Complexes of Some Transition Metal with 2-Benzoyl thiobenzimidazole and 1,10-Phenanthroline and Studying their Antibacterial Activity

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Received 20/9/2015
Accepted 20/12/2015

Abstract:
Mixed ligands of 2-benzoyl Thiobenzimiazole ($L_1$), with 1,10-phenanthroline ($L_2$) complexes of Cr(III), Ni(II) and Cu(II) ions were prepared. The ligand and the complexes were isolated and characterized in solid state by using FT-IR, UV-Vis spectroscopy, $^1$H, $^{13}$C-NMR, flame atomic absorption, elemental micro analysis C.H.N.S, magnetic susceptibility , melting points and conductivity measurements. 2-Benzoyl thiobenzimiazole behaves as bidentate through oxygen atom of carbonyl group and nitrogen atom of imine group. From the analyses Octahedral geometry was suggested for all prepared complexes. A theoretical treatment of ligands and their metal complexes in gas phase were studied using HyperChem-8 program, moreover, ligands in gas phase also has been studied using Gaussian program (GaussView Currently Available Version (5.0.9) along with Gaussian 09 which was the latest in the Gaussian series of programs). The antibacterial activity of the prepared complexes have been determined and compared with that of the ligand and the standard metronidazole.

Key words: Mixed ligands, 1,10-Phenanthroline, Theoretical treatment, Antibacterial activity.

Introduction:
The interaction of heterocyclic thiones with metals is still the topic of several studies as these ligands contain chemically effective groups and are advantageous model compounds for sulfur containing analogues of purine and pyrimidine bases. Heterocyclic 2-thiones bind to a metal in different ways, leading to the formation of monomeric or polymeric complexes [1]. Mercapto-1,3-azole ligands play an important role in industry and medicine [2,3]. One of their attractive characters is their acidity, which could affect their chemical reactivity toward transition metal ions and determine the complexes final structure [4].
1,10-phenanthroline has been extensively used as ligand, due to their high chemical stability and their good coordination ability. This ligand coordinate easily to metal ions forming a stable ring with five atoms [5]. Metal complexes of phenanthroline chelators are of great interest since they exhibit numerous biological properties such as antitumor and antibacterial activity [6,7].

Mixed ligand complexes plays an important role in numerous chemical and biological systems like water softening, ion exchange resin, electroplating, dying, antioxidant, photosynthesis in plants, removal of undesirable and harmful metals from living organisms. Many of these metal complexes shown good biological activity against pathogenic microorganisms[8,9]. In this study has been devoted to prepared and characterize the mixing ligands and their metal complexes. In vitro antibacterial activity of all prepared compounds have also been performed.

Materials and Methods:

A- Instrumentation:

All chemicals and solvents used and were of highest purity obtained from Fulka, Merck and BDH. Melting point apparatus of Gallen Kamp M.F.B-60 was employed to gauge the prepared compounds melting points, Elemental CHNS analysis were carried out on EM-017.mth instrument, the FT-IR spectra were recorded in range (4000-200 cm⁻¹) as CsI disc on IR-Prestige-21, Single beam path Laser, Shimadzu Fourier Transform infrared Spectrophotometer, UV-Visible spectra were measured using UV-1800PC Shimadzu, in the range (190-1100) nm. The ¹H, ¹³C-NMR spectra were recorded on Burker 400MHz instrument using DMSO-d⁶ as solvent and TMS as internal reference in AL-Bayt University, Jordan. The magnetic susceptibility values of the prepared complexes were carried out in room temperature using Magnetic Susceptibility Balance of Johanson mattey catalytic system division. Atomic absorption measurements of the prepared complexes were obtained using Shimadzu Atomic Absorption 680 Flame Spectrophotometer. The conductance values of the prepared complexes were preformed using 0.001M Ethanol as a solvent, (WTW) Conductometer. The conventional method were used to prepare metal complexes.

