Ibn Al-Haitham Journal for Pure and Applied Sciences
Journal homepage: jih.uobaghdad.edu.iq
PISSN: 1609-4042, EISSN: 2521-3407
IHJPAS. 2025, 38(3)

Design, Synthesis of Some New Quinazolinone Derivatives and Evaluation of their Antibacterial Activity

Aseel Jassim Mohammed[1*] and Oday H.R. Al-Jeilawi [2]
[1,2] Department of Chemistry, College of Science, University of Baghdad, Baghdad, Iraq.
*Corresponding Author.

Received: 24 June 2023 Accepted: 22 November 2023 Published: 20 July 2025
doi.org/10.30526/38.3.3620

Abstract

The novel quinazolinone derivatives were synthesized in excellent yields, manufactured, characterized, and investigated for their biological activity. This study aims to produce new quinazolinone derivatives and study their antibacterial activity. Quinazolinone derivatives were synthesized in three steps: the first step included the reaction of methyl anthranilate with isothiocyanatobenzene to produce a thiourea derivative (A1). In the second step (A1) was reacted with hydrazine hydrate to synthesized 3-Amino-2-(phenylamino) quinazolin-4(3H)-one (A2). The third step consisted of the reaction of (A2) with various organic compounds (phenylisotiocyanate, phenylisocyanate, acid halide, benzyl halide, and alkyl halide derivatives) to produce new derivatives. FT-IR, ^{1}HNMR, and ^{13}C NMR spectroscopy were used to identify the chemical structure of these compounds. The agar well diffusion technique was used to determine the antibacterial activity levels exhibited by the samples. *Staphylococcus aureus* and *Escherichia coli* were used as test organisms in this study. When compared to the antibiotic used as a standard, amikacin, these compounds demonstrated superior antibacterial activity.

Keywords: Antibacterial activity, Methyl anthranilate, Thiourea derivative, Quinazolinone derivatives.

1. Introduction

Heterocyclic compounds are a significant area of organic chemistry, which are recognized by the presence of a hetero atom in their cyclic structure in addition to basic carbon atoms like (O, N, S, P, Si and As) (1). Quinazolinones, also referred to as quinazolines, are a class of organic compounds that belong to the category of heterocyclic aromatic chemical substances (2). The molecule in question has a two-ringed structure, with one ring being benzene and the other being pyrimidine (3, 4). They were initially discovered in the late 19th century by Griess (5) Quinazolinones and their derivatives are highly effective compounds in many fields (6). such as medical, pharmaceutical, agricultural and industrial fields (insecticide, anticorrosion, and anti-oxidant) (7-11).

There are many applications in pharmacology and physiology for the chemical synthesis known as quinazolinones. Many quinazolinone compounds have been employed clinically

due to their low toxicity and high efficiency (12). Recently, there has been a surge of interest in the synthesis of high-nitrogen-containing heterocyclic systems due to their vast range of potential applications. In medicinal chemistry, molecules based on the quinazolinone core play a significant role. That's because they're part of a big genus of products that prevent cancer and boost the immune system (13). A carbonyl group and two nitrogen atoms in (2, 4) positions form one ring of the heterocyclic chemical compounds known as quinazolinones, which also contain a benzene ring (14). Many scientists have experimented with different approaches to synthesizing quinazolinone nuclei over the years (15-17). Researchers in medicinal chemistry have demonstrated a significant interest in the biological assay of quinazoline and quinazolinone derivatives due to the importance of these fused heterocyclic compounds (18). The pharmacological properties of nitrogenated scaffolds, such as quinazolinones, have sparked significant interest in their anticancer effects (19). Infectious diseases are developing resistance to current therapies worldwide. Numerous investigations have yielded novel quinazolinone compounds with substantial antibacterial and antifungal activity, targeting DNA and cell walls (20-24). In the current study, quinazolinone derivatives synthesized from reaction of methyl anthranilate with isothiocyanatobenzene to produced thiourea derivative (A1) and (A1) was reacted with hydrazine hydrate to synthesized 3-Amino-2-(phenylamino) quinazolin-4(3H)-one (A2), the final step included reaction of (A2) with various organic compounds to produce new derivatives and study their antibacterial activity. This study aims to create new quinazolinone derivatives and study their antibacterial activity.

2. Materials and Methods

All successful products had their melting points determined in open glass capillaries using the Gallenkamp device, and the results were uncorrected. The TLC method was used to monitor the progression of the reactions (silica gel on aluminum sheet). Many types of eluents were used According to the type of reactants, such as ethyl acetate: petroleum ether (2:1), hexane:ethyl acetate (3:2), chloroform:methanol (1:1), hexane: ethanol (3:2). In the chemistry department of the college of education of pure science at the university of Basrah, some of the produced compounds were characterized using ^{1}HNMR and ^{13}C NMR spectra on a Bruker Avance Neo 400 spectrometer, DMSO-d_6 as a solvent, and tetramethyl silane as an internal standard.

2.1. Synthesis of Methyl-2-(3-phenylthioureido) benzoate (A1) (25)

About (1.3 mL, 0.01 mol) of methyl anthranilate was dissolved in 5 mL ethanol and then added (1.2 mL, 0.01 mol) of phenyl isothiocyanate, the reaction completion after refluxed for 15 hrs, TLC, a solvent system hexane, monitors the reaction: ethyl acetate (3:2). The solution was added to crush ice then filtered the precipitate, washed in ethanol and water and left to dry. The physical properties are listed in **Table (1)**.

2.2. Synthesis of 3-amino-2-(phenyl amino) quinazolin -4(3H)-one (A2) (26)

About (0.5 g, 0.001 moles) methyl-2-(3-phenylthioureido) benzoate (A1) was dissolved in 6 mL of dimethylformamide and heated until (A1) completely dissolved. Then, an excess of hydrazine hydrate (4 mL) was added, resulting in a change in color to a turquoise hue. The reaction was completed after being refluxed for 8 hrs. The reaction was monitored by TLC using a solvent system of hexane:ethyl acetate (3:2). The mixture was then cooled with crushed ice. The precipitate was then filtered, washed with water, and left to dry; it was subsequently recrystallized with ethanol. The physical properties are listed in **Table (1)**.

