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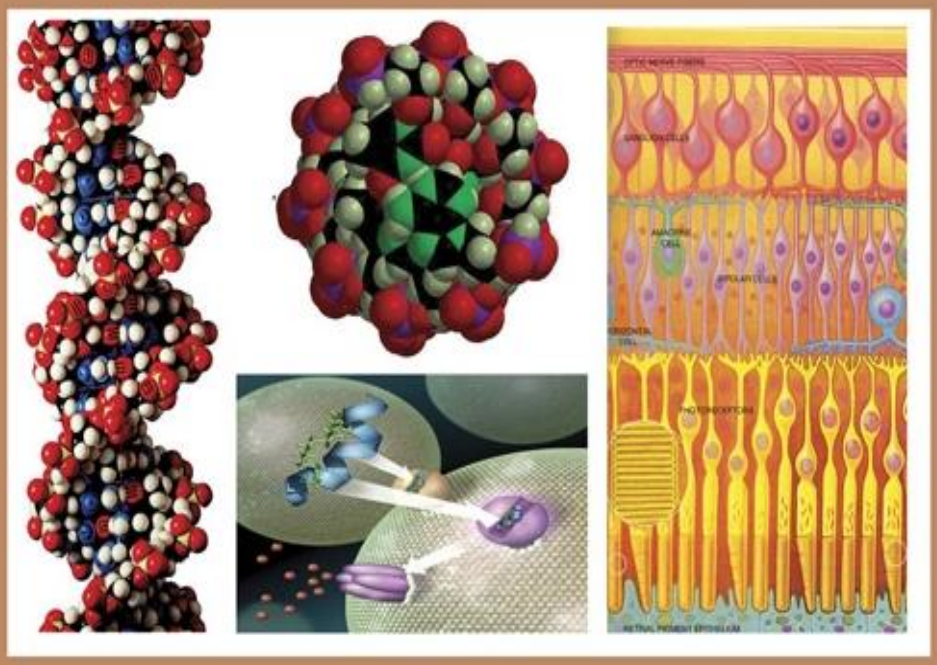

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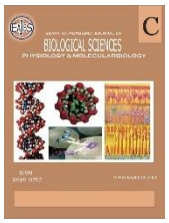

Synthesis, Characterization of Novel Triazin Complex, and Studying its Antimicrobial Activity

Duha A. Mahmood [1], Mohanad M. Kareem [2] and Israa N. Witwit [1]

[1]Department of Chemistry, College of Sciences, University of Kufa, Kufa, Iraq.

[2]Department of Chemistry, College of Sciences, University of Babylon, Babylon, P.O. Box 51002, Hilla, Iraq.

***E-mail:** sci.mohanad.mousa@uobabylon.edu.iq

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ABSTRACT

Novel triazine playcentre complex$C_1[Cu_3(DA_1)(H_2O)_6Cl_6$ was prepared by reflection between (3)mmole of copper chloride salt with (1) mmol of (DA_1[N-Itaconimide melamine monomer(IMM)] for (3-3.5) hours. The prepared ligand and their complex characterized by FT-IR, Mass, Elemental analyses, and conductivity then antimicrobial activity of the complex was studied against two pathogenic strains of *E.coli* and *S. aurous* at three values of concentrations of (10 ppm,20 ppm and 30 ppm by using standards by disk-diffusion method.

