

Research Article

Catalytic Synthesis of α -Aminonitriles Using Nano Copper Ferrite (CuFe_2O_4) under Green Conditions

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Received 11 November 2013; Accepted 11 December 2013; Published 12 March 2014

Academic Editor: Kazuaki Ishihara

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Copper ferrite nanomaterial (CuFe_2O_4) as reusable heterogeneous initiator in the synthesis of α -aminonitriles. The nanocatalyst is easily recovered and its reusability is recorded. Synthesis of α -aminonitriles derivatives by one-pot reaction of different aldehydes with amines and trimethylsilyl cyanides has been developed using nano copper ferrite (CuFe_2O_4) catalyst under room temperature and green solvent (water as solvent) conditions. α -aminonitriles are important in preparing a wide variety of amino acids, amides, diamines, and nitrogen containing heterocycles.

1. Introduction

α -aminonitriles are significantly important intermediates for the synthesis of a wide variety of amino acids, amides, diamines, and nitrogen-containing heterocycles [1]. Among the methods reported for the synthesis of α -aminonitriles, nucleophilic addition of cyanide ion to imines (Strecker reaction) is of great importance to modern organic chemistry as it offers one of the most direct and viable methods for the synthesis of α -aminonitriles [2]. Strecker reaction [3], the oldest known synthesis of α -aminonitriles, is one of the most general methods potentially useful for syntheses of amino acids and other bioactive compounds including natural products. In addition, the Strecker reaction represents one of the simplest and most economical methods for the preparation of α -amino acids for both laboratory and industrial scales [2]. Since 1850, a number of publications have appeared on this reaction. Still this reaction is under active investigation. Recently, synthesis of hepatitis C virus NS3 serine protease inhibitors [4], (\pm)-phthalascidin 622 [5], and novel boron-containing retinoids [6] has been reported following this strategy. A number of new catalysts have also been reported for this reaction which includes lanthanum(III)-binaphthyl disulfonate [7],

nanocrystalline magnesium oxide [8], BINOL-phosphoric acid [9, 10], $\text{Fe}(\text{Cp})_2\text{PF}_6$ [11], Jacobsen's thiourea catalyst [12], N-heterocyclic carbene (NHC)-amidate palladium (II) complex [13], $\text{Yb}(\text{OTf})_3$ -pybox [14], K_2PdCl_4 [15], gallium (III) triflate [16], bisformamides [17], IBX/TBAB [18], Lewis base, for example, N,N-dimethylcyclohexylamine [19], superparamagnetic iron oxide [20], and ionic liquid [21]. To prepare α -aminonitriles (precursor to α -amino acids) generally an imine is reacted with a cyanide source. Notable among them are HCN [22], KCN [23], $(\text{EtO})_2\text{P}(\text{O})\text{CN}$ [24, 25], Et_2AlCN [26, 27], Bu_3SnCN [28, 29], and TMSCN [6, 7, 9–29]. Among these cyanide sources, trimethylsilyl cyanide (TMSCN) is relatively easy to handle and highly soluble in organic solvents. The addition of cyanide anions to imines (the Strecker reaction) [3] provides one of the most important and straightforward methods for the synthesis of α -aminonitriles, which are useful intermediates for the synthesis of amino acids [30] and nitrogen containing heterocycles such as thiadiazoles and imidazoles [31] and other biologically useful molecules such as saframycin A, a natural product with anti-tumour activity, or phthalascidin, a synthetic analogue, which exhibits even greater potency [32]. Several modifications of Strecker reaction have been reported using a variety of cyanide reagents, such as alkaline cyanides [1, 2, 29, 33].

Despite the advantages of homogeneous metal catalysts, difficulties in recovering the catalyst from the reaction mixture severely inhibit their use in industry. Heterogeneous catalysis results in easy separation and recycling of catalyst. Recent reports reveal that magnetic nanoparticles are efficient catalysts and they can be easily separated from reaction mixture [34]. The high surface area to volume ratio of metal oxide nanoparticle is mainly responsible for their catalytic performance [34]. Copper ferrite nanomaterial is one such reusable catalyst which shows profound catalytic activity in organic synthesis [35]. Thus it is clearly evident that the need for the development of new and flexible protocols is required in such a way that they should be more economic and environmentally benign. Here, we report nano copper ferrite (CuFe_2O_4) as a reusable catalyst, for the synthesis of α -aminonitrile derivatives with shorter reaction times in good to moderate yields.

