Synthesis and characterisation of ferrocenyl chalcone

A Dissertation

Submitted in partial fulfillment

FOR THE DEGREE OF

MASTER OF SCIENCE IN CHEMISTRY

Under Academic Autonomy

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

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ORISSA-769008

CERTIFICATE

This is to certify that the dissertation entitled "**Synthesis and characterization of ferrocenyl chalcone"** being submitted by Ipsita De to the Department of Chemistry, National Institute of Technology, Rourkela, Orissa, for the award of the degree of Master of Science is a record of bonafide research carried out by her under my supervision and guidance. To the best of my knowledge, the matter embodied in the dissertation has not been submitted to any other University / Institute for the award of any Degree or Diploma.

N.I.T. Rourkela.

Date: *Dr. Saurav Chatterjee*

(Supervisor)

ACKNOWLEDGEMENTS

With deep regards and profound respect, I avail this opportunity to express my deep sense of gratitude and indebtedness to Dr.Saurav Chatterjee , Department of Chemistry, National Institute of Technology, Rourkela, for introducing the present project topic and for his inspiring guidance, constructive criticism and valuable suggestion throughout the project work. I most gratefully acknowledge his constant encouragement and help in different ways to complete this project successfully.

I acknowledge my sincere regards to all staff's member, Department of Chemistry, NIT Rourkela for their enthusiasm in promoting the research in chemistry and for their kindness and dedication to students. I specially record my deep appreciation and thanks to Dr. Rupam Dinda for his encouragements, which set me on the right track.

I am also thankful to my lab mates Vijaylakshmi Tirkey, Sasmita Mishra, Sagarika Pasayat, Sumanta Patel, Saswati, Subhashree Das, and, who worked with me since last one year and to my classmates also.

Last but not the least, I remember with gratitude my family members who were always a source of strength, support and inspiration.

Rourkela

Date: (Ipsita De)

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INTRODUCTI0N

1.1. Sandwich compounds:

The sandwich complexes are organometallic compounds consisting of more than one cyclopentadienyl rings bonded to central metal atom in a variety of structural motif. Different types of sandwich compounds are known for example metallocenes, half sandwich complexes, multidecker sandwich compounds, various arene type sandwich compounds etc (Figure 1). Some of these complexes are readily synthesized and shows unique properties like electrochemical, bioactivity, catalysis and other optoelectronics properties.

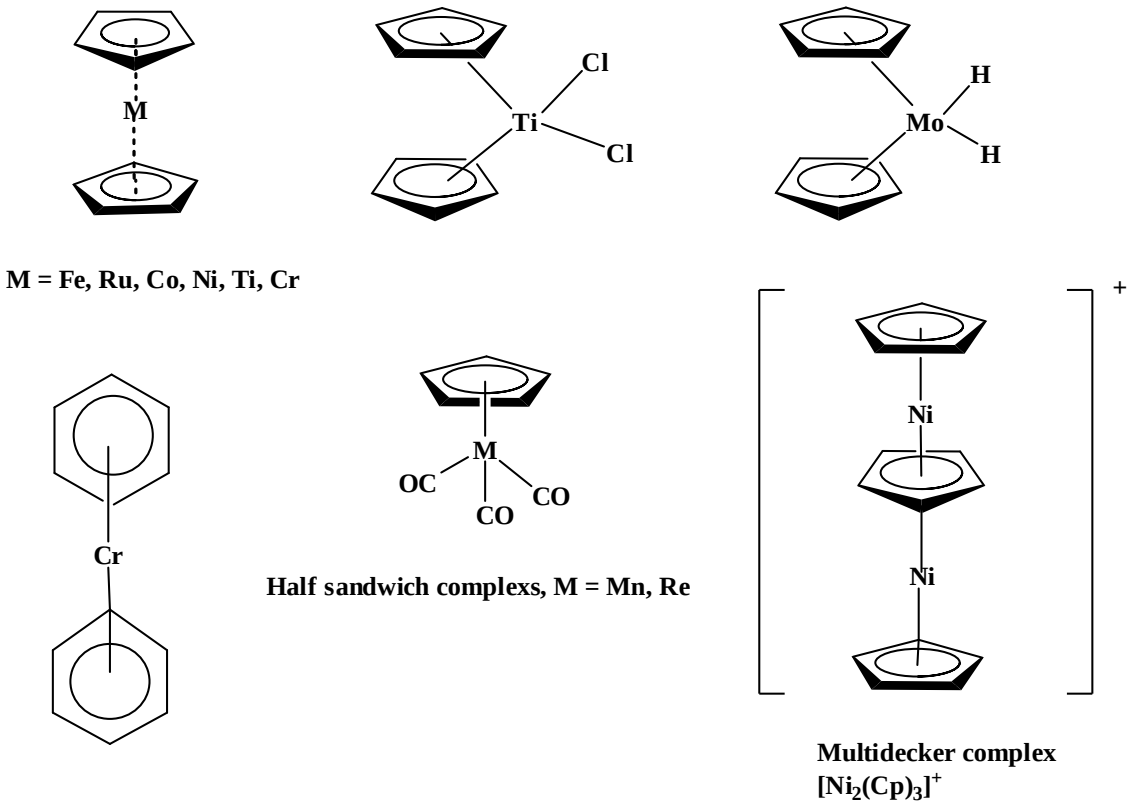


Figure 1: sandwich complexes

Several titanium based sandwich compounds, $[(\eta^5\text{-}C_5Me_4R_1)_2Ti]$, ($R_1$=iPr, tBu, $SiMe_3$, $SiMe_2CH_2CH_2Ph$, $SiMe_2Ph$, $SiMePh_2$) have been synthesized recently by different research

groups as shown in Figure 2.[1,2] These titanocene compounds have 1,1'-disubstituted groups attached to each of the cp rings and has been used for the synthesis of other organometallic sandwich compounds.

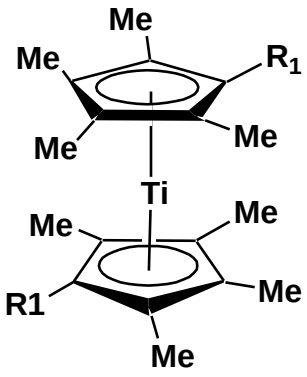
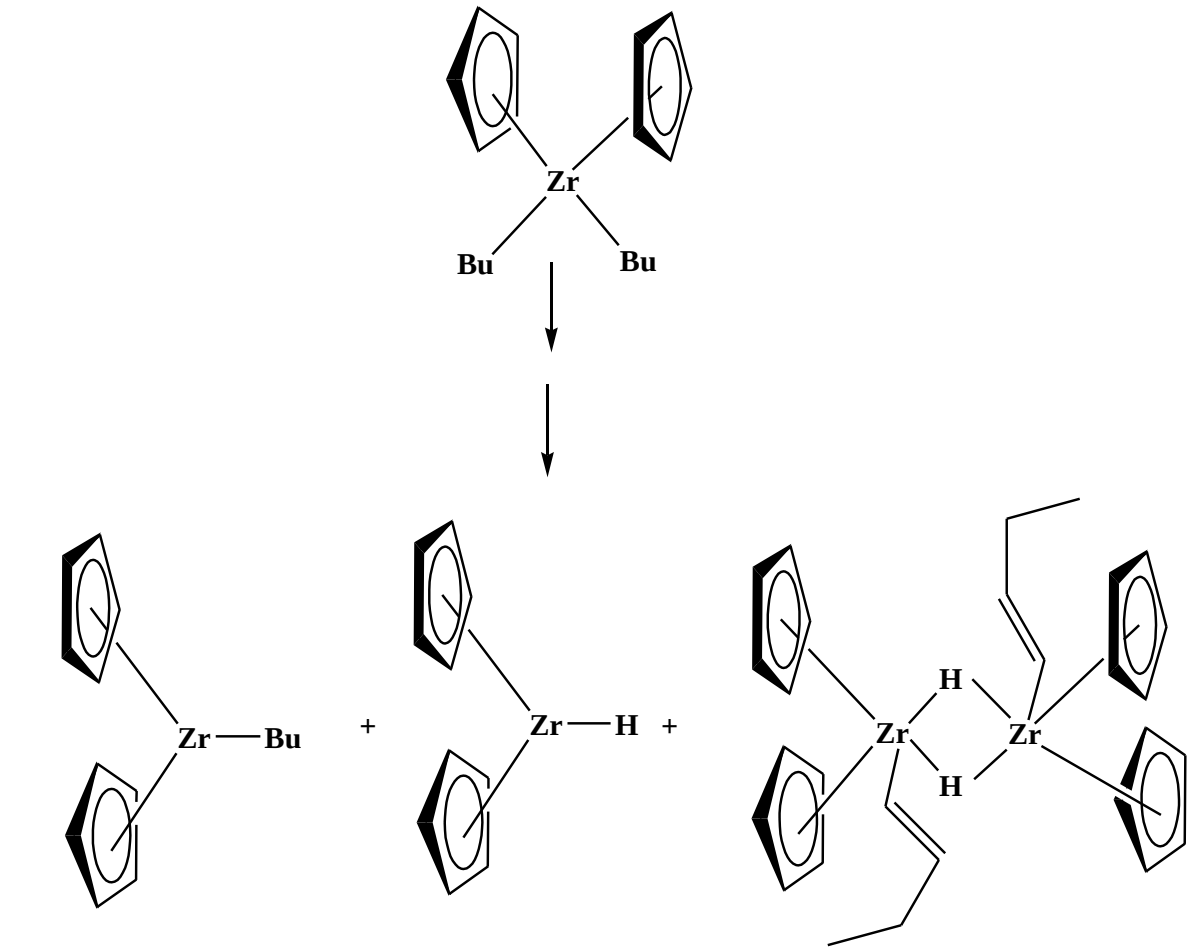


