Metal-organic Frameworks Based on Flexible Ligands (FL-MOFs): Structure and Application

Zu-Jin Lin, Jian Lü, Maochun, Hong and Rong Cao*

State Key Laboratory of Structural Chemistry, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fujian, Fuzhou, 350002, China

E-mail: rcao@fjirsm.ac.cn; Fax: (+86) 591-8379-6710; Tel: (+86) 591-8379-6710.

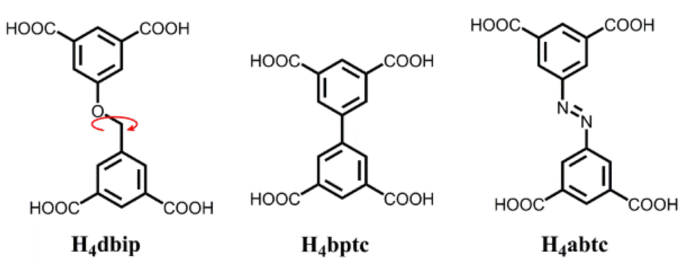

Fig. S1 The flexible and rigid tetracarboxylate ligands.

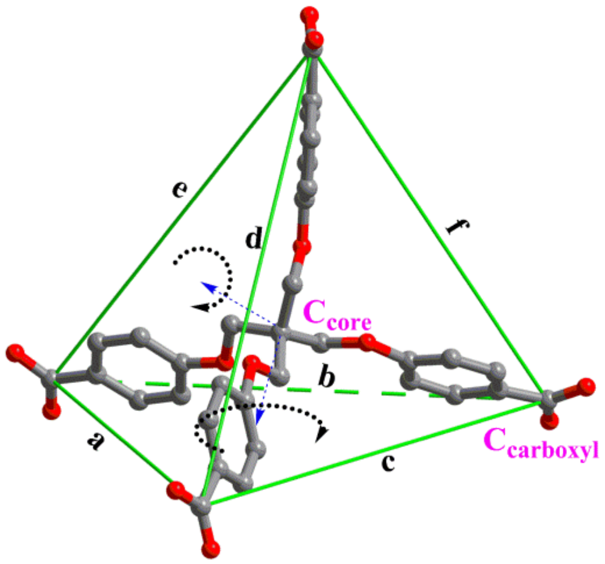

Fig. S2 The $C_{carboxyl}$ tetrahedron in H_4tcm ligand, which can be uniquely determined by the lengths (denoted as *a-f*) of six edges ($C_{carboxyl}$-$C_{carboxyl}$). $C_{carboxyl}$-$C_{carboxyl}$ edge scheme: *a*, the shortest edge; *b-e*: coplanar with *a* edge, *b* or *c* is the smallest value among *b-e*; view from C_{core}, both the edges *a-b-c* and *a-d-e* are clockwise arrangements.

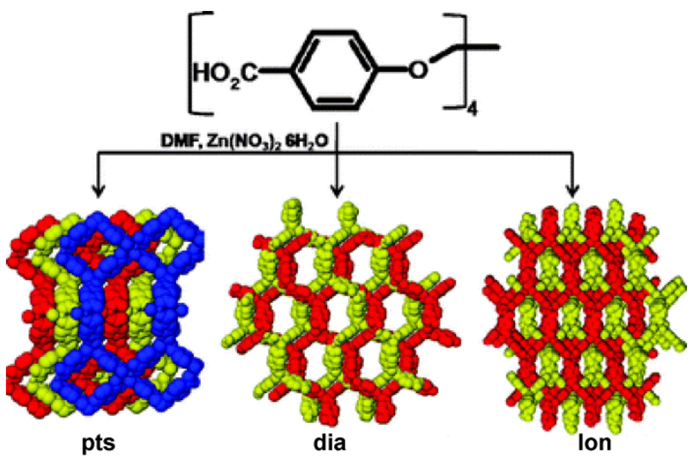

Fig. S3 Supramolecular isomers based on H_4tcm and zinc cations.

Table S1 The lengths of six edges in the $C_{carboxyl}$ tetrahedron of the H_4tcm.

