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СИНТЕЗ, ХАРАКТЕРИЗАЦИЯ И СКРИНИНГ АНТИМИКРОБНОЙ АКТИВНОСТИ НЕКОТОРЫХ НОВЫХ ОСНОВАНИЙ ШИФФА И ПРОИЗВОДНЫХ ТИАЗОЛИДИНОНА, ПОЛУЧЕННЫХ ИЗ АРОМАТИЧЕСКИХ КАРБОНОВЫХ КИСЛОТ

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В этом исследовании были оценены антимикробные свойства вновь синтезированных оснований Шиффа (4a-4e) и тиазолидиноновых соединений (5a-5e), полученных из 3,5-динитробензойной кислоты. Эти соединения были получены путем реакции 3,5-динитробензойной кислоты (1) с этанолом в нескольких каплях концентрированной H_2SO_4 для получения эфира (2). Гидразид кислоты (3), полученный путем обработки эфира гидразингидратом, реагировал с соответствующими альдегидами, включая 4-бромбензальдегид, 4-хлорбензальдегид, 4-гидроксибензальдегид, 4-метоксибензальдегид и 4-гидрокси-3-метоксибензальдегид, соответственно, для образования оснований Шиффа (4a-4e). Тиазолидиноновые соединения (5a-5e) были получены реакцией циклоконденсации соединений (4a-4e) с тиогликолевой кислотой. Различные методы, включая масс-спектроскопию, ^{1}H ЯМР, ^{13}C-ЯМР и FT-IR, были использованы для поиска новых соединений, которые проявили умеренную антибактериальную активность против четырех видов бактерий в соответствии с биологическими результатами. Эффективность производных тиазолидинона против Candida albicans была посредственной. Соединения показали валентные полосы поглощения при 1625-1639 см$^{-1}$, принадлежащие азометиновым группам, и вызванную амином потерю полос поглощения при 3392, 3311 см$^{-1}$. Основания Шиффа показали синглетные сигналы при δ (8.33-8.87) м.д. для азометиновых групп и сигналы при 150.67-150.75 м.д. для углерода по ^{1}H ЯМР и ^{13}C ЯМР. Соединения тиазолидинона показали валентные полосы поглощения при 1701-1708 см$^{-1}$ из-за карбонильной группы лактамного кольца. Сигналы при (170.99-171.19) м.д. относятся к карбонильной группе углерода лактамного кольца для соединений тиазолидинона.

Ключевые слова: основание Шиффа, тиазолидинон, карбоновая кислота, антимикробная активность

SYNTHESIS, CHARACTERIZATION AND SCREENING OF ANTIMICROBIAL ACTIVITY FOR SOME NEW SCHIFF BASES AND THIAZOLIDINONE DERIVATIVES DERIVED FROM AROMATIC CARBOXYLIC ACID

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In this study, the antimicrobial properties of newly synthesized Schiff bases (4a-4e) and thiazolidinone compounds (5a-5e) generated from 3,5-dinitrobenzoic acid were assessed. These compounds were obtained by reacting 3,5-dinitrobenzoic acid (1) with ethanol in a few drops of concentrated H_2SO_4 to produce the ester (2). The acid hydrazide (3), which was produced by treating the ester with hydrazine hydrate, reacted with the proper aldehydes, including 4-bromobenzaldehyde, 4-chlorobenzaldehyde, 4-hydroxybenzaldehyde, 4-methoxybenzaldehyde, and 4-hydroxy-3-methoxybenzaldehyde, respectively, to form Schiff bases (4a-4e). The thiazolidinone compounds

