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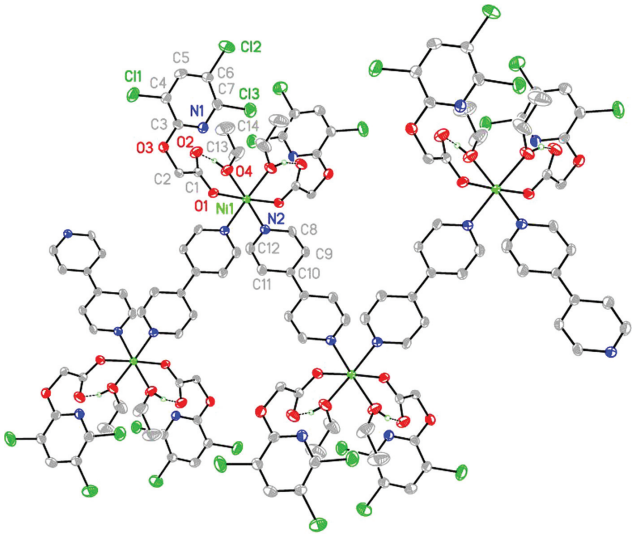
The crystal structure of *catena*-poly[(μ_2-4,4′-dipyridine-κ^2*N*,*N*′)-bis(3,5,6-trichloropyridine-2-oxyacetato-κ*O*)-bis(ethanol-κ*O*)nickel(II)], $C_{28}H_{26}Cl_6N_4NiO_8$



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Abstract

$C_{28}H_{26}Cl_6N_4NiO_8$, monoclinic, I_2/a (no. 15), $a = 15.7577(10)$ Å, $b = 12.6174(7)$ Å, $c = 16.7333(10)$ Å, $\beta = 99.609(6)$Å, $V = 3280.3(3)$ Å^3, $Z = 4$, $R_{gt}(F) = 0.0674$, $wR_{ref}(F^2) = 0.1665$, $T = 291.2(3)$ K.

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A part of the molecular structure is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list of the atoms including atomic coordinates and displacement parameters.

Source of material

$NiCl_2 \cdot 6H_2O$ (0.3 mmol, 0.074 g). 4,4′-dipyridine (4,4′-dipy, 0.3 mmol, 0.047 g) and ligand 3,5,6-trichloropyridine-2-oxyacetic acid (3,5,6-Htcpa, 0.3 mmol, 0.078 g) were dissolved in a mixture of 20 mL of water/ ethanol (*V*:*V* = 1:1). Then the pH of the mixture was neutralized with KOH (0.1 mol·L^{-1}) to pH = 6.5. After that, the mixed solution was sealed in a 25 mL Teflon reactor and kept under autogeneous pressure at 393 K for 3 days. After cooling to room temperature at a rate of 279 K·h^{-1}, green block crystals of the title compound were obtained and collected. Yield: 20 mg (16%, based on ligand 3,5,6-Htcpa). **Anal.** Calcd for $C_{28}H_{26}Cl_6N_4NiO_8$(%): C, 41.08; H, 3.20; N, 6.85. Found: C, 41.01; H, 3.29; N, 6.92.

Table 1: Data collection and handling.

Crystal:	Green block
Size:	0.29 × 0.25 × 0.22 mm
Wavelength:	Mo *Kα* radiation (0.71073 Å)
μ:	1.14 mm^{-1}
Diffractometer, scan mode:	SuperNova, ω
θ_{max}, completeness:	28.4°, >99%
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int}:	7139, 3421, 0.051
Criterion for I_{obs}, $N(hkl)_{gt}$:	$I_{obs} > 2\ \sigma(I_{obs})$, 2154
$N(param)_{refined}$:	217
Programs:	CrysAlis^{PRO} [1], Olex2 [2], SHELX [3, 4]

Experimental details

CrysAlisPro 1.171.39.46 (Rigaku Oxford Diffraction, 2018) [1] was used for empirical absorption correction using spherical harmonics, implemented in SCALE3 ABSPACK scaling algorithm. Using Olex2 [2], the structure was solved with the ShelXT [3] structure solution program using Intrinsic Phasing and refined with the ShelXL [4] refinement package. The H atoms bonded to C atoms were fixed, with C—H distance of 0.93 Å; and/or positioned geometrically in the riding-model approximation, with C—H distance of 0.97 Å; $U_{iso}(H) = 1.2U_{eq}(C)$.