2. Experimental

2.1. Chemicals and Apparatus. Melting points were determined by Thieles tube method. ^1H -NMR spectra were recorded on a Bruker AM 300 MHz spectrometer using CDCl_3 as a solvent and tetramethylsilane as an internal standard. The chemical shifts are expressed in δ (ppm). FT IR spectrometer of Perkin Elmer was used for study. Thin layer chromatography (TLC) was done with precoated silica gel plates (GF254 Merck) using benzene: ethyl acetate (9.5:0.5, v/v) as the mobile phase. Melting points were recorded on a Stuart Scientific Apparatus SMP3 (UK) in open capillary tubes.

2.2. Catalyst Synthesis Procedure

2.2.1. Synthesis of the Nano Copper Ferrite (CuFe_2O_4) Catalyst. The catalyst was synthesized by citrate gel precursor method [36]. Copper (II) nitrate and iron (III) nitrate were taken in stoichiometric proportions and minimum amount of deionized water was added to produce clear cationic solution. Citric acid solution was then prepared in stoichiometric ratio. Aqueous solutions with 1:1 molar ratio of metal ion solutions were mixed and citric acid was added in equimolar ratio to the above mixed metal ion solution. pH was adjusted to 7 by adding ammonia solution. The aqueous mixture was kept for stirring to form a highly viscous gel. The gel was then heated gradually up to 90°C to evolve reddish brown gases and they became dried gel which was finally treated at 350°C for 1 h to observe whether the dry gel burnt out in self propagating manner to form loose powder. The finely powdered particles were calcinated at 500°C . The powder was then characterized.

2.3. Procedure for Synthesis of α -Aminonitriles. To the reaction mixture of aldehyde (1 mmol), amine (1 mmol), trimethylsilyl cyanide TMS-CN (1.5 mmol) was added to a solution of nano copper ferrite (CuFe_2O_4) catalyst (15 mg) and glacial acetic acid (1 mL), in water (50 mL), and the resulting mixture was stirred vigorously at room temperature for appropriate time. The reaction was monitored by TLC. After completion of the reaction, as indicated by TLC, the

reaction mixture was filtered and washed with EtOAc (2×20 mL) and the catalyst was separated by filtration. The organic solvent was removed under reduced pressure. After purification by chromatography on silica gel (ethyl acetate/n-hexane 20:80), α -aminonitriles were obtained.

Selected Spectral Data 2-(2,4-Dichlorophenyl)-2-(p-tolylamino) acetonitrile (4a). IR (KBr, cm^{-1}): 3331, 3024, 2920 2230. ^1H NMR (300 MHz, CDCl_3): δ_{H} 2.16 (s, 3H), 4.03 (br s, 1H), 5.65 (s, 1H), 6.73 (dd, $J = 8.5, 0.7$ Hz, 2H), 6.96 (t, $J = 7.2$ Hz, 1H), 7.25–7.30 (m, 2H), 7.43 (dd, $J = 8.5, 2.0$ Hz, 1H), 7.64 (d, $J = 2.0$ Hz 1H), 7.70 (d, $J = 8.5$ Hz, 1H). ^{13}C NMR (100 MHz, CDCl_3): δ_{C} 21.94, 51.52, 114.30, 117.24, 120.57, 122.433, 128.06, 129.62, 129.89, 130.31, 134.33, 136.65, 144.27. Anal. calcd for $\text{C}_{14}\text{H}_{10}\text{Cl}_2\text{N}_2$: C, 60.67; H, 3.64; N, 10.11%. Found: C, 60.50; H, 3.60; N, 1.48%.

