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Synthesis, Spectral Characterization and Anticancer Study of Bio-Complexes Pd from Methyl Imidazole

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Abstract

The prepared bio- ligand derived from chalcone -azo (E)-1-(4-(E)-4-methyl-derivative of di-nitrogen atoms-cycle. In view of the effect of the compensating groups on the effectiveness and uses of the five-cyclic heterogeneous compounds, in this research new substitutes for the aromatic azo and chalcon compounds were prepared from different raw materials and compounds that could have different biological effects and effects on the cell of the organism were prepared and their physical and spectral properties were studied. The importance of studying the spectral characterization of a number of prepared compounds containing different groups of compensators, which may have an impact in the inorganic chemistry field or the industrial field., In addition to anti-cancer study against cancer cell.

Key Words: chalcone , azo, 4- methyl imidazole, inorganic.

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INTRODUCTION

It could be noticed that, a better understanding of stability and intense color within the visible area of complexes which derived from azo imidazole due to unpaired electrons (Abate, 2020 .; Abd, 2022) of azo-imine functional groups that it coordinated with empty orbitals of metal ions (Afaq , 2019 ., Altaie, 2022). All chalcone compounds consider as catalysts, antimicrobials , colorants, corrosion (Al-Daffay, & Alhamdani, 2022 .; Alina, 2021), inhibitors and in optical physics , printer and electronic fields and food industry, therefore the complexes show high inhibition activity (Bouhdada, 2022 .; Dian, 2022.; Djmal, 2022) against breast cancer line (MCF-7) .In addition, complexes derived from chalcones (Cleasen-schmedit condensation) of acetophenone derivatives and benzaldihyde derivatives will be given (α,β – unsaturated carbonyl compounds) have an important role in coordination of metal ions and as anticancer. Palladium complexes with azo ligands have been investigated as antitumor . The majority of Palladium complexes were found to be more active than their free ligands (Göknil, et al 2022 .; Hussein, & Khalid , 2021 .; Hussein, & Abbas, 2017).Derivative of imidazole and chalcone and attempted preparation and identification some of metal ions which coordinated with it (Najiyah, et al 2022 .; Mahmood, & Jawad 2021) .

METHODOLOGY

Constituents and quantities

All substance materials and diluents which have been used in this search in high purity. In addition, number of measurements have been done such as technical spectral instruments.

Combination of (LMN) chalet

This chalet was combined by dual ladders: Firstly, (Cleasen-schmedit condensation) [16]by solving (4.05g, 0.02 mole) carbonyl – amine dreivative with (60ml) basic solution with emotive and cooling in the slush soak at (some minutes.) . Then, an basic elucidation of 4-Nitrobenzaldehide (4.5g, 0.03 mole) was added slowly with exciting at (7hrs.) at apartment heat. The thickened solution was formed , which it was kept overnight . Following , diazotate of selected compounds bestowing to readings it (Najiyah, et al 2022 .; Mahmood, & Jawad 2021) .,figure (1)

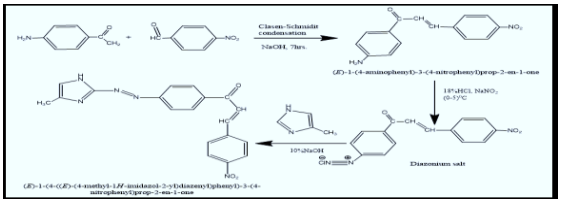


Fig.1. Synthesis (LMN) ligand.