Formulae	a (Å)	b (Å)	c (Å)	d (Å)	e (Å)	f (Å)	comments	References
$\{[Zn_2(tcm)(H_2O)(DMF)]\cdot 3DMF\}_n$	11.983	13.025	13.566	13.071	13.639	12.186	isomers	1
$\{[Zn_2(tcm)(DMF)]\cdot x(H_2O,DMF)\}_n$	8.296	12.524	14.404	12.95	13.344	13.033		
$\{[Zn(H_2tcm)]\cdot x(H_2O, DMF)\}_n$	10.172	13.995	12.999	13.558	14.328	11.347		
$\{[Zn_2(tcm)(H_2O)]_2\cdot H_2O\}_n$	9.319	9.896	14.945	13.105	15.031	11.419		2
$\{[Zn_4O(tcm)_{1.5}]\cdot 4DMA\cdot 10DEF\cdot 10H_2O\}_n$	10.68	11.256	14.883	13.658	14.883	10.68		3
$\{[Cu_2(tcm)(H_2O)_2]\cdot 7DMF\cdot 3(1,4\text{-dioxane})\cdot MeOH\}_n$ (SNU-21)	10.805	11.507	15.341	11.507	15.341	12.318	isomers	4
$\{[Cu_2(tcm)(H_2O)_2]\cdot 4DMA\cdot (H_2O)_2\}_n$	8.227	13.177	13.226	13.177	13.226	13.66		5
$\{Cd_6(tcm)_3(H_2O)_6\cdot Guest\}_n$	11.773	13.89	13.019	13.879	13.421	11.812	isomers	6
	11.509	14.012	12.947	13.455	13.811	11.272		
	11.708	13.913	13.159	13.753	13.337	11.383		
$\{Cd_2(tcm)(H_2O)_2\cdot Guest\}_n$	9.452	14.06	12.975	13.821	13.796	11.949		6
$\{Cd_2(tcm)(H_2O)_3\cdot Guest\}_n$	10.734	13.378	11.197	14.934	12.707	13.031		
$\{[Co_3(Htcm)_2](DMF)_8(H_2O)_{13}\}_n$	7.977	12.975	13.771	14.152	14.555	11.56		5
$\{[Zn_4(tcm)_2(H_2O)_3(DMA)]\cdot 2H_2O\}_n$	9.274	14.98	10.287	15.104	13.137	11.755		7
	9.028	14.882	10	15.152	13.146	11.458		
$\{Cd_2(tcm)(DMA)_2(H_2O)_2\}_n$	10.998	13.753	13.753	13.753	13.753	10.998		
	10.02	14.018	14.018	14.018	14.018	10.02		
$\{[Co_3(tcm)_2]\cdot [NH_2(CH_3)_2]_2\cdot 8DMA\}_n$	7.577	12.329	12.976	14.087	14.842	12.444	isomorphous	8
$\{[Mn_3(tcm)_2]\cdot [NH_2(CH_3)_2]_2\cdot 8DMA\}_n$	7.638	12.757	12.295	14.807	14.066	12.564		
$\{[Cd_3(tcm)_2]\cdot [NH_2(CH_3)_2]_2\cdot 8DMA\}_n$	7.546	12.338	13.123	14.089	14.849	12.308		
$\{[Y_3(tcm)_2\cdot (NO_3)\cdot (DMA)_2\cdot (H_2O)]\cdot 5DMA\cdot 2H_2O\}_n$	8.516	13.446	15.076	13.712	15.115	8.635	isomorphous	
$\{[Dy_3(tcm)_2\cdot (NO_3)\cdot (DMA)_2\cdot (H_2O)]\cdot 5DMA\cdot 2H_2O\}_n$	8.652	15.112	13.434	15.108	13.684	8.683		
$\{[In_2(tcm)_3\cdot (OH)_2]\cdot 3DMA\cdot 6H_2O\}_n$	9.768	14.436	12.978	13.868	13.83	11.393		