INTRODUCTION

Triazin ligands are a class of organic molecules which are containing one or more Triazine rings, this ring can be substated with a variety of functional groups to create different ligands[David M. L.; Hussain, Izhar; White, Andrew J. P.; Williams, David J. (1999)]. These ligands were studied extensively due to their ability to form stable complexes with a variety of metal ions, their rigidity and shapes can be controlled by modifying the substituents on the Triazine ring.Triazine ligands can adopt several coordination behaviours such as Monodentate [Zhu, H., Yu, Z., You, X.(1999,)]. , Bidentate [Elokil, I., ; M., ; A. ; Ahmed F., ; Shishay, ; and Sabike L..(2019).]Tridentate [Yanling Hu., Jing Su., Xiaojuan W., and Changhui Y..(2013), Shu-Kun L. and Sheng-Lung P.(2003), Shanmugakala R. ,Tharmaraj.P , Sheela C.D , and Anitha.C.(2012).] Poly dentate [ALPHONSE.L, THARMARAJ.P, AVILA.B JOSEPHINE, and MARY TERESITA.V.(2020)] multiple metal ion center complexes [Maekawa.M; Sugimoto, Kunihisa; Okubo, Takashi; Kuroda-Sowa, Takayoshi; Munakata, Megumu (2016) resulting polynuclear complexes which have found in various fields, including catalysis, magnetic and electronic materials, and biomedical research [Lashgari N., Eshtiagh-Hosseini H., Gholami M., and Aliyan, H. (2021).] Triazine ligands and their complexes take a lot of attention from researchers in different fields, especially as chelating for metal ions separation, and purification[Lashgari N., Eshtiagh-Hosseini H., Gholami M., and Aliyan, H. (2021)]., their role in Catalysis processes [Cheng X., Qi H., Gao F., and Gao Y., (2017)], Anti-Corrosion agents [DheerajS. C., Quraishi M.A, Wan Nik W.B, Vandana S.(2021)], as well as their importance in bio, and medical Applications [Mei-Hui Yu, Xiao-Ting Liu, Brian Space, Ze Chang, and Xian-He Bu. (2021)].

The Aim of our study concentrated on experimenting antimicrobial activity of its novel triazine complex after it's characterization against *E. coli* and *S. aurous* in different concentrations.

MATERIALS AND METHODS

All chemicals were from Fluka, Meck, and B.D.H. with high purity. Stuart melting point /SMP30 used to measure melting point of ligand and it's complex, Element analysis of the ligand carried out by CHN element analyzer 1108 and Element analysis of complexes measured by C.H.N.S. mth EA 99 Atomic, The IR spectra were recorded using a Bruker Tensor II Fourier Trans Infrared Spector Promoter AT-FT-IR within the range (400-4000) cm^{-1}.

1. Synthesis of Compound [A_1]: N- (m-Carboxyphenyl) Itaconic Acid:

Mixture of *m*-amino benzoic acid (5 g, 0.1 mol) in acetone gradually added to a solution of itaconic anhydride (3.2 g, 0.1 mol) in acetone, ether and with continuous stirring for 3 hrs. at ambient temperature. Then the solution was filtered and the precipitate of crude *m*-CPIA was dried and then recrystallized from ethanol to obtain pure 90% Yield, m.p 233-234 °C.

2.Synthesis of Compound [A_2[: N-(3-Carboxyphenyl) Itaconimide:

A mixture of (4.0 g, 0.017mol) in (6 mL,0.06mol) acetic anhydride, add(0.7 gm, 0.0085mol) Sodium acetate were heated at 90 °C for2 hrs and it became a clear, homogenous brown liquid. The solvent was evaporated from the mixture to give a white powdery precipitate, Add ice water and stir for an hour at room temperature, then filter and dry the product. The obtained precipitate was recrystallized from ethyl acetate obtaining the product in a 90% Yield. m.p 241-244 ^{0}C.

3.Synthesis of compound [A_3]: .*N*-[3-(Chlorocarbonyl) phenyl] Itaconimide:

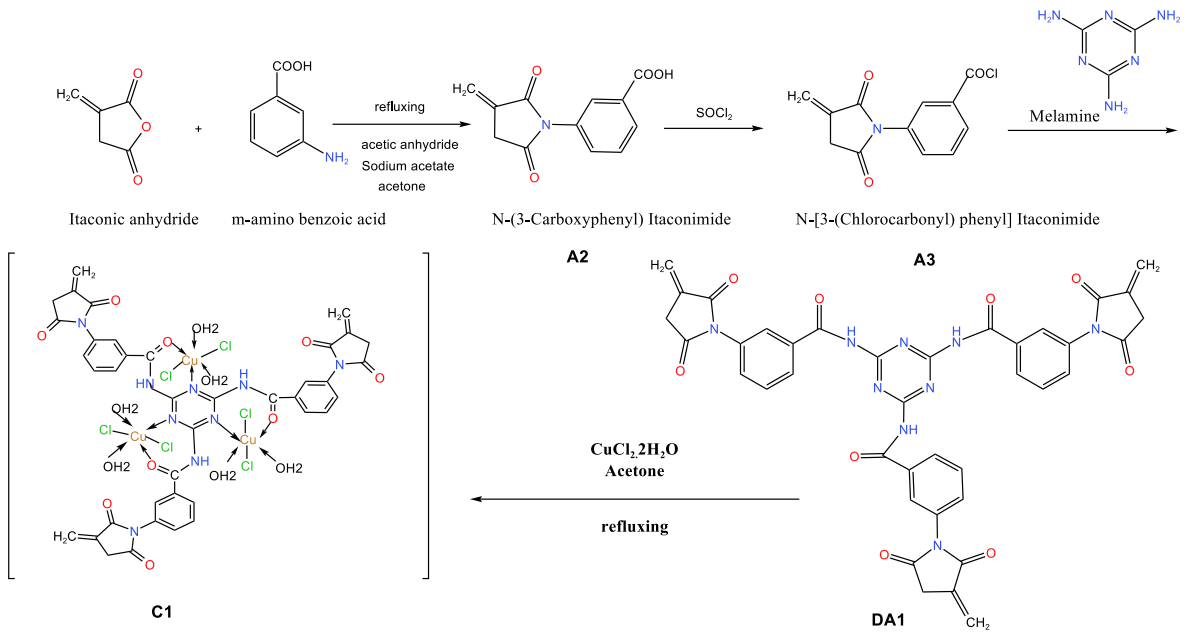
A mixture of (5.5.gm, 0.0107.mmol) in thionyl chloride (10.6mL) and(10.6ml) chloroform was Heated and stirred at 65^{0}C for 6 hrs. Cool the reaction solution, then add (10.6 ml) hexane The unreacted thionyl chloride was evaporated off and residual product was recrystallized from DCM to get pure dark brown crystals of acid chloride. It was obtained in 90%.yield, m.p 130-134 ^{o}C.

4.Synthesis of [DA_1] Compound: N-Itaconimide Melamine Monomer:

3-Itaconimide benzoyl chloride (3.0 mmol, 5.0 g) was added with stirring to the solution of (1.0 mmol,1.0 g) of melamine in (20)mL of acetone, then add sodium carbonate(0.009 mmol, 0.18 g) was added dropwise at room temperature and then heated for 3-3-5 hr. at 60-65 °C, The solvent was yield, m.p 260-263°C.

5.Synthesis [$Cu_3(DA_1)(H_2O)_6Cl_6$] Complex (C1):

A mixture of (5.1 g, 3 mmol) $CuCl_2.2H_2O$, and (5.5 g, 1 mmol) (DA_1) dissolved in (30) mL of acetone, then refluxed for (3) hr. where brown precipitate was separated during reflux, which is filtered, washed with distilled water, dried, then recrystallized from hot ethanol; yield (80%), m.p239-241^{0}C.



Scheme 1: Synthesis route of compounds (A_1-A_3) and (DA_1-C_1)**.**

RESULTS AND DISCUSSION

1.Infrared Spectrum of The Complex:

FT-IR of (C1) complex exhibited a broad band of v(O-H) at (3500) cm- due to the H_2O molecule inside the coordination sphere, that is supported by the appearance frequency of *v*(M-H_2O) at (567) cm-. [Darshana A., Apoorva A. Patel, and S. Patel.(2013), Masoud M.S., Hemdan S.S., Elsamra, R.M.I.(2023)] The frequencies for *v*(=C-H) of maleimide aromatic system at (3075) and the amide (N-H) groups are observed at (3385-3255) cm - did not showed noticeable changes, whereas v(C=O) of carbonyl shifted to (1708) and (1662) cm- due to the involvement of carbonyl group in coordination with the copper ion. *v* (C=N), and *v*(C-N) of the Triazine ring changes in both positions, and intensity in (C1) complex spectrum, these peaks shifted to (1602) cm-, and (1366) cm- respectively, which is indicating coordination though nitrogen atoms of Triazine ring.

New peaks appeared in the complex spectrum at (470) cm-, (430) cm$^-$ refers to the vibrations of *v*(M-O), and *v*(M-N) [Maliyappa M.R., and Keshavayya, J.(2022), Maryam L., Hadiseh A., Marzieh S., Maryam A., and Samira J.(2021)]. which showed the coordination process through Triazin ring, Oxygen atom of carbonyl m and aqua molecules . as shown in Figure (1).