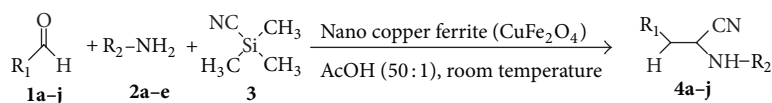
2-(4-Fluorophenyl)-2-(p-tolylamino) acetonitrile (4b). IR (KBr, cm^{-1}): 3345, 3020, 2922, 2231. ^1H NMR (300 MHz, CDCl_3): δ_{H} 2.14 (s, 3H), 3.95 (br s, 1H), 5.40 (s, 1H), 6.63 (d, $J = 8.5$ Hz, 2H), 7.07 (d, $J = 8.0$ Hz, 2H), 7.15 (t, $J = 8.5$ Hz, 2H), 7.45–7.51 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3): δ_{C} 20.62, 50.04, 114.76, 114.91, 116.40, 116.65, 118.13, 129.14, 130.20, 142.13, 161.45. Anal. calcd for $\text{C}_{15}\text{H}_{13}\text{FN}_2$: C, 74.98; H, 5.45; N, 11.66%. Found: C, 74.81; H, 5.31; N, 11.69%.

2-(4-Chlorophenyl)-2-(p-tolylamino) acetonitrile (4c). IR (KBr, cm^{-1}): 3336, 3017, 2923, 2225. ^1H NMR (300 MHz, CDCl_3): δ_{H} 2.30 (s, 3H), 3.97 (s, 1H), 5.38 (s, 1H), 6.77 (d, $J = 8.5$ Hz, 2H), 7.12 (d, $J = 8.0$ Hz, 2H), 7.46 (d, $J = 8.5$ Hz, 2H), 7.55 (d, $J = 8.5$ Hz, 2H). ^{13}C NMR (100 MHz, CDCl_3): δ_{C} 21.03, 50.24, 114.66, 118.03, 128.37, 130.06, 130.14, 132.57, 135.98, 142.10. Anal. calcd for $\text{C}_{15}\text{H}_{13}\text{ClN}_2$: C, 70.18; H, 5.10; N, 10.91%. Found: C, 70.09; H, 5.05; N, 10.88%.

2-(4-Bromophenylamino)-2-phenylacetonitrile (4d). IR (KBr, cm^{-1}): 3325, 3036, 2965, 2234, 1597, 1226, 925, 763; ^1H NMR (300 MHz, CDCl_3): δ_{H} 3.96 (sb, 1H), 5.30 (s, 1H), 6.65 (d, 2H, $J = 8.3$ Hz), 6.66 (t, 1H), 7.17 (t, 2H), 7.33 (d, 2H, $J = 8.3$ Hz), 7.56 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3): δ_{C} 49.95, 113.43, 116.70, 119.84, 124.47, 128.66, 129.65, 132.35, 133.43, 143.36; Anal. Calcd for $\text{C}_{14}\text{H}_{11}\text{BrN}_2$: C, 58.56; H, 3.86; N, 9.76. Found: C, 58.44; H, 3.56; N, 9.63.

2-(N-Anilino)-2-(4-chlorophenyl) acetonitrile (4e). IR (KBr, cm^{-1}): 3315, 3026, 2950, 2237, 1605, 1456, 1261, 1240, 885, 756; ^1H NMR (300 MHz, CDCl_3): δ_{H} 4.05 (bs, 1H), 5.40 (s, 1H), 6.75 (d, 2H, $J = 7.6$ Hz), 6.90 (t, 1H, $J = 7.4$ Hz), 7.27 (t, 2H, $J = 8.9$ Hz), 7.46 (d, 2H, $J = 8$ Hz), 7.55 (d, 2H, $J = 8$ Hz); ^{13}C NMR (100 MHz, CDCl_3): δ_{C} 164.74, 164.31, 142.25, 131.62, 129.75, 129.02, 126.86, 124.05, 121.16, 21.64; Anal. Calcd for $\text{C}_{14}\text{H}_{11}\text{ClN}_2$: C, 69.28; H, 4.57; N, 11.54. Found: C, 69.11; H, 4.43; N, 11.32.