B- Synthesis of compounds

1- Preparation of 2-benzoyl Thiobenzimiazole

According to the literature [10], The ligand 2-benzoyl Thiobenzimiazole prepared as in the following scheme :

Scheme(1): Preparation of 2-benzoyl Thiobenzimiazole

2- Preperation of complexes by conventional method

A Solution containing primary ligand 2-benzoyl Thiobenzimiazole (0.254gm, 1mmole) and secondary ligand 1,10-phenanthroline (0.198gm,1mmole) each dissolved in 5 ml of absolute ethanol was added to a warm solution of metal salts (1mmole) of [CrCl₃.6H₂O(0.26g); Ni(NO₃)₂.6H₂O(0.29g);Cu(NO₃)₂.3H₂O (0.24g)], in 10 ml of absolute ethanol. The mixture was heated and refluxed with stirring for (3-4) hrs. The colored products was filtered, washed several
times with ethanol, and dried using the electrical oven at (65°C).

Results and Discussion:
The physio-chemical properties of the complexes are tabulated in Table (1).

Table (1): Some analytical and physical data of the ligands and their metal complexes.

| Compd.          | Colour      | Yield % | M. p. °C | M.Wt g.mol⁻¹ | % Elemental micro analysis / Found (Calc.) | Metal% Found (Calc.) |
|-----------------|-------------|---------|----------|--------------|------------------------------------------|----------------------|
| C₂H₄N₅SO₂L₁     | Light yellow | 86      | 169-171  | 254.00       | 67.01 (66.14) 4.22 (3.93) 11.53 (11.02) 13.02 (12.59) |                      |
| C₂H₄N₅H₂O₂L₂    | White       | ----    | 100-102  | 198.00       | (72.72) (5.05) (14.14) ----- |                      |
| [CrL₂Cl₂]Cl₂H₂O | Green       | 72.70   | 146-148  | 646.49       | 48.29 (48.26) 3.86 (3.71) 8.68 (8.66) 8.95 (8.94) 7.99 (8.94) |                      |
| [NiL₂(OH)₂(NO₃)₂]Cl₂H₂O | Green | 83.25  | 180-182  | 706.69       | 44.03 (44.14) 3.10 (3.67) 11.77 (11.88) 4.44 (4.52) 7.97 (8.30) |                      |
| [CuL₂OH₂(OONO₂)₂]NO₃.H₂O | Dark Blue | 84.37  | 150-152  | 666.54       | 47.45 (46.80) 3.43 (3.45) 12.68 (12.60) 4.68 (4.80) 10.00 (9.53) |                      |

FT-IR Spectra:
The most important infrared bands for the ligands and their complexes are reported in Table (2). The most important bands appeared in the spectrum of ligand L₁, appeared at (1705; 1620; 784; and 1176 cm⁻¹) which assigned to stretch frequency of ν(C=O); ν(C=N); ν(CS); and ν(CSC) respectively [11].

The spectra of metal complexes show that the band related to stretch frequency of ν(C=O) was shifted to the lower or higher frequencies about (12 to 20cm⁻¹) in complexes, which indicate that the uncharged oxygen of carbonyl group take part in the coordination[11],more evidences new weak bands appeared in the spectra of complexes at lower frequencies about (~ 462-489 cm⁻¹) which assigned to ν (M-O) bond[15].Also the band related to the stretching frequency of ν(C≡N) was shifted to the lower frequency in CrL₂ about (9 cm⁻¹) and to the higher in CuL₂ and NiL₂ frequencies about (~7-8cm⁻¹). This means that the nitrogen of (C≡N) group also coordinated with metal ion, a new weak bands were recorded at lower frequencies by (~563-570 cm⁻¹) which assigned to stretch frequency of ν(M-N) bond was supported this coordinate[11,12].So, this ligand behaves as a bidentate through (cyclic N and O) atoms. Higher shifting frequencies related to the amide(II) in metal complexes, also ν(NH) group shift to higher in among L₁ complexes due to the possible hydrogen bonding interaction between (C=O) and (N-H) moiety[11].The presence of peaks that attributed to the aromatic C=C and C≡N stretching of L₂ around (1616-1419 cm⁻¹) [11], so the spectra of the complexes show also characteristic bands which shifted and assigned to the stretching vibration of ν(C=C+C≡N) of co-ligand. The band at (400 cm⁻¹) related to (C-C out of plane bending) shifts to higher frequency and splits into two components in the complexes, which again confirms the coordination of co-ligand through two nitrogen, besides it shows bands at (~ 271-288 cm⁻¹) has also been observed in all the complexes indicating co-ligand nitrogen coordination with metal ions as (M-N)[12]. The spectrum of CuL₂ and NiL₂ exhibited bands which appeared at 1018, 1292, 1381 and 1427 cm⁻¹; 783, 1041, 1234 and 1373 cm⁻¹ respectively, probably attributed to the vibrations of
ionic and non-ionic nitrate group[11]. CrL1L2 complex was observed band at 312 cm⁻¹ due to the coordination of metal ion with chloride ions[11]. A broad band with maximum (3352-3448 cm⁻¹) which assigned to lattice water as well as coordinated in coordination sphere.