Table 1. Physical properties of synthesized compounds

Comp	IUPAC names	Chemical formula	M.wt (g/mol)	M.P(℃)	Color	Yield %
A1	Methyl-2-(3-phenylthioureido) benzoate	$C_{15}H_{14}O_2N_2S$	286.35	314-316	White	54
A2	3-Amino-2-(phenyl amino) quinazolin -4(3H)-one	$C_{14}H_{12}ON_4$	252.28	162-164	Brown	86
B1	1-(4-oxo-2-(phenylamino) quinazolin-3(4H)-yl)-3-phenyl thiourea	$C_{21}H_{17}ON_5S$	387.46	224-227	White	82
B2	1-(4-oxo-2-(phenylamino) quinazolin-3(4H)-yl)-3-phenyl urea	$C_{21}H_{17}O_2N_5$	371.40	200-202	White	91
C1	N-(4-oxo-2-(phenylamino)quinazolin-3(4H)-yl)furan-2-carboxamide	$C_{19}H_{14}O_3N_4$	346.35	266-270	Yellow	21
C2	4-methoxy-N-(4-oxo-2-(phenylamino)quinazolin-3(4H)-yl)benzamide	$C_{22}H_{18}O_3N_4$	386.41	253-255	Very light brown	50
D1	3-((4-nitrobenzyl)amino)-2-(phenylamino)quinazolin-4(3H)-one	$C_{21}H_{17}O_3N_5$	387.40	gummy		
D2	3-(benzylamino)-2-(phenylamino)quinazolin-4(3H)-one	$C_{21}H_{18}ON_4$	342.40	135-138	Brown	60
F1	2-(phenylamino)-3-(prop-2-yn-1-ylamino)quinazolin-4(3H)-one	$C_{17}H_{14}ON_4$	290.33	318-320	Nutty	72
F2	3-(allylamino)-2-(phenylamino)quinazolin-4(3H)-one	$C_{17}H_{16}ON_4$	292.34	318-320	Nutty	87

2.3. Synthesis of 1-(4-oxo-2-(phenylamino) quinazolin-3(4H)-yl)-3-phenyl thiourea and 1-(4-oxo-2-(phenylamino) quinazolin-3(4H)-yl)-3-phenyl urea (B1,B2) (27)

A 0.001 mol of phenyl isothiocyanate, phenyl isocyanate, respectively, were added to the solution (0.5 g, 0.001 mol) A2 in 10 mL of DMF. The produced solution was refluxed for 12-18 hrs, and the reaction was monitored by using TLC with an eluent solution (2:1) of ethyl acetate and petroleum ether. When the reaction was finished, the mixture was added to ice water, where it became a white precipitate. The precipitate was then filtered, washed with water, and dried. The physical properties are listed in **Table (1)**.

2.4. Synthesis of N-(4-oxo-2-(phenylamino)-quinazolin-3(4H)-yl)substituted amide and (C1,C2) (28)

About (0.5 g, 0.001 mol) from A2 was dissolved in 10 mL of DMF, then a few drops of trimethylamine. After that, 0.001 mol of acid chlorides (4-methoxybenzoyl chloride and 2-furyl chloride) were added. The solution of the reaction was refluxed for 8 hrs. The reaction was monitored by TLC using a solvent system of ethyl acetate and petroleum ether (2:1). After the reaction was complete, the mixture was added to ice water. The precipitate of the final products was filtered, washed with water, and dried. The physical properties are listed in **Table (1)**.

2.5. Synthesis of 3-(substituted) amino)-2-(phenylamino) quinazolin-4(3H)-one (D1, D2) (29)

About (0.5 g, 0.001 mol) from A2 was dissolved in (10 mL) of DMF with stirring and heating, then a few drops of triethylamine were added, then (0.001 mol) from benzyl halides (benzyl chloride and 4-nitrobenzyl bromide) were added, and the solution was refluxed for 8 hrs. The reaction was monitored by using TLC with a solvent system (3:2) of hexane and ethanol. After the reaction finished, the mixture was added to ice water. The precipitate of the final products was filtered and washed with water, then left to dry. The physical properties are listed in **Table (1**).

2.6. Synthesis of 3-(alkylamino)-2-(phenylamino) quinazolin-4(3H)-one (F1,F2) (24)

A (0.5 g) from A2 was dissolved in 10 mL DMF with heating, followed by adding drops of Et3N (0.001 mol) from different alkyl halides(propargyl chloride and allyl bromide), and the reaction mixtures were still refluxed for 7 hrs. The reaction was monitored by using TLC, with a solvent system of hexane and ethanol (3:2). After the reaction was complete, the mixture was transferred to a Petri dish until the solvent had evaporated, and the precipitate of the product was washed with ethanol. The physical properties are listed in **Table 1**.

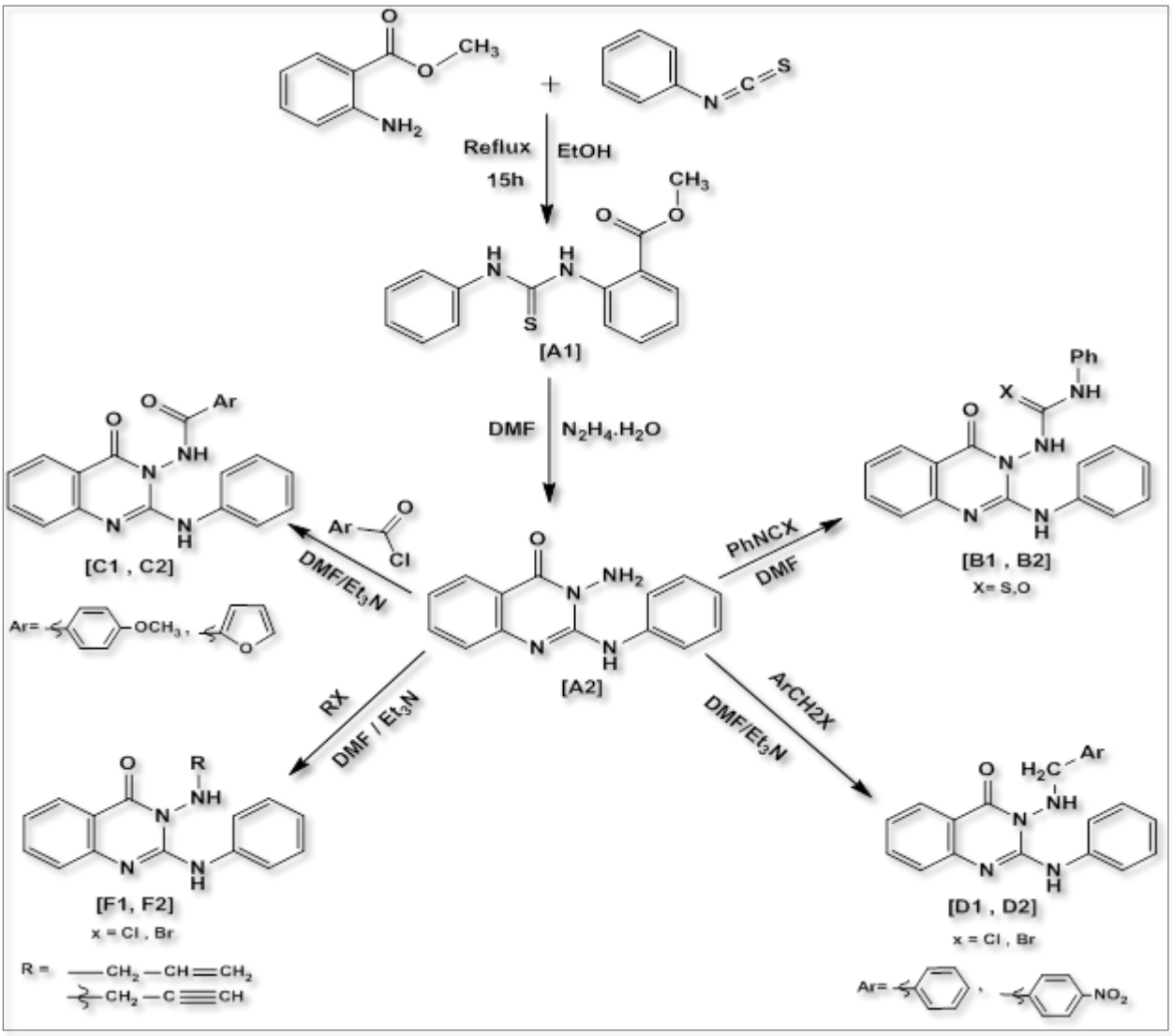
2.7. Anti-bacterial activity determination

