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LETTER ARTICLE

Ultrasonic Assisted Synthesis of 2, 3-Dihydroquinazolin-4(1*H*)-ones Involving Three-Component Reaction of Isatoic Anhydride, Amines and Pyrazole Carbaldehydes Catalyzed by [γ-Fe_2O_3@HAp-SO_3H]

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Abstract: The combination of [γ-Fe_2O_3@HAp-SO_3H] as a catalyst and ultrasonic effect catalyzed the synthesis of diverse derivatives of 2, 3-dihydroquinazolin-4(1*H*)-ones which is reported in this study. The products were synthesized *via* the one-pot three-component reaction of isatoic anhydride, amines and pyrazole carbaldehydes in water: EtOH catalyzed by recoverable [γ-Fe_2O_3@HAp-SO_3H]. This paper conducted an investigation of the effect of various solvents, temperatures and catalysts on the reactions. Short reaction times, mild reaction conditions, simple work-up, the desired yields and the use of an appropriate catalyst are the advantages of this novel method. The new derivatives were validated by using FT-IR, ^{1}HNMR, and ^{13}CNMR. Moreover, the synthesized compounds were screened for their antimicrobial activity against bacterial strains.

Keywords: 2, 3-Dihydroquinazolinone, pyrazole carbaldehydes, ultrasonic, [γ-Fe_2O_3@HAp-SO_3H], catalyst, one-pot three-component reaction.

1. INTRODUCTION

Heterocycles has acquired a central position in organic and natural chemistry [1]. Nitrogen-containing heterocycles are a basic part of many drug compounds, physiologically active natural products and synthetic molecules [2]. Quinazolin-4-ones are essential fused heterocycles which were found to have useful biological and pharmacological activities involving antifungal, analgesic, antidiabetic, antitumor, antibacterial, anticonvulsant and antihypertensive [3]. Among quinazolinones, 2, 3-dihydroquinazoline-4(1H) ones are attractive forms. In 2015, we examined a one-pot three components reaction between isatoic anhydride, ammonium acetate and pyrazole carbaldehydes in the presence of [BDBIm]Br under microwave irradiation [4]. We were interested in developing these reactions by using the ultrasound method with various amines in the presence of an acid nanocatalyst. [γ-Fe_2O_3@HAp]-supported dual acidic nanocatalyst is known as a novel, heterogeneous and reusable catalyst. This catalyst was used in the reaction to be performed in mild conditions, with good yields, low cost and short reaction times. An environmentally friendly and inexpensive catalyst that requires a fairly easy work-up procedure without using a large amount of hazardous organic and natural solvents makes it a proper replacement for previously applied procedures [5]. We would like to report a one-pot reaction for 2, 3-dihydroquinazoline-4(1*H*)-ones from isatoic anhydride, pyrazole carbaldehydes (Table **4**) and amine (such as ammonium acetate, ammonium carbonate, aniline, 4-methyl aniline, 4-ethoxy aniline, 4-chloro aniline) using [γ-Fe_2O_3@HAp-SO_3H] as a nanocatalyst under ultrasonic Scheme **1**.

2. RESULTS AND DISCUSSION

Firstly, as a model reaction, the one-step reaction of (1 mmol) isatoic anhydride, (0.6 mmol) ammonium carbonate and (1 mmol) pyrazole carbaldehyde in water: ethanol under ultrasound irradiation using [γ-Fe_2O_3@HAp-SO_3H] was investigated under diverse conditions. The reactions were performed in pure water, EtOH, H_2O: EtOH (1:1), H_2O: EtOH (3:1) and H_2O: EtOH (1:3) (Table **1**). We were observed using H_2O: EtOH (3:1) as a solvent which obtained the best yield [6, 7]. Also, the reactions were carried out in different temperatures such as at 40°C, 50°C, and 60°C) under sonication. It was found that increasing the reaction temperature improved the vapor pressure of the solvent and built up cavitation which further accelerated the reaction [8]. Thus, we preferred to use (1 mmol) isatoic anhydride, (1mmol) pyrazole carbaldehyde, (0.6 mmol) ammonium

