

Nickel (II)-complex ligand as host for Potassium ion guest. Spectroscopic characterization and X-ray structure determination

Mayoro DIOP^{a1}, Mamou SARR^a, Amar DIOP^a, Ibrahima Elhadj THIAM^a,
Aliou Hamady BARRY^b, Mohamed GAYE^a, Natalia Alvarez^c and
Javier Ellena^d

^aDepartment of Chemistry, University Cheikh Anta Diop, Dakar, Sénégal

^bDepartment of Chemistry, University Nouakchott, Nouakchott, Mauritanie

^cFacultad de Química, General Flores 2124, Udelar, Montevideo, 11800, Uruguay

^dInstituto de Física de São Carlos, Universidade de São Paulo, CP 369, 13.560-970, São Carlos, SP, Brazil

Corresponding Author : Mayoro DIOP

Abstract: The title complex, $\{[Ni(hab)]K[(hab)Ni]\} \cdot SCN$ (H_2hab is bis(2-hydroxy-3-methoxybenzylidene)-1,2-diaminobenzene) crystallizes in the Monoclinic space group $P2_1/c$ with unit cell dimensions $a = 11.5891(13) \text{ \AA}$, $b = 17.307(2) \text{ \AA}$, $c = 19.781(2) \text{ \AA}$, $\beta = 92.368(10)^\circ$, $V = 3964.2(8) \text{ \AA}^3$, $Z = 4$, $R_1 = 0.106$ and $wR_2 = 0.305$. The Ni^{II} cation is in a N_2O_2 inner and has a distorted square-planar coordination environment. The Ni^{II} cation is linked by two imino nitrogen atoms and two bridged phenolate oxygen atoms. The potassium cation is octacoordinated in O_8 donor site and linked by four bridged phenolate oxygen atoms and four methoxy oxygen atoms. In the crystal, the $\{[Ni(hab)]K[(hab)Ni]\}^+$ cations form layers parallel to the ab plane. The SCN^- anions are located in the interlayer space and connect the layers via $C-H \dots N$ and $C-H \dots S$ hydrogen bonds, forming three dimensional network.

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I. Introduction

In the past decades a numerous heteronuclear coordination compounds derived from ligand having two compartments of different sizes have been reported [1-4]. These types of compounds can be synthesized after isolating the mononuclear complex in which the metal ion occupies the smaller cage. The reactions of these mononuclear species with metallic centers of different natures can lead compounds with very varied structures [5-8]. The control of the experimental conditions during the synthesis reactions made it possible to construct structures with interesting physico-chemical properties [9, 10]. Both polynuclears and co-crystals were obtained with salen type ligands [11-13]. Complexes with Na^+ ions are widely studied because of their implications for molecular recognition of biological systems [14-16]. The study of the structures of these complexes shows that the Na^+ ion systematically occupies the open site while the transition metal is in the closed N_2O_2 site of smaller size [17-20]. The H_2hab (bis (2-hydroxy-3-methoxybenzylidene)-1,2-diaminobenzene) Schiff base obtained by condensation of 3-methoxysalicylaldehyde and o-phenylenediamine allows to generate several types of 3d/4f and 3d/Na heteronuclear complexes in which the 3d metal invariably occupies the N_2O_2 site [17], [21-24]. It is in this context that we report the synthesis of a complex Ni^{2+}/K^+ formulated as follows $\{[Ni(hab)]K[Ni(hab)]\} \cdot NCS$. The compound is obtained by initially isolating the mononuclear nickel (II) complex before reacting the latter with potassium thiocyanate to obtain a heterotrinnuclear complex.

II. Experimental section

2.1. Starting materials and Instrumentations

Commercially available 1,2-diaminobenzene, 3-methoxysalicylaldehyde, $NiCl_2 \cdot 6H_2O$ and $KSCN$ were purchased from Aldrich and used without further purification. The analyses for carbon, hydrogen and nitrogen were carried out using a LECO CHNS-932 instrument. The IR spectra were recorded as KBr discs on a Perkin Elmer Spectrum Two spectrophotometer (4000–400 cm^{-1}). UV–VIS spectra were recorded in methanol solution concentration of 10^{-3} M at $25^\circ C$ and wavelength was reported in nm using a Perkin Elmer Lambda 365 UV/VIS

¹ Corresponding author : mayorodiop2000@yahoo.fr

spectrophotometer. The molar conductance of 10^{-3} M solution of the metal complex in DMF was measured at 25 °C using a WTW LF-330 conductivity meter with a WTW conductivity cell. Room temperature magnetic susceptibility of the powdered sample was measured using a Johnson Matthey scientific magnetic susceptibility balance (calibrant $\text{Hg}[\text{Co}(\text{SCN})_4]$).