(5a-5e) were produced by the cyclocondensation reaction of compounds (4a-4e) with thioglycolic acid. A variety of techniques, including mass spectroscopy, ^{1}H NMR, ^{13}C NMR, and FT-IR, were employed to find novel compounds, which exhibited mild antibacterial activity against four kinds of bacteria according to the biological results. The effectiveness of the thiazolidinone derivatives against Candida albicans was mediocre. The compounds showed stretching absorption bands at 1625-1639 cm^{-1}, belonging to azomethine groups, and the amine-induced loss of absorption bands at 3392, 3311 cm^{-1}. Schiff bases exhibited singlet signals at δ (8.33-8.87) ppm for azomethine groups and signals at 150.67-150.75 ppm for carbon by ^{1}H NMR and ^{13}C NMR. Thiazolidinone compounds showed stretching absorption bands at 1701-1708 cm^{-1} due to the lactam ring carbonyl group. The signals at (170.99-171.19) ppm are affording to the carbon carbonyl group of the lactam ring for thiazolidinone compounds.

Keywords: Schiff base, thiazolidinone, carboxylic acid, anti-microbial activity

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INTRODUCTION

Hugo Schiff synthesized azomethine chemicals (Schiff bases) in 1864. Schiff bases are produced when primary amine and carbonyl molecules (aldehyde or ketone) undergo a condensation process. Stable Schiff bases are often produced by the condensation reaction of aromatic amines and aldehydes [1]. Schiff bases are generally expressed as RHC=N–R1. Aryl, heterocyclic, and alkyl groups are distinguished by R and R1 [2, 3]. Since Schiff bases may be easily created from low-cost starting materials, a large range of ligands can be created for straightforward reaction conditions. In addition, cyclization reactions can produce macrocyclic compounds with imimine groups [4].

Numerous investigations on the biological characteristics of compounds that include Schiff bases and are connected to the existence of the imine group (C=N) have been carried out. Strong qualities including simplicity, usefulness, and adaptability make these compounds extremely important [5]. Understanding the nature of different molecules provides a challenge to biological activists [6]. Their biological significance is noteworthy, as evidenced by their antibacterial [7], antifungal [8], antioxidant [9], antiviral [10], analgesic [11], anticancer [12], and Alzheimer's disease [13] properties. Additionally, they prevent the production of peptidoglycan by inhibiting the bacterial enzyme Mur B. The medical field makes extensive use of antibiotics and their derivatives [14]. A carbonyl molecule, an amine, and mercaptoacetic acid were reported to react either in a one-step or two-step process to produce 1,3-thiazolidin-4-ones. The production of these molecules from piperonilamine also made use of ultrasound sonochemistry. Although antibiotics have been utilized to prevent or lessen bacterial growth, bacterial pathogens have long been able to successfully fight antibiotics because they have evolved systems to resist them [15,16]. Penicillins, cephalosporins, carbapenems, nocardicins, and monobactams are among the β-lactam antibiotics that frequently contain the 2-azetidinone ring system and are used to treat bacterial infections [17].

Schiff base ligands' exceptional capacity to bind a wide variety of metals in diverse oxidation states makes them important for advancements in coordination chemistry. Extensive study is constantly being conducted on the interactions between metal complexes and Schiff bases. The search for possible uses of these systems is made easier by the vast number of structurally described metal systems. The main application for Schiff base-based metal complexes has been in homogeneous catalysis. Furthermore, these complexes have garnered a lot of interest due to their strong biological activity and application as metalloenzyme active site models. Utilizing these substances as molecular building blocks to produce functional, longer-lasting supramolecular materials has recently drawn increasing attention to Schiff base-metal chemistry [4].

A particular group of thiazolidine derivatives are thiazolidinone chemicals. They are known as 1,3-

thiazolidine-4-one because of their five-member ring, which contains nitrogen and sulfur atoms. They are stable in acidic media at moderate temperatures when they have a carbonyl group at position four [18]. Thiazolidinone molecules are biologically effective due to the presence of nitrogen and sulfur atoms. The thiazolidine-4-one moiety has been found in several synthetic compounds that have antibacterial [19], antifungal [20], anticancer [21], antiparasitic [22], antiviral [23], antioxidant [24], anticonvulsant [25], analgesic [26,27], and anti-inflammatory activators [28] characteristics. Thiazolidinone compounds have recently emerged as a promising area of research due to their antitumor activity in the central nervous system, kidney, colon, leukemia, lung, breast cancer cells, melanoma, and prostate [29].

