

# Nano Copper Ferrite Catalyzed One-pot Synthesis and Microbial Studies of Chalcone Derivatives

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**Abstract:** Chalcones are aromatic ketones which forms a central core for various important biological active compounds. A series of chalcones were prepared by Claisen-Schmidt condensation of appropriate aromatic aldehydes with acetophenones in the presence of nano copper ferrite in ethanol. All the synthesized compounds have been characterized by FT-IR, <sup>1</sup>H-NMR and MASS spectroscopy. The synthesized compounds are screened for their biological activities against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis* using cup plate method and disc diffusion method.

**Keywords:** Chalcone, Nano copper ferrite, Synthesis, Claisen-Schmidt condensation, Biological activity.

## 1. INTRODUCTION

In the past decades, multi component reactions [MCRs] have an important role in organic synthesis due to their simple procedures, excellent yields, convergence, ideal atom efficiency, atom economy and exploratory power leading to the straight forward synthesis of various compounds. These are one step reactions, where the reactants are subjected into a single reactor to form a desired product without any intermediate formation. It has great advantage over convergent and conventional synthesis [1-4].

The development of efficient and eco-friendly synthetic methodologies for the rapid construction of potentially bioactive compounds became a major task for chemists in organic synthesis. Improving the effectiveness of these MCRs with other strategies such as improving yield, short reaction time and magnetically separable catalysts is the key component in the reported methods[5-7]. The use of nano magnetic catalysts with high surface to volume ratio and the ease of separating them with strong external magnets from the reaction mixture offers several advantages including higher yields, shorter reaction time, ease of separation of the catalyst and its reuse.

Claisen-Schmidt condensation plays an important role in the construction of variety of Chalcones. Chalcones are familiar intermediates for synthesizing various Biological active compounds. The term “chalcone” is a generic term used to define compounds with the 1,3-diphenylprop-2-en-1-one framework (Figure-1). These are present in edible plants and are considered to be precursors of flavonoids and isoflavonoids [8]. The compounds with the backbone of chalcones have been reported to possess various biological activities such as anti-inflammatory[9], antimalarial[10], anticancer[11], antiviral[12], antioxidant[13], antimicrobial[14], antiulcerative[15], antihyperglycemic[16],

analgesic[17], inhibition of chemical mediators release[18], inhibition of tyrosinase[19] and inhibition of aldose reductase[20] activities. The presence of a reactive  $\alpha,\beta$ -unsaturated keto functional group in chalcones is found to be responsible for their antimicrobial activity[21]. A vast literature available for the synthesis of chalcones compounds using Claisen-Schmidt condensation includes catalysts such as NaOH[22], Clay[23], SiO<sub>2</sub>-H<sub>2</sub>SO<sub>4</sub>[24], HBr[24], anhydrous AlCl<sub>3</sub>[25], Ba(OH)<sub>2</sub>[26], I<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>[27], KOH[28] have also been found to catalyze this reaction. However, these methods suffer from drawbacks such as a long reaction time[28], excess use of catalyst[25], lower yields[27], toxicity, difficulty in product isolation[24] and harsh refluxing conditions[23]. Hence in continuation of our work to develop eco-friendly technique for synthesis of heterocyclic compounds an attempt has been made to synthesize chalcones derivatives using Claisen-Schmidt condensation of aromatic aldehyde and acetophenone in ethanol using nano copper ferrite as heterogeneous catalyst. (Scheme-1)