Table (2): The most diagnostic FTIR of the ligands and their metal complexes in (cm⁻¹).

| Compd.  |  L₁  |  L₂  | [Cr L₁L₂Cl]Cl₂H₂O | [Ni L₁L₂(OH)₃(NO₃)]NO₃·3H₂O | [CrL₁L₂(OH)₃(NO₃)]N O₃·4H₂O |
|----------|------|------|-------------------|-------------------------------|-------------------------------|
| ν(N-H)   | 3151 | ----- | 3140             | 3155                         | 3150                         |
| ν(C=O)   | 1705 | ----- | 1717             | 1689                         | 1685                         |
| ν(C=N)   | 1620 | ----- | 1611             | 1628                         | 1627                         |
| ν(C=C)   | 1504 | ----- | 1500             | 1516                         | 1500                         |
| ν(C=O)   | 3059 | 3059  | 3059             | 3080                         | 3070                         |
| δ(C-H)   | 783,883,848 | 802,731 | 883,848,806,783 | 883,848,825                  | 875,848,823,802 |
| δ(C-H)   | 1234,1284,117,6,1130 | 1265,1202,116,1138,1033 | 1284,1253,1219,1199,1176,1103 | 1262,1234,1210,1200,1172,1145,1103 | 1292,1226,1203,1167,149,1103 |
| ν(CSC)   | 1176 | ----- | 1199             | 1172                         | 1149                         |
| ν(CS)    | 748  | ----- | 752              | 752                          | 750                          |
| ν(C=N+1  | 1614,1589,1585,1504,1446,1419 | 1611,1600,1578,1500,1470,1450,1423 | 1628,1600,1585,1516,1450,1427 | 1619,1585,1500,1450,1427 |
| ν(M-M)   | 1199 | ----- | 565              | 570                          | 563                          |
| ν(M-O)   | 486  | ----- | 474              | 474                          | 462                          |
| ν(M-N)   | 288  | ----- | 273              | 273                          | 271                          |

Where ooop= out of plane , ip= in plane Phen. = Phenanthroline

Electronic spectral, Magnetic moment studies and Conductivity:

The electronic spectrum of L₁ exhibited four main bands. The first and second absorption bands appeared at (45871, 40485 cm⁻¹) respectively due to (π→π*) transition located on the C=C group. The third and fourth absorption bands attributed to (n→π*) electronic transition may be located on the Nitrogen atom of the -C=N-group or Oxygen on C=O group, which appeared at (32786,29239 cm⁻¹) respectively [10,13,14] as listed in Table (3).

The electronic Spectrum of co-ligand L₂ show absorption band in the ultraviolet region at (43859 cm⁻¹) due to the (π→π*) transition for the inter-ligand aromatic system (C=C), and other absorption bands at (30959 and 38022) due to the (n→π*) transition of imine group (C=N) [13].

Cr(III) Complex: The spectrum of green Cr(III) consists of two bands observed at 17006, 24390 cm⁻¹ refers to ⁴A₂g→⁴T₂g , ⁴A₂g→⁴T₁g(F) transitions[15].The ν₃ band calculated to be 38379 cm⁻¹ which corresponding to ⁴A₂g→⁴T₁g(p) transition. The magnetic value 3.92 B.M. for Chromium (III) is observed, this value came in with published octahedral geometry around Cr(III) ion[16,17].

Ni(II) Complex: The electronic spectrum, shows two bands at 11001, 16233cm⁻¹ which assigned to ³A₂g→³T₂g , ³A₂g→³T₁g(F) respectively and ³A₂g→³T₁g(p) transitions calculated and its found to be 27855 cm⁻¹. These bands indicate an octahedral geometry around Ni(II) ion [18]. Magnetic measurement show to be 3.02 B.M and this came with published Oh around Ni(II)[15,19].
The diagrams of Tanabe–Sugano used to estimate the value of ν3 in the complexes of Cr(III) and Ni(II) ions. In addition to the calculation of values; 10Dq, nephelauxetic factor β, Racah parameter B' and 15B' Table (3).

