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Diverse Applications of β-enaminone Ligands and their Metal Complexes: A Review Article

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Keywords: β-enaminone, diverse applications, complexes.

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Abstract:

As they include both nucleophilic and electrophilic moieties on the same skeleton, enaminones are an important subclass of chemical compounds that contain conjugated NC=C-C=O fragments. These active sites aid in the production of organic molecules containing linear or cyclic heteroatoms. Enaminones and the chemica1 compounds produced from them are both biologically active against the most dangerous bacteria. As a result, they have been utilized as starting materials for the synthesis of anti-inf1ammatory, antibacteria1, anticonvulsant, anticancer, anti-urease, anti-malaria1, optically luminescent, corrosion inhibition, and antitumor agents. Their synthesis has usually a terrific deal of interest and a plethora of synthetic paths have been narrated, including Lewis's acids, P2O5/SiO2, Cu- nanoparticles, and heteropoly acid. Enaminone metal complexes have serval applications in industry and engineering. The definition, significance, and diverse applications of β-enaminone 1igands and their meta1 complexes are presented in this review study.

Keywords: β-enaminone, diverse applications, complexes.

التطبيقات المتنوعة لليكاندات بيتا – ايناميون ومعقداتها الفلزية: مقال مراجعة

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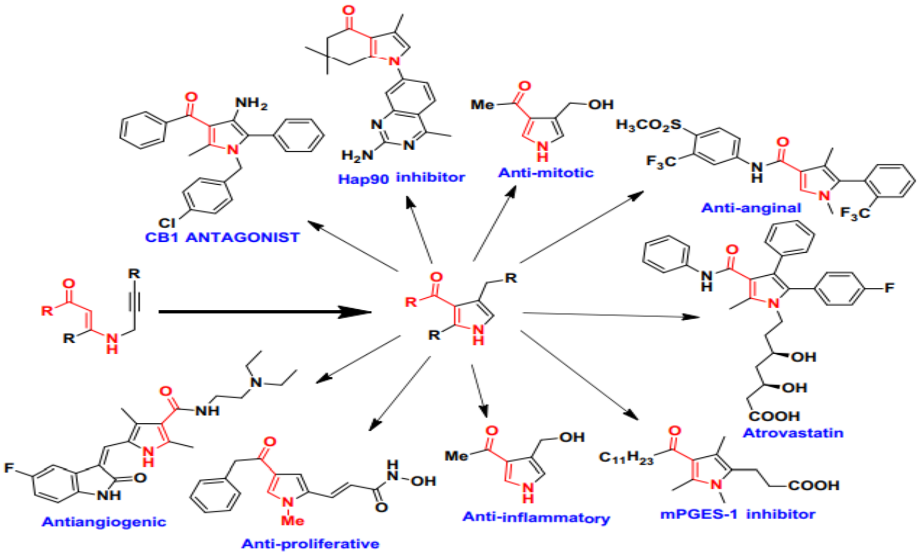
الخلاصة:

نظرًا لأن الإينامينونات تشتمل على كل من الجزئين نيوكليوفيلي والكتروفيلي في نفس الهيكل التركيبي، فانها تعد مجموعة فرعية مهمة من المركبات الكيميائية التي تحتوي على أجزاء $NC=C\text{-}C=O$ مترافقة. تساعد هذه المواقع النشطة في إنتاج جزيئات عضوية تحوي ذرات مختلفة خطية او حلقية. إن الإينامينونات والمركبات الكيميائية المنتجة منها نشطة بيولوجيًا ضد أخطر أنواع البكتيريا. ونتيجة لذلك، فقد تم استخدامها كمواد أولية لتخليق مضادات الالتهاب، ومضادات البكتيريا، ومضادات الاختلاج، ومضادات السرطان، ومضادات اليورياز، ومضادات الملاريا، والإضاءة البصرية، ومثبطات التآكل، وعوامل مضادة للأورام. لقد حظي تركيبها بقدر كبير من الاهتمام، وقد تم ذكر عدد كبير من دورها في التحضير الصناعي، بما في ذلك أحماض لويس، و$P2O5/SIO2$، والجسيمات النحاسية، وحوامض البوليمرات المتغايرة. تحتوي معقدات بيتا-ينامينون الفلزية على تطبيقات مهمة في الصناعة والهندسة أيضاً تم عرض تعريف وأهمية والتطبيقات المتنوعة لليكاندات بيتا-ايناميون ومعقداتها الفلزية في هذه الدراسة المراجعة.

الكلمات المفتاحية: بيتا – إناميون، تطبيقات، معقدات متنوعة.

1. Introduction:

Enaminones are compounds derived from –di-carbonyl compounds with the (N–C=C–C=O) system. Enaminones are a kind of organic chemical that may be easily produced by different processes such as condensation, adjunct, cleavage of hetero-cyclic, and acylation. -enaminon is a chemical that is employed in the production of chemicals, bioactive substances, medicines, anti-tumor, anti-microbial, antiepileptic, and other therapeutic activities. it is also utilized as an intermediate step (medium step) in the synthesis of numerous chemical compounds [1-4]. In fact, they are commonly employed as intermediates in the production of key medicinal compounds. Because of their chemical transformations and different chemica1 reactivity due to their electron amusing and electron flawed cores, these intriguing compounds are extremely important. One advantage of compounds with an enaminones organization in their building is that they are extremely steady molecu1es. They are easily created utilizing generally accessible and little-cost starting ingredients. Enaminones are also one of the greatest beginning resources for organic production strategies since they may be made utilizing inexpensive starting ingredients [5-8], **Scheme l**.



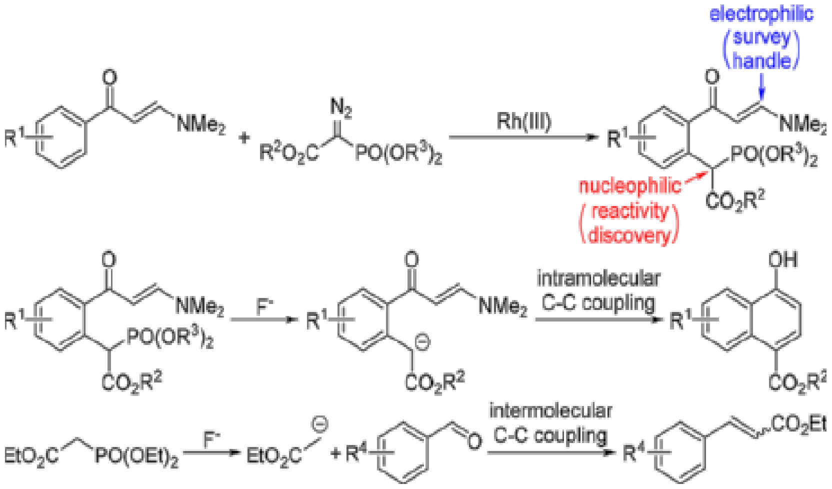
Scheme 1: Examples of bioactive b-enaminones

Enaminones and their complexes have some applications on a variety of grounds. Enaminones have received a lot of attention because of their capacity to system compounds (they are excellent poly-dentate ligands), since following complexation, the effectiveness, and characteristics of β-enaminones are much improved. Enaminone complexes exhibit a diverse range of living functions. A copper-based greenish-yellow comp1ex was produced utilizing a ferroceny1 enaminone, which is an excellent replacement for olefin polymerization catalysts. Zinc and iron enaminone complexes with antibacterial action have also been found. Various enaminone complexes have been found to have fungicidal and bactericidal activity critical to 8 kinds of bacteria and 3 kinds of fungi [9-12]. A review of the literature reveals the toxicity possible of the ligand β-enaminone and its CdII complex hostile to MCF7. Compounds of different ions with ligands β-enaminone have also been discovered to have remarkable anti-urease properties. Enaminones have grown in importance because they may be employed as effective chelating ligands for transition metals, and the anions they form are isoelectronic substitutes for cyclopentadieny1-based anions. [13-16]