EXPERIMENTAL SECTION

Materials

All materials were provided by companies (Fluka, Merch, and Sigma-Aldrich).

Instruments

The Digimelt MPA 161 (MSRS) electronic was used to measure the melting points. FT-Infrared spectra were collected at Ibn-Sina using a spectrophotometer (Shimadzu FT-IR-8400S). An Agilent mass spectrometer model 5975C VL MSD was used to perform mass spectroscopy at the University of Tehran in Iran. The University of Kashan in Iran measured ^{1}H-NMR spectra in DMSO-d_6 using a Bruker BioSpin GmbH. In the Department of Biology, College of Science, University of Al-Mustansiriyah, prepared compounds were tested for antimicrobial effectiveness against (*Staphylococcus aureus* and *Staphylococcus epidermidis*) (G+) and (*Escherichia coli* & *Klebsiella pneumoniae*) (G-), as well as antifungal efficacy against *Candida albicans*.

Synthesis of ethyl 3,5-dinitrobenzoate (2) [30]

After dissolving 10 mmol of 3,5-dinitrobenzoic acid in 15 mL of ethanol, five drops of concentrated H_2SO_4 were added, and the solution was heated for five hours. Following that, the solvent was removed under low pressure. Ethyl acetate (2×25 mL) was used to extract the product, followed by distilled water, $NaHCO_3$, and anhydrous magnesium sulfate for drying. The residue was recrystallized after the solvent was extracted at a lower pressure from absolute ethanol, yielding compound (2) as white crystals (64%), m.p. (94-95 °C). FT-IR (KBr, ν cm^{-1}): 3091 ($CH_{ar.}$), 2981, 2939, 2895, 2875 ($CH_{aliphatic}$), 1730 ($C=O_{ester}$), 1593 (C=C).

Synthesis of 3,5-dinitrobenzohydrazide (3) [30]

Hydrazine hydrate (50 mmol, 80%) was added to a solution containing 10 mmol ethyl 3,5-dinitro benzoate (**2**) and 15 mL of absolute ethanol. The mixture was heated for twenty h. The solvent and excess hydrazine hydrate were then removed under reduced pressure, leaving a deep brown solid that was washed with hot absolute ethanol to yield (83%), (m.p.: 215-217 °C). FT-IR (KBr, ν cm^{-1}): 3392 (NH_{2asym}), 3311 (NH_{2sym}), 3207 (NH), 3072 ($CH_{ar.}$), 1645 ($C=O_{amide}$), 1573 (C=C), 1525 (NO_{2asym}), 1346 (NO_{2sym}).

Synthesis of Schiff bases 4(a-e) [31]

General procedure:

Aldehyde (1 mmol) was dissolved in absolute ethanol (10 mL), followed by 3 drops of CH_3COOH and 1 mmol of compound **3**. The mixture had been refluxed for 24 h. The solvent was evaporated, and the product was recrystallized using ethanol to yield the compounds (**4a**-**4e**).

N-(4-Bromobenzylidene)-3,5-dinitrobenzohydrazide (4a): FT IR (KBr, ν cm^{-1}); deep brown, yield 87%; 3392 ($OH_{tautomer}$), 3340 (NH), 3099 (CH_{ar}), 2929 ($CH_{aliphatic}$), 1656 ($C=O_{amide}$), 1631 (C=N), 1579, 1487 (C=C), 1525 (NO_{2asym}), and 1346 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 6.11-8.41 (m, 7H, aromatic), 8.66 (s, 1H, CH=N), 12.08 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; (108.82-149.15) (12C aromatic), 150.76 (C=N), 162.31 (C=O).

