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Synthesis, Structure, and Magnetic Study of Two **Tridecanuclear Planar Cobalt Clusters with Unique Core** Geometries

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The reaction of $Co(NO_3)_2 \cdot 6H_2O$ with N,N-diethanolamine (H₂L1) in the presence of sodium acetate, using triethylamine as a base, leads to a tridecanuclear mixed-valent cobalt cluster $[Co^{II}_{9}Co^{III}_{4}(OH)_{6}(H_{2}O)_{2}(L1)_{8}(OAc)_{4}](NO_{3})_{4}\cdot 24H_{2}O$ (1). Similar reaction with a newly designed hydroxy- and nitrogen-rich chelating ligand 2-[bis(pyridin-2-ylmethyl)amino]-2-(hydroxymethyl)propane-1,3-diol (H₂L2) gives a mixedvalent Co_{13} cluster $[Co^{II}_{7}Co^{III}_{6}(OH)_{12}(L2)_{6}](NO_{3})_{8}\cdot 10H_{2}O$ (2).

Introduction

The synthesis of new polynuclear 3d-metal complexes (clusters) for single-molecule magnets (SMMs)^[1] has attracted great interest in coordination chemistry because SMMs exhibit fascinating physical properties, such as slow magnetic relaxation and quantum tunneling effect, and may have potential application in information storage and quantum computing at the molecular level.^[2] To date, the number of polynuclear Mn and Fe complexes that behave as SMMs is increasing rapidly and examples can be easily found in the literature.^[3] As a large anisotropic ion, Co^{II} is another candidate for SMMs. The first Co^{II} complex that displayed slow magnetic relaxation was reported in 2002.^[4] Over the past decade, a number of Co-containing SMMs have been reported, for example, complexes with Co4 molecular squares,^[5] Co₄ cubanes^[4,6] and related species,^[7] Co₅ square pyramids,^[8] and Co₈ systems.^[9] Among these, the most studied structural type for Co^{II}-based SMMs is the planar Co7 disc^[10] consisting of a central cobalt ion surrounded by a ring of six cobalt ions.

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The cobalt ions in both 1 and 2 are nearly coplanar, forming a novel shieldlike configuration for 1 and a unique hexagram structure for 2, both of which have not been observed for the polynuclear cobalt clusters. The magnetic susceptibility investigation showed that complexes 1 and 2 exhibited ferromagnetic coupling between Co^{II} ions. Further magnetic studies revealed a slight frequency dependence of 2, which suggests that 2 might be a single-molecule magnet.

However, there is still much to learn about the parameters that control slow relaxation in these Co^{II} systems. By focusing on the planar Co₇ disc-based clusters, it may be possible to examine systematically how structure relates to magnetism and hence improve their magnetic properties. In the development of new synthetic routes to metal clusters, the choice of ligands is always a key issue. Others have explored a wide variety of potentially chelating and bridging ligands that might foster the formation of disc clusters. These ligands include aromatic carboxylic acids,^[11] aromatic alcohols,^[12] alcohol amines,^[13] pyridyl alcohols,^[14] and so on.^[15] In our continuing efforts to synthesize new polynuclear cobalt clusters, we successfully used a commercial ligand ($H_2L1 = N, N$ -diethanolamine) and a novel hydroxy- and nitrogen-rich ligand derived from tris-(hydroxymethyl)aminomethane (TRIS) $\{H_2L2 = 2-[bis(pyr$ idin-2-ylmethyl)amino]-2-hydroxymethylpropane-1,3-diol} (Scheme 1) to assemble two novel planar mixed-valent Co₁₃ clusters based on Co₇ discs, formulated as $[Co^{II}_9Co^{III}_4(OH)_6$ -



Scheme 1. Synthesis of the H₂L2 ligand.

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 $(H_2O)_2(L1)_8(OAc)_4](NO_3)_4 \cdot 24H_2O$ (1) and $[Co^{II}_7Co^{III}_6 - (OH)_{12}(L2)_6](NO_3)_8 \cdot 10H_2O$ (2). Herein, we report their preparation, crystal structure, and magnetic properties.