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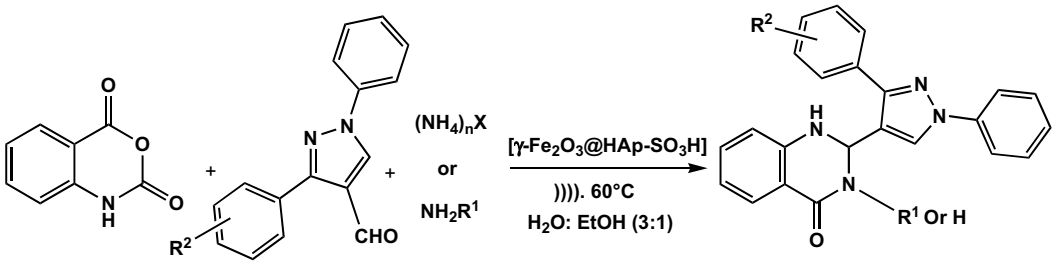


R^1 = C_6H_5 , 4-Me C_6H_4, 4-OEt C_6H_4, 4-Cl C_6H_4
R^2 = H, OH, Cl, OMe
X = OAc^-, CO_3^{2-}
n = 1, 2

Scheme (1). Synthesis of 2, 3-dihydroquinazolin-4(1*H*)-ones catalyzed by [γ-Fe_2O_3@HAp-SO_3H].

Table 1. Optimization of the solvent for the synthesis of 2, 3-dihydroquinazolin-4(1*H*)-ones.

Entry	Solvent	Time (h)	Yield (%)
1	EtOH	2	60
2	Pure water	1	62
3	H_2O: EtOH 1:1	1	84
4	H_2O: EtOH 1:3	2	72
5	H_2O: EtOH 3:1	1	90

carbonate[1] and 10 mg catalyst in water: ethanol (3:1) at 60°C as the best choice for synthesizing 2, 3-dihydroquinazoline-4(1*H*)-ones [9]. To show the advantages of [γ-Fe_2O_3@HAp-SO_3H], compared to K10, nano-Fe_3O_4, $Cu(OAc)_2$, *p*-TsOH, and iodine (Table **2**). The resulting product was obtained in the yield of 82%, 87%, 79%, 71%, 85%, and 92%. Also, some reactions were examined in the absence of a catalyst (Table **3**). It was proven that [γ-Fe_2O_3@HAp-SO_3H] is a powerful catalyst for the activation of the substrates and intermediates in the direction of the reaction [10].

To expand the efficiency of the process, this catalyzed reaction was combined with ultrasound [11]. The prepared pyrazole carbaldehydes and also amine derivatives or ammonium salts were used to synthesize the related products in good yields.

The results demonstrate the high potential of this novel strategy such as low cost, good yields, short reaction times, the use of a simple recoverable catalyst and easy work-up for the synthesis of substituted 2, 3-dihydroquinazoline-4(1*H*)-ones. The structures of the products were confirmed by FT-IR, ^{1}HNMR and ^{13}CNMR spectroscopy [12].

To examine the recyclability of the catalyst, the nanocatalyst was separated from the product by attaching an external magnetic field, washed with diethyl ether, dried under vacuum and reused in the next run. The results showed that the activity of the nanocatalyst remained unchanged for four consecutive runs [5, 13].

The application of ultrasound is popular as a profitable tool in synthesis, also improving the green methods and organic reactions. Sonication speeds up the reaction by producing a driving energy by cavitation, and by the creation and collapse of bubbles, thereby, increasing the rate and selectivity [12]. Ultrasound can have special physical and chemical effects on the reaction. Similar experiments were carried out with stirring under refluxing conditions. It was found that the reactions under refluxing demanded longer reaction times and resulted in lower yields (Table **3**) [8].