N-(4-Chlorobenzylidene)-3,5-dinitrobenzohydrazide (4b): Deep brown, yield 52%, Mp 226-228 °C; FT IR (KBr, ν cm^{-1}); 3471 ($OH_{tautomer}$), 3344 (NH), 3095 (CH_{ar}), 2928 ($CH_{aliphatic}$), 1651 ($C=O_{amide}$), 1631 (C=N), 1581, 1489 (C=C), 1529 (NO_{2asym}), 1344 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 6.09-8.45 (m, 7H, aromatic), 8.63 (s, 1H, CH=N), 12.07 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; (108.84-149.11) (12C aromatic), 150.73 (C=N), 162.28 (C=O); MS found: 348.2 [M+] (calc. for $C_{14}H_9ClN_4O_5$, 348.7).

N-(4-Hydroxybenzylidene)-3,5-dinitrobenzohydrazide (4c): Orange, yield 82%, Mp 238-240 °C; FT IR (KBr, ν cm^{-1}); 3475 (OH), 3381 ($OH_{tautomer}$), 3294 (NH), 3099 (CH_{ar}), 2926 ($CH_{aliphatic}$), 1662 ($C=O_{amide}$), 1639 (C=N), 1581, 1448 (C=C), 1514 (NO_{2asym}), 1346 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 6.1-8.40 (m, 7H, aromatic), 8.52 (s, 1H, CH=N), 10.2 (s, 1H, OH), 12.01 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; (108.84-149.25) (12C aromatic), 150.68 (C=N), 162.08 (C=O).

N-(4-Methoxybenzylidene)-3,5-dinitrobenzohydrazide (4d): Orange, yield 79%, Mp 189-191 °C; FT IR (KBr, ν cm^{-1}); 3446 ($OH_{tautomer}$), 3361 (NH), 3078 (CH_{ar}), 2978 ($CH_{aliphatic}$), 1656 ($C=O_{amide}$), 1633 (C=N), 1583, 1483 (C=C), 1525 (NO_{2asym}), 1346 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 2.32 (s, 3H, OCH_3), 6.11-8.74 (m, 7H, aromatic), 8.87 (s, 1H, CH=N), 12.00 (s, 1H, NH); ^{13}C NMR (75 MHz,

DMSO-d_6) δ, ppm; Overlap with signal of solvent (OCH_3), (108.78-149.15) (12C aromatic), 150.75 (C=N), 162.16 (C=O).

N-(4-Hydroxy-3-methoxybenzylidene)-3,5-dinitrobenzohydrazide (4e): Orange, yield 73%, Mp 151-155 °C; FT IR (KBr, ν cm^{-1}); 3475 (OH), 3379 ($OH_{tautomer}$), 3269 (NH), 3053 (CH_{ar}), 2933 ($CH_{aliphatic}$), 1656 (C=O_{amide}), 1625 (C=N), 1583, 1461 (C=C), 1521 (NO_{2asym}), 1344 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.69 (s, 3H, OCH_3), 6.1-8.29 (m, 6H, aromatic), 8.33 (s, 1H, CH=N), 9.62 (s, 1H, OH), 11.89 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 55.94 (OCH_3), (108.85-149.60) (12C aromatic), 150.69 (C=N), 162.16 (C=O).

Synthesis of thiazolidinone compounds (5a-5e) [31]

General procedure:

The Schiff bases (**4a-4e**) (0.5 mmol) in benzene (20 mL) were gradually mixed with mercaptoacetic acid (0.1 mL, 1 mmol). The mixture was allowed to reflux for 24 h in a water bath. Absolute ethanol was used to recrystallize the yield.

N-(2-(4-Bromophenyl)-4-oxothiazolidin-3-yl)-3,5-dinitrobenzamide (5a): Brown, yield 67%, Mp 220-222 °C; FT IR (KBr, ν cm^{-1}); 3463 ($OH_{tautomer}$), 3338 (NH), 3089 (CH_{ar}), 2927, 2875 ($CH_{aliphatic}$), 1701 (C=O_{Lactam}), 1652 (C=O_{amide}), 1581, 1485 (C=C), 1527 (NO_{2asym}), 1346 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.68 (s, 2H, CH_2-S), 5.24 (s, 1H, CH-N), 6.08-8.63 (m, 7H, aromatic), 12.05 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 34.52 (CH_2-S), 41.04 (CH-N), (108.85-149.12) (12C aromatic), 162.27 (C=O_{amide}), 170.99 (C=O_{Lactam}).