Preparation of Complexes

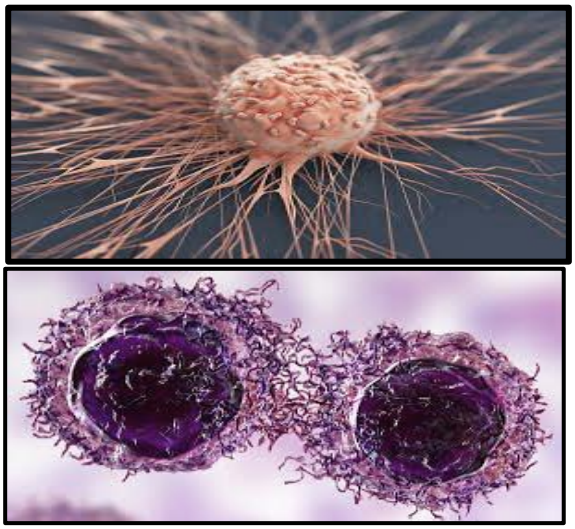
All solid Chaletes-ion were prepared by accumulation acetone clarification of ligand (LMN) to elucidations ions (II) with acetonitrile elucidation of each ion (II) in mole share (L:M) as (2:1) through thrilling and thermo-method about (some minutes.) , the dyed participations were collected , desiccated and crystallized by burning solvent.

Tab.1. Amount of some properties.

Chalets	*M wt*	*Dyed*	*Melting*	*Yield %*	*(Found) Calc.%*			
					% C	*% H*	*% N*	*% M*
LMN= $C_{19}H_{15}N_5O_3$	361.35	Dark-orange	102-105	80	63.09-63.02	4.15-4.1	19.37-19.2	------
$[Co(C_{19}H_{15}N_5O_3)_2Cl_2]$	852.63	Dark red dish-Brown	204-208	79	53.48-53.12	3.51-3.39	16.41-16.22	6.91-6.22
$[Ni(C_{19}H_{15}N_5O_3)_2Cl_2]$	852.39	Red dish brown	220-224	77	53.49-53.13	3.51-3.33	16.42-16.38	6.88-6.72
$[Cu(C_{19}H_{15}N_5O_3)_2Cl_2]$	857.24	Dark Brown	198-200	89	53.19-53.1	3.49-3.3	16.33-16.13	7.41-7.35
$[Zn(C_{19}H_{15}N_5O_3)_2Cl_2]$	859.09	Red dish Brown	212-218	76	53.07-52.96	3.49-3.31	16.29-16.18	7.61-7.55
$[Cd(C_{19}H_{15}N_5O_3)_2Cl_2]$	906.11	Light red dish Brown	198-202	78	50.32-50.12	3.31-3.22	15.45-15.39	12.4-12.34
$[Hg(C_{19}H_{15}N_5O_3)_2Cl_2]$	994.29	Dark brown	185-188	88	45.86-45.79	3.01-2.98	14.08-13.9	———
$[Pd(C_{19}H_{15}N_5O_3)_2]Cl_2$	900.12	Red dish brown	215-218	74	50.65-50.49	3.33-3.29	15.55-15.4	11.82-11.78

Type of Cancer Cell

The type of cancer cell in natural :



RESULTS AND DISCCUSION

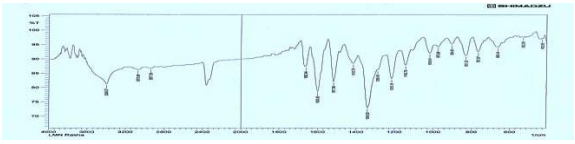
FTIR Varieties of (LMN) chalet and its relations

The FTIR spectrum of free l chalet appeared strong band at (1600)cm-1 referred to carbonyl group of chalcone , this band did not grieve any changes in varieties of relation because of incoordination. However, both bands (N=N) and (C=N) have publicized plentiful variations in shapes, frequencies in addition to intensities in the spectra of all chalets due to the management with chalet . In addition, there are new bands noticed in all complexes due to (M-N) group.

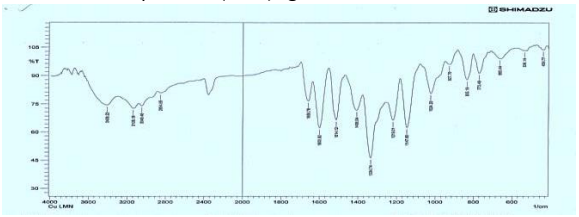
Tab.2. Amount of some properties.