Based on our test results and also other reported mechanisms in the literature, the suggested mechanism of the reaction is recommended in Scheme **2**. The interaction of the nanocatalyst and isatoic anhydride forms a reactive intermediate (I), then, the N- nucleophilic primary amine attacks on the carbonyl unit of I to form an intermediate (II). Decarboxylation reaction and proton transfer produce an intermediate (III). Subsequently, the reaction of an activated aldehyde with III gives H_2O to form an imine intermediate (IV). In the presence of the nanocatalyst, the amide functional group in intermediate (IV) could be formed by the tautomerism phenomenon (V). Thus, the intermolecular nucleophilic attack of the amide nitrogen on the activated imine carbon provides an intermediate (VI). Finally, 1,5-proton transfer produces the desired product [10, 16].

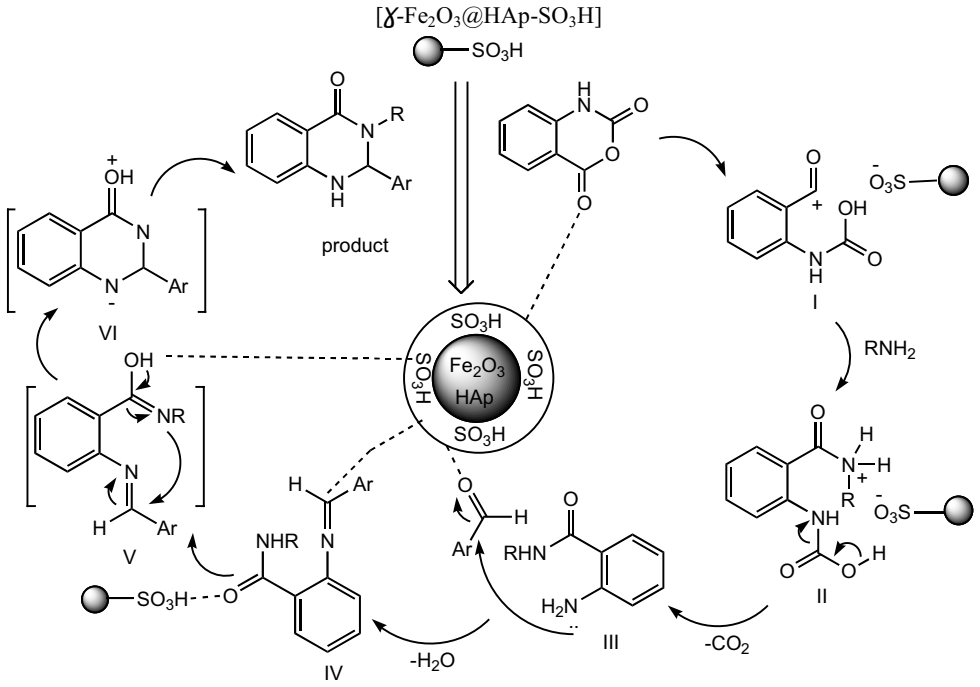
[1]Ammonium carbonate (0.6 mmol) contains 1.2 mmol ammonium ion.

Table 2. Effect of the catalysts in the reaction of isatoic anhydride, ammonium carbonate and 1, 3-diphenyl-1*H*-pyrazole-4-carbaldehyde.

Entry	Catalyst[a]	Time (h)	Yield (%)[b]
1	K10	2	82
2	Nano-Fe_3O_4	1.5	87
3	$Cu(OAc)_2$	3	79
4	*p*-TsOH	5	71
5	Iodine	2.5	85
6	[γ-Fe_2O_3@HAp-SO_3H]	1	92

[a]Amount of catalyst used for entries: 1 (5% w/w) [11], 2 (15 mol%) [14], 3 (0.05 g), 4 (10 mol%) [5], 5 (5 mol%) [15], 6 (10 mg = 0.9 mol %) [13].