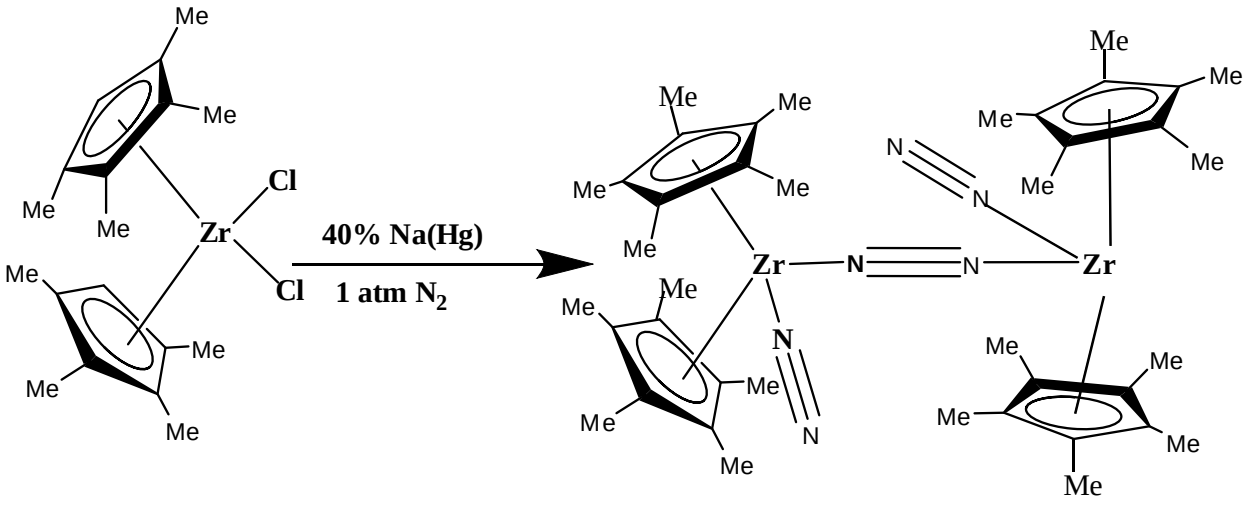
Figure 2: $[(\eta^5\text{-}C_5Me_4R_1)_2Ti]$ (R_1=$SiMe_3$,$SiMe_2CH_2CH_2Ph$,$SiMe_2Ph$,$SiMePh_2$)

Zirconocene sandwich compounds have found widespread application as a two-electron reductant in several organic synthesis.[3] Dioumaev and Harrod reported the addition of n-BuLi to $(\eta^5\text{-}C_5H_5)_2ZrCl_2$ in the absence of any substrate leading to the formation of $[Cp_2Zr(n\text{-}Bu)_2]$ which subsequently affords paramagnetic butylzirconocene(III), zirconocene(III) hydride and diamagnetic butenylzirconocene(IV) hydride dimer in multistep reaction.[4] (Scheme 1).

When $[(\eta^5\text{-}C_5Me_5)_2ZrCl_2]$ reacted with sodium amalgam reductase under an atmosphere of N_2 it produces a dinitrogen complpex, $[(\eta^5\text{-}C_5Me_5)_2Zr(\eta^5\text{-}N_2)]_2(\mu_2, \eta^1, \eta^1\text{-}N_2)]$. Treatment of the Zirconium-dinitrogen complex with mineral acid results in the formation of free hydrazine.[5] (Scheme 3)



Scheme 1



Scheme 2

1.2 FERROCENE CONTAINING COMPOUNDS :

Ferrocenyl compounds have been extensively studied in recent years and it is gaining research importance as a substituent in medicinal chemistry due to some of its unique properties and stability. These compounds illustrate anticancer, antimalarial and other biological activity due to lipophilicity and electronic effects and other interesting properties of the ferrocene ring associated with the substitutents. Recently a groups of ferrocenyl chalcones related with aromatic and polycyclic compounds such as ferrocene[6], naphthalene[7] and anthracene[8] are studied because these systems were designed in order to modulate the electrochemical and optical properties of the polycyclic moieties by the electron donating ferrocenyl group through the enone linkage (Figure 3)

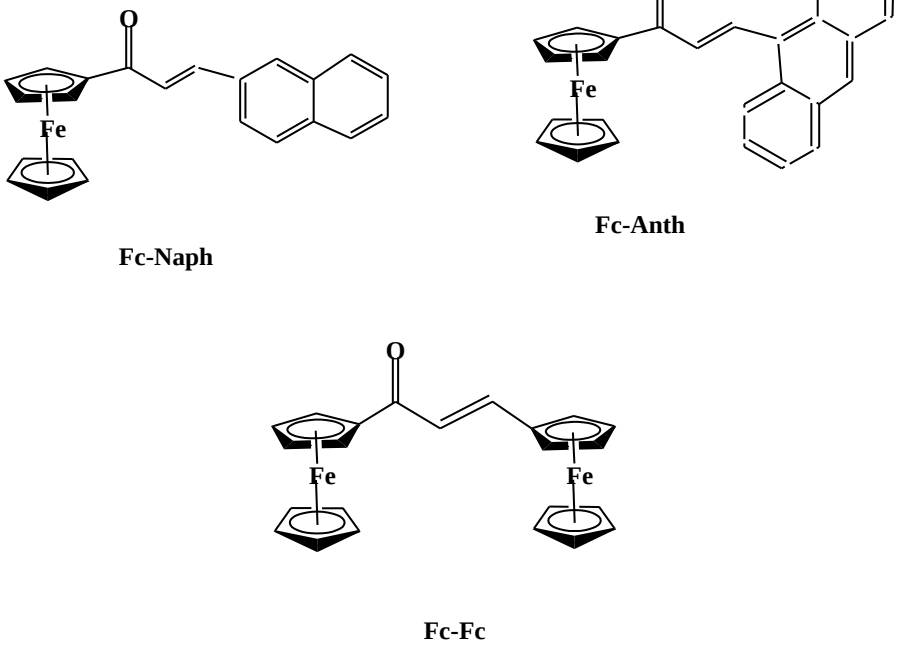


Figure 3

The optical properties of the naphthalene and anthracene moieties were quenched by the ferrocenyl moiety which acts as a quencher[9]. Some ferrocenyl derivative have been reported to show interesting electrochemical and spectroscopic properties[,10].

Ferrocene skeleton is extensively applied in biological systems and it is used in the design of drugs because of being readily recognized by amino acids, proteins, DNA, and carbohydrates in

vivo[11]. Ferrocene-related organometallic compounds are active to hamper the proliferation of many kinds of tumor cells. Ferrocene is incorporated because it may be combined with organic moieties to form conjugation and non-conjugation systems. As for example, ferrocifen can be prepared by replacing one benzene ring in tamoxifen, in which the cyclopentadienyl ring (Cp) forms a conjugation system with other benzene rings[12,13]. On the other hand, in ferrocene cyclopentadienyl (Cp) ring can connect with the carbon chain in chloroquine to generate ferroquine where the ferrocenyl moiety forms a non-conjugation system in ferroquine[14,15].

1.3 CHALCONES:

Chalcones [(Ar–COCH=CH–Ar')] are the aromatic ketone and also an enone which forms the central core for a variety of important biological compounds. Chalcones are present in nature as precursors of flavionoids and it is also considered as precursors of isoflavionoids[16] Chalcone functionating group present in some derivatives of flavionoids (Figure 4).

