Contents lists available at ScienceDirect





# Inorganic Chemistry Communications

journal homepage: www.elsevier.com/locate/inoche

# Temperature-controlled dimensionality variety from 3D to 2D and 1D based on Cd(II)/ip/bmb polymers

## Chunying Xu, Linke Li, Qianqian Guo, Hongwei Hou\*, Yaoting Fan

Department of Chemistry, Zhengzhou University, Zhengzhou 450052, PR China

## ARTICLE INFO

ABSTRACT

Article history: Received 25 February 2011 Accepted 15 April 2011 Available online 23 April 2011

Keywords: Temperature Dimensionality Cadmium Photoluminescence  $\{[Cd(bmb)(ip)] \cdot H_2O\}_n$  (2), and  $[Cd(bmb)(ip)(CH_3CH_2OH)(H_2O)]_n$  (3) (bmb = (1,4-bis(2-methylbenzimidazol-1-ylmethyl) benzene);  $H_2ip = 1,3$ -benzenedicarboxylic acid). A careful investigation of the structures discloses that temperature parameters have significant effects on the conformations and coordination modes of the ligands and enhanced temperature favors the formation of higher dimensional products. In addition, the thermal stabilities and photoluminescence properties of polymers 1–3 in the solid state have also been investigated. © 2011 Elsevier B.V. All rights reserved.

By controlling the hydrothermal reaction temperature, three coordination polymers with the same ingredients

but different dimensional architectures from 3D to 2D and 1D have been obtained, namely,  $[Cd(bmb)(Hip)_2]_n(1)$ ,

Recently, the rational design and construction of metal-organic coordination complexes with the same ingredients but different structures have attracted wide-spread interest due to their potential applications in magnetism, adsorption, separation, transportation of gasses and liquids as well as catalysis [1-4]. Remarkable progress has been made on the theoretical analysis and practical manipulation of such interesting complexes, but the dimensionality control of the resulting products is still a great challenge at present [5–7], because the final structures are frequently modulated by various factors [8–18]. Among them, one factor, so-called reaction temperature, can't be ignored based on the following considerations: i) under different temperatures, flexible organic ligands inherently hold the potential of adopting different conformations [19,20]; ii) the reaction temperature plays a crucial role in tuning the coordination mode of organic carboxylic ligand [21,22]. So, under the same reagent conditions, the reaction temperature can be used as a structure-directing agent and various dimensional (0D-3D) architectures, to some extent, could be purposefully obtained. However, due to the complexity and difficult prediction of the final composition and structure, the influential principles are still less ascertained [23–25]. Consequently, the exploration of tuning the dimensionality of a complex through reaction temperature modification provides an impetus for the further research of coordination complexes. In this work, the dimensionality of Cd(II)/ip/ bmb polymers were adjusted from 3D self-penetrated pillared-layer framework to 2D (4, 4) grid-layer and 1D trapezoid-like chain by varying the hydrothermal reaction temperatures. Structural determinations indicates that the mixed ligands with different conformations and coordination modes compete to bind toward the octahedral Cd(II) ion, which changes the spatial arrangement of the mixed ligands and tunes the dimensionality of the resulting complexes to reduce with the decreasing of reaction temperature.

As shown in Scheme 1, the freely conformational bmb, various coordination modes of H<sub>2</sub>ip, and cadmium with high coordination number are selected to synthesis polymers **1–3** [26] under different hydrothermal conditions. At a high temperature of 160 °C, octahedral Cd(II) center is ligated by two *trans*-conformational bmb (with a N<sub>donor</sub>---N-C<sub>sp3</sub>---C<sub>sp3</sub> torsion angle of 77.26°) and four Hip<sup>-</sup> with the coordination mode of type I (Scheme 2). As a result, a charming 3D



<sup>\*</sup> Corresponding author. Tel./fax: +86 371 67761744. *E-mail address:* houhongw@zzu.edu.cn (H. Hou).

<sup>1387-7003/\$ -</sup> see front matter © 2011 Elsevier B.V. All rights reserved. doi:10.1016/j.inoche.2011.04.018

Scheme 1. Schematic diagram of the synthetic conditions and topology for polymers 1–3.