M-N	υ(C=O) Chalcone	N=N	C=N)υ	υ (N-H)	Compound
.....	1600	1415	1517	3398	LMN
440	1600	1409	1510	3394	$[Co(LMN)_2Cl_2]$
443	1600	1411	1512	3423	$[Ni(LMN)_2)Cl_2]$
439	1600	1408	1514	3408	$[Cu(LMN)_2Cl_2]$
432	1600	1413	1514	3392	$[Zn(LMN)_2Cl_2]$

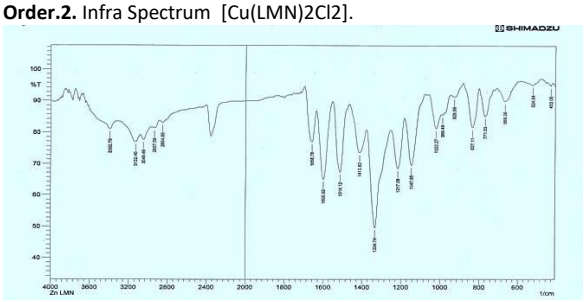
453	1600	1413	1516	3402	$[Cd(LMN)_2]Cl_2$
449	1600	1411	1510	3390	$[Hg(LMN)_2Cl_2]$
432	1600	1408	1519	3444	$[Pd(LMN)_2]Cl_2$



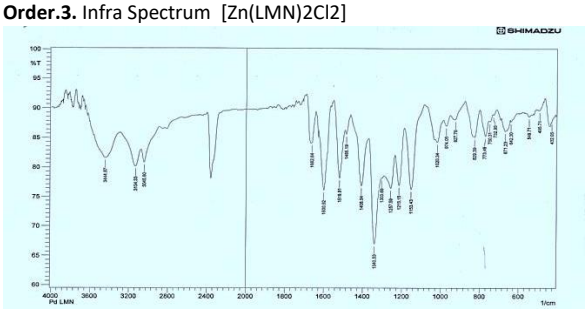
Order.1. Infra Spectrum (LMN) ligand.



Order.2. Infra Spectrum [Cu(LMN)2Cl2].



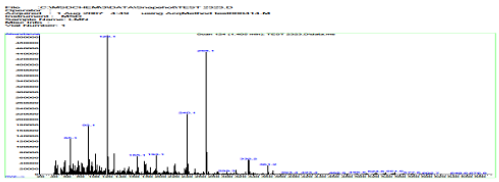
Order.3. Infra Spectrum [Zn(LMN)2Cl2]



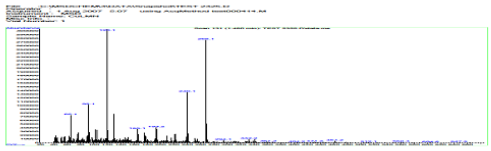
Order.4. Infra Spectrum [Pd(LMN)2] Cl2

Mass gamut

Mass gamut of new chalet (LMN) in addition to Cu(II) chalet remain publicized in shape.(5) besides (6) However, the suggestion fragmentation of ligand is presented in scheme(2) , which is appeared base beak at (M/Z*) (361.2) for mother molecule and other mass spectral fragmentations, which are agreement the formula.



Order.5: Mass spectra (LMN) chalet



Order.6: Mass spectra of Cu(II) complex

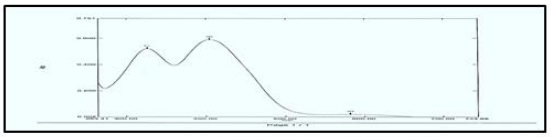
Electronic Spectra

This study compared the gamut of permitted chalet per the varieties of its multiplexes, all compounds were dissolved in DMSO at (1x10-4)M , the result show red shift in electronic spectral of all complexes , which is referred to coordination with ligand , the data of all compounds is consisted in table (4).

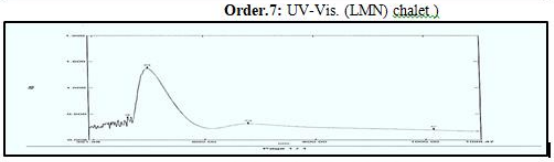
Tab.3. Amount of some properties.