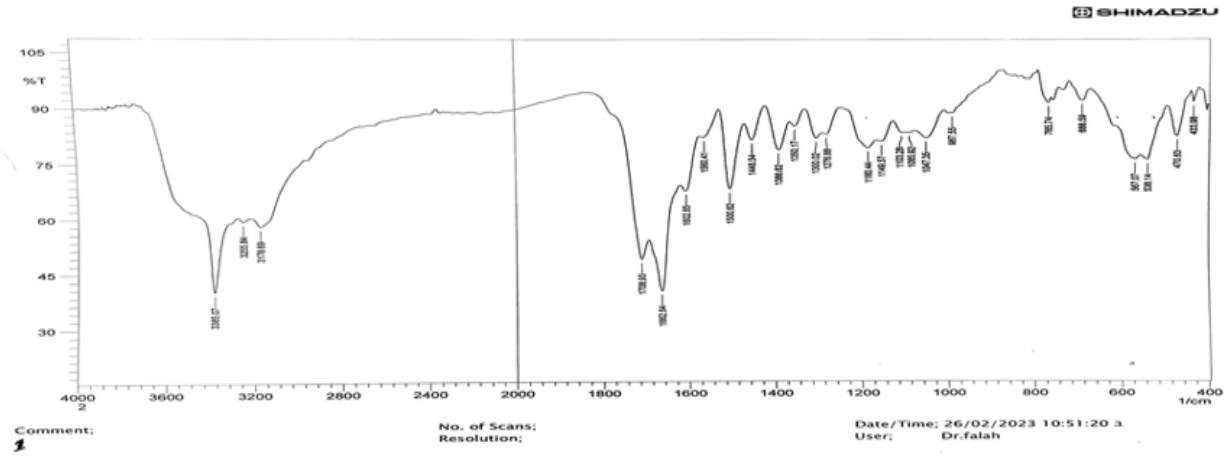


Fig. 1. FT-IR spectrum of compound [C1].

2 Molar Conductivity, Solubility, and some of physical properties of the complex:

Molar conductivity plays an essential role in coordination chemistry because it will clarify the ionic and non-ionic nature of complex in different solvents. , The values shown in Table (1) of $(10)^{-3}$ M of the studied complex in ethanol and dimethyl sulphoxide refers to the non-ionic character of them which indicated existing of chloride ions inside of the coordination sphere [Arab Ahmadi R., Hasanvand F., Bruno G., Amiri Rudbari H., and Amani. S. (2013), Israa N. Witwit, Zahraa Y. Motaweq, and Husham M. Mubark. (2019), Esraa Muneer A. Al-Da'amy, and Salih H. K.(2020), Ibtihal K, Fawzi Yaha, Ghusoon J. (2019).] also the addition of $AgNO_3$ drops to the complex solutions without precipitation of AgCl supported the absence of chloride ions as a counter ion outside the coordination sphere.

The Solubility of complex were tested against organic, and non-organic solvents, the best solubility with DMSO, DMF, and acetone Because organic solvents like DMF and DMSO can effectively dissolve nonpolar or weakly polar molecules, these compounds tend to have a higher solubility in them while they were parity dissolved in Toluene, as shown in Table (2).

Table 1. Molar conductance of metal complex in 10^{-3} molar DMF, and Ethanol.

Complexes	Molar Conductance, $cm^2ohm^{-1}mol^{-1}$	
	DMF	Ethanol
$C_1[Cu_3(DA_{19})(H_2O)_6Cl_6]$	5.0	3.6

Table 2. The solubility of prepared ligand complex in some solvents.

Co.	H_2O	EtOH	$CHCl_3$	Ether	Toluene	DMSO	Hexane	DMF	Acetone
DA_1	partial	-	-	-	partial	+	-	+	+
C1	-	+	-	-	partial	+	-	+	+

Table 3. Some of the physico-chemical properties of free ligands and their complex.

Co.	Time	yield (%)	Mp. (°C)	R_f value	color	M.F	M.Wt
DA_1	3 hr.	85%	261-263	0.69 Hexane : Acetone (1:3)	Off-White	$C_{39}H_{27}O_9N_9$	765.70
C_1	3 hr.	80%	239-241	0.54 hexane : Acetone (1:3)	light brown	$Cu_3C_{39}H_{39}O_{15}Cl_6N_9$	1383.48

3 Mass Spectrum of (C1) Complex:

Mass spectrometry is an important tool in the field of coordination chemistry since it enables scientists to identify comprehensive information on the structure, composition, and behaviour of metal complexes.

