# Synthesis and characterisation of Co(III) complexes of *N*-formyl hydroxylamines and antibacterial activity of a Co(III) peptide deformylase inhibitor complex

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## Supporting information

**GSK322**

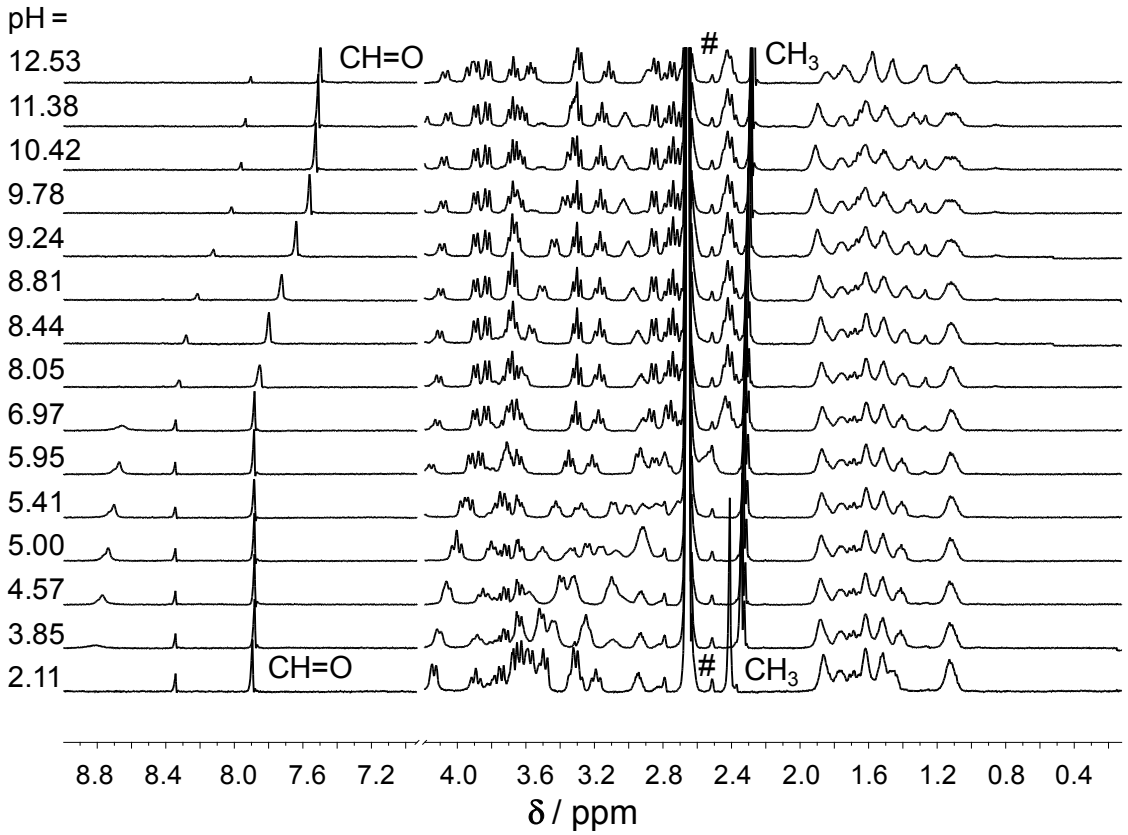



Figure S1. $^{1}$H NMR spectra recorded for GSK322 at indicated pH values (solvent peaks: #). {$c_L$ = 0.96 mM; 30% (v/v) DMSO-$d_6$/$H_2O$; I = 0.1 M (KCl); T = 25°C}

**$[Co(tren)(HFA_{-1H})](PF_6)_{1.5}Cl_{0.5}$ (1)**

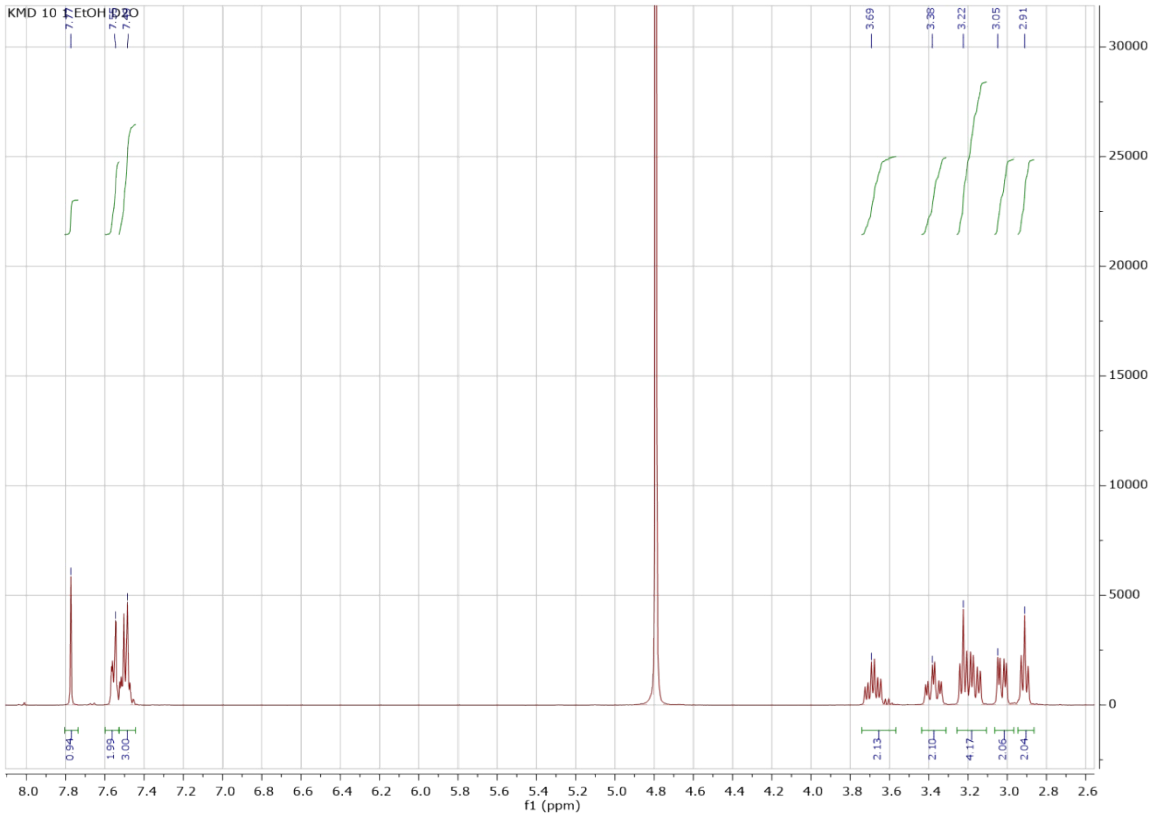



Figure S2. $^1$H NMR spectrum of **1** (in $D_2O$).