Scheme 2. The coordinated mode of the H<sub>2</sub>ip ligand.

self-penetrated pillared-layer framework **1** is obtained. Reducing the reaction temperature to 130 °C, bmb also adopts *trans*-conformation but with a larger  $N_{donor}$ ... $N-C_{sp3}$ ... $C_{sp3}$  torsion angle of 99.87°, which occupies two coordinated sites of octahedral Cd(II) ion. Two ip<sup>2-</sup> with the chelating coordination fashion of type II (Scheme 2) occupy the other four coordinated sites of octahedral Cd(II) ion. Under the cooperation of bmb and ip<sup>2-</sup>, **2** exhibits 2D (4, 4) grid-layers. When a low hydrothermal reaction temperature of 100 °C is selected, a 1D trapezoid-like chain **3** is generated. Different from **1** and **2**, an EtOH/ H<sub>2</sub>O mixed solution is used due to the poor solubility of bmb at low temperature. The formation of low-dimensional polymer may be due to the fact that *trans*-conformational bmb (with a N<sub>donor</sub>...N-C<sub>sp3</sub>...C<sub>sp3</sub>.

а

torsion angle of 87.95°) and two ip<sup>2–</sup> (with the coordination mode of type III) only occupy three coordinated sites of octahedral Cd(II), and the others are occupied by terminally coordinated solvent molecules. Thus, it can be concluded that the different reaction temperatures essentially influence the conformation of bmb and coordination mode of ip<sup>2–</sup>, and induce different cooperative coordination fashions of the two ligands with the octahedral Cd(II) ion, which leads the dimensionality of polymers **1–3** to reduce with the decreasing of reaction temperature.

Single crystal X-ray diffraction analysis [27] indicates that each Cd(II) ion of **1** exhibits a slightly distorted octahedral environment (Fig. 1a), which comprises four carboxylic oxygen atoms from two symmetry-related Hip<sup>-</sup> anions in the equatorial plane and two nitrogen atoms from two bmb ligands in the apical site. The incompletely deprotonated Hip<sup>-</sup> ligands link adjacent Cd(II) ions to form a 2D (4,4) coordination network in *bc*-plane (Fig. 1b). Obviously, due to the specific spatial torsion of Hip<sup>-</sup> (with a O<sub>donor</sub>···C<sub>sp2</sub>···O<sub>donor</sub> torsion angle of 155.92°), the charming right and left handed helical chains with an alternate arrangement fashion are observed in Cd(II)/(Hip) layer. The helical pitches are both 11.070(2) Å corresponding to the length of *b*-axis. Furthermore, these helical layers are pillared by *trans*-conformational bmb via the Cd–N connections to generate a 3D pillar-layered framework







**Fig. 1.** (a) Coordination environment of Cd(II) ion in polymer 1 with hydrogen atoms omitted for clarity (thermal ellipsoids at 30% probability level). (b) The Hip<sup>-</sup> links adjacent Cd(II) ions to form a 2D (4,4) coordination network in bc plane with the charming right and left handed helical chains arranging alternately. (c) The 2D layers are pillared by bmb to generate a 3D pillar-layered framework.

(Fig. 1c). To further understand the structure of **1**, the Cd(II) atom can be considered as a six-connected node, and the bmb and Hip<sup>-</sup> serve as linkers. As highlighted in Scheme **1**, the combination of nodes and linkers produces a 6-connected framework with a Schläfli symbol of  $4^4 \cdot 6^{10} \cdot 8$ . Careful inspection of such framework suggests that the net is self-penetrating. Each six-membered shortest circuit is catenated by two rods of the same network. Self-penetration is an unusual form of topological entanglement [28–30]. Thus, **1** can be considered as another example of the self-penetrated coordination polymers.

In **2**, the coordination environment around the Cd(II) center is best portrayed as a distorted  $[CdO_4N_2]$  octahedral geometry (Fig. 2a), ligated by four oxygen atoms (O1, O2, O1B, and O2B) from two symmetryrelated ip<sup>2–</sup> anions and two nitrogen atoms (N1 and N1B) from two distinct bmb. The bmb adopts *trans*-conformation with two flexures toward opposite direction, and links neighboring Cd(II) ions to afford a fascinating *meso*-helical chain with left- and right-handed helical loops in one single strand along the *c*-axis (Fig. 2b). The  $ip^{2-}$  anion takes the coordination mode of type II (as illustrated in Scheme 2) bridging adjacent Cd-bmb meso-helices (Fig. 2c) to generate a 2D puckered layer. The Cd···Cd distance across  $ip^{2-}$  is 9.267 Å. Simplifying the Cd(II) as a node, polymer **2** shows a 4<sup>4</sup> topology. These 2D grid-layers are stacking in an offset fashion along *ac*- plane with some displacement between two layers (Scheme 1).