2-(N-Anilino)-2-(4-methoxy-phenyl)-acetonitrile (4f). IR (KBr, cm^{-1}): 3435, 2920, 2233, 1595, 1511, 1247, 1175, 820, 746, 680; ^1H NMR (300 MHz, CDCl_3): δ_{H} 3.80 (s, 3H), 3.95 (s, 1H), 5.30 (s, 1H), 6.73 (d, $J = 8.7$ Hz, 2H), 6.86 (t, $J = 7.4$ Hz, 1H), 6.93 (d, $J = 8.8$ Hz, 2H), 7.20 (t, $J = 7.2$ Hz, 2H), 7.42 (d, $J = 7.2$ Hz, 2H).



SCHEME 1: The synthesis of α -aminonitriles in the presence of nano copper ferrite (CuFe_2O_4) in water as green solvent at room temperature.

TABLE 1: Effect of amount of catalyst on the synthesis of 2-(4-Nitrophenyl)-2-(phenylamino)acetonitrile (**4i**), (optimization of the amount of nano copper ferrite (CuFe_2O_4) catalyst with AcOH).

Entry	Amount of catalyst (mg)	Reaction time	^a Yield (%)
1	0 (not catalyst)	18 hrs	—
2	0 (not catalyst)	24 hrs	—
3	5	72 min	74
4	10	55 min	82
5	15	55 min	98
6	25	55 min	84
7	30	55 min	79

^aIsolated yields.

= 8.7 Hz, 2H); ¹³C NMR (100 MHz, CDCl_3): δ_c 49.75, 55.65, 114.13, 114.61, 118.43, 120.22, 126.11, 128.60, 129.56, 144.70, 160.43; Anal. Calcd for $\text{C}_{15}\text{H}_{14}\text{N}_2\text{O}$: C, 75.45; H, 5.58; N, 11.70. Found: C, 75.34; H, 5.38; N, 11.56.

2-(*N*-Anilino)-2-(4-methylphenyl) acetonitrile (**4g**). IR (KBr, cm^{-1}): 3310, 3024, 2231, 1663, 1557, 1255, 1120, 762; ¹H NMR (300 MHz, CDCl_3): δ_H 2.35 (s, 3H), 3.50 (bs, 1H), 5.33 (s, 1H), 6.62 (d, $J = 7.6$ Hz, 2H), 6.74 (t, $J = 7.5$ Hz, 1H), 7.16 (t, $J = 8.0$ Hz, 4H), 7.65 (d, $J = 8.1$ Hz, 2H); ¹³C NMR (100 MHz, CDCl_3): δ_c 21.41, 50.10, 114.35, 117.97, 120.16, 127.07, 129.45, 129.92, 131.16, 139.43, 145.16; Anal. Calcd for $\text{C}_{15}\text{H}_{14}\text{N}_2$: C, 81.08; H, 6.35; N, 12.59. Found: C, 65.20; H, 6.21; N, 12.43.

2-(*N*-Anilino)-2-(4-hydroxyphenyl) acetonitrile (**4h**). IR (KBr, cm^{-1}): 3341, 3027, 2235, 1606, 1264, 1159, 831, 748; ¹H NMR (300 MHz, CDCl_3): δ_H 4.55 (br s, 1H), 5.16 (s, 1H), 6.75–6.86 (m, 5H), 7.21 (t, $J = 7.4$ Hz, 2H), 7.34 (d, $J = 8.2$ Hz, 2H), 9.80 (br s, 1H); ¹³C NMR (100 MHz, CDCl_3): δ_c 49.35, 113.77, 115.62, 118.43, 119.27, 124.30, 128.43, 129.10, 145.33, 156.27; Anal. Calcd for $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}$: C, 74.98; H, 5.39; N, 12.49. Found: C, 74.71; H, 5.21; N, 12.33.