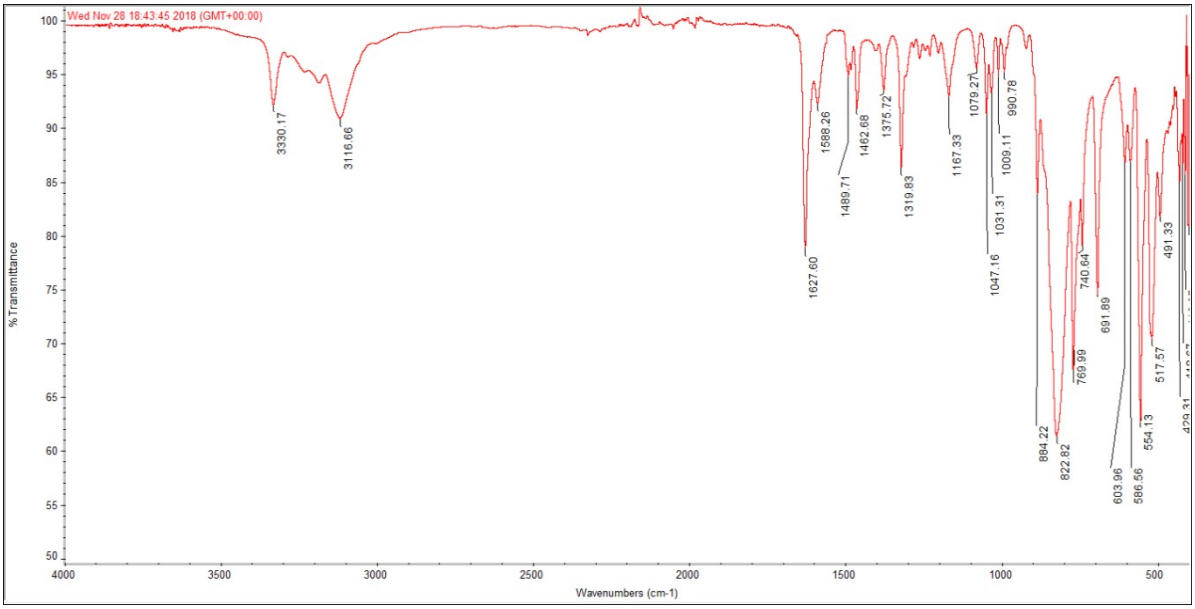



Figure S3. IR spectrum of **1**.

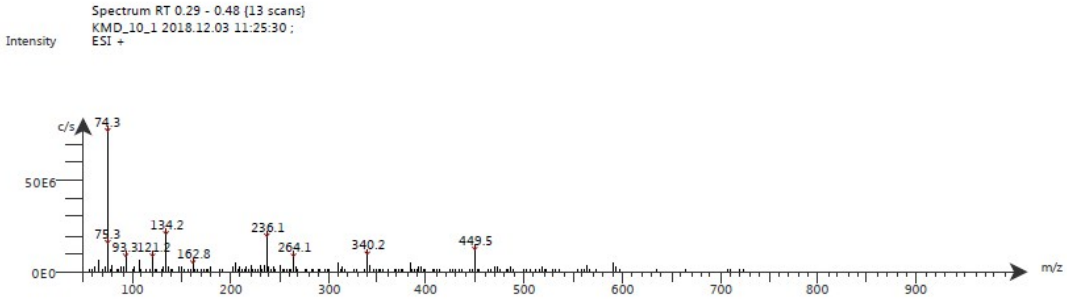



Figure S4. ESI mass spectrum of **1** (positive mode).

**[Co(tpa)(HFA$_{-1H}$)]Cl$_2$ (2)**

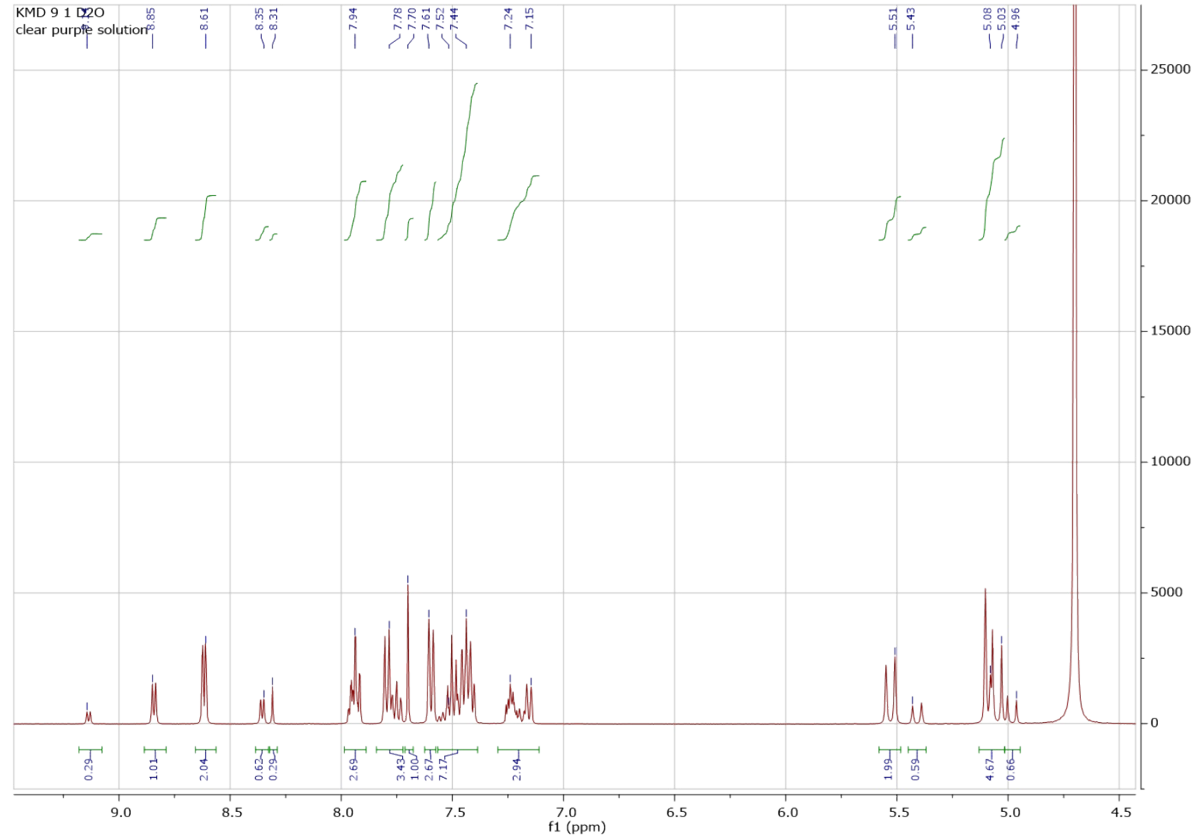



Figure S5. $^1$H NMR spectrum of **2** (in $D_2O$).

