Electronic Supplementary Information (ESI)

Novel 3D Lanthanide-Organic Frameworks with an Unusual Infinite Nanosized Ribbon $[Ln_3(\mu_3\text{-OH})_2(\text{-CO}_2)_6]^{+}_{n}$ (Ln = Eu, Gd, Dy): Syntheses, Structures, Luminescence, and Magnetic Properties

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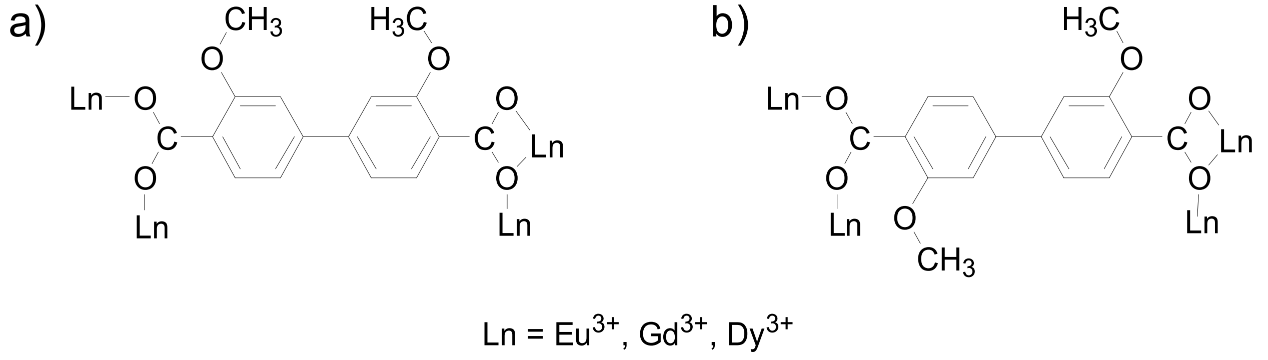

Scheme S1 The coordination modes of L ligand in complexes **1**-**3**.

Table S1 Selected bond angles (°) for complexes 1-3

	1^{a}		
O1W-Eu1-O2	70.48(15)	O2W-Eu2-O3	127.31(12)
O1W-Eu1-O3	129.53(13)	O2W-Eu2-O5	125.05(12)
O1W-Eu1-O11	133.49(13)	O2W-Eu2-O18	64.10(12)
O1W-Eu1-O12	133.33(13)	O2W-Eu2-O19	73.60(13)
O1W-Eu1-O20^{i}	72.34(12)	O2W-Eu2-O13^{v}	137.39(14)
O1W-Eu1-O8^{ii}	65.69(12)	O2W-Eu2-O14^{v}	127.50(11)
O1W-Eu1-O6^{iii}	129.88(13)	O2W-Eu2-O4^{iii}	72.01(11)
O1^{iv}-Eu1-O1W	79.43(14)	O2W-Eu2-O6^{iiii}	77.03(12)
O2-Eu1-O3	144.26(13)	O3-Eu2-O5	77.75(12)
O2-Eu1-O11	76.68(14)	O3-Eu2-O18	84.05(12)
O2-Eu1-O12	126.01(13)	O3-Eu2-O19	148.85(12)
O2-Eu1-O20^{i}	79.28(13)	O3- Eu2-O13^{v}	93.51(13)
O2-Eu1-O8^{ii}	102.32(14)	O3- Eu2-O14^{v}	71.24(11)
O2-Eu1-O6^{iii}	77.17(13)	O3-Eu2-O4^{iii}	126.59(11)
O1^{iv}-Eu1-O2	146.56(12)	O3-Eu2-O6^{iii}	69.63(12)
O3-Eu1-O11	96.14(12)	O5-Eu2-O18	73.30(13)
O3-Eu1-O12	65.95(10)	O5-Eu2-O19	71.10(13)
O3-Eu1-O20^{i}	131.67(11)	O5-Eu2-O13^{v}	69.52(14)
O3-Eu1-O8^{ii}	70.23(10)	O5-Eu2-O14^{v}	105.87(12)
O3-Eu1-O6^{iii}	67.58(11)	O4^{iii}- Eu2-O5	136.90(12)
O1^{iv}-Eu1-O3	67.83(11)	O5-Eu2-O6^{iii}	147.37(13)
O11-Eu1-O12	51.77(12)	O18-Eu2-O19	87.07(13)
O11-Eu1-O20^{i}	69.89(12)	O13^{v}-Eu2-O18	142.37(14)
O8^{ii}-Eu1-O11	155.69(12)	O14^{v}-Eu2-O18	154.63(12)
O6^{iii}-Eu1-O11	70.17(11)	O4^{iii}-Eu2-O18	136.08(12)
O1^{iv}-Eu1-O11	117.11(12)	O6^{iii}-Eu2-O18	101.93(12)
O12-Eu1-O20^{i}	69.77(11)	O13^{v}-Eu2-O19	75.81(13)
O8^{ii}-Eu1-O12	131.03(11)	O14^{v}-Eu2-O19	117.10(12)
O6^{iii}-Eu1-O12	96.64(10)	O4^{iii}-Eu2-O19	78.99(12)
O1^{iv}-Eu1-O12	66.94(11)	O6^{iii}-Eu2-O19	141.52(12)
O8^{ii}-Eu1-O20^{i}	134.24(11)	O13^{v}-Eu2-O14^{v}	48.27(12)
O6^{iii}-Eu1-O20^{i}	137.19(11)	O4^{iii}-Eu2-O13^{v}	73.61(14)
O1^{iv}-Eu1-O20^{i}	77.95(12)	O6^{iii}-Eu2-O13^{v}	112.38(12)
O6^{iii}-Eu1-O8^{ii}	85.82(10)	O4^{iii}-Eu2-O14^{v}	61.60(11)
O1^{iv}-Eu1-O8^{ii}	77.28(12)	O6^{iii}- Eu2-O14^{v}	64.59(10)
O1^{iv}-Eu1-O6^{iii}	135.34(11)	O4^{iii}-Eu2-O6^{iii}	68.58(11)
O3-Eu3-O4	76.60(11)	O12-Eu3-O17	74.41(12)
O3-Eu3-O6	99.05(11)	O7^{vi}-Eu3-O12	81.83(12)
O3-Eu3-O12	69.21(11)	O12-Eu3-O14^{vii}	138.91(12)
O3- Eu3-O17	96.97(12)	O1^{iv}-Eu3-O12	66.30(11)
O3-Eu3-O7^{vi}	142.34(11)	O7^{vi}-Eu3-O17	97.85(12)
O3-Eu3-O14^{vii}	143.90(12)	O14^{vii}-Eu3-O17	77.08(13)
O1^{iv}-Eu3-O3	68.91(11)	O1^{iv}-Eu3-O17	140.70(12)
O4- Eu3-O6	69.54(11)	O7^{vi}-Eu3-O14^{vii}	73.42(13)
O4-Eu3-O12	136.58(11)	O1^{iv}-Eu3-O7^{vi}	77.80(11)