The crystal structure of **3** also contains an octahedral Cd(II) ion, which is coordinated by three oxygen atoms from different carboxylic groups of two symmetry-related ip<sup>2–</sup> anions, one nitrogen atoms from bmb, and two oxygen atoms from water and ethanol molecules. Different from polymers **1** and **2**, two carboxylic groups of ip<sup>2–</sup> adopt different coordination modes: one carboxylic group adopts bidentate chelate mode and the other adopts monodentate fashion (type III in Scheme 2). The ip<sup>2–</sup> anion acts as  $\mu_2$ -bridge linking Cd(II) ions to produce a 1D linear chain. In addition, the adjacent Cd/ip chains are



**Fig. 2.** (a) Coordination environment of Cd(II) ion in polymer 2 with hydrogen atoms and free water molecules omitted for clarity (thermal ellipsoids at 30% probability level). (b) The bmb linking neighboring Cd(II) ions afford a fascinating *meso*-helical chain with left- and right-handed helical loops in one single strand along the *c*-axis. (c) The ip<sup>2-</sup> anions bridge adjacent Cd-bmb meso-helices to generate a 2D layer.



**Fig. 3.** The center Cd(II) ion show a distorted octahedral geometry in polymer 3. The adjacent Cd/ip chains are joined by bmb to form a slightly distorted 1D trapezoid-like chain decorated with water and ethanol molecules at both sides.

joined by *trans*-conformational bmb to form a slightly distorted 1D trapezoid-like chain decorated with water and ethanol molecules at both sides (Fig. 3).

In order to study the differences between these complexes with the same ingredients but different dimensionalities in the properties, thermogravimetric analyses (TGA) and photoluminescence spectrum of polymers 1-3 were performed. The PXRD patterns were comparable to the corresponding simulated ones calculated from the singlecrystal diffraction data (Fig. S1 in the Supplementary information), indicating a pure phase of each bulky sample. As shown in Fig. S2 (in the Supplementary information), polymers 1-3 show high thermal stabilities. For the 3D framework 1 without any lattice molecules, only one weight-loss stage is observed between 365 °C and 682 °C, which is attributed to the collapse of the pillared-layer framework (obsd: 85.8%; calcd: 86.1%). For the 2D polymer 2, a weight loss of 2.31% is detected in the range of 46-131 °C corresponding to the loss of lattice water molecule (calcd: 2.73%), and then a plateau region follows. The overall framework starts to decompose at about 385 °C. The TGA curve of low-dimensional polymer 3 displays a multi-step thermal weight-loss process. The first step weight loss (obsd: 7.99%) at 130-171 °C, corresponding to the loss of an ethanol molecule (calcd: 8.79%), and then a plateau region follows. The second step weight loss of 3.84% is observed from 314 °C to 355 °C corresponding to the loss of a coordinated water molecule (calcd: 3.44%). The unusual weight loss may be because the presence of hydrogen-bonding between the coordinated water molecules and  $ip^{2-}$  anions [31]. The removal of organic components occurs in the range of 381-541 °C. In addition, polymers 1-3 show different fluorescent emissions bands at 412 nm for 1 ( $\lambda_{ex}\!=\!360$  nm), 445 nm for 2 ( $\lambda_{ex}\!=\!370$  nm), and 411 nm for 3  $(\lambda_{ex} = 354 \text{ nm})$  respectively (Fig. S3a). Similar emissions can also be observed for free H<sub>2</sub>ip ( $\lambda_{em}$  = 389 nm,  $\lambda_{ex}$  = 321 nm) (Fig. 4). Thus, the emissions of the three polymers should be assigned to intra-ligand charge transitions of H<sub>2</sub>ip. The red-shift is probably caused by the coordination of  $ip^{2-}$  to the metal centers [32]. The varying degrees of red-shift are due to the changes of the coordination environments and various coordination mode of H<sub>2</sub>ip. The decreasement of fluorescent intensities of polymers 1-3 is attributed to the coordination of ip<sup>2-</sup> to the metal center, which lowers the rigidity of ip<sup>2–</sup> and increases the loss of energy by radiationless decay [33]. Moreover, the  $ip^{2-}$  ligands adopt different coordination modes in polymers **1–3** (Scheme 2) and the rigid of ip<sup>2-</sup> with bidentate chelating coordination fashion of carboxylic group is stronger than that of  $ip^{2-}$  with monodentate coordination mode of carboxylic group. So, the fluorescent intensities of **2** and **3** are stronger than that of **1**.