2.2. Synthesis of the metal-ligand complex

The complex $[(\text{NiL})\cdot(\text{H}_2\text{O})]$ was prepared according to the experimental process described in the literature with slight modification. To a solution of o-vanillin (0.7602 g, 5 mmol) in 10 mL of ethanol was added 5 mL aqueous solution of Na_2CO_3 0.2 M and 10 mL of an ethanolic solution of $\text{NiCl}_2\cdot 6\text{H}_2\text{O}$ (0.1185g, 5 mmol). The mixture is refluxed for 30 mn and a solution of 1,2-diaminobenzene (0.250 g, 2.5 mmol) in 10 mL of ethanol was added. The resulting mixture was refluxed for 120 min. On cooling a brown precipitate which appears was filtered off, washed with 3×10 mL of ether and dried in air yielding an orange compound formulated as $[(\text{NiL})\cdot\text{H}_2\text{O}]$. Yield: 80%. M.p.: 245 °C. FT-IR (KBr, ν , cm^{-1}): 3373 (OH) (br, water), 1606 (C=N) 1586 (C=C), 1543 (C=C), 1441 (C=C), 1439, 1340, 1243, 1111, 733. UV-visible (λ , nm): 511. Anal. calcd. for $\text{C}_{22}\text{H}_{20}\text{NiN}_2\text{O}_5$: C, 58.58; H, 4.47; N, 6.21. Found: C, 55.49; H, 4.39; N, 6.18 %. Λ_M ($\Omega^{-1}\text{cm}^2\text{mol}^{-1}$): 10.

2.3. Synthesis of the trinuclear complex

The filtrate of a mixture of KSCN (0.0972 g, 1 mmol) in 20 mL of absolute ethanol was added to a DMF solution (5 mL) of the $[(\text{NiL})\cdot\text{H}_2\text{O}]$ (0.4511 g, 2 mmol). The resulting solution was heated under reflux for 2 hours. After cooling the solution was filtered and the filtrate was kept at 298 K. After two weeks crystals suitable for X-ray diffraction were collected and formulated as $\{[(\text{NiL})_2\text{K}]\cdot(\text{SCN})\}$. Yield: 85%. FT-IR (KBr, ν (cm^{-1})): 2053 (S=C=N), 1606 (C=N), 1584 (C=C), 1545 (C=C), 1463 (C=C), 1440, 1238, 1191, 731. Anal. calcd. for $\text{C}_{45}\text{H}_{36}\text{Ni}_2\text{KN}_5\text{O}_8\text{S}$: C, 56.10; H, 3.77; N, 7.27; S, 3.33 %. Found: C, 56.07; H, 3.73; N, 7.22; S, 3.30 %. Λ_M ($\Omega^{-1}\text{cm}^2\text{mol}^{-1}$): 128.

2.4. X-ray data collection, structure determination and refinement

Diffraction: Rigaku AFC12 goniometer equipped with an enhanced sensitivity (HG) Saturn724+ detector mounted at the window of an FR-E+ SuperBright Mo-K α rotating anode generator ($\lambda = 0.71075$ Å) with VHF Varimax optics (100 μm focus). Cell determination, data collection, data reduction, cell refinement and absorption correction: *CrysAlisPro* 1.171.39.34b. [25]. Gaussian absorption correction was applied. Structure solution and refinement were performed using *SHELXT* [26] and *SHELXL-2014/7* [27]. All hydrogen atoms were added in calculated positions and refined in riding mode on the parent atom. Molecular graphics were generated using *ORTEP-3* [28].

Table-1. Crystallographic data and refinement parameters for the complex.