O4-Eu3-O17	84.30(12)	O1^{iv}-Eu3-O14^{vii}	135.57(12)
O4-Eu3-O7^{vi}	139.26(12)	Eu1^{iii}-O1-Eu3^{iii}	99.72(12)
O4-Eu3-O14^{vii}	67.43(12)	Eu1-O3-Eu2	108.19(14)
O1^{iv}-Eu3-O4	124.37(11)	Eu1-O3-Eu3	101.04(11)
O6-Eu3-O12	140.58(11)	Eu2-O3-Eu3	123.09(13)
O6-Eu3-O17	144.95(12)	Eu1^{iv}-O6-Eu3	121.30(12)
O6-Eu3-O7^{vi}	88.11(12)	Eu2^{iv}-O4-Eu3	105.64(11)
O6-Eu3-O14^{vii}	71.62(12)	Eu1^{iv}-O6-Eu2^{iv}	110.70(14)
O1^{iv}-Eu3-O6	74.34(11)	Eu1-O12-Eu3	99.69(11)
Eu2^{iv}-O6-Eu3	105.64(11)	Eu2^{viii}-O14-Eu3^{vii}	92.03(12)

2^{b}

O1W-Gd1-O2	70.80(18)	O1W-Gd1-O3	129.20(14)
O1W-Gd1-O11	133.57(14)	O1W-Gd1-O12	132.98(14)
O1W-Gd1-O20^{i}	72.15(13)	O1W-Gd1-O7^{ii}	65.45(14)
O1^{iii}-Gd1-O1W	78.96(16)	O1W-Gd1-O6^{iv}	130.61(15)
O2-Gd1-O3	144.12(13)	O2-Gd1-O11	76.84(14)
O2-Gd1-O12	126.40(14)	O2-Gd1-O20^{i}	79.29(14)
O2-Gd1-O7^{ii}	100.84(15)	O1^{iii}-Gd1-O2	146.60(12)
O2-Gd1-O6^{iv}	77.25(13)	O3-Gd1-O11	96.30(12)
O3-Gd1-O12	65.92(10)	O3-Gd1-O20^{i}	131.93(12)
O3-Gd1-O7^{ii}	70.89(12)	O1^{iii}-Gd1-O3	67.79(11)
O3-Gd1-O6^{iv}	67.46(12)	O11-Gd1-O12	51.92(12)
O11-Gd1-O20^{i}	69.80(12)	O7^{ii}-Gd1-O11	155.23(13)
O1^{iii}-Gd1-O11	117.21(12)	O6^{iv}-Gd1-O11	69.93(12)
O12-Gd1-O20^{i}	70.01(11)	O7^{ii}-Gd1-O12	132.04(12)
O1^{iii}-Gd1-O12	66.92(12)	O6^{iv}-Gd1-O12	96.28(11)
O7^{ii}-Gd1-O20^{i}	134.55(13)	O1^{iii}-Gd1-O20^{i}	78.21(12)
O6iv-Gd1-O20^{i}	136.89(12)	O1 ^{iii}-Gd1-O7 ^{ii}	78.41(12)
O6^{iv}-Gd1-O7^{ii}	85.44(12)	O1^{iii}-Gd1-O6^{iv}	135.20(11)
O2W-Gd2-O3	127.77(12)	O2W-Gd2-O5	125.24(14)
O2W-Gd2-O18	64.27(13)	O2W-Gd2-O19	73.45(13)
O2W-Gd2-O13	137.44(15)	O2W-Gd2-O14^{v}	126.93(13)
O2W-Gd2-O4^{iv}	71.51(13)	O2W-Gd2-O6^{iv}	76.99(12)
O3-Gd2-O5	77.30(13)	O3-Gd2-O18	84.14(12)
O3-Gd2-O19	148.68(12)	O3-Gd2-O13^{v}	92.89(13)
O3-Gd2-O14^{v}	71.45(11)	O3-Gd2-O4^{iv}	126.86(11)
O3-Gd2-O6^{iv}	69.73(12)	O5-Gd2-O18	73.32(13)
O5-Gd2-O19	71.38(13)	O5-Gd2-O13^{v}	69.85(15)
O5-Gd2-O14^{v}	106.23(12)	O4^{iv}-Gd2-O5	137.19(12)
O5-Gd2-O6^{iv}	147.01(13)	O18-Gd2-O19	87.14(13)
O13^{v}-Gd2-O18	142.77(14)	O14^{v}-Gd2-O18	154.79(12)
O4^{iv}-Gd2-O18	135.75(12)	O6^{iv}-Gd2-O18	101.61(12)
O13^{v}-Gd2-O19	76.34(13)	O14^{v}-Gd2-O19	117.03(12)
O4^{iv}-Gd2-O19	78.82(12)	O6^{iv}-Gd2-O19	141.59(12)
O13^{v}-Gd2-O14^{v}	47.96(13)	O4^{iv}-Gd2-O13^{v}	73.79(14)
O6^{iv}-Gd2-O13^{v}	112.11(12)	O4^{iv}-Gd2-O14^{v}	61.49(11)
O6^{iv}-Gd2-O14^{v}	64.54(11)	O4^{iv}-Gd2-O6^{iv}	68.82(11)
O3-Gd3-O4	76.76(12)	O3-Gd3-O6	99.46(12)