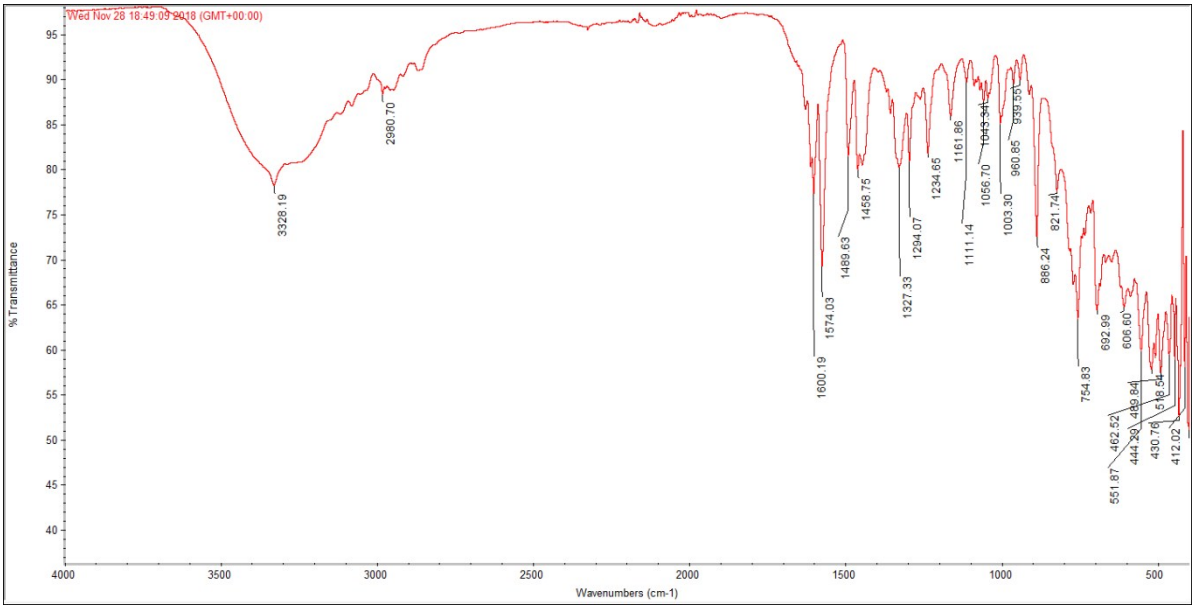



Figure S6. IR spectrum of **2**.

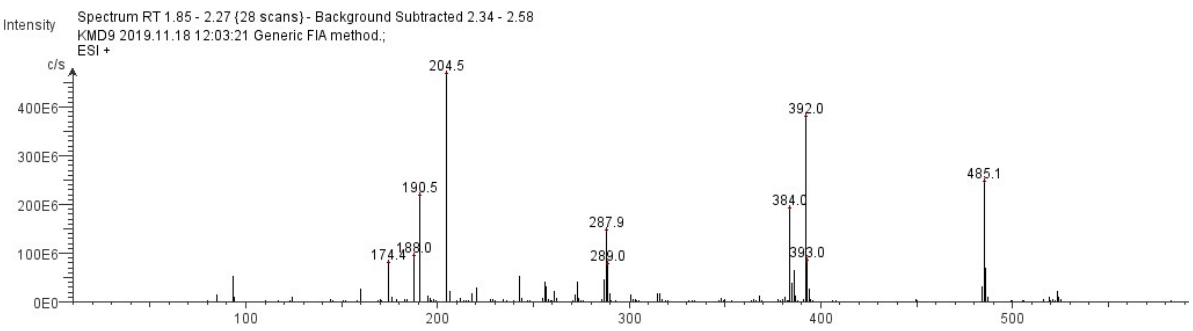



Figure S7. ESI mass spectrum of **2** (in positive mode).