The antibacterial activity of each of the synthesized compounds is described in **Table (1**). The in vitro antibacterial activity of some samples was analyzed using the agar well-diffusion technique (30). The materials were tested against different strains of bacteria, including *E. coli* and *Staphylococcus aureus*. The antibiotic Amikacin served as the benchmark for comparison. In a solution of DMSO at a concentration of 1 mg per mL, test samples and standard references were generated After being sanitized and reduced to a liquid form, the agar was then mixed with a microbe suspension at a ratio of (1 ml/ 100 mL of medium) of medium and put onto a Petri dish to a depth of about 3 millimeters., The test samples and references were placed in wells created in a solidified medium. The resultant plates were then chilled for 1 hour at 5 °C and subsequently incubated for 18 hours at 37 °C. The inhibition zones on the growth of bacteria that were induced by the test samples and the standard references were measured in millimeters, and the findings are presented in **Table (4).**

3. Results and Discussion

Scheme (1) includes synthesized quinazolinone derivatives by reacting methyl anthranilate with isothiocyanateobenzene to make A1, then reacting A1 with hydrazine hydrate to make A2, and finally reacting A2 with with various organic compounds (phenylisotiocyanate, phenylisocyanate), acid halide, benzyl halide and alkyl halide derivatives in DMF as solvent and Et_3N as a catalyst to produce new quinazolinone derivatives. The TLC was used to determine where the reaction stopped. The FT-IR spectral data of compound (A1) showed the disappearance absorbance of υ (NH_2) for methyl anthranilate while appearance a new absorption at (3245) cm^{-1}, which was attributed to the secondary amine group υ (NH), in addition stretching and bending vibrations at (1533, 1288 and 989) cm^{-1} due to involving interaction between (C=S) group and (C-N) group of the C=S group attached to a nitrogen atom (31,32). These bands were good evidence for the formation of the compound (A1) (**Figure 1**). The FT-IR spectral data of A2 derivative showed the disappearance of υ (C=S), while the appearance of two new stretching vibrations at (3450) and (3305) cm^{-1} for (NH_2) and bands at (1660) cm^{-1} and (1616) cm^{-1} due to C=O amide and C=N, respectively. The ^{1}HNMR spectral data of compound A2 a singlet signal at 5.8 ppm, which belongs to the NH_2 proton, and a singlet signal at 9.8 ppm, which belongs to the N-H proton (33). The FT-IR spectrum of compounds (B1, B2) showed the disappearance of (NH_2), while the band at (1531, 1232 and 929) cm^{-1} due to (C=S interaction with –N-C=S) for B1 and band at (1662) cm^{-1} due to (C=O) for B2 will appear (34), the ^{1}HNMR spectrum of compound (B1, B2) showed singlet signals at (8.72-9.82) ppm due to one proton for the (H-N), a singlet signal at (9.56-13.07) ppm due to two protons for (NH urea and thiourea) group, While the ^{13}C NMR spectrum showed signals at signals at (153.29-160.29) ppm for (C=N), 176.52 and 180.06 ppm for (C=O) and (C=S) group respectively. The FT-IR spectrum of compound (C1, C2) showed the disappearance of υ (NH_2), while the band at υ (1662) cm^{-1}, υ (1622) cm^{-1} due to amide group (C=O) and (C=N). The ^{1}HNMR spectrum of

compound (C1) showed singlet signal at δ= (9.56) ppm was due to one proton for the (H-N) group, and a singlet signal at δ= (13.07) ppm due to one proton for (O=C-NH) group, While the ^{13}C NMR spectrum compound (C1) showed signals at (140.7) ppm for (C-N), (160.29) ppm, (176.52) ppm for (C=O) group. The FT-IR spectrum of compound (D1,D2) showed the disappearance of υ (NH_2), while the bands at υ (3442- 3431) cm^{-1} were due to (N-H) will appear (**Fingers 2-9**).



Scheme 1. Synthesis of quinazolinone derivatives

The ^{1}HNMR spectrum of compound (D1,D2) showed singlet signals at (3.42-3.45) ppm due to one proton of (N<u>H</u>-CH_2) While the ^{13}C NMR spectrum of compound (D1) showed signals at (162.03) ppm for (C=N) and signal at (167.2) ppm for carbonyl group. The FT-IR spectrum of compound (F1,F2) showed the disappearance of υ (NH_2), while the bands at υ (3440-3429) cm^{-1} due to (N-H). FT-IR, ^{1}HNMR and ^{13}C NMR spectral data for some derivatives are listed in **Tables (2**) and **(3)** respectively.

Table 2. FT-IR spectral data for synthesized derivatives

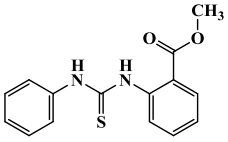
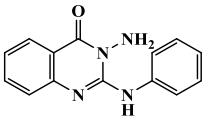
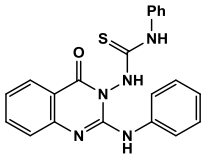
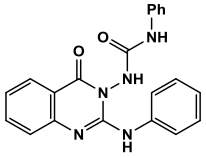
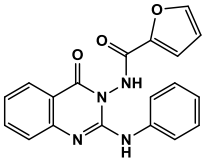
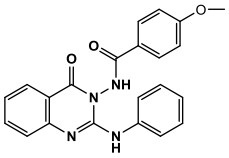
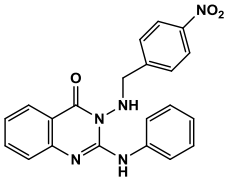
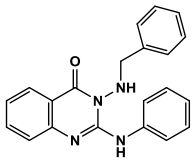
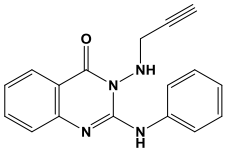
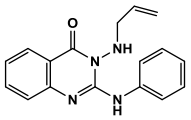
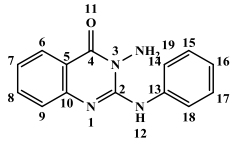
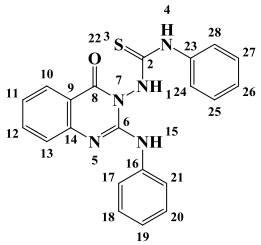
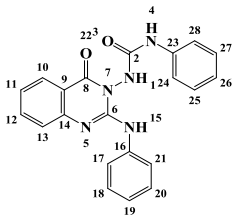
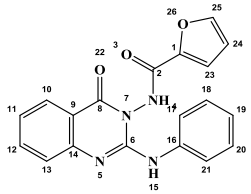
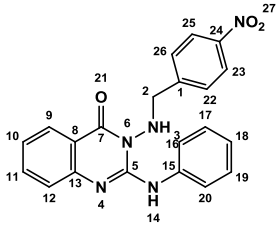
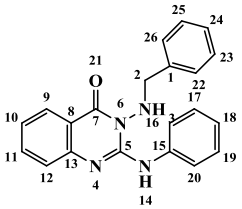
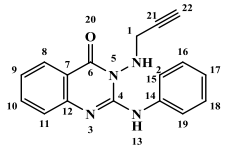
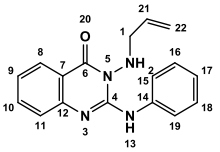
No.	Com. Structure	Major FT-IR Absorptions cm^{-1}					
		υ (NH)	υ (C-H) arom.	υ (C-H) aliph.	υ(C=O) quinazoline	υ (C=C) arom.	Other bands
A1		3245	3029	2968, 2891	--	1598, 1558	1665 (C=O) ester, (1533,1288,989) (C=S) interaction with (-N-C=S)
A2		3224	3058	---	1660	1577, 1541	3450(asym) and 3305(sym) (NH_2) , 1616 (C=N)
B1		3242	3033	--	1662	1595, 1552	1531, 1232, 929 (C=S) interaction with (N-C=S)
B2		3245	3035	--	1662	1595, 1554	1650(C=O) for urea , 1622 (C=N)
C1		3247	3033	--	1662 overlap with (C=O) of amide	1562, 1531	1620 (C=N)
C2		3217	3033	2972, 2846	1662 overlap with (C=O) of amide	1560, 1533	1600 (C=N)
D1		3442	3065	2975, 2941	1681	1550	1606 (C=N), (1521, 1348) NO_2
D2		3431	3060	2977, 2943	1689	1573, 1552	1600 (C=N)
F1		3429	3060	2981, 2937	1681	1571, 1560	3151 (CH) acetylenic , 2100 (C≡C)
F2		3440	3045	2997, 2877	1674	1575, 1548	1635 (C=C) , 1600 (C=N)