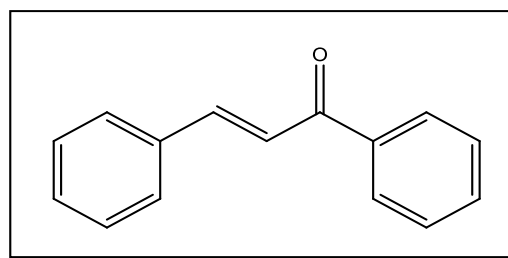


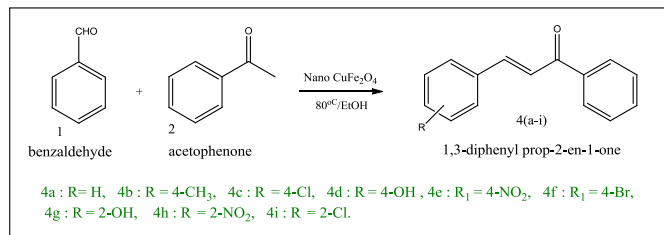
Figure 1 Structure of Chalcone

## 2. EXPERIMENTAL METHODS

### 2.1 Materials and Reagents

All chemicals used in this process are of AR grade fine chemicals, without any further purification. The synthesized chalcones derivatives were characterized by <sup>1</sup>H-NMR(400MHz)spectra were obtained using Bruker-Advance spectrophotometer in CDCl<sub>3</sub>. FTIR spectra were recorded on Bruker Alpha FT-IR with Opus 6.1 version, Mass spectra were determined on Perkin- Elmer PESCIEX-API 2000, equipped with ESI source used online with a HPLC system after the UV detector. XRD spectra were recorded on PANanalytical-Xpertpro diffractometer and the average crystallite size was determined from the corresponding XRD data. The micro structural morphology was studied with a scanning electron microscope(SEM) JEOL-JSM 6610 LV.

Magnetization measurements were made using a commercial vibrating sample magnetometer (VSM) model BHU-50 of Riken Denshi Co. Ltd. Japan.



Scheme-1. Synthesis of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives catalysed by nano copper ferrite.

### 2.2 General procedure for the synthesis of nano copper ferrite:

For the preparation of catalyst, aqueous solutions of stoichiometric amounts of copper nitrate along with ferric citrate were reacted with citric acid in 1:1 molar ratio. pH of the solution was increased to 7 by adding of ammonia to complete the reaction and ethane diol was added. The solution was evaporated very slowly over a period of ten to thirteen hours to dryness. Colour and viscosity changed as the solution turns into puffy mass and porous dry gel. As soon as the solvent removal completed, dried precursor undergoes a self-ignition reaction to form an absolute fine powder known as as-synthesized powder. The as-synthesized powder, thus obtained was calcined in a Muffle furnace at 500 °C for 2 hr to remove the residual carbon and furnace cooled.

### 2.3 Characterization of Nano Copper ferrite:

2.3.1 X-ray diffraction (XRD) analysis: Figure 2 show typical XRD pattern for nano copperferrite samples, which was sintered at 500 °C. The pattern shows all the characteristic peaks of a spinal structure and confirms the phase formation indicating the absence of other impurity phases. The XRD parameters of various peaks were compared with the standard data of the cubic copper ferrites (JCPDS # 77-10) and found to be in cubic phase. The particle size and other characteristics of the copper ferrite nano particles obtained from the XRD pattern using Scherer's formula was found be 30 nm .

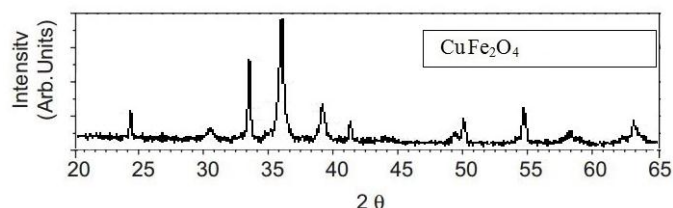


Figure 2 XRD of Nano CuFe<sub>2</sub>O<sub>4</sub>

### 2.3.2 Infrared Spectroscopy:

In order to confirm the formation of the spinel phase and to understand the nature of the residual carbon in the samples, the FT-IR spectra of the As-synthesized powders and thermally treated powder were recorded and shown in Figure 3.

The small absorption bands around 2350 cm<sup>-1</sup> and 1020 cm<sup>-1</sup> are due to traces of adsorbed or atmospheric CO<sub>2</sub>. The main absorption band appearing around 575 cm<sup>-1</sup> is due to tetrahedral sites and is found to be shifted to higher values on doping with cobalt. The band around 410 cm<sup>-1</sup> is due to octahedral sites and is shifted to lower values upon increasing the concentration of cobalt ions. These observations may be attributed to the fact that the absorption bands for pure copper ferrite appear around 575 cm<sup>-1</sup> and 410 cm<sup>-1</sup> respectively and it is evident that the inclusion of cobalt is responsible for shifting the bands appropriately to higher values for ν<sub>1</sub> and lower values for ν<sub>2</sub>.