**[Co(tpa)(GSK322$_{-1H}$)](PF$_6$)$_2$ (3)**

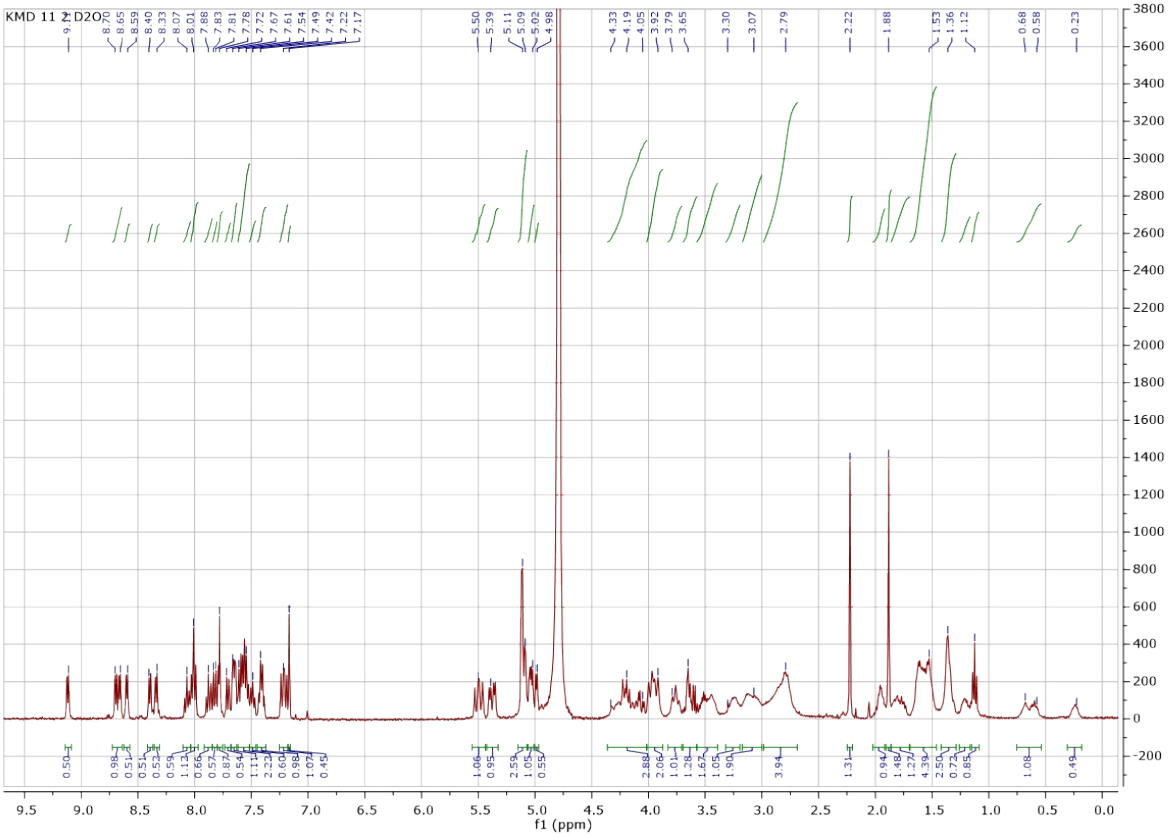
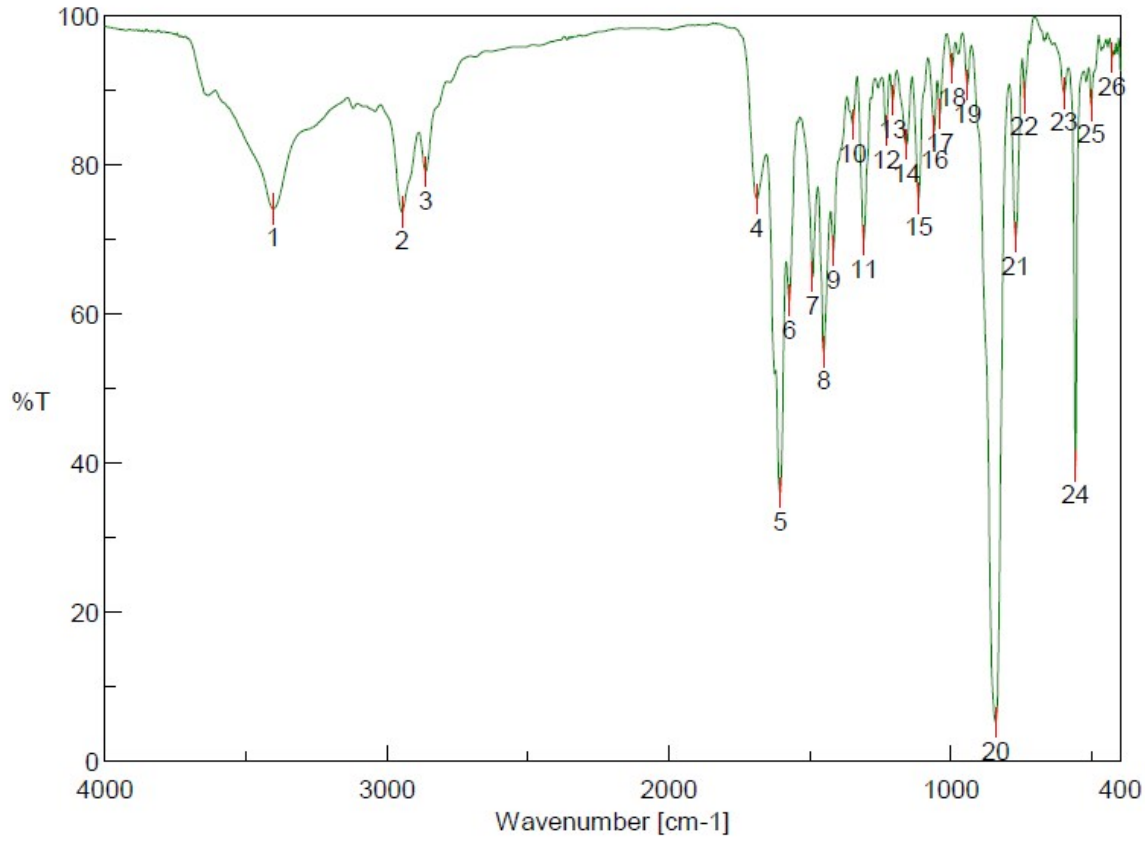



Figure S8. $^1$H NMR spectrum of **3** (in $D_2O$).




1. 3403.74 74.024 2. 2946.7 73.6211 3. 2862.81 79.0386 4. 1688.37 75.3912

5. 1605.45 35.9978 6. 1573.63 61.7324 7. 1490.7 64.9615 8. 1451.17 54.8672

9. 1417.42 68.3965 10. 1348 85.359 11. 1309.43 69.8434 12. 1230.36 84.4816

13. 1206.26 88.6109 14. 1158.04 82.6462 15. 1114.65 75.4982

16. 1058.73 84.3987 17. 1039.44 86.7941 18. 996.053 92.8385 19. 942.056 90.6581

20. 841.776 5.24176 21. 770.423 70.2436 22. 739.567 88.8853 23. 598.789 89.5028

24. 558.291 39.6029 25. 502.366 87.9308 26. 428.12 94.314

Figure S9. IR spectrum of **3**.