Cu(II) Complex: The electronic spectrum, show broad absorption band at 14814 cm\(^{-1}\) which assigned to \(^{2}\)E\(_{g}\)→\(^{2}\)T\(_{2g}\) and other bands at 36630,3478 cm\(^{-1}\) which related to charge transfer transitions. Magnetic measurement showed to be 1.85 B.M and this came with published Octahedral around Cu(II)[20].

The conductance measurements indicate that the ionic behavior for all prepared complexes as illustrated in Table (3).

**NMR spectra for ligand**

**Table (3):** Electronic spectra, Conductance in Ethanol solvent and magnetic moment (B.M) for the ligands and their metal complexes.

| Compd. | L\(_1\) | L\(_2\) | [Cr L\(_1\)L\(_2\)Cl]Cl\(_2\).2H\(_2\)O | [Ni L\(_1\)L\(_2\)OHONO\(_2\)]NO\(_3\).3H\(_2\)O | [CuL\(_1\)L\(_2\)OHONO\(_2\)]NO\(_3\).1/2H\(_2\)O |
|--------|--------|--------|----------------|----------------|----------------|
| Absorption Bands cm\(^{-1}\) (nm) | 29239(342) | 30959(323) | 17006(588) | 11001(909) | 14814(675) |
| Assignments | n→\(\pi^*\) | \(\pi^*\)→\(\pi^*\) | \(^{4}\)A\(_{2g}\)→\(^{2}\)T\(_{2g}\) | \(^{3}\)A\(_{2g}\)→\(^{2}\)T\(_{2g}\) | \(^{2}\)E\(_{g}\)→\(^{2}\)T\(_{2g}\) |
| | | | | | | ILCT |
| | | | \(^{4}\)A\(_{2g}\)→\(^{2}\)T\(_{1g}\)(P) | \(^{3}\)A\(_{2g}\)→\(^{2}\)T\(_{1g}\)(P) | \(^{2}\)E\(_{g}\)→\(^{2}\)T\(_{1g}\) |
| \(B^\dagger\) (cm\(^{-1}\)) | 918 | 1035 | 918 | 1035 | 918 |
| \(B'^\dagger\) (cm\(^{-1}\)) | 811 | 739 | 811 | 739 | 811 |
| \(B\) | 0.88 | 0.71 | 0.88 | 0.71 | 0.88 |
| \(Dq/B^\dagger\) (cm\(^{-1}\)) | 2.00 | 1.45 | 2.00 | 1.45 | 2.00 |
| 10Dq (cm\(^{-1}\)) | 16220 | 10715 | 16220 | 10715 | 16220 |
| 15B\(\dagger\) (cm\(^{-1}\)) | 12165 | 11085 | 12165 | 11085 | 12165 |
| \(\lambda'\) (cm\(^{-1}\)) | -180 | | -180 | | -180 |
| \(\mu_{eff}\) B.M. | 3.92 | 3.02 | 3.92 | 3.02 | 3.92 |
| \(\mu_{s}\) cm\(^{-1}\)T | 36.3 | 40.1 | 36.3 | 40.1 | 36.3 |
| Suggested geometry | Oh | Oh | Oh | Oh | Oh | Oh |
Theoretical Studies:
In this work, Hyperchem-8 program was used to calculate the heat of formation ($\Delta H^o_f$), binding energy ($\Delta E_b$) and dipole moment ($\mu$) for the free ligands and their metal complexes using semi-empirical (ZINDO/I & PM3) and molecular mechanics (AMBER) methods at 298K [21]. It was found that the complexes are more stable than the ligands Table (4). Furthermore, the electrostatic potential for free ligands was calculated to investigate the reactive site of the molecules Figure (2). PM3 was used to evaluate the vibrational spectra of free ligands. It has been found that these obtained frequencies agree well with the experimental results; in addition, the calculation helped to assign unambiguously the most diagnostic bands, Table (6,7). Electronic spectra measurements for the ligands was calculated theoretically by using ZINDO/S method and comparing it with experimental results. It was found that there was a close agreement between the theoretical calculation and experimental results Table (8). While Gaussian program semi-empirical (PM3) method was used to evaluate the geometry optimization, dipole moment ($\mu$) and total energy as shown in Table (5), electrostatic potential, $E_{LUMO}$ and $E_{HOMO}$ was obtained Figure (2) and evaluate the vibrational spectra by PM3 as above mentioned Table (6,7). Electronic spectra measurements for the ligands was calculated theoretically by using the job type : Single point energy (SP) along with ZINDO method and also along with CIS method (3-21G) Table (9).