2-(4-Nitrophenyl)-2-(phenylamino) acetonitrile (**4i**). IR (KBr, cm^{-1}): 33112, 3017, 2245, 1663, 1590, 1461, 1101, 756; ¹H NMR (300 MHz, CDCl_3): δ_H 4.15 (d, $J = 8.0$ Hz, 1H), 5.22 (d, $J = 8.0$ Hz, 1H), 6.61 (d, $J = 8.0$ Hz, 2H), 6.73 (t, $J = 7.8$ Hz, 1H), 7.02 (t, $J = 7.8$ Hz, 2H), 7.50 (d, $J = 8.05$ Hz, 2H), 7.94 (d, $J = 8.05$ Hz, 2H); ¹³C NMR (100 MHz, CDCl_3): δ_c 49.30, 114.33, 115.76, 118.17, 119.45, 123.90, 127.83, 129.31, 144.89, 156.60; Anal. Calcd for $\text{C}_{14}\text{H}_{11}\text{N}_3\text{O}_2$: C, 66.40; H, 4.38; N, 16.59. Found: C, 66.29; H, 4.22; N, 16.43.

2-(*N*-Anilino)-2-phenyl acetonitrile (**4j**). IR (KBr, cm^{-1}): 3335, 3021, 2946, 2235, 1600, 1515, 1282, 955, 750; ¹H NMR (300 MHz, CDCl_3): δ_H 3.96 (bs, 1H), 5.42 (s, 1H), 6.73 (d, $J = 7.6$ Hz, 2H), 6.85 (t, $J = 7.4$ Hz, 1H), 7.27 (t, $J = 7.6$ Hz, 2H), 7.42 (m, 3H), 7.56 (m, 2H); ¹³C NMR (100 MHz, CDCl_3): δ_c 49.86,

114.17, 118.15, 119.93, 127.28, 129.30, 129.63, 129.59, 133.96, 144.55; Anal. Calcd for $\text{C}_{14}\text{H}_{12}\text{N}_2$: C, 80.74; H, 5.81; N, 13.45. Found: C, 80.56; H, 5.63; N, 13.32.

3. Result and Discussion

We wish to report the best reaction conditions for the synthesis of α -aminonitrile derivatives, the one-pot three component condensation of benzaldehyde (**1a**), aniline (**2a**), and TMS-CN (**3**) was examined in the presence of nano copper ferrite (CuFe_2O_4) with AcOH under room temperature and the obtained results are summarized in Table 1, (Scheme 1). In an effort to develop an optimal catalytic system, various reaction parameters like effect of different amounts of catalyst and time for the preparation of α -aminonitriles derivatives were studied.

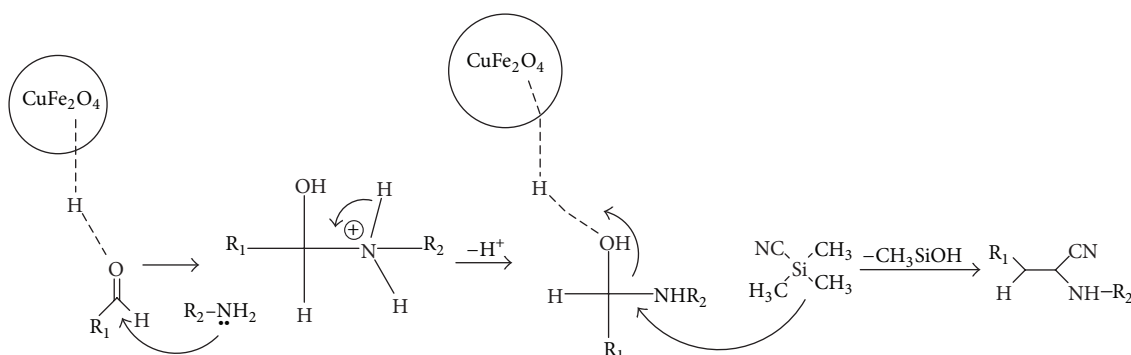
The same reaction was used to optimize the amount of the catalyst. The results show (Table 1) that 15 mg nano copper ferrite (CuFe_2O_4) with AcOH is required to complete the reaction in 55 minutes. To further improve the yield and to optimize the reaction conditions, the same reaction was carried out in the presence of (5, 15, 25, and 30 mg) of catalyst under similar conditions. Reaction with 5 mg of the catalyst required a longer reaction time and the yield of product was dramatically increased up to 74% after stirring the mixture for only 72 min. The reaction was checked without the catalyst and it was found that the reaction did not proceed even after 18 and 24 h (Table 1). These observations established the crucial role of nano copper ferrite (CuFe_2O_4) in the expedition of the reaction time and the product yield. The results also show (Table 2) that 15 mg nano copper ferrite (CuFe_2O_4) without AcOH is required to complete the reaction in 66 minutes with a yield 90.5%.