Chalet	λ_{max} (nm)	Absorption gangs(cm^{-1})	Conversions	μ_{eff} (B.M)	shap	Hybridization	Conduct $S.mol^{-1}.cm^2$
LMN	404	24752	n →π*				
	326	30674	π →π*	----	----	----	----
	245	40816	π →π*				
$[Co(LMN)_2Cl_2]$	679	14727	$^4T_1g_{(F)} \rightarrow {}^4A_2g_{(F)}$	4.7	Octahedral	Sp^3d^2	38.3
	463	21598	*M.L.CT*				
	346	28901	*I.LC.T.*				
$[Ni(LMN)_2)Cl_2]$	508	19230	*M.L.C.T*	2.64	same	Sp^3d^2	43.4
	342	29239	*I.LC.T.*				
	290	34482	*I.LC.T.*				
$[Cu(LMN)_2Cl_2]$	670	14925	$^2B1g \rightarrow {}^2Eg$	1.81	same	Sp^3d^2	8.5
	522	19157	*M.L.C.T.*				

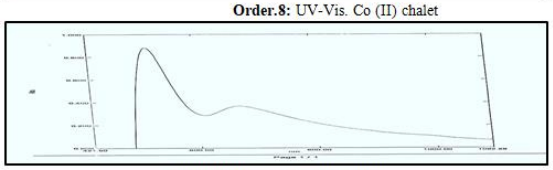
[Zn(LMN)$_2$Cl$_2$]	496	20161	*M.L. C.T.*	Dia	same	Sp^3d^2	25
[Cd(LMN)$_2$)Cl$_2$]	502	19920	*M.L. C.T*	Dia	same	Sp^3d^2	16.9
[Hg(LMN)$_2$Cl$_2$]	509	19646	*M.L. C.T*	Dia	same	Sp^3d^2	22.5
[Pd(LMN)$_2$] Cl$_2$	528	18939	$^1A_1g \rightarrow {}^1B_1 g$	Dia	Square planer	dsp^2	72.16



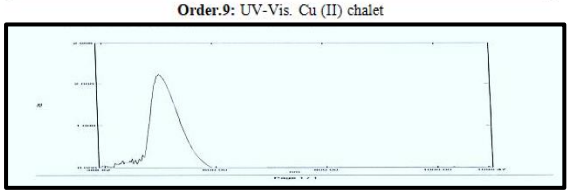
Order.7: UV-Vis. (LMN) chalet.)



Order.8: UV-Vis. Co (II) chalet



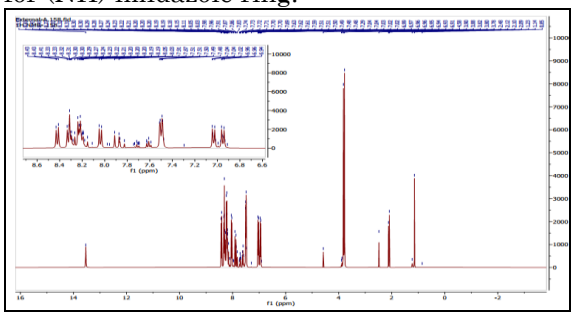
Order.9: UV-Vis. Cu (II) chalet



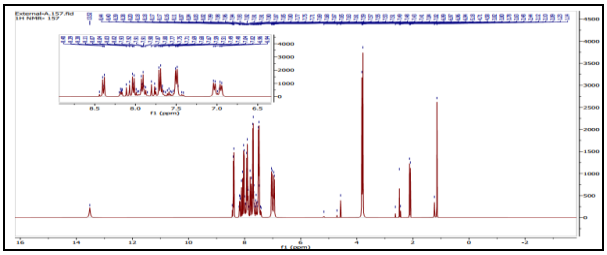
Order.10. UV-Vis. Cd (II) chalet

H-NMR Varieties

1H-NMR Varieties of ligand (LMN) and Hg(II)chalet characterized in DMSO-d6 solvent and TMS reference both spectra appeared a signals at (6.9,6.7)and (7.1,7.3)ppm owed to (CH=CH-CO) of chalcone derived [17], and signal at (2.3,2.4)ppm credited to (CH3) cluster in imidazole sphere [15] . While, multiples protons around (7-8)ppm denoted to aromatic rings and signal at (13.8, 13.7)ppm for (NH) imidazole ring.