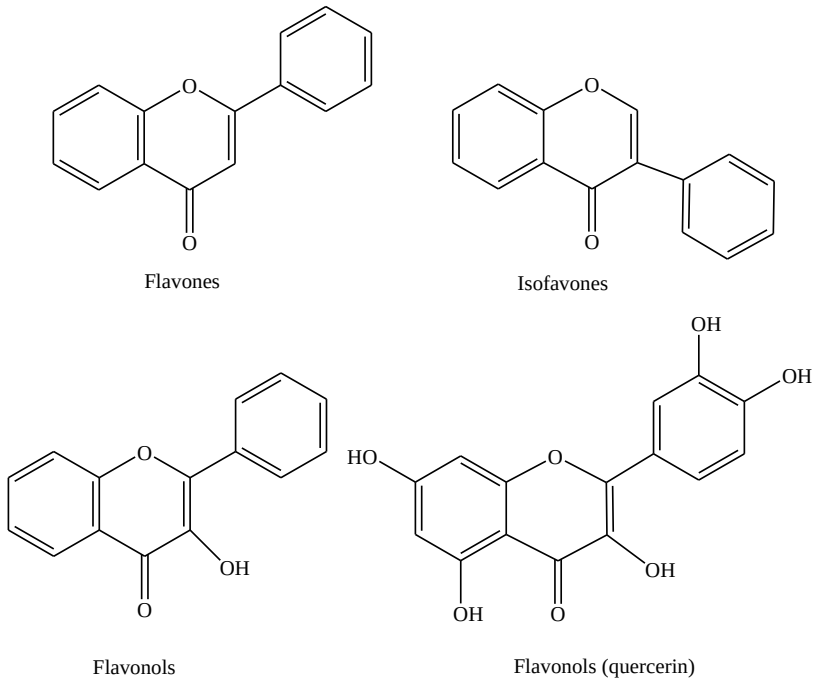
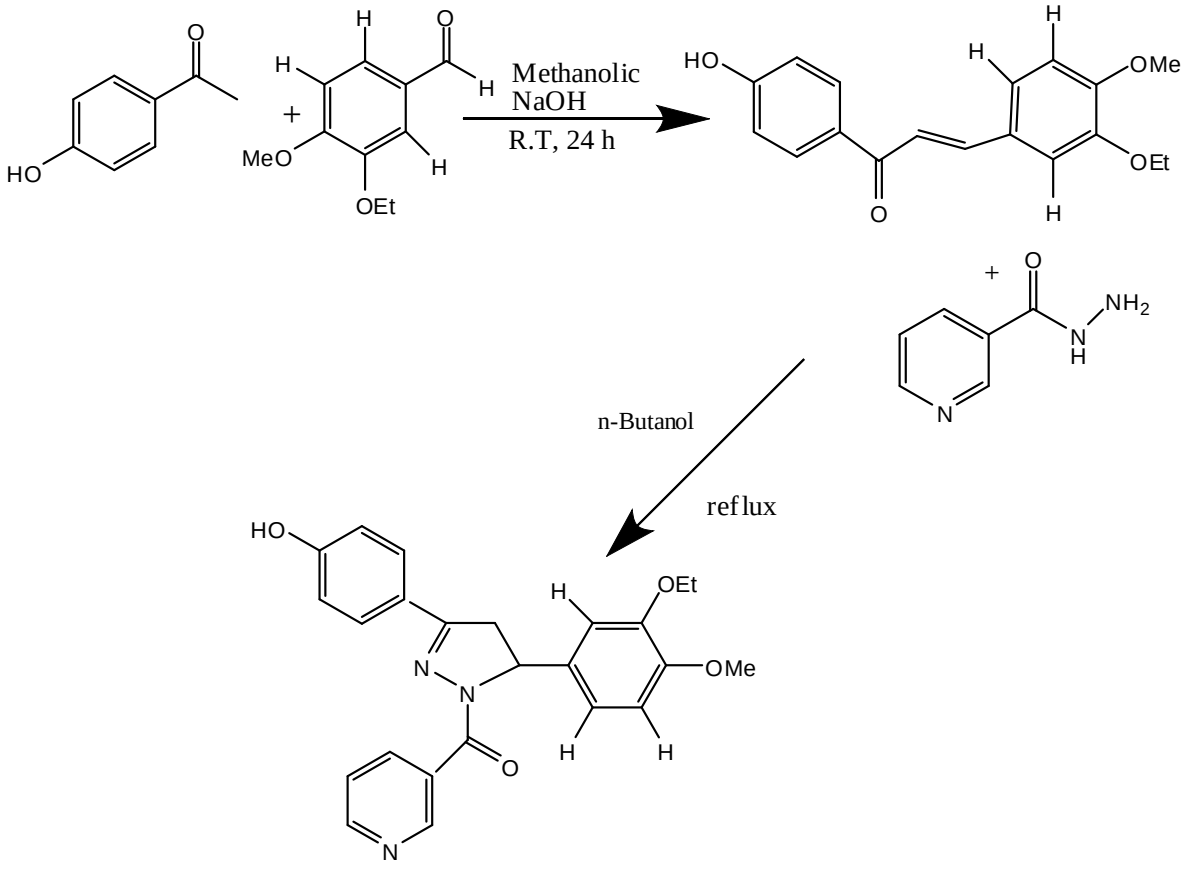


Figure 4 Chalcone containing compounds

Chalcones are readily synthesized in the laboratory by various synthetic methods. Structural modification of chalcone template can be readily achieved. Chalcones are present in edible plants and constitute one of the major classes of natural products with wide range distribution in fruits, vegetables, tea and soy based food stuff[17]. Recent investigation shows that chalcones have been subjects for their interesting biological activities[18,19]. The main functions of chalcone are purifying blood, strengthing immune system, monitors cholesterol level, regulates blood pressure, prevents thrombus, suppress acid secretion, prevent cancer and promotes metabolism.

Most of the chalcones are prepared by the condensation of ketone with aromatic aldehyde following Claisen–Schmidt reaction[20.]

Recently some research groups prepared some chalcones compounds which are very reactive to nicotinohydrazide.resulting 1, 3, 5-trisubstitutedpyrazoline which show potential anti malarial activity of malaria parasite (Scheme 3). [21]



Scheme 3

1.4 Ferrocenyl chalcones

Ferrocenyl chalcones belong to a chalcone family in which one or both the aromatic group is substituted by the ferrocenyl unit. Some Ferrocenyl chalcones have been synthesized recently and shows a variety interesting properties due to the linking of ferrocenyl moiety to the chalcone framework.. Recent reports shows that. some ferrocenyl chalcones has been used as ligands leading to the formation of Hg complexes. These complexes showed interesting uv-visible spectroscopic properties (Figure 5).[22]

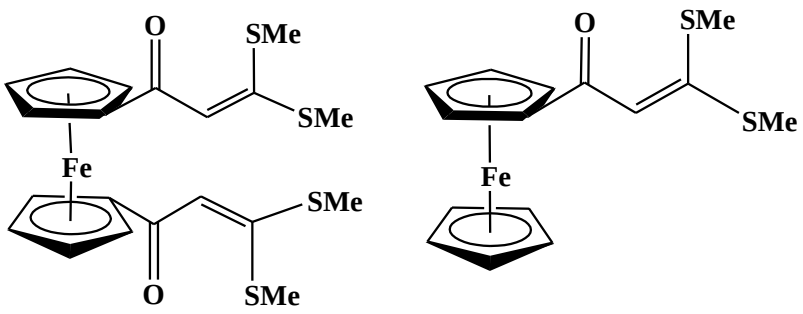


Figure 5

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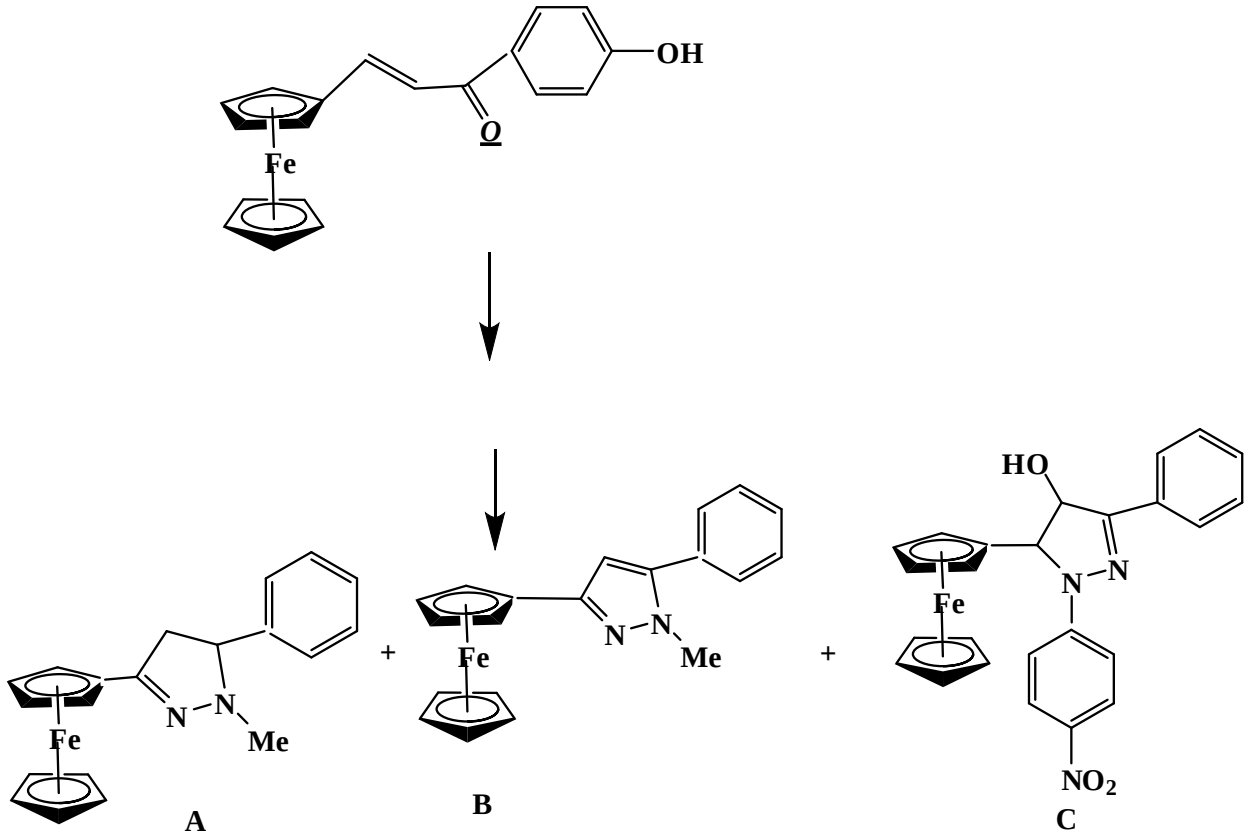
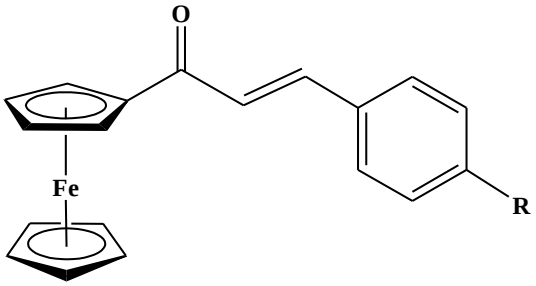
Like chalcone, ferrocenyl chalcone also very sensitive, resulting 3-ferrocenyl-pyrazole, 3-ferrocenyl-pyrazoline, and byproduct (scheme 4).[23]



Scheme 4

Recently ferrocenyl chalcones containing N-ethyl carbazole moiety has been reported by Dong-Young Noh which is designed to modulate the electrochemical and optical properties of the polycyclic moieties by the electron donating ferrocenyl group through the enone linkage[24] .