N-(2-(4-Chlorophenyl)-4-oxothiazolidin-3-yl)-3,5-dinitrobenzamide (5b): Deep brown, yield 63%, Mp 178-180 °C; FT IR (KBr, ν cm^{-1}); 3471 ($OH_{tautomer}$), 3344 (NH), 3086 (CH_{ar}), 2928, 2654 ($CH_{aliphatic}$), 1701 (C=O_{Lactam}), 1653 (C=O_{amide}), 1583, 1489 (C=C), 1531 (NO_{2asym}), 1344 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.70 (s, 2H, CH_2-S), 5.26 (s, 1H, CH-N), 7.39-9.07 (m, 7H, aromatic), 12.05 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 34.50 (CH_2-S), 41.05 (CH-N), (108.83-150.70) (12C aromatic), 162.29 (C=O_{amide}), 171.14 (C=O_{Lactam}).

N-(2-(4-Hydroxyphenyl)-4-oxothiazolidin-3-yl)-3,5-dinitrobenzamide (5c): Orange, yield 50%, Mp 117-119 °C; FT IR (KBr, ν cm^{-1}); 3472 (OH), 3440 ($OH_{tautomer}$), 3360 (NH), 3072 (CH_{ar}), 2985, 2912 ($CH_{aliphatic}$), 1708 (C=O_{Lactam}), 1666 (C=O_{amide}), 1593, 1446 (C=C), 1533 (NO_{2asym}), 1348 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.68 (s, 2H, CH_2-S), 5.15 (s, 1H, CH-N), 6.31-8.41 (m, 7H, aromatic), 9.70 (s, 1H, OH), 11.10 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 34.58 (CH_2-S), 41.42 (CH-N), (108.83-149.30) (12C aromatic), 150.70 (C=O_{amide}), 171.15 (C=O_{Lactam}). MS found: 410 [M^++6] (calc. for $C_{16}H_{12}N_4O_7S$, 404).

N-(2-(4-Methoxyphenyl)-4-oxothiazolidin-3-yl)-3,5-dinitrobenzamide (5d): Deep brown, yield 78%, Mp 109-111 °C; FT IR (KBr, ν cm^{-1}); 3424 ($OH_{tautomer}$), 3376 (NH), 3082 (CH_{ar}), 2976, 2926 ($CH_{aliphatic}$), 1705 (C=O_{Lactam}), 1685 (C=O_{amide}), 1597, 1460 (C=C), 1533 (NO_{2asym}), 1348 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.40 (s, 2H, CH_2-S), 3.70 (s, 3H, OCH_3), 5.48 (s, 1H, CH-N), 6.15-8.75 (m, 7H, aromatic), 10.96 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 34.54 (CH_2-S), 41.36 (CH-N), 52.79 (OCH_3), (108.80-157.65) (12C aromatic), 163.81 (C=O_{amide}), 171.19 (C=O_{Lactam}).

N-(2-(4-Hydroxy-3-methoxyphenyl)-4-oxothiazolidin-3-yl)-3,5-dinitrobenzamide (5e): Yellow, yield 51%, Mp 133-135 °C; FT IR (KBr, ν cm^{-1}); 3471 (OH), 3427 ($OH_{tautomer}$), 3380 (NH), 3082 (CH_{ar}), 2970, 2877 ($CH_{aliphatic}$), 1706 (C=O_{Lactam}), 1680 (C=O_{amide}), 1585, 1463 (C=C), 1517 (NO_{2asym}), 1346 (NO_{2sym}); ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm; 3.60 (s, 2H, CH_2-S), 3.79 (s, 3H, OCH_3), 5.20 (s, 1H, CH-N), 6.07-8.31 (m, 7H, aromatic), 10.20 (s, 1H, OH), 11.84 (s, 1H, NH); ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm; 34.56 (CH_2-S), 41.22 (CH-N), 55.96 (OCH_3), (108.80-150.70) (12C aromatic), 162.05 (C=O_{amide}), 171.04 (C=O_{Lactam}).

