Electronic Supplementary Material (ESI) for Chemical Society Reviews.

Supporting information

Mixed-metal Metal-Organic Frameworks

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Table S1: Frequency (column 6) analysis of spectroscopic and microscopic characterization techniques used in 101 studies of MM-MOFs. Main information (column 3) in the context of MM-MOFs characterization (Questions 1-4 in the main article, see section 3 and Figure 10) is also listed, as well as the potential for performing experiments in situ (column 4), this means under environmental conditions relevant for typical applications of MOFs in gas sorption or catalysis. Column 5 lists whether the technique provides bulk (B), surface (S) or spatially resolved (SR) information, with a resolution of typical MOF crystallite size or better ($\sim$1 μm).

#	Characterization technique	Main information	In situ?	Spatial info	Freq.
1	Mass spectrometry (MS)	Global concentration of (metal) elements	No	B	18
2	Atomic Absorption Spectroscopy (AAS)		No	B	10
3	Atomic Emission Spectroscopy (AES)		No	B	42
4	X-ray fluorescence (XRF)		Yes	B	8
5	Powder X-ray diffraction (PXRD)	Crystal structure, lattice constants, identification of crystalline phases	Yes	B	88
6	Single crystal X-ray diffraction (SCXRD)		Yes	B	35
7	Neutron powder diffraction (NPD)		yes	B	1

8	Mössbauer spectroscopy	Metal oxidation state and local environment	Yes	B	7
9	X-ray / UV photoelectron spectroscopy (XPS)/(UPS)	Metal oxidation and binding state	No	S	16
10	X-ray absorption near-edge structure (XANES)	Metal oxidation and binding state, symmetry of metal complex	Yes	B	11
11	Extended X-ray Absorption Fine Structure (EXAFS)	Local environment of metal ions: distances, identities, and coordination numbers in neighboring shells	Yes	B	11
12	UV-Vis-NIR spectrophotometry (UV-Vis-NIR)	Transition energies for valence electrons: identity, oxidation state and coordination of metal ions	Yes	B, SR	28
13	Photolumines-cence (PL)		Yes	B, SR	10
14	Raman scattering spectroscopy	Lattice and local vibrational modes: binding state of metals ions	Yes	B	5
15	Fourier transform infrared spectro-scopy (FTIR)		Yes	B	51
16	Electron Paramagnetic Resonance (EPR)	Electronic ground state (oxidation state, complex symmetry) and local environment of paramagnetic metal ions	Yes	B	14
17	Solid State Nuclear Magnetic Resonance (SS-NMR)	Binding state of diamagnetic metal ions	Yes	B	8
18	Scanning electron microscopy (SEM)	Morphology	No	SR	40

19	Transmission electron microscopy (TEM)	Morphology, crystal structure	No	SR	8
20	Energy Dispersive X-ray spectroscopy (EDX, EDS)	Local element analysis	No	SR	33

Table S2: Literature overview of reported mixed-metal MOFs

MIL	Entry	Metal*	Synthesis approach	Subject	Reference
MIL-53	1	Al^{3+}/Cr^{3+}	Direct Synthesis	Incorporation, Breathing	[1]
	2	Al^{3+}/Cr^{3+}	Direct Synthesis	Breathing	[2]
	3	Al^{3+}/V^{3+}	Direct Synthesis	Incorporation, Breathing, Gas adsorption	[3]
	4	Al^{3+}/V^{3+}	Direct Synthesis	Incorporation	[4]
	5	Al^{3+}/V^{3+}	Direct Synthesis	Breathing	[5]
	6	Al^{3+}/V^{3+}	Direct Synthesis	Breathing Influence of oxygen	[6]
	7	Al^{3+}/V^{3+}	Direct Synthesis	Catalysis	[7]
	8	Cr^{3+}/Fe^{3+}	Direct Synthesis	Incorporation, Gas adsorption	[8]
	9	Fe^{3+}/V^{3+}	Direct Synthesis	Incorporation	[9]
	10	Cr^{3+}/V^{3+}	Direct Synthesis	Incorporation Breathing	[10]
	11	Al^{3+}/V^{4+}	Direct Synthesis	Sensing	[11]
MIL-53-Br	1	Al^{3+}/Fe^{3+}	Post-Synthetic exchange in H_2O	Incorporation	[12]

