.87
Arg-7	4.61	1.84-1.76	1.69	Hδ 3.21
Pro-8	4.41	2.27-2.02	1.87	Hδ 3.82-3.65
Cys-9	4.38	2.86		
His-10	4.90	3.07		Hδ 7.70 Hε 7.00
Pro-11	4.38	2.26	1.94	Hδ 3.77-3.46

*The two proline were not distinguishable.

Table 9S. ^{1}H Chemical shift of cW fragments 2.0 mM in D_2O at pH 8.5 and 298 K

	Hα	Hβ	Hγ	Others
Pro-12	4.10	2.28	1.89	Hδ 3.18
Cys-13	4.27	2.80		
His-14	4.62	3.00		Hδ 6.85 Hε 7.65
Tyr-15	4.52	2.97		Hδ 7.06 Hε 6.80
Ile-16	4.35	1.75	1.43-1.10	Hδ 0.89
Pro-17	4.31	2.28	1.97	Hδ 3.65
Arg-18	4.60	1.76	1.76	Hδ 3.21
Pro-19*	4.42	2.30-1.90	2.00	Hδ 3.83–3.63
Lys-20	4.58	1.73	1.53	Hδ 1.73 Hε 3.03
Pro-21*	4.42	2.30-1.90	2.00	Hδ 3.83–3.63
Arg-22	4.26	1.86	1.71	Hδ 3.21

*The two proline were not distinguishable.

Table 10S.[1]H Chemical shift of Ac-cW fragments 2.0 mM in D_2O at pH 8.4 and 298 K

	Hα	Hβ	Hγ	Others
Pro-12	4.35	2.27	1.95	Hδ 3.64
Cys-13	4.29	2.80		
His-14	4.62	3.00		Hδ 6.87 Hε 7.65
Tyr-15	4.51	2.97		Hδ 7.06 Hε 6.80
Ile-16	4.35	1.76	1.45-1.10	Hδ 0.87
Pro-17	4.31	2.28	1.97	Hδ 3.66
Arg-18	4.60	1.76	1.76	Hδ 3.21
Pro-19*	4.42	2.30-1.90	2.00	Hδ 3.82–3.62
Lys-20	4.58	1.73	1.53	Hδ 1.73 Hε 3.03
Pro-21*	4.42	2.30-1.90	2.00	Hδ 3.82–3.62
Arg-22	4.26	1.86	1.71	Hδ 3.21

*The two proline were not distinguishable.

Table 11S.[1]H Chemical shift of sW fragments 2.0 mM in D_2O at pH 8.5 and 298 K

	Hα	Hβ	Hγ	Others
Pro-8	3.99	2.21	1.85	Hδ 3.14
Cys-9	4.63	3.12		
His-10	4.94	3.10-2.92		Hδ 7.00 Hε 7.70
Pro-11	4.40	2.30-1.81	2.10-1.99	Hδ 4.02–3.49
Pro-12	4.48	2.21-1.84	2.10-1.93	Hδ 3.60–3.50
Cys-13	4.43	3.24-3.14		
His-14	4.64	3.00		Hδ 6.89 Hε 7.66
Tyr-15	4.54	2.94		Hδ 7.04 Hε 6.89
Ile-16	4.35	1.72	1.42-1.06	Hδ 0.86
Pro-17	4.30	2.31	2.02-1.92	Hδ 3.63
Arg-18	4.28	1.85	1.77-1.69	Hδ 3.21

Table 12S.[1]H Chemical shift of Ac-sW fragments 2.0 mM in D_2O at pH 8.5 and 298 K

	Hα	Hβ	Hγ	Others
Pro-8	4.22	2.14-1.71	1.91	Hδ 3.58
Cys-9	4.61	3.15		
His-10	4.93	3.10-2.93		Hδ 7.00 Hε 7.71
Pro-11	4.42	2.30-1.81	2.10-1.99	Hδ 4.03-3.51
Pro-12	4.47	2.21-1.84	2.10-1.93	Hδ 3.60-3.50
Cys-13	4.44	3.25-3.13		
His-14	4.65	2.99		Hδ 6.89 Hε 7.68
Tyr-15	4.54	2.94		Hδ 7.04 Hε 6.79
Ile-16	4.34	1.72	1.41-1.06	Hδ 0.86
Pro-17	4.28	2.30	2.02-1.92	Hδ 3.65
Arg-18	4.28	1.85	1.77-1.69	Hδ 3.21