Table (4): Conformation energetic (in K.J.mol$^{-1}$) and dipole moment (in Debye) for ligands and their metal complexes using HyperChem-8 program.

| Comp.   | PM3            |              |              | ZINDO/I          |              |
|---------|----------------|--------------|--------------|-----------------|--------------|
|         | $\Delta H^o_f$ | $\Delta E_b$ | $\mu$        | $\Delta H^o_f$ | $\Delta E_b$ | $\mu$        |
| L$\_1$  | 303.9117786    | -13358.685   | 6.968        | 26522.21357     | 40184.81035  | 9.906        |
| L$\_2$  | 298.3251322    | -10971.26213 | 2.991        | 22179.41782     | 33449.00509  | 3.931        |
| CrL$\_1$L$\_2$ | -----------  | -----------  | -----------  | 50260.82068     | 75833.07304  | 14.85        |
| NiL$\_1$L$\_2$ | -----------  | -----------  | -----------  | 53842.76836     | 81110.62856  | 7.556        |
| CuL$\_1$L$\_2$ | -----------  | -----------  | -----------  | 54229.48008     | 81404.87388  | 7.006        |
Table (5): Conformation energetic in (in K.J.mol⁻¹) and dipole moment (in Debye) for ligands using Gaussian program.

| Ligand | Total energy | \( \mu \) |
|--------|--------------|----------|
| \( L_1 \) | 228.7938415 | 4.4212   |
| \( L_2 \) | 299.1957838 | 2.9937   |

Table (6): Comparison of experimental and theoretical vibrational frequencies for primary ligand by HyperChem8 and Gaussian programs.

| Ligand | \( \nu_{C=O} \) | \( \nu_{C=N} \) | \( \nu_{C-S} \) | \( \nu_{N-H} \) | \( \nu_{C=C} \) | \( \nu_{C-H} \) aromatic |
|--------|----------------|----------------|----------------|----------------|----------------|-----------------------|
| \( L_1 \) | 1705* | 1620* | 748* | 1504* | 1504* | 3059* |
| Exp. | 1902.24 | 1566.56 | 690.35 | 1502.68 | 1502.68 | 3075.10 |
| (11.568) | (-3.298) | (-7.707) | (-0.087) | (-0.087) | (0.526) |
| Hyper. | 1951.87 | 1601.71 | 881.73 | 1535.20 | 1535.20 | 3054.19 |
| (14.479) | (-1.129) | (17.878) | (2.074) | (2.074) | (-0.157) |
| Gas. | | | | | | |

Table (7): Comparison of experimental and theoretical vibrational frequencies for co-ligand by HyperChem8 and Gaussian programs.

| Ligand | \( \nu_{(C=N+C=C)} \) | \( \nu_{(C-H)\text{ aromatic}} \) | \( \delta(C-N) \) |
|--------|----------------|----------------|----------------|
| \( L_2 \) | 1616* | 2981* | 1446* |
| Exp. | 1760.93 | 3063.20 | 1395.01 |
| (8.968) | (2.757) | (-3.526) |
| Hyper. | 1697.77 | 3031.80 | 1518.71 |
| (5.060) | (1.704) | (5.028) |
| Gas. | | | |

Where:* : Experimental frequency  
: Theoretical frequency  
( ) : Error % due to main different in the experimental measurements and theoretical treatment of vibrational frequency.

Table (8): Ultra violet spectra of ligands from ZINDO/S calculation and experiment data using HyperChem8 program.

| Ligand | Transition | Experimental | Theoretical (ZINDO/S) |
|--------|------------|--------------|----------------------|
| \( L_1 \) | \( n\rightarrow\pi^* \) | 29239(342) | 343 |
| | \( n\rightarrow\pi^* \) | 32786(305) | 303 |
| | \( \pi\rightarrow\pi^* \) | 40485(247) | 228 |
| | \( \pi\rightarrow\pi^* \) | 45871(218) | ----- |
| \( L_2 \) | \( n\rightarrow\pi^* \) | 30959(323) | ----- |
| | \( n\rightarrow\pi^* \) | 38022(263) | 278 |
| | \( \pi\rightarrow\pi^* \) | 43859(228) | 218 |