MIL-88B	1	Fe^{3+}/Ni^{2+}	Direct Synthesis	Incorporation	[13]
MIL-100	1	$Sc^{3+}/Cr^{3+}/Fe^{3+}/Al^{3+}$	Direct Synthesis	Incorporation, Catalysis	[14]
	2	Fe^{3+}/Ni^{2+}	Direct Synthesis	Incorporation	[13]
MIL-101	1	$Cr^{3+}/Fe^{3+}/Al^{3+}$	Post-synthetic exchange in H_2O	Incorporation, Adsorption	[12]
	2	Cr^{3+}/Fe^{3+}	Direct synthesis	Incorporation, Catalysis	[15]
	3	Cr^{3+}/Fe^{3+}	Post-synthetic exchange in Ethanol	Incorporation, Catalysis	[16]
	4	Cr^{3+}/Mg^{2+}	Direct synthesis	Adsorption	[17]
	5	Cr^{3+}/Ce^{3+}	Direct synthesis	Catalysis	[18]
MIL-103	1	Eu^{3+}/Tb^{3+}	Direct synthesis	Lanthanide thermometer	[19]
MIL-127	1	Fe^{3+}/Ni^{2+}	Direct synthesis	Adsorption Incorporation	[13]
	2	Fe^{3+}/Co^{2+}	Direct synthesis	Incorporation	[13]
	3	Fe^{3+}/Mg^{2+}	Direct synthesis	Incorporation	[13]
MIL-808	1	Zr^{4+}/Ce^{4+}	Direct synthesis	Incorporation	[20]

MIL = Materials Institute Lavoisier; * = oxidation state of the metal salts

UiO	**Entry**	**Metal***	**Synthesis approach**	**Subject**	**Reference**
UiO-66	1	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Incorporation	[12]
	2	Zr^{4+}/Hf^{4+}			

	3	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Adsorption	[21]
	4	Zr^{4+}/Ce^{4+}	Direct synthesis	Incorporation	[20]
	5	Zr^{4+}/Ce^{4+}	Direct synthesis	Incorporation	[22]
	6	Zr^{4+}/Ce^{3+}	Direct synthesis	Adsorption	[23]
	7	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Separation	[24]
	8	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Catalysis	[25]
	9	Zr^{4+}/Ce^{4+}	Direct synthesis	Incorporation	[26]
UiO-66 $(NH_2)_x$	1	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Catalysis	[27]
	2	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Catalysis	[28]
UiO-67	1	Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Photo-degradation	[29]
	2	Zr^{4+}/Ce^{3+}	Direct synthesis	Adsorption	[23]
UiO-67-Ru	1	Zr^{4+}/Ti^{4+}	Post-Synthetic exchange in DMF	Photo-degradation	[29]

UiO = Universitet i Oslo; DMF = Dimethylformamide * = oxidation state of the metal salts

MOF	**Entry**	**Metal***	**Synthesis approach**	**Subject**	**Reference**
MOF-5	1	Zn^{2+}/Co^{2+}	Post-synthetic exchange in DMF/MeCN	Thermo-dynamic study	[30]
		Zn^{2+}/Ni^{2+}	Post-synthetic exchange in DMF		
	2	Zn^{2+}/Co^{2+}	Direct synthesis	Adsorption	[31]
	3	$Zn^{2+}/TiCl^{2+}$ Zn^{2+}/V^{2+} Zn^{2+}/VCl^{2+}	Post-synthetic exchange in DMF	Incorporation, redox chemistry	[32]

