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### Co(II) NING 2,6-PIRIDINDIKARBON KISLOTASI BILAN KOMPLEKS BIRIKMASI SINTEZI VA TADQIQI

Annotatsiya

2,6-piridindikarbon kislotasi (2,6-PDCA)ning metall ionlari bilan ta'sirlashishi va uning metallokompleks birikmalarining xossalari tadqiq qilish maqsadida, kobalt(II) atsetat va monoetanolin bilan M:L:L 1:2:2 nisbatdagi koordinatsion soni oltiga teng bo'lgan, yangi kompleks birikmasi olinib, uning monokristali o'stirildi. Uning tarkibi va tuzilishi RTT yordamida aniqlandi. Kompleks birikmada 2,6-piridindikarbon kislotasi ligandi tridentant holatda koordinatsiyalangan. Hirshfeld sirtini Crystal Explorer 17.5 dasturi yordamida tahlil qilindi. Kompleks birikma kristalining IQ-spektri tahlil o'tkazilib, tegishli bog'larning tebranish chastotasi kuzatildi.

**Kalit so'zlar.** 2,6-piridindikarbon kislotasi (2,6-PDCA, dipic), kobalt(II) atsetat, monokristall.

### СИНТЕЗ И ИЗУЧЕНИЕ СЛОЖНОГО СОЕДИНЕНИЯ Co(II) С 2,6-ПИРИДИНЕДИКАРБОНОВОЙ КИСЛОТОЙ

Аннотация

Для изучения взаимодействия 2,6-пиридиндикарбоновой кислоты (2,6-ПДКА) с ионами металлов и свойств ее металлокомплексных соединений был получен новый комплексный продукт с ацетатом кобальта(II) и моноэтаноломином в соотношении M:L:L 1:2:2 и координационным числом шесть, а также выращен его монокристалл. Состав и структура комплекса были определены с помощью РСА. В комплексном продукте лиганд 2,6-пиридиндикарбоновой кислоты координирован в тридентатном состоянии. Поверхность Хиршфельда была проанализирована с помощью программы Crystal Explorer 17.5. Был проанализирован ИК-спектр кристалла комплексного соединения, и определены частоты колебаний соответствующих связей.

**Ключевые слова:** 2,6-пиридиндикарбоновая кислота (2,6-ПДКА, дипик), ацетат кобальта(II), монокристалл.

### SYNTHESIS AND STUDY OF A COMPLEX COMPOUND OF Co(II) WITH 2,6-PYRIDINEDICARBOXYLIC ACID

Annotation

To study the interaction of 2,6-pyridinedicarboxylic acid (2,6-PDCA) with metal ions and the properties of its metal complexes, a new complex product with cobalt(II) acetate and monoethanolamine in a 1:2:2 M:L:L ratio and a coordination number of six was synthesized and grown as a single crystal. The composition and structure of the complex were determined using X-ray. In the complex product, the 2,6-pyridinedicarboxylic acid ligand is coordinated in the tridentate state. The Hirshfeld surface was analyzed using Crystal Explorer 17.5. The IR spectrum of the crystal of the complex compound was analyzed, and the vibration frequencies of the corresponding bonds were determined.

**Keywords:** 2,6-pyridinedicarboxylic acid (2,6-PDCA, dipic), cobalt(II) acetate, single crystal.

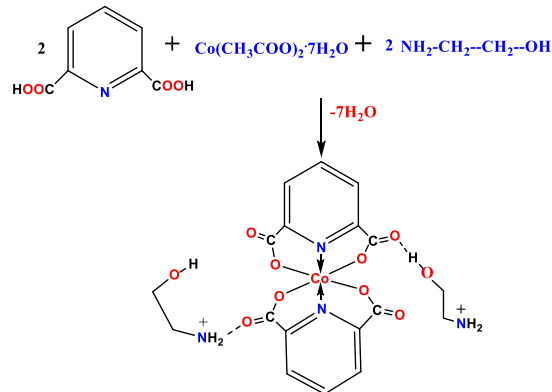
**Kirish.** Jahonda 2,6-almashigan piridin hosilalari hamda ularning d-metall tuzlari bilan hosil qilgan aralash ligandli kompleks birikmalarining tadqiqoti, ularning tarkibi, tuzilishi, xossalari bo'yicha ko'plab izlanishlar olib borilmoqda. Bu borada, yuqori konformasion harakatchan karbon kislotalar asosidagi ligandlarning oraliq metallar bilan yangi tuzilish va funksiyalarni o'zida namoyon etuvchi kompleks birikmalari sintezi, hosil bo'lgan kompleks birikmalar tuzilishining turli omillarga, jumladan, metall tabiatiga, ligand o'rinbosarining mavjudligiga bog'liq ligini, shuningdek, markaziy ionga ligandning koordinatsiyalanishi, bog' tabiati hamda fizik-kimyoviy va biologik xossalari aniqlash katta ahamiyat kasb etadi