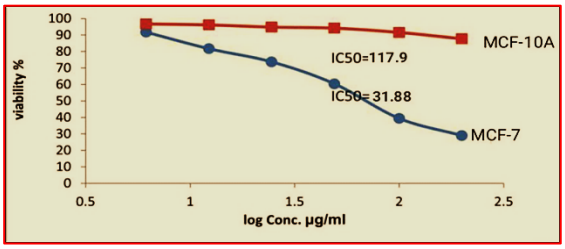
Order.11. Resonance (LMN)ligand



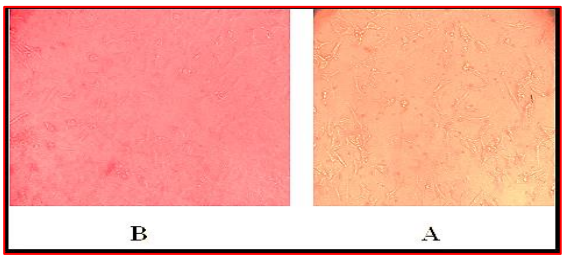
Order.12. Resonance Hg(II)complex

Cytotoxic Activity of Complex

The result of this study investigated that, IC50= (31.88) breast tumor line(MCF-7) . However, IC50= (117.9) for well cells line(MCF-10A) ,it indicated Pd(II) chalet could be charity as suggested medicine of this kind of cancer.



Order.3. activity-Tumor of Pd(II) chalet



Order.4. (A)(MCF-7) and(B) (MCF-10A) Under inverted microscope.

CONCLUSIONS

This search involved synthesis of different chalet chalcone besides imidazole and prepared its relations presented an Octahedral except Pd(II) complex which took square planer . Additionally, this search appeared sharp bands that indicated to new synthesized ligands. Also this bio-compound gave good results against of cancer cell.

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AUTHOR CONTRIBUTIONS

The author carried out : Conceptualization, Methodology, Investigation, Software.

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There is no backing.