		Zn^{2+}/Cr^{2+} $Zn^{2+}/CrCl^{2+}$ Zn^{2+}/Mn^{2+} Zn^{2+}/Fe^{2+}			
MOF-14	1	Zn^{2+}/ Co^{2+} Zn^{2+}/Ni^{2+} Zn^{2+}/ Cu^{2+}	Post-synthetic exchange in DMF	Incorporation	[33]
MOF-74	1	Mg^{2+}/Co^{2+} $Mg^{2+}/Co^{2+}/Ni^{2+}/Zn^{2+}$ $Mg^{2+}/Co^{2+}/Ni^{2+}/Zn^{2+}/Sr^{2+}/Mn^{2+}$ $Mg^{2+}/Co^{2+}/Ni^{2+}/Zn^{2+}/Sr^{+2}/Mn^{2+}/Cd^{2+}/Ba^{2+}/Fe^{2+}/Ca^{2+}$	Direct synthesis	Incorporation	[34]
	2	Zn^{2+}/Co^{2+}	Direct synthesis	Adsorption Band gap energy	[35]
	3	Co^{2+}/Ni^{2+}	Direct synthesis	Adsorption	[36]
	4	Mg^{2+}/Ni^{2+} Mg^{2+}/Cd^{2+}	Direct synthesis	Incorporation, Adsorption	[37]
	5	Co^{2+}/Ni^{2+}	Post synthetic exchange in DMF	Catalysis	[38]
	6	Mg^{2+}/Ni^{2+} Mg^{2+}/Co^{2+}	Direct synthesis	Incorporation Adsorption	[39]
	7	Cu^{2+}/Co^{2+}	Direct synthesis	Catalysis	[40]
	8	Mg^{2+}/Cd^{2+}	Direct synthesis	Incorporation	[41]

MOF = metal-organic framework; DMF = Dimethylformamide; CH_3CN = Acetronitril; * = oxidation state of the metal salts.

HKUST-1	**Entry**	**Metal***	**Synthesis**	**Subject**	**Reference**

			approach		
HKUST-1	1	Cu^{2+}/Zn^{2+}	Direct-synthesis	Incorporation Adsorption	42
	2	Cu^{2+}/Zn^{2+}	Direct-synthesis	Structural changes	43
	3	Cu^{2+}/Zn^{2+}	Direct-synthesis	Spin lattice relaxation of Co and CO2	44
	4	Cu^{2+}/Zn^{2+}	Direct synthesis	Adsorption of small molecules by solid-state NMR	45
	5	Cu^{2+}/Zn^{2+}	Direct synthesis	Three-pulse ESEEM on adsorption and desorption of deuterated H2	46
	6	Cu^{2+}/Zn^{2+}	Post-synthetic exchange in MeOH	Incorporation	47
	7	Cu^{2+}/Zn^{2+}	Direct synthesis	Adsorption	48
	8	Cu^{2+}/ Ru^{3+}	Direct synthesis	Incorporation	49
	9	Cu^{2+}/Li^{+}	Direct synthesis	Adsorption	50
	10	Cu^{2+}/Na^{+}			
	11	Cu^{2+}/K^{+}			

HKUST = Hong Kong University of Science and Technology; * = oxidation state of the metal salts.

ZIF	Entry	Metal*	Synthesis approach	Subject	Reference
ZIF-8	1	Zn^{2+}/Cu^{2+}	Direct synthesis	Catalysis	51
	2	Zn^{2+}/Co^{2+}	Direct synthesis	Adsorption	52

	3	Zn^{2+}/Co^{2+}	Direct synthesis	separation	[53]
BM ZIF-20	1	Zn^{2+}/Co^{2+}	Direct synthesis	Catalysis	[54]
ZIF-71	1	Mn^{2+}/Zn^{2+}	Post-synthetic	Incorporation	[55]
ZIF-67	1	Zn^{2+}/Co^{2+}	Direct synthesis	Separation	[56]

ZIF = zeolitic imidiazolate framework; * = oxidation state of the metal salts

Compounds	**Entry**	**Metal***	**Synthesis approach**	**Subject**	**Reference**
$Al(OH)_{1-x}V(O)_x$ (1,4-NDC)	1	Al^{3+}/V^{3+}	Direct synthesis	Incorporation	[3]
COMOC-2-V_x-Al_{1-x}	1	Al^{3+}/V^{4+}	Direct synthesis	Incorporation Adsorption	[57]
$[CoNi(\mu_3\text{-tp})_2(\mu_2\text{-pyz})_2]$	1	Co^{2+}/Ni^{2+}	Direct synthesis	Dye removal	[58]
CPM-4-M	1	In^{3+}/Co^{2+}	Direct synthesis	Incorporation	[59]
CPM-15-M		$In^{3+}/Mg^{2+}/Mn^{2+}/Co^{2+}/Ni^{2+}/Cd^{2+}$		Incorporation Adsorption	[60]
CPM-16-M		$In^{3+}/Mn^{2+}/Co^{2+}/Ni^{2+}$		Incorporation	[60]
CPM-17-M		$In^{3+}/Co^{2+}/Zn^{2+}$		Incorporation	[60]
CMP-15		In^{3+}/Co^{2+}, Mg^{2+}, Mn^{2+}, Ni^{2+}, Cd^{2+}		Incorporation Adsorption	[61]
CPM-18-M		$In^{3+}/Nd^{3+}/Sm^{3+}$		Incorporation	[62]