Table 13S. Potentiometric and spectroscopic data for proton and Cu^{2+} complexes of **Ac-sW** Ac-PCHPPCHYIPR-NH_2. Metal to ligand ratio = 1:1; $[Cu^{2+}]$ = 0.001 M.

	log β	logK	UV-Vis		CD		EPR	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$	$A_{\parallel}$/mT	$g_{\parallel}$
HL	9.65(1)	$logK_{O\text{-}Tyr}$ = 9.65						
H_2L	16.33(1)	$logK_{Nim}$ = 6.68						
H_3L	22.16(1)	$logK_{Nim}$ = 5.83						
CuL	8.27(1)		593	41	713	+0.147	16,5	2.28
					523	+0.189		
					338	+0.259		
					258	+3.212		
$CuH_{-1}L$	1.39(2)	6.88	580	83	627	+0.268	17,6	2.24
					526	+0.472		
					337	+0.610		
					255	+7.398		
					?231_{sh}	+0.696		
$CuH_{-2}L$	-8.14(2)	9.53	575	101	625	+0.231	17,3	2.24
					524	+0.395		
					335	+0.643		
					255	+7.283		
					231_{sh}	+0.734		
$CuH_{-3}L$	-19.41(5)	11.27	minor					

Table 14S. Potentiometric and spectroscopic data for proton and Cu^{2+} complexes of **sW** PCHPPCHYIPR-NH_2. Metal to ligand ratio = 1:1; [Cu^{2+}] = 0.001 M.

	log β	logK	UV-Vis		CD		EPR	
Species			λ/nm	ε/$M^{-1}cm^{-1}$	λ/nm	Δε/$M^{-1}cm^{-1}$	$A_{\parallel}$/mT	$g_{\parallel}$
HL	9.75(1)	$logK_{O\text{-}Tyr}$ = 9.75						
H_2L	18.12(1)	$logK_{NH2}$ = 8.37						
H_3L	24.71(1)	$logK_{Nim}$ = 6.59						
H_4L	30.52(1)	$logK_{Nim}$ = 5.81						
CuHL	19.98(3)		minor					
CuL	14.67(3)	5.31	629	109	671	-0.981	16,8	2.22
					571	+0.383		
					489_{sh}	+0.285		
					332	+0.332		
					282	-1.380		
					239	-3.702		
$CuH_{-1}L$	7.26(4)	7.41	649_{sh}	41	680_{sh}	-0.258	20,8	2.17
			518	118	550	-0.621		
					480	+0.680		
					310	+0.918		
					256	+2.361		
					236	-5.040		
$CuH_{-2}L$	-2.40(6)	9.66	514	143	551	-0.932	20,7	2.17
					480	+0.811		
					312	+1.054		
					255	+3.902		
					231	-9.353		