In summary, three high thermal stability fluorescent polymers with the same components, 3D self-penetrating pillared-layer framework for **1**, 2D (4, 4) grid-layer for **2**, and 1D trapezoid-like chain for **3** have been obtained at the hydrothermal reaction temperatures of 160 °C, 130 °C and 100 °C respectively. Further investigation indicates that the conformations and coordination modes of the ligands in **1**, **2** and **3** are obviously different. And this difference induced by varying reaction temperatures should be responsible for the fact that the overall dimensionality of the resulting complex reduces with the decreasing of reaction temperature.

#### Acknowledgments

This work was financially supported by the National Natural Science Foundation (Nos. 20971110, 91022013 and 20801048), Program for New Century Excellent Talents of the Ministry of Education of China (NCET-07-0765), and the Outstanding Talented Persons Foundation of Henan Province.



Fig. 4. Photoluminescences of polymers 1-3 and free ligands.

### Appendix A. Supplementary material

Crystallographic data for the structural analysis have been deposited with the Cambridge Crystallographic Data Center, CCDC reference numbers 813926-813928 for complexes **1–3**. These data can be obtained free of charge via www.ccdc.cam.ac.uk/conts/retrieving. html (or from the Cambridge Crystallographic Data Centre, 12, Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033). Details on XRD patterns, TGA curves and tables are list in supplementary content. Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.inoche.2011.04.018.

#### References

- Z. Zeng, R.-H. Wang, B. Twamley, D.A. Parrish, J.M. Shreeve, Chem. Mater. 20 (2008) 6176.
- [2] M. Kurmoo, H. Kumagai, M. Akita-Tanaka, K. Inoue, S. Takagi, Inorg. Chem. 45 (2006) 1627.
- [3] K. Liu, X. Zhu, J. Wang, B. Li, Y. Zhang, Inorg. Chem. Commun. 13 (2011) 976.
- [4] J.-K. Cheng, J. Zhang, P.-X. Yin, Q.-P. Lin, Z.-J. Li, Y.-G. Yao, Inorg. Chem. 48 (2009) 9992.
- [5] E.-C. Yang, T.-Y. Liu, Q. Wang, X.-J. Zhao, Inorg. Chem. Commun. 14 (2011) 285.
- [6] J.J.M. Amoore, C.A. Black, L.R. Hanton, M.D. Spicer, Cryst. Growth Des. 5 (2005) 1255.
- [7] V. Štrukil, L. Fábián, D.G. Reid, M.J. Duer, G.J. Jackson, M. Eckert-Maksić, T. Friščić, Chem. Commun. 46 (2010) 9191.
- [8] W.-C. Song, J.-R. Li, P.-C. Song, Y. Tao, Q. Yu, X.-L. Tong, X.-H. Bu, Inorg. Chem. 48 (2009) 3792.
- Q. Zhang, J. Zhang, Q.-Y. Yu, M. Pan, C.-Y. Su, Cryst. Growth Des. 10 (2010) 4076.
  M. Yoshizawa, M. Nagao, K. Umemoto, K. Biradha, M. Fujita, S. Sakamoto, K.
- Yamaguchi, Chem. Commun. (2003) 1808.
- [11] S.R. Batten, K.S. Murray, Coord. Chem. Rev. 246 (2003) 103.
- [12] J. Xu, X.-Q. Yao, L.-F. Huang, Y.-Z. Lia, H.-G. Zheng, CrystEngComm 13 (2011) 857.
- [13] S.M. Chen, C.Z. Lu, Q.Z. Zhang, J.H. Liu, X.Y. Wu, Eur. J. Inorg. Chem. (2005) 423.
- [14] S.H. Cho, B. Ma, S.T. Nguyen, J.T. Hupp, T.E. Albrecht-Schmitt, Chem. Commun. (2006) 2563.
- [15] Q.-K. Liu, J.-P. Ma, Y.-B. Dong, J. Am. Chem. Soc. 132 (2010) 7005.
- [16] D.P. Martin, R.M. Supkowski, R.L. LaDuca, Inorg. Chem. 46 (2007) 7917.
- B. Zheng, H. Dong, J. Bai, Y. Li, S. Li, M. Scheer, J. Am. Chem. Soc. 130 (2008) 7778.
  J.-G. Lin, Y.-Y. Xu, L. Qiu, S.-Q. Zang, C.-S. Lu, C.-Y. Duan, Y.-Z. Li, S. Gao, Q.-J. Meng,
- Chem. Commun. (2008) 2659.
- [19] V. Iancu, A. Deshpande, S.-W. Hia, Nano Lett. 6 (2006) 820.
  [20] F. Luo, M.-b. Luo, Y.-h. Liu, CrystEngComm 12 (2010) 1750.
- [21] D. Liu, Z.-G. Ren, H.-X. Li, Y. Chen, J. Wang, Y. Zhang, J.-P. Lang, Cryst. Eng.
- Commun. 12 (2010) 1912. [22] J.-D. Lin, J.-W. Cheng, S.-W. Du, Cryst. Growth Des. 8 (2008) 3348.
- [23] M.-L. Tong, S. Kitagawa, H.-C. Chang, M. Ohba, Chem. Commun. (2004) 418.
- [23] M.-L. Tong, S. Kitagawa, H.-C. Chang, W. Onba, Chem. Commun. (2004) 418.
  [24] X. Wang, L. Liu, T. Makarenko, A.n J. Jacobson, Cryst. Growth Des. 10 (2010) 3752.
- [25] S. Dey, B. Ojha, G. Das, CrystEngComm 13 (2011) 269.