CPM-19-M		$In^{3+}/Nd^{3+}/Pr^{3+}$		Incorporation	62
CPM-20-M		In^{3+}/Co^{2+}		Incorporation Adsorption	62
CPM-21-M		$In^{3+}/Mn^{3}/Co^{3+}/Cu^{3+}$		Incorporation	62
CPM-23-M		In^{3+}/Mg^{2+}		Incorporation	62
CPM-26-M		$In^{3+}/Co^{2+}/Zn^{2+}$		Incorporation	60
CPM-31		In^{3+}/Zn^{2+}		Incorporation	59
CPM-32		In^{3+} $/Co^{2+}$		Incorporation	59
CPM-200		V^{3+}/Mg^{2+}		Adsorption	63
		Fe^{3+}/Mg^{2+}			
		In^{3+}/Mg^{2+}			
		In^{2+}/Ni^{2+}			
		In^{2+}/Mn^{3+}			
		In^{3+}/Co^{2+}			
		Ga^{3+}/Mg^{2+}			
		Sc^{3+}/Mg^{2+}			
CTOF-1	1	Ti^{4+}/Co^{2+}	Direct synthesis	Adsorption	64
CTOF-2	1	Ti^{4+}/Co^{2+}	Direct-synthesis	Adsorption	64
Cu(II)–MOF*		Cu^{2+}/Zn^{2+}	Direct synthesis	Adsorption	65
CuMg(pdc)$_2$(H$_2$O)$_4$]·2H$_2$O}$_n$ (1), [CuCa(pdc)$_2$]n (2),[CuSr(pdc)$_2$(H$_2$O)$_3$]$_n$ (3), and {[CuBa(pdc)$_2$(H$_2$O)$_5$]· H$_2$O}$_n$ (4)	1	$Cu^{2+}/Mg^{2+}/Ca^{2+}/Sr^{2+}/Ba^{2+}$	Direct synthesis	Catalysis	66
Eu$_{0.0069}$Tb$_{0.9931}$-DMBDC	1	Eu^{3+}/Tb^{3+}	Direct synthesis	Lanthanide thermometer	67
Eu$_{0.37}$Tb$_{0.63}$-BTC-a	1	Eu^{3+}/Tb^{3+}	Direct synthesis	Lanthanide thermometer	68
iso1	1	Cu^{2+}/Mn^{2+}	Direct synthesis	Adsorption	69