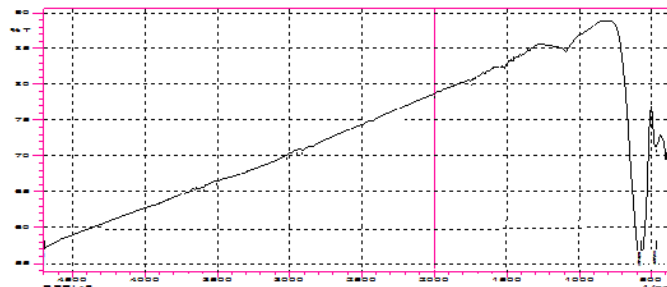


Figure 3 FT-IR Spectrum of nano copper ferrite

### 2.3.3 Morphological and elemental analysis (SEM & EDAX):

Figures 4 shows the typical SEM image of the nano copperferrite sintered at 500 °C . Figure 5 shows the iron and copper ratio in the nano crystals as determined by EDAX was very much close to the atomic ratio in the formula CuFe<sub>2</sub>O<sub>4</sub>.

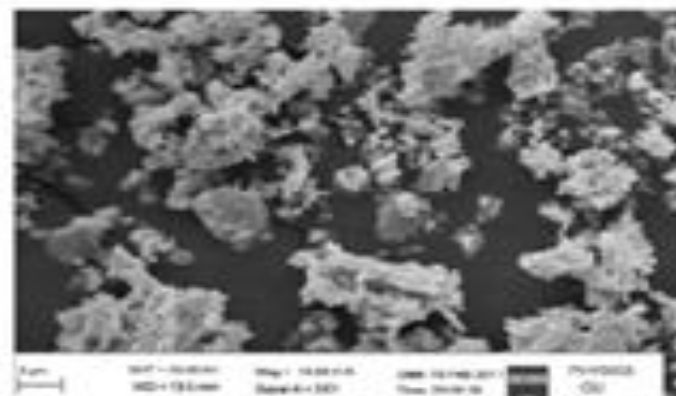


Figure 4. SEM images of Nano CuFe<sub>2</sub>O<sub>4</sub>

### 2.4 General procedure for the synthesis of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives:

A mixture of an aromatic aldehyde (10 mmol), and Acetophenone (10 mmol) in ethanol (10 ml) and copper ferrite nano catalyst (500 mg) (which is prior activated in microwave oven for 2 minutes) was refluxed at 80 °C for 2 hours and the reaction was monitored by thin-layer chromatography(n-hexane: ethyl acetate 3:1). After completion of the reaction, the catalyst was separated by a strong Neodymium magnet and washed with ethanol for its next use. The reaction mixture was filtered and the product is re-crystallized using ethanol to give the corresponding pure product. The pure products were characterized by FT-IR, <sup>1</sup>H-NMR and MASS spectra.