**Adabiyotlarning tahlili.** 2,6-piridindikarbon kislotasi (2,6-PDCA, dipic) bir yoki bir nechta karboksilat kislorod atomlari orqali barqaror komplekslar hosil qiluvchi ko'p qirrali N, O-xelatlovchi, bidentat va tridentat xelatlovchi liganddir [1-4]. Qiziqishning sababi shundaki, ligand H2pda va markaziy piridin halqasi va ikkita karboksilat guruhi o'rtasida qattiq 120 ° burchakka ega va shuning uchun hosil bo'lish uchun turli xil bog'lanish usullarini ta'minlay oladi [5-7].

So'nggi paytlarda monoetanolinlar va oddiy bir o'rnini bosuvchi benzoy kislotalar asosidagi aralash ligandlardan tayyorlangan oltita muvofiqlashtirilgan mono- va ikki yadroli mis komplekslari, xususan, monoetanolin (MEA) va p-nitrobenzo kislotasi (p-nitrobenzo) va yuqori darajadagi mualliflar tomonidan nashr etilgan [Cu<sup>2+</sup>(MEA)<sub>2</sub>] va [2Cu<sup>2+</sup>(MEA)<sub>2</sub>(H<sub>2</sub>O)<sub>2</sub>]. Yann-Teller effekti tufayli buzilgan oktaedrik tuzilishli komplekslar. Bitta [Co(dipic)<sub>2</sub>](MEA)<sub>2</sub> tarkibli yangi kompleks birikmaning monokristali piridin-2,6-dikarboksilik kislotasi (PDC yoki dipic) bilan (MEA) aralashgan holatda o'stirildi.

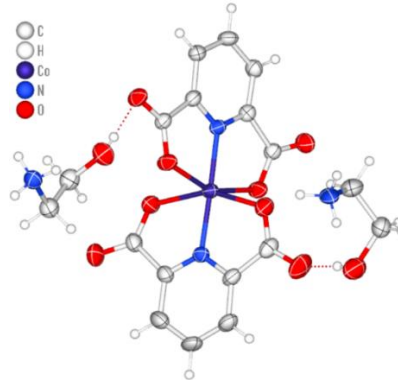
Hozirgi vaqtda kimyogarlar metall ionlariga birlashtirilgan donor atomlarining soniga qarab di, tri, tetra yoki ko'p ligandli komplekslar bo'lishi mumkin bo'lgan qiziqarli fizik-kimyoviy xossalari tufayli aralash ligand komplekslari bo'yicha keng qamrovli tadqiqotlar olib bormoqda [8-11].

**Tajribaviy qism.** Kobalt(II)atsetat kristallogidratidan  $\text{Co}(\text{CH}_3\text{COO})_2 \cdot 7\text{H}_2\text{O}$  0.1525 gr (0.5 mmol), 0.167 gr (1 mmol) 2,6-PDCA ni tegishli suvda eritib, 1;2 mol nisbatdagi eritmaları tayyorlandi. Eritmalar aralastirildi. Aralash ligandli kompleks birikma olish maqsadida monoetanolamin (MEA) ning eritmasidan tomizildi. So'ngra magnitli aralastirgich yordamida 60 °C da 30 minut davomida intensiv aralastirildi. Eritma xona haroratida qoldirildi. Natijada 10 kundan so'ng idish tubida och yashil rangli kompleks birikma monokristali o'sganligi kuzatildi. Reaksiya tenglamasi quyidagicha (1-sxema). RTT analizi uchun yaroqli kristallar ajratilib, tekshirilganda  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  tarkibli ekanligi aniqlandi. Unumi 86 %  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  ( $M_r=431.2\text{g/mol}$ ).



1-sxema.  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  kompleks birikmasi sintezi

**Tahlil va natijalar.** Ushbu kompleks birikma triclinic singoniyaga ega,  $P^{-1}$  fazoviy guruhga ega. Ikki tridentat dipik ligandlarning har biri karboksilik guruhning ikkita kislorod atomi va dipik dianion ligandlarining piridil halqasining azot atomlari va monoetanolamin kationlari (MEA) orqali koordinatsiyalanadigan qarama-qarshi ionlardir.