$In_xGa_{1-x}(O_2C_2H_4)_{0.5}$(hfipbb)	1	$Ga^{3+}/In^{3+}/Al^{3+}$	Direct synthesis	Multi-component reaction Strecker	[70]
MFM-300	1	Ga^{3+}/Fe^{3+}	Direct synthesis	Adsorption Catalysis	[71]
$[M_xM'_{2-x}(ca)_2(1,4\text{-dimb})]_n$	1	Ni^{2+}/Co^{2+}	Direct synthesis	Magnetism	[72]
M'MOF-1, M'MOF-2	1	Fe^{3+}/ Ag^{3+}	Direct synthesis	Incorporation	[73]
M'MOF-4, -5,-6,-7	1	Cd^{2+}/ Zn^{2+}/ Cu^{2+}	Direct synthesis	Separation	[74]
PVDC-1	1	Yb^{3+},Er^{3+}	Direct synthesis	Lanthanide MOF barcode	[75]
$Tb_{0.9}Eu_{0.1}$PIA	1	Tb^{3+}/Eu^{3+}	Direct synthesis	Luminescent Thermometer	[76]
Eu_xTb_{1-x} MOF	1	Tb^{3+}/Eu^{3+}	Direct synthesis	pH and temperature sensors	[77]
$Nd_{0.577}Yb_{0.423}$BDC-F_4	1	Nd^{3+}/Yb^{3+}	Direct synthesis	Near infrared thermometer	[78]
$[(Tb_{0.914}Eu_{0.086})_2(PDA)_3(H_2O)]\cdot 2H_2O$	1	Tb^{3+}/Eu^{3+}	Direct synthesis	Nanothermom-ters	[79]
$Tb_{1-x}Eu_x$FTPTC	1	Tb^{3+}/Eu^{3+}	Direct synthesis	Cryogenic luminescent thermometer	[80]
$Tb_{0.99}Eu_{0.01}(BDC)_{1.5}(H_2O)_2$	1	Tb^{3+}/Eu^{3+}	Direct synthesis	Nanothermome-ter	[81]
$Eu_xTb_{1-x}L$ (H_2L: 1,3-bis(4-carboxyphenyl)imidazolium)	1	Tb^{3+}/Eu^{3+}	Direct synthesis	Temperature Sensing	[82]
$Tb_{0.01}Gd_{0.99}L$ (H_4L = [1,1′:4′,1″-terphenyl]-2′,4,4″,5′-tetracarboxylic acid)	1	Tb^{3+}/Gd^{3+}	Direct synthesis	Luminescent Sensor of Picric Acid	[83]
$[Y_{1.8}Tb_{0.2}(PDA)_3(H_2O)1]\cdot{}_2H_2O$	1	Y^{3+}/Tb^{3+}	Direct synthesis	Nitro explosives detection	[84]

$[Y_{1.8}Eu_{0.2}(PDA)_3(H_2O)_1]\cdot 2H_2O$	1	Y^{3+}/Eu^{3+}	Direct synthesis	Sensor for Nitroaromatic Explosives	85
$Zn_3(BDC)_3$ [Cu(Pyen)] (M'MOF 1)	1	Zn^{2+}/Cu^{2+}	Direct synthesis	Molecular sieving	86
ZTOF-1	1	Zn^{2+}, Ti^{4+}	Direct synthesis	Adsorption	87
Zn/Cu-BTC	1	Cu^{2+}/Zn^{2+}	Direct synthesis	Incorporation Desulfurization	48
$Fe_2(BDT)_3$	1	Fe^{2+}/Fe^{3+}	Direct synthesis	Conductivity	88
Fe(1,2,3 triazolate)$_2$(BF$_4$)$_x$	1	Fe^{2+}/Fe^{3+}	Direct synthesis	Conductivity	89
$[(M1)_{3-x}(M2)_xO]_2(TCPP\text{-}M)_3$	1	Mn^{2+}/Fe^{3+} Ni^{2+}/Fe^{3+} Co^{2+}/Ni^{2+} Mn^{2+}/Co^{2+} Mn^{2+}/Mg^{2+} Mn^{2+}/Ni^{2+}	Direct synthesis	Incorporation Catalysis	90

NDC = naphthalene-2,6-dicarboxylate; COMOC = Center for Ordered Materials Organosilica and Catalysis; pyz = pyrazine ; CPM = crystalline porous material ; CTOF = cobalt-titanium organic framework ; pdc = pyridine-2,5-dicarboxylic acid; DMBDC = 2,5-dimethoxy-1,4-benzenedicarboxylate; iso = isoreticular; H$_2$hfibb = 4,4'-hexafluoroisopropylidene-bis-(benzoic acid) ; MFM = Manchester framework material; 1,4-dimb = 1,4-di-(1-imidzolyl-methyl)-benzene = ; H$_2$PVDC = 4,4'-(1E,1'E)-2,2'-(2,5-dimethoxy-1,4-phenylene)bis(ethane-2,1-diyl)dibenzoic acid; M'MOF = mixed-metal-organic framework ; H$_2$PIA = 5-(pyridin-4yl)isophthalic acid; H$_2$pyen = 5-mthyl-4-oxo-1,4-dihydro-pyridine-3-carbaldehyde; BDC = benzene-1,4-dicarboxylic acid; ZTOF = zinc-titanium-organic framework; H$_2$BTC = benzene-1,3,5-tricarboxylic acid ;* = oxidation state of the metal salts; H$_2$BDT = 5,5′- (1,4-phenylene)bis(1H-tetrazole); PDA = 1,4-phenylenediacetic acid; FTPTC = 2′-fluoro-[1,1′:4′,1′′-terphenyl]-3,3′′,5,5′′-tetracarboxylic acid.