Table (9): Comparison of experimental and theoretical electronic transition for ligands from CIS and ZINDO calculation and experiment method using Gaussian program.

| Ligand | Transition | Experimental | Theoretical |
|--------|------------|--------------|-------------|
| \( L_1 \) | \( n\rightarrow\pi^* \) | 29239(342) | 179.52 |
| | \( n\rightarrow\pi^* \) | 32786(305) | 303.7 |
| | \( \pi\rightarrow\pi^* \) | 40485(247) | 45871(218) |
| \( L_2 \) | \( n\rightarrow\pi^* \) | 30959(323) | 223.64 |
| | \( n\rightarrow\pi^* \) | 38022(263) | 311.26 |
| | \( \pi\rightarrow\pi^* \) | 43859(228) | |

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Bactericidal activity of the standard (metronidazole), L₁ and synthesized metal complexes

Antibacterial activity of the prepared ligand and its metal complexes were tested in vitro for antibacterial activity according to the disk diffusion method [22] against the following pathogenic microorganism: *Staphylococcus aureus* (Gram-positive bacteria) and *Pseudomonas aeruginosa*, *E.Coli* and *Salmonella* (Gram-negative bacteria), the prepared agar and petridishes were sterilized by autoclaving for (15 min) at 121°C. The agar plates were surface inoculated uniformly from the broth culture of the tested microorganisms. In the solidified medium suitable spaced apart holes were made all (6 mm) in diameter compounds (0.01mg of the compounds dissolved in 10ml of ethanol solvent).

These plates were incubated at 37°C for 24hrs, the inhibition zones caused by the various compounds on the bacteria were examined. The results of the preliminary screening test are listed in Figure (3). The data reveal that some complexes have higher activities other have lower than free ligand. These results indicate that the degree of growth.
inhibition is highly dependent on (i) the nature of donor atoms (ii) the nature of the metal ion (iii) the chelate effect of the ligand (iv) the total charge on the complex ion (v) the geometrical structure of the complexes (vi) the nature of the counter ions that neutralize the complex [23]. The chelating theory considerably reduces the polarity of the metal ion mainly because of partial partnership of positive charge with the donor groups and possible electron delocalization over the whole chelating ligand. Such coordination could also enhance the lipophilic character of the central metal atom, which subsequently favours its permeation through the lipid layer of the cell membranes[24].

![Graph showing antibacterial activities](image)

**Fig. (3): Antibacterial activities for standard (metronidazole), L₁ and their metal complexes**

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معقدات بعض الفلزات الانتقالية مع 2- بنزويل ثابينزاميدازول و1-10 فينانثرولين ودراسة فعاليتهما المضادة للبكتريا

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الخلاصة:

تم تحضير الليكيندات الممزجة لـ 2- بنزويل ثابينزاميدازول (L1) و1-10 فينانثرولين (L2) ان معقدات الكرص (III)، النحاس (II) والمكلاك (II) ، عزلت وشخصت الليكيندات المعقدة المحضرة وبحالة تصلبية بواسطة تقنيات الاستشعار تحت الحمراء والأشعة فوق البنفسجية المرئية، وأطواق الروتين التريتيزيتي والاتصال الذري الليهي، والتحليل الدقيق للعناصر، والحساسية المغناطيسية، ودرجة الانصهار والتوظيفية الكهربيّة. الليكيند 2- بنزويل ثابينزاميدازول يشكل ثنائي السن من خلال ارتباطه بذرة الأوكسجين لمجموعة الكاربونيل وذرة النيترجين لمجموعة الأمين. ان الشكل الهندسي المقترح لجميع المعقدات المحضرة ثماني السطوح. أجريت المعالجة النظرية للليكيندات والمعقدات المحضرهم في الطور الغازي باستخدام برنامج Gaussian (GaussView (5.0.9) Gaussian 09) وليكيندات فقط باستخدام برنامج Hyper chem.-8. ثم تم تعيين الفعالية المضادة لللكرياك للمعقدات المحضرة ومقارنتها بلكرياك والمادة القياسية المترويديازول.

الكلمات المفتاحية: الليكيندات الممزجة، 1-10 فينانثرولين، المعالجة النظرية، الفعالية المضادة لللكرياك.