Comment

At the beginning stage of the coordination chemistry, aromatic carboxylate ligands have been frequently selected to construct metal-organic frameworks due to their rich structural features and valuable potential applications [5–9]. Subsequently, modification of these carboxylate ligands by various electron donating and withdrawing substituents groups such as Me- [10, 11], ^{t}Bu- [12, 13], MeO- [10, 14, 15],

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Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2).

Atom	*x*	*y*	*z*	U_{iso}*/U_{eq}
C1	0.7488(3)	0.4078(4)	0.3258(3)	0.0379(12)
C2	0.7127(4)	0.3887(4)	0.2373(3)	0.0414(13)
H2A	0.7416	0.3282	0.2182	0.050*
H2B	0.6520	0.3717	0.2321	0.050*
C3	0.6715(3)	0.5633(4)	0.1934(3)	0.0408(13)
C4	0.6951(4)	0.6599(4)	0.1645(4)	0.0517(15)
C5	0.6454(4)	0.7480(5)	0.1724(4)	0.0599(17)
H5	0.6608	0.8144	0.1554	0.072*
C6	0.5715(4)	0.7347(4)	0.2068(4)	0.0543(16)
C7	0.5525(3)	0.6362(5)	0.2317(3)	0.0466(14)
C8	0.5976(3)	0.2057(4)	0.5490(3)	0.0442(13)
H8	0.5999	0.2613	0.5858	0.053*
C9	0.5386(3)	0.1276(4)	0.5532(3)	0.0435(13)
H9	0.5032	0.1307	0.5924	0.052*
C10	0.5312(3)	0.0435(4)	0.4989(3)	0.0325(11)
C11	0.5867(4)	0.0459(4)	0.4435(3)	0.0547(16)
H11	0.5848	−0.0081	0.4055	0.066*
C12	0.6452(4)	0.1277(5)	0.4439(4)	0.0557(16)
H12	0.6816	0.1266	0.4056	0.067*
C13	0.8826(5)	0.5237(6)	0.5548(4)	0.097(3)
H13A	0.9334	0.4930	0.5872	0.117*
H13B	0.8415	0.5370	0.5908	0.117*
C14	0.9061(6)	0.6224(6)	0.5252(5)	0.120(3)
H14A	0.8573	0.6531	0.4910	0.181*
H14B	0.9518	0.6121	0.4945	0.181*
H14C	0.9253	0.6690	0.5699	0.181*
Cl1	0.78527(12)	0.67082(15)	0.11876(13)	0.0864(7)
Cl2	0.50957(14)	0.84462(14)	0.21820(14)	0.0975(7)
Cl3	0.46002(10)	0.61493(14)	0.27188(10)	0.0668(5)
N1	0.6018(3)	0.5516(3)	0.2259(2)	0.0412(11)
N2	0.6521(2)	0.2079(3)	0.4962(2)	0.0343(9)
Ni1	0.7500	0.32936(6)	0.5000	0.0262(2)
O1	0.7342(2)	0.3337(2)	0.3724(2)	0.0397(8)
O2	0.7901(3)	0.4905(3)	0.3453(2)	0.0568(11)
O3	0.7229(2)	0.4792(3)	0.1871(2)	0.0499(10)
O4	0.8467(3)	0.4474(3)	0.4975(2)	0.0553(11)
H4	0.846(3)	0.477(3)	0.4507(8)	0.083*

—OH and —SO_3H [16–18], —SH [19, 20], —NH_2 [21, 22], —NO_2 [23, 24], —CF_3 [25], —CN [26], —F [27–30], —Cl [31–33], —Br [34–37], —I [38–40], has been employed. Because of the steric and/or electronic effects of the substituent groups, these decorated ligands may afford new supramolecular assemblies owing to their special linking types and ligand-metal interactions. Among them, the halogen containing carboxylate ligands are attractive as they may form halogen bonds, which played an important role in the fields of molecular recognition and supramolecular assemblies.