Several techniques aimed at the production of β-enaminones employing Lewis acid reagents, including Bi(TFA), Er(OTf), and Yb(OTf), have been described in the literature. Furthermore, β-enaminones have been produced employing microwave and ultrasonic irradiation. All of these procedures, however, have their own downsides and restrictions, such as lengthier reaction times, the use of costly substances, the usage of hazardous solvents, and the employment of moisture-sensitive Lewis acids. The majority of these approaches relied heavily on secondary amines. In continuation of our ongoing research into novel synthetic methodologies for organic synthesis and the function of transition metal catalysts in such synthesis, we present here the selective and efficient synthesis of β-enaminones utilizing Cu-nano-particles. Transition metal nanoparticles have been exploited as decent catalysts in a variety of synthesis carbon-based transformations in recent years due to their extraordinary volume ratio to surface area coordination places, which are primarily accountable for their catalyst activity. Copper- nano-particles are less expensive than typical catalysts and insist on just minor reaction settings to produce a high yield in reaction time [17-20].

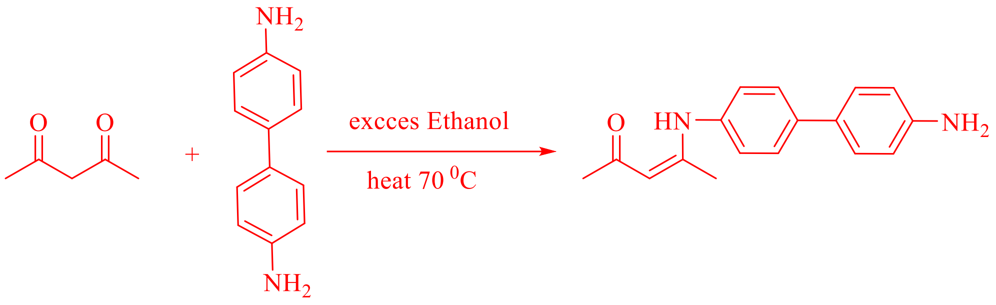
2. Theory: A literature review of the synthesis of β-enaminone ligands and their metal complexes

Using enaminone-directed Rh(III)-catalyzed CH coupling with alpha-diazo-alpha-phosphono acetate, a C-C de-phosphorylation reaction in the presence of fluoride was explored to form 4- hydroxy -l- naphthoates and (E) - selective alpha, Peta- unsaturated ester could be produced by performing intermolecular C-C coupling of alpha- phosphono acetate and Benz aldehyde [21], Scheme 2.



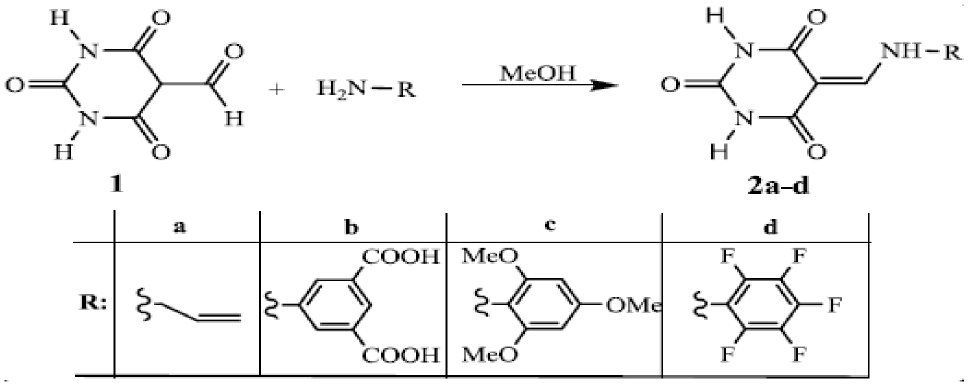
Scheme 2: β-enaminone compounds

Three new ligands for enaminone derived from the chemical compound benzidine were prepared: L_3 (c_1)= (z)-4-((4-amino-[1,1-bi phenyl]-4-yl)amino)pent-3-en-2-one , L_3 (d1)= (z)-5-((4'- amino-[1,1-bi-phenyl]-4-yl)amino)hept-4-en-3-one, and L_3 (e_1)= (z)-3-((4'-amino-[1,1-bi-phenyl]-4-yl)amino)-1-phenylbut-2-en-1-one of the important things that make this special lesson of β-enaminones has many important features and potential tenders that caught the attention of researchers is the bond between the two vinyl clusters in the p-position relative to NH_2 group. Also, the availability of NH_2 group greeneries room for more functionalization of our compounds. The use of a cheap, light, clean, and effective catalyst, which favors the chemistry approach, is one of the greatest significant advantages provided by this method [22], Scheme 3.



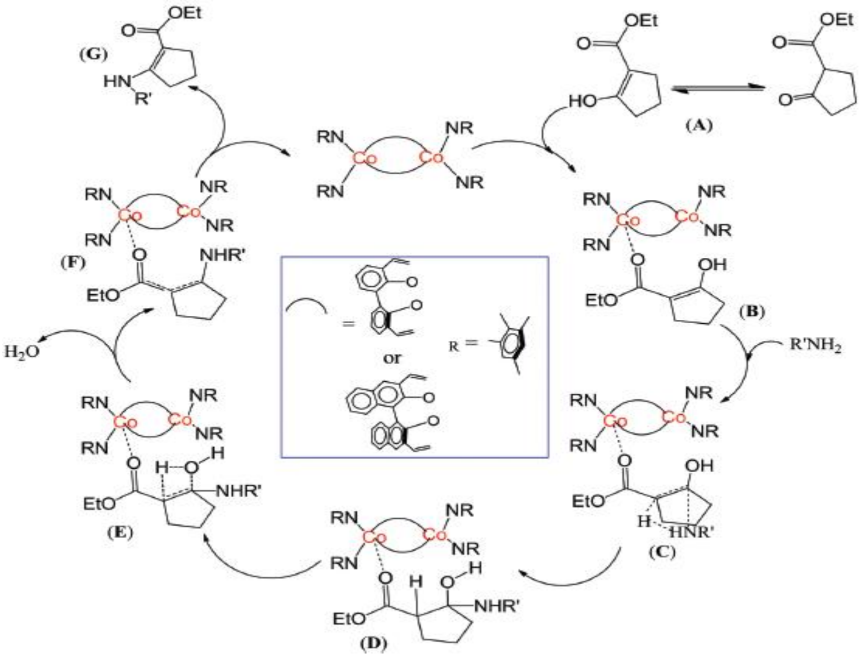
Scheme 3: Structure of L_1

Four enaminone compounds derived from the reaction of 5-formyl barbituric acid and selected specific amines were prepared with high productivity and efficiency. The prepared compounds were characterized by several spectroscopic methods, including FTIR, ^1H and ^{13}C NMR, and CHN. There was great agreement between the results obtained and the results mentioned for similar derivatives in the medical literature [23], Scheme 4.