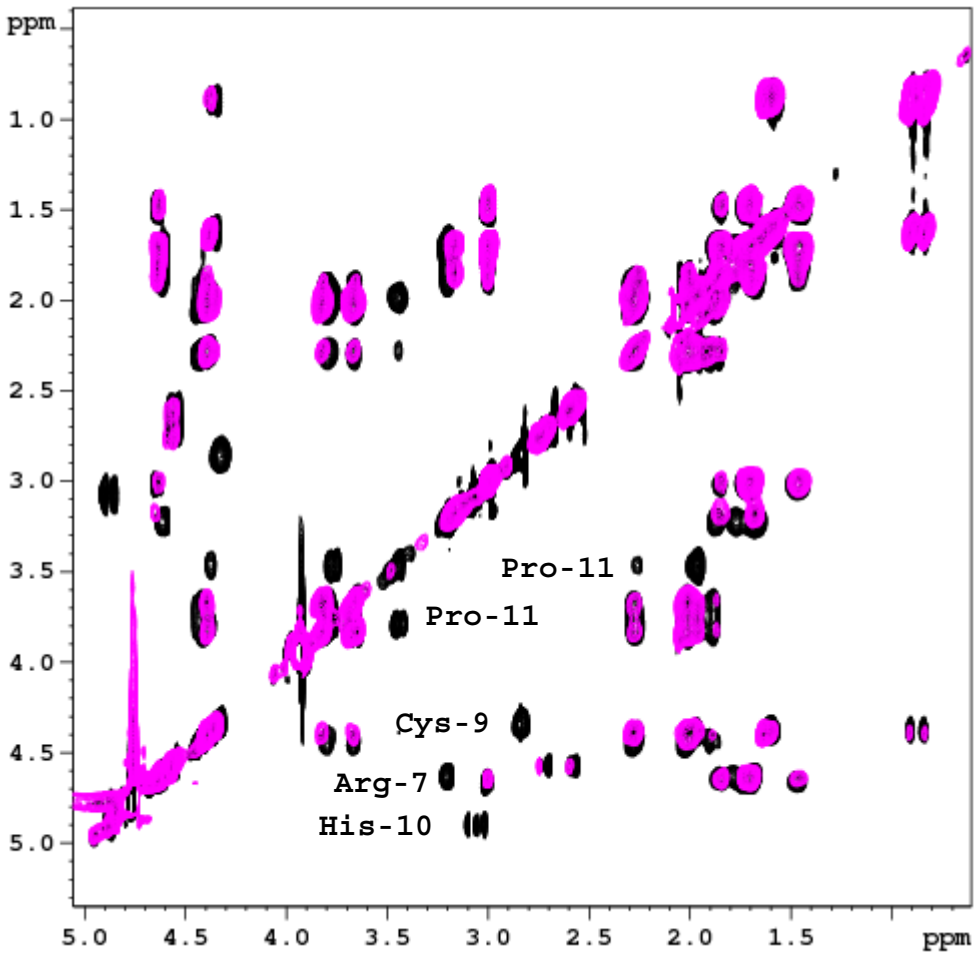

Figure 1S. Selected regions of the TOCSY spectrum of Ac-nW in D_2O 2.0 mM at pH 8.5 and T 298 K: in the absence (black) and in the presence of 1.0 Ni^{2+} eq. (magenta). The broadening of selected cross-peaks upon metal addition are shown.

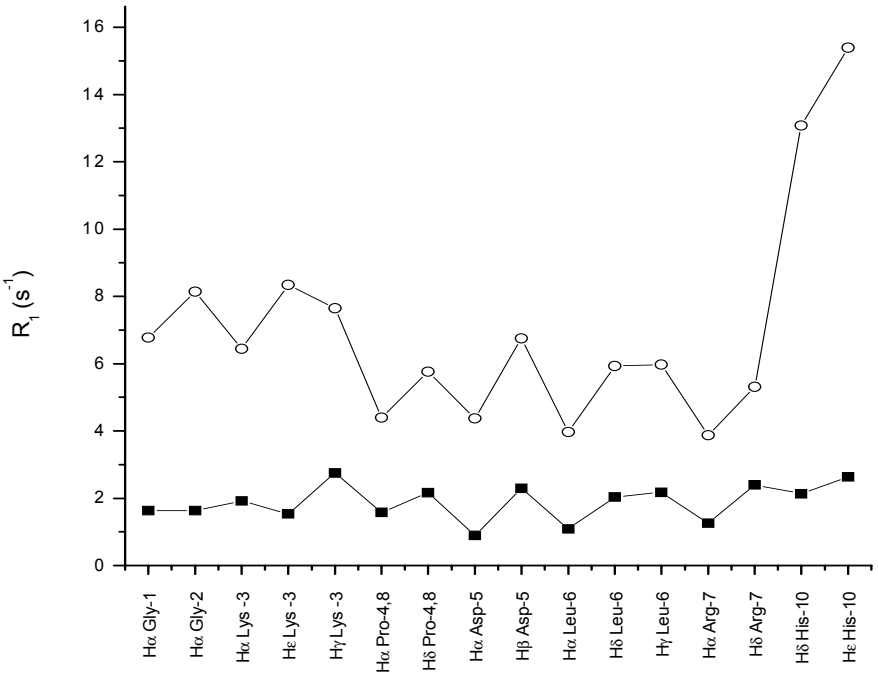

Figure 2S. ^{1}H longitudinal relaxation rates of Ac-nW (solid square) and nW (open circle) calculated in presence of 1.0 Ni^{2+} equivalents.