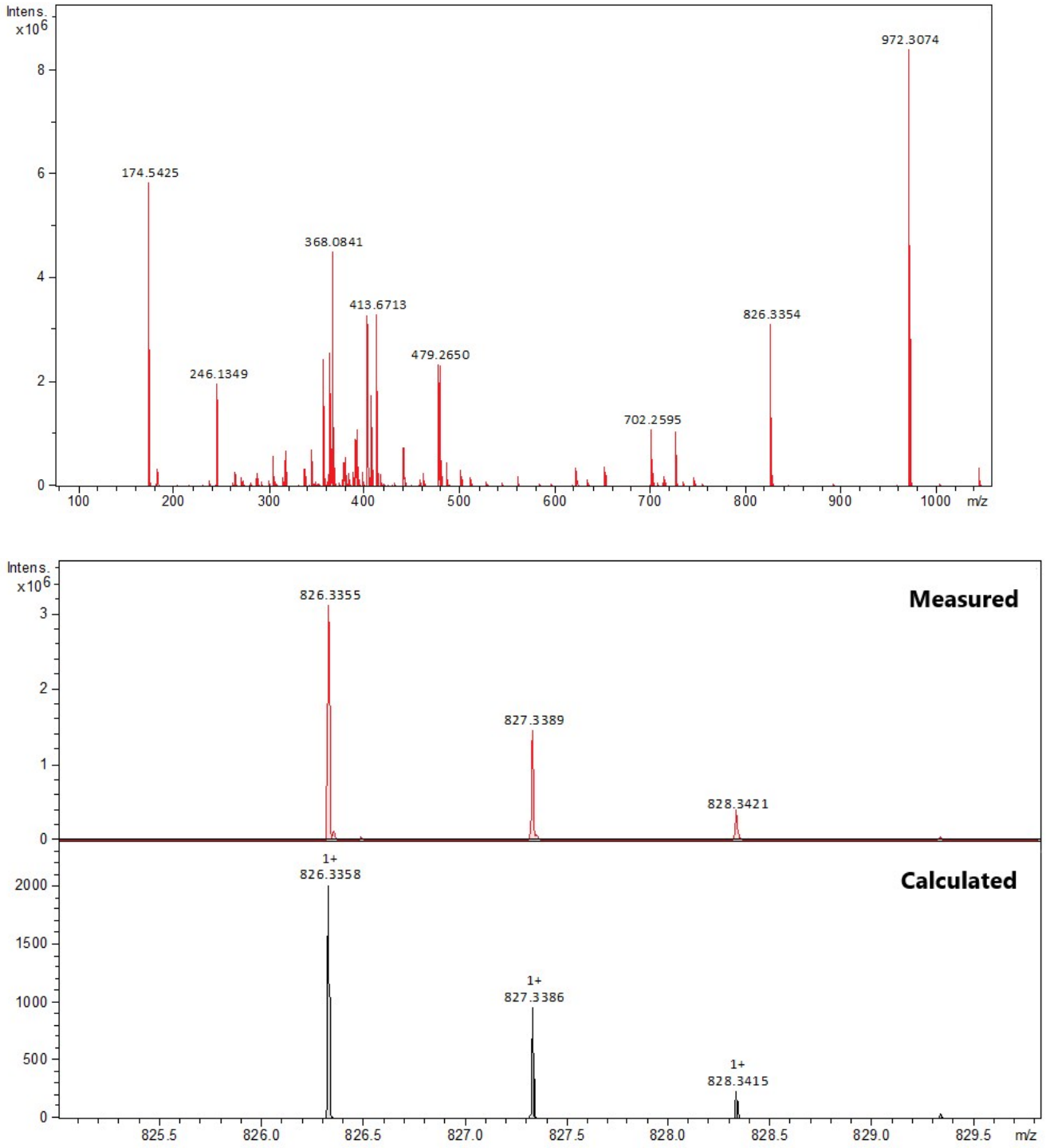



Figure S10. HR-ESI mass spectrum of **3** (positive mode).

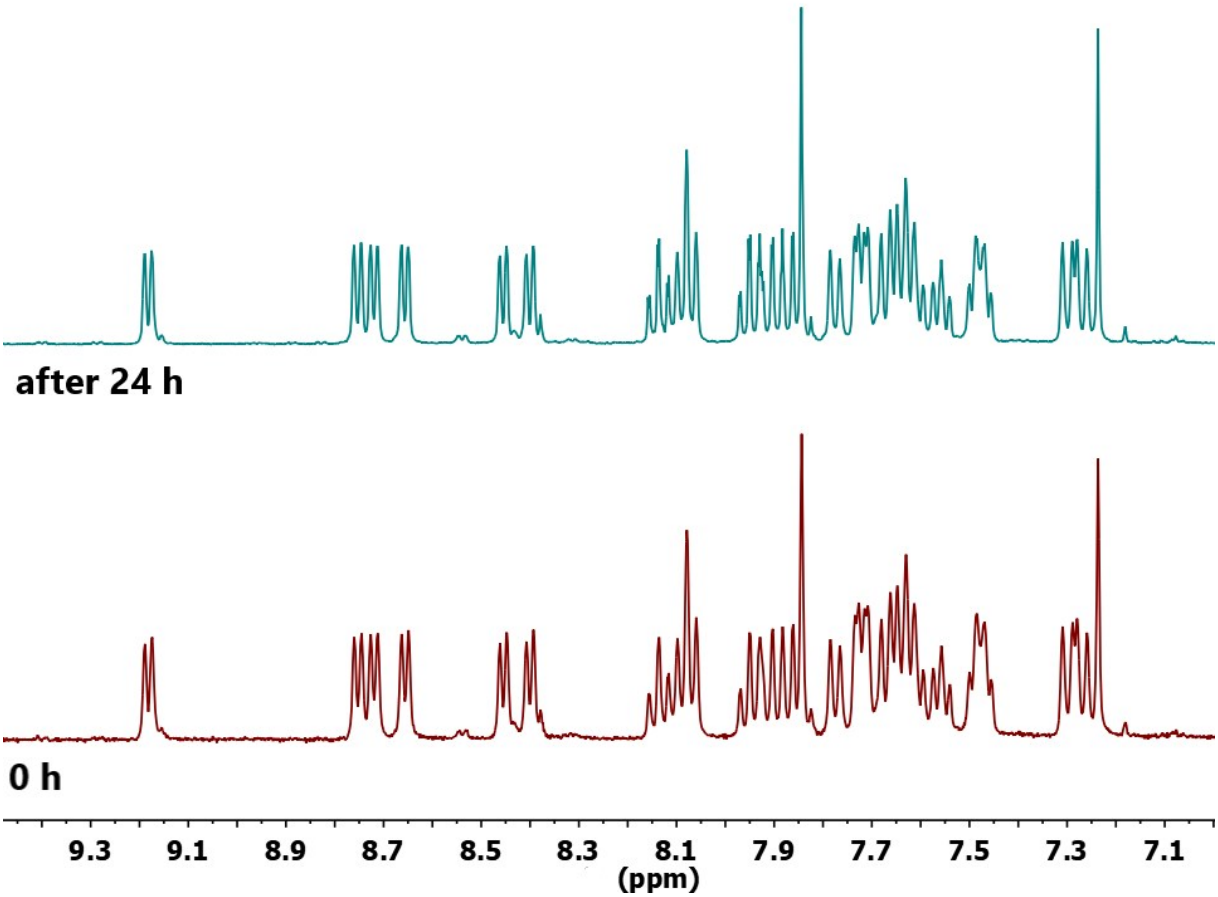



Figure S11. Solution stability of **3** in $D_2O$ over 24 h.

## X-Ray Crystallography

Table S1. Crystal data and structure refinement for GSK322, **1** and **2**.

| Identification code | GSK322 | **1** | **2** |
|---|---|---|---|
| CCDC No. | | | |
| Empirical formula | $C_{26}H_{42}FN_7O_5$ | $C_{26}H_{48.67}ClCo_2F_{18}N_{10}O_{4.33}P_3$ | $C_{25}H_{34}Cl_2CoN_5O_7$ |
| Formula weight | 551.66 | 1158.95 | 646.40 |
| Temperature (K) | 100(2) | 100(2) | 100(2) |
| Crystal system | monoclinic | monoclinic | monoclinic |
| Space group | C2 | $P2_1/n$ | $P2_1/c$ |
| a (Å) | 21.6357(10) | 15.0010(7) | 15.2195(12) |
| b (Å) | 9.0441(4) | 16.7068(8) | 13.7845(11) |
| c (Å) | 17.7227(8) | 16.6727(8) | 14.5792(13) |
| α (°) | 90 | 90 | 90 |
| β (°) | 126.2917(10) | 90.2890(19) | 105.564(3) |
| γ (°) | 90 | 90 | 90 |
| Volume (Å$^3$) | 2795.2(2) | 4178.4(3) | 2946.5(4) |
| Z | 4 | 4 | 4 |
| $\rho_{calc}$ (g/cm$^3$) | 1.311 | 1.842 | 1.457 |
| μ (mm$^{-1}$) | 0.097 | 1.103 | 0.815 |
| F(000) | 1184.0 | 2349.0 | 1344.0 |
| Crystal size (mm$^3$) | 0.439 × 0.188 × 0.15 | 0.27 × 0.12 × 0.08 | 0.35 × 0.27 × 0.08 |
| Radiation | MoKα (λ = 0.71073) | MoKα (λ = 0.71073) | MoKα (λ = 0.71073) |
| Reflections collected | 31597 | 9027 | 13118 |
| Independent reflections | 6264<br>$R_{int}$ = 0.0347,<br>$R_{sigma}$ = 0.0242 | 9027<br>$R_{int}$ = 0.1324,<br>$R_{sigma}$ = 0.0385 | 13118<br>$R_{int}$ = 0.0380,<br>$R_{sigma}$ = 0.0471 |
| Data/restraints/parameters | 6264/106/410 | 9027/43/598 | 13118/25/390 |
| Goodness-of-fit on F$^2$ | 1.047 | 1.040 | 1.031 |
| Final R* indexes [$I$>=2σ ($I$)] | $R_1$ = 0.0370,<br>$wR_2$ = 0.0880 | $R_1$ = 0.0502,<br>$wR_2$ = 0.1149 | $R_1$ = 0.0697,<br>$wR_2$ = 0.1685 |
| Final R indexes [all data] | $R_1$ = 0.0432,<br>$wR_2$ = 0.0926 | $R_1$ = 0.0618,<br>$wR_2$ = 0.1221 | $R_1$ = 0.0870,<br>$wR_2$ = 0.1798 |
| Largest diff. peak/hole (e Å$^{-3}$) | 0.27/-0.35 | 1.78/-0.99 | 1.29/-2.06 |
| Flack parameter | -0.1(2) | - | - |