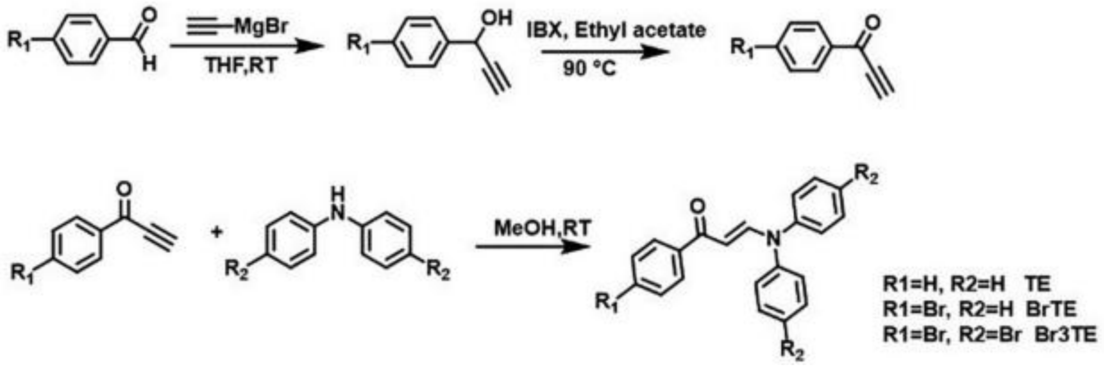
Scheme 4: Synthesis of Enaminone Derivatives

Prepared tetradentate ligands derived from 2 , 20- penaphthol and 2 ,20- diphenol, namely H_2L_1 (1)= 3, 30 - bis [((2,4,6- tri-methyl – phenyl) imino) methyl] - [1, 10] – bi- phenyl -2,20 –diol and H_2L_2 (3)= 3,30 –bis [((2,4,6- tri -methyl phenyl) imino) methyl] - [1, 10] –bi-naphthalenyl -2,20 -diol, which in turn reacted with cobalt acetate tetrahydrate to prepare Co [3,30 – bis - ((R) – imino methyl) - (1, 10) – bi-phenyl -2,20 - dioxo] 2 (2) and Co [3, 30 -bis-((R) – imino methyl) - (1, 10) –bi-naphthalenyl -2, 20 – dioxo]2 (4) (where R= 2, 4, 6-$Me_3C_6H_2$). The prepared compounds were characterized by several spectroscopic methods, including CHN, Mass spectra, FTIR, UV-Vis, magnetic measurement, and single-crystal X-ray diffraction analysis. The presence of tetrahedral structure for both 2 and 4 metal ions was diagnosed by X-ray crystallography. Synthesis of β-enaminone from 1, 3- di-carbonyl compounds and aliphatic amines under ambient conditions using metal complexes 2 and 4 successfully catalyzed the reaction [24], Scheme 5.



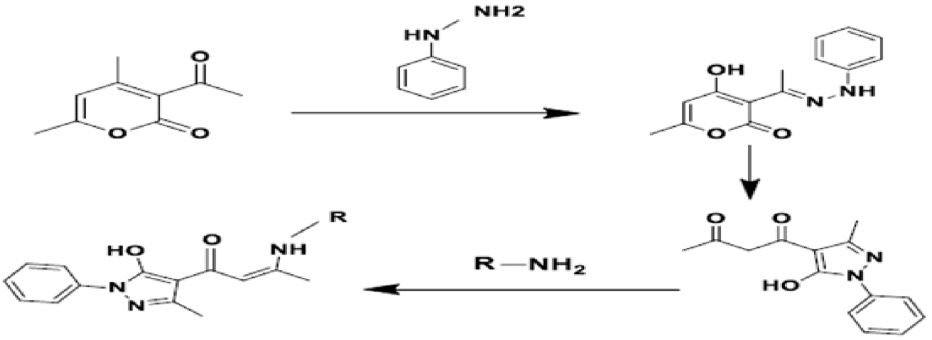
Scheme 5: Synthesis of di-nuclear cobalt complexes (2,4) by β – enaminones.

Three derivatives of trans enaminone, namely (non-brominated (TE), tri-brominated (Br$_3$-TE), and mono-brominated (Br-TE), were designed and prepared with aggregation-induced emission properties. With different fluorescence properties, two kinds of Br-TE quartzes B &G were obtained and through halogen bond formation their state (solid) fluorescence was improved. The higher products of Br-TE-G are due to stronger multiple intermolecular interactions that may restrict molecular movements, causing a lower decay rate (enhanced radioactive and non-radioactive), in addition to halogen bond interactions, and this was concluded through theoretical calculations and careful examination of single crystal data. To control the state (solid) production goods of luminous resources, specifically fluorescent resources, halogen bonding is rarely relied upon, which represents the interaction between molecules [25], Scheme 6.



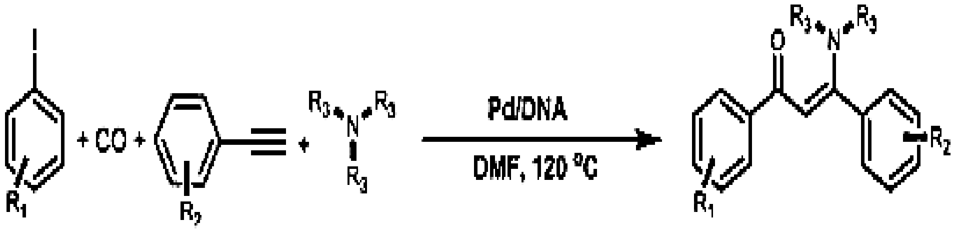
Scheme 6: Preparation of trans enaminone derivatives (TE, Br$_3$-TE and Br-TE)

In recent decades, there has been a surge in the chemistry of heterocycles. This has resulted in an astounding number of molecules with at least one heterocycle in their structure. In fact, more than two-thirds of the 65 million chemical molecules comprise a heterocyclic structure. Heterocycles are significant not only for their richness and exceptional diversity, but also for their biological, medical (vitamins, hormones, antibiotics, etc.), industrial, and technical applications (corrosion inhibitors, dyes, stabilizers, pesticides, herbicides, etc.). Many natural substances of plants, animals, or synthetic origin have nitrogenous structures among the many families of heterocyclic compounds. The pyrazolo-enaminones are among them **[26]**, **Scheme 7**.



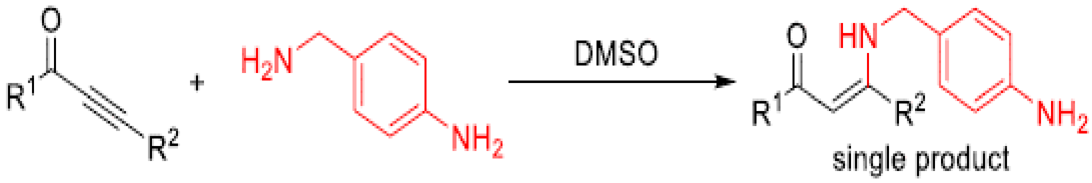
Scheme 7: Synthesis of pyrazole-enaminones

β-Enaminone compounds were prepared through a new one-pot procedure in the presence of the Pd-DNA catalyst, with the use of amino sources (NPr_3, NEt_3, and NBu_3). The method comprises sequential Sonogashira carbonyl coupling of a terminal alkyne to an aryl iodide and oxidative dealkylation of the tertiary amines. The catalyst was used in many subsequent tests with the same results after it was successfully recovered. On the basis of the activity of palladium nanoparticles, the reaction mechanism was proposed **[27]**, **Scheme 8**.



Scheme 8: Preparation of β-enaminone in the presence of palladium catalyst

By aza-Michael addition of aminoalkyl-, thio-aniline, and phenol- with ynones under metal-free conditions with high efficiency and chemical selectivity, the selective chemical preparation of β-enaminones was achieved with a yield of up to 99% in 31 examples. From β-enaminone, the novel dual-1,5-di-substituted tri-azole scaffold was prepared subsequently **[28]**, **Scheme 9**.