Lately, a trichloro substituent aromatic carboxylate ligand, namely, 3,5,6-trichloropyridine-2-oxyacetic acid (3,5,6-Htcpa) has aroused our interests. A series of compounds, including co-crystal Zn^{II} [41] and Ni^{II} complexes [42], binuclear Cd^{II} cluster [43], 1D Ni^{II} [44] , Co^{II} [45] and Mn^{II} [46] polymers containing this ligand, have been reported by us recently.

Single-crystal X-ray diffraction analysis shows that the asymmetric unit of **I** includes one half of a Ni^{II} ion, one 3,5,6-tcpa ligands, one half of a 4,4′-dipy together with one ethanol molecule.

The six-coordinated Ni^{II} ion is bonded to two carboxy oxygen of two unidentate 3,5,6-tcpa anions [Ni1-O1 = 2.109(3) Å], two pyridyl nitrogen atoms of two 4,4′-dipy [Ni1-N2 = 2.168(4) Å] as well as two hydroxy oxygen atoms of two ethanol molecules [Ni1-O4 = 2.136(4) Å] (see the figure).

The *trans* O1-Ni1-O1A and O4-Ni1-N2 bond angles are 177.05(17)° and 177.13(14)° respectively, and the cis ones lie in the range of 85.75(13) to 92.19(13)°.

The μ_2-4,4′-dipy molecules bridge the neighbouring Ni^{II} ions with their nitrogen atoms to form zigzag chain structure along the *a* axis. The Ni···Ni separation across 4,4′-dipy is 11.452 Å. The adjacent Ni···Ni distance parallel to the *a* axis is 15.758 Å. The 3D crystal packing is constructed by O—H···O hydrogen bonding and weak Cl···Cl halogen bonding.

The hydroxy atom (O4) of ethanol as donor involves in intra-molecular hydrogen bond with uncomplexed carboxy oxygen (O2) of 3,5,6-tcpa as acceptor.

The halogen···halogen interactions are seen between C6-Cl2 and C7G-Cl3G (symmetry code for G: x, $3/2 - y$, $1/2 + z$) of adjacent 1D chain with a Cl2···Cl3G separation of 3.444 Å. In **I**, the geometries of these halogen bonds is characterized by angles of C6-C12···Cl3G (119.20°) and Cl2···Cl3G-C7G (93.02°), nearly corresponding to halogen bond of Type II [47, 48].

Comparing **I** with $[Ni(3,5,6\text{-tcpa})_2(4,4'\text{-dipy})\ 1/2]_n$ (**II**) [44], both of which prepared from the same starting reactants, some important similarities and differences can be found as follows: (i) The structure. They are both 1D polymer. The title structure is a zigzag chain, while **II** is a linear structure. (ii) The μ_2-function of 4,4′-dipy. Both 4,4′-dipy join Ni^{II} centers to form the corresponding polymer. (iii) The composition. There are complexed ethonal molecules in **I**, but absence in **II**. This is because of the use of the mixed H_2O-ethanol solvent for synthesis of **I**, while pure H_2O solvent for that of **II**. (iv) The coordination mode of 3,5,6-tcpa. It is monodentate in **I**, but bidentate in **II**. (v) The coordination geometry of Ni^{II} ion. It is in octahedron for **I**, while in tetragonal pyramid for **II**.

From the above careful disscussion, it was confirmed again that the different synthesis conditions, such as by changing the solvent, greatly affected the composition and structure of complexes.

Now, many further attempts on developing new complexes with 3,5,6-Htcpa as the first ligand, for instance

by the use of other solvents, introducing other N/O-donor bridging or chelate auxiliary ligands will be gradually implemented.