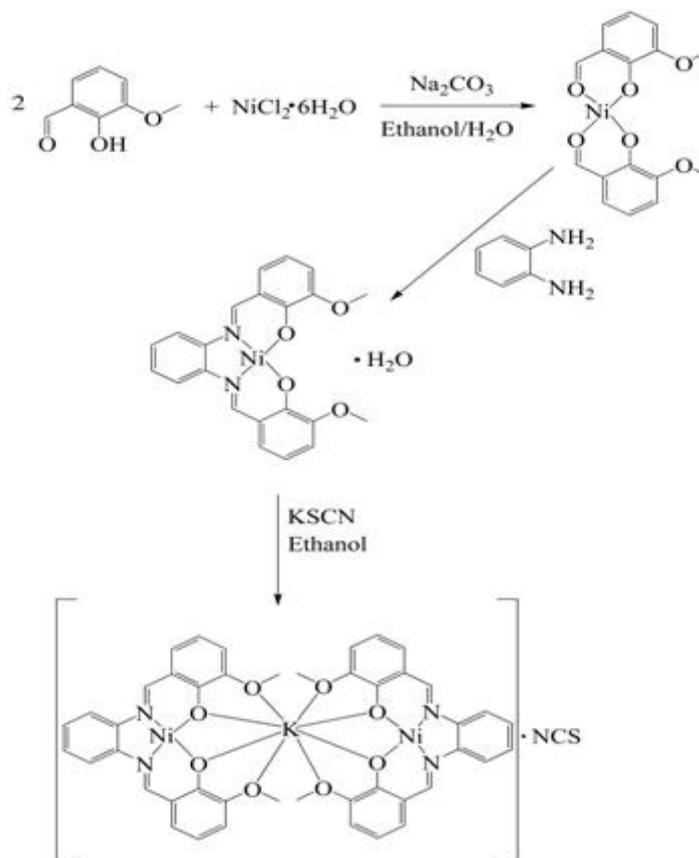
Formula of refinement	$\text{C}_{44}\text{H}_{36}\text{KN}_4\text{Ni}_2\text{O}_8\cdot\text{CNS}$
Molecular weight (g/mol)	963.37
Crystal system	Monoclinic
Space group	P21/c
<i>a</i> (Å)	11.5891 (13)
<i>b</i> (Å)	17.307 (2)
<i>c</i> (Å)	19.781 (2)
β (°)	92.368 (10)
<i>V</i> (Å ³)	3964.2 (8)
<i>Z</i>	4
<i>D_c</i> (g cm ⁻³)	1.694
Crystal size (mm)	0.28 × 0.27 × 0.18
Crystal color	metallic dark red
Crystal habit	block
Mo <i>K</i> α (Å)	0.71073
μ (mm ⁻¹)	1.17
<i>T</i> (K)	293
θ_{min} , θ_{max}	2.569, 25.350
<i>hkl</i> ranges	-10, 13 ; -14, 20 ; -23; 23
Measured reflections	14247
Independent reflections	7230
Reflections with $[I > 2\sigma(I)]$	4563
No. of parameters	563
<i>R</i> _{int}	0.064
<i>R</i> ₁ (F) [$I > 2\sigma(I)$]	0.106
<i>wR</i> ₂ (<i>F</i> ²)	0.305

Goodness-of-fit	1.09
$\Delta\rho_{\max}, \Delta\rho_{\min}$ ($e \text{ \AA}^{-3}$)	0.99, -1.00

III. Result and discussion

3.1. General Studies

The aim of the present work was to study the coordination of nickel(II)-ligand to potassium cations in order to synthesize a trinuclear complex. The condensation of 3-methoxysalicylaldehyde with 1,2-diaminobenzene in the presence of Ni^{II} afforded a metal-ligand which can act as a chelating ligand with the cation K^{I} , to produce a trinuclear complex (Scheme 1). Accordingly, the dimethylformamide solution of metal-ligand was treated with KSCN solution in absolute ethanol in 2:1 molar ratio. The resulting solution was refluxed during two hours before filtered-off and left under slow evaporation. Crystals suitable for X-ray diffraction were isolated after two weeks. The elemental analysis results are in good agreement with the calculated values for the metal-ligand and the trinuclear complex which are non-hygroscopic and stable in air. Both metal-ligand and trinuclear complexes are diamagnetic. The metal ligand molar conductivity Λ is $5 \Omega^{-1} \text{cm}^2 \text{mol}^{-1}$ indicating a non-electrolytic nature in DMF solution, while the trinuclear complex gives $128 \Omega^{-1} \text{cm}^2 \text{mol}^{-1}$ in accordance with a 1:1 electrolyte in DMF [29]. The infrared spectra of the metal-ligand exhibits a band at 1606 cm^{-1} characteristic of C=N chromophore coordinated to the metal center through the azomethine atom. Additional bands attributable to C=C of the aromatic rings are also pointed. On comparison the spectra of the trinuclear complex exhibits additional band at 2053 cm^{-1} which is attributable to the S=C=N uncoordinated moiety [30]. Both bands characteristic of C=C and C=N remain unchanged. The UV-Vis spectrum of both nickel(II)-ligand and the trinuclear compounds are recorded in methanol solution in the range of 200–1000 nm. The two spectra are comparable and show one absorption band attributable to the $\pi \rightarrow \pi^*$ transition of the aromatic rings in the range 280–295 nm and an additional band in the range 310–330 nm which can be attributed to the $n \rightarrow \pi^*$ transitions of the C=N chromophore. The high intensity bands due to LMCT appeared near 450 nm and the band at 511 nm are consistent with the observed d-d transitions of a diamagnetic square planar nickel(II) center complex [31].