Scheme 9: Synthesis of β-enaminones

Relying on enaminone or 1,2-benzenediamine and on (S)-quinenamine as a chiral tertiary amine (as a hydrogen bond donor), twenty-four new organocatalysts were prepared. By transferring (S)-quininamine (9 examples) with the amination of N, N-dimethylanaminone, anemone-type catalysts were prepared., whereas the l,2-benzenediamine-type catalysts were created in three stages using (S)-quininamine and ortho-fluoronitrobenzene derivatives. Their interest in the Michae1 buildup of acetylacetone to trans nitro styrene seemed hazy. Up to 72 percent of enantioselectivities were reported [29], Fig. l.

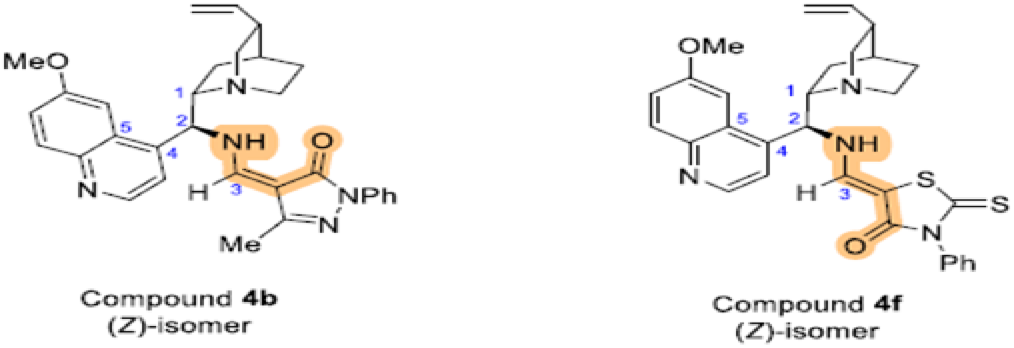
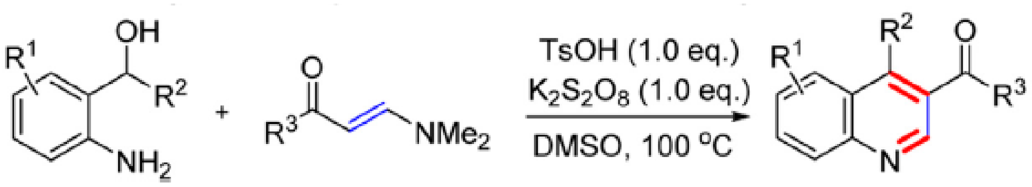


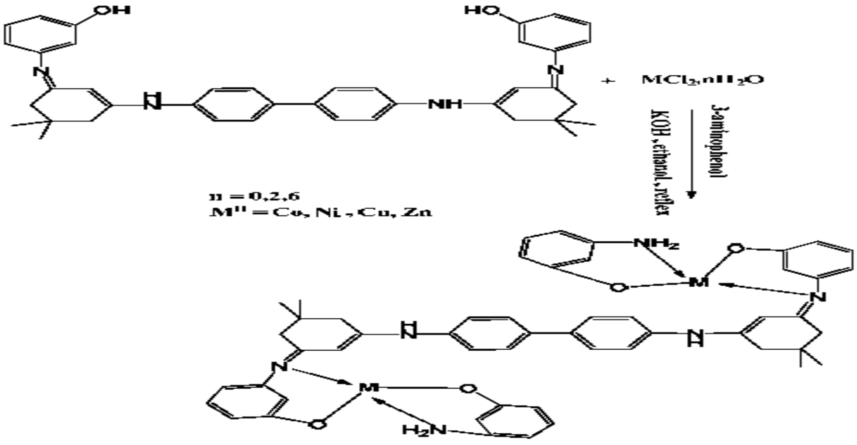
Fig. 1: Molecular structures of enaminones 4b (left) and 4f (right)

A transition-meta1-free technique for constructing 3-sub-stituted or 3,4-di-substituted quinolinyl from widely accessible N, N - di-methyl enaminones and o-amino benzyl alcohols is described. The explicit oxidant cyclol condensation route stands a comprehensive range of functional groups, admitting for the capable preparation of different quinolinyl in reasonable to appropriate product. During the oxidative cyclization route, a C(sp^3) - O bond cleavage, a C= N bind, and a C=C bond creation arise, and a mechanism has been postulated. Finally, we established an effortless technique for the preparation of 3- substituted or 3,4- di-substituted quinolines with adequate to good products utilizing wide accessible N, N- di-methy1 enaminones, and o-aminobenzy1 alcohols supported by Ts OH /$K_2S_2O_8$. This direct oxidative cyclocondensation route improved the approach for synthesizing quinolines from o-aminobenzy1 alcohols [30], Scheme 10.



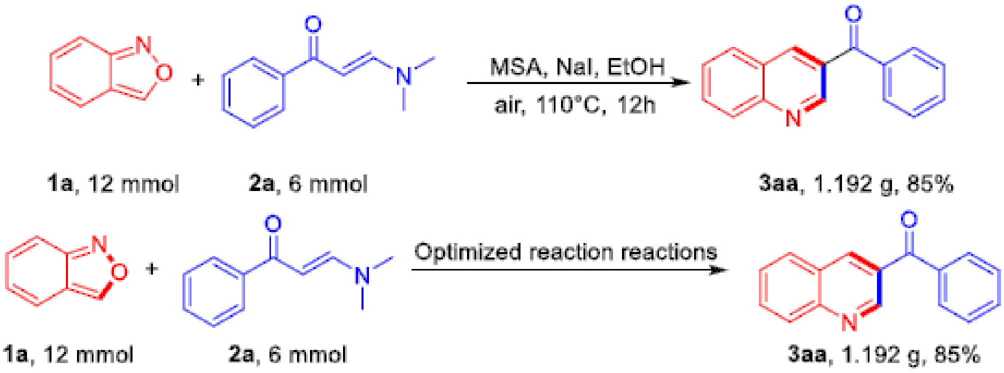
Scheme 10: Synthesis of quino1ines from β-enaminones

This research involves synthesizing one ligand and then complicating it with meta1s. The ligand (L_3) was created by combining the ligand (L_1) with 3-aminopheno1, rubbing it, and then melting it. Complexes of cobalt, nickel, copper, zinc, and cadmium ions with (L3) and 3-aminophenol were prepared by reacting meta1 salts with (L_3) and 3-aminophenol in ethanol. Physical and spectroscopic techniques of the fashioned ligands and complexes, such as electrical conductivity, magnetic sensitivity, melting points, UV-Vis spectrum, infrared (FTIR), and nuclear magnetic resonance spectra of the proton and carbon ($_1$HNMR), were used to establish the structures' validity (^{13}C-NMR) [31], Scheme 11.