The reaction was then performed in various solvents using nano copper ferrite (CuFe_2O_4) with AcOH as the catalyst to identify the best condition. It suggests that nano copper ferrite (CuFe_2O_4) and AcOH (with amount of 15 mg)

TABLE 2: Effect of amount of catalyst on the synthesis of 2-(4-Nitrophenyl)-2-(phenylamino)acetonitrile (**4i**), (optimization of the amount of nano copper ferrite (CuFe_2O_4) catalyst without AcOH).

Entry	Amount of catalyst (mg)	Reaction time	^a Yield (%)
1	5	80 min	69
2	10	65 min	77
3	15	66 min	90.5
4	25	66 min	78
5	30	68 min	71

^aIsolated yields.



SCHEME 2: Suggested mechanism for the synthesis of α -aminonitriles derivatives in presence of acidic nano copper ferrite (CuFe_2O_4).

TABLE 3: Synthesis of 2-(4-Nitrophenyl)-2-(phenylamino)acetonitrile (**4i**) in the presence of (nano copper ferrite (CuFe_2O_4) catalyst with AcOH) and various solvents at room temperature (solvent optimization).

Entry	Solvent	^a Yield (%)
1	H_2O	98
2	$\text{C}_2\text{H}_5\text{OH}$	59
3	DMF	81
4	DMSO	80
5	CHCl_3	77
6	$\text{C}_6\text{H}_5\text{CH}_3$	79
7	CH_3OH	72
8	CH_2Cl_2	78
9	CCl_4	83
10	C_6H_6	76
11	n-Hexane	69

^aIsolated yields.

is the best catalyst amount in aqueous medium for the reaction (Table 3).

In addition to different benzaldehyde derivatives, this reaction was also tested with alkyl aldehydes or (aliphatic aldehydes) such as acetaldehyde, isobutyraldehyde, propionaldehyde and butyraldehyde, and aniline, their yields are as follows: 72, 76, 79, 82%.

The results listed in Tables 1 and 2 showed that the conversions were sensitive to the catalyst type (nano copper ferrite (CuFe_2O_4) catalyst with AcOH and without AcOH). The results showed that nano copper ferrite (CuFe_2O_4) catalyst with AcOH promoted the reaction more effectively

TABLE 4: Synthesis of 2-(4-Nitrophenyl)-2-(phenylamino)acetonitrile (**4i**) in the presence of (nano copper ferrite (CuFe_2O_4) catalyst without AcOH) and various solvents at room temperature (solvent optimization).

Entry	Solvent	^a Yield (%)
1	H_2O	90.5
2	$\text{C}_2\text{H}_5\text{OH}$	51
3	DMF	73
4	DMSO	72.5
5	CHCl_3	70
6	$\text{C}_6\text{H}_5\text{CH}_3$	71
7	CH_3OH	65
8	CH_2Cl_2	70.5
9	CCl_4	77
10	C_6H_6	72
11	n-Hexane	64

^aIsolated yields.

than nano copper ferrite (CuFe_2O_4) catalyst without AcOH (Tables 2 and 4).

One reason for the increase in the catalytic activity may be related to the number of available active sites. A proposed mechanism for the role of nano copper ferrite (CuFe_2O_4) catalyst with AcOH in the reaction of aldehydes, amine and trimethylsilyl cyanide is presented in Scheme 2.

We suggest a mechanism for the formation of α -aminonitriles derivatives which it has been hypothesized that the reaction proceeds. First, aldehydes activated by the acidic proton of nano copper ferrite (CuFe_2O_4) (nano copper ferrite (CuFe_2O_4) with AcOH) react with amines to form a key intermediate.

TABLE 5: Synthesis of α -aminonitriles derivatives in the presence of acidic nano copper ferrite (CuFe_2O_4) (nano copper ferrite (CuFe_2O_4) catalyst with AcOH) and water as green solvent at room temperature.