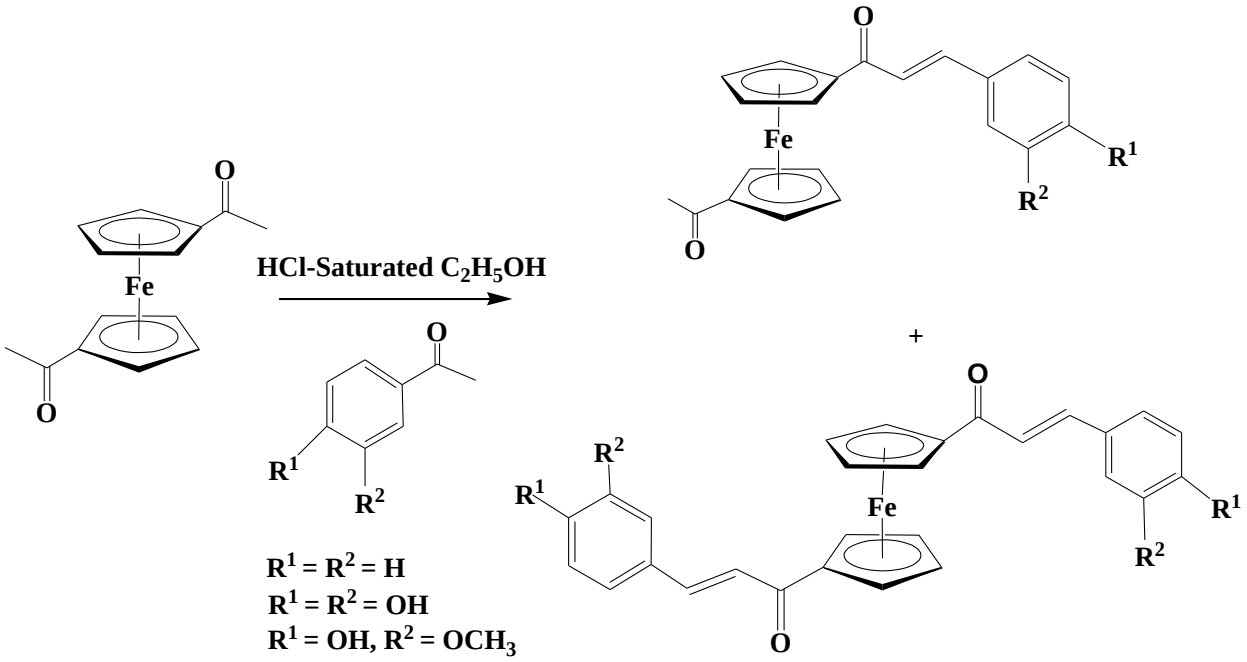
Several other ferrocene-containing chalcones [Fc-CO-CH=CH-C_6H_4] (R = OCH_3, CH_3, Ph, *t*Bu, H, Br and CF_3) has been investigated based on their electrochemical and spectroscopical behavior as well as with DFT calculations (Figure 6). These compounds were prepared by Claisen-Schmidt condensation of acetylferrocene and the appropriate benzaldehyde derivative under room temperature stirring condition. The redox potential of the Fc/Fc^+ couple depends on the electronic properties of the ligands which are being bonded to the cyclopentadienyl rings[25].



R = OCH_3, CH_3, C_6H_5, ^tBu, H, Br, CF_3

Figure 6

Synthesis of disbstituted ferrocenyl chalcones have been carried out by the condensation of 1,1′-diacetylferrocene with benzaldehyde, vanillin, and protocatechualdehyde, respectively, to produce 1,1′-dicinnamoylferrocene, 1-acetyl-1′-(*m*-methoxyl-*p*-hydroxyl)cinnamoylferrocene (VAN-1), 1,1′-bis(*m*-methoxy-*p*-hydroxy)cinnamoylferrocene (VAN-2), and 1-acetyl-1′-(*m*,*p*-dihydroxy)cinnamoylferrocene (PCA-1) (Scheme 5).



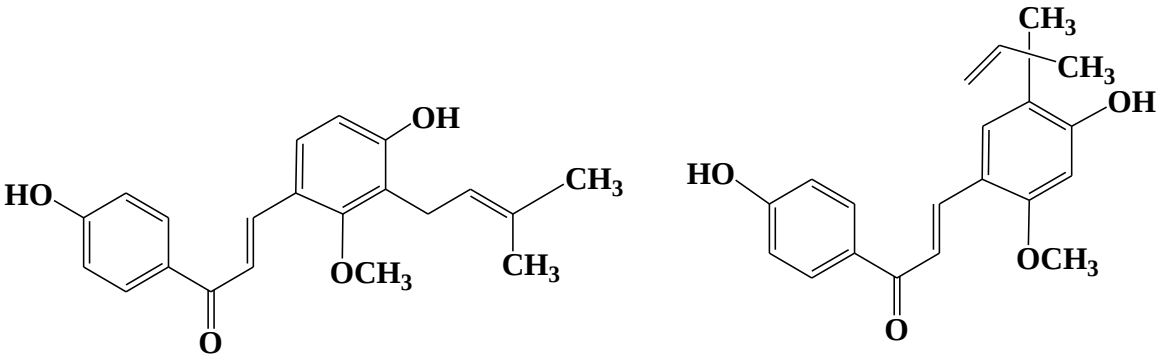
Scheme 5. Derivative of ferrocenyl chalcone

1.5. BIOLOGICAL ACTIVITIS:-

1.5.1. ANTI-BACTERIAL ACTIVITY

Chalcones are known to show substantial antibacterial activity[26]. Many research groups are engaged to identify the structure of chalcones that possess antibacterial activity,or synthesized or modified natural chalcones. Among the retro-chalcones licochalcone A and licochalcone B showed potent antibacterial activity especially to Bacillus S ubtills, Micrococcus luteus, Staphylococcus aureus. Tsukiyama et. al. first reported the bacterial effects of licochalcone A[27].

It was shown by MICs of 2-15µg/ml for gram positive bacteria including spore forming bacteria like (the genera Bacillus coagulans,B.subtills and Bacillus sterothermophilus=>MIC =2µg/ml[28];toxin producing bacteria such as Bacillus cerous MIC=3µg/ml).The antibacterial activity of licochalcone A was defiant to 800 to 120^0c for 15 minutes,and it is stable at pH 5.0 to pH 7.0[29]. It was reported that licochalcone A shows antibacterial activity in the presence of 3% (wt/vol) NaCl. According to Friis-Moller and calleagues, at concentration of 1-2 mg l^{-1} the licochalcone A repressed the growth of Legionella pneumophila, Legionella wardsworthii, Legionella bozemanii, Legionella dumoffi ,Legionella feelei. It was recorded that free hydroxide on 4th position of the ring was necessary for the anti bacterial activity[30].



Licochalcone C **Licochalcone A**

Figure 7

1.5.2. ANTI-LEISHMANIAL ACTIVITY:-

Leishmaniasis is a group of common disease which is caused by protozoan parasites belonging to the genus Leishmania. Various research work has been going on to prevent this disease. Licochalcone A is one of the naturally occurning chalcone under this investigation. Various types of diseases are caused by Laishmania majorto (skin disease).

It has been reported by Chen et.al that licochalcon A reserved the activities of nicotinamide adenine dinucleotide reduced-fumarate reductase (NADH-FRD) AND succnate dehydrogenase (SAD) in permeabilized promastigotes in a concentration dependent manner[31].

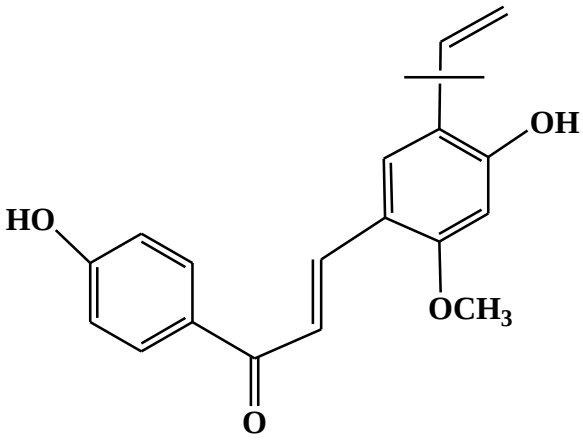
This compound also reserved the activities of SDH,NADH dehydrogenase (NAD) , SCC, NADH-NCC. In mammalion cells IC_{5o}s of licochalcone A for SDH were present 67 times higher than the IC for FRD in the parasites. The effect of Licochalcone A depends on time and concentration[32]. It is evedent that the Licochalcone A first inhibits FRD of the parasite , then it influence the parasite respiratory chain and after that it affects the function and ultra structure of parasite mitrocondria. And atlast kills the parasite. Licochalcone C helps for growthing the L. Major parasite as like as Licochalcone A. The chalcone and chloro chalcone depends on the concentration effect.It affect on the in vitro growth of Leishmania braziliensis Promastigotes and on Trypanosoma cruzi epimastigotes without any evidence of a cytotoxic effect on mouse peritoneal macrophages.