Results and Discussion

Synthesis

The 1:1:1:1 reaction of $Co(NO_3)_2 \cdot 6H_2O$, H_2L1 , NaOAc·3H₂O, and Et₃N in MeOH gave a dark blue solution from which dark blue crystals of 1 were isolated in a moderate yield. A similar reaction with a new H₂L2 ligand afforded red-brown crystals of 2, also in a moderate yield. In both cases, NaOAc·3H₂O was added. Although the OAc⁻ anion was only found as a terminal ligand in the structure of 1, it is also necessary to the formation of complex 2. In the absence of NaOAc \cdot 3H₂O, 2 could not be obtained as immediate precipitation happened upon the addition of Et₃N. Since an evident color change is observed upon mixing of the reagents, it is likely that the oxidation step occurs during the initial reaction rather than the crystallization process, as commonly observed for the synthesis of polynuclear metal complexes with mixed carboxylate and chelating alcohol/alkoxide ligands.^[16] The formation of both 1 and 2 is very sensitive to the amount of base that is used. For example, the reactions with more Et₃N can cause either an oily solution or unidentified solids, whereas those with less Et_3N lead to poor yields of 1 and 2.

Description of the Crystal Structures

Complex 1 crystallizes in the monoclinic space group C2/c. Its asymmetrical unit contains half a $[Co^{II}_{9}Co^{III}_{4}(OH)_{6}]$ $(H_2O)_2(L1)_8(OAc)_4]^{4+}$ cation, two NO_3^- anions, and twelve lattice water molecules. A partially labeled plot of this cationic cluster is shown in Figure 1a, and selected bond lengths and angles are listed in Table S1 in the Supporting Information. This tridecanuclear cobalt aggregate is assembled by eight L1²⁻, four acetate, six hydroxo anions, and two water molecules. The structure of 1 is a derivation of a disclike Co₇ cluster, in which the Co ions are approximately coplanar (the mean deviation from the plane defined by the seven Co atoms is 0.058 Å), which forms corner-shared double Co₇ discs with a length of approximately 12.6 Å and a width of approximately 5.5 Å (Figure 1, b). The Co_{13} core can be also described as a shieldlike structure composed of fourteen edge-sharing Co₃ triangles in which the Co₃, Co₄, Co5, Co6, and Co7 ions and their centrosymmetric equivalents make up the edge of the shield, whereas Co1, Co2, and Co2A define the internal frame of the shield (Figure 1, c). Each of the Co ions in 1 adopts a distorted-octahedral geometry. The central Co1 atom is coordinated by six hydroxide μ_3 -O atoms, with each O atom shared by two Co atoms of the hexagonal ring consisting of Co₂, Co₃, Co₄, and their centrosymmetric equivalents. The Co atoms in the hexagonal ring all adopt a CoO₆ coordination sphere, with Co2 coordinated by four ethoxyl O atoms from four different L1²⁻ anions and two hydroxo groups, and Co3 and

Co4 both surrounded by two ethoxyl O atoms from two different L1²⁻ anions, two hydroxo O atoms, one carboxyl O from bridging acetate and one O atom from a bridging water molecule. Two Co atoms outside the hexagonal ring (Co6 and Co6A) are also in a CoO₆ coordination sphere completed by a chelated acetate anion and four ethoxyl O atoms from four different L1²⁻ anions. The other four Co atoms outside the ring (Co5, Co5A, Co7, and Co7A) are triply chelated by two L1²⁻ ligands. An analysis of the Co-O and Co-N bond lengths (Table S1), which are shorter for Co5 and Co7 [1.884(2) to 1.962(3) Å] than for Co1, Co2, Co3, Co4, and Co6 [1.969(2) to 2.264(2) Å] reveals that Co5 and Co7 are in a higher oxidation state than Co1, Co2, Co3, Co4, and Co6. Based on the bond-valence sum (BVS) calculations, Co5 and Co7 are assigned the oxidation state of +3, whereas Co1, Co2, Co3, Co4, and Co6 are assigned the oxidation state of +2 (Table S3 in the Supporting Information).^[17] The N.N-diethanolamine ligands in 1 are all doubly deprotonated; each chelates to one Co atom with N and two ethoxyl O atoms that further connect to another three Co atoms, displaying a (k^1) – $(\mu_2-\mu_3)$ – μ_4 coordination mode (Scheme 2, a). Considering the charge on the anionic ligands and the oxidation state of Co atoms, together with



Figure 1. (a) The partially labeled tridecanuclear structure of complex 1. The carbon and hydrogen atoms, together with solvent molecules, have been omitted for clarity. (b) The core of the structure of 1 showing only Co and bridged O atoms. (c) The Co core of 1. Color code: pink (Co^{III}), rose (Co^{II}), red (O).