O3-Gd3-O12	68.94(11)	O3-Gd3-O17	96.59(12)
O3-Gd3-O14^{vi}	144.41(12)	O3-Gd3-O8^{vii}	142.70(12)
O1^{iii}-Gd3-O3	69.10(11)	O4-Gd3-O6	69.42(11)
O4-Gd3-O12	136.42(11)	O4-Gd3-O17	84.25(12)
O4-Gd3-O14^{vi}	67.82(13)	O4-Gd3-O8^{vii}	138.92(13)
O1^{iii}-Gd3-O4	124.42(11)	O6-Gd3-O12	141.00(11)
O6-Gd3-O17	144.81(12)	O6-Gd3-O14^{vi}	71.76(12)
O6-Gd3-O8^{vii}	88.25(12)	O1^{iii}-Gd3-O6	74.47(11)
O12-Gd3-O17	74.13(12)	O12-Gd3-O14^{vi}	138.37(12)
O8^{vii}-Gd3-O12	82.14(12)	O1^{iii}-Gd3-O12	66.59(11)
O14^{vi}-Gd3-O17	76.96(13)	O8^{vii}-Gd3-O17	97.59(13)
O1^{iii}-Gd3-O17	140.71(13)	O8^{vii}-Gd3-O14^{vi}	72.66(13)
O1^{iii}-Gd3-O14^{vi}	135.47(12)	O1^{iii}-Gd3-O8^{vii}	78.20(12)
Gd1^{iv}-O1-Gd3^{iv}	99.76(12)	Gd1-O3-Gd2	108.20(14)
Gd1-O3-Gd3	100.85(11)	Gd2-O3-Gd3	123.33(13)
Gd2^{iii}-O4-Gd3	102.39(12)	Gd1^{iii}-O6-Gd3	121.17(13)
Gd2^{iii}-O6-Gd3	105.90(12)	Gd1^{iii}-O6-Gd2^{iii}	110.81(14)
Gd1-O12-Gd3	99.76(11)	Gd2^{viii}-O14-Gd3^{vi}	91.38(12)

3^{c}

O1W-Dy1-O2	69.4(2)	O1W-Dy1-O3	129.6(2)
O1W-Dy1-O11	65.25(19)	O1W-Dy1-O20	71.9(2)
O1W-Dy1-O7^{i}	132.5(2)	O1W-Dy1-O8^{i}	133.0(2)
O1W-Dy1-O6^{ii}	130.1(2)	O^{iii}-Dy1-O1W	79.2(2)
O2-Dy1-O3	144.60(19)	O2-Dy1-O11	100.5(2)
O2-Dy1-O20	79.1(2)	O2-Dy1-O7^{i}	76.6(2)
O2-Dy1-O8^{i}	126.68(19)	O2-Dy1-O6^{ii}	78.06(19)
O1^{iii}-Dy1-O2	145.62(19)	O3-Dy1-O11	71.03(17)
O3-Dy1-O20	132.05(18)	O3-Dy1-O7^{i}	97.12(18)
O3-Dy1-O8^{i}	66.40(16)	O3-Dy1-O6^{ii}	67.22(16)
O1^{iii}-Dy1-O3	67.97(17)	O11-Dy1-O20	133.86(18)
O7^{i}-Dy1-O11	155.75(18)	O8^{i}-Dy1-O11	132.32(17)
O6^{ii}-Dy1-O11	85.61(16)	O1^{iii}-Dy1-O11	77.66(17)
O7^{i}-Dy1-O20	69.83(19)	O8^{i}-Dy1-O20	69.73(18)
O6^{ii}-Dy1-O20	137.43(18)	O1^{iii}-Dy1-O20	78.23(19)
O7^{i}-Dy1-O8^{i}	52.64(18)	O6^{ii}-Dy1-O7^{i}	70.20(18)
O1^{iii}-Dy1-O7^{i}	118.37(19)	O6^{ii}-Dy1-O8^{i}	96.71(16)
O1^{iii}-Dy1-O8^{i}	67.39(17)	O1^{iii}-Dy1-O6^{ii}	135.10(17)
O2W-Dy2-O3	128.68(18)	O2W-Dy2-O5	124.58(19)
O2W-Dy2-O17	137.3(2)	O2W-Dy2-O19^{iv}	73.3(2)
O2W-Dy2-O14^{v}	64.6(2)	O2W-Dy2-O4^{ii}	71.49(18)
O2W-Dy2- O6^{ii}	77.30(18)	O3-Dy2-O5	78.00(18)
O3-Dy2-O17	92.09(19)	O3-Dy2-O19^{iv}	148.93(19)
O3-Dy2-O14^{v}	84.14(19)	O3-Dy2-O4^{ii}	126.13(17)
O3-Dy2-O6 ^{ii}	69.68(17)	O5-Dy2-O17	69.7(2)
O5-Dy2-O19^{iv}	71.0(2)	O5-Dy2-O14^{v}	73.3(2)
O4^{ii}-Dy2-O5	137.09(18)	O5-Dy2-O6 ^{ii}	147.63(18)
O17-Dy2-O19^{iv}	75.8(2)	O14^{v}-Dy2-O17	142.9(2)
O4^{ii}-Dy2-O17	74.08(19)	O6^{ii}-Dy2-O17	112.29(18)