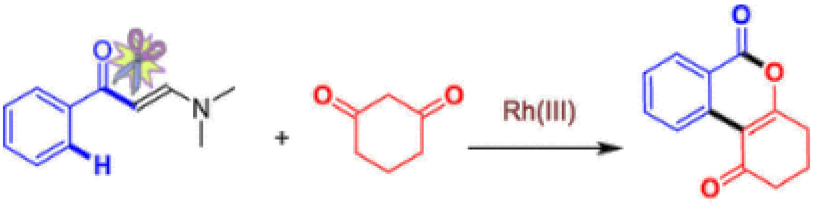
Scheme 11: Preparation of mixed 1igand (L^3) complexes

The aza-Michae1 additive and intramolecu1ar annu1ation of enaminones with anthranilic has been established as a ion - technology for the preparation of 3-acyl quinolones. Methanesulfonic acid (MSA) and sodium iodide (Sodium iodide) are also important components of the process. This ring-opening/reconstruction process is easy to use, wide substrate range, offers high products, and is very efficient. Finally, under transition metal ion-free conditions, a gentle and efficient mechanism for the preparation of a wide range of 3-acyl quinolines has been developed. By intra-molecular annulation and aza-Michael addition, the process made effective use of a range of enaminones and anthranils, giving a series of 3-acyl quinolines. Investigations of the mechanism indicated that there was no radical step in the pathway. It was noted that MSA and NaI were critical to the success of the transformation [32], Scheme l2.



Scheme 12: Gram-scale reaction

Via Ru $^{(III)}$ - catalyzed C–H bond stimulation and successive intra-molecular C–C cyclization of β-enaminones and 1, 3 -di-carbonyl products, iso-coumarins were prepared. With a wide range of materials with high functional mass tolerance, selective cleavage of the enaminone C-C bond, and mild reaction conditions the synthetic protocol has been characterized. By reacting with $PhI(OAc)_2$, 1,3 –di-carbonyl products can generate in situ iodinium as a carbene precursor for the preparation of multi-cyclic scaffolds where bioactive skeletons and synthetic precursors have been prepared useful as an application of this method [33], Scheme l3.



Scheme 13: Synthesis of isocoumarins

Complexes (Mix ligand) formula [(M)(L_1)(8.h.q)] were prepared where (L_1) represents a new ligand of β-enaminone and (8. h.q) represents (8-hydroxyquinoline) and (M) represents the ions of the following transition elements [Ni (II), Cu (II), Co (II), Zn (II) and Cd (II)]. The prepared products were diagnosed by various Devices, including; FT/IR, ^{1}H/ ^{13}C NMR, Uv/Vis, and CHNS, and through the results of the measurements, it was concluded that the ligand binds with metal ions by O and N atoms outside the ring, that is, it behaves like a bi-dentate ligand [34] , Fig. 2.

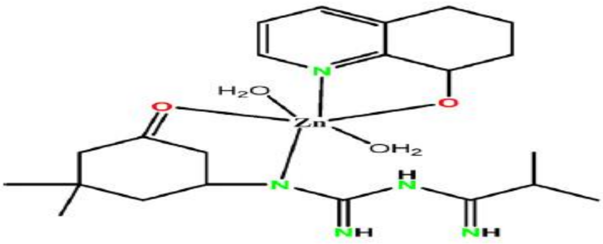


Fig. 2: Structure of Zn complex

3. Diverse applications of β-enaminone ligands and their metal complexes

3.1. Anti-cancer activity and docking studies.

Green chemistry and a stereospecific synthesis route were used to create (Z) - enaminones (amide substituted) as potential Pl$_3$K inhibitors and breast cancer medicines. Competitive EL1SA was used to evaluate Pl$_3$K inhibition. The anticancer potentia1 was evaluated using a panel of cancer cell lines including MCF-7 (breast cancer), G-36l (skin cancer), and HCT ll6 (colon cancer). In the Pl$_3$K experiment, 2(c and f) were indifferent to the suggested inhibitory activity, as shown by the obtained IC$_{50}$ (>1.0 M). The 1C$_{50}$ range (0.05 M) revealed that compounds 2a, 2b, and 2d have excellent activity potential, but compounds 2e and 2i have a moderate action potential 1C$_{50}$ (0.l and 0.25) respectively. The docking study suggested that the hydrophobic interactions in the Pl3K binding small were completely overpowered by the binding attraction of the extremely powerful ligands (2a, 2d, and 2b: Ki = l8.l6, 56.l4 and 84.87 nM, respectively). The antipro1iferative activity dominance of chosen complexes (2a, 2b, and 2d) against MCF-7 was indicated by MTT test findings. The comparative activity of 2a, 2b, and 2d were equivalent to those of the standard, doxorubicin, at 84.56, 80.87, and 90.l2 percent, respectively (82.l6 percent). SAR tests revealed that (Z) - enaminones (amide substituted) are effective inhibitors of PI$_3$K for the treatment of breast cancer [35], Fig. 3.

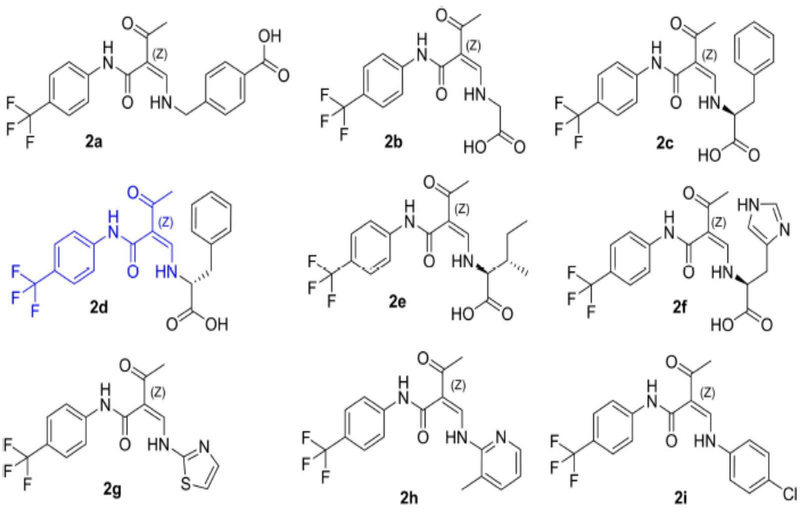


Fig. 3: The structure of (Z) - enaminones (amide substituted)

The two compounds novel enaminone (PFA) and Cadmium complex (PFA-Cd), were prepared and the results of the measurements were very consistent with their composition through their diagnosis with various devices: FT-IR, UV-Vis, ICP/AES, TGA, ^{13}C,^{1}H/NMR and MS. In addition, the ligand and its complex were examined to determine their toxicity against (MCF-7). As an anti-cancer agent compared to PFA-Cd, it was found that PFA was more active. To find the dominant binding pattern of the synthesized compound in the vicinity of the DNA double helix structure, molecular docking studies were performed. By calculating its toxicity to (MCF-7), the anticancer potential of the new enaminone and its cadmium compound was estimated **[36]**, **Fig. 4**.

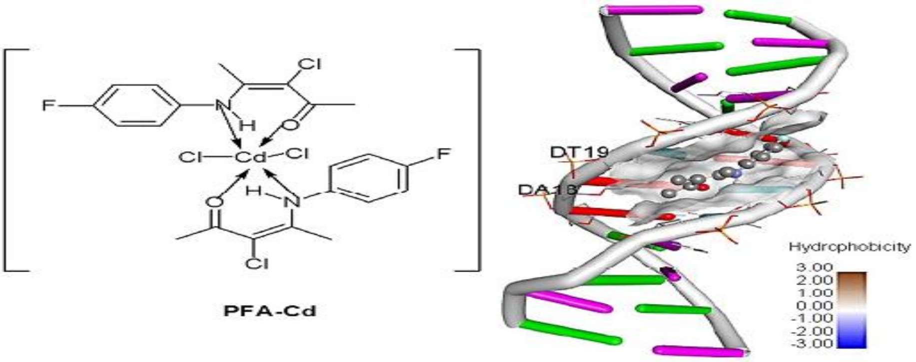


Fig. 4: synthesis of the Enaminone complex PFA-Cd

Metal complexes were prepared through the interaction of the new ligand [3- chloro -4- ((4-methoxy phenyl) amino) pent -3- en -2- one (PA)] with metal ions Co (II), Cd(II) and Mo(0), which were diagnosis by various devices such as ^{1}H, ^{13}C / NMR, UV/Vis, FAB-MS, TGA, ICP-OES and FTIR. The ligand binds to metal ions through the N atom of the NH_2 group and O of the CO group, i.e., it behaves like a bi-dentate. Tests of cytotoxic and urease inhibition activities were also conducted for the prepared compounds, where the metal complexes showed an octahedral geometric shape. The Co (II) compound (PA-Co) is additionally important compared drug thiourea as a reference, as the results of the studies showed. When studying the cobalt complex on MCF-7, Toxicity analysis showed that the compound has a higher toxicity result than the enaminone compound and the other complexes. To find out the putative binding mode within the target protein, molecular docking simulations were performed **[37]**, **Fig. 5**.