**GSK322**

Description of GSK322 in Figure 3. Intramolecular H-bonding between O12 and N18 (2.773(2) Å). ABAB hydrogen bonded stack parallel to the b-axis N15…O14† = 2.827(2), and N16…O11‡ = 2.787(3) Å (symmetry transformation † = 0.5-x, -0.5+y, 1-z, ‡ = 0.5-x, 0.5+y, 1-z), and interdigitated via the pyrazino-oxazine rings. The disordered THF solvent molecules occupy the lattice voids between stacks.

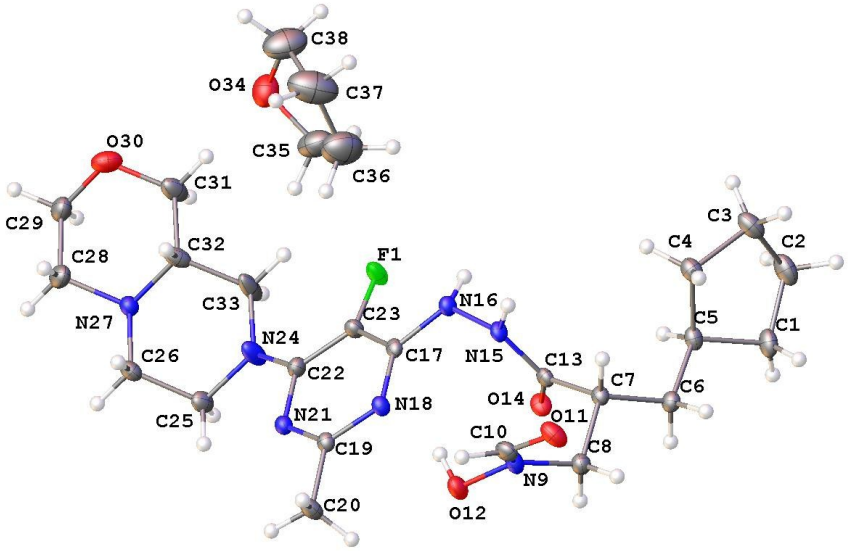



Figure S12. Fully labelled structure of GSK322 with only the main disordered THF moiety shown (85% occupied). Displacement shown at 50% probability.

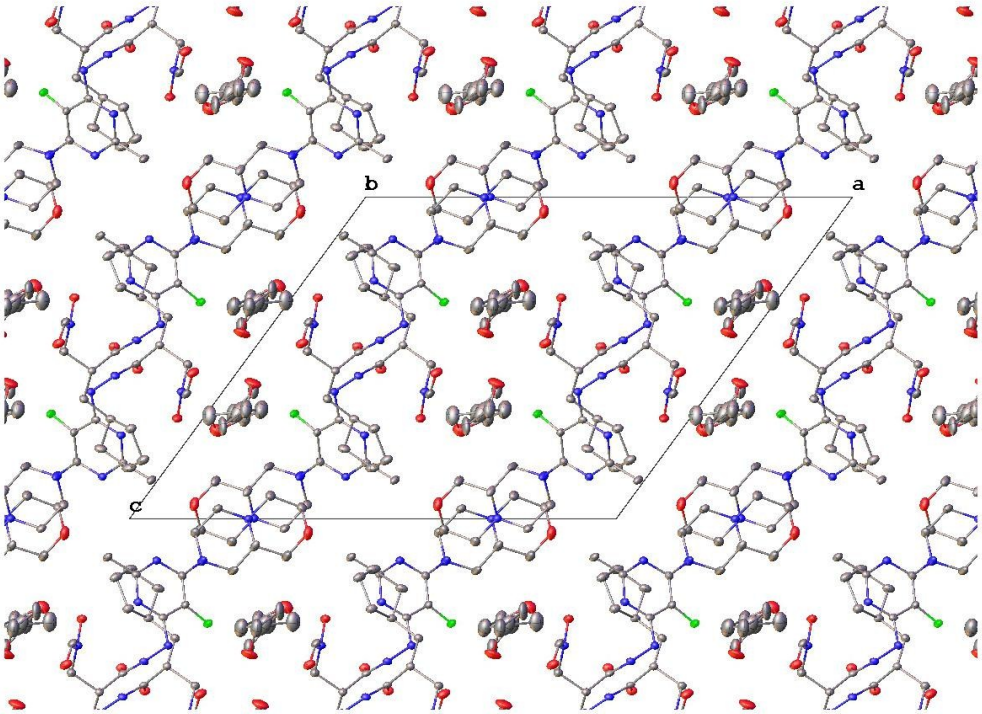



Figure S13. Packing diagram of GSK322 viewed normal to the b-axis showing the hydrogen bonded interdigitated stacks end on with disordered THF occupying the lattice voids.

Complex **1**

Description of **1** in Figure 4. The structure of **1** consists of two independent molecules of the cation in the asymmetric unit with octahedrally coordinated Co atoms (deviation 0.239 and 0.244 from ideal octahedral for Co1 and Co2 respectively by SHAPE analysis). There are four external anions, three $PF_6$ and one disordered chloride, to balance the charge. A partially occupied water molecule completes the asymmetric unit. Both cations are structurally similar and form hydrogen bonded dimers via N4…O14$^{\$}$ = 3.106(7) and N24…O34$^{\#}$ = 3.023(7) Å (symmetry transformation \$ = -x+1,-y+1,-z+1, # = -x,-y+1,-z+1). Further hydrogen bonding of chlorides and the partially occupied water molecule links each dimer. In the extended structure, the compound forms discrete cation/anion layers.