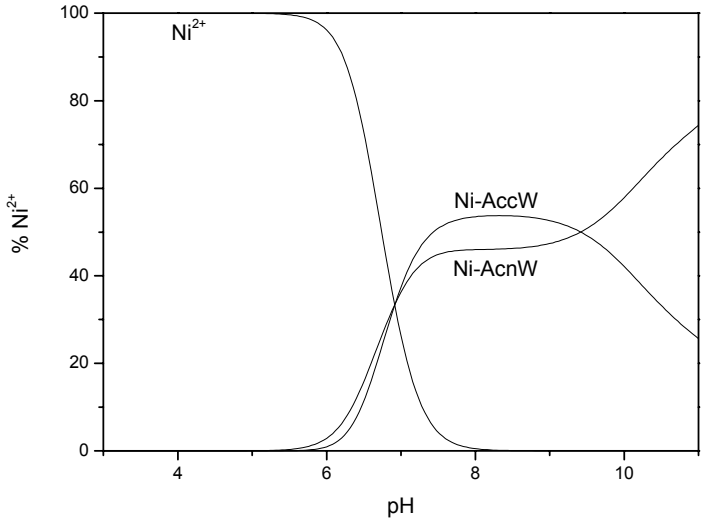

Figure 3S. tribution profile of competition between Ac-nW and Ac-cW in coordination of Ni^{2+}; $[Ni^{2+}] = 0.001$; ligand to metal ratio 1.1:1.

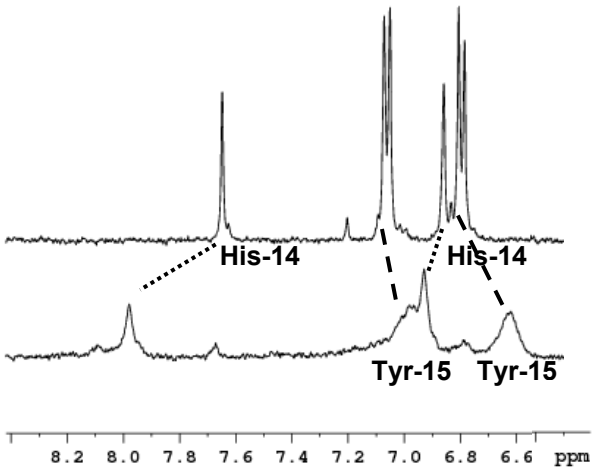

Figure 4S. Aromatic region of ^{1}H 1D spectra of the Ac-cW in absence (upper trace) and in the presence of 1.0 Ni^{2+} (lower trace). The solutions were 2.0 mM, pH 8.4 T=298 in D_2O.