[b]Isolated yield.



Scheme (2). Proposed mechanism.

2.1. Microbial Test

All products were screened for their *in vitro* antibacterial activity against two Gram-negative bacterial strains: *Escherichia coli* (*E. coli*) and *Pseudomonas aeruginosa* (*P. aeruginosa*) and two Gram-positive bacterial strains: *Staphylococcus aureus* (*S. aureus*) and *Micrococcus luteus* (*M. luteus*) by paper diffusion method. Moderate to significant antibacterial activities were for the prepared quinazolinones (Table **5**). Tetracyclin and ciprofloxacin were used as reference drugs (ref). All the synthesized products, in the concentration of 20 µg/ml, were tested [2, 17, 18, 21].

3. EXPERIMENTAL

3.1. Apparatus, Materials

All the materials were purchased from Merck and Aldrich. The melting points were recorded on a Thermo 9100 apparatus. The NMR spectra were measured on an Ultrashield 400 Bruker (400 MHz for ^1H and 100 MHz for ^{13}C) spectrometer using TMS as an internal standard and DMSO-d_6 as the solvent. Sonication was performed using a Sono Swiss ultrasonic with a frequency of 50 or 60 Hz and a nominal power 280 W. FT-IR spectra were determined on an Alpha Bruker spectrophotometer using the pressed KBr [8, 19].

3.2. Synthesis of [γ-Fe_2O_3@HAp], [γ-Fe_2O_3@HAp-SO_3H]

$FeCl_2.4H_2O$ (1.85 mmol) and $FeCl_3.6H_2O$ (3.7 mmol) were dissolved in (30 ml) water and then were added to (10 ml) NH_4OH solution (25%), until a black precipitate of Fe_3O_4 was obtained. After 15 min, the milky solution was obtained by adding 100 ml of $Ca(NO_3)_2.4H_2O$ (33.7 mmol, 0.05 M) and $(NH_4)_2HPO_4$ (20 mmol, 3.0 M) solutions were

Table 3. The one-pot reaction[a] of isatoic anhydride, pyrazole carbaldehydes and ammonium salts or primary amines in diverse conditions.

Entry	Aldehyde (R^2)	Amine	Product	Conditions	Catalyst[b]	Time (min)	Yield (%)[c]	M.p. (°C)
1 [4]	4-OMe	NH_4OAc	a	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	60	92	223-225
2 [4]	2-OH	NH_4OAc	b	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	60	89	236-238
3 [4]	4-OH	NH_4OAc	c	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	50	93	235-237
4 [4]	4-Cl	NH_4OAc	d	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	70	85	190-192
5 [4]	H	NH_4OAc	e	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	45	93	238-240
6	H	$(NH_4)_2CO_3$	f	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	45	92	284-286
7	H	$C_6H_5NH_2$	g	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	55	91	193-195
8	H	4-$MeC_6H_4NH_2$	h	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	60	93	205-207
9	H	4-$OEtC_6H_4NH_2$	i	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	55	94	219-221
10	H	4-$ClC_6H_4NH_2$	j	60°C/ultrasound	[ɣ-Fe_2O_3@HAp-SO_3H]	80	88	215-217
11	H	$(NH_4)_2CO_3$	f	Reflux/Stirring	None	360	70	285-287
12	H	$C_6H_5NH_2$	g	Reflux/Stirring	None	370	70	192-194
13	H	4-$MeC_6H_4NH_2$	h	Reflux/Stirring	None	370	72	204-206
14	H	4-$OEtC_6H_4NH_2$	i	Reflux/Stirring	None	365	74	218-220
15	H	4-$ClC_6H_4NH_2$	j	Reflux/Stirring	None	390	65	216-218
16	H	$(NH_4)_2CO_3$	f	Reflux/Stirring	[ɣ-Fe_2O_3@HAp-SO_3H]	180	75	285-287
17	H	$C_6H_5NH_2$	g	Reflux/Stirring	[ɣ-Fe_2O_3@HAp-SO_3H]	190	73	194-196
18	H	4-$MeC_6H_4NH_2$	h	Reflux/Stirring	[ɣ-Fe_2O_3@HAp-SO_3H]	200	70	204-206
19	H	4-$OEtC_6H_4NH_2$	i	Reflux/Stirring	[ɣ-Fe_2O_3@HAp-SO_3H]	190	78	220-222
20	H	4-$ClC_6H_4NH_2$	j	Reflux/Stirring	[ɣ-Fe_2O_3@HAp-SO_3H]	210	66	216-218