Scheme 1. Synthetic scheme for metal-ligand and the heterotrinuclear complex preparation

Table-2: Selected bonds lengths (Å).

Ni1—O3	1.832 (8)	K1—O4	2.654 (9)
Ni1—N1	1.853 (8)	K1—O1	2.596 (7)
Ni1—O2	1.854 (7)	K1—O2	2.673 (7)
Ni1—O3	1.832 (8)	K1—O3	2.707 (8)
Ni1—N2	1.866 (9)	K1—O4	2.654 (9)
Ni2—N3	1.868 (9)	K1—O5	2.630 (8)
Ni2—N4	1.844 (9)	K1—O6	2.725 (7)
Ni2—O6	1.839 (7)	K1—O7	2.706 (7)
Ni2—O7	1.842 (7)	K1—O8	2.604 (8)
C1—O1	1.443 (11)	S1—C45	1.63 (2)
O3—Ni1—N1	175.1 (3)	O2—K1—O3	54.5 (2)
O3—Ni1—O2	83.8 (3)	O2—K1—O6	144.8 (2)
N1—Ni1—O2	95.4 (3)	O7—K1—O6	53.6 (2)
O3—Ni1—N2	96.7 (4)	O6—Ni2—O7	83.4 (3)
N1—Ni1—N2	84.2 (4)	O6—Ni2—N4	175.8 (3)
O2—Ni1—N2	178.9 (4)	O7—Ni2—N4	95.0 (4)
O8—K1—O5	167.2 (3)	O6—Ni2—N3	95.1 (4)
O1—K1—O4	171.3 (3)	O7—Ni2—N3	178.3 (4)
O4—K1—O7	110.4 (3)	N4—Ni2—N3	86.6 (5)

Table 3: Hydrogen bonds

C13—H13...N5 ⁱ	0.93	2.58	3.50 (2)	169.1
C22—H22A...S1 ⁱⁱ	0.96	3.03	3.978 (15)	169.7
C23—H23A...S1 ⁱⁱⁱ	0.96	2.99	3.936 (15)	170.5

Symmetry codes: (i) $-x, -y+1, -z+1$; (ii) $x, -y+1/2, z+1/2$; (iii) $-x+1, -y+1, -z+1$

3.2. Crystal structure of the complex {[Ni(hab)]K[(hab)Ni]}·SCN

The complex formulated as {[Ni(hab)]K[(hab)Ni]}·SCN (**H₂hab** is bis(2-hydroxy-3-methoxybenzylidene)-1,2-diaminobenzene) crystallizes in the monoclinic space group P2₁/c. Details for the structure solution and refinement are summarized in Table 1. The selected bond distances and angles are listed in Tables 2. The structure is showed in Fig. 1a. In the complex each of the two nickel(II) ions occupies the N(imino)₂O(phenoxo)₂ compartment of on [hab]²⁻ moiety, while the potassium(I) ions is coordinated by the two open O(phenoxo)₂O(methoxy)₂ compartment of the two [hab]²⁻ moieties. In the title complex, C₄₄H₃₆KN₄Ni₂O₈·SCN, each Ni atom located in N₂O₂ inner is tetracoordinated. The Ni^{II} cations are in a slightly distorted square planar geometry with all *transoid* N—Ni—O angles being 175.1 (3)° and 178.9 (4)° for Ni1 and 175.8 (3)° and 178.3 (4)° for Ni2. The values of the *cisoid* angles for the two Ni atoms are in the range [83.4 (3)–96.7 (4) °]. The values of the angle sum around each Ni is 360.1° proving the slight distortion of the environment around the Ni atoms. The Ni1—O2 and Ni1—O3 distances of 1.854 (7) Å and 1.832 (8) Å and Ni2—O6 and Ni2—O7 distances of 1.839 (7) Å and 1.842 (7) Å are comparable and are longer than those found in a similar complex [32]. The Ni—N distances in the complex which fall in the range [1.844 (9)–1.868 (9) Å] are comparable to Ni—N distances found in a reported complex [33]. The potassium cation has an O₈ donor set made up by four μ_2 -bridging phenolate oxygen atoms and four methoxy oxygen atoms from the ligand molecules acting in unidentate fashion and forming a distorted polyhedron. The K⁺ cation share four phenolate oxygen atoms with Ni atoms.