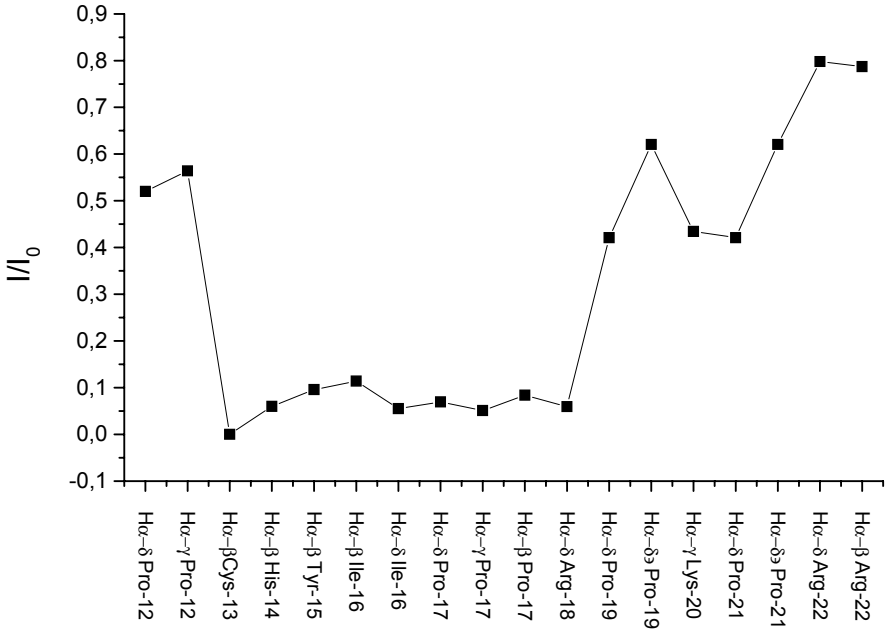

Figure 5S. I/I_0 profiles of the ^1H-^1H TOCSY correlations of Ac-cW in absence (I_0) and in presence (I) of 1.0 Ni^{2+} equivalents; 2.0 mM, pH 8.4 and T=298.

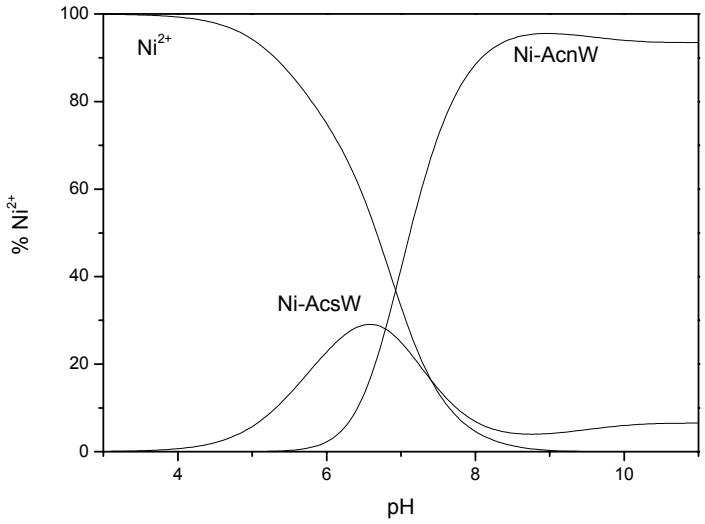

Figure 6S. Distribution profile of competition between Ac-nW and Ac-sW in coordination of Ni^{2+}; $[Ni^{2+}] = 0.001$; ligand to metal ratio 1.1:1.