[a]Reaction conditions: isatoic anhydride (1 mmol), pyrazole carbaldehydes (1 mmol) (Table **4**) and ammonium salts (ammonium acetate: 1.2 mmol, ammonium carbonate: 0.6 mmol) or primary amines (1.2 mmol) in H_2O: EtOH (3:1).

[b]Amount of catalyst used for reactions: 10 mg.

[c]Isolated yield.

Table 4. Physical data for the derivatives of pyrazole-4-carbaldehydes.

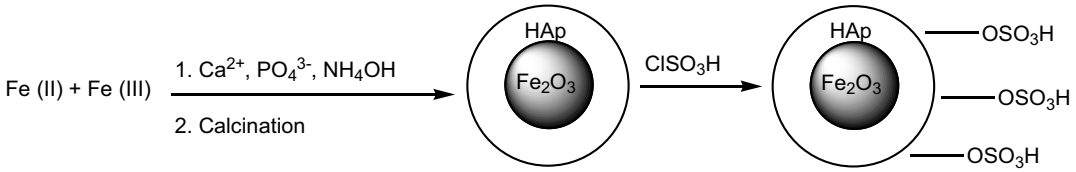
Entry	R^2	Molecular Formula	Molecular Weight	M.p. (°C)	Yield (%)
1	4-OMe	$C_{17}H_{14}O_2$	278	123-125	90
2	2-OH	$C_{16}H_{12}O_2$	264	115-117	80
3	4-OH	$C_{16}H_{12}O_2$	264	233-235	83
4	4-Cl	$C_{16}H_{11}ClO$	282.5	148-150	88
5	H	$C_{16}H_{12}O$	248	156-158	93

adjusted to pH=11, added drop-wise to the black precipitate over 30 min, and then heated to 90°C for 2h. The solutions were cooled down and aged overnight at room temperature. Following this, the dark brown precipitate was obtained, filtered, washed with water and air-dried under vacuum. The reddish-brown powder of [ɣ-Fe_2O_3@HAp] was formed by heating to 300°C for 3h.

1g $ClSO_3H$ was added to 1g [ɣ-Fe_2O_3@HAp]. The mixture was stirred until the HCl gas evolution stopped for 6h. Then the nanocatalyst was separated by an external magnet, washed with water and with (100 ml) diethyl ether twice and dried under vacuum at room temperature (Scheme **3**) [5, 13].

Table 5. Antibacterial activity of the derivatives of 2, 3-dihydroquinazolin-4(1*H*)-one.

Zone of Growth Inhibition in (mm)				
Compounds	***S. aureus***	***P. aeruginosa***	***E. coli***	***M. luteus***
a	7	16	18	25
b	8	20	14	7
c	21	10	16	12
d	13	10	12	14
e	25	24	15	13
f	20	18	12	22
g	6	11	15	20
h	15	13	7	16
i	-	17	10	8
j	5	12	7	10
DMSO	-	-	-	-
Tetracyclin (ref)	16	20	18	20
Ciprofloxacin (ref)	20	22	20	18



Scheme (3). Synthesis of [χ-Fe_2O_3@HAp-SO_3H].