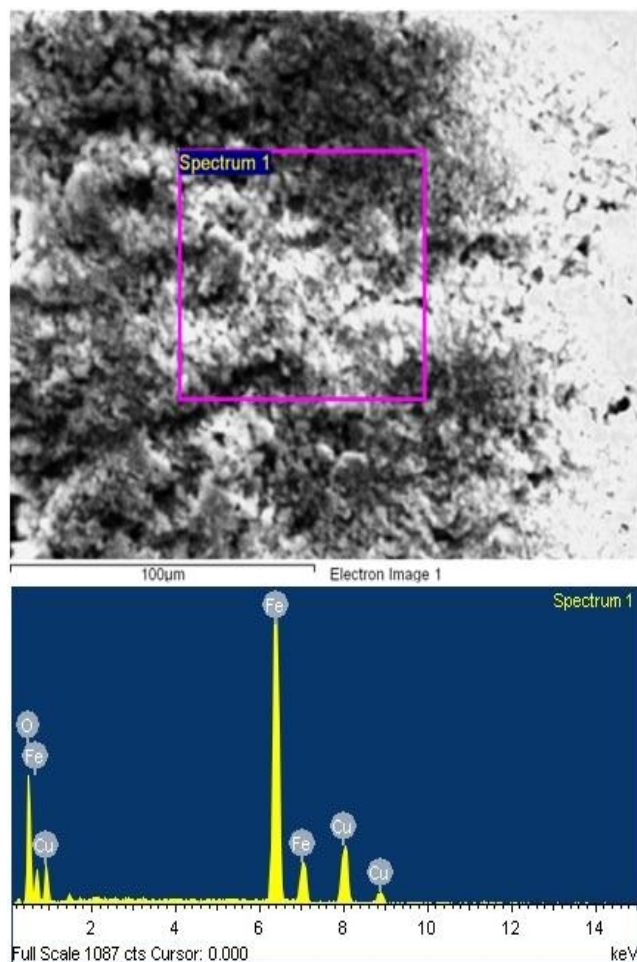


Figure 5. EDAX image of Nano  $\text{CuFe}_2\text{O}_4$

### 3 RESULT AND DISCUSSION

#### 3.1. Catalytic Study

In this a convenient and efficient protocol for the synthesis of 1,3-diphenyl prop-2-ene-1-one (chalcone) derivatives by Claisen-Schmidt condensation using copper ferrite nano particles as an efficient catalyst is reported and summarized in Scheme 1.

##### 3.1.1. Effect of loading of catalyst on the synthesis of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives:

The present reaction investigated under different amounts of catalyst. The result reveals that 500mg of catalyst is enough to get a high yield of product. On further increment of catalyst quantity will not lead appreciable change in the yield of product. Hence 500mg of catalyst was taken to perform the reaction. For this study, mixture of benzaldehyde and acetophenone in ethanol was chosen as the model reaction (Scheme 1) The results are tabulated in table 2.

##### 3.1.2. Comparative catalytic activity of nano copper ferrite with other catalysts for the synthesis of 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives:

Reaction times for the formation of 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives with various catalysts are presented in Table 3. It is observed that with other catalysts and particularly under reflux conditions the reaction times are

very much higher. The present method offers a comparatively shorter reaction time, high yield. (Table 3)

##### 3.1.3. Effect of solvent on synthesis of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives:

Investigation of reaction medium for the process revealed that solvent play a major role in the reaction. The results are summarized in Table 4. It was found that polar solvents such as acetic acid,  $\text{CH}_3\text{CN}$  and  $\text{C}_2\text{H}_5\text{OH}$  were much effective than non-polar solvents. Trace amount of yield observed when  $\text{H}_2\text{O}$  was used as solvent, presumably due to the aggregation of the hydrophobic catalyst. Although  $\text{CH}_3\text{COOH}$  is effective, low yield was obtained when the catalyst was reused. Therefore ethanol was a selected solvent.

##### 3.1.4. Effect of Temperature on Synthesis of hexahydroquinazolin-2(1H)-one/thiones

The reaction temperature for the formation of 1,3-diphenyl prop-2-ene-1-one(chalcone) with nano copper ferrite catalyst is  $80^\circ\text{C}$  is presented in table 5. It is observed that at below  $80^\circ\text{C}$  temperature yield of the product is low and reaction time is high. So the reaction is carried out at  $80^\circ\text{C}$ .

##### 3.1.4. Plausible mechanism for the formation of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives:

It can be understood from the similar studies reported in the literature,[14] the plausible reaction mechanism of this one - pot three component reaction is described in Scheme 2. The first step is the formation of enol 3 that obtained from acetophenone 2 in the presence of Lewis acid ( $\text{Fe}^{+3}$ ). The second step is the aromatic aldehyde 1 reacts in protonated form with enol 3 in the presence of catalyst and forming aldol addition product 5. In third step the Aldol addition product undergoing dehydration to form corresponding 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives 4

#### 3.2 Spectral Data of Chalcones. spectral data for the synthesized chalcones

##### 1,3-diphenylprop-2-en-1-one (4a):

IR (KBr): 1615 (C=O, Carbonyl Str), 1470, 1412  $\text{cm}^{-1}$  (C=C Aromatic Str);  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.84 (1H, d, =CH-Ar), 7.37(1H, m, C=O), 7.30-7.51 (8H, m, Ar-H), 6.80 (2H, d, Ar-H); ESI-MS  $m/z(\%)$ : 209 ( $[\text{M}+\text{H}]^+$  100).