$\{[Pb_2(tcm)\cdot(DMA)_2]\cdot 2DMA\}_n$	10.609	15.333	12.065	15.333	12.065	11.194		
$\{[Zn(tcm)(bipy)]\cdot x\text{solvent}\}_n$	10.448	13.536	13.245	13.792	14.57	10.495		9
$\{[Zn_2(tcm)(CH_3CH_2OH)]\cdot 3H_2O\}_n$	11.136	11.997	13.516	12.761	14.01	13.057		10
$\{[Mn_3(tcm)_2]^{2-}\cdot 2\,[NH_2(CH_3)_2]^{+}\cdot 9DMF\}_n$	7.518	13.859	12.802	14.881	13.093	11.514		11
$\{Mn_{1.3}Ni_{2.7}(tcm)_2(H_2O)_7(DMF)\cdot 16DMF\}_n$	8.29	12.735	13.774	14.226	14.39	11.838		
$\{[Mn_3(tcm)_2]^{2-}\cdot 2[NH_2(CH_3)_2]^{+}\cdot 9DMF\}_n$	8.927	13.546	12.408	14.608	13.686	12.261		
$\{MnCo_3(tcm)_2(H_2O)_2\cdot 12DMF\}_n$	7.839	13.085	14	14.297	14.424	11.262		
$\{Mn_{1.3}Ni_{2.7}(tcm)_2(H_2O)_7(DMF)\cdot 16DMF\}_n$	8.535	12.968	14.153	13.523	14.392	11.903		
$\{[Y(tcm)[NH_2(CH_3)_2]\cdot x\text{solent}\}_n$	5.373	14.191	13.654	14.615	14.313	6.361	isomorphous	12
$\{[La(tcm)[NH_2(CH_3)_2]\cdot x\text{solent}\}_n$	5.176	13.871	14.463	14.545	14.737	6.235		
$\{[Co_2(tcm)(dib)]\cdot 3DMF\}_n$	12.066	12.686	13.541	12.74	130731	12.233		13
$\{[Co_4(tcm)_2(dib)_3(H_2O)_4]\cdot 4H_2O\}_n$	10.785	13.601	13.339	14.114	13.461	11.476		
$\{[Co_2(tcm)(dibp)]\cdot 5DMF\}_n$	10.484	15.271	11.587	15.285	12.966	10.526		
$\{Co_2(tcm)(dibp)_2\}_n$	10.253	13.557	13.557	13.557	13.557	10.253		
$\{Co_2(tcm)(tt)_2\}_n$	11.817	12.892	13.954	13.155	13.954	11.817	isomorphous	14
$\{Mn_2(tcm)(tt)_2\}_n$	11.87	12.903	14.096	13.339	14.096	11.87		
$\{Zn_2(tcm)(tt)_2\}_n$	11.955	13.91	12.701	13.91	13.113	11.955		
$\{Cd_2(tcm)(tt)_2\}_n$	12.104	13.926	12.191	13.926	12.859	12.104		
$\{[Co_2(tcm)(tim)]\cdot 4.25H_2O\}_n$	10.122	14.09	13.409	14.058	14.212	10.184		15
$\{[Cd_4(tcm)_2(tim)_2]\cdot 4H_2O\cdot DMF\}_n$	10.36	13.922	13.991	13.922	13.991	10.454		
$\{[Co_2(tcm)(etbipy)]\cdot 2DMF\cdot 5H_2O\}_n$	12.26	12.429	12.707	14.295	12.789	12.283	isomorphous	16
$\{[Zn_2(tcm)(etbipy)]\cdot 2.5DMF\cdot 2H_2O\}_n$	12.289	12.425	12.776	14.263	12.708	12.291		
$\{[Cd(H_2tcm)]\cdot 3DMF\cdot 3.5H_2O\}_n$	9.352	15.005	11.406	15.123	12.129	12.719		

H_4tcm = tetrakis[4-(carboxyphenyl)oxamethyl] methane acid; bipy = 4,4'-bipyridine; dibp = 4,4'-di(1H-imidazol-1-yl)-1,1'-biphenyl; dib = 1,4-di(1H-imidazol-1-yl)benzene; tt = 4-Tolyl-2,2':6',2''-terpyridine; tim = tetrakis(imidazol-1-ylmethyl)methane; etbipy = (*E*)-1,2-di(pyridin-4-yl)ethane.

Table S2 Selected gas adsorption and separation of FL-MOFs.