REFERENCES

1. Abate FO, Sottile M, Leon IE, Vergara MM, Katz NE. Asymmetrical dirhenium (I) complex with 4,4'' –Azobis(2,2'-bipyridine) as a bridging ligand: synthesis, physicochemical properties and applications in detection of biologically relevant thiols and in chemotherapy for bone cancer. J Braz Chem Soc. 2020;31(11):2299-2306. Google Scholar Crossref
2. Abd RA, Sadeq S, Muhammad FM, Ali KH. Experimental Investigation of Nanofluid Turbulent Flow Over Microscale Backward-Facing Step. J Adv Res Fluid Mech Therm Sci. 2022;99(2):119–134. Google Scholar Crossref
3. Afaq JK, Saad MM, Feiz AH. Preparation and characterization of new AzoChalcone ligands mixed ligands transition metal complexes with a study of padium complex anticancer activity. Res J Pharm Tech. 2019;12(1):5847-5855. Google Scholar Crossref
4. Alaq Saeed Abdulhussain. The efficacy and safety of vitamin C administration to women with history of premature preterm rupture of membrane in prevention of such event in current pregnancy: Randomized controlled clinical trial. J Popul Ther Clin Pharmacol. 2022;29(04):188–194. Google Scholar Crossref
5. Afaq JK, Saad MM, Feiz AH. Synthesis and characterization of new chalcone-Azo ligands and its transition metal mixed ligands complexes with a biological activity study of Pd(II) Complex. Int J Pharm Res. 2019;11(14):761-770. Google Scholar Crossref
6. Afaq JK, Bilal SA, Fatima JA. Preparation, Determination and study Toxicity Effects of new mixed ligands complexes derivative from 8-Hydroxy Quinoline with Pd(II). Egypt J Chem. 2021;64(9):5285-5290. Google Scholar Crossref
7. Al-Daffay RKH, Al-Hamdani AA. Synthesis and Characterization of Some Metals Complexes with New Acidicazo Ligand 4-[(2-Amino-4-Phenylazo)-Methyl]-Cyclohexane Carboxylic Acid. Iraqi J Sci. 2022;63(8):3264–3275. Google Scholar Crossref
8. Djamal HD, Muhammad NA, Bajuri, Mahamat IB. Performance Investigation of Vertical Axis Wind Turbine with Savonius Rotor using Computational Fluid Dynamics (CFD). CFD Lett. 2022;14(8):116–124. Google Scholar Crossref
9. Hussain N, Abass G. New acid dyes and their metal complexes based on substituted phenols for leather: synthesis, characterization and optical studies. J Appl Res Technol. 2017;15(4):346-355. Google Scholar Crossref
10. Kallio T, Kekkonen J, Stenius P. Acid/base properties and adsorption of an azo dye on coating pigments. J Dispersion Sci Technol. 2006;27(6):825-834. Google Scholar Crossref
11. Juvekar V, Lim CS, Lee DJ, et al. An azo dye for photodynamic therapy that is activated selectively by two–photon excitation. Chem Sci. 2021;12(1):427-434. Google Scholar Crossref
12. Layla AM, Muna AH, NoorAlhuda B. Preparation and characterization of some complexes with new (Azo-Schiff base) Ligand and study of complex as Anticancer. Indian J Forensic Toxicol. 2020;14(2):1223-1231. Google Scholar Crossref
13. Nada HH, Raheem TM. Synthesis, Spectral characterization, thermal analysis, Antimicrobial and Antitumor properties of new azo ligand with some of its Transition Metal complexes. Int J Pharm Res. 2019;11(1):618-637. Google Scholar Crossref
14. Mahmood NA, Zainab MF. Anticancer Study of Innovative Macrocyclic Formazan Compounds from Trimethoprim Drug. Egypt J Chem. 2023;66(1). Google Scholar Crossref