##### 1-phenyl-3-(p-tolyl)prop-2-en-1-one (4b):

IR (KBr): 1640 (C=O Carbonyl Str), 1592, 1486 (C=C Aromatic Str);  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.90 (1H, d, =CH-Ar), 7.40(1H, m, C=O), 7.25-7.44 (8H, m, Ar-H), 7.11 (2H, m, Ar-H), 2.34 (m, - $\text{CH}_3$ ); ESI-MS  $m/z(\%)$ : 223 ( $[\text{M}+\text{H}]^+$  100).

##### 3-(4-chlorophenyl)-1-phenylprop-2-en-1-one (4c):

IR (KBr): 1664, 1606 (C=O Carbonyl Str), 1526 (C=C Aromatic Str), 752,724  $\text{cm}^{-1}$  (-Cl Str);  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.87 (1H, d, =CH-Ar), 7.44 (1H, m, C=O), 7.30-7.42 (9H, m, Ar-H); ESI-MS  $m/z(\%)$ : 243 ( $[\text{M}+\text{H}]^+$  100).

**3-(4-hydroxyphenyl)-1-phenylprop-2-en-1-one (4d):**

IR (KBr): 1667, 1602 ( C=O Carbonyl Str), 1542, 1510 ( C=C Aromatic Str), 3005  $\text{cm}^{-1}$ (-OH) ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  7.93 (1H, d, =CH-Ar), 7.41(1H, m, C=O), 7.11-7.25 (6H, m, Ar-H), 6.80 (2H,d, Ar-H), 5.33 (1H, m, -OH); ESI-MS  $m/z(\%)$  : 225 ( $[\text{M}+\text{H}]^+$  100).

**3-(4-nitrophenyl)-1-phenylprop-2-en-1-one (4e):**

IR (KBr): 1673 ( C=O Carbonyl Str), 1594, 1520 ( C=C Aromatic Str), 1372, 1344  $\text{cm}^{-1}$ (-NO<sub>2</sub>) ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  7.81-7.99 (1H, m, =CH-Ar), 7.45-7.51(1H, m, C=O), 7.21-7.34 (9H, m, Ar-H) ; ESI-MS  $m/z(\%)$  : 254 ( $[\text{M}+\text{H}]^+$  100).

**3-(4-bromophenyl)-1-phenylprop-2-en-1-one (4f):**

IR (KBr): 1659,1603 ( C=O Carbonyl Str), 1538 ( C=C Aromatic Str), 589  $\text{cm}^{-1}$  (-Br) ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  7.86 (1H, d, =CH-Ar), 7.62(1H, m, C=O), 7.40-7.58 (8H, m, Ar-H), 7.01-7.05 (1H,m, Ar-H), 5.33 (1H, m, -OH); ESI-MS  $m/z(\%)$  : 287 ( $[\text{M}+\text{H}]^+$  100).

**3-(2-hydroxyphenyl)-1-phenylprop-2-en-1-one(4g):**

IR (KBr): 1685, 1604 ( C=O Carbonyl Str), 1541 ( C=C Aromatic Str), 3172  $\text{cm}^{-1}$ (-OH) ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  7.88-7.91 (1H, d, =CH-Ar), 7.52 (1H, m, C=O), 7.39-7.47 (6H, m, Ar-H), 6.49-6.71 (2H,d, Ar-H), 5.32 (1H, m, -OH); ESI-MS  $m/z(\%)$  : 224 ( $[\text{M}]^+$  100).