Compound	Formula	Pore Volume Ratio (%)	Surface area (m^2 g^{-1})[a]		Adsorption Capacity (wt %)		Q_{st} (CO_2)[d]	CO_2/N_2[e]	CO_2/CH_4[e]	Ref.
			BET	Langmuir	H_2[b]	CO_2[c]				
	$\{[Zn_2(tcm)(CH_3CH_2OH)]\cdot 3H_2O\}_n$	34.4	367	479	0.32	—	—	—	—	10
	$\{[Zn_4O(tcm)_{1.5}]\cdot 4DMA\cdot 10DEF\cdot 10H_2O\}_n$	80	—	—	—	—	—	—	—	3
SNU-21S	$\{[Cu_2(tcm)(H_2O)_2]\cdot 7DMF$ $\cdot 3(1,4\text{-dioxane})\cdot MeOH\}_n$	73.8	—	905	1.95	18.4	36.1	19.7[g]	2.73[g]	17
	$\{[Cu_2(tcm)(H_2O)_2]\cdot 4DMA\cdot (H_2O)_2\}_n$	48	382	507	1.22	—	—	—	—	5
	$\{Cu_4(ptmtip)(H_2O)_4\cdot (solvent)\}_n$	72	2896		2.37	16.7[h]	35.2	—	—	
	$\{Cu_4(H_4phmhip_2)(H_2O)_x(DMF)_{4-x}$ $\cdot (solvent)\}_n$	56	1490	—	1.80	18.4[h]	29.7	—	—	18
	$\{Cu_4(bmatip_3)(H_2O)_3(DMF)_3\cdot (solvent)\}_n$	76	—	—	—	—	—	—	—	
	$\{Cu(ppip)\cdot xsolvent\}_n$	58.6	—	—	—	—	—	—	—	
	$\{Cu(mpip)\cdot xsolvent\}_n$	53.6	—	—	—	—	—	—	—	19
	$\{Cu(mpip)\cdot xsolvent\}_n$	58.6	—	—	—	—	—	—	—	
	$\{Zn_{24}(bcbd)_8(H_2O)_{24}\}_n$	71	74.47	—	—	—	—	—	—	20
rht-MOF-7	$\{Cu_3(tdpat)(H_2O)_3\cdot xsolvent\}_n$	70	—	2170[i]	—	28.7	44.7	—	—	21

rht-MOF-4a	$\{Cu_3(pttip)(H_2O)_3\cdot xsolvent\}_n$	75	1070[i]	1590[i]	1.9	—	—	—	—	22
rht-MOF-5	$\{Zn_3(ptptip)(H_2O)_3\cdot xsolvent\}_n$	85.7	—	—	—	—	—	—	—	
	$\{Cu_{24}(bmbb)_{12}(H_2O)_{16}(DMSO)_8\}_n$	42.8	—	—	—	—	—	—	—	23
	$\{[Cu_6(mdip)_3(H_2O)_6]\cdot 3DMA\cdot 6H_2O\}_n$	70.2	1943	2425	3.0	—	—	—	—	24
	$\{[Cu_6(bbpm)_3(DMF)\cdot(H_2O)_5]\cdot(DMF)_x\}_n$	70.7	2010	2665	—	—	—	—	—	25
	$\{[Cd_4(tdm)(bipy)_4]\cdot xsolvent\}_n$	59.4	—	—	—	—	—	—	—	26
	$\{[Cd_4(tdm)(azpy)_4]\cdot xsolvent\}_n$	62.0	—	—	—	—	—	—	—	
	$\{[Cd_4(tdm)(etbipy)_4]\cdot xsolvent\}_n$	62.6	—	—	—	—	—	—	—	
	$\{[Cd_4(tdm)(bpb)_4]\cdot xsolvent\}_n$	63.8	—	—	—	—	—	—	—	
	$\{Zn_4O(tcom)_{1.5}\cdot xsolvent\}_n$	75.7	—	—	—	~5.9	—	—	—	27
	$\{Zn_4O(tcvom)_{1.5}\cdot xsolvent\}_n$	83.7	—	—	—	~16.7	—	—	—	
	$\{Zn_4O(tcnm)_{1.5}\cdot xsolvent\}_n$	84.6	—	—	—	16.6[h]	—	—	—	
	$\{[Zn_3(btctb)_2\{Cr_3O(isonic)_6(H_2O)_2(OH)\}]\cdot xDMF\}_n$	80	—	—	—	—	—	—	—	28
	$\{Mn_6(hco)_2(dibp)_{1.5}(H_2O)_5\}_n$	45.1	—	—	—	—	—	—	—	29
	$\{[Zn_7(H_6htt)_2(OH)_2(H_2O)_9]\cdot 12.25H_2O\}_n$	71.7	—	—	—	—	—	—	—	30
	$\{[Cu_2(dbip)\cdot(H_2O)_2]\cdot xsolvent\}_n$	67.2	1773	—	—	33.4	~54	21.13	—	31
			232	—	—	—	—	—	—	32