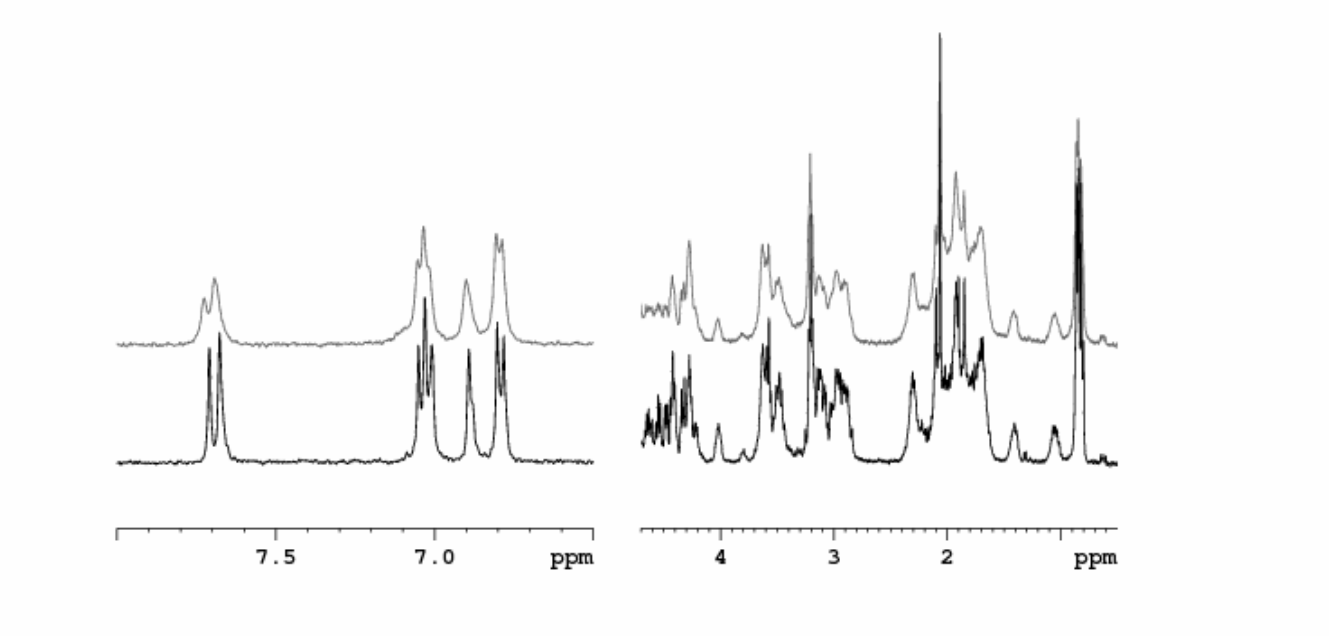

Figure 7S. H ^{1}D spectra of the Ac-sW in absence (black trace) and in the presence of 1.0 Ni^{2+} (grey trace). The solutions were 1.0 mM, pH 6 T=298 in D_2O.

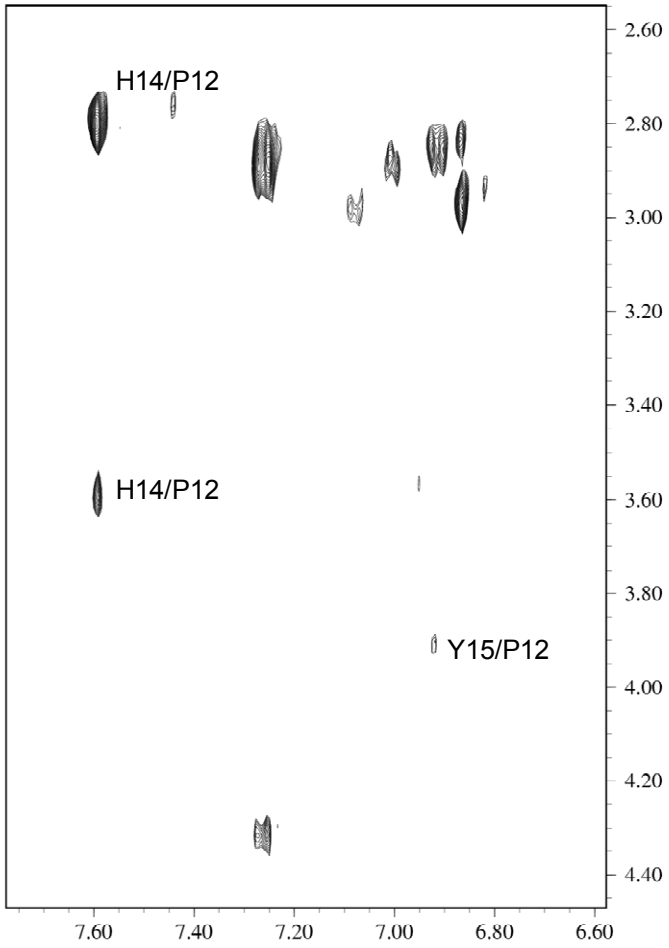

Figure 8S. Selected region of the NOESY spectrum of cW 2 mM at pH 8.5 in the presence of 1.0 Ni^{2+} eq. The long range NOEs between residues located in the proximity of the binding site are indicated.