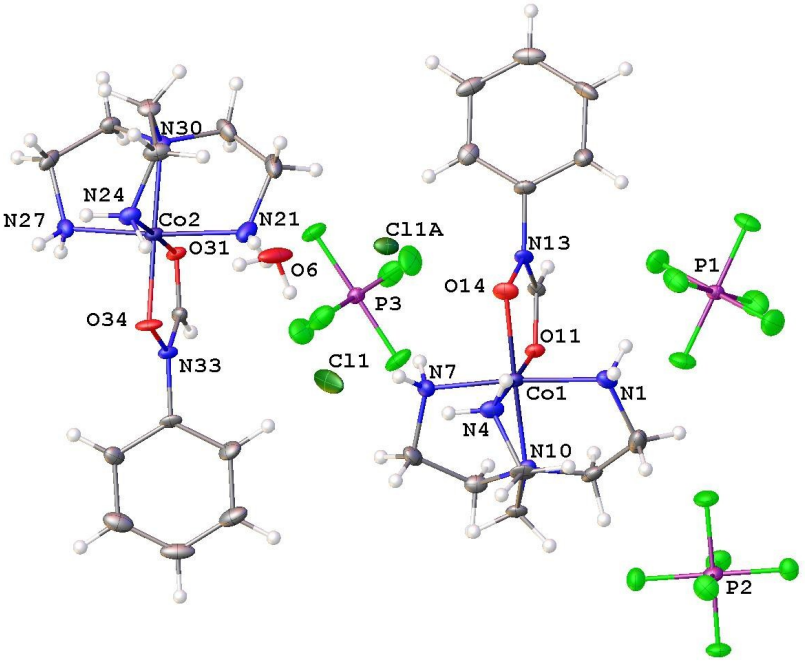



Figure S14. Full asymmetric unit of **1** with heteroatoms labelled only. Both disordered chloride positions are shown (80:20% occupancy) and hydrogen atoms on O6 have been placed to optimize hydrogen bonding with Cl1 only.

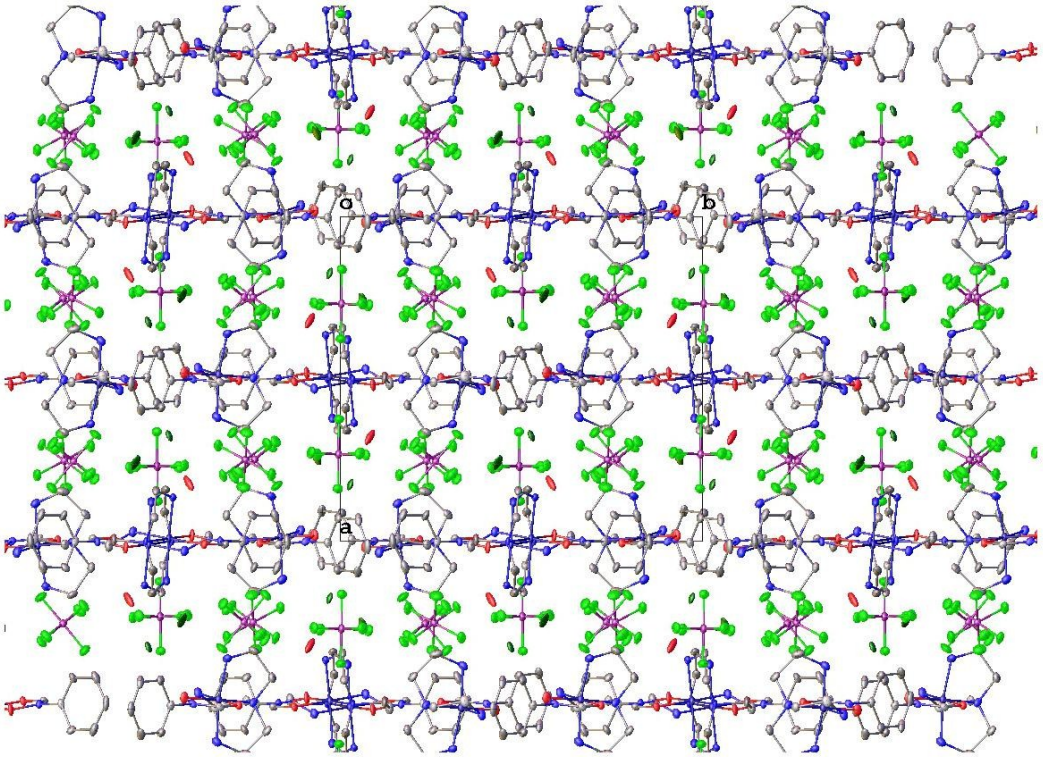



Figure S15. Extended structure of **1** showing discrete cation/anion layers.

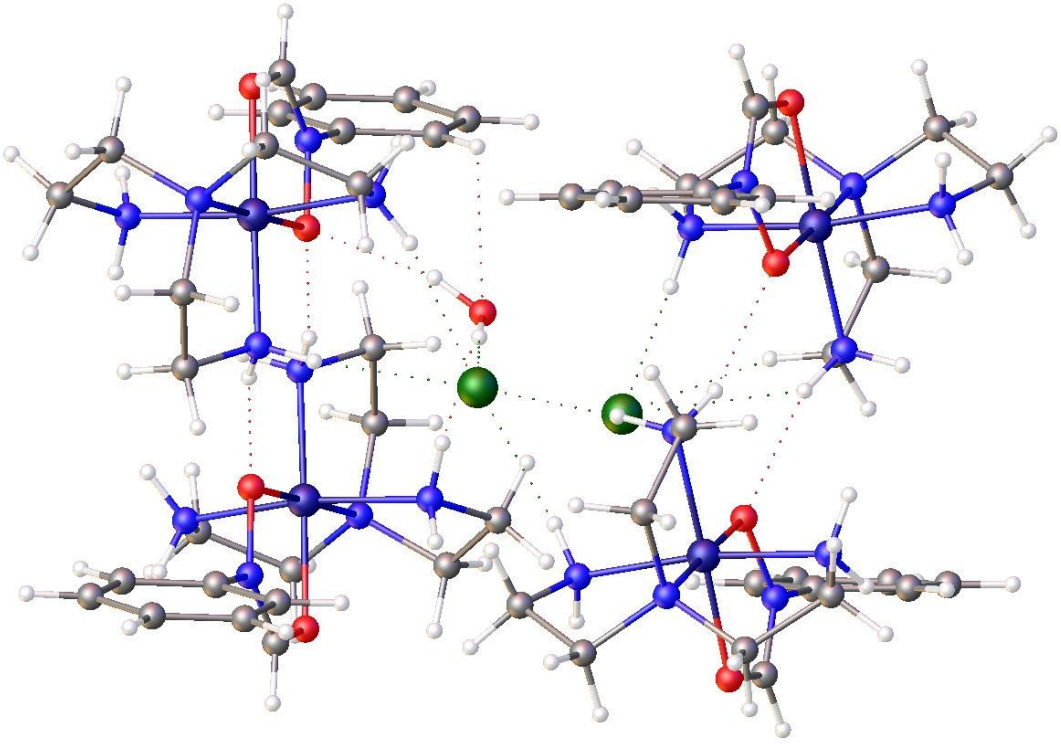


Figure S16. Hydrogen bonded dimer in **1** linked via the partially occupied water molecule and the disordered chlorides.