			—	—	—	—	—	—	—	33
	$\{[Cu_4(tdm)(H_2O)_4]\cdot xsolvent\}_n$	64.0	1115	1722	2.12	27.5	—	—	—	34
PCN-26			1854	2545	2.57	35.6	—	49	8.4	35
	$\{In_2(tdm)(NH_2CH_3)_2\cdot xsolvent\}_n$	65.1	1555	1707	1.49	19.6	21.14	—	—	36
			752	991	1.12	12.1	—	15.5[j]	—	37
	$\{[In(dibp)\cdot(Me_2NH_2)]\cdot xsolvent\}_n$	70.3	8.12	19.45	—	—	—	—	—	
	$\{[In(dibp)\cdot tma)]\cdot xsolvent\}_n$	—	13.67	21.35	—	—	—	—	—	
	$\{[In(dibp)\cdot tea)]\cdot xsolvent\}_n$	—	5.81	13.63	—	—	—	—	—	
	$\{[In(dibp)\cdot tpa)]\cdot xsolvent\}_n$	—	37.41	57.05	—	—	—	—	—	
	$\{[In(dibp)\cdot(tba)]\cdot xsolvent\}_n$	—	325.65	477.77	—	—	—	—	—	38
	$\{[In_2(tdm)\cdot(Me_2NH_2)]\cdot xsolvent\}_n$	65.7	83.39	—	—	—	—	—	—	
	$\{[In_2(tdm)\cdot(tma)]\cdot xsolvent\}_n$	—	13.40	-22.55	—	—	—	—	—	
	$\{[In_2(tdm)\cdot(tea)]\cdot xsolvent\}_n$	—	754.63	1099.46	—	—	—	—	—	
	$\{[In_2(tdm)\cdot(tpa)]\cdot xsolvent\}_n$	—	36.26	54.17	—	—	—	—	—	
	$\{[In_2(tdm)\cdot(tba)]\cdot xsolvent\}_n$	—	120.76	181.45	—	—	—	—	—	
	$\{[Ln(cpia)(H_2O)_2]\cdot 4H_2O\}_n$	32.1	—	147	—	4.3	—	—	—	39
	$\{Cd_6(tcm)_3\cdot(H_2O)_6\}_n$	42.3	231	249	—	5.6[h]	—	—	—	1
	$\{In_2(OH)_2(obb)_2\}_n$	47.7	354.1	518	—	7.2	—	—	—	40