3.3. General Procedure for the Synthesis of Pyrazole Carbaldehydes

A mixture of acetophenone (43 mmol), phenylhydrazine (6 ml) and 30 ml water was stirred for 30 min. The resulted mixture was filtered, washed with water to remove the excess chemicals and then dried. Then, 15 mmol of hydrazone was dissolved in Vilsmeir-Hack reagent (DMF: $POCl_3$) (25:5 ml), stirred at 50-60°C for 5-6 h, poured onto crushed ice and neutralized with sodium bicarbonate. Following this, the resulting solid was filtered, washed with water and dried to obtain pyrazole carbaldehyde (Scheme **4**) [20-22].

3.3.1. 1,3-Diphenyl-1H-pyrazole-4-carbaldehyde

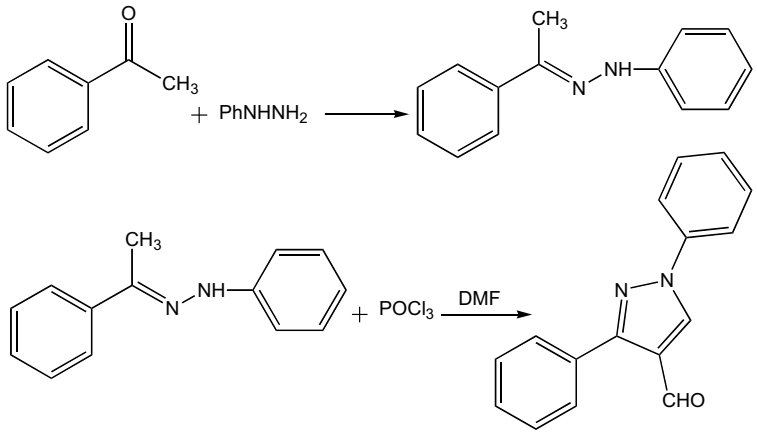
Creamy solid mp: 156-158°C. FT-IR (KBr): 3060 (Ar-CH), 2786-2837 (CH=O), 1672 (C=O), 1451-1525-1226 (-C=C), (-C=N), (-N-N) cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 9.88 (s, 1H, -C*H*=O), 8.53 (s, 1H, -NC*H*=), 7.75-7.37 (m, 10H, Ar-*H*). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 189.7 (*C*H=O), 154.3 (*C*=N pyrazole), 133.4 (*C*H-N pyrazole), 119.1 (C=*C* pyrazole), 145.6, 142.5, 130.9, 130.2, 128.7, 126.6, 122.4, 118.8, 116.9.

3.4. General Procedure for the Synthesis of Products (a-j)

The mixture of one-pot three component of isatoic anhydride (1 mmol), amines (1.2 mmol) or ammonium salts (ammonium acetate: 1.2 mmol, ammonium carbonate: 0.6 mmol), pyrazole carbaldehyde (1 mmol) and nanocatalyst (10 mg) in H_2O: EtOH (3:1) was poured into a 25 ml round-bottomed flask and positioned in the ultrasonic and irradiated at 60°C. The progress of the reaction was checked by TLC. The solid catalyst was separated by an external magnet. The precipitation of the reaction was filtered off, washed with water and ethanol and recrystallized from ethanol to give pure products (Scheme **1**) (Table **3**) [8, 12, 19].

3.4.1. 2-(1, 3-diphenyl-1H-pyrazole-4-yl)-2, 3-dihydroquinazolin-4(1H)-one (f)