Table 3. The ^{1}HNMR and ^{13}C NMR spectral data of some synthesized compounds

No.	Comp. Structure	^{1}H NMR	^{13}C NMR
A2		5.8(s,2H, N<u>H</u>$_2$) 7.03-8.91(m,13H, Ar-<u>H</u>), 9.8 (s,1H, N<u>H</u>)	120.95-147.6(C_5-C_{10} and C_{13}-C_{18}), 159.55(C_2), 167(C_4).
B1		7.1-7.97(m,14H, Ar-<u>H</u>), 9.82 (s,1H, -N-<u>H</u>), 13.07(s, 2H, NH-C=S)	116.17-139.91 (C_9-C_{14} and C_{16}-C_{21} and C_{23}-C_{28}), 160.29 (C_6), 176.52 (C_8), 180.06 (C_2)
B2		6.95-7.97 (m,14H, Ar-<u>H</u>) 8.72(s, 1H, NH), 9,56(s,1H, O=C-NH), 10.20(s,1H, O=C-NH-N)	114.30-140.20 (C_9-C_{14} and C_{16}-C_{21} and C_{23}-C_{28}), 153.01(C_6) , 160.3 (C_2), 176.52 (C_8)
C1		7.2-8.3(m,12H, Ar-<u>H</u>) 9.56 (s,1H, N<u>H</u>) 13.07 (s,1H, O=C-N<u>H</u>)	116.16-139.78(C_1, C_9-C_{14} , C_{16}-C_{21}, C_{23}, C_{24} and C_{26}), 140.07 (C_6) ,160.29 (C_2) 176.52 (C_8)
D1		3.45(d,2H, NH-C<u>H</u>$_2$) 4.7(t,1H, CH_2-N<u>H</u>), 7.3-8.4(m,13H, Ar-<u>H</u>), 9.62 (s,1H, N<u>H</u>)	52.93(C_2), 116.51-161.17(C_1, C_8-C_{13}, C_{15}-C_{20} and C_{22}-C_{26}), 162.03 (C_5), 167.26 (C_7)
D2		3.42(d,2H, N-C<u>H</u>$_2$) 4.47(s,1H, CH_2-N<u>H</u>) 7.2-8.3(m,14H, Ar-H) 9.56(s,1H, NH)	52.4 (C_2), 120.05-157.39 (C_1, C_8-C_{13}, C_{15}-C_{20} and C_{22}-C_{26}), 159.05 (C_5) 161.21 (C_7)
F1		2.89(s,1H, ≡C<u>H</u>) 3.34(t,2H, NH-C<u>H</u>$_2$),4.06-4.36(t,1H, NH-C<u>H</u>$_2$) 7.52-8.32 (m, 9H, Ar-<u>H</u>), 9.63 (s,1H, N<u>H</u>)	53.40(C_1), 72.68(C_{22}), 82.85 (C_{21}), 116.51-136.41(C_7-C_{12} and C_{14}-C_{19}), 148.98 (C_4) 159.05 (C_6)
F2		3.3 (t,1H, N-N<u>H</u>), 3.8(t,2H, -C<u>H</u>$_2$-CH=CH_2) 5.1,5.3(d,2H, -CH_2-CH=C<u>H</u>$_2$) 5.97(m,1H, -CH_2-C<u>H</u>=CH_2), 7.4-8.2(m,9H, Ar-<u>H</u>), 9.5 (s,1H, N<u>H</u>)	56.06(C_1),116.40(C_{22}),133.33(C_{21}), 119.36-130.33 and 135.38-147.71(C_7-C_{12} and C_{14}-C_{19}), 157.16 (C_4), 161.22 (C_6)