The cations Ni^{II} and K^I are arranged in the following sequence: Ni—K—Ni. The metal atoms are found at non-linear positions [Ni—K—Ni, 162.44 (9)°] as shown in Fig. 1a. The Ni—K distances of 3.759 (3) Å and 3.788 (3) Å distances are found to be longer than those found in heteronuclear Ni/K complexes [34, 35]. The molecules complex form a zigzag layers parallel to the *ab*-plane Fig. 1b. Within the zigzag chain, the cations SCN⁻ which are located in the interlayer space, connect the layers via weak hydrogen bond of types C—H...N and C—H...S resulting in three dimensional network.

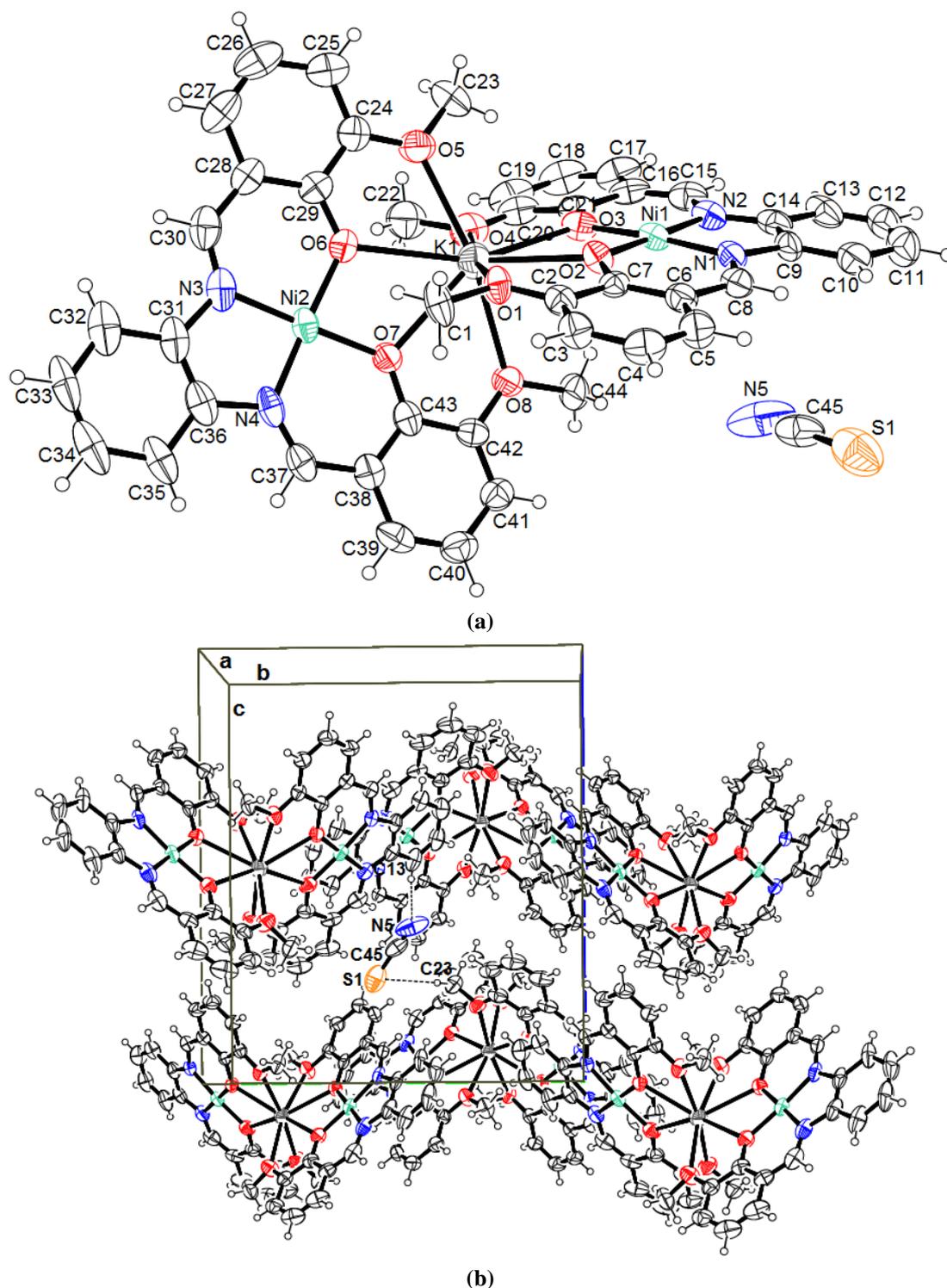


Figure 1: ORTEP plot (30% probability ellipsoids) showing the molecule structure of the heterotrinnuclear complex (a) and the hydrogen bonds (b) in the complex.

IV. Conclusion

The Schiff base which is widely used to prepare dinuclear complexes is also capable of giving polynuclear structures. The main characteristic in the case of the use of a transition metal and an element of the block seems to be the systematic occupation of the N_2O_2 site by the transition metal. All examples to our knowledge give this type of behavior. Using this ligand, we have isolated and determined the X-ray diffraction structure a hetero-tri-nuclear Ni-K-Ni complex. As expected, the Ni^{II} ion occupies the N_2O_2 site while the K^I cation occupies the O_8 site. The three dimensional network is formed with zigzag layers parallel to the *ab*-plane. The SCN^- anion is located in the interlayer and connect layers via weak hydrogen bond.

V. Supplementary material

CCDC 1861725 contains the supplementary crystallographic data for the reported complex. These data can be obtained free of charge via <http://www.ccdc.cam.ac.uk/conts/retrieving.html>, or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: (+44)-1223-336-033; e-mail: deposit@ccdc.cam.ac.uk. or [www: http:// www.ccdc.cam.ac.uk](http://www.ccdc.cam.ac.uk)).