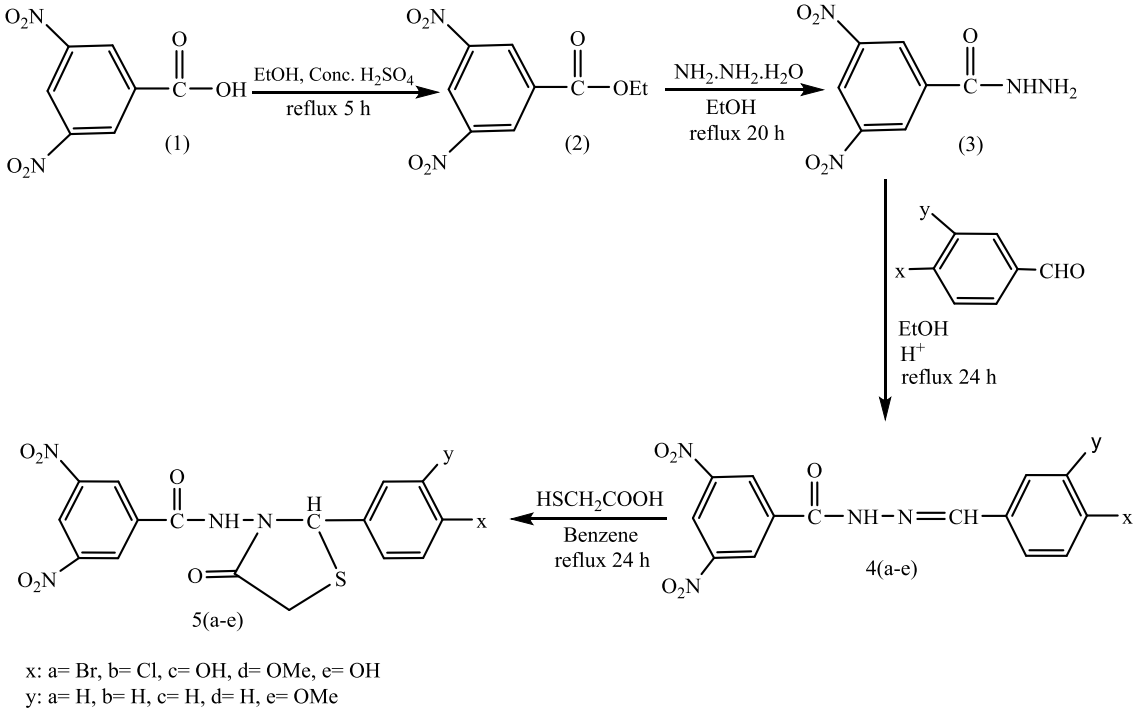
RESULTS AND DISCUSSION

This study produced several novel Schiff bases and thiazolidinone derivatives, beginning with an aromatic carboxylic acid, Scheme.

These chemicals were obtained by reacting compound (1) with 100% ethanol in the presence of a few drops of concentrated H_2SO_4 to produce the ester (**2**) from the aromatic carboxylic acid (3,5-dinitrobenzoic acid) (**1**). Acid hydrazide (**3**) was created by treating the ester (**2**) with hydrazine hydrate (80%). FT-IR spectra and melting point measurements were used to confirm the structures of each compound. The FT-IR spectrum of acid hydrazide showed stretching bands at (3392, 3311, 3207, and 1645) cm^{-1} because of (asym. and sym. NH_2, NH, and C=O amide), and the stretching absorption band at (1730) cm^{-1} for (C=O) of ester vanished.