MSF-2	MSF-2	39.8	622	—	1.03	—	—	—	—	41
MSF-4	MSF-4	39.3	767	—	1.58	—	—	—	—	41
	$\{Zn_2(tcm)(bipy)\}_n$	—	1150	—	—	5[h]	—	—	—	42
	$\{[M_2(tpom)(_D\text{-cam})_2]\cdot 2H_2O\}_n$	26.4%	111	380	—	—	—	—	—	43
	$\{[Zn_3(tcpt)_2(H_2O)_2]\cdot 3H_2O\cdot TEA\cdot 2DMF\}_n$	41.4	—	535	1.02	8.1	—	—	—	44
	$\{[Cd_3(tcpt)_2(H_2O)_6]\cdot 1.5H_2O\cdot 2EtOH\cdot DMF\}_n$	41.5	—	417	1.17	11.0	—	—	—	44
NJU-bai3	$\{[Cu_3(H_3cip)_2(H_2O)_5]\cdot xGuest\}_n$	76.9	2690	3100	—	27.3	36.5	—	—	45
HNUST-1	$\{Cu_2(bdpt)\}_n$	71.0	1400	1620	2.14	30.7	~30.5	39.8	7.2	46
HNUST-3	$\{[Cu_2bdpo]\cdot xsolvent\}_n$	73.2	2412	2784	2.2	16.6[h]	24.8	26.1[g]	7.9[g]	47
	$\{[Cu_{24}(bcbd)_8(H_2O)_{24}]\cdot xsolvent\}_n$	74	3160	3570		42.54	26.3	22[k]	—	48
	$\{Cu_3(btbip)\}_n$	81.1	3288	—	—	—	~24	34.3	8.6	49
	$\{Cu_3(tatbip)\}_n$	81.1	3360	—	—	—	~24	34.3	8.6	49
Cu-tdpat	$\{[Cu_3(tdpta)(H_2O)_3]\cdot 10H_2O\cdot 5DMA\}_n$	70.2	1938	2608	2.65	44.5	42.2	16[l]	—	50
	$\{[Zn(btz)]\cdot DMF\cdot 0.5H_2O\}_n$	45.6	1151	1222	2.28	35.6	31.2	35.6	21.1	51
SNU-100	$\{[Zn_3(TCPT)_2(HCOO)][NH_2(CH_3)_2]\}_n$	38.1	814	—	1.81	14.1[h]	—	25.5[f]	—	52
SNU-Li	—	—	924	—	1.93	15.3[h]	—	37.8[f]	—	52
SNU-Mg	—	—	959	—	1.99	15.1[h]	—	32.6[f]	—	52
SNU-Ca	—	—	935	—	1.88	15.1[h]	—	40.4[f]	—	52

SNU-Co	—	—	1000	—	2.16	16.8[h]	—	31.0[f]	—	
SNU-Ni	—	—	982	—	1.98	16.6[h]	—	37.4[f]	—	

[a] Derived from N_2 adsorption at 77 K. [b] Measured at 77 K and 1 atm. [c] Measured at 273 K and 1 atm. [d] The zero coverage isosteric heats of CO_2 adsorption (Q_{st}) calculated by using Clausius–Clapeyron equation. [e] Selectivities were calculated from the ratios of Henry constants for gas adsorption isotherms at 273 K. [f] Selectivities were calculated from the ratios of Henry constants for gas adsorption isotherms at 298 K. [g] The selectivities calculated from the uptake ratio by weight at 298 K. [h] Measured at 298 K and 1 atm. [i] Derived from Ar isotherm at 87 K. [j] The selectivities calculated from the uptake ratio by molar ratios at 273 K. [k] The IAST-predicted selectivity for equimolar CO_2/N_2 mixtures at 298 K. [l]The selectivities calculated from the uptake ratio by molar ratios at 298 K.

1 J. Tian, R. K. Motkuri, P. K. Thallapally and B. P. McGrail, *Cryst. Growth Des.*, 2010, **10**, 5327.

2 T.-F. Liu, J. Lü, Z. Guo, D. M. Proserpio and R. Cao, *Cryst. Growth Des.*, 2010, **10**, 1489.

3 T.-F. Liu, J. Lu, X. Lin and R. Cao, *Chem. Commun.*, 2010, **46**, 8439.

4 T. K. Kim and M. P. Suh, *Chem. Commun.*, 2011, **47**, 4258

5 L.-L. Liang, J. Zhang, S.-B. Ren, G.-W. Ge, Y.-Z. Li, H.-B. Du and X.-Z. You, *CrystEngComm*, 2010, **12**, 2008.

6 J. Tian, R. K. Motkuri, P. K. Thallapally and B. P. McGrail, *Cryst. Growth Des.*, 2010, **10**, 5327.

7 L.-L. Liang, S.-B. Ren, J. Zhang, Y.-Z. Li, H.-B. Du and X.-Z. You, *Dalton Trans.*, 2010, **39**, 7723

8 T.-F. Liu, J. Lue, C. Tian, M. Cao, Z. Lin and R. Cao, *Inorg. Chem.*, 2011, **50**, 2264

9 P. K. Thallapally, J. Tian, M. R. Kishan, C. A. Fernandez, S. J. Dalgarno and et al., *J. Am. Chem. Soc.*, 2008, **130**, 16842

10 Z. Guo, R. Cao, X. Wang, H. Li, W. Yuan, G. Wang, H. Wu and J. Li, *J. Am. Chem. Soc.*, 2009, **131**, 6894.

11 J. Tian, L. V. Saraf, B. Schwenzer, S. M. Taylor, E. K. Brechin, J. Liu, S. J. Dalgarno and P. K. Thallapally, *J. Am. Chem. Soc.*, 2012, **134**, 9581.