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References

1. Oxford Diffraction Ltd: CrysAlis^{PRO}. Rigaku Oxford Diffraction, Version 1.171.39.6a, England (2018).
2. Dolomanov, O. V.; Bourhis, L. J.; Gildea, R. J.; Howard, J. A. K.; Puschmann, H.: OLEX2 : a complete structure solution, refinement and analysis program. J. Appl. Crystallogr. **42** (2009) 339–341.
3. Sheldrick, G. M.: SHELXT – integrated space-group and crystal-structure determination. Acta Crystallogr. **A71** (2015) 3–8.
4. Sheldrick, G. M.: Crystal structure refinement with SHELXL. Acta Crystallogr. **C71** (2015) 3–8.
5. Mehrotra, R. C.; Bohra, R.: Metal carboxylates. Academic Press, London (1983).
6. Li, J.-X.; Du, Z.-X.: Crystal structure of *catena*-poly[(μ_2-4,4′-bipyridine-κ^2N:N')-tetraquamanganese(II)]-(3-(carboxylatomethyl) benzoic acid)-water (1/2/2), $C_{28}H_{34}MnN_2O_{14}$. Z. Kristallogr. NCS **230** (2015) 339–340.
7. Du, Z.-X.; Li, J.-X.: Crystal structure of *catena*-poly[(μ_2-4,4′-bipyridine-κ^2N:N')-tetraqua-cobalt(II)]-(3-(carboxylatomethyl) benzoic acid)-water (1/2/2), $C_{28}H_{34}CoN_2O_{14}$. Z. Kristallogr. NCS **230** (2015) 321–322.
8. Li, J.-X.; Du, Z.-X.: Syntheses, structures and magnetic properties of two mononuclear nickel(II) complexes based on bicarboxylate ligands. Z. Naturforsch. **70b** (2015) 505–511.
9. Li, J.-X.; Du, Z.-X.: Zinc and cobalt complexes with (2-carboxyphenoxy) acetic acid ligand: syntheses, structures, fluorescent and magnetic properties. J. Coord. Chem. **69** (2016) 2563–2572.
10. Han, M.-L.; Wang, J.-G.; Ma, L.-F.; Guo, H.; Wang, L.-Y.: Construction of Cd(II) coordination polymers based on R-isophthalate (R = -CH_3 or -OCH_3) and flexible *N*-donor co-ligands: syntheses, structures and photoluminescence. CrystEngComm **14** (2012) 2691–2701.
11. Alturk, S.; Avci, D.; Basoglu, A.; Tamer, O.; Atalay, Y.; Dege, N.: Copper(II) complex with 6-methylpyridine-2-carboxyclic acid: experimental and computational study on the XRD, FT-IR and UV-Vis spectra, refractive index, band gap and NLO parameters. Spectrochim. Acta, Part A **190** (2018) 220–230.
12. Wang, J.-G.; Chai, N.; Wang, S.-C.; Ma, L.-F.; Wang, L.-Y.: Two new 3-D coordination polymers with 5-*tert*-butyl isophthalic acid and flexible *N*-donor co-ligands bearing linear trinuclear secondary building blocks. Inorg. Chem. Commun. **30** (2013) 143–146.
13. Chang, X.-H.: Crystal structure of poly[(μ_4-5-tertbutylisophthalato-κ^4O:O':O'':O''')-(1,3-dimethyl-2-imidazolidinone-κO)zinc(II)] $C_{17}H_{22}N_2O_5Zn$. Z. Kristallogr. NCS **233** (2018) 1043–1045.
14. Qin, J.-H.; Ma, L.-F.; Hu, Y.; Wang, L.-Y.: Syntheses, structures and photoluminescence of five zinc(ii) coordination polymers based on 5-methoxyisophthalate and flexible *N*-donor ancillary ligands. CrystEngComm **14** (2012) 2891–2898.
15. Ma, L.-F.; Zhao, J.-W.; Han, M.-L.; Wang, L.-Y.; Du, M.: Two novel 3-D coordination polymers with 5-methoxyisophthalate and flexible *N*-donor co-ligands showing pentanuclear or alternate mono/binuclear Cu(II) units. Dalton Trans. **41** (2012) 2078–2083.