2' ,6' –Dihydroxy-4' –methoxy chalcone has an important activity in vitro against promastigotes and intracellur amastigotes of Leishmania amazonensis , with 50% effective doses of 0.5 µM/ml and 24µM/ml respectively[33].2 ,6 –Dihydroxy-4 –methoxy chalcone is very much toxic to the parasite.Various hydrochalcone derivaties were prepared by Hermoso et al.[34]

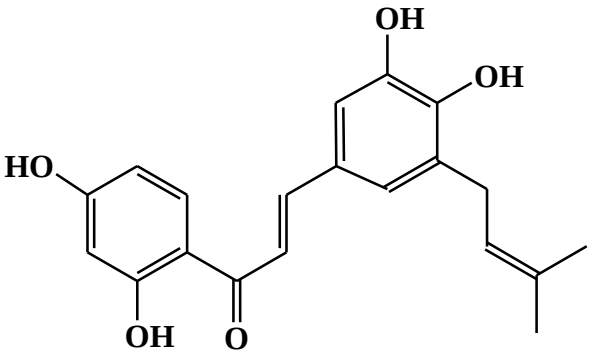
1.5.3. ANTI-MALARIAL ACTIVITY :-

It is found to be lipophilic and has electron donating entity with no hydrogen bond donor or acceptor property.The ferrous ion can undergo reversible oxidation–reduction and the nature of the substituents on the ferrocene ring has a marked influence on the antimalarial propertys.[35]

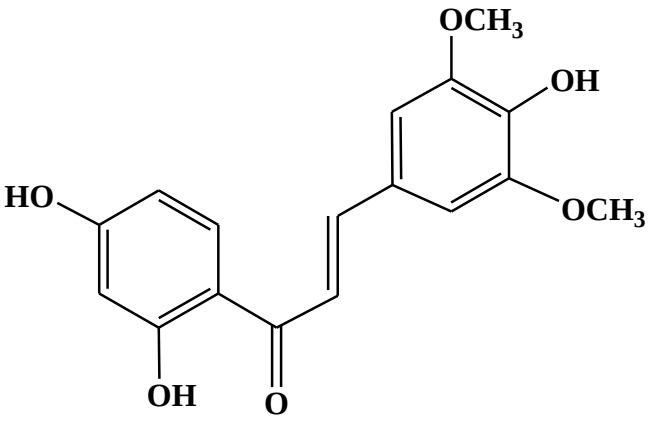
The two important human being malaria parasites are Plasmodium falciparum and P. It is seen that in a ferrocenyl compound, 'Ferroquine' synthesized by the replacement of a CH_2 group in the anti-malarial chloroquine is active against both chloroquine-sensitive and chloroquine-resistant Plasmodium falciparum, and is currently in Phase II clinical trials Chalcones have antimalarial activity, because of a Michael addition of nucleophilic species to the double bond of the enone[36,37]. It was recorded by Liu et al.[38] and Go et al. that in vitro antimalarial properties of chalcones against a strain of chloroquinine-resistant human being malarial parasite,P. falciparum was mainly resolute by the properties of ring B. Alkoxylated chalcones were more active than the hydoxylated analogues. For alkoxylated chalcones the IC_{50} value were less than 6.5 µM. The most important hydoxylated chalcone was 4-chloro-2',4'–hydroxy chalcone and its IC_{50} value was 12.3 µM against a strain of chloroquine-resistant human being malarial parasite , P. falcifarum. IC_{50} values for another few chalcones were below 20 µM. These two chalcones were found to inhibit sorbitol-induced hemolysis ofparasitized erythrocytes to an important extent at a concentration of 10µM[39].
5-Prenylbutein,licoagrochalcone A and hemobutein had in vitro antiplasmodial activity against the chloro-quine sensitive[40].



licoagrochalcone A



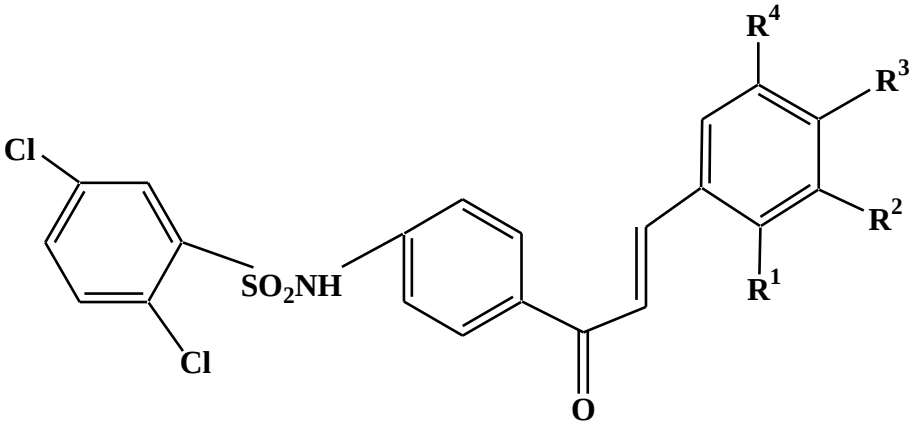
5-Prenylbutein



Homobutein

Figure 8

Many sulfonamide chalcones contains di and tri methoxy substituted groups in aromatic ring A and it showed inhibition levels of β hematin formation with IC_{50} = 0.48µM and IC_{50}=0.67.



R^1 = H; R^2, R^3, R^4 = OCH_3

R1, R3 = F; R2, R4 = H

Figure 9

Sulfonamide chalcones having one Cl, F, OCH_3 or CH_3

group were less active than di or tri substituted analogues. Groups of phenylurenyl chalcone derivatives with substitution were discovered by Dominguez et al[41]. They reported that in most cases the activity was governed to a large extent by groups attached to the substituted aromatic ring A.

In the groups of 4'-phenylurenyl chalcone derivatives the para position in the urenyl ring plays an excellent role in antimalarial activity[42]. But 4'-phenylurenyl chalcones were less reactive than 3'-phenylurenyl chalcone derivatives.

2,4-Dimethoxy-4'-butoxy chalcone was an important compound with outstanding antimalarial activities against in vitro and in vivo parasites without any toxicity[43]. This compound had concentration dependent inhibitory effect on the hypoxanthine uptake of the chloro-quine susceptible and chloroquine resistant. The IC_{50} valus were 8.9µM and 14.8µM respectively.

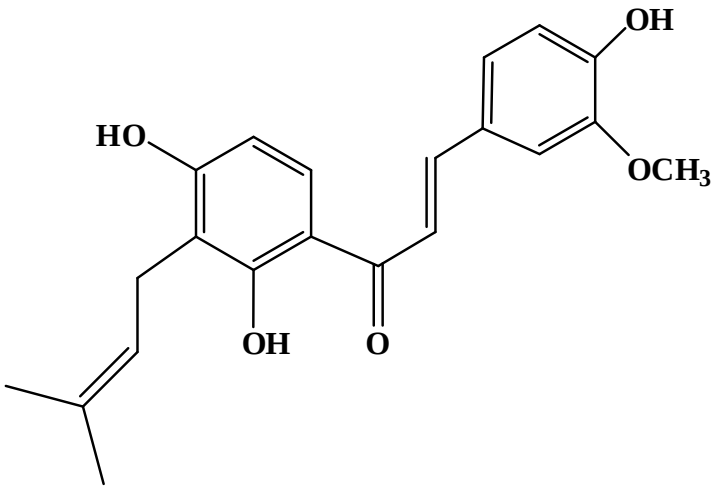


Figure 10 Crotaorixin

It was secluded from aerial parts of the Crotalaria orixensis exhibited 100% inhibition of maturation of Plasmodium falciparum parasite from ring stage to schizont stage both at 50 µg/ml and 10µg/ml concentration[44].

Medicagenin was the deprenylated compound and has been recently isolated from the roots of Crotalaria.[45]

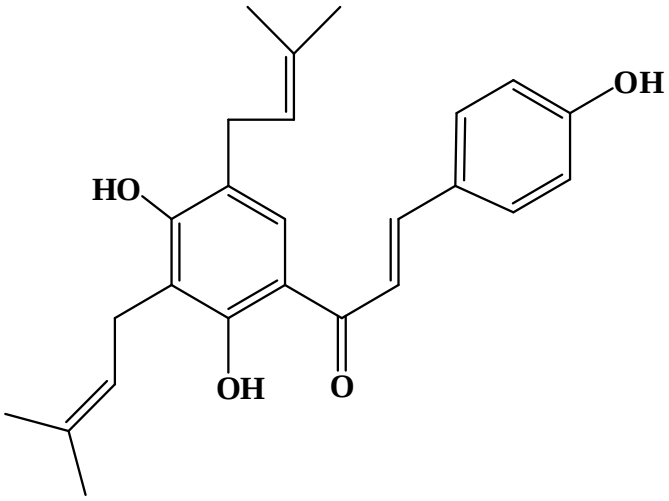


Figure 11 Medicagenin

Medicagenia inhibited the parasites 100% at 2µg/ml concentration while the chromenodihydro chalcones from crotalaria ramosissima showed lower activity.

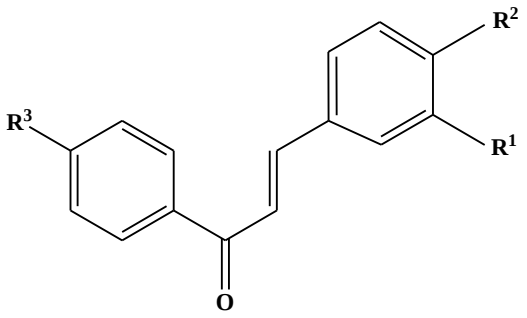
In vitro evaluation of 4'-tert-butylo-4-bromochalcone had the ebility to inhibitrecombinant P. falciparum iron superoxide dismutase it also had an important antimalarial activities against chloraquine-sensitive P. falciparum strain (IC_{50}=37µM) and the chloroquine-resistant strains (IC_{50} =27µM)[46] .

Larsen et. Al[47]. recorded the antiplasmodial activity of two series of E and Z conformationlly restricted analogues and their parent chalcones against P. falciparum. The Z conformation analogue with the double bond were some how inactive than the E conformation analogues. It has been tasted by Frolich et al that in vitro antiplasmodial activity of prenylated chalcone derivatives from hops against the chloro-quine sensitive strain poW and the multiresistant clone Dd2 using a hypoxanthine-incorporation assay.

Xanthohumal was the main hop chalcone .It was the most active with IC_{50} valus of 8.2+0.3µM (poW) and 24.0+0.8µM (Dd2).

1.5.4. ANTI-FUNGAL ACTIVITY:-

Dermatophytes are generally known as a group of fungi it characteristically infect the keratinized areas of the body and dermatomycoses are very difficult to eradicate. By various research work it is very exciting that the chalcone derivatives showed activity against dermatophytes of fungi.It has been reported by Lopez et al. that chalcones 13 - 16 against a panel of human opportunistic pathogenic fungi,using the Agar dilution method[48].