The preparation of Schiff bases **4(a-e)** involved reacting an amine (acid hydrazide) with substituted aromatic aldehydes such as 4-bromobenzaldehyde, 4-chlorobenzaldehyde, 4-hydroxybenzaldehyde, 4-methoxybenzaldehyde, and 4-hydroxy-3-methoxybenzaldehyde while glacial acetic acid (a few drops) was present. Absolute ethanol was used as the solvent. Melting points and spectroscopy methods such as

FTIR, ^{1}H NMR, ^{13}C NMR, and some mass spectroscopy were used to analyze Schiff bases **4(a-e)**. These compounds had stretching absorption bands at (1625-1639) cm^{-1} that were attributed to (C=N) azomethine groups. The stretching absorption bands at (3392, 3311) cm^{-1} vanished as a result of the amine's (acid hydrazide) asymmetry and symmetry. NH_2. Schiff bases' ^{1}H-NMR and ^{13}C-NMR spectra showed singlet signals for (1H, HC=N) azomethine groups at δ (8.33-8.87) ppm and signals for carbon (C=N) at (150.67-150.75) ppm. The mass spectrum of Schiff base (**4b**) exhibited molecular ion (m/z = 348.2 [M$^+$]) while the predicted molecular weight is 348.7.



Scheme. Pathway of synthesis of 4(a-e) and 5(a-e)
Схема. Путь синтеза 4(a-e) и 5(a-e)

Thioglycolic acid and azomethine compounds (**4a**–**4e**) were treated in dry benzene as a solvent to produce thiazolidinone derivatives (**5a**–**5e**). Melting points and spectroscopy methods, including FTIR, ^{1}H NMR, ^{13}C NMR, and some mass spectroscopy, were used to identify these compounds. The FT-IR spectra revealed that the carbonyl group (C=O) of the lactam ring for thiazolidinone compounds **5(a-e)** caused stretching absorption bands at (1701-1708) cm^{-1}, but the absorption band at (1625-1639) cm^{-1}, which belonged to (C=N) azomethine groups, vanished. The azomethine group signals for Schiff bases vanished at δ (8.33-8.87) ppm for (^{1}H, HC=N) and at (150.67-150.75) ppm for carbon (C=N), according to the ^{1}H NMR and ^{13}C NMR spectra for thiazolidinone derivatives. The signals of carbon carbonyl lactam ring at (170.99-171.19) ppm for thiazolidinone compounds. The mass spectrum of thiazolidinone (**5c**) indicated molecular ion m/z = 410.5 [M$^+$+6]. This could be attributed to the molecule gaining six atoms of the nitrogen, oxygen, and sulfur isotopes. The predicted molecular weight of thiazolidinone (**5c**) is 404. Since the other samples are similar and will yield identical results, only one sample was measured using mass spectrometry.

Anti-microbial efficacy study

The synthesized compounds were screened using the disc diffusion method [32] against four different types of bacteria, including *S. aureus*, *S. epidermidis*, *E. coli*, *K. pneumoniae*, and one type of fungus, *C. albicans*. Muller Hinton agar was used to test the produced chemicals against fungus and bacteria. All chemicals were dissolved in DMSO to achieve a concentration of 0.01 M. The inhibitory zones were identified following the conclusion of the incubation periods for bacterial growth, which is 24 h at 37 °C, and fungal growth, which is 5 days at 25 °C. Table contains the zone of inhibition data. This study was carried out at the University of Al-Mustansiriyah's Department of Biology, College of Science.

According to Table and Figure, we deduce that compounds **4d**, **4e** and **5e** did not exhibit inhibition

against *Staphylococcus epidermidis*, whereas compounds **4b**, **4e**, **5d** and **5e** did not exhibit inhibition against *Escherichia coli*, and compound **5e** did not exhibit inhibition against *Klebsiella pneumoniae*. The compounds, except for compound **5a**, which showed excellent efficacy against *Klebsiella pneumonia*, showed low to moderate activity against the different species of bacteria under investigation. Low activity was shown by Schiff bases **4(a-e)**, whereas moderate efficacy was shown by thiazolidinone compounds **5(a-e)** against *Candida albicans*. Because thiazolidinone derivatives contain nitrogen and sulfur atoms in their five-member ring, they exhibit higher activity than Schiff bases.