16. Du, Z.-X.; Li, J.-X.; Han, R.-Q.: Syntheses, characterizations and crystal structures of two copper coordination polymers both having Cu_2Cl_2 bridging subunit $[Cu_I(bipy)\ 1/2Cl]_n$ (1) and $\{[(Cu^{II})_4(phen)_4(SSA)_2Cl_2](H_2O)_2(DMF)_2\}_n$ (2). J. Chem. Crystallogr. **41** (2011) 34–38.
17. Li, J.-X.; Du, Z.-X.: Syntheses, structures and fluorescent properties of copper(II) and manganese(II) helical complexes bridged by 4,4′-dipyridylsulfide. Chin. J. Struct. Chem. **31** (2012) 877–883.
18. Xu, T.-Y.; Wang, H.; Li, J.-M.; Zhao, Y.-L.; Han, Y.-H.; Wang, X.-L.; He, K.-H.; Wang, A.-R.; Shi, Z.-F.: A water-stable luminescent Zn(II) coordination polymer based on 5-sulfosalicylic acid and 1,4-bis(1*H*-imidazol-1-yl)benzene for highly sensitive and selective sensing of Fe^{3+} ion. Inorg. Chim. Acta **493** (2019) 72–80.
19. Li, J.-X.; Du, Z.-X.: Crystal structure of *catena*-5-sulfosalicylato-κ^2O,O')-bis(μ_2-4- thiolatopyridinium-κ^2S:S) cadmium(II)] hydrate, $Cd(C_7H_4O_6S)(C_5H_5NS)_2{\cdot}2.5\ H_2O$. Z. Kristallogr. NCS **226** (2011) 331–332.
20. Du, Z.-X.; Li, J.-X.: The synthesis, structure and magnetic properties of a mononuclear cobalt compound with dipyrimidine sulfane ligand derived from 2-thiobarbituric acid. Inorg. Chim. Acta **436** (2015) 159–162.
21. Chang, X.-H.; Zhai, Z.-M.; Lu, X.-M.: Crystal structure of tetraaqua-bis (μ_2-5-aminoisophthalato-κ^3N:O,O')-bis(4,4′- dipyridylsulfide-κ^1N) dizinc(II), $C_{36}H_{34}N_6O_{12}S_2Ni_2$. Z. Kristallogr. NCS **235** (2020) 73–75.
22. Shao, Z.-C.; Meng, X.-R.; Hou, H.-W.: Two new Cd-II and Zn-II coordination polymers incorporating 1-aminobenzene-3,4,5-tricarboxylic acid: synthesis, crystal structure and characterization. Acta Crystallogr. **C75** (2019) 1065–1072.
23. Han, M.-L.; Ling, X.-L.: Crystal structure of diaqua-bis (5-nitrobenzene-3-carboxy-1,2-dicarboxylato)- bis(1-(3-(1*H*-benzimidazol-1-yl)propyl)-benzimidazole)manganese(II), $[Mn(H_2O)_2(O_2NC_9H_3O_6)_2(C_{17}H_{17}N_4)_2]$, $C_{52}H_{44}MnN_{10}O_{18}$. Z. Kristallogr. NCS **227** (2012) 574–576.
24. Li, G.-L.; Liu, G.-Z.; Ma, L.-F.; Xin, L.-Y.; Li, X.-L.; Wang, L.-Y.: Crystallographic determination of solid-state structural transformations in a dynamic metal-organic framework. Chem. Commun. **50** (2014) 2615–2617.
25. Chai, J.; Liu, Y.; Liu, B.; Yang, B.: Effect of substituent groups R = -CH_3, -Br and -CF_3) on the structure, stability and redox property of $[Cr(R\text{-}pic)_2(H_2O)_2]NO_3{\cdot}H_2O$ complexes. J. Mol. Struct. **1150** (2017) 307–315.
26. Li, J.-X.; Du, Z.-X.; Wang, J.-G.; Wang, T.; Lv, J.-N.: Zinc and manganese coordination polymers constructed by a new coordination mode of 4,5-dicyanoimidazolate ligand: syntheses, crystal structures, fluorescent and magnetic properties. Inorg. Chem. Commun. **15** (2012) 243–247.
27. Feng, X.; Sun, Y. L.; Li, R.-F.; Zhang, T.; Guo, N.; Wang, L. Y.: Two novel europium coordination polymers based on fluorine