13=> R^1, R^3= H; R^2 = NO_2

14=> R^1=OCH_3; R^2, R^3=H

15=>R^1 ,R^3 =H ;R^2 =CH_3

16=>R^1=OCH_3; R^2=H; R^3 =Br

Figure 12

The electron withdrawing groups in the para position increased the potency but electron donating donating groups decreased the antifungal activity. For the presence of NO_2 and Cl group in the ortho position the antifungal activity decreased ,that phenomenan proved that there was an steric effect which results from the size of substitution and the repultion between them.

For the enone linkage , a structural requirement was necessary but not itself sufficient for the antifungal activity. 16 does not possess any electron withdrawing group in the para position of ring A and no substituent at ortho position. But it has strong antifungal activity against microsporum canis whose MIC value is 25µM/ml,microsporum gypseum (MIC=1.5µM/ml), Trichophyton rubrum (3µM/ml), Trichophyton floccosum (0.5µM/ml).It was observed that 2-chloro-2'-hydroxy-4'-6'-dimethoxy-chalcone had the lowest MIC against T. rubrum.

Svetaz et. al. reported that the methanolic extract of Zuccagnia punctata having 2',4'-dihydroxy chalcone (17) showed very good activity (MIC=6.25 and 3.12 µM/ml) against Phomopsis longicolla Hobbs CE117, and (MIC =6.25µM/ml) Colletotrichum truncatum CE 175 respectively[47].

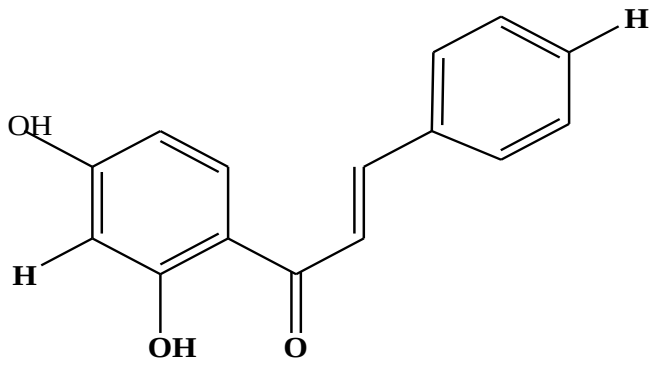


Figure 13

Suman et al[48] reported various substituted chalcones for their antifungal activity against Rhizoctonia solani,Fusarium oxysporum and Colletotrichum capsicum strains of Phytopathogenic fungi and they also tasted that α,β-dibromo-3,3'-dixitro-chalcone had antifungal activity against three fungi with MIC=6.25µM/ml and 4-4'-dimethylchalcone showed activity against C.capsicum whose MIC =6.25µM/ml.

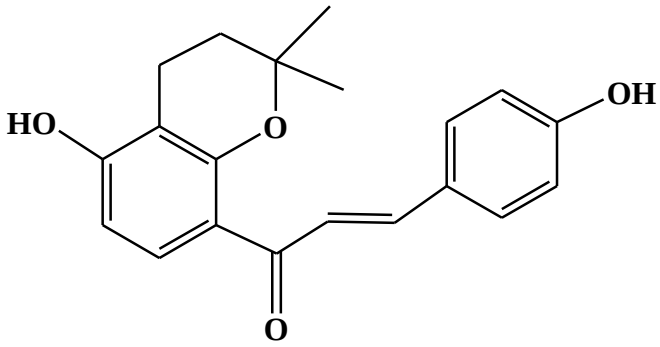


Figure 14 Crotmadine

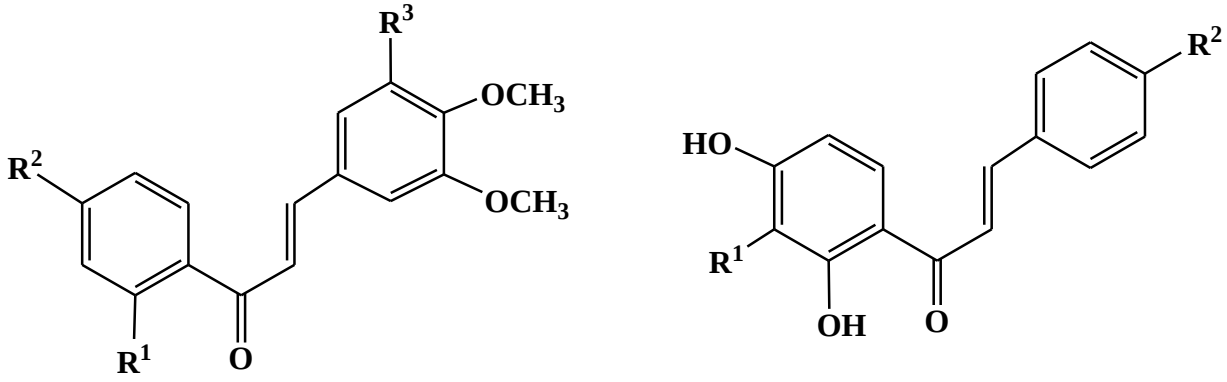
Crotmadine was present in leaves and stems of Crotalaria madurensis[49]. It exhibited antifungal activity against T. mentagrophytes at a concentration of 62.5µg/ml . Jayasinghe et al. showed that chalcone derivatives were isolated from Artocapus nobilis. It showed very good activity against Cladosporium cladosporioides having MIC values range 2-15 µg/spot.Okunade showed

that biological selection of dihydrochalcone derivatives were established relatively good activity against the acid-fast bacterium Mycobacteria intracellulare.

2',4',6'-trihydroxy-3'-methyldihydrochalcone showed good activity against B.subtilis and T. mentagrophytes at 60µg/disk. [50]

1.5.5. ANTI-VIRAL ACTIVITY:-

The antiviral properties of chalcone depends on specific substitution patterns. Onyilagha et al[51-52] looked into the hydroxyl and methoxy substituted chalcones derivatives for antiviral activity against tomato ring-spot nepovirus (ToRSV) infectively. Chalcone showed antiviral activity of hydroxylation of ring B at 2',3',4',position and c-4 position of ring A against ToRSV. C-5 hydroxylated chalcones did not show any antiviral activities. The antiviral activity of chalcones were obviously lost when they were applied before or after ToRSV infection. Some important effective inhibitory compounds were



18 => R^1, R^2 = H; R^3 = OCH_3

19 => R^1, R^2 = OH; R^3 = OCH_3

20 => R^1, R^2 = OH

21 =>R^1 = H; R^2 = OCH_3

Figure 15

Acquired immunodeficiency syndrome (AIDS),a life threatening problem which is caused by HIV virus since 1980 and flavonoids have been investigated for anti HIV activity. Wang et al.tasted that Xanthohumol was an important selective inhibitor of HIV-1 and it may represent a novel therapeutic agent for HIV-1 infection[53]. The EC_{50}'s of Xanthohumol on reducing p24 antigen and RT production were 1.28 µg/ml.[54]

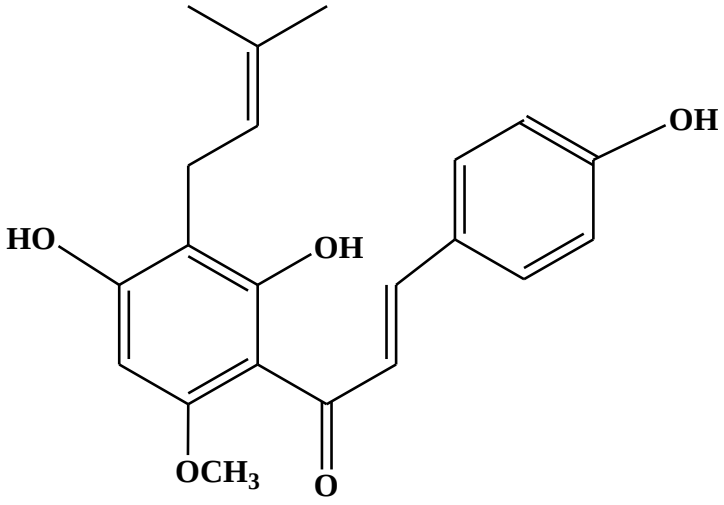


Figure 16 Xanthohumol

It also reduced HIV-1 replication in peripheral blood mononuclear cells (PBMC) infected with HIV-1_{IIIB}, and the EC_{50} of Xanthohumol for reducing p29 antigen production was 20.74µg/ml.

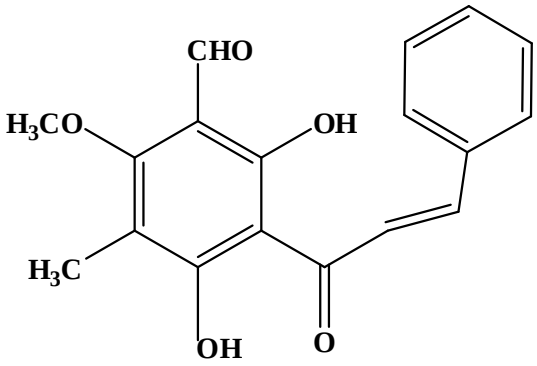


Figure 17

Wu and colleagues reported chalcone 17 from genus Desmos showed potent anti-HIV activity with a good therapeutic inden[55].

The reducing activity of Butein and Phloretin on HIV-1 protease was tasted by Xu et. al. using fluorescence and HPLC assays . According to their analysis it has been reported that at 50µg/ml concentration. Butein showed 50% inhibition where as for Phloretin it was only 27%.