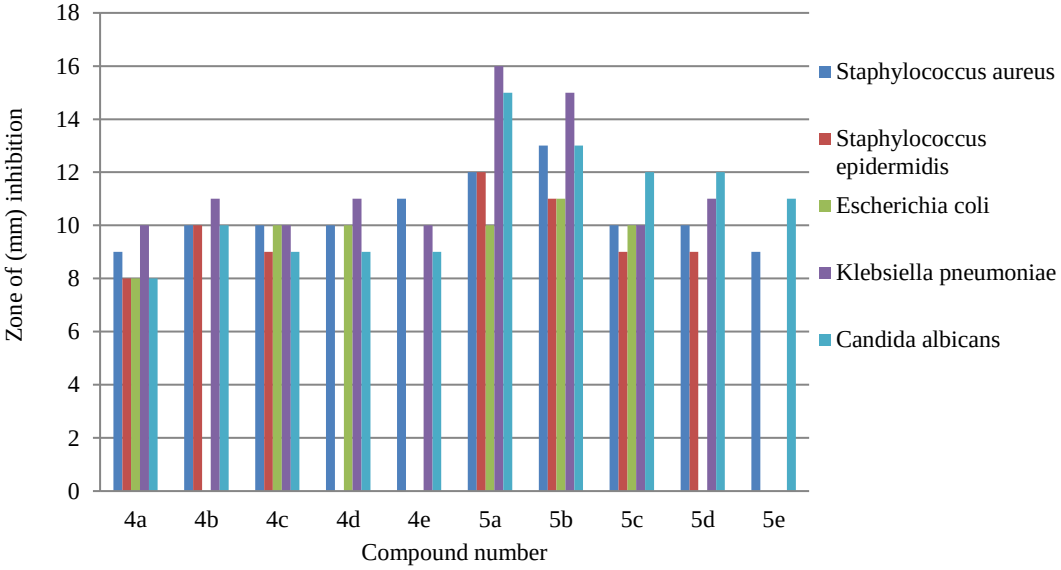


Fig. The inhibition zone diameter (mm) of prepared compounds against four bacteria and one fungus
Рис. Диаметр зоны ингибирования (мм) приготовленных составов для четырех бактерий и одного грибка

Table

Anti-microbial estimating values (inhibition zone in mm) for final compounds 4(a-e) and 5(a-e)
***Таблица.* Оценочные значения антимикробной активности (зона ингибирования в мм) для конечных соединений 4(a-e) и 5(a-e)**

Compound No.	*Staphylococcus aureus*	*Staphylococcus epidermidis*	*Escherichia coli*	*Klebsiella pneumoniae*	*Candida albicans*
4a	9	8	8	10	8
4b	10	10	-	11	10
4c	10	9	10	10	9
4d	10	-	10	11	9
4e	11	-	-	10	9
5a	12	12	10	16	15
5b	13	11	11	15	13
5c	10	9	10	10	12
5d	10	9	-	11	12
5e	9	-	-	-	11
DMSO	-	-	-	-	-

CONCLUSION

FTIR, ^{1}H NMR, ^{1}C NMR, and certain mass spectroscopy methods were used to analyze new Schiff bases and thiazolidinone derivatives. The produced compounds' biological activity was assessed against one kind of fungus (*Candida albicans*) and four species of bacteria (G+) (*S. aureus*, *S. epidermidis*) and (G-) (*E. coli*, *K. pneumoniae*). The evaluation's findings revealed that while some of the compounds had low to moderate effectiveness against the four species of bacteria and the utilized fungus, others were ineffective against three of them.

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CONFLICT OF INTERESTS

The authors declare the absence of a conflict of interest warranting disclosure in this article.

Авторы заявляют об отсутствии конфликта интересов, требующего раскрытия в данной статье.

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