substituted and similar carboxylate ligands: syntheses, structures and luminescence. Inorg. Chem. Commun. **73** (2016) 190–195.
28. Zhang, J.; Liu, Y.-Y.; Ying, K.: Crystal structure of 2,2′-bipyridino-tetrafluorophthalato-copper(II) $[Cu(C_8HF_4O_4)(C_{10}H_8N_2)_2](C_8H_2F_4O_4)(C_8HF_4O_4)$, $C_{44}H_{20}CuF_{12}N_4O_{12}$. Z. Kristallogr. NCS **227** (2012) 410–412.
29. Zhang, J.; Liu, Y.-Y.; Ying, K.: Crystal structure of (1,10-phenanthroline)(tetrafluorophtahlato)copper(II), $[Cu(C_8F_4O_4)(C_{12}H_8N_2)_2](C_8H_2F_4O_4)$, $C_{40}H_{18}CuF_8N_4O_8$. Z. Kristallogr. NCS **227** (2012) 568–570.
30. Li, J.-X.; Du, Z.-X.; Feng, X.: A new binuclear Ni^{II} complex with tetrafluorophthalate and 2,2′-bipyridine ligands: synthesis, crystal structure and magnetic properties. Z. Naturforsch. **74b** (2019) 833–838.
31. Zhang, J.; Li, J.-X.: Synthesis, structure and magnetic properties of a binuclear copper(II) complex constructed by a new coordination mode of the tetrachlorophthalate ligand. Z. Naturforsch. **71b** (2016) 45–49.
32. Sharma, R.-P.; Saini, A.; Kumar, J.; Kumar, S.; Venugopalan, P.; Ferretti, V.: Coordination complexes of copper(II) with herbicide-trichlorophenoxyacetate: syntheses, characterization, single crystal X-ray structure and packing analyses of monomeric $[Cu(\gamma\text{-pic})_3(2,4,5\text{-trichlorophenoxyacetate})]\cdot H_2O$, $[trans\text{-}Cu(en)_2(2,4,5\text{-trichlorophenoxyacetate})_2]\cdot 2\ H_2O$ and dimeric $[Cu_2(H_2tea)_2(2,4,5\text{-trichlorophenoxyacetate})_2]\cdot 2\ (H_2O)$. Inorg. Chim. Acta **457** (2017) 59–68.
33. Xu, X.; Hu, F.; Ma, Y.; Gao, J.; Shuai, Q.: Facile microwave synthesis, structural diversity and herbicidal activity of six novel alkaline-earth metal complexes (AECs) based on skeletal isomerization chlorophenoxyacetic acids. New J. Chem. **42** (2018) 4155–4166.
34. Li, J.-X.; Du, Z.-X.; Bai, R.-F.: Crystal structure of aqua-bis (5-bromo-6-methylpicolinato-κ^2N,O) zinc(II) dihydrate, $C_{14}H_{16}Br_2N_2O_7Zn$. Z. Kristallogr. NCS **235** (2020) 63–65.
35. Li, S.-H.; Wang, J.-G.: Crystal structure of (μ_2-5-bromoisophthalate-$\kappa\ ^2O:O'$)bis(2-methyl-4*H*-imidazole-κN)cobalt(II), $C_{16}H_{15}BrCoN_4O_4$. Z. Kristallogr. NCS **229** (2014) 421–422.
36. Chang, X.-H.: The crystal structure of poly[(m_4-4-bromoisophthalato -$\kappa^4O:O':O'':O'''$)zinc(II)], $C_8H_3BrO_4Zn$. Z. Kristallogr. NCS **235** (2020) 3–4.
37. Miroslaw, B.; Mahmoudi, G.; Ferenc, W.; Cristovao, B.; Osypiuk, D.; Sarzynski, J.; Gluchowska, H.; Franconetti, A.; Frontera, A.: Halogen interactions in dinuclear copper(II) 2,4-dibromophenoxyacetate – crystal structure and quantum chemical calculations. J. Mol. Struct. **1202** (2020) 127227.