15. Kamya G, Rajwinder K, Anju G, Rajendra A. Chalcones: A review on synthesis and pharmacological activities. J Appl Pharm Sci. 2021;11(1):001-014. Google Scholar Crossref
16. Jaber AK, Rasha NA. Synthesis and characterization of some Transition metal complexes of new ligand chalcone-Azo derivatives from P-methyl-4,5-diphenyl imidazole and study Biological Effect of Pd(II) Complex. NeuroQuantology. 2022;20(3):173-181. Google Scholar Crossref
17. Esraa R, Muneer A, Salih K. Spectrophotometric Determination of Cu(II) in Analytical Sample Using a New Chromogenic Reagent (HPEDN). Indones J Chem. 2020;20(5). Google Scholar Crossref
18. Nagham Mahmood A. Synthesis and Biological Study of Hetero (Atoms and Cycles) Compounds. Der Pharma Chemica. 2016;8(6):40-48. Google Scholar Crossref
19. Mahmood A. Synthesis and Chemical Identification of Macro Compounds of (Thiazol and Imidazol). Res J Pharm Tech. 2015;8(1):78-84. Google Scholar Crossref
20. Aljamali NM. Review in Azo Compounds and its Biological Activity. Biochem Anal Biochem. 2015;4(169). doi:10.4172/2161-1009.1000169. Google Scholar Crossref
21. Kadhim SM, Mahdi M. Preparation and Characterization of New (Halogenated Azo-Schiff) Ligands with Some of their Transition Metal Ions Complexes. Iraqi Journal of Science. 2022;63(8):3283–3299. Google Scholar | Crossref
22. Mohamad BJ, Zghair FA, Fadhil ZT. Clinical and Histopathological Features of Ovarian Cancer in Iraq, Baghdad Between 2014-2020. Iraqi Journal of Science. 2022;63(6):2354–2361. Google Scholar | Crossref
23. Mahmood NA, Jawad SF. Preparation, spectral Characterization, Thermal Study, and Antifungal Assay of (Formazane -Mefenamic acid)- Derivatives. Egyptian Journal of Chemistry. 2022;65(2):411. DOI: 10.21608/EJCHEM.2021.88727.4266. Google Scholar | Crossref
24. Salih AR, Al-Messri ZAK. Synthesis, Characterization and Evaluation of Some Pyranopyrazole Derivatives as Multifunction Additives for Medium Lubricating Oils. Iraqi Journal of Science. 2022;63(7):2827–2838. Google Scholar | Crossref
25. Nagham MA. Synthesis of Antifungal Chemical Compounds from Fluconazole with (Pharma-Chemical) Studying. Research journal of Pharmaceutical, biological and chemical sciences. 2017;8(3):564-573. Google Scholar | Crossref
26. Sarah MA, Mahmood NA. Synthesis, Investigation and Anticancer Evaluation of Novel Macrocyclic Formazan and Linear Formazan. European Chemical Bulletin. 2022;11(11):46-63. Google Scholar | Crossref
27. Kavaz D. Characterization, Synthesis, and Evaluation of Antimicrobial, Anticancer Properties of Laurus nobilis-derived ZnO Nanoparticles. NanoWorld J. 2023;9(3):55-61. Google Scholar | Crossref
28. Supriya V, Poiba VR, Vangalapati M. Catalytic Activity of Nanocomposite: Synthesized Electrochemical Sludge using Iron Electrodes and Marine Algae (Fe3 O4 /marine algae NP) for the Degradation of Emerging Pollutant Malathion. NanoWorld J. 2023;9(2):29-36. Google Scholar | Crossref
29. Khashi'le NS, Waini I, Wahid NS, Arifin NM, Pop I. Radiative Hybrid Ferrofluid Flow Over a Permeable Shrinking Sheet in a Three-Dimensional System. CFD Letters. 2022;14(11):9–21. https://doi.org/10.37934/cfdl.14.11.921. Google Scholar | Crossref
30. Mahmood NA, Jad SF. Preparation, Diagnosis and Evaluation of Cyclic-Tryptophan Derivatives as Anti