O14^{v}-Dy2-O19^{iv}	88.6(2)	O4^{ii}-Dy2-O19^{iv}	78.52(19)
O6^{ii}-Dy2-O19^{iv}	141.37(19)	O4^{ii}-Dy2-O14^{v}	136.12(19)
O6^{ii}-Dy2-O14^{v}	101.00(19)	O4^{ii}-Dy2-O6^{ii}	68.63(17)
O3-Dy3-O4	76.82(17)	O3-Dy3-O6	99.56(17)
O3-Dy3-O8^{i}	69.13(17)	O3-Dy3-O13^{v}	96.67(18)
O1^{iii}-Dy3-O3	68.73(17)	O3-Dy3-O12^{iii}	141.84(17)
O3-Dy3-O18^{iii}	145.18(19)	O4-Dy3-O6	69.57(17)
O4-Dy3-O8^{i}	136.62(17)	O4-Dy3-O13^{v}	83.96(19)
O1^{iii}-Dy3-O4	124.44(18)	O4-Dy3-O12^{iii}	139.88(17)
O4-Dy3-O18^{iii}	68.64(18)	O6-Dy3-O8^{i}	140.94(17)
O6-Dy3-O13^{v}	144.58(18)	O1^{iii}-Dy3-O6	74.73(17)
O6-Dy3-O12^{iii}	88.85(18)	O6-Dy3-O18^{iii}	72.81(18)
O8^{i}-Dy3-O13^{v}	74.41(18)	O1^{iii}-Dy3-O8^{i}	66.30(17)
O8^{i}-Dy3-O12^{iii}	80.93(17)	O8^{i}-Dy3-O18^{iii}	136.98(18)
O1^{iii}-Dy3-O13^{v}	140.69(18)	O12^{iii}-Dy3-O13^{v}	97.48(19)
O13^{v}-Dy3-O18^{iii}	75.88(18)	O1^{iii}-Dy3-O12^{iii}	78.00(17)
O1^{iii}-Dy3-O18^{iii}	136.27(18)	O12^{iii}-Dy3-O18^{iii}	72.87(19)
Dy1^{ii}-O1-Dy3^{ii}	99.94(18)	Dy1-O3-Dy2	108.34(19)
Dy1-O3-Dy3	100.41(18)	Dy2-O3-Dy3	123.5(2)
Dy2^{iii}-O4-Dy3	102.71(18)	Dy1^{iii}-O6-Dy3	121.0(2)
Dy2^{iii}-O6-Dy3	105.95(19)	Dy1^{iii}-O6-Dy2^{iii}	110.83(19)
Dy1^{vi}-O8-Dy3^{vi}	99.63(18)		

[a]Symmetry codes: i) -1 + *x*, *y*, *z*; ii) 2 - *x*, 1/2 + *y*, 1/2 - *z*; iii) *x*, 1/2 - *y*, -1/2 + *z*; iv) *x*, 1/2 - *y*, 1/2 + *z*; v) 3 - *x*, 1/2 + *y*, 1/2 - *z*; vi) 2 - *x*, - *y*, 1 - *z*; vii) 3 - *x*, -*y*, 1- *z*; viii) 3 - *x*, -1/2 + *y*,1/2-*z*. [b]Symmetry codes: i) 1 + *x*, *y*, *z*; ii) –1 – *x*, *y* – 1/2, 3/2 – *z*; iii) *x*, 3/2 – *y*, *z* – 1/2; iv) *x*, 3/2 – *y*, 1/2 + *z*; v) –2 – *x*, *y* – 1/2, 3/2 – *z*; vi) –2 – *x*, 2 – *y*, 1 – *z*; vii) –1 – *x*, 2 – *y*, 1 – *z*; viii) –2 – *x*, 1/2 + *y*, 3/2 – *z*. [c]Symmetry codes: i) 1 – *x*, *y* – 1/2, 3/2 – *z*; ii) *x*, 1/2 – *y*, *z* – 1/2; iii) *x*, 1/2 – *y*, 1/2 + *z*; iv) 1 + *x*, *y*, *z*; v) 2 – *x*, *y* – 1/2, 3/2 – *z*; vi) 1 – *x*, 1/2 + *y*, 3/2 – *z*.