**3-(2-nitrophenyl)-1-phenylprop-2-en-1-one (4h):**

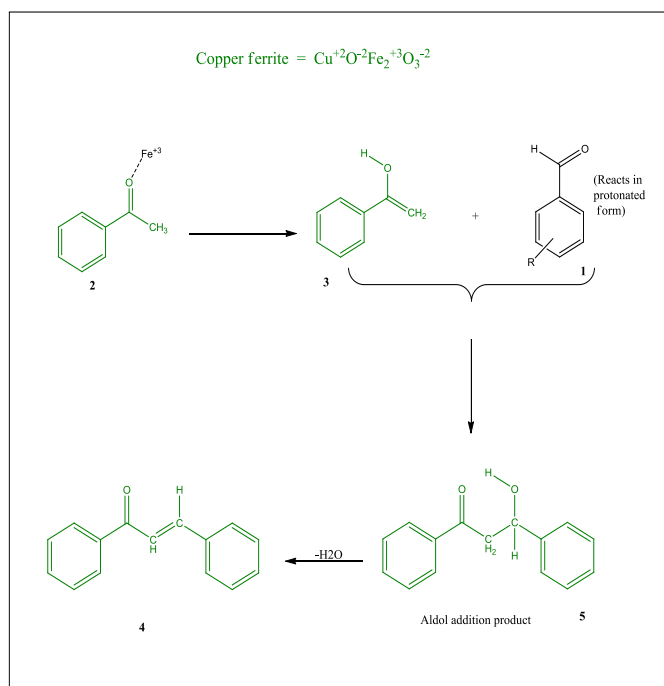
IR (KBr): 1689, 1613( C=O Carbonyl Str), 1525 ( C=C Aromatic Str), 1345  $\text{cm}^{-1}$ (-NO<sub>2</sub>) ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  8.69-8.71 (1H, m, Ar-H), 7.83-7.99 (1H, m, =CH-Ar), 7.45(1H, m, C=O), 7.38-7.52(8H, m, Ar-H) ; ESI-MS  $m/z(\%)$  : 254 ( $[\text{M}+\text{H}]^+$  100).

**3-(2-chlorophenyl)-1-phenylprop-2-en-1-one (4i):**

IR (KBr): 1615 ( C=O Carbonyl Str), 1541 ( C=C Aromatic Str), 727,632  $\text{cm}^{-1}$  ;  $^1\text{H NMR}$  (400 mHz,  $\text{CDCl}_3$ ):  $\delta$  7.82-7.91 (1H, d, =CH-Ar), 7.47 (1H, m, C=O), 7.39-7.50 (9H, m, Ar-H) ; ESI-MS  $m/z(\%)$  : 243 ( $[\text{M}+\text{H}]^+$  100).

Table 1

S.No.	Compound	R	Time(h rs)	Yield( %)
1	1,3-diphenylprop-2-en-1-one 4(a)	H	2	96
2	1-phenyl-3-(p-tolyl)prop-2-en-1-one 4(b)	4-CH <sub>3</sub>	2	95
3	3-(4-chlorophenyl)-1-phenylprop-2-en-1-one 4(c)	4-Cl	2.25	94
4	3-(4-hydroxyphenyl)-1-phenylprop-2-en-1-one 4(d)	4-OH	2.5	94
5	3-(4-nitrophenyl)-1-phenylprop-2-en-1-one 4(e)	4-NO <sub>2</sub>	3	93
6	3-(4-bromophenyl)-1-phenylprop-2-en-1-one 4(f)	4-Br	2.5	94
7	3-(2-hydroxyphenyl)-1-phenylprop-2-en-1-one 4(g)	2-OH	2.5	95
8	3-(2-nitrophenyl)-1-phenylprop-2-en-1-one 4(h)	2-NO <sub>2</sub>	2.5	95
9	3-(2-chlorophenyl)-1-phenylprop-2-en-1-one 4(i)	2-Cl	2.25	95



Scheme-2 Plausible mechanism for the formation of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives

**4. Recycling of the Catalyst**

Catalyst reusability is of major difficulty in heterogeneous catalysis. Catalyst recycling was achieved by fixing the catalyst magnetically at the bottom of the Refluxing flask with a strong Neodymium Magnet, after which the solution containing the product was taken off with a pipette, the catalyst washed thrice with ethyl acetate, dried. The fresh reactants dissolved in ethyl alcohol was introduced into the round bottom flask, followed by refluxing, allowing the reaction to proceed for the next run. The catalyst was consecutively reused for five times without any noticeable loss of its catalytic activity.(Table 6)

Table 2: Effect of catalyst loading on the formation of 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives.