Mass fragmentation path of (C1) complexes started by losing copper, chloride, and aqua molecules from the complex indicated by [Cu]+ peaks at m/z=62.96, and m/z=65.96, while chloride ion showed fragments at m/z=35.5, and m/z= 37.01 [William H., and Scott McIndoe J. D.,(2005).]]Molecular peak of free ligand exhibited at m/z=765 which fragmented in path as explained in Figure (2) and scheme(2), the base peak appeared at m/z =127.8 for [$C_6H_9NO_2]^+$.

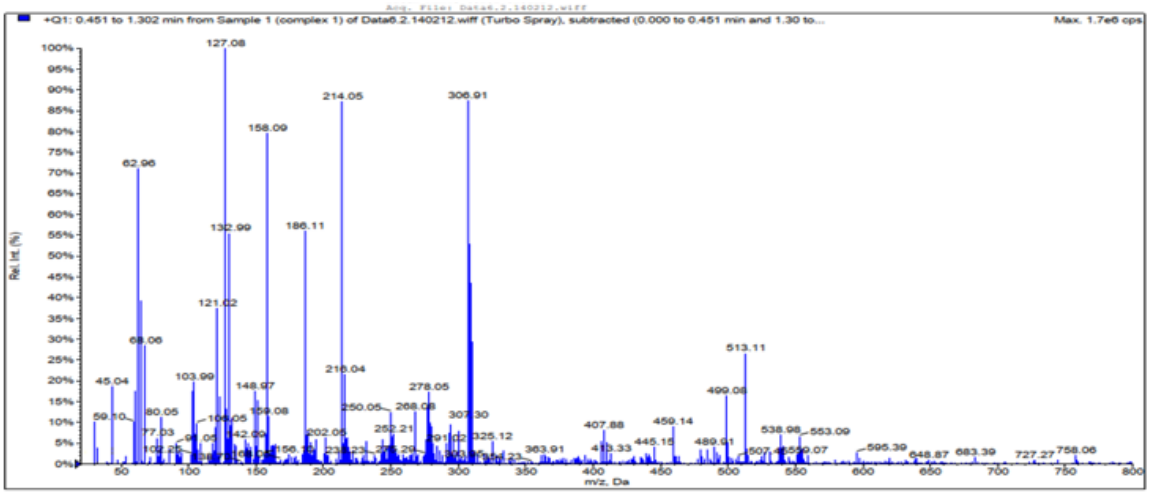
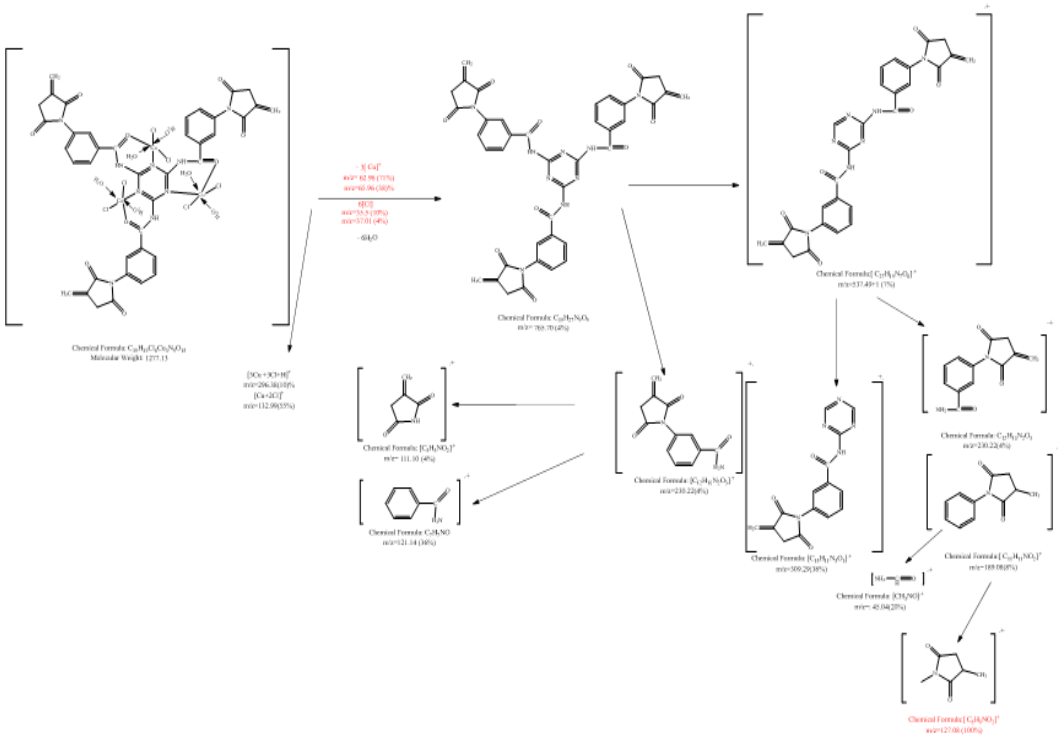


Fig. 2. Mass Spectrum of (C1) Complex.