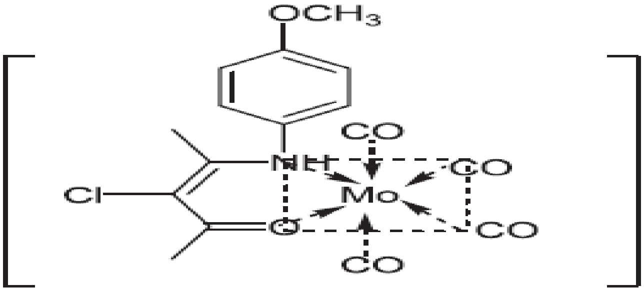


Fig. 5: Synthesis of Metal Complexes

The amount of education investigating the anti-cancer actions of (NPEs) N – propargylic-peta-enaminones is incomplete despite enaminone being a significant structural metal created in a change of pharmacologically active compounds. On human breast cancer cells the cytotoxic and apoptotic properties of twenty-three diverse NPEs were studied. By MTT assay, cytotoxicity was measured, and by flow cytometry, cell cycle distributions and apoptosis were studied. It showed positive deliveries in cancer cell (breast) identified by ADME and NPEs analysis which means low unfractionated values, good lipophilicity values and high bioavailability [38], Fig. 6.

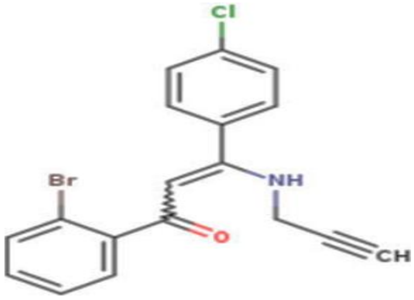


Fig. 6: Strucure of β-enaminones (NPEs 9)

3.2. Anti-urease activity

New ligands (enaminone) were synthesized: (Ac-PCA)= 3-chloro-4-(4-chloro phenyl) aminopent – 3 - en- 2 - one and (Ac-BA)= 4- (benzyl amino) -3- chloro pent – 3 - en- 2 - one with Cu (II), Co (II) and Cd (II) complexes. The antiacetylcholinesterase (AChE) and anti-urease actions of these recently synthesized compounds were explored further. The (Ac - BA) - Cu(II) complex was effective against AChE, but the (Ac - BA)$_2$ - Co(II) complex was effective towards urease. The compounds had slight or no enzyme inhibitory action. To assess their likely binding mechanism, the chemica1s were docked into acety1cho1inesterase enzymes [39], Fig. 7.

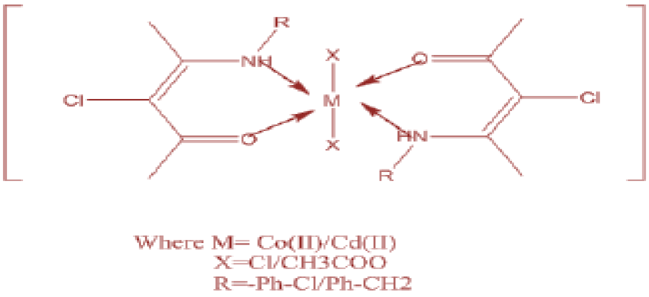
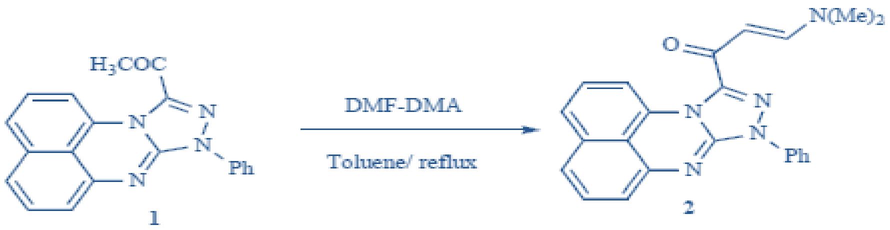


Fig. 7: Proposed structure of 6-coordinated enaminone complexes

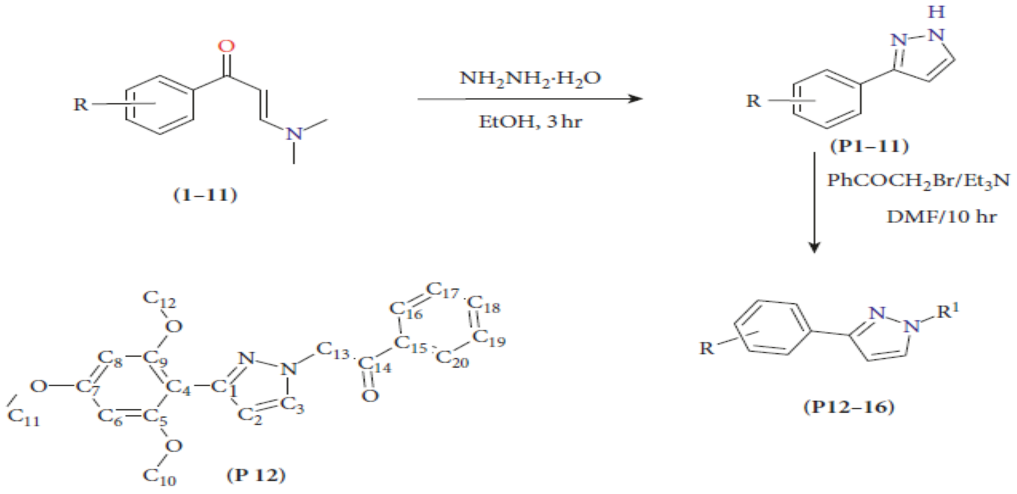
3.3. Antimicrobial activity

The compound enaminone 2, (E)-3-(dimethylamino)-l-(8-phenyl-8H-[l,2,4]triazo1o [4, 3-a] pyrimidine-10-y1) prop -2- en-l-one was synthesized, and reactions of enaminone 2 with various kinds of hydrazine hydrate or hydrazonoyl chlorides yielded new substituted pyrazoles. Enaminone was also reacted with 6- amino-2- thioxo pyrimidin -4- one to create 2-thioxo pyrido pyrimidinone derivative. Pyridotriazolopyrimidines are formed when the 1atter thione derivative combines with hydrazonoy1 ch1orides. The reaction of enaminone 2 with hydroxylamine yielded 5-(8-Pheny1-8*H*-[l,2,4]triazo1o[4,3-a]perimidin-10-yl) isoxaz ole. The structure of the new perimidine-derivatives was validated using spectroscopic and CHNS. The anti-bacterial activity of enaminone and freshly synthesized compounds was examined, and the findings indicated that certain derivatives are more effective than the reference medications uti1ized **[40]**, **Scheme l4**.