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the existence of two μ_2 -H₂O molecules (O13 and O13A) and six μ_3 -OH ions (O14, O15 O16 and their centrosymmetric equivalents), complex 1 can be formulated as [Co-^{II}₉Co^{III}₄(OH)₆(H₂O)₂(L1)₈(OAc)₄]·(NO₃)₄·24H₂O.^[18] In 1, the adjacent Co···Co distance is ranged from 3.024 to 3.179 Å, while that between the central Co1 and the outer Co5, Co6 and Co7 is 5.313, 6.281 and 5.330 Å, respectively.



Scheme 2. Coordination modes of (a) $L1^{2-}$ and (b) $L2^{2-}$ anions.

Complex 2 belongs to the monoclinic space group $P2_1/c$. Its asymmetric unit consists of two crystallographically independent [Co^{II}_{3.5}Co^{III}₃(OH)₆(L2)₃]⁴⁺ clusters, eight NO₃⁻ anions, and ten lattice water molecules. Since these two cationic clusters differ only marginally in the interatomic distances and angles, only one will be discussed in detail. The cationic cluster unit comprises six (Co1, Co2, Co3, Co4, Co5 Co6) and a half cobalt ions (Co7) with Co7 located at the crystallographic inversion center, three L2²⁻ anions, and six μ_3 -hydroxo groups. As shown in Figure 2 (a), the molecular structure of 2 is a tridecanuclear cobalt cluster that can be formulated as $[Co^{II}_{7}Co^{III}_{6}(OH)_{12}(L2)_{6}]$ - $(NO_3)_8$ ·10H₂O. It has a disclike Co₇ core in the center surrounded by six more Co atoms. The Co atoms in 2 are nearly coplanar (the maximal deviation from the plane defined by the Co atoms is 0.1433 Å), resulting in a hexagram structure composed of twelve edge-sharing Co3 triangles, which include the six that form the hexagon in the middle and another six that make up the points of the star (Figure 2, b and c). The diagonal of this hexagram is approximately 10.69 Å. The central Co7 atom, lying on a crystallographic inversion center, is in a nearly perfect octahedral environment formed by six μ_3 -hydroxo oxygen atoms with all-trans octahedral angles of 180° and Co-O bonds varied over a narrow range [2.064(2)-2.071(2) Å] (Table S2 in the Supporting Information). Each Co atom in the middle hexagonal ring has an O₆ donor set made up by two methoxy O atoms from the L2²⁻ dianion and four μ_3 -oxo oxygen atoms, of which two also connect to the central Co atom and the other two to the Co atom at the vertices of the star. The six Co atoms (Co1, Co2, Co3, and their centrosymmetric equivalents) at the vertices of the star are six-coordinate by three nitrogen and two oxygen atoms from an $L2^{2-}$ ligand and one μ_3 -hydroxo atom, forming a distorted-octa-

hedral geometry. The Co–N and Co–O bond lengths of Co1, Co2, and Co3 fall in the range of 1.880(2) to 1.927(3) Å, which suggests that they have an oxidation state of +3, as also confirmed by the BVS calculations (Table S3 in the Supporting Information). For the other Co atoms at the central hexagonal ring (Co4, Co5, Co6, and their



Figure 2. (a) Partially labeled tridecanuclear structure of complex 2. The carbon and hydrogen atoms, together with solvent molecules have been omitted for clarity. (b) The core of the structure of 2 showing only Co and bridged O atoms. (c) The Co core of 2. Color code: Pink (Co^{III}), rose (Co^{II}), red (O).

centrosymmetric equivalents), the Co–O bond lengths are in the range of 2.034(2) to 2.187(2) Å, which are normal for a Co^{II} ion. The adjacent Co···Co distances vary from 3.046

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60

54

48

24

18

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to 3.145 Å, and those between the central Co7 and the outer Co1, Co2, and Co3 are 5.347, 5.318, and 5.343 Å, respectively. The L2²⁻ anion chelates to one Co atom with three N and two methoxy O atoms, each of which is further connected to another Co atom, exhibiting a $(k^1-k^1-k^1)-(\mu_2-\mu_2)$ μ_2)- μ_3 coordination mode (Scheme 2, b).