12 S. Dang, Z.-M. Sun, H. Zhang and E. Ma, *J. Mater. Chem.*, 2012, **22**, 16920

13 W. Yang, M. Guo, F.-Y. Yi and Z.-M. Sun, *Cryst. Growth Des.*, 2012, **12**, 5529.

14 J. Guo, J.-F. Ma, J.-J. Li, J. Yang and S.-X. Xing, *Cryst. Growth Des.*, 2012, **12**, 6074.

15 J. Guo, J. Yang, Y.-Y. Liu and J.-F. Ma, *CrystEngComm*, 2012, **14**, 6609

16 L. Zhou, Y.-S. Xue, J. Zhang, H.-B. Du and X.-Z. You, *CrystEngComm*, 2013, **15**, 6199.

17 T. K. Kim and M. P. Suh, *Chem. Commun.*, 2011, **47**, 4258.

18 J. F. Eubank, H. Mouttaki, A. J. Cairns, Y. Belmabkhout, L. Wojtas, R. Luebke, M. Alkordi and M. Eddaoudi, *J. Am. Chem. Soc.*, 2011, **133**, 14204.

19 J. F. Eubank, L. Wojtas, M. R. Hight, T. Bousquet, V. C. Kravtsov and M. Eddaoudi, *J. Am. Chem. Soc.*, 2011, **133**, 17532.

20 F. Nouar, J. F. Eubank, T. Bousquet, L. Wojtas, M. J. Zaworotko and M. Eddaoudi, *J. Am. Chem. Soc.*, 2008, **130**, 1833.

21 R. Luebke, J. F. Eubank, A. J. Cairns, Y. Belmabkhout, L. Wojtas and M. Eddaoudi, *Chem. Commun.*, 2012, **48**, 1455.

22 J. F. Eubank, F. Nouar, R. Luebke, A. J. Cairns, L. Wojtas, M. Alkordi, T. Bousquet, M. R. Hight, J.

Eckert, J. P. Embs, P. A. Georgiev and M. Eddaoudi, *Angew. Chem., Int. Ed.*, 2012, **51**, 10099.

23 Perry, V. C. Kravtsov, G. J. McManus and M. J. Zaworotko, *J. Am. Chem. Soc.*, 2007, **129**, 10076.

24 X.-S. Wang, S. Ma, P. M. Forster, D. Yuan, J. Eckert, J. J. López, B. J. Murphy, J. B. Parise and H.-C. Zhou, *Angew. Chem., Int. Ed.*, 2008, **47**, 7263.

25 C. Li, W. Qiu, W. Shi, H. Song, G. Bai, H. He, J. Li and M. J. Zaworotko, *CrystEngComm*, 2012, **14**, 1929.

26 Z. Lin, T. Liu, B. Xu, L. Han, Y. Huang and R. Cao, *CrystEngComm*, 2011, **13**, 3321.

27 Y.-Q. Lan, H.-L. Jiang, S.-L. Li and Q. Xu, *Adv. Mater.*, 2011, **23**, 5015.

28 A. Schoedel, A. J. Cairns, Y. Belmabkhout, L. Wojtas, M. Mohamed, Z. Zhang, D. M. Proserpio, M. Eddaoudi and M. J. Zaworotko, *Angew. Chem., Int. Ed.*, 2013, **52**, 2902.