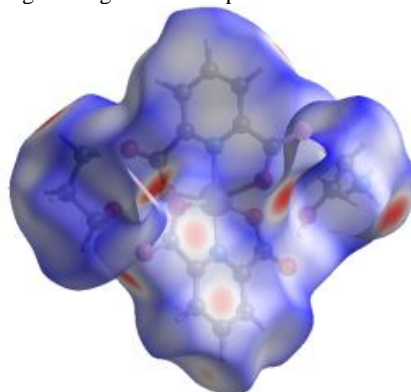


1-rasm.  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  kompleksining molekulyar tuzilishi

Ushbu kompleks buzilgan oktaedrik kompleks struktura ega.  $[\text{Co}(\text{dipic})_2]^{2-}$  divalent anion  $2[\text{NH}_3\text{CH}_2\text{CH}_2\text{OH}]^+$  ikki valentli kation bilan muvozanatlangan zaryaddir. Har bir 2,6-PDCA ligandning karboksil guruhining O atomi bilan vodorod bog'lanish orqali ikkita monoetanolamin (MEA) molekulari bog'langan.

Hirshfeld sirtini Crystal Explorer 17.5 dasturi yordamida tahlil qilindi. Qizil va ko'k dog'larning  $d_{\text{norm}}$  bo'yicha standart o'lchamlari mos ravishda -0,64 va 1,15 ga teng.

Hirshfeld yuzasini tahlil qilish natijasida quyidagi o'zaro ta'sirlar aniqlandi: O... H/H... O (50,8%), H... H (18,9%), H... C/C... H (10,8%), C... C (9,2%), O... C/C... O (5,8%), H... N/N... H (2,7%), N... N/N... H (2,5%). Chuqur qizil dog'lar qo'shni turlar bilan kuchli yaqin o'zaro ta'siri ko'rsatadi. Kompleks birikmaning molekulasida uchastkaning o'rtasida qisqa va tor tikanlar bo'lgan keng hudud umumiy Hirshfeld sirtlarining O-H/H-O o'zaro ta'siri sifatida aks ettiriladi va bu kompleks uchun hisoblangan eng yuqori foizdir va bu dipik lagandning metall kompleksi bilan solishtirish mumkin.

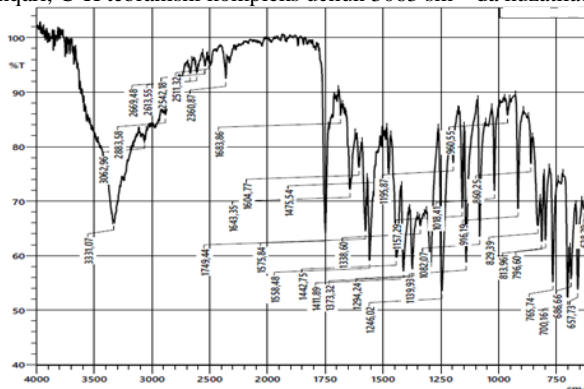


2-rasm.  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  ning uch o'lchamli Hirshfeld sirtining  $d_{\text{norm}}$  bo'yicha xaritasi ko'rinishi.

Co (II) kompleksining dnormasi uchun Hirshfeld yuzasi xaritasi (2-rasm) ko'rinib turibdiki, o'tkir qizil rang monoetanolamin (MEA) ning vodorod aloqasi va dipic ligandning karboksilik guruhining kislorodli aloqasi o'rtasida molekulararo vodorod bog'lanish kuzatilganligini ko'rsatadi.

Kompleks kristalining IQ-spektri tahlil qilindi.

Kompleksda OH-guruhiga xos keng intensiv valent tebranish  $3063\text{--}3331\text{ cm}^{-1}$  soha oralig'ida kuzatilgan (3-rasm). Co(II) kompleksda  $\text{COO}^-$  guruhining mavjudligi  $n(\text{COO}^-)$  va  $n(\text{COO}^-)$  tebranishlarining yutilish zonalarida mos ravishda  $1643$  va  $1373\text{ cm}^{-1}$  da CO cho'zilishi  $1573\text{ cm}^{-1}$  da paydo bo'ldi. Aniqlangan amin guruhlarining  $n(\text{NH})$  protoni tufayli  $2511\text{--}2360\text{ cm}^{-1}$  da tebranishlar kuzatildi. Bundan tashqari, C-H tebranishi kompleks uchun  $3063\text{ cm}^{-1}$  da kuzatiladi.



3-rasm.  $[\text{Co}(\text{dipic})_2](\text{MEA})_2$  kompleksining IQ-spektri

C-O tebranish ma'lumotlar kuzatildi  $1338$  va  $1082\text{ cm}^{-1}$  va mintaqadagi kuchli yutilish chiziqlarining  $1683\text{--}1411\text{ cm}^{-1}$  C = N cho'zilishi bilan bog'liq tebranishlar kuzatilgan. M-N va M-O uchun  $657\text{--}628\text{ cm}^{-1}$  kuzatildi.