The metal topologies in 1 and 2 have not been seen for Co_{13} clusters. However, the Co_{13} motif of 1 resembles that in $[Co_{13}(mosao)_8(Hmosao)_6]$ ·3DMF·MeOH·3H₂O $(H_2 mosao = 3-methoxysalicylaldoxime)$ in which two Co_7 discs are intercrossed by sharing three Co atoms, forming a butterfly-like structure.^[19] In other structurally characterized Co₁₃ clusters, the metal core motifs have irregular shapes, based on either a Co₄ tetrahedron or a Co₅ square pyramid.^[1a]

Magnetic Properties

The magnetic susceptibility of 1 and 2 was measured on a polycrystalline powder sample in the temperature range of 2–300 K under a field of 0.1 T, as shown in Figure 3. The χT values at 300 K are 25.08 and 18.67 cm³ K mol⁻¹ for 1 and 2, respectively, which are much higher than the spinonly values ($S_i = 3/2$ and $g_{Co} = 2$) of 16.88 and $13.13 \text{ cm}^3 \text{ K} \text{ mol}^{-1}$ expected for the noninteracting nine Co^{II} ions in 1 and seven CoII ions in 2. This behavior is common for CoII complexes, and can be attributed to the orbital contribution of Co^{II.[20]} The γT values of 1 show a slight increase up to 30 K, and then increase sharply to a maximum value of $57.32 \text{ cm}^3 \text{ K mol}^{-1}$ at 2.5 K (35.68 cm³ K mol⁻¹ at 6 K for 2) followed by a fall to $56.82 \text{ cm}^3 \text{ K mol}^{-1}$ at 2.0 K $(20.50 \text{ cm}^3 \text{ K mol}^{-1} \text{ for } 2)$. The smooth increase in χT from 300 to 30 K for both complexes is generally associated with a compensation of ferromagnetism as well as spin-orbit couplings of the Co^{II} ions.^[21] The increase below 30 K for 1 and 2 are due to the ferromagnetic interactions between Co^{II} ions, whereas the decrease at low temperature might be caused by magnetic anisotropy of CoII ions and/or the Zeeman effect for both compounds. The data above 10 K for 1 and 20 K for 2 obey the Curie–Weiss law, which gives a Weiss constant θ = 4.19 K for 1 and θ = 4.15 K for 2 (Figure S2 in the Supporting Information). The positive Weiss constants further suggest the presence of ferromagnetic interactions in 1 and 2. This ferromagnetic coupling is consistent with the Co^{II}–O–Co^{II} bridging angles (ca. 90°), which favors the orthogonality of the magnetic orbitals.^[22]

To determine the spin ground state, the field dependence of magnetization in different magnetic fields (1-7 T) were collected in the temperature range 2-8 K, and they are plotted as reduced magnetization $(M/N\beta)$ versus H/T in Figure 4. These data show that saturation occurs with a value of 19.36 N β for 1 (15.15 N β for 2) and the various isofield lines do not superimpose, which clearly indicates the presence of the excited state and zero-field splitting in these clusters. The curves cannot be fitted by the ANISOFIT method^[23] owing to the ferromagnetic interactions resulting from nine highly anisotropic Co^{II} ions of 1 (seven for 2).^[24]



2

300

250



100

50

Furthermore, the magnetization was measured as a function of the applied field at 2 K and the data is shown in Figure 5.

T/K

150

T/K

200



Figure 4. Plots of reduced magnetization ($M/N\beta$) versus H/T at 2-8 K and 1–7 T for (a) 1 and (b) 2.

At low temperature, each CoII ion can be treated as an effective spin, $S_{\text{eff'}} = 1/2$, with anisotropy g values.^[21b] The M versus H data of 1 do not reach saturation even at 8 T,

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Figure 5. Plots of $M/N\beta$ versus H for complexes 1 and 2 measured at 2 K.

but are equal to 19.39 $N\beta$, which are consistent with a ground state of S' = 9/2 with g > 4.31, whereas **2** reaches a saturation value of 15.23 at 8 T, in agreement with the ground state of S' = 7/2 with g = 4.35. These results are also in line with the low temperature χT data, which give S' = 9/2 with g = 4.44 for **1** and S' = 7/2 with g = 4.22 for **2**.



Figure 6. The ac susceptibility of **2** measured in a zero dc field and plotted as (a) $\chi'T$ versus T and (b) χ'' versus T.