29 F.-Y. Yi, S. Dang, W. Yang and Z.-M. Sun, *CrystEngComm*, 2013, **15**, 8320.

30 M. Wu, F. Jiang, W. Wei, Q. Gao, Y. Huang, L. Chen and M. Hong, *Cryst. Growth Des.*, 2009, **9**, 2559.

31 Z. Liang, J. Du, L. Sun, J. Xu, Y. Mu, Y. Li, J. Yu and R. Xu, *Inorg. Chem.*, 2013, **52**, 10720.

32 R. Patra, H. M. Titi and I. Goldberg, *CrystEngComm*, 2013, **15**, 2853.

33 Z. Lin, T. Liu, X. Zhao, J. Lü and R. Cao, *Cryst. Growth Des.*, 2011, **11**, 4284.

34 Y.-S. Xue, Y. He, S.-B. Ren, Y. Yue, L. Zhou, Y.-Z. Li, H.-B. Du, X.-Z. You and B. Chen, *J. Mater. Chem.*, 2012, **22**, 10195.

35 W. Zhuang, D. Yuan, D. Liu, C. Zhong, J.-R. Li and H.-C. Zhou, *Chem. Mater.*, 2011, **24**, 18.

36 Z. Lin, Y. Huang, T. Liu, X. Li and R. Cao, *Inorg. Chem.*, 2013, **52**, 3127.

37 Y.-S. Xue, Y. He, L. Zhou, F.-J. Chen, Y. Xu, H.-B. Du, X.-Z. You and B. Chen, *J. Mater. Chem. A*, 2013, **1**, 4525.

38 Z. Lin, T. Liu, Y. Huang, J. Lü and R. Cao, *Chem.-Eur. J.*, 2012, **18**, 7896.

39 P. Lama, A. Aijaz, S. Neogi, L. J. Barbour and P. K. Bharadwaj, *Cryst. Growth Des.*, 2010, **10**, 3410.

40 Y.-X. Tan, F. Wang, Y. Kang and J. Zhang, *Chem. Commun.*, 2011, **47**, 770.

41 J. Zhang, Y.-S. Xue, L.-L. Liang, S.-B. Ren, Y.-Z. Li, H.-B. Du and X.-Z. You, *Inorg. Chem.*, 2010, **49**, 7685.

42 P. K. Thallapally, J. Tian, M. Radha Kishan, C. A. Fernandez, S. J. Dalgarno, P. B. McGrail, J. E. Warren and J. L. Atwood, *J. Am. Chem. Soc.*, 2008, **130**, 16842.

43 S.-B. Ren, L. Zhou, J. Zhang, Y.-L. Zhu, Y.-Z. Li, H.-B. Du and X.-Z. You, *CrystEngComm*, 2010, **12**, 1635.

44 L. Han, Y. Yan, F. Sun, K. Cai, T. Borjigin, X. Zhao, F. Qu and G. Zhu, *Cryst. Growth Des.*, 2013, **13**, 1458.

45 J. Duan, Z. Yang, J. Bai, B. Zheng, Y. Li and S. Li, *Chem. Commun.*, 2012, **48**, 3058.

46 B. Zheng, H. Liu, Z. Wang, X. Yu, P. Yi and J. Bai, *CrystEngComm*, 2013, **15**, 3517.

47 Z. Wang, B. Zheng, H. Liu, X. Lin, X. Yu, P. Yi and R. Yun, *Cryst. Growth Des.*, 2013, **13**, 5001.

48 B. Zheng, J. Bai, J. Duan, L. Wojtas and M. J. Zaworotko, *J. Am. Chem. Soc.*, 2010, **133**, 748.

49 B. Zheng, Z. Yang, J. Bai, Y. Li and S. Li, *Chem. Commun.*, 2012, **48**, 7025.

50 B. Li, Z. Zhang, Y. Li, K. Yao, Y. Zhu, Z. Deng, F. Yang, X. Zhou, G. Li, H. Wu, N. Nijem, Y. J. Chabal, Z. Lai, Y. Han, Z. Shi, S. Feng and J. Li, *Angew. Chem., Int. Ed.*, 2012, **51**, 1412.

51 P. Cui, Y.-G. Ma, H.-H. Li, B. Zhao, J.-R. Li, P. Cheng, P. B. Balbuena and H.-C. Zhou, *J. Am. Chem. Soc.*, 2012, **134**, 18892.

52 H. J. Park and M. P. Suh, *Chem. Sci.*, 2013, **4**, 685.