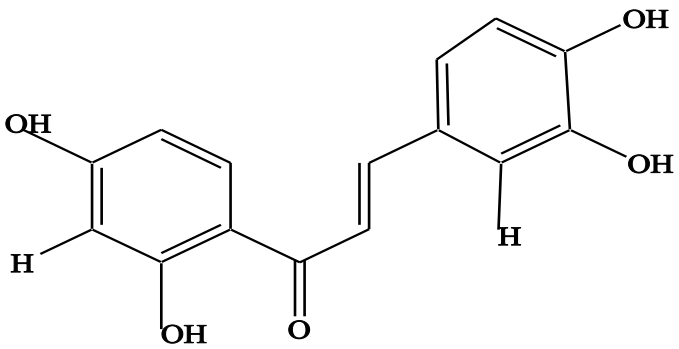


Figure 18 Butein

3,3',4,4'-tetrahydroxy-2-methoxy chalcone had a negative effect on HIV transcription because they bind to some specific protein factors.[56]

Cardamonin showed an important anti-HIV-1 PR activity with IC_{50} value of 31 µg/ml.

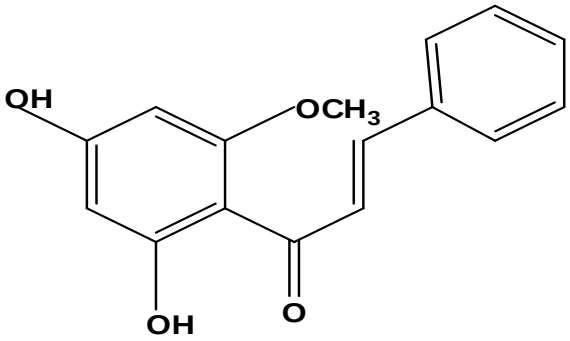
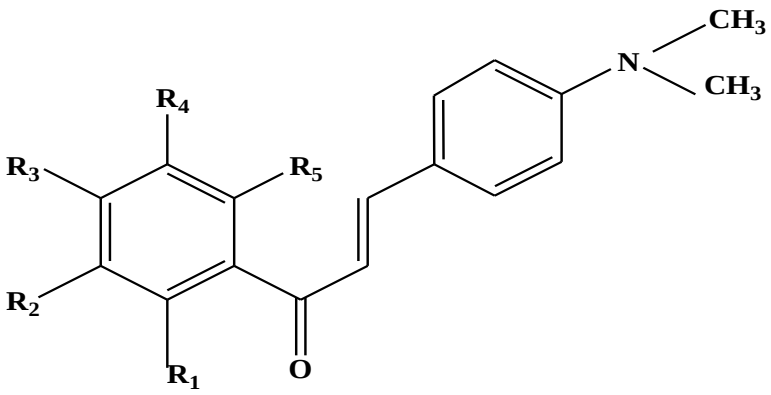


Figure 19 Cardamonin

1.5.6. ANTI-INFLAMMATORY ACTIVITY:-

Herencia et. Al[57]. reported a series of chalcone derivatives for possible anti-inflammatory effect .23 worked as a scavenger of superoxide anion generated by stimulated human neutrophilsor by the hypoxanthine / xanthine oxidase system with IC_{50}=0.1 and 0.3 µM respectively.



R_1,R_4,R_5=H;R_2,R_3=OCH_3

R_1,R_5=OCH_3;R_2,R_3,R_4=H

R1,R4=OCH3;R2,R3,R5=H

Figure 20

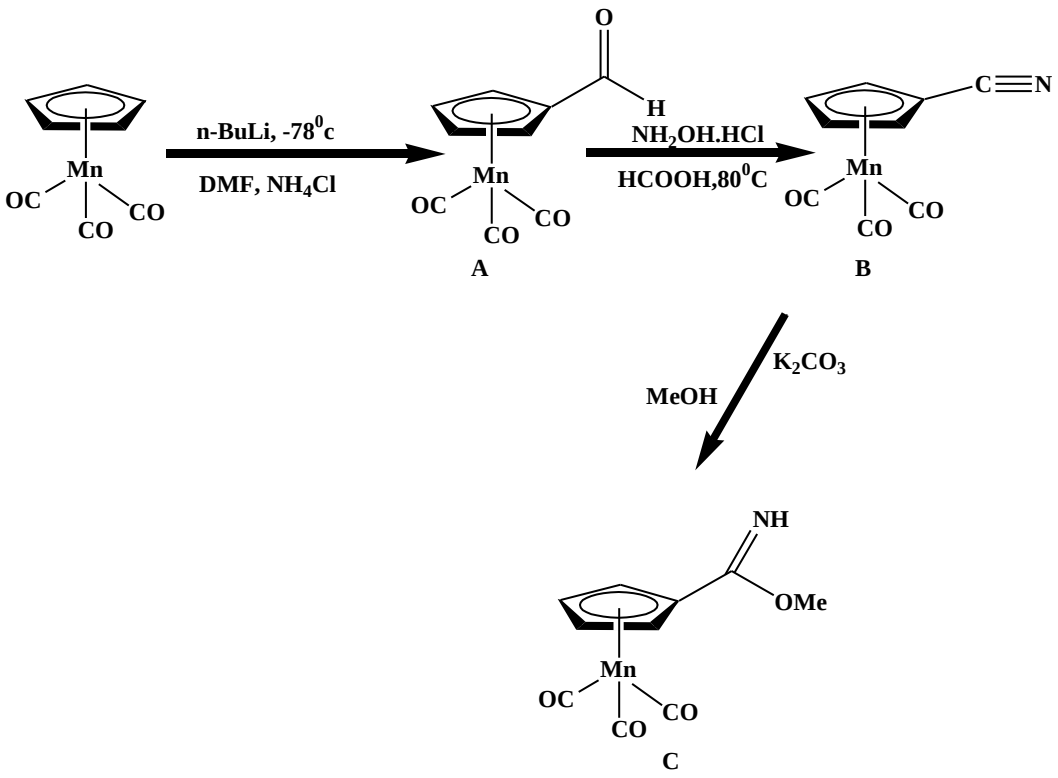
Chapter 2

Ferrocenyl and cymantrenyl chalcones: Synthesis and Characterization

2.1. Introduction

Recently, synthesis of ferrocenyl chalcones have been extensively focused for their interesting biological properties and for their use as precursor for various other important molecules. Both ferrocene and chalcones have been separately known to form a large number of derivatives which not only shows potential biological properties but also various other optoelectronics and electrochemical properties. It has been recently explored that Incorporation of three dimensional ferrocenyl groups instead of flat aryl substitutent into the chalcon moiety can results in favorable change in biological and other properties.

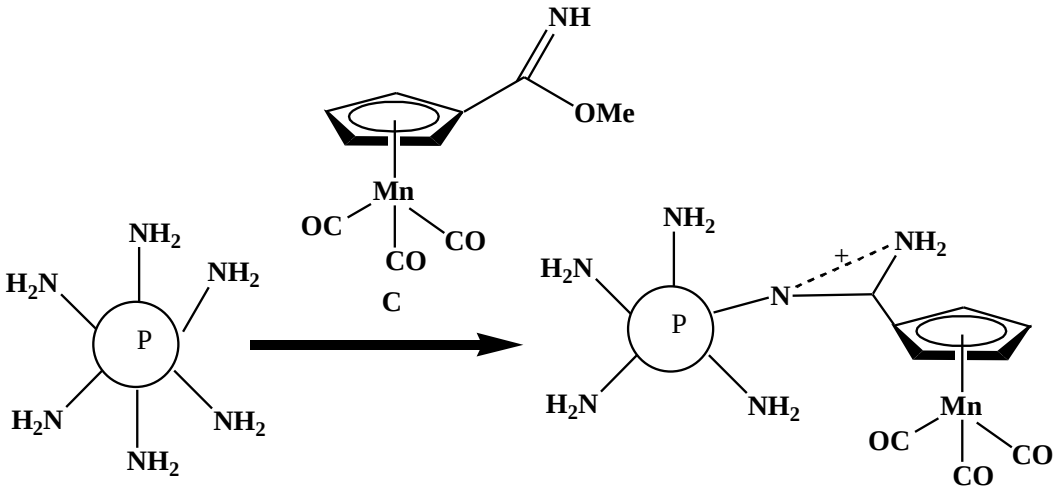
Recently some research groups synthesized formylcymantrene(A), cyanocymantrene(B), cymentrenyl methyl imidate from cymentrene [(η^5-cyclopentadienyl)tricarbonyl manganese] (scheme 7).[58]



Scheme 7

Bovin Serum Albumin (protein) used for labeling assays because it is inexpensive and easily available. This protein in borate buffer PH 9.0 was be treated with different quantities of C

dissolved in MeOH. (scheme 8)



Scheme 8

Recently S.-K et.al.synthesized ferrocenyl chalcone with two pyrenyl groups (Figure 21). Di-pyrenyl compounds readly form an excimer intramolecularly and this type of compounds also have on-off switchable chemosensor properties towords specific anions or cations. [59]

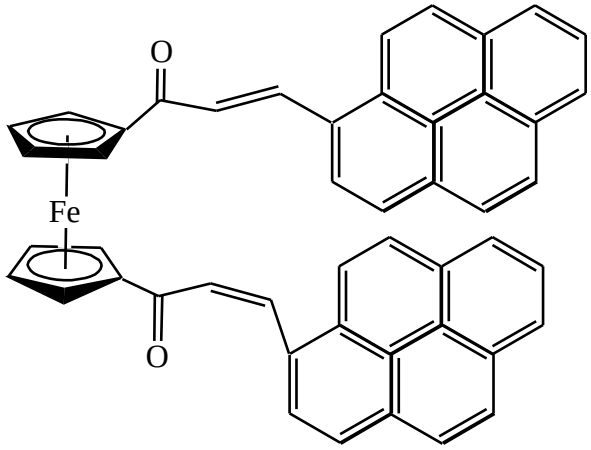


Figure 21

2.2 Experimental Sections

2.2.1 General Procedures

All reactions and manipulations were carried out under an inert atmosphere of dry, pre-purified argon using standard schlenk line techniques. Solvents were purified, dried and distilled under

argon atmosphere prior to use. Infrared spectra were recorded on a Perkin Elmer Spectrum RX-I spectrometer as dichloromethane solutions in 0.1 mm path lengths NaCl cell and NMR spectra on a 400 MHz Bruker spectrometer in $CDCl_3$. TLC plates (20x20 cm, Silica gel 60 F254) were purchased from Merck. [$CpMn(CO)_3$], Ferrocene were purchased from Sigma Aldrich.