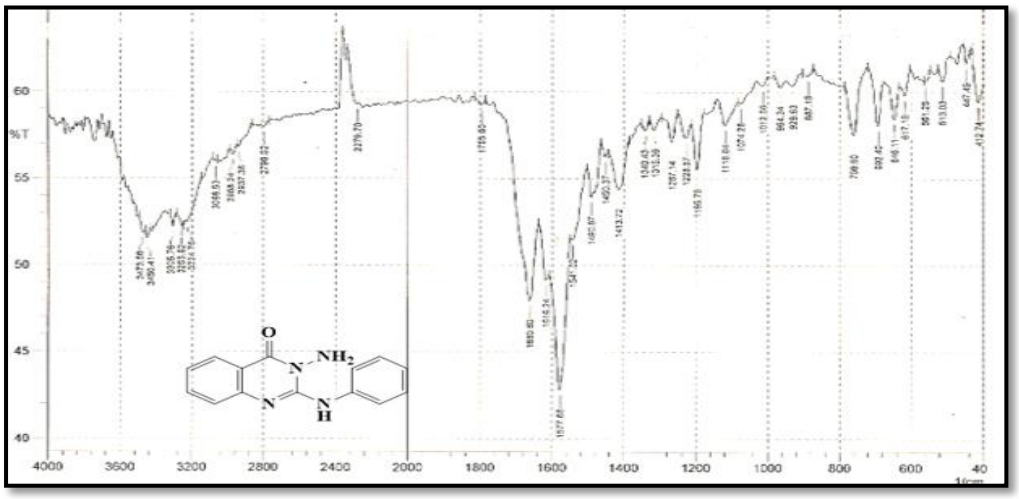


Figure 1. FT-IR spectrum for compound A2

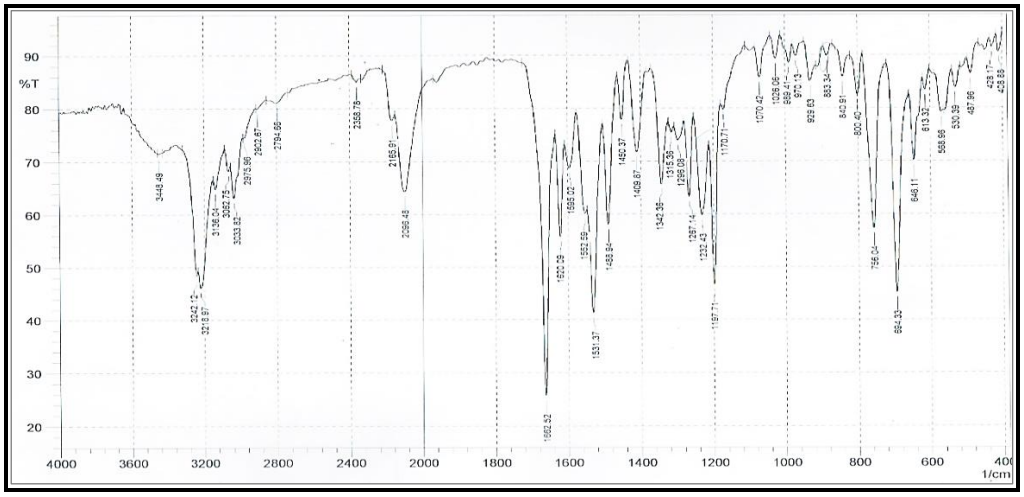


Figure 2. FT-IR spectrum for compound B1

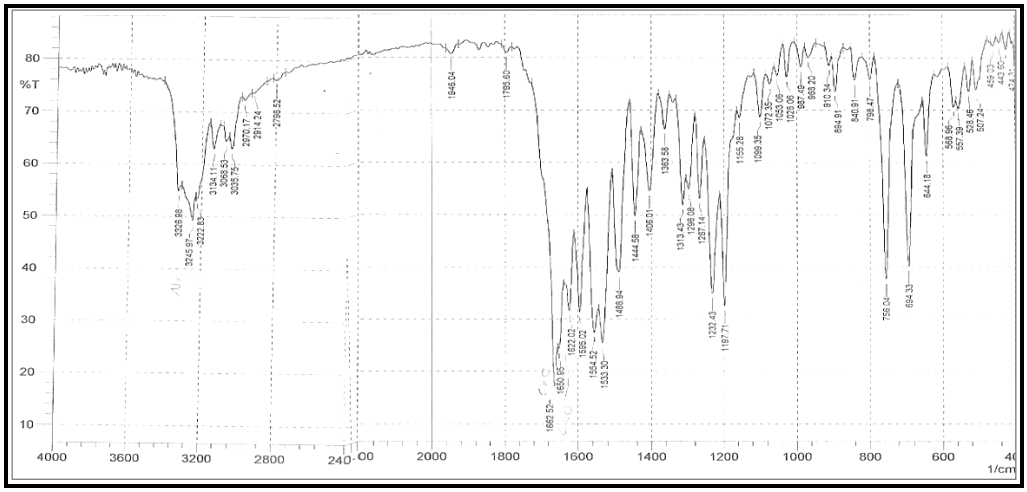


Figure 3. FT-IR spectrum for compound B2

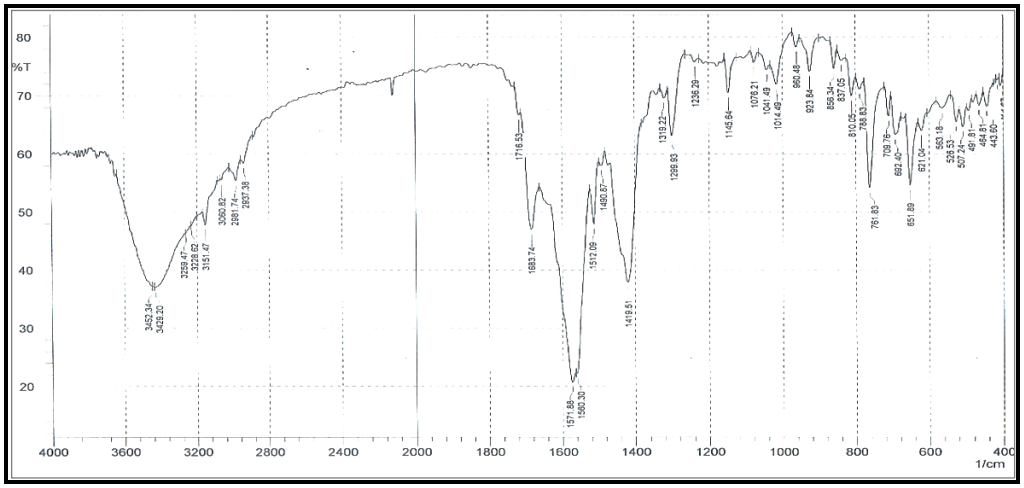


Figure 4. FT-IR spectrum for compound F1.