Table S2 Hydrogen-bonding geometry (Å, °) for complexes **2-3**

Complexes	D–H···A	d(D–H)	d(H···A)	d(D···A)	∠D–H···A
	O1W–H1WA···O19^{i}	0.86(5)	2.01(5)	2.813(6)	155(5)
	O1W–H1WA···O13^{ii}	0.86(5)	2.44(4)	2.961(6)	120(4)
	O1W–H1WB···O9^{ii}	0.87(3)	2.25(5)	3.018(6)	148(6)
2[a]	O2W–H2WA···O3W	0.85(5)	1.93(5)	2.742(6)	159(5)
	O2W–H2WB···O16	0.84(5)	2.21(5)	2.992(6)	155(5)
	C1–H1A···O1W^{iii}	0.93	2.50	3.057(9)	119
	C2–H2A···O19^{iv}	0.93	2.51	3.123(7)	124
	O1W–H1WA···O19	0.86(6)	1.91(6)	2.769(8)	176(12)
	O1W–H1WB···O10	0.86(5)	2.37(6)	3.020(9)	133(7)
	O1W–H1WB···O16^{i}	0.86(5)	2.59(8)	3.202(9)	130(8)
3[b]	O2W–H2WA···O15^{ii}	0.85(6)	2.15(6)	2.973(9)	161(6)
	O2W–H2WB···O3W	0.84(6)	1.98(7)	2.740(9)	150(6)
	C1–H1A···O1W^{iii}	0.93	2.44	3.011(11)	120
	C2–H2A···O19^{iv}	0.93	2.45	3.062(11)	123

[a]Symmetry codes: i) 1 + *x*, *y*, *z*; ii) -1 - *x*, *y* - 1/2, 3/2 - *z*; iii) *x*, 3/2 - *y*, 1/2 + *z*; iv) *x*, 3/2 - *y*, *z* - 1/2.

[b]Symmetry codes: i) *x* – 1, *y*, *z*; ii) 2 – *x*, *y* – 1/2, 3/2 – *z*; iii) *x*, 1/2 – *y*, *z* – 1/2; iv) 1 + *x*, 1/2 – *y*, 1/2 + *z*.

Table S3 C–H···π / π···π stacking interaction (Å, °) for complexes **2** and **3**

Complexes	D–H···A / π···π	d(H···π) / d(π···π)	∠C–H···π / dihedral angle
2	C34–H34C···π (C11–16)	3.198	159.2
	C34–H34B···π (C21–26)^{i}	3.333	159.3
	C18–H18C···π (C27–32)	2.886	140.6
	C26–H26A···π (C27–32)^{i}	3.107	117.9
	π (C5–10)···π (C21–26)	3.815	10.8
3	C10–H10A···π (C21–26)	3.699	109.9
	C26–H26A···π (C5–10)	3.484	117.1

Symmetry code: i) –2 – *x*, 2 – *y*, 1 – z.

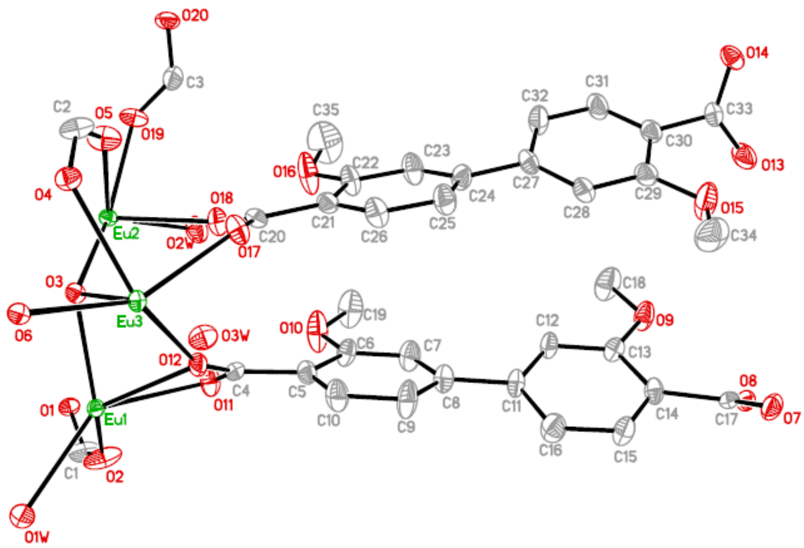

Fig. S1 ORTEP drawing (at 50% probability) of the asymmetric unit for complex **1**.

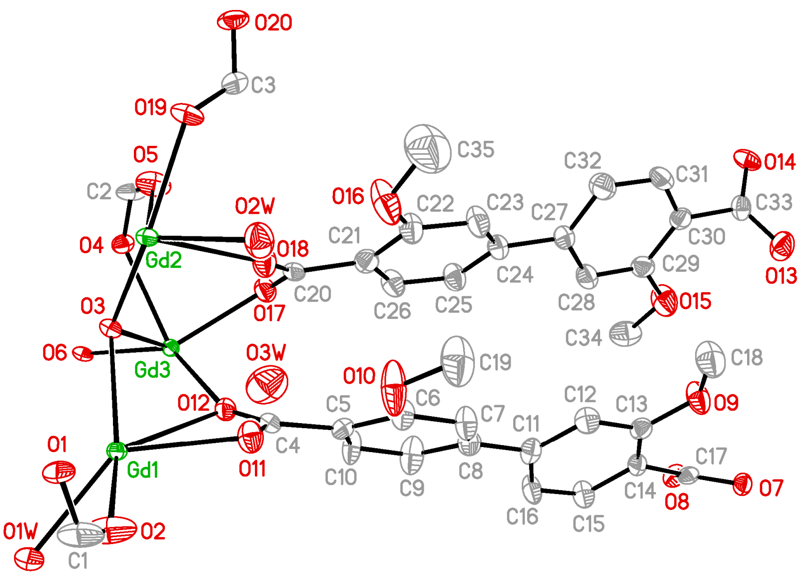

Fig. S2 ORTEP drawing (at 50% probability) of the asymmetric unit for complex **2**.