Brown solid mp : 284-286°C. FT-IR (KBr): 3260 (N-H), 3061, 1663 (C=O), 1499-1550 (C=C_{arom}), 1379 cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 8.92 (s, N*H*CO), 8.33 (NC*H*=, s, 1H), 7.98 (d, 1H, *J*=8.1 Hz), 7.81 (d, 1H, *J*=7.4 Hz), 7.68 (d, 1H, *J*=7.6 Hz), 7.55 (t, 1H, *J*=7.8 Hz), 7.49 (t, 1H, *J*=7.4 Hz), 7.36 (t, 1H, *J*=7.3 Hz), 7.30 (t, 1H, *J*=7.5 Hz), 7.09 (s, N*H*), 6.78 (t, 1H, *J*=8.3 Hz) 5.91 (2NC*H*-, s, 1H). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 60.2 (2NC*H*-), 114.6, 117.7, 118.2, 118.6, 120.3, 126.5,127.1, 127.5, 128, 128.3, 128.4, 128.5, 129.4, 129.6, 129.7, 132.3, 133.2, 139.3, 148.6, 150.8, 164.1 (*C*=O); Anal. Calcd for $C_{23}H_{18}N_4O$: C,75.39; H, 4.95; N, 15.29%; Found: C, 75.48; H, 5.01; N, 15.21%.



Scheme (4). Synthesis of pyrazole carbaldehyde.

3.4.2. 2-(1, 3-diphenyl-1H-pyrazole-4-yl)-3-phenyl-2, 3-dihydroquinazolin-4(1H)-one (g)

Brown solid mp : 193-195°C. FT-IR (KBr): 3266 (N-H), 3063, 1625 (C=O), 1494-1545 (C=C_{arom}), 1397 cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 8.72 (NC*H*=, s, 1H), 7.89 (m, 1H), 7.74 (d, 1H, *J*=7.6 Hz), 7.52 (d, 1H, *J*=7.3 Hz), 7.29 (t, 1H, *J*=7.7 Hz), 7.28 (d, 1H, *J*=7.6 Hz), 7.23 (d, 1H, *J*=7.0 Hz), 7.17 (d, 1H, *J*=8.0 Hz), 6.92 (t, 1H, *J*=7.9 Hz), 6.90 (N*H,* s, 1H), 6.61 (2NC*H*-, s, 1H). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 66.3 (2N*C*H-), 114.9, 115.5, 118.3, 118.3, 118.4, 120.1, 126.6, 126.9, 127.9, 128.1, 128.2, 128.3, 128.4, 128.5, 128.6, 128.6, 128.7, 129, 129.6, 129.7, 132.3, 133.6, 139, 139.9, 147, 147.1, 150.6, 162.9 (*C*=O); Anal. Calcd for $C_{29}H_{22}N_4O$: C, 78.71; H, 5.01; N, 12.66%; Found: C, 78.76; H, 5.10; N, 12.74%.

3.4.3. 2-(1, 3-diphenyl-1H-pyrazole-4-yl)-3-(p-tolyl)-2, 3-dihydroquinazolin-4(1H)-one (h)

Brown solid mp : 205-207°C. FT-IR (KBr): 3277 (N-H), 3120, 1634 (C=O), 1503-1551 (C=C_{arom}), 1381 cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 8.62 (NC*H*=, s, 1H), 7.82 (d, 1H, *J*=7.8 Hz), 7.77 (d, 1H, *J*=7.6 Hz), 7.65 (d, 1H, *J*=6.7 Hz), 7.49 (t, 1H, *J*=7.6 Hz), 7.42 (d, 1H, *J*=7.3 Hz), 7.41 (t, 1H), 7.38 (N*H,* s, 1H), 7.33 (d, 1H, *J*=8.2 Hz), 6.97 (t, 1H, *J*=8.0 Hz), 6.81 (t, 1H, *J*=7.9 Hz), 6.48 (2NC*H*-, s, 1H), 2.19 (s, 3H). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 20.5 (*C*H_3), 66.3 (2N*C*H-), 114.9, 114.9, 115.5, 117.9, 118.2, 120.3, 120.3, 120.5, 127.7, 128.1, 128.2, 128.2,128.3, 128.5, 128.9, 128.9, 129, 129.6, 129.7, 132.3, 133.6, 135.8, 137.3, 139, 147, 150.6, 162.9 (*C*=O); Anal. Calcd for $C_{30}H_{24}N_4O$: C, 78.92; H, 5.30; N, 12.27%; Found: C, 78.84; H, 5.35; N, 12.33%.