Scheme 2. Suggested mass fragmentation paths of (C1) Complex

4. Antimicrobial Activity Of Triazine Ligand And Metal Complex:

Biochemical processes are significantly impacted by metal complexation. Similar metal complexes have been shown to have increased biological activity [Israa N., Husham M., and Abid Allah M.(2020)]. Complexation has increased the antibacterial efficacy when compared to a plain ligand, providing new opportunities for combating antibiotic resistance. In order to compare complex to the usual medication maxipime, the antibacterial properties evaluated against a number of harmful bacterial species, including E. coli and S. aures.

Zones of inhibition for prepared metal complex against *E. coli* and *S. aurous* are shown in Table 2. low inhibition zone was identified at lower doses, but at higher concentrations, such as 20 ppm and 30 ppm, all the synthesized metal complex had modest inhibitory zones that ranged from 2.0 to 15 mm, as explained in the Table (4) , and Figures (3,4).

Table 4. Biological activity of ligand and metal complex.

Concentration Ppm(mg/ml)	Compounds	Inhibition Zone for E. Coli of compounds	Inhibition Zone for S. aurous of compounds
10 ppm	DA_1	26	22
	$C_1[Cu_3(DA_1)(H_2O)_6Cl_6]$	0	0
20ppm	DA_1	28	25
	$C_1[Cu_3(DA_1)(H_2O)_6Cl_6]$	2.0	0
30 ppm	DA_1	33	27
	$C_1[Cu_3(DA_1)(H_2O)_6Cl_6]$	3.0	1.0

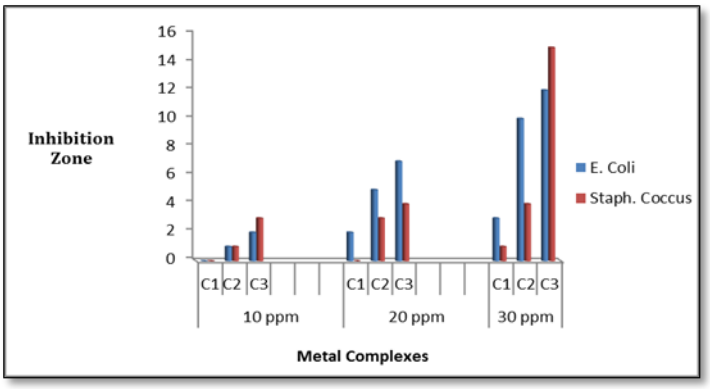


Fig. 3. Inhibition Zone for E. Coli and Staph. Coccus of the metal complex (C1) in different Concentration (10 ppm, 20 ppm and 30 ppm).

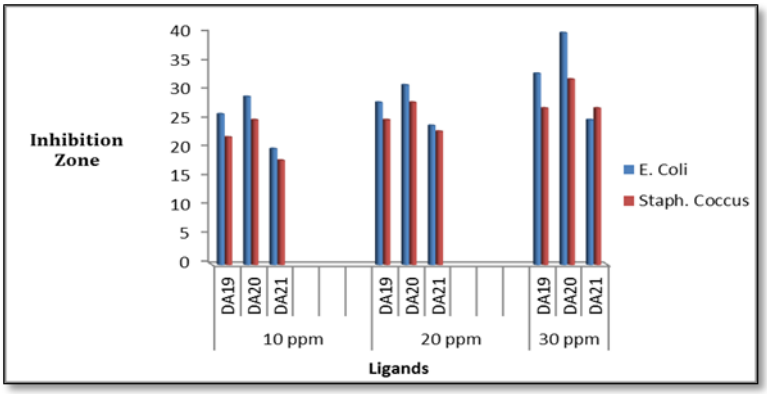


Fig. 4 . Inhibition Zone for E. Coli and Staph. Coccus of ligand(DA1) in different Concentration (10 ppm, 20 ppm and 30 ppm).

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