Alternating current (ac) susceptibility measurements were also carried out in a 3.0 Oe ac field oscillating at the indicated frequencies (311–1311 Hz) and with a zero direct current (dc) field. Both in-phase (χ') and out-of-phase (χ'') were determined to see if slow relaxation of magnetization occurs for 1 and 2. No frequency-dependence behavior was observed for 1 (Figure S3 in the Supporting Information). However, very small frequency-dependent in-phase and out-of-phase signals were detected for 2 below 3.5 K, which revealed the onset of slow relaxation of magnetization (Figure 6). The above results suggested that 2 might be a SMM. At the 2.0 K limit of our magnetometer, no peaks in χ'' versus *T* curves were seen in 2. Thus, quantitative estimation of the relaxation kinetics was not possible.

Conclusion

In summary, two novel mixed-valent planar Co₁₃ clusters have been successfully synthesized by means of a normal N,N-diethanolamine ligand and a new hydroxy- and nitrogen-rich chelating ligand. They are extended disclike Co₇ clusters, the metal core structures of which have not yet been reported for polynuclear cobalt clusters. Complex 1 has a planar Co₁₃ structure with a novel shieldlike configuration whereas complex 2 has a unique Co₁₃ hexagram structure. The formation of 1 indicates that the N,N-diethanolamine ligand can indeed support high nuclearity clusters when coupled with appropriate carboxylate ligands. Magnetic studies indicate that 1 and 2 both display dominant ferromagnetic interactions between the Co^{II} centers. The ac susceptibility data show that 2 exhibits a slight frequency-dependence behavior at static zero field below 3.5 K, which suggests that it might be a single-molecule magnet (SMM).

Experimental Section

General: All the materials were purchased from the commercial sources and used without further purification. Elemental analyses of C, H, and N were carried out with a Vario EL III elemental analyzer. The powder XRD patterns were recorded on crushed single crystals in the 2θ range 5–65° using Cu- K_a radiation. The XRD of **1** and **2** were measured on a PANalytical X'Pert PRO X-ray diffractometer (Figure S1 in the Supporting Information). Magnetic susceptibilities were measured on polycrystalline samples with a Quantum Design PPMS-9T system. Diamagnetic corrections were made using Pascal's constants.

Synthesis of H₂L2 and Complexes 1 and 2

H₂L2: A mixture of 2-amino-2-hydroxymethylpropane-1,3-diol (1.21 g, 10.0 mmol) and 2-picolyl chloride hydrochloride (3.28 g, 20.0 mmol) in MeCN (100 mL) was heated at reflux under an Ar atmosphere for 48 h in the presence of K₂CO₃ (5.52 g, 40.0 mmol) and KI (1.66 g, 10.0 mmol). The resulting orange solution was filtered, and the solvent was removed under reduced pressure. The pale yellow solid obtained was purified by chromatography using MeOH/ethyl acetate (v/v 1:3) as the eluant. H₂L2 was obtained as a pale yellow solid (1.6 g, 52%). ¹H NMR (CDCl₃): δ = 8.583–6.938 (m, 8 H, Py-H), 4.153 (s, 4 H, Py-CH₂), 3.789 (s, 6 H,



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CCH₂OH) ppm. ¹³C NMR (CDCl₃): δ = 160.92, 148.84, 137.11, 123.20, 122.28, 65.83, 65.26, 50.62, 25.37 ppm. C₁₆H₂₁N₃O₃ (303.36): calcd. C 63.48, H 7.03, N 13.76; found C 63.35, H 6.98, N 13.85.

[Co^{II}₉Co^{III}₄(OH)₆(H₂O)₂(L1)₈(OAc)₄](NO₃)₄·24H₂O (1): Solid NaOAc·3H₂O (136 mg, 1.00 mmol) was added to a stirred solution of Co(NO₃)₂·6H₂O (290 mg, 1.00 mmol) and H₂L1 (107 mg, 1.00 mmol) in MeOH (20 mL), which caused a rapid color change from pink to light blue, then NEt₃ (0.140 mL) was added. The final mixture was under vigorous stirring for 0.5 h before filtration. The filtrate was left undisturbed at ambient temperature for about one week. X-ray-quality dark blue needle crystals of 1 were collected by filtration, washed with cold MeOH (2×5 mL), and dried under vacuum (0.25 g, yield 25%). Co₁₃C₄₀H₁₄₂N₁₂O₆₈ (2645.73): calcd. C 18.14, H 5.37, N 6.35; found C 17.88, H 5.43, N 6.30.