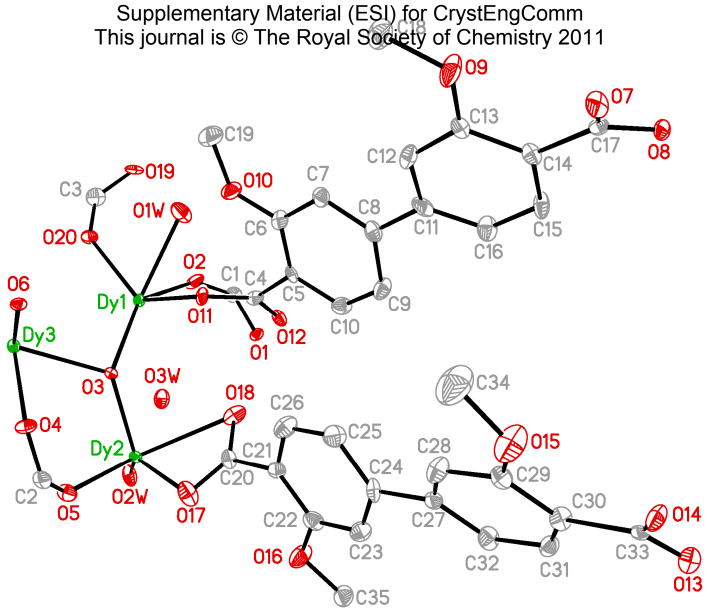

Fig. S3 ORTEP drawing (at 50% probability) of the asymmetric unit for complex **3**.

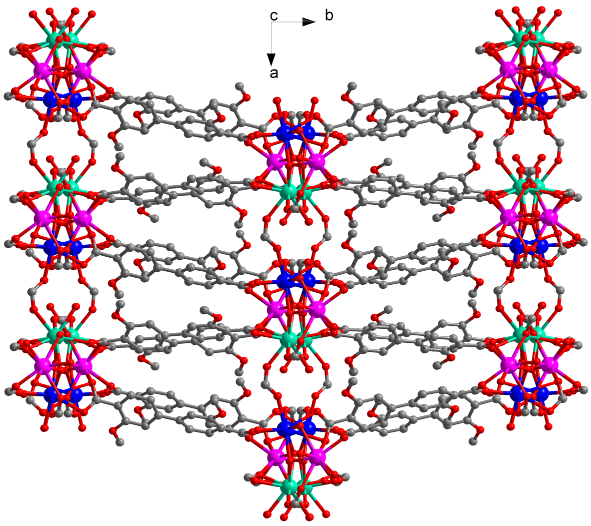

Fig. S4 Ball and stick viewed of 3D framework in **2** from *c* axis.

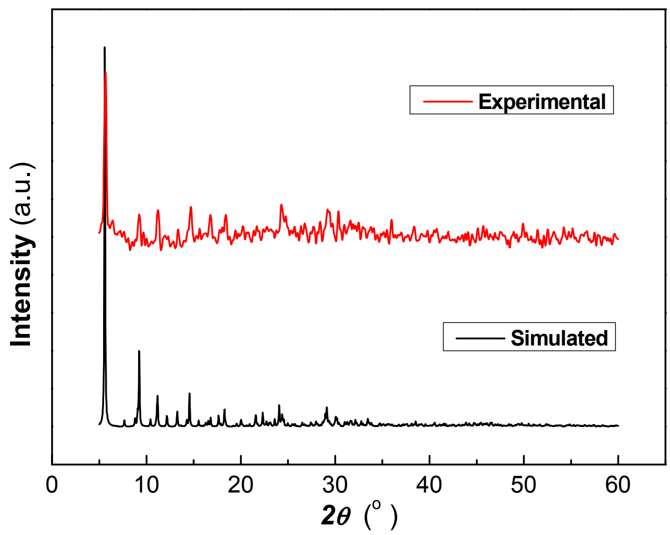

Fig. S5 Experimental and simulated X-ray powder diffraction patterns of complex **1**.

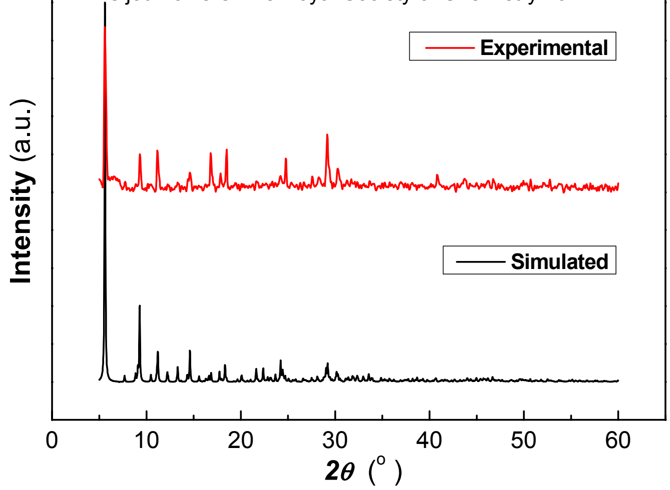

Fig. S6 Experimental and simulated X-ray powder diffraction patterns of complex **2**.

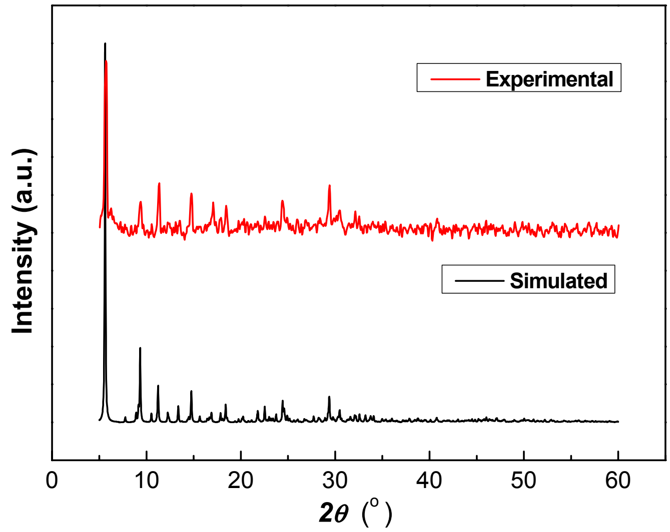

Fig. S7 Experimental and simulated X-ray powder diffraction patterns of complex **3**.