**Xulosa.** Tadqiqotlar natijasida 2,6-piridindikarbon kislotasining nikel(II) atsetat va xlorid kislotaning M:L:L 1:2:2 nisbatdagi polimer tuzilishli kompleks birikmasi sintez qilindi. Sintez qilingan kompleksning tarkibi va tuzilishi RTT yordamida aniqlandi. Hirshfeld sirti tahliliga ko'ra molekula tarkibidagi atomlarning asosiy o'zaro ta'sirlashuvlarni O... H/H... O (50,8%), H... H (18,9%), H... C/C... H (10,8%). Kompleksda OH-guruhiga xos keng intensiv valent tebranish  $3063\text{--}3331\text{ cm}^{-1}$  soha oralig'ida kuzatilgan.

#### ADABIYOTLAR

- Mirzaei M. et al. On the importance of non-covalent interactions in the structure of coordination Cu (II) and Co (II) complexes of pyrazine-and pyridine-dicarboxylic acid derivatives: experimental and theoretical views //CrystEngComm. – 2014. – T. 16. – No. 27. – pp. 6149-6158.
- Das B., Baruah J. B. Water clusters in mixed ionic complexes with metal dipico linate anions //Journal of molecular structure. – 2013. – T. 1034. – C. 144-151.
- Hadadzadeh H. et al. Pyridine-2, 6-dicarboxylic acid (Dipic): crystal structure from co-crystal to a mixed ligand nickel (II) complex //Journal of Chemical Crystallography. – 2010. – T. 40. – C. 48-57.
- Ilkimen H. et al. Synthesis and characterization of a novel proton salt of 2-amino-6-nitrobenzothiazole with 2, 6-pyridinedicarboxylic acid and its metal complexes and their antimicrobial and antifungal activity studies // Journal of Molecular Structure. – 2016. – T. 1120. – P. 25-33.
- Khayit Kh. Turaev, Yusufjon E. Nazarov, Abdukadir Kh. Tashkulov, Sherzod A. Kasimov, Bekmurod Kh. Alimnazarov, Jamshid M. Ashurov, Aziz B. Ibragimov, Takashiro Akitsu, Changkun Xia, Abul Monsur Showkot Hossain. Synthesis of mononuclear Ni (II) and binuclear Cu (II) complexes from pyridine-2, crystal structure and Hirschfeld surface analysis, 6-dicarboxylic acid with monoethanolamine and hydrochloric acid solution //Structural Chemistry. – 2025. – C. 1-13 <https://link.springer.com/article/10.1007/s11224-025-02468-9>
- Ghosh S.K., Ribas J., Bharadwaj P.K. Metal-organic framework structures of Cu (II) with pyridine-2, 6-dicarboxylate and different spacers: identification of a metal bound acyclic water tetramer //CrystEngComm. – 2004. – T. 6. – №. 45. – C. 250-256.
- Ghosh S.K., Ribas J., Bharadwaj P.K. Characterization of 3-D Metal– Organic Frameworks Formed through Hydrogen Bonding Interactions of 2-D Networks with Rectangular Voids by CoII-and NiII-Pyridine-2, 6-dicarboxylate and 4, 4'-Bipyridine or 1, 2-Di (pyridyl) ethylene //Crystal growth & design. – 2005. – T. 5. – №. 2. – C. 623-629.
- Nazarov Y.E., Turaev Kh.Kh., Suyunov J.R., Ibragimov B.T., Alimnazarov B.Kh., Ashurov J.M. 8-Hydroxyquinolinium trichlorido(pyridine-2,6-dicarboxylic acid- $\kappa^3\text{O,N,O}$ )copper(II) dihydrate Acta Crystallographica Section E: Crystallographic Communications, 2024, 80(10), c 1049–1053 <https://doi.org/10.1107/S2056989024009186>
- Yusufjon E.Nazarov, Khayit Kh. Turaev, Sherzod A. Kasimov, Jamshid M. Ashurov, Alisher G. Eshimbetov, Aziz B. Ibragimov, Abror K.Nomozov, Changkun Xia, Abul Monsur Showkot Hossain Synthesis, crystal structures, DFT calculations, and hirshfeld surface analysis of tris(quinolin-8-olato- $\kappa^2\text{N,O}$ )cobalt(III) acetic acid monosolvate and Bis( $\mu$ -quinolin-8-olato- $\kappa^2\text{N,O}$ )diaquabis(nitrato- $\kappa^2\text{O,O}$ )dinickel(II)complexes Journal of Molecular Structure xxx (xxxx) 145469 <https://doi.org/10.1016/j.molstruc.2026.145469>
- Y.E.Nazarov, Kh.Kh. Turayev, J.M. Ashurov, Sh.A.Kasimov, J. R. Suyunov, N.A.Ermuratova, and K.N.Kornilov Synthesis and Crystal Structure of Bis(2,6-diaminopyridinium) Tetrachlorozincate(II) Crystallography Reports, 2025, Vol. 70, No.3, pp.461–469. <https://doi.org/10.1134/S106377452460220X>