Breast Cancer Agents. Biomed Pharmacol J. 2021;14(4):7-17. Available from: https://bit.ly/3HuvlVG. Google Scholar | Crossref

31. Nor AA, Sud SA, Mahmood A. Synthesis, Characterization and Thermal Analysis for New Amoxil Ligands. Asian Journal of Chemistry. 2019;31(5):1022-1026. Google Scholar | Crossref
32. Kasnazany SAS, Barznjy LGK, Fatih AA, Mirza AN, Krbchna SJJ. Comparative study related to physico-chemical properties of four tomato cultivars grown in Kurdistan region, Iraq. Kufa Journal for Agricultural Sciences. 2021;13(2):41–52. Retrieved from https://journal.uokufa.edu.iq/index.php/kjas/article/view/3654. Google Scholar | Crossref
33. Mahmood NA, Abed SM. Bio Studies of Novel Macrocyclic Sulfazan and Linear Sulfazan (Creation, Analysis and Anticancer Assessment). Journal of Pharmaceutical Negative Results. 2022;13(4):351–363. https://doi.org/10.47750/pnr.2022.13.04.043. Google Scholar | Crossref
34. Shireen RR, Mahmood NA, Al-Zuhairi AJ. Guanine substituted heterocyclic derivatives as bioactive compounds. Biochem. Cell. Arch. 2020;20(2):3651-3655. DocID: https://connectjournals.com/03896.2020.20.3651. Google Scholar | Crossref
35. Mohammed D, Enouz AJ, Areaaer AHJ. Effect of Adding Different Levels of Antioxidant and Imported Ginseng (Panax) Roots to The Diet in The Microbial. Kufa Journal for Agricultural Sciences. 2021;13(2):1–5. Google Scholar | Crossref
36. Hasan A, Khan N, Vijay D, Pasha Z, Kale PP. From Detection to Prevention: Managing Oral Precancerous Conditions. *Onkologia i Radioterapia*. 2023;17(10). Google Scholar | Crossref
37. Muhammad JS, Zuhaila I, Norsarahaida SA. Effect of Different Types of Stenosis on Generalized Power Law Model of Blood Flow in a Bifurcated Artery. *J Adv Res Fluid Mech Therm Sci*. 2021;87(3):172-183. Google Scholar | Crossref
38. Sabah R, Abbas AS, Al-Kazazz FF, Al-Ameri SAH. Investigation on Glucose and levels of Zn and Cu in Sera of Iraqi Males addicted on Methamphetamine or Tramadol. *J Adv Sci Eng Technol*. 2020;3(2). Google Scholar | Crossref
39. Mahmood NA, Almosawy MGA. Preparation of Nano Materials and Nano-Chemical Compounds with Adsorption Applications. *J Chem Health Risks*. 2023;13(4):142-157. ISSN: 2251-6727. Google Scholar | Crossref
40. Talib AA, Kadhium AJ, Mohammed MS. Preparation, Characterization and Biological Study of Complexes of Co(II) and Cu(II) with Mixed ligands of Azo naphthol compounds. *J Chem Health Risks*. 2023;13(4):133-141. ISSN: 2251-6727. Google Scholar | Crossref
41. Mohaisen HN, Ahmed MA. Influence of the Induced Magnetic and Rotation on Mixed Convection Heat Transfer for the Peristaltic Transport of Bingham plastic Fluid in an Asymmetric Channel. *Iraqi J Sci*. 2022:1770-1785. Google Scholar | Crossref
42. Sabah R. Simultaneous HPLC estimation of Amphetamine and Caffeine abuse drugs in Iraqi human addicts. *J Adv Sci Eng Technol*. 2021 Dec;4(1):25-31. Available from: Google Scholar | Crossref
43. Raheem DAA, Abd AM Z. Biosynthesis, characterization, Antioxidant and Antihemolysis activity of Silver nanoparticles (AgNPs) produced using Cynophyta Alga Extract (*Spirulina platensis*). *J Alharf*. November;Issue 19. Google Scholar | Crossref
44. Widad IY, Tariq HM, Afaq JK. Preparation, characterization of some metal complexes of new mixed ligands derived from 5-methyl imidazole and study the biological activity of Palladium (II) Complex as anticancer. *NeuroQuantology*. 2022;20(1):71-83. Google Scholar | Crossref
45. Wasu S, Mohd FM, Arkom P, Maizirwan M, Makatar W. The Effect of Air Equivalent Ratio on Combustion and Gasification Process Characteristics of Oil Palm Biomass in Fluidized Bed Reactor. *J Adv Res Fluid Mech Therm Sci*. 2022;99(2):108–118. Google Scholar | Crossref
46. Al sahib SA, awad SH. Synthesis, Characterization of Chitosan para-hydroxyl Benzaldehyde Schiff Base Linked Maleic Anhydride and the Evaluation of Its Antimicrobial Activities. *Baghdad Sci J*. 2022 Dec 1;19(6):1265. Available from: Google Scholar | Crossref
47. Mwafaq RK, Abbas AK, Abdullah LAH, Abdul Ghafour KH. The Immunohistochemically Estimation of CD63 in Iraqi Patients with Gastric Cancer. *Baghdad Sci J*. 2023 May 19;19(5):0932. Available from: Google Scholar | Crossref
48. Hassan AK, Atiya MA, Luaibi IM. A Green Synthesis of Iron/Copper Nanoparticles as a Catalytic of Fenton-like Reactions for Removal of Orange G Dye. *Baghdad Sci J*. 2022 Dec 1;19(6):1249. Available from: Google Scholar | Crossref