References

- [1]. M. Minelli, W. Hart-Cooper, J.G. Sinnwell, D.T. Blumberg, I.A. Guzei, L.C. Spencer, J.P.S. Vázquez, A.S. Peralta, M.S. Torres, Synthesis, structure, and characterization of molybdenum(VI) imido complexes with N-salicylidene-2-aminothiophenol, *Polyhedron*, 146, 2018, 26–34.
- [2]. A.K. Maji, A. Chatterjee, S. Khan, B.K. Ghosh, R. Ghosh, Synthesis, crystal structure, catecholase and phenoxazinone synthase activities of a mononuclear cobalt(III) complex containing in situ formed tridentate N-donor Schiff base, *J. Mol. Struct.* 1146, 2017, 821–827.
- [3]. G.-M. Yu, L. Zhao, Y.-N. Guo, G.-F. Xu, L.-F. Zou, J. Tang, Y.-H. Li, Synthesis, structures and magnetic properties of di- and tetranuclear manganese complexes derived from a 3-methoxysalicylaldehyde benzoylhydrazide ligand, *J. Mol. Struct.*, 982, 2010, 139–144.
- [4]. A. Bhattacharyya, S. Sen, K. Harms, S. Chattopadhyay, Formation of three photoluminescent zinc(II) complexes with Zn2O2 cores: Examples of bi-dentate bonding modes of potentially tri- and tetra-dentate Schiff bases, *Polyhedron*, 88, 2015, 156–163.
- [5]. N. Hari, A. Jana, S. Mohanta, Syntheses, crystal structures and ESI-MS of mononuclear–dinuclear, trinuclear and dinuclear based one-dimensional copper(II)–s block metal ion complexes derived from a 3-ethoxysalicylaldehyde–diamine ligand, *Inorg. Chim. Acta*, 467, 2017, 11–20.
- [6]. P. Chakraborty S. Mohanta, Mononuclear and heterometallic dinuclear, trinuclear and dimer-of-dinuclear complexes derived from single- and double-compartment Schiff base ligands having a less utilized diamine, *Polyhedron*, 87, 2015, 98–108.
- [7]. H.-R. Wen, S.-J. Liu, X.-R. Xie, J. Bao, C.-M. Liu, J.-L. Chen, A family of nickel–lanthanide heterometallic dinuclear complexes derived from a chiral Schiff-base ligand exhibiting single-molecule magnet behaviors, *Inorg. Chim. Acta*, 435, 2015, 274–282.
- [8]. P. A. Vigato, S. Tamburini, The challenge of cyclic and acyclic schiff bases and related derivatives, *Coord. Chem. Rev.*, 248, 2004, 1717–2128.
- [9]. S. Roy, M.G.B. Drew, S. Chattopadhyay, Synthesis and characterization of three hetero-dinuclear complexes with CuO₂M cores (M = Na, Hg): Exploration of their phenoxazinone synthase mimicking activity, *Polyhedron*, 150, 2018, 28–34.
- [10]. [S. Majumder, M. Fleck, C.R. Lucas, S. Mohanta, A new tetraaminodiphenol macrocyclic ligand and its two dicopper(II) complexes: Syntheses, crystal structures, electrochemistry and magnetochemistry, *J. Mol. Struct.*, 1020, 2012, 127–133.
- [11]. W. Wang, R. Li, X. Hua, R. Zhang, Methanol electrooxidation on glassy carbon electrode modified with bimetallic Ni(II)Co(II)salen complexes encapsulated in mesoporous zeolite A, *Electrochim. Acta*, 163, 2015, 48–56.
- [12]. A.M. Atria, Y. Moreno, E. Spodine, M.T. Garland, R. Baggio, A discrete dinuclear Cu(II)–Gd(III) complex derived from a Schiff base ligand, [CuGd(ems)(NO₃)₃H₂O][Cu(ems) (ems: N,N'-ethylene-bis-5-methoxy salicylaldehydeimine), *Inorg. Chim. Acta*, 335, 2002, 1–6.
- [13]. [M.G. Quintero-Téllez, J.L. Alcántara-Flores, S. Bernès, M.L.A. Carrasco, M.M.M. Otero, Y. Reyes-Ortega, Synthesis, spectroscopic and structural characterization of bis[N,N'-3-azapentane-1,5-diyl-bis(salicylideneiminato)]-dicobalt(III), *Inorg. Chem. Commun.*, 70, 2016, 41–46.