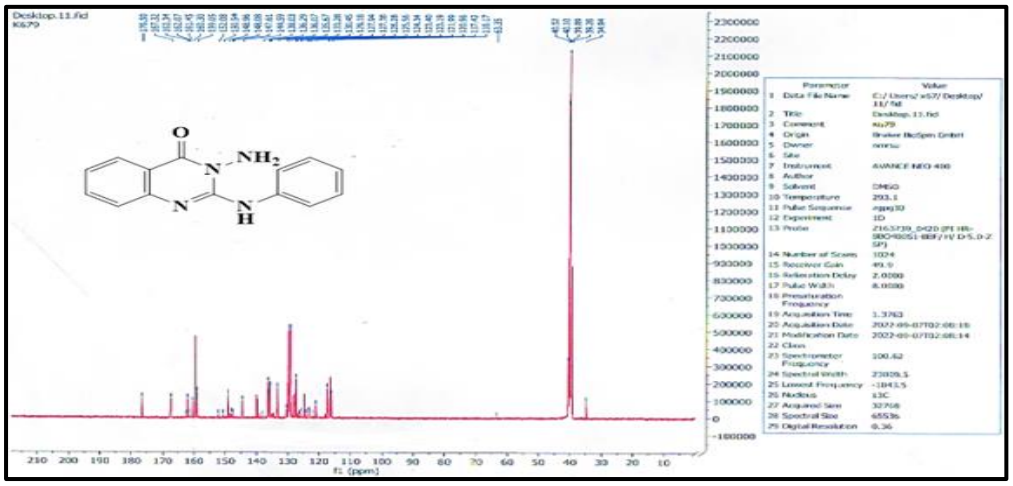


Figure 5. [1]HNMR spectrum for compound (A2)**.**

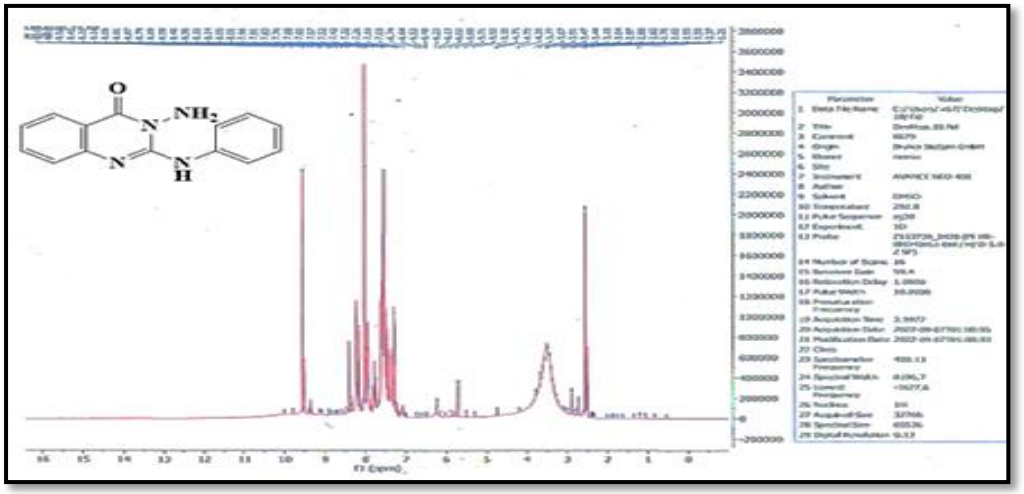


Figure 6. [13]C NMR spectrum for compound (A2)**.**

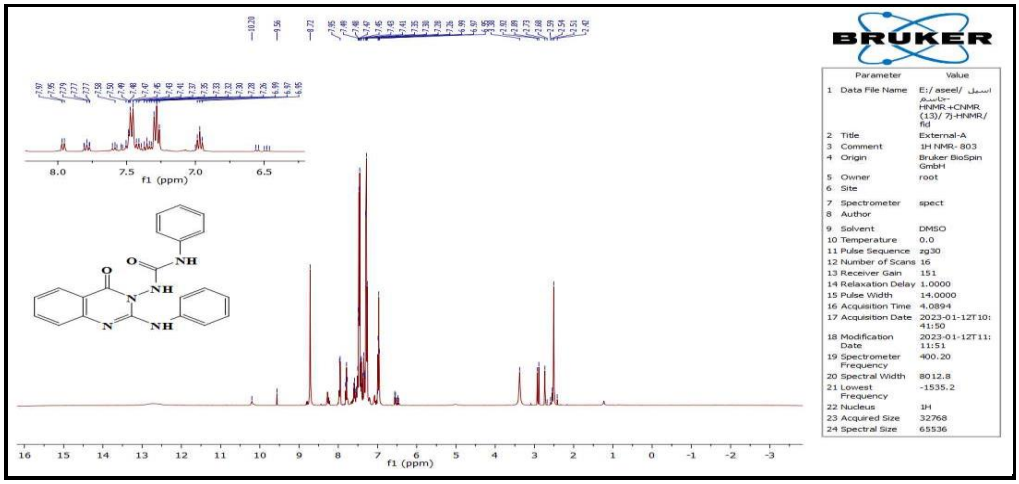


Figure 7. [1]HNMR spectrum for compound (B1).

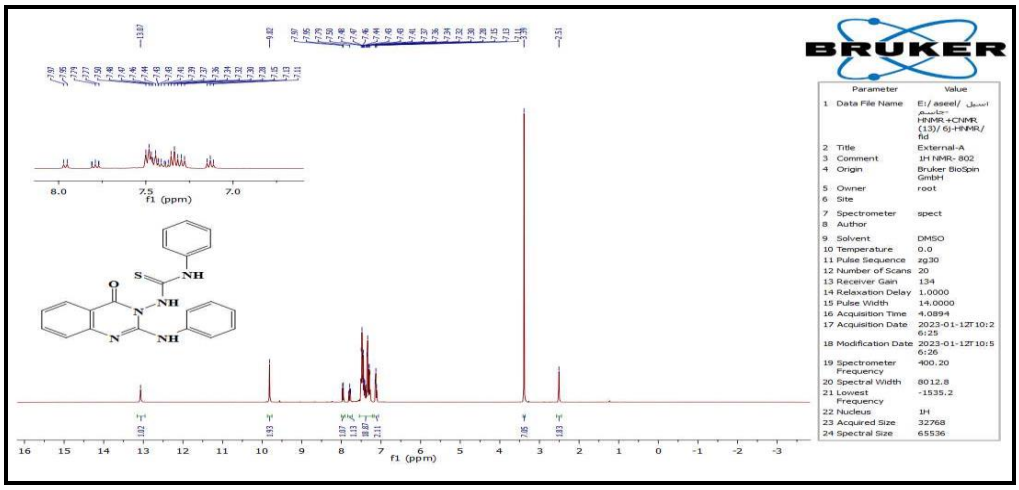


Figure 8. [13]C NMR spectrum for compound (B1).

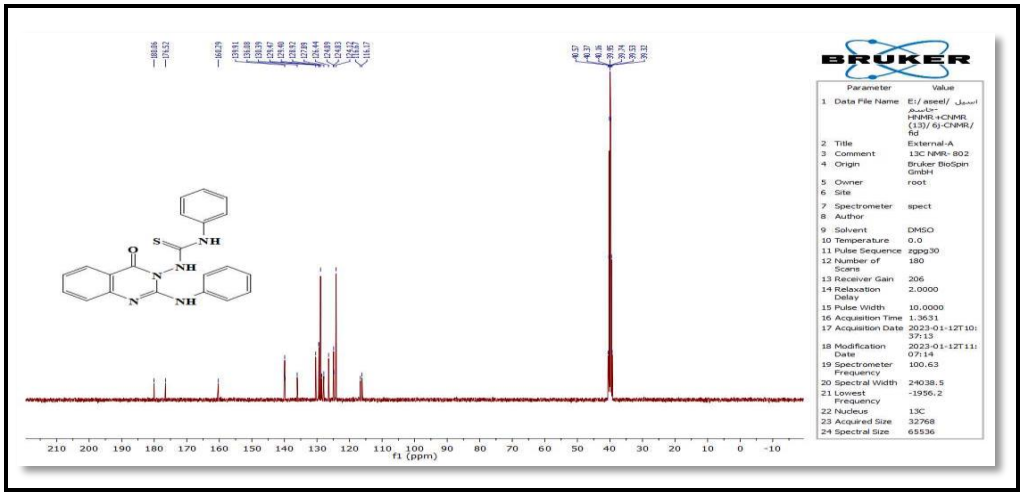


Figure 9. [1]HNMR spectrum for compound (B2).