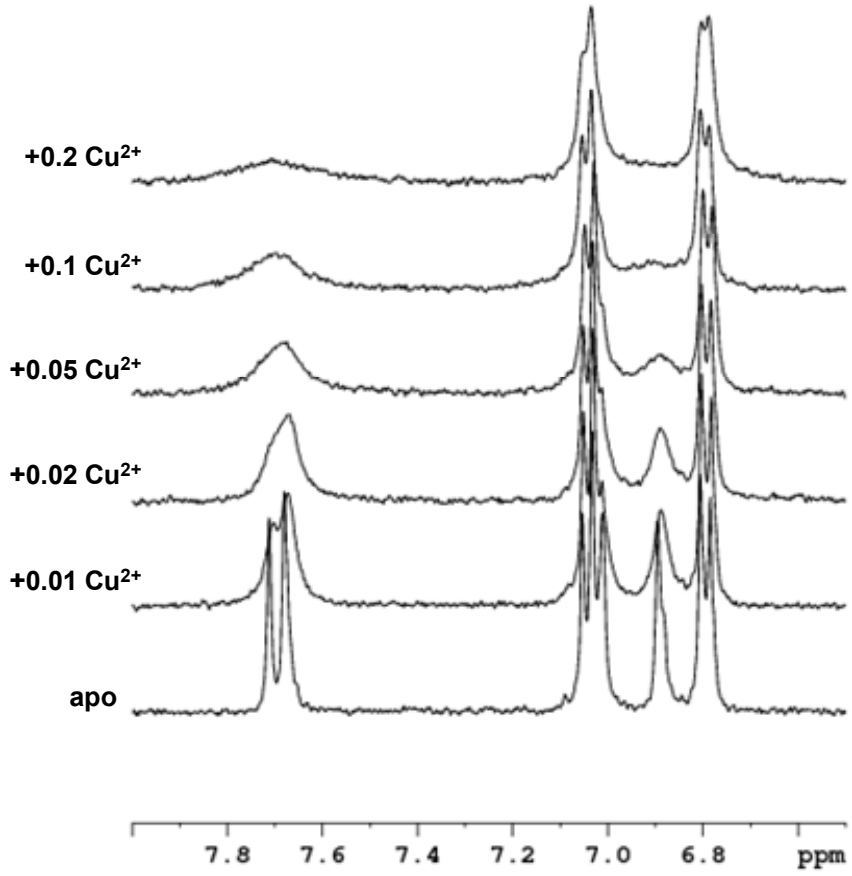

Figure 9S. Aromatic region of ^{1}H 1D spectra of the Ac-sW 2.0 mM T=298, pH 8.5, in the absence (apo) and in the presence of Cu^{2+}.

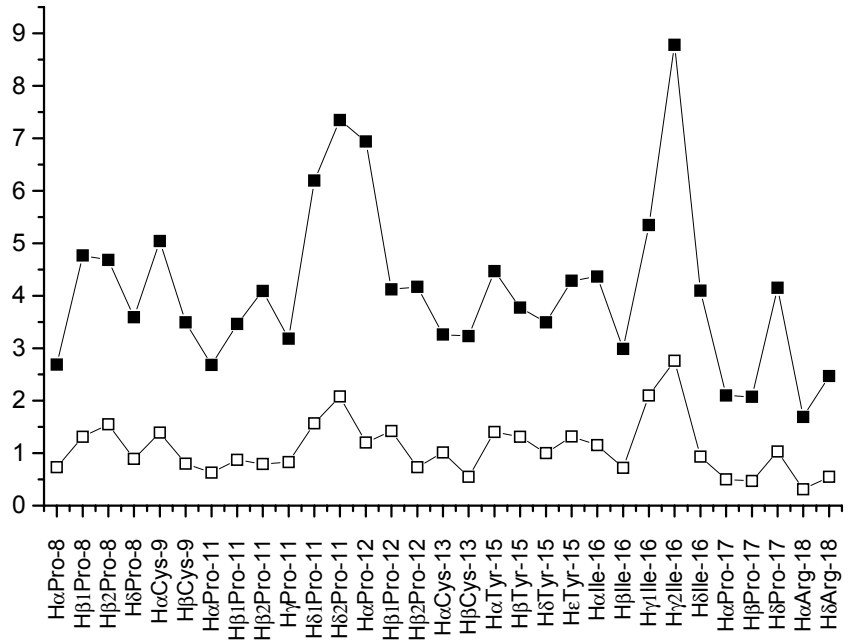

Figure 10S. Proton paramagnetic relaxation contributions (R_{1p}) of Ac-sW, calculated in presence of 0.1 (open squares) and 0.4 (solid squares) Cu^{2+} equivalents.