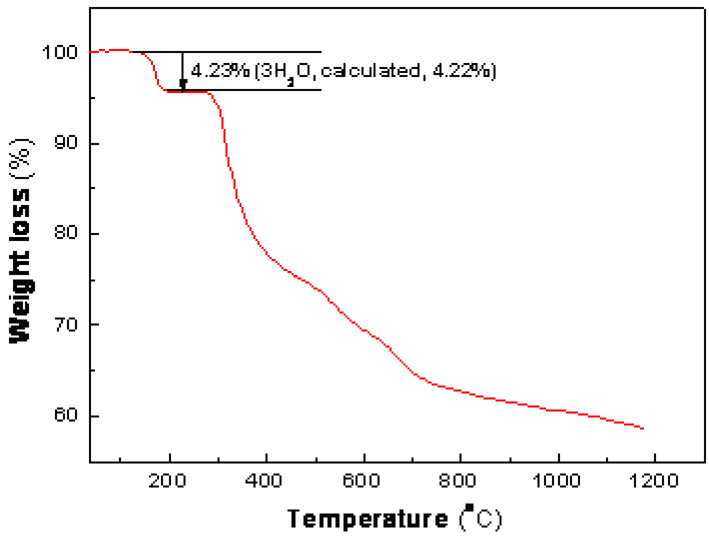

Fig. S8 TGA curve for complex **1**.

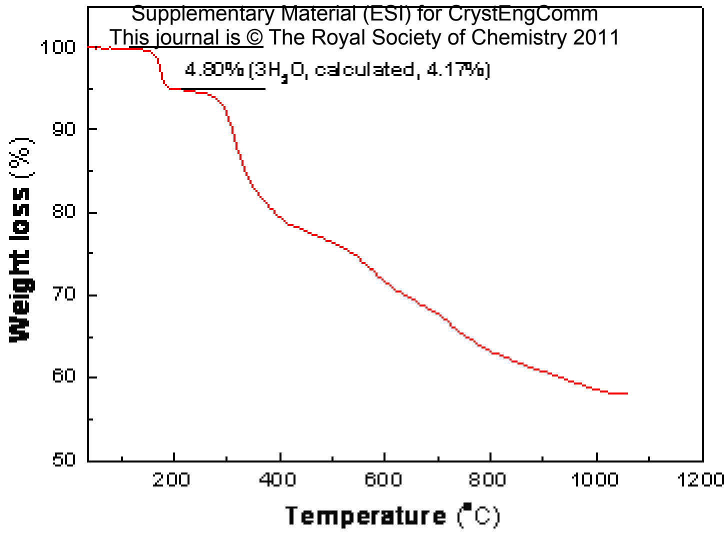

Fig. S9 TGA curve for complex **2**.

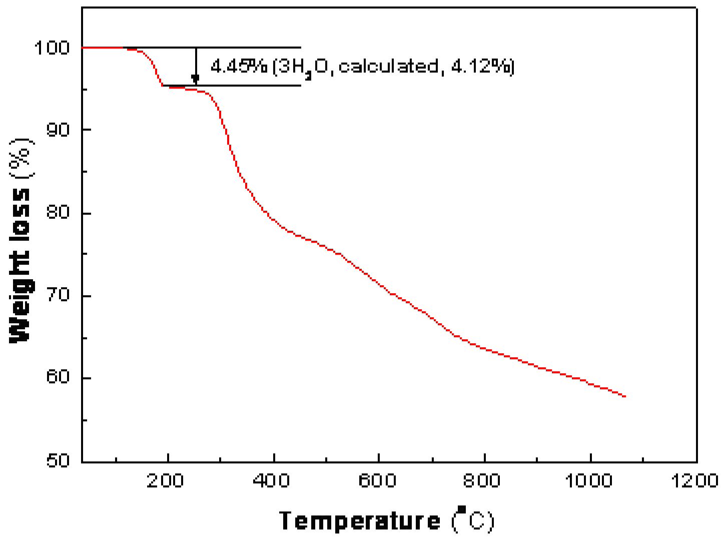

Fig. S10 TGA curve for complex **3**.