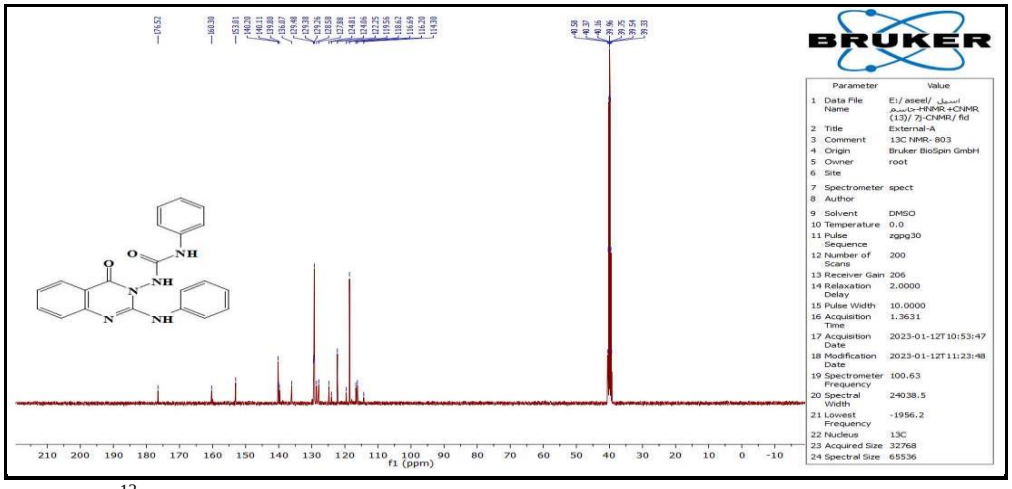


Figure 10. ^{13}C NMR spectrum for compound (B2).

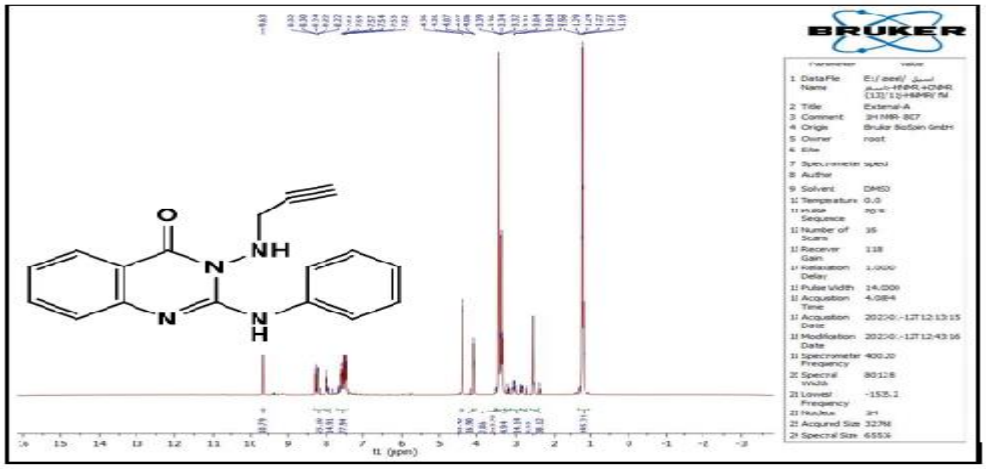


Figure 11. ^{1}HNMR spectrum for compound (F1).

3.1. Biological activity

The compounds studied had modest effects on the bacteria. Compounds B2, C2, D1, and F1 were the most effective against *Escherichia coli* bacteria, while they were less effective against gram-positive bacteria *Staphylococcus aureus*, which were affected the same way by all compounds. For comparison, Amikacin was used as the antibiotic, and DMSO served as the carrier (**Table 4**).

Table 4. Antibacterial zone of inhibition (mm) of synthesized derivatives

Comp. code	*Gram positive bacteria* *Staphylococcus aureus*	*Gram negative bacteria* *Escherichia coli*
B1	8	8
B2	8	10
C1	8	8
C2	8	11
D1	8	13
D2	8	8
F1	8	11
F2	8	8
Amikacin	15	32

4. Conclusion

The synthesis of several novel quinazolinone derivatives was carried out in three stages, and the compounds were characterized using various spectroscopic methods. The synthetic

compounds exhibited a diverse portfolio of potentially promising antibacterial properties. Compounds D1, C2, and F1 exhibited a strong inhibition zone against gram-positive bacteria.

Acknowledgment

The authors thank the head of the Department of Chemistry at the College of Science, University of Baghdad, for providing a laboratory for the preparation of scientific research, and the head of the postgraduate laboratory in the Biology Department for measuring antimicrobial activity.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Funding

The researchers did not receive any funding.

Ethical Clearance

According to the authors, none of the studies presented in this article have involved humans or animals.

References

1. Nief OA, Alzahawy HMG, Abdallah EK, Attia AM. Synthesis and identification of five-membered ring heterocyclic compounds derived from trimethoprim. Al-Nahrain J Sci. 2018;1:1–7. https://doi.org/10.22401/ANJS.00.1.01.
2. Al-Sultani KT, Al-Majidi SM, Al-Jeilawi OH. Synthesis, identification and evaluation biological activity for some new triazole, triazoline and tetrazoline derivatives from 2-mercapto-3-phenyl-4(3H) quinazolinone. Iraqi J Sci. 2016; 57(1B):295–308.
3. Khan I, Ibrar A, Ahmed W, Saeed A. Synthetic approaches, functionalization and therapeutic potential of quinazoline and quinazolinone skeletons: the advances continue. Eur J Med Chem. 2015; 90:124–169. https://doi.org/10.1016/j.ejmech.2014.10.084.
4. Monier M, Abdel-Latif DEL-M, Elattar KM. Bicyclic 6+6 systems: advances in the chemistry of heterocyclic compounds incorporated pyrimido[1,2-a]pyrimidine skeleton. Mini-Rev Org Chem. 2020; 17(6):717–739. http://dx.doi.org/10.2174/1389557519666190925161145.
5. Maiden TMM, Harrity JPA. Recent developments in transition metal catalysis for quinazolinone synthesis. Org Biomol Chem. 2016;14(34):8014–8025. https://doi.org/10.1039/C6OB01402J.
6. Ranjith R. The chemistry and biological significance of imidazole, benzimidazole, benzoxazole, tetrazole and quinazolinone nucleus. J Chem Pharm Res. 2016; 8(5):505–526.
7. Lazou M, Tarushi A, Gritzapis P, Psomas G. Transition metal complexes with a novel guanine-based (E)-2-(2-(pyridin-2-ylmethylene)hydrazinyl)quinazolin-4(3H)-one: synthesis, characterization, interaction with DNA and albumins and antioxidant activity. J Inorg Biochem. 2020; 206:111019. https://doi.org/10.1016/j.jinorgbio.2020.111019.
8. Özturk S, Okay S, Yıldırım A. Synthesis, anticorrosion, antibacterial, and antifungal activity of new amphiphilic compounds possessing quinazolin-4(3H)-one scaffold. Russ Chem Bull. 2020; 69: 2205–2214. https://doi.org/10.1007/s11172-020-3023-0.
9. Wang X, Hu H, Zhao X, Chen M, Zhang T, Geng C, Mei Y, Lu A, Yang C. Novel quinazolin-4(3H)-one derivatives containing a 1,3,4-oxadiazole thioether moiety as potential bactericides and fungicides: design, synthesis, characterization and 3D-QSAR analysis. J Saudi Chem Soc. 2019; 23(8):1144–1156. https://doi.org/10.1016/j.jscs.2019.07.006.
10. Al-Jeilawi OH, Al-Ani HN, Al-Zahra A, Al-Sultani KT. Exploring the potential of quantum chemical calculations for synthesized quinazoline derivatives as superior corrosion inhibitors in

acidic environment. Phys Chem Res. 2024;12(1):205–217. https://doi.org/10.22036/pcr.2023.390388.2314.