- [26] (a) Synthesis of 1: A mixture of Cd(NO<sub>3</sub>)·4H<sub>2</sub>O (61.7 mg, 0.2 mmol), bmb (36.6 mg, 0.1 mmol), isophthalic acid (33.2 mg, 0.2 mmol) and NaOH (8.0 mg, 0.2 mmol) in 10 mL distilled H<sub>2</sub>O was sealed in a 25 mL Teflon-lined stainless steel container and heated at 160 °C for 3 days. After the mixture cooled to room temperature at a rate of 5 °C/h, colorless pillar-like crystals of 1 were obtained with a yield of 32% (based on Cd). Anal. Calc. For  $C_{40}H_{32}N_4O_8Cd$  (%): C, 59.38; H, 3.99; N, 6.92. Found: C, 59.86; H, 4.13; N, 7.11. IR (KBr, cm<sup>-1</sup>): 2924(m), 2853(w), 1707(w), 1609(m), 1555(s), 1508(w), 1457(m), 1382(s), 1226(w), 1163(w), 1016(w), 990(w), 916(w), 857(w), 745(s), 719(m), 662(w), 475(w); (b) Synthesis of 2: The reaction of 2 was carried out in the procedures similar to those of 1, only heating to 130 °C. Colorless prism crystals were generated directly with a yield of 52% (based on Cd). Anal. Calc. For C<sub>32</sub>H<sub>28</sub>N<sub>4</sub>O<sub>5</sub>Cd (%): C, 58.15; H, 4.27; N, 8.48. Found: C, 57.98; H, 4.04; N, 8.62. IR (KBr, cm<sup>-1</sup>): 3435(s), 2923(w), 2166(w), 1607(s), 1557(s), 1506(w), 1477(w), 1458(m), 1406(m), 1379(m), 1292(w), 1162(m), 1105(m), 991(m), 918(m), 860(m), 735(w), 719(s), 659(w), 615(w); (c) Synthesis of 3: The synthetic procedure for 3 is similar to that for 1 except that  $H_2O$  was replaced by  $H_2O/CH_3CH_2OH$  (4:1) and the hydrothermal temperature was 100 °C, affording colorless plate-like crystals with a yield of 59% (based on Cd). Anal. Calc. For  $C_{22}H_{23}N_2O_6Cd$  (%): C, 50.44; H, 4.23; N, 5.35. Found: C, 50.71; H, 4.14; N, 5.57. IR (KBr, cm<sup>-1</sup>): 3399(s), 2973(w), 2370(w), 1633(m), 2603(s),1550(s), 1510(m), 1474(m), 1458(m), 1382(s), 1291(m), 1159(m), 1076(w), 1012(w), 931(w), 838(m), 808(w), 742(s), 725(s), 670(w), 612(w).
- [27] Crystal data for 1:  $C_{40}H_{32}N_4O_8Cd$ , M = 809.11, monoclinic, space group P2(1)/c,  $a = 9.6181(19), b = 11.070(2), c = 16.659(3) \text{ Å}, \beta = 101.39(3), v = 1738.7(6) \text{ Å}^3$ Z=2, Dc=1.545 cm<sup>-3</sup>, F000=824.0, Mo K $\alpha$  radition,  $\lambda=0.71073$  Å, T=293 (2) K,  $\mu=0.690$  cm<sup>-1</sup>, GOF=1.076,  $R_1=0.0289$ ,  $wR_2=0.0663$  [ $I>2\sigma(I)$ ]. Adsorption correction: Multi-scan  $(T_{min}/T_{max} = 0.883/0.914)$ . Crystal data for 2: C<sub>32</sub>H<sub>28</sub>N<sub>4</sub>O<sub>5</sub>Cd, M=661.00, monoclinic, space group C2/c, a=9.2668(19), b=9.2668(19), c=17.267(3) Å, β=101.49(3), v=2952.3(10) Å<sup>3</sup>, Z=4, Dc=1.483 cm<sup>-3</sup>, *F000*=1336.0, Mo Kα radition,  $\lambda=0.71073$  Å, T=293 (2) K,  $\mu$ =0.787 cm<sup>-1</sup>, *GOF*=1.080, *R*<sub>1</sub>=0.0525, *wR*<sub>2</sub>=0.1053 [*I*>2 $\sigma$ (*I*)]. Adsorption correction: Multi-scan ( $T_{min}/T_{max} = 0.797/0.834$ ). Crystal data for 3: C<sub>22</sub>H<sub>23</sub>N<sub>2</sub>O<sub>6</sub>Cd, M = 523.84, triclinic, space group P-1, *a* = 10.187(2), *b* = 10.874 (2), c = 11.291(2) Å,  $\alpha = 64.42(3)$ ,  $\beta = 71.62(3)$ ,  $\gamma = 75.04(3)$ ,  $\nu = 1059.7(3)$  Å<sup>3</sup> Z = 2, Dc = 1.635 cm<sup>-3</sup>, F000 = 526.0, Mo K $\alpha$  radition,  $\lambda = 0.71073$  Å, T = 293 (2) K,  $\mu = 1.072 \text{ cm}^{-1}$ , GOF = 1.081,  $R_1 = 0.0312$ ,  $wR_2 = 0.0740 [I > 2\sigma(I)]$ . Adsorption correction: Multi-scan ( $T_{min}/T_{max} = 0.764/0.851$ ). X-ray data collection was carried out using a Rigaku Saturn 724 CCD diffractometer. The data were corrected for Lorentz and polarization effects. The structures were solved by direct methods and refined with a full-matrix least-squares technique based on F<sup>2</sup> with the SHELXL-97 crystallographic software package. The hydrogen atoms were assigned with common isotropic displacement factors and included in the final refinement by using geometrical restrains.
- [28] S.S. Chen, J. Fan, T. Okamura, M.S. Chen, Z. Su, W.Y. Sun, N. Ueyama, Cryst. Growth Des. 10 (2010) 812.
- [29] G.S. Yang, Y.Q. Lan, H.Y. Zang, K.Z. Shao, X.L. Wang, Z.M. Su, C.J. Jiang, Cryst. Eng. Commun. 11 (2009) 274.
- [30] V.A. Blatov, L. Carlucci, G. Ciani, D.M. Proserpio, CrystEngComm 6 (2004) 377.
- [31] W.-L. Zhang, Y.-Y. Liu, J.-F. Ma, H. Jiang, J. Yang, G.-J. Ping, Cryst. Growth Des. 8 (2008) 1250.
- [32] K. Jiang, L.-F. Ma, X.-Y. Sun, L.-Y. Wang, CrystEngComm 13 (2011) 330.
- [33] G.-X. Liu, K. Zhu, H.-M. Xu, S. Nishihara, R.-Y. Huang, X.-M. Renac, CrystEngComm 12 (2010) 1175.