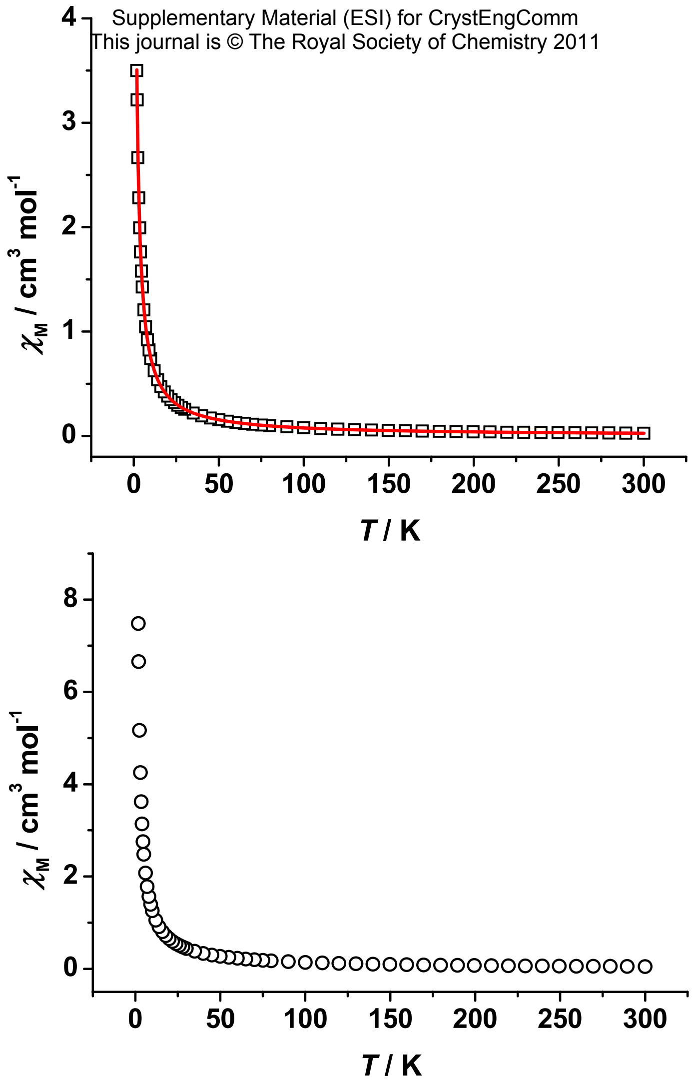

Fig. S11 Variable-temperature susceptibilities for **2** (□) and **3** (○) under a field of 100 Oe. The red solid line is the fitting result for **2**.

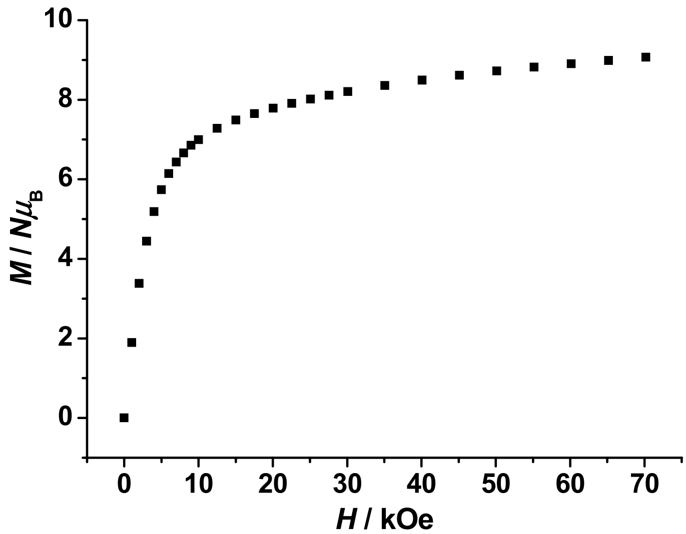

Fig. S12 M-H plot for **3** at 1.8 K.

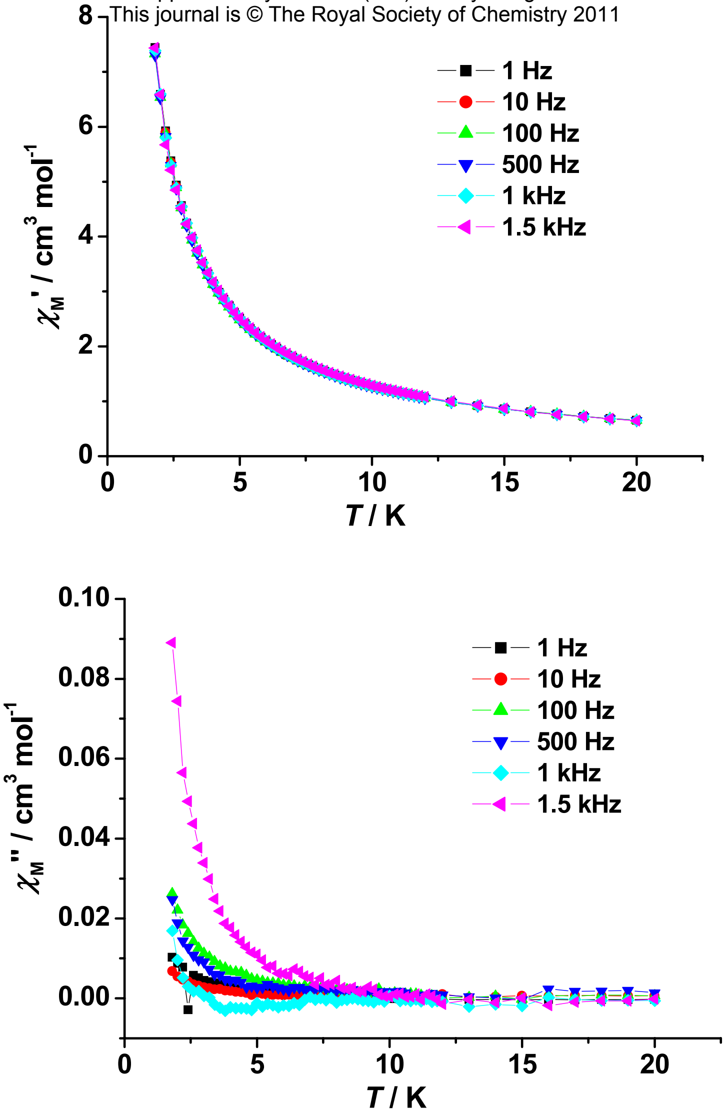

Fig. S13 AC susceptibilities for **3** in $H_{dc} = 0$ (top) and $H_{ac} = 5$ Oe (bottom).