2.2.1. Synthesis of Monoaldehyde ferrocene (1)

2.79 gm of ferrocene (0.015 mole) was dissolved in 12ml of chloroform with continous stirring in room temperature under N_2 atmosphere and the mixture turned into a dark brown coloured solution. In another round bottom flask, DMF was taken in an ice bath and to it $POCl_3$ was added in small portion with stirring. Then the mixture of DMF and $POCl_3$ was added to the ferrocene solution keeping the solution in an ice bath for 10 mins. The ice bath was removed and the whole mixture with some brown precipitate was refluxed in an oil bath with continous stirring for 6 hours. Then it was separated in a separating funnel using ice and distilled water and filtered. The combined organic layers were dried in rotavapor. The reaction mixture was dissolved in dichloromethane and subjected purification by Thin Layer Chromatography using pet-ether and ethylacetate solution mixtures (10:1).

1: IR(ν_{CO}, cm^{-1},CH_2Cl_2) 1652

2.2.3. Synthesis of Acetyl cymantrene (2)

A 100 ml two necked flask equipped with glass stoppers, magnetic stirring bar was connected with a nitrogen cylinder. In this flask 2.4 g (0.01 moles) of cymantrene was taken and then to it 25 ml of CH_2Cl_2 quickly poured. To the stirring solution of cymantrene, 1.5 ml (0.019 moles) of acetyl chloride was added drop wise from the syringe. The stirred reaction mixture was cooled in the ice bath for 15 minutes then 2.5 g (0.019 moles) of anhydrous $AlCl_3$ was added in small portions during 15 minutes , the cooling bath was removed and the reaction mixture was stirred for additional 30 minutes at room temperature. The color of the reaction mixture immediately transformed to dark yellowish brown.

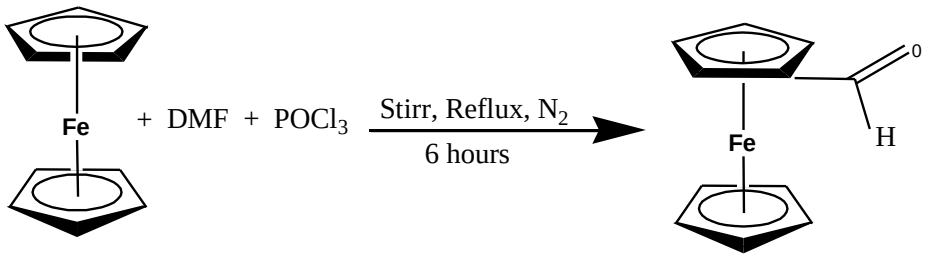
The formation of the monoacetyl derivative of cymantrene was checked by Thin Layer Chromatography (using CH_2Cl_2 / hexane in 1:1 ratio). The reaction mixture was then poured on

50 g of crashed ice in 50 ml of water in the beaker. The flask was then rinsed with small amount of CH_2Cl_2 and the combined layers were transferred into a separatory funnel. The organic layer contained the desired product monoacetyl cymantrene and was extracted with CH_2Cl_2 . The combined organic layers were extracted twice with water and then finally dried to obtain the monoacetyl cymantrene for further ligand synthesis. The chemical equation is given in Scheme 9.

1: IR(ν_{CO}, cm^{-1},CH_2Cl_2) 1729 (vs), 1932.5 (vs, br), 2025.4 (vs)

2.3 RESULTS AND DISCUSSION

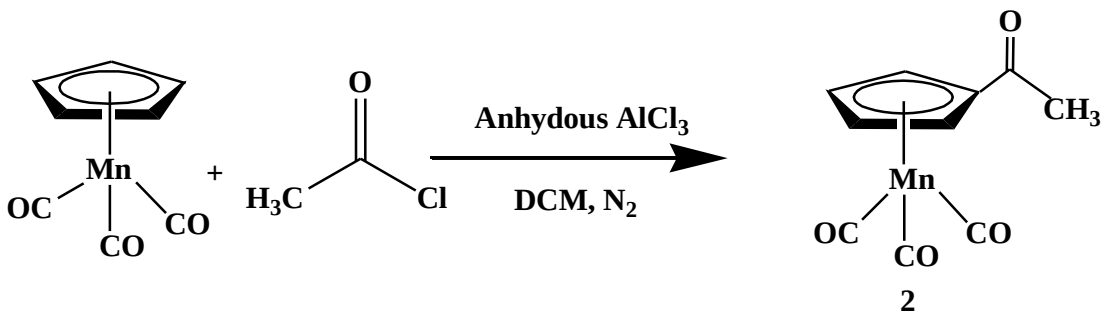
Monoferrocenyl aldehyde (**1**) has been prepared from the reaction of ferrocene with $POCl_3$ in dimethylformamide solvent. The compound was purified by column chromatography using Ethylacetate/ pet ether solvent mixture.



1

Scheme 9

Room temperature reaction of $[CpMn(CO)_3]$ with acetyl chloride in presence of $AlCl_3$ lead to the formation of a yellow colored acetyl cymantrene (**2**) in almost 90 % yield (Scheme 10). Compound **2** was isolated by column chromatography using pet ether /dichloromethane solvent mixture and spectroscopic characterization was performed to predict the compound.



Scheme 10

FTIR spectra for both the compounds **1** and **2** reveals the presence of ketonic C=O groups at 1678 cm^{-1} and metal carbonyl in the region 2025-1933 cm^{-1} for compound 2.

2.4 CONCLUSION

Acetyl cymantrene $[(\eta^5\text{-}C_5H_4)Mn(CO)_3]$ on reaction with monoaldehyde ferrocene $[(\eta^5C_5H_4)Fe\text{-}(\eta^5C_5H_5)CHO]$ led to the formation of a bimetallic chalcone $[(\eta^5C_5H_4)Mn(CO)_3\}COCH{=}CH\}([(\eta^5\text{-}C_5H_4)Fe(\eta^5C_5H_4)\}]$ (3). Tentative structure of compound 3 has been predicted from the spectroscopic characterization which reveals the presence of ferrocenyl and cymantrenyl moiety in the two end of a chalcone.

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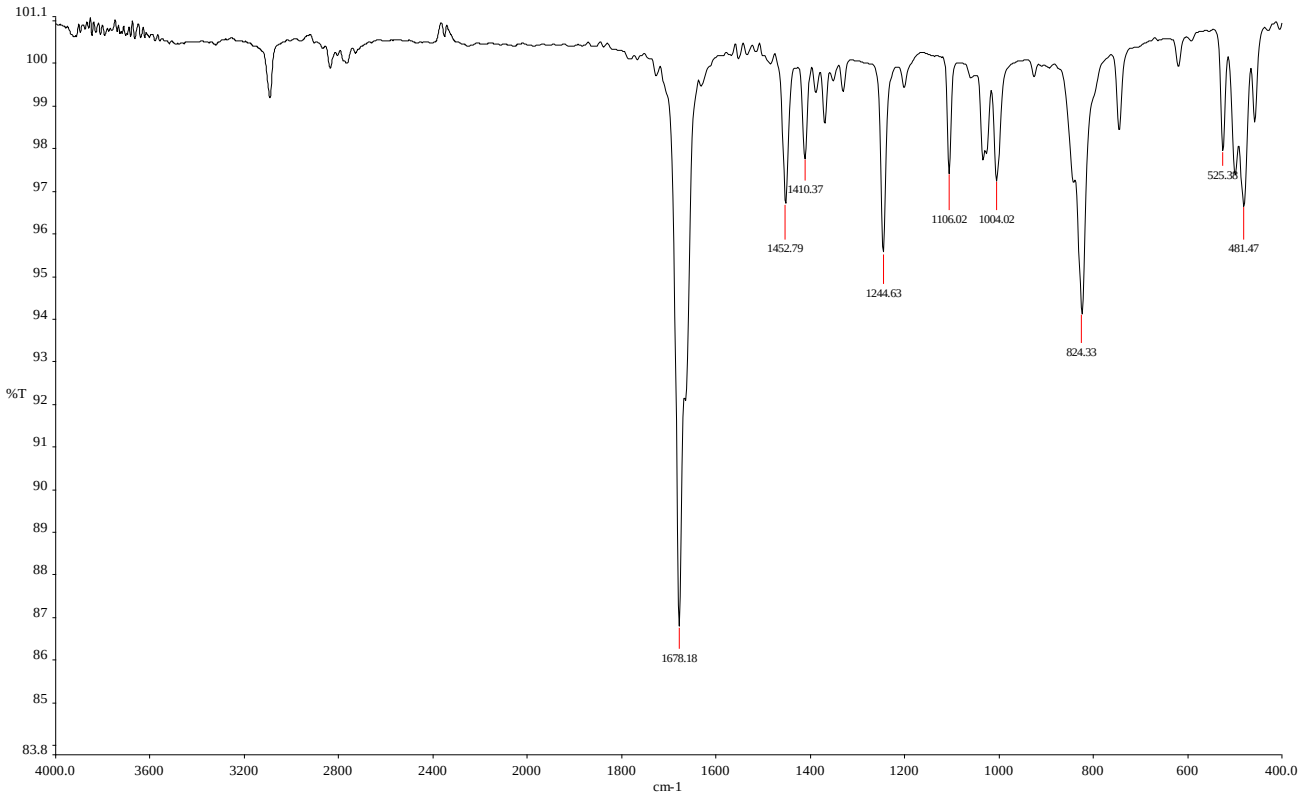
Annexure

FTIR Spectra of FcCHO (1)



FTIR Spectra of $CpMnCOCH_3$ (2)