3.4.4. 2-(1, 3- diphenyl-1H-pyrazole-4-yl)-3-(4-ethoxyphenyl)-2, 3-dihydroquinazolin-4(1H)-one (i)

Brown solid mp : 219-221°C. FT-IR (KBr): 3303 (N-H), 3060, 2978, 1632 (C=O), 1508-1551 (C=C_{arom}), 1388 cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 8.61 (NC*H*=, s, 1H), 7.81 (d, 1H, *J*=7.7 Hz), 7.77 (d, 1H, *J*=7.5 Hz), 7.64 (d, 1H, *J*=6.5 Hz), 7.50 (t, 1H, *J*=7.4 Hz), 7.41 (d, 1H, *J*=7.0 Hz), 7.34 (m, 1H), 6.96 (d, 1H, *J*=8.1 Hz), 6.81 (t, 1H, *J*=8.3 Hz), 6.71 (d, 1H, *J*=8.3 Hz), 6.45 (2NC*H*-, s, 1H), 3.91 (q, 2H, *J*=6.8 Hz), 1.26 (t, 3H, *J*=6.6 Hz). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 14.5 (*C*H_3), 63 (*C*H_2), 66.5 (2N*C*H-), 113.9, 114.1, 114.2, 114.7, 114.8, 115.4, 117.9, 118.2, 118.3, 120.3, 122.1, 126.5, 128.1, 128.1, 128.2, 128.3, 128.4, 128.8, 129.5, 129.7, 132.3, 132.3, 133.5, 139, 147, 150.6, 156.8, 163 (*C*=O); Anal. Calcd for $C_{31}H_{26}N_4O_2$: C, 76.52; H, 5.39; N, 11.51%; Found: C, 76.60; H, 5.45; N, 11.46%.

3.4.5. 3-(4-chlorophenyl)-2-(1, 3-diphenyl-1H-pyrazole-4-yl)-2, 3-dihydroquinazolin-4(1H)-one (j)

Brown solid mp : 215-217°C. FT-IR (KBr): 3275 (N-H), 3120, 1631 (C=O), 1493-1551 (C=C_{arom}), 1380 cm^{-1}. ^{1}HNMR (400 MHZ, DMSO-d_6): δ_H = 8.22 (NC*H*=, s,1H), 7.92 (d, 1H, *J*=8.1 Hz), 7.77 (d, 1H, *J*=7.4 Hz), 7.70 (d, 1H, *J*=7.6 Hz), 7.63 (t, 1H, *J*=7.8 Hz), 7.52 (t, 1H, *J*=7.4 Hz), 7.45 (m, 1H), 7.05 (N*H,* s, 1H), 6.01 (2NC*H*-, s, 1H). ^{13}CNMR (100 MHZ, DMSO-d_6): δ_C = 66.2 (2N*C*H-), 114.9, 115, 115.2, 118, 118.3, 119.2, 119.8, 126.6, 127.7, 128.2, 128.2, 128.3, 128.4, 128.6, 128.7, 129.2, 129.3, 129.6, 129.7, 129.8, 130.9, 132.3, 133.8, 138.6, 139, 147.2, 150.6, 163 (*C*=O); Anal. Calcd for $C_{29}H_{21}ClN_4O$: C, 73.03; H, 4.44; N, 11.75%; Found: C, 73.11; H, 4.50; N, 11.69%.

CONCLUSION

In summary, we have successfully developed a convenient and facile synthetic protocol to produce 2, 3-dihydroquinazolin-4(1*H*)-ones *via* the selectivity reactions involving isatoic anhydride, pyrazole carbaldehydes and amines or ammonium salts using [γ-Fe_2O_3@HAp-SO_3H] as a reusable catalyst under sonication. The synthesized products have shown moderate to significant antibacterial activities against the examined microbial strains.

CONSENT FOR PUBLICATION

Not applicable.

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CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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