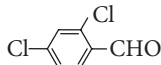
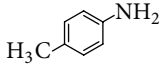
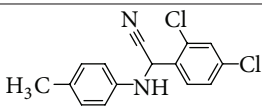
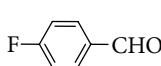
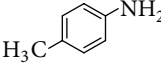
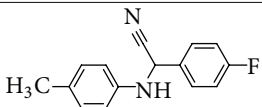
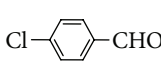
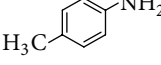
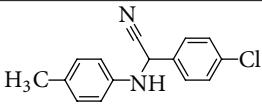
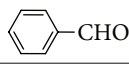
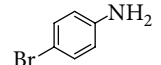
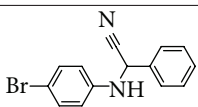
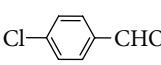

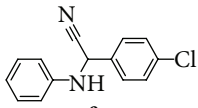
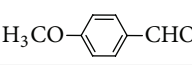

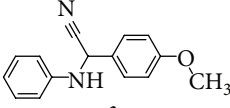
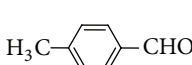

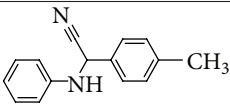
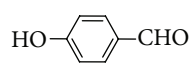

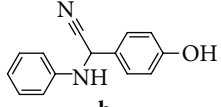
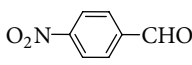

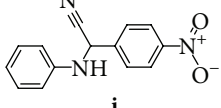
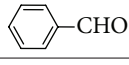

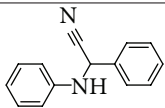


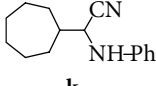

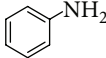
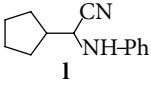
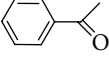
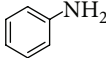
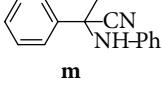
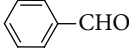
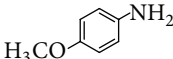
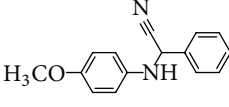
Entry	Carbonyl compound	Amine	Product	Time (min)	^a Yield (%)	Mp ($^{\circ}\text{C}$)
1			 a	75	92	115–117
2			 b	70	90 (90, 89.5, 89.5, 89) ^b	104–106
3			 c	73	92	83–85
4			 d	75	94.5	100–102
5			 e	70	94 (93.5, 93, 93, 92.5) ^b	109–110
6			 f	69	91 (91, 90, 90, 89.5) ^b	95–97
7			 g	68	94 (94, 93, 92.5, 92) ^b	70–73
8			 h	65	93	121–123
9			 i	55	98 (98, 98, 97, 97) ^b	90–92
10			 j	50	93 (93, 92.5, 92, 92) ^b	73–74
11			 k	81	72	80–83

TABLE 5: Continued.

Entry	Carbonyl compound	Amine	Product	Time (min)	^a Yield (%)	Mp (°C)
12			 1	75	75	49–52
13			 m	65	78	110–112
14			 n	62	93	107–109

^aIsolated yields. ^bCatalyst was reused over four runs.

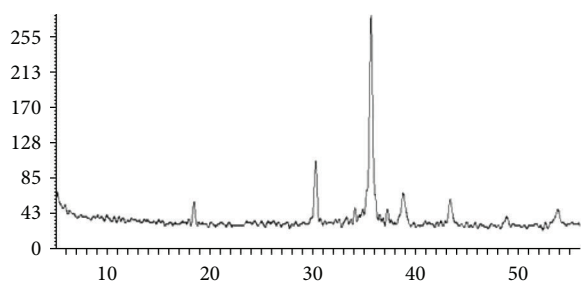


FIGURE 1: XRD spectrum of nano copper ferrite (CuFe_2O_4) at 500°C .