11. Al-Zahra A, Al-Ani HN, Al-Jeilawi OH. Experimental and theoretical study of 3-benzyl-2-mercaptoquinazolin-4(3H)-one (BMQ) as an inhibitor of carbon steel corrosion in acidic media. Int J Sci Nutral. 2018; 9(1):105–113.
12. Xing Z, Wu W, Miao Y, Tang Y, Zhou Y, Zheng L, Fu Y, Song Z, Peng Y. Recent advances in quinazolinones as an emerging molecular platform for luminescent materials and bioimaging. Org Chem Front. 2021; 8(8):1867–1889. https://doi.org/10.1039/D0QO01425G.
13. Nguyen CT, Nguyen QT, Dao PH, Nguyen TL, Nguyen PT, Nguyen HH. Synthesis and cytotoxic activity against K562 and MCF-7 cell lines of some N-(5-arylidene-4-oxo-2-thioxothiazolidin-3-yl)-2-((4-oxo-3-phenyl-3,4-dihydroquinazoline-2-yl)thio)acetamide compounds. J Chem. 2019; 2019(2b):1–8. http://dx.doi.org/10.1155/2019/1492316.
14. Shamaya AN, Al-Jeilawi OH, Khudhair NA. Novel synthesis of some N-hydroxy phthalimide derivatives with investigation of its corrosion inhibition for carbon steel in HCl solution. Chem Methodol. 2021; 5(4):331–340. https://doi.org/10.22034/chemm.2021.131305.
15. Nasab RR, Karami B, Khodabakhshi S. Selective solvent-free Biginelli condensation using tungstate sulfuric acid as powerful and reusable catalyst. Bull Chem React Eng Catal. 2014; 9(2):148–154. https://doi.org/10.9767/bcrec.9.2.6794.148-154.
16. Mohammadkhani L, Heravi MM. Microwave-assisted synthesis of quinazolines and quinazolinones: an overview. Front Chem. 2020; 8:580086. https://doi.org/10.3389/fchem.2020.580086.
17. Karaali N. A convenient method for the synthesis of 3,4-dihydroquinazolines from iminoester hydrochlorides via microwave irradiation. J Chem Res. 2019; 43(3–4):140–143. https://doi.org/10.1177/1747519819857513.
18. Auti PS, George G, Paul AT. Recent advances in the pharmacological diversification of quinazoline/quinazolinone hybrids. RSC Adv. 2020; 10(68):41353–41392. https://doi.org/10.1039/D0RA06642G.
19. Kushwaha N, Sahu A, Mishra J, Soni A, Dorwal D. An insight on the prospect of quinazoline and quinazolinone derivatives as anti-tubercular agents. Curr Org Synth. 2023; 20(8):838-869. https://doi.org/ 10.2174/1570179420666230316094435.
20. 20. Xu M, Wu P, Shen F, Ji J, Rakesh K. Chalcone derivatives and their antibacterial activities: current development. Bioorg Chem. 2019; 91:103133. https://doi.org/10.1016/j.bioorg.2019.103133.
21. Sharma P, Sharma D, Sharma A, Saini N, Goyal R, Ola M, Chawla R, Thakur V. Hydrazone comprising compounds as promising anti-infective agents: chemistry and structure-property relationship. Mater Today Chem. 2020; 18:100349. https://doi.org/10.1016/j.mtchem.2020.100349.
22. Rossi R, Ciofalo M. An updated review on the synthesis and antibacterial activity of molecular hybrids and conjugates bearing imidazole moiety. Molecules. 2020; 25(21):5133. https://doi.org/10.3390/molecules25215133.
23. El-Saadi MT, Amin NH. Synthesis, docking and biological evaluation of 2,4-disubstituted quinazolines with multi-target activities as anti-cancer and antimicrobial agents. Egypt J Chem. 2020; 63(10):3721–3734. https://doi.org/10.21608/ejchem.2020.23300.2385.
24. Oleiwi AQ, Al-Jeilawi OH, Dayl SA. Synthesis, characterization of some thiourea derivatives based on 4-methoxybenzoyl chloride as antioxidants and study of molecular docking. Iraqi J Sci. 2023; 64(1): 1–12. https://orcid.org/0000-0002-1317-8268.
25. Sayahi MH, Saghanezhad SJ, Bahadorikhalili S, Mahdavi M. CuBr-catalysed one-pot multicomponent synthesis of 3-substituted 2-thioxo-2,3-dihydroquinazolin-4(1H)-one derivatives. Appl Organomet Chem. 2019; 33(1):e4635. http://dx.doi.org/10.1002/aoc.4635.
26. Tokalı FS, Demir Y, Demircioğlu İH, Türkeş C, Kalay E, Şendil K, Beydemir Ş. Synthesis, biological evaluation, and in silico study of novel library sulfonates containing

quinazolin-4(3H)-one derivatives as potential aldose reductase inhibitors. Drug Dev Res. 2022; 83(3):586–604. https://doi.org/10.1002/ddr.21887.

27. Saeed S, Hussain R. A convenient way for the preparation of novel thiourea derivatives containing biologically active quinazoline moiety. Eur Chem Bull. 2013; 2(7):465–467.
28. Bousfield TW, Pearce KP, Nyamini SB, Angelis-Dimakis A, Camp JE. Synthesis of amides from acid chlorides and amines in the bio-based solvent Cyrene™. Green Chem. 2019; 21(13):3675–3681. https://doi.org/10.1039/C9GC01180C.
29. Salvatore RN, Yoon CH, Jung KW. Synthesis of secondary amines. Tetrahedron. 2001; 57(37): 7785–7812. http://dx.doi.org/10.1016/S0040-4020(01)00722-0.
30. Erhonyota C, Edo GI, Onoharigho FO. Comparison of poison plate and agar well diffusion method determining the antifungal activity of protein fractions. Acta Ecol Sin. 2023; 43(4):684–689. https://doi.org/10.1016/j.chnaes.2022.08.006.
31. Latheef L, Kurup MP. Synthesis and spectral studies of 3-azacyclothiosemicarbazones. J Adv Sci Res. 2019; 10(Suppl 2):333–338. https://www.sciensage.info/index.php/JASR/article/view/395.
32. Rao C, Venkataraghavan R. The C=S stretching frequency and the "–N–C=S bands" in the infrared. Spectrochim Acta A Mol Spectrosc. 1989; 45:299–305.
33. Silverstein RM, Webster FX, Kiemle DJ. Spectrometric identification of organic compounds. 7th ed. New York: John Wiley & Sons; 2005.
34. Mustafa IF, Hussain EM. Synthesis and antimicrobial evaluation of new 1,3,4-thiadiazole derivatives.IHJPAS.2017;27(1):297–305.https://jih.uobaghdad.edu.iq/index.php/j/article/view/395.