Table S2. Selected Hydrogen bonds for **1** [Å and °].

| D-H...A | d(D-H) | d(H...A) | d(D...A) | <(DHA) |
|---|---|---|---|---|
| C(5)-H(5B)...Cl(1A)#1 | 0.99 | 2.64 | 3.393(10) | 133.1 |
| N(1)-H(1B)...Cl(1A)#1 | 0.91 | 2.01 | 2.914(9) | 174.1 |
| N(4)-H(4A)...O(14)#1 | 0.91 | 2.23 | 3.106(7) | 162.4 |
| N(4)-H(4A)...Cl(1A)#1 | 0.91 | 2.81 | 3.398(9) | 123.7 |
| N(7)-H(7A)...Cl(1) | 0.91 | 2.30 | 3.179(6) | 161.9 |
| C(40)-H(40)...O(6)#5 | 0.95 | 2.71 | 3.309(19) | 121.6 |
| N(21)-H(21A)...O(6) | 0.91 | 2.08 | 2.987(10) | 172.7 |
| N(24)-H(24A)...Cl(1)#5 | 0.91 | 2.42 | 3.292(6) | 160.6 |
| N(24)-H(24B)...O(34)#5 | 0.91 | 2.15 | 3.023(7) | 160.4 |
| N(27)-H(27B)...Cl(1)#5 | 0.91 | 2.33 | 3.202(6) | 160.8 |
| O(6)-H(6C)...O(34)#5 | 0.87 | 2.02 | 2.854(18) | 161.7 |
| O(6)-H(6D)...Cl(1) | 0.87 | 2.09 | 2.959(15) | 175.7 |

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+1; #5 -x,-y+1,-z+1

Complex **2**

Description for the cation of **2** shown in Figure 6 with Co1 octahedrally coordinated (deviation from octahedral ideal is 0.261 by SHAPE[1] analysis) and the cation balanced by two hydrated chloride anions. One chloride is disordered over four sites. The cations and the ordered chloride from an interdigitated 2D slab consisting of face-to-face cations parallel to the (100) direction, surrounded on either side by water and disordered chloride anions.

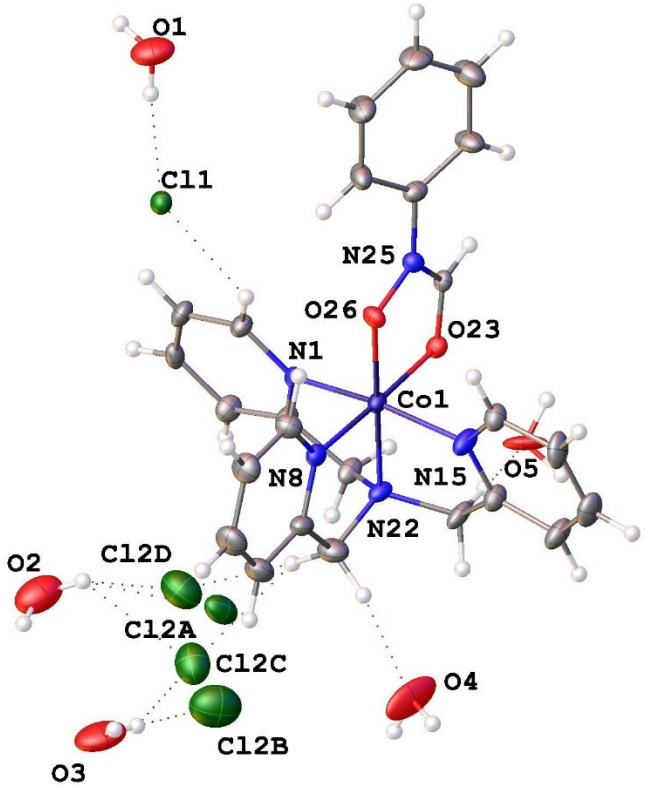



Figure S17. Full cation/anion and solvent assemblage of **2** with heteroatom labelling only. Cl2 is disordered over four locations with A 21%, B 39%, C 20% and D 20% occupied. Dashed lines indicate hydrogen bonding interactions.

[1] Llunell, M.; Casanova, D.; Cirera, J.; Alemany, P.; Alvarez, S. SHAPE: Program for the stereochemical analysis of molecular fragments by means of continuous shape measures and associated tools, 2.1; University of Barcelona: Barcelona, 2013.

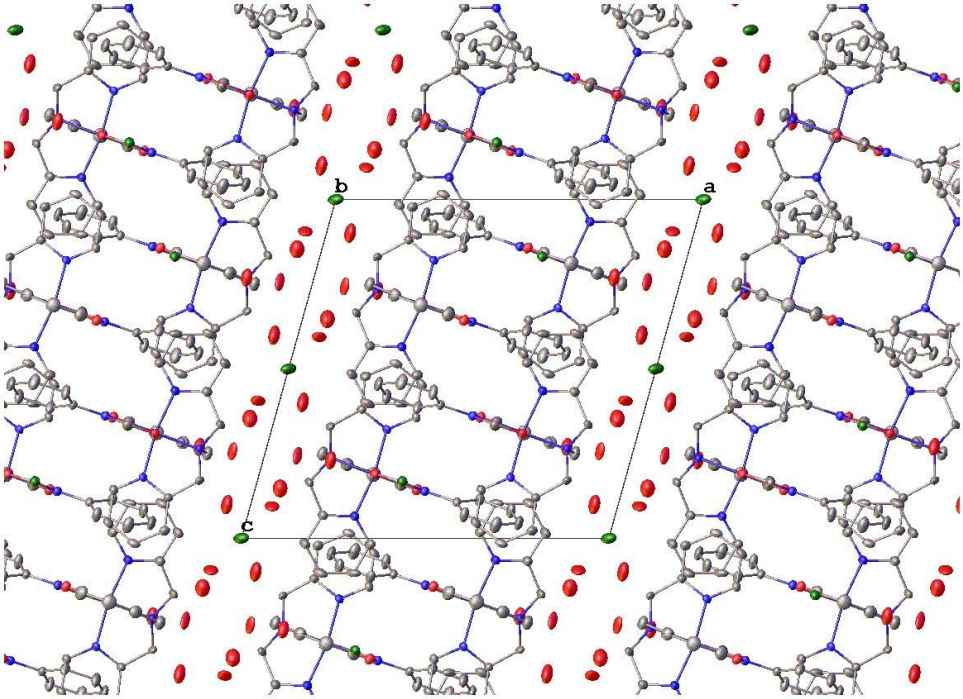



Figure S18. Packing motif in **2** showing the cation/chloride slab arrangement parallel to (100) with the water /disordered chloride layer separating each slab.