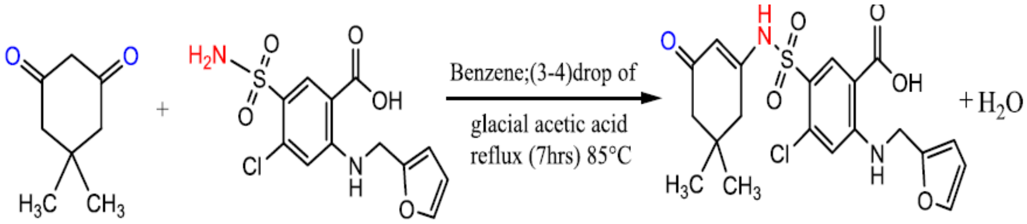
Scheme 14: Synthesis of enaminone 2

Several pyrazoles generated from alternative enaminones were synthesized and tested for antibacterial activity. The antibacterial effectiveness of the produced compounds was originally tested against ATCC- 6538, NCTC- 10418, NCTC- 10400 and ATCC- 27853. Compounds (P1, P11 and P6) showed considerable antibacteria1 activity in the disc diffusion experiment during first screening. These compounds were tested for anti-bacterial effectiveness at various time periods and offered considerable action for 6 hrs. Gram-positive bacteria were found to have higher +e activity. At 24 hrs., however, the activity was only identified against (G+) bacteria, except (P11), which demonstrated antibacterial effectiveness towards kinds of bacteria. P11 had the greatest antibacteria1 efficacy alongside both (G+) and (G-) bacteria **[41]**, **Scheme 15**.



Scheme 15: Synthesis of products (P1–P16)

Complexes (mixed ligand) $[M(L_1)(Q)]$ and $[M(L_1)(Q)Cl_2]$ were prepared where (L_1) represents a new ligand of β-enaminone and (Q) represents (8-Hydroxyquinoline) and (M) represents the ions of the following transition elements; Ni (II), Co (II), Pt (IIII), Cd (II) and Pd (II). The prepared products were diagnosed by various devices, including FT / IR, (^1H / ^{13}C NMR, UV / Vis, and CHNS), and through the results of the measurements, it was concluded that the complexes octahedral geometry except Pd (II) complex was square planar. The effectiveness of the prepared compounds was studied against specific types of microorganisms, such as Escherichia coli, Staphylococcus aureus, and Candida albicans, where the complexes showed higher effectiveness than the prepared ligand **[42]**, **Scheme l6**.



Scheme 16: Synthetic route for the ligand $[H_2L_1]$

Complexes (mixed ligand) $[(M)(L_1)(3ph)]$ were prepared where (L_1) represents a new ligand of β-enaminone and (3ph) represents (3-amino phenol) and (M) represents the ions of the following transition elements [Co (II), Ni (II), Cu (II), Zn (II), and Cd (II)]. The prepared compounds were characterized by various devices, including (FT/IR, ^1H / ^{13}C NMR, Uv / Vis and CHNS), and through the results of the measurements, it was concluded that the ligand binds to the metal ions through the oxygen and nitrogen atoms, that is, it behaves like a tetra-dentate ligand. The prepared compounds were compared with the antibiotic ciprofloxacin after their effectiveness towards microorganisms, as the biological activity of these compounds was good **[43]**, **Fig. 8**.

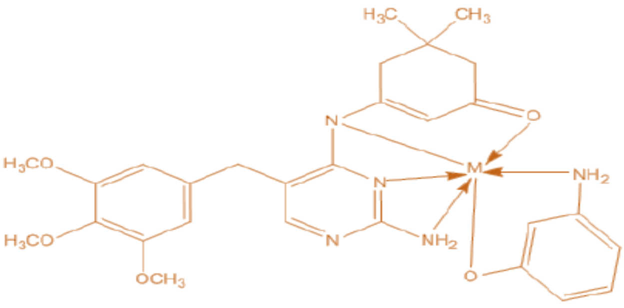
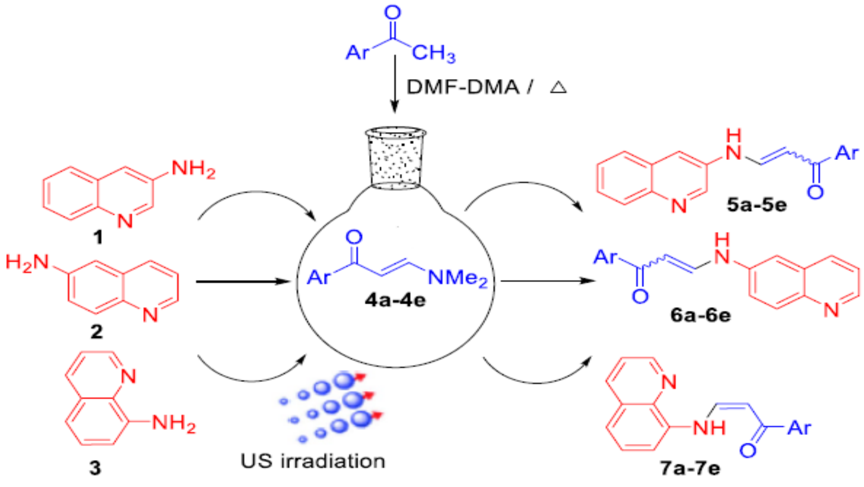


Fig. 8: Proposed structures of complexes

3.4. Anti-malarial activity

A new range of side chain-modified beta-aminaminone quinolines have been synthesized in good to excellent yields. The geometry of all the prepared compounds was inferred through spectroscopic, X-ray crystallographic, and analytical data. The effectiveness of the prepared compounds against malaria was tested against the chloroquine-sensitive strain $^3D_7$ and the chloroquine-resistant strain K_1. Using ivermectin as a positive control, the prepared products were calculated aimed at their in vitro effect on microfilariae & adulticide towards adult helminths and B. malayi microfilariae **[44]**, **Scheme l7**.



Ar = C_6H_5, 4-$CH_3C_6H_4$, 4-$CH_3OC_6H_4$, 4-ClC_6H_4, 4-BrC_6H_4

Scheme 17: Synthesis of quinoline β-enaminones

3.5. DFT Studies

Via thermally activated O-quinomethide, the study shows the preparation of enaminone-resorcin. All enaminone units in the state (solid) share a uni-directional line of twelve intra-molecular H-bonds that form about the cavity shown in the crystal structure. Control by temperature and solvent in the solution where the enaminone-resorcin arene is present as a mixture of substances conforming to the distribution. Using the DFTB / GFN2 –x TB method and the fast semi-empirical DFT B3LYP/6-31G (d, p) method in different solvents, the results of theoretical calculations were compared with experimental data **[45]**, **Fig. 9**.