- [14]. [J. Lü, F. Li, D.-Q. Yuan, and R. Cao, “Assembly of two novel three-dimensional networks driven by Alkali metals with an irreversible structural conversion,” *Polyhedron*, vol. 26, no. 13, pp. 2979–2986, 2007.
- [15]. [P. Mukherjee, M.G.B. Drew, A. Figuerola, A. Ghosh, Incorporation of a sodium ion guest in the host of copper(II)-Schiff-base complexes: Structural characterization and magnetic study, *Polyhedron*, 27, 2008, 3343–3350.
- [16]. F. Derguini, K. Nakanishi, J. Buck, U. Hämmerling, F. Grün, Spectroscopic Studies of Anhydroretinol, an Endogenous Mammalian and Insect retro-Retinoid, *Angew. Chem., Int. Ed. Engl.*, 33, 1994, 1837–1839.
- [17]. [M. Das, S. Chatterjee, S. Chattopadhyay, Unique example of a trigonal dodecahedral Na⁺ in a compartmental Schiff base N,N'-(1,2-Phenylene)-bis(3-methoxysalicylideneimine), *Inorg. Chem. Commun.*, 14, 2011, 1337–1340.
- [18]. P. Bhowmik, S. Chatterjee, S. Chattopadhyay, Heterometallic inorganic–organic frameworks of sodium–nickel(vanen): Cation–π interaction, trigonal dodecahedral Na⁺ and unprecedented heptadentate coordination mode of vanen²⁻, *Polyhedron*, 63, 2013, 214–221.
- [19]. P. Bhowmik, K. Harms, S. Chattopadhyay, Formation of polynuclear copper(II)–sodium(I) heterometallic complexes derived from salen-type Schiff bases, *Polyhedron*, 49, 2013, 113–120.
- [20]. P.P. Chakrabarty, D. Biswas, S. García-Granda, A.D. Jana, S. Saha, Sodium ion assisted molecular self-assembly in a class of Schiff-base copper(II) complexes, *Polyhedron*, 35, 2012, 108–115.
- [21]. M. Sarr, M. Diop, I.E. Thiam, M. Gaye, A.H. Barry, N. Alvarez, J. Ellena, Co-crystal structure of a dinuclear (Zn–Y) and a trinuclear (Zn–Y–Zn) complexes derived from a Schiff base ligand, *Eur. J. Chem.*, 9, 2018, 67–73.
- [22]. F. Yang, G.-M. Li, P. Chen, P.-F. Yan, G.-F. Hou, μ-Acetato-diacetato{μ-6,6'-dimethoxy-2,2'-[o-phenylenebis(nitrilomethanylylidene)] diphenolato}gadolinium(III)zinc, *Acta Crystallogr.*, E67, 2011, m1185.
- [23]. Y. Bao, G.-M. Li, F. Yang, P.-F. Yan, P. Chen, {μ-6,6'-Dimethoxy-2,2'-[cyclohexane-1,2-diylbis(nitrilomethylidyne)]diphenolato}methanol-μ-nitrate-dinitratocopper(II)europium(III), *Acta Crystallogr.*, E66, 2010, m1379.
- [24]. F.Z.C. Fellah, J.-P. Costes, C. Duhayon, J.-C. Daran, J.-P. Tuchagues, Mononuclear Cu and dinuclear Cu–Ln complexes of benzimidazole based ligands including N and O donors: Syntheses, characterization, X-ray molecular structures and magnetic properties, *Polyhedron*, 29, 2010, 2111–2119.
- [25]. *CrysAlisPro 1.171.39.34b. Rigaku Oxford Diffraction*, 2017.
- [26]. G.M. Sheldrick, SHELXT – Integrated space-group and crystal-structure determination, *Acta Crystallogr.*, A71, 2015, 3–8.
- [27]. G.M. Sheldrick, Crystal structure refinement with it SHELXL, *Acta Crystallogr.*, C71, 2015, 3–8.
- [28]. L.J. Farrugia, ORTEP-3 for Windows - a version of it ORTEP-III with a Graphical User Interface (GUI), *J. Appl. Crystallogr.*, 30, 1997, 565.
- [29]. W.J. Geary, The use of conductivity measurements in organic solvents for the characterisation of coordination compounds, *Coord. Chem. Rev.*, 7, 1971, 81–122.
- [30]. J.G. Malecki A. Maroń, Molecular and spectroscopic properties of chloride and thiocyanate hydridecarbonyl ruthenium(II) complexes with pyridine derivative ligands, *Polyhedron*, 30, 2011, 1225–1232.