38. Ridenour, J. A.; Carter, K. P.; Cahill, C. L.: RE-*p*-halobenzoic acid–terpyridine complexes, part III: structural and supramolecular trends in a series of *p*-iodobenzoic acid rare-earth hybrid materials. CrystEngComm **19** (2017) 1190–1203.
39. Carter, K. P.; Kalaj, M.; Cahill, C. L.: Harnessing uranyl oxo atoms *via* halogen bonding interactions in molecular uranyl materials featuring 2,5-diiodobenzoic acid and *N*-donor capping ligands. Inorg. Chem. Front. **4** (2017) 65–78.
40. Li, B.; Dong, M.-M.; Fan, H.-T.; Feng, C.-Q.; Zang, S.-Q.; Wang, L.-Y.: Halogen···halogen interactions in the assembly of high-dimensional supramolecular coordination polymers based on 3,5-diiodobenzoic acid. Cryst. Growth Des. **14** (2014) 6325–6336.
41. Li, J.-X.; Du, Z.-X.; Wang, J.; Feng, X.: Two mononuclear zinc(II) complexes constructed by two types of phenoxyacetic acid ligands: syntheses, crystal structures and fluorescence properties. Z. Naturforsch. **74b** (2019) 839–845.
42. Du, Z.-X.; Li, J.-X.: Crystal structure of tetraaqua-bis(2-((3,5,6-trichloropyridin-2-yl)oxy)acetato-κO)-nickel(II)—diaqua-bis(2-((3,5,6-trichloropyridin-2-yl)oxy)acetato-nickel(II), $C_{28}H_{24}Cl_{12}N_4Ni_2O_{18}$. Z. Kristallogr. NCS **235** (2020) 881–883.
43. Li, J.-X.; Du, Z.-X.: A binuclear cadmium(II) cluster based on π···π stacking and halogen···halogen interactions: synthesis, crystal analysis and fluorescent properties. J. Cluster Sci. **31** (2020) 507–511.
44. Du, Z.-X.; Li, J.-X.; Bai, R.-F.: The crystal structure of *catena*-poly(μ_2-4,4′-bipyridine-$\kappa^2N:N'$)-tetrakis(μ_2-2- ((3,5,6-trichloropyridin-2-yl)oxy)acetato-$\kappa^2O:O'$) dinickel(II)], $C_{19}H_{10}Cl_6N_3NiO_6$. Z. Kristallogr. NCS **235** (2020) 55–56.
45. Du, Z.-X.; Li, J.-X.; Bai, R.-F.: Crystal structure of *catena*-poly[μ_2-4,4′-bipyridine-$\kappa^2N:N'$)-tetrakis(μ_2-2- ((3,5,6-trichloropyridin-2-yl)oxy)acetato-$\kappa^2O:O'$) dicobalt(II)], $C_{19}H_{10}Cl_6CoN_3O_6$. Z. Kristallogr. NCS **235** (2020) 15–17.
46. Li, J.-X.; Du, Z.-X.; Pan, Q.-Y.; Zhang, L.-L.; Liu, D.-L.: The first 3,5,6-trichloropyridine-2-oxyacetate bridged manganese coordination polymer with features of π···π stacking and halogen···halogen interactions: synthesis, crystal analysis and magnetic properties. (2020) https://doi.org/10.1016/j.ica.2020.119677.
47. Biju, S.; Gopakumar, N.; Bunzli, J.-C. G.; Scopelliti, R.; Kim, H. K.; Reddy, M. L. P.: Brilliant photoluminescence and triboluminescence from ternary complexes of Dy^{III} and Tb^{III} with 3-phenyl-4-propanoyl-5-isoxazolonate and a bidentate phosphine oxide coligand. Inorg. Chem. **52** (2013) 8750–8758.
48. Cavallo, G.; Metrangolo, P.; Milani, R.; Pilati, T.; Priimagi, A.; Resnati, G.; Terraneo, G.: The halogen bond. Chem. Rev. **116** (2016) 2478–2601.