S.No.	Catalyst loading in (mg)	Time (hrs)	Yield* (%)
1.	200	2	42
2.	300	2	66
3.	400	2	78
4.	500	2	96
5.	600	2	96

\*Reaction conditions: aromatic aldehyde(10 mmol), and Acetophenone(10 mmol) in ethanol(10 ml) and  $\text{CuFe}_2\text{O}_4$  Nano particles (500 mg)

Table 3: Comparative catalytic activity of Nano Copper Ferrite with other catalysts.

S.No.	Catalyst	Time (hrs)	Temp (°C)	Yield* (%)	Ref.
1.	NaOH	12	R.T.	Not reported	22
2.	HBr	12	100	Not reported	24
3.	AlCl <sub>3</sub>	12	R.T.	Not reported	25
4.	KOH	24	R.T.	Not reported	28
5.	Clay	3	170	Not reported	23
6.	SiO <sub>2</sub> -H <sub>2</sub> SO <sub>4</sub>	3	80	Not reported	24
7.	I <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub>	1.5	M.W.	94	27
8.	CuFe <sub>2</sub> O <sub>4</sub>	2	80	96	Present work

\*Reaction conditions: aromatic aldehyde(10 mmol), and Acetophenone(10 mmol) in ethanol(10 ml) and CuFe<sub>2</sub>O<sub>4</sub> Nano particles (500 mg)

Table 4. Effect of solvent on synthesis of 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives

S.No.	Catalyst	Solvent	Time(Hrs)	Yield(%) <sup>a</sup>
1	CuFe <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> O	48	trace
2	CuFe <sub>2</sub> O <sub>4</sub>	CH <sub>2</sub> Cl <sub>2</sub>	20	30
3	CuFe <sub>2</sub> O <sub>4</sub>	CH <sub>3</sub> COOH	12	85,55 <sup>b</sup>
4	CuFe <sub>2</sub> O <sub>4</sub>	CH <sub>3</sub> CN	5	90
5	CuFe <sub>2</sub> O <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	2	96

All reactions were carried out under reflux conditions with 500 mg of catalyst. <sup>a</sup> Isolation yields <sup>b</sup> Catalyst was reused.

Table 5: Effect of Temperature on the formation of 1,3-diphenyl prop-2-ene-1-one(chalcone) derivatives

S.No.	Catalyst	Temperature (°C)	Time (hrs)	Yield (%) <sup>a</sup>
1	CuFe <sub>2</sub> O <sub>4</sub>	R.T.	24	20
2	CuFe <sub>2</sub> O <sub>4</sub>	40	12	50
3	CuFe <sub>2</sub> O <sub>4</sub>	60	6	75
4	CuFe <sub>2</sub> O <sub>4</sub>	80	2	96

All reactions are carried out using 500 mg of catalyst in Ethyl alcohol. <sup>a</sup> Isolated yield

Table 6. Recyclability of the catalyst in the reaction, synthesis of 1,3-diphenyl prop-2-ene-1-one(Chalcone) derivatives

Run no.	Yield(%)
1	96
2	94
3	93
4	91
5	90

## 5. BIOLOGICAL ACTIVITY

The antibiotic potency can be determined using the microbial assays. The basic principle of microbial assay lies in comparison of the inhibition of growth of bacteria by measuring concentration of the product to be investigated with that produced by known concentration of the antibiotic having a known activity.

The methods used for assay are cup plate method and disc diffusion method.

The cup plate method is based on the diffusion of an antibiotic from a cavity through the solidified agar layer of a petridish. Growth of inoculated microbe is inhibited entirely in a circular zone around a cavity containing a solution of the antibiotics.