Compounds	**Entry**	**Metal**	**Synthesis approach**	**Subject**	**Reference**

$Cd_3[(Cd_4Cl)_3(BTT)_8(H_2O)_{12}]_2$	1	$Co^{2+}/Ni^{2+}/Cd^{2+}$	Post-synthetic exchange in Methanol	Adsorption	[91]
MFU-4l	1	Zn^{2+}/Co^{2+}	Post-synthetic exchange in DMF	Thermo-dynamic study	[30]
MFU-4l	1	Zn^{2+}/Co^{2+}	Post-synthetic exchange in DMF	Catalysis	[92]
MMPF-5	1	Cd^{2+}/Co^{2+}	Post-synthetic exchange in DMSO	Catalysis	[91]
$Mn_3[(Mn_4Cl)_3(BTT)_8(CH3OH)_{10}]_2$	1	$Li^{+}/Cu^{+}/Fe^{2+}/Co^{2+}/Ni^{2+}/Cu^{2+}/Zn^{2+}/Mn^{2+}$	Post-synthetic exchange in methanol	Adsorption	[93]
MOF 1, $Cd1.5(H_3O)_3[(Cd_4O)_3(hett)_8]\cdot 6H_2O$	1	Pb^{2+}/ Cd^{2+}	Post-synthetic exchange in water	Incorporation	[94]
Ni-ITHD	1	$Zn^{2+}/Ni^{2+}/Co^{2+}/Cu^{2+}$	Direct synthesis and Post-synthetic exchange in DMF	Incorporation Adsorption	[95, 96]
PCN-333	1	Cr^{3+}/Fe^{3+}	Post-synthetic exchange in DMF	Incorporation	[97]
PCN-426	1	$Mg^{2+}/Fe^{3+}/Cr^{3+}$	Post-synthetic exchange in DMF	Incorporation	[98]
PCN-922-PCN921		Cu^{2+}/Zn^{2+}	Post Synthetic exchange in DMF	Incorporation	[99]
Porph@MOM-10-M	1	$Cd^{2+}/Mn^{2+}/Cu^{2+}/$	Post-Synthetic exchange in Methanol	Catalysis	[100]
Post 65 $(Mn(H_3O)$	1	$Mn^{2+}/Fe^{2+}/Co^{2+}/Ni^{2+}/C$	Post-Synthetic exchange in	Incorporation	[101]

[$(Mn_4Cl)_3$(h mtt)$_8$]		u^{2+}	DMF		
$Zn_{1.6}Cu_{6.4}L_{16}$	1	Zn^{2+}/Cu^{2+}	Post-synthetic exchange in water	Incorporation	[102]
$Co_{1.2}Cu_{6.8}L_{16}$	1	Cu^{2+}/Co^{2+}	Post-synthetic exchange in water	Incorporation	[102]
Zr(Ti)-NDC		Zr^{4+}/Ti^{4+}	Post-synthetic exchange in DMF	Catalysis	[103]
PMOF-2		Zn^{2+}/Cu^{2+}	Post-synthetic exchange in Methanol	Kinetics	[47]
SURMOF-1		$Cu^{2+}/Zn^{2+}/Ni^{2+}/Co^{2+}$	Post synthetic exchange in DMF	Incorporation	[33]
{[M(L)$_2$(H_2O)$_2$].2(anion).guest.($2H_2O$)$_n$		$Zn^{2+}/Cu^{2+}/Cd^{2+}$	Post-synthetic exchange in water	Incorporation	[104]

H_3BTT.2HCl = 1,3,5-Tris(2H-tetrazol-5-yl)benzene hydrochloride; MMPF = metal-metalloporphyrin framework; H_2ett = 5,5',10,10',15,15'-Hexaethayltruxene-2,7,12-tricarboxylic acid; ITHD = ith-d net topology; PCN = porous coordination network; MOM = metal-organic materials; H_2NDC = naphthalene-2,6-dicarboxylic acid; DMF = dimethylformamide ; DMSO = dimethylsulfoxide;

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