[Co^{II7}₇Co^{III}₆(OH)₁₂(L2)₆](NO₃)₈·10H₂O (2): A solution of H₂L2 (100 mg, 0.330 mmol), Co(NO₃)₂·6H₂O (191 mg, 0.660 mmol), and NaOAc·3H₂O (136 mg, 1.00 mmol) in MeOH (20 mL) was stirred for 10 min and then Et₃N (0.280 mL) was added under vigorous stirring, which caused a rapid color change from pink to redbrown. The solution was further stirred for 1 h, filtered, and the filtrate was left undisturbed at ambient temperature for about one week. X-ray-quality red-brown prism crystals of 2 were collected by filtration, washed with cold MeOH (2×5 mL), and dried under ambient temperature (0.14 g, 15%). C₉₆H₁₂₆Co₁₃N₁₈O₃₀·H₂₀N₈O₃₄ (2778.3 + 676.2): calcd. C 33.35, H 4.23, N 10.54; found 32.95, H 4.03, N 10.46.

X-ray Crystallography: X-ray diffraction data were collected on a Rigaku diffractometer with a Mercury CCD area detector (Mo- K_{α} ; $\lambda = 0.71073$ Å) at 293(2) K. Empirical absorption corrections were applied to the data using the Crystal Clear program.^[23] The structures were solved by the direct method and refined by the full-matrix least-squares cycles on F^2 using the SHELXTL-97 program.^[25] Metal atoms were located from the *E* maps and other non-hydrogen atoms were refined anisotropically.

Table 1. Crystal data and experimental details for complexes ${\bf 1}$ and ${\bf 2}$.

	1	2
Formula	C ₄₀ H ₁₄₂ Co ₁₃ N ₁₂ O ₆₈	C ₉₆ H ₁₂₆ Co ₁₃ N ₁₈ O ₃₀ ·H ₂₀ N ₈ O ₃₄
$M_{\rm r}$	2645.74	3454.24
Crystal system	monoclinic	monoclinic
Space group	C2/c	P2(1)/c
a [Å]	30.206(7)	30.508(3)
<i>b</i> [Å]	12.064(3)	20.2981(16)
c [Å]	26.736(6)	22.881(2)
a [°]	90	90
β [°]	90.744(3)	97.6740(10)
γ [°]	90	90
$V[Å^3]$	9742(4)	14042(2)
Ζ	4	4
$D_{\rm calcd.} [\rm g cm^{-3}]$	1.804	1.314
$\mu \text{ [mm^{-1}]}$	2.263	1.556
F(000)	5444	5676
Reflections collected	36527	80040
Reflections unique	11013	19014
R _{int}	0.0285	0.0343
$R_1^{[a]}$	0.0424	0.0500
$wR_2^{[b]}$	0.1093	0.1509
Goodness of fit on E^2	1.066	0.999

[a] $R_1 = \Sigma ||F_o| - |F_c|| / \Sigma |F_o|$. [b] $wR_2 = [\Sigma w (F_o^2 - F_c^2) 2 / \Sigma w (F_o^2)^2]^{0.5}$.

The oxygen atom of the uncoordinated methanol group in H_2L2 was disordered over two positions in a ratio of 65:35. The hydrogen atoms were positioned geometrically except those of hydroxo and methoxy groups, which were not added. PLATON/SQUEEZE was employed to remove the diffused electron density of heavily disordered water molecules of **2** and the final formula was calculated from the TGA result (Figure S4 in the Supporting Information). Crystal data and experimental details for complexes **1** and **2** are given in Table 1.

CCDC-906114 (for 1) and -906115 (for 2) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

Supporting Information (see footnote on the first page of this article): Selected bond lengths and angles, XRD, TGA, and additional magnetic data.

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Cluster Compounds

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Synthesis, Structure, and Magnetic Study of Two Tridecanuclear Planar Cobalt Clusters with Unique Core Geometries

Keywords: Cluster compounds / Mixedvalent compounds / Cobalt / Magnetic properties



Two novel mixed-valent Co_{13} clusters with unique shieldlike and hexagram core architectures were synthesized and structurally characterized. The magnetic susceptibility investigation showed that they both exhibited ferromagnetic coupling between Co^{II} ions and one of them might be a singlemolecule magnet.