S. No.	Microorganism	MTCCNO
1	Escherichia coli (Gram -ve)	2692
2	Pseudomonas aeruginosa (Gram -ve)	2453
3	Staphylococcus aureus (Gram +ve)	902
4	Bacillus subtilis (Gram +ve)	441

S. No.	Sample	Microorganism	Concentration of the sample		
			10µl	20µl	30µl
			Zone of inhibition (mm)		
			10µl	20µl	30µl
1	4a	Escherichia coli	V1.1	V1.2	V1.4
		Pseudomonas aeruginosa	V1.2	V1.7	V1.9
		Staphylococcus aureus	-	-	-
		Bacillus subtilis	V1.1	V1.3	V1.5
2	4b	Escherichia coli	10µl	20µl	30µl
		Pseudomonas aeruginosa	V1.3	V1.5	V1.7
		Staphylococcus aureus	-	-	V1.2
		Bacillus subtilis	V1.4	V1.8	V2.0
3	4c	Escherichia coli	V1.2	V1.6	V1.8
		Pseudomonas aeruginosa	-	-	-
		Staphylococcus aureus	V1.4	V1.7	V2.0
		Bacillus subtilis	-	-	-
4	4d	Escherichia coli	10µl	20µl	30µl
		Pseudomonas aeruginosa	V1.5	V1.8	V2.3
		Staphylococcus aureus	V2.5	V2.7	V3.0
		Bacillus subtilis	-	V1.6	V2.4
5	4e	Escherichia coli	-	V1.8	V2.3
		Pseudomonas aeruginosa	-	V1.3	V1.5
		Staphylococcus aureus	-	-	-
		Bacillus subtilis	-	V1.2	V1.5
6	4f	Escherichia coli	-	-	-
		Pseudomonas aeruginosa	-	-	-
		Staphylococcus aureus	-	-	-
		Bacillus subtilis	-	-	-
7	4g	Escherichia coli	10µl	20µl	30µl
		Pseudomonas aeruginosa	-	-	-
		Staphylococcus aureus	-	-	-
		Bacillus subtilis	-	-	-
8	4h	Escherichia coli	10µl	20µl	30µl
		Pseudomonas aeruginosa	-	-	-
		Staphylococcus aureus	-	-	-
		Bacillus subtilis	-	-	-
9	4i	Escherichia coli	10µl	20µl	30µl
		Pseudomonas aeruginosa	V1.7	V2.1	V2.5
		Staphylococcus aureus	V2.0	V2.4	V2.8
		Bacillus subtilis	V2.0	V2.5	V2.7
10	Standard Streptomycin	Escherichia coli	V2.4	V2.6	V3.0
		Pseudomonas aeruginosa	10µl	20µl	30µl
		Staphylococcus aureus	V2.5	V2.7	V3.0
		Bacillus subtilis	V2.0	V2.8	V3.0
		Staphylococcus aureus	V2.5	V2.7	V3.0
		Bacillus subtilis	V2.7	V3.0	V3.5

The antibacterial activity of the samples is assessed using the different concentration of the sample i.e., low, intermediate, high.

The present investigation reveals that the zone of inhibition increased as the concentration of the sample increased. This is seen in case of the compounds 4b, 4d and 4i. Hence the MIC (Minimum Inhibitory Concentration) of these samples that can inhibit bacterial growth is 10 $\mu$ l, 20 $\mu$ l and 30 $\mu$ l respectively. Thus the above samples are able to show antibacterial activity on *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis*. The MIC (Minimum Inhibitory Concentration) of 4b sample that can inhibit *Pseudomonas aeruginosa* bacterial growth is 30 $\mu$ l and the MIC (Minimum Inhibitory Concentration) of 4d sample that can inhibit *Staphylococcus aureus* and *Bacillus subtilis* bacterial growth are 20 $\mu$ l and 30 $\mu$ l respectively. The investigation reveals that the zone of inhibition increased as the concentration of the sample compound increased.

## 6. CONCLUSION

CuFe<sub>2</sub>O<sub>4</sub> Nano particles has been successfully used as catalyst for Claisen-Schmidt condensation using aldehydes and acetophenones. Utilization of this catalyst has several advantages: high yield, the preparation of catalyst is simple, low catalyst loading, convenient operation, no formation by-products, the catalyst can be easily recycled with magnet and reused. The main contribution of this work is synthesizing copper ferrite nano particles successfully, which shows a balance between recyclization and activity for the Claisen-Schmidt condensation.

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