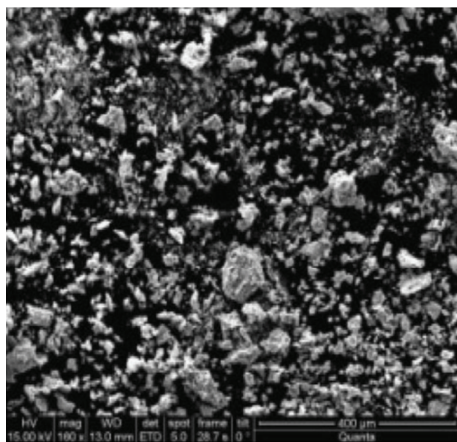


FIGURE 2: SEM image of nano copper ferrite (CuFe_2O_4).

Considering the above observations, we carried out a series of reactions using various carbonyl compounds, amines, and TMSCN in presence of nano copper ferrite (CuFe_2O_4) with (15 mg) AcOH in water as solvent (Scheme 1). Most of the aldehydes reacted efficiently with aniline and TMSCN to furnish the corresponding products in excellent yields (72–98%) (Table 5). We also continued our tests with three component Strecker reaction catalyzed by nano copper ferrite (CuFe_2O_4) with AcOH, and the results showed that among acetophenone (78%) and cyclic ketones, cyclopentanone (75%), and cycloheptanone (72%), the yields were less in comparison with benzaldehydes Table 5, entries 11–13. In

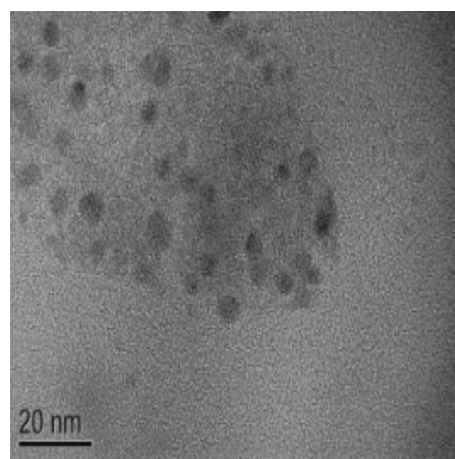


FIGURE 3: TEM image of nano copper ferrite (CuFe_2O_4).

all the cases, the reactions were completed within 50 min to 81 min and the products were obtained in excellent yield (Table 5).

XRD studies were carried out to the above nano ferrite and XRD spectrum is presented in Figure 1. From the XRD data, it is observed that the copper ferrites are spinal crystals. From the XRD data, the size of the copper ferrite particles is calculated by using sheerer formula, and the particle size is found to be 20 nm. This shows that the synthesized powder has nanosized crystalline. The scanning electron microscope studies are carried out on the copper ferrite sample at 500°C , and it is presented in Figure 2. The TEM image was recorded and presented in Figure 3. The lump size with irregular morphology was observed and it was found at $400\ \mu\text{m}$ at 500°C . From the above study, we observed a less number of pores with smaller lump size, resulting in fine grained microstructure with respect to ferrites.

3.1. Catalyst Recovery Nano Copper Ferrite (CuFe_2O_4). At the end of the reaction, the catalysts could be recovered by a simple filtration. The recycled catalyst could be washed with dichloromethane and subjected to a second run of the reaction process with the same substrate. The results of the

first and subsequent experiments were almost consistent in yields (98, 98, 97, 97% after four runs) (Table 5).

4. Conclusion

In conclusion, we have demonstrated a highly efficient and convenient method for the synthesis of α -aminonitriles derivatives in reaction of different aromatic aldehydes with acyl hydrazide under room temperature with water as green solvent. This method not only offers substantial improvements in the reaction rates and yields, but also avoids the use of hazardous catalysts or solvents. In our experiments, the reusability of the catalyst was examined by repetitive use of the catalyst. The catalyst was recycled and no appreciable change in activity was noticed after four cycles. This reaction will be applicable to the synthesis of various organic compounds of medicinal interests. Moreover, the mild reaction conditions, high yields, easy work-up, and clean reaction profiles as an interesting alternative to the existing methods. Therefore, this method is eco-friendly.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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