- [31]. M. Amirasr, K.J. Schenk, S. Meghdadi, M. Morshedi, Synthesis, characterization and X-ray crystal structures of [Ni(Me-sal)2dpt] and [Ni(Me-sal)dpt]Cl, *Polyhedron*, 25, 2006, 671–677.
- [32]. M.F. Iskander, T.E. Khalil, S. Foro, Synthesis, characterization and X-ray crystal structures of nickel(II) and copper(II) complexes derived from salicylaldehyde cyanoacetylhydrazone. An unexpected ligand transformation, *Inorg. Chim. Acta*, 453, 2016, 633–646.
- [33]. M.D. Revenco, O. V. Palamarcuic, P.N. Bourosh, J. Lipkowski, M. Gdaniec, Y.A. Simonov, R. Clérac, New template reactions of salicylaldehyde S-methyl-isothiosemicarbazone with 2-formylpyridine promoted by Ni(II) or Cu(II) metal ions, *Inorganica Chimica Acta*, 368, 2011, 157–164.
- [34]. V.B. Arion, V.Ch. Kravtsov, J.I. Gradinaru, Y.A. Simonov, N.V. Gerbeleu, J. Lipkowski, J.-P. Wignacourt, H. Vezin, O. Mentré, Potassium-controlled synthesis of heterotopic macrocycles based on isothiosemicarbazide, *Inorg. Chim. Acta*, 328, 2002, 123–133.
- [35]. R. Biswas, M.G.B. Drew, A. Ghosh, Synthesis and crystal structure of a novel octa-aqua bridged star-shaped Ni₄K complex, *Inorg. Chem. Commun.*, 24, 2012, 1–3.

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