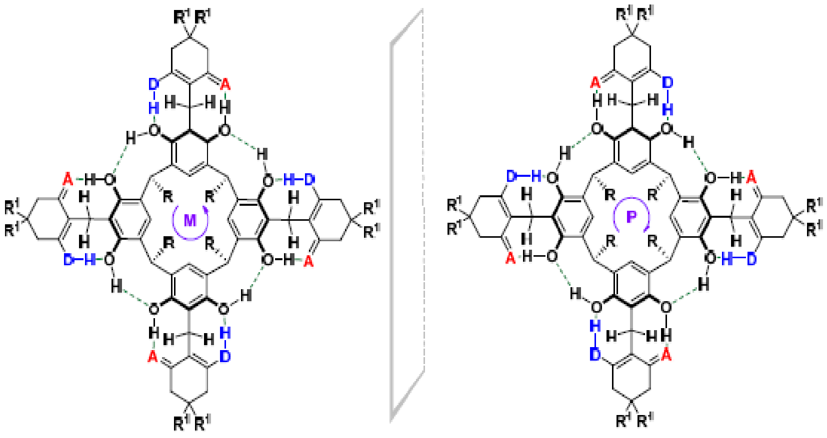
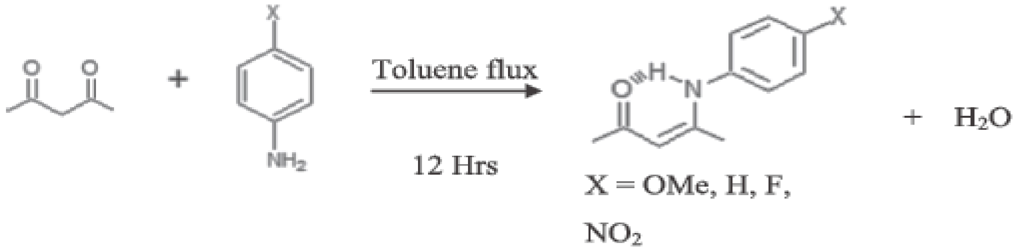


Fig. 9: Enantiomers (P and M) of β-enaminone derivatives

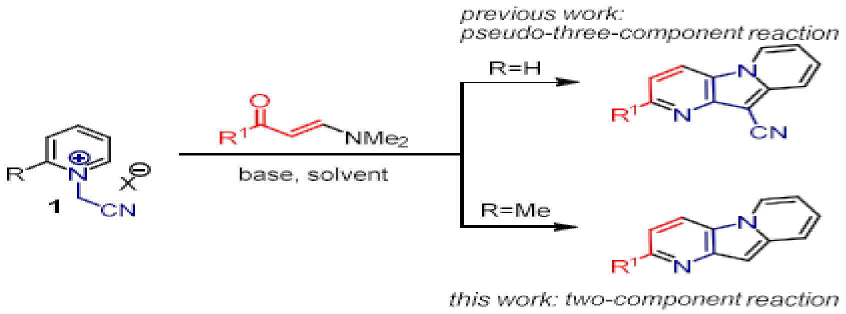
3.6. Optically luminescence

By the method of the condensation reaction of four aromatic amines with acetylacetone in acidic media, β-enaminone compounds were prepared. To explore the luminescent emission on organic solids, optically stimulated luminescence was used. B-Enaminones from the type of organic crystals showed good sensitivity to beta radiation. Optically stimulated luminescence was also recorded for these crystals **[46]**, **Scheme 18**.



Scheme 18: Synthesis of organic crystals-enaminones

Pyridinium y1ides are widely known as cyc1oaddition reaction dipoles. In turn, instead of a l,3-dipolar cycloaddition, the microwave-abetted collaboration of N - (cyanomethy1)-2-alkyl pyridinium - salts with β-enaminones incomes as a chain (domino) of cyc1oisomerization and cyc1ocondensation processes. The reaction occurs in the existence of a base (NaC_2H_5) and uses safe solvents. The optical characteristics of the resultant pyrido [2, 3 -b] indo-lizines were investigated, and it was discovered that they emit green light with high fluorescence quantum yields **[47]**, **Scheme l9**.



Scheme 19: General plan of work

By luciferase assay, the activity of fifteen quinolin beta-enaminone derivatives towards amastigotes and promastigotes (Leishmania) was studied. By Giemsa staining in hamsters and BALB/c mice infected with L. donovani, reduction of organismal parasite burden was assessed. By means of scintillation and fluorescence assays, the level of intracellular ATP and Ca^{2+} was determined in the activated 3D-treated promastigotes. The 3D compound could be nominated as a promising therapeutic candidate for visceral leishmaniasis due to its inhibition of the L. donovani mitochondrial complex to the extent of apoptosis **[48]**, **Fig. 10**.

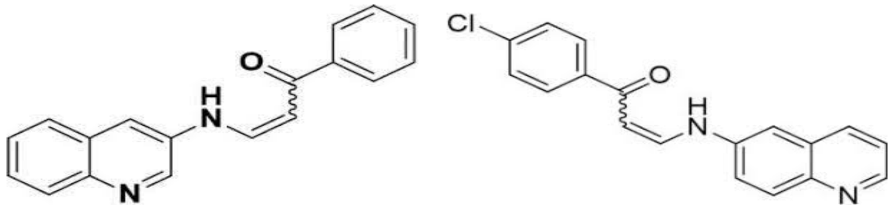
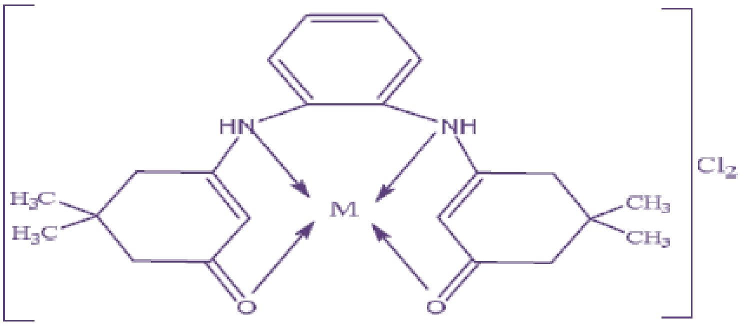


Fig. 10: Structure of quinolinyl β-enaminone derivatives

3.7. Corrosion inhibition

Through the reaction of (dimedone) and (1,2-phenylenediamine), the β-enaminone ligand was prepared, which in turn reacted with the ions of the transition elements Mn (II), Cd (II), Co (II), Ni (II), Cu (II), and Zn(II) to prepare complexes with the general formula M(L)]Cl_2. The prepared compounds were characterized by several spectroscopic methods, including From the results of the measurements, it was found that the ligand is tetra dentate CHNS, TGA, FTIR, UV-Vis, ^{1}H, ^{13}C /NMR. The study demonstrated the ability of the ligand to inhibit corrosion-ordinary steel in tap water by losing weight. In addition, the effectiveness of the prepared compounds against selected types of bacteria and fungi was studied by diffusion method [49], **Fig. 11**.



M=Mn(II), Co(II), Ni(II), Cu(II), Cd(II) and Zn(II)

Fig. 11: The suggested chemical structure of the complexes

3.8. Nano Studies

β-enaminones and the compounds derived from them are among the most important compounds with high biological activity. By treating aliphatic and aromatic amines substituted with acyclic/cyclic 1,3-diketones over magnetically separable $CoFe_2O_4$NPs, high yields of several β-enaminones (86-97 %) were obtained. The latter was created as a result of co-precipitation. examination validated its purity, fine crystallinity, elemental distributions, morphology, magnetic characteristics, and thermal stability. Thus, $CoFe_2O_4$ NPs were a superb green heterogeneous nano-catalyst to produce -enaminones, with strong recyclability and little activity loss [50], **Scheme 20**.

Scheme 20: Synthesis of b-enaminones catalyzed by $CoFe_2O_4$ NPs

4. Conclusions

Through this article, β-enaminone ligands and their metal complexes were identified, with a study of their different applications in terms of their role in biological activity, as antioxidants, anticancer, urease, as catalysts for some reactions, and as corrosion inhibition for some metals in acidic, alkaline, or neutral mediums, as fluorescence sensors, and DFT, Nano studies.

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