ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

One pot and stepwise synthesis of some new azo thiazolidin-4-one derivatives and their biological evaluations.

Chinar M. Burhan, Awaz J. Hussein
Department of Chemistry, College of Education, Salahaddin University–Erbil, Erbil-Kurdistan, Iraq

A B S T R A C T:

(2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3- substitutedphenylthiazolidin-4-ones derivatives (4a-h) have been synthesized from the reaction of 2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl) phenyl)diazenyl)benzaldehyde (2) with different substituted aniline, followed by cyclization with mercaptoacetic acid via either a one-pot three-component condensation and stepwise process. The structure of synthesized compounds were elucidated by FT-IR, ^{1}H-NMR, ^{13}C-NMR and DEPT ^{13}C NMR. Finally, the animicrobile activity of these compounds were evaluated by the well diffusion assay against *S. aureus* Gram-positive and *E. coli* Gram-negative bacteria.

KEY WORDS: Heterocyclic compound, Schiff base, thiazolidine-4-one, mercaptoacetic acid, biological activity..
DOI: http://dx.doi.org/10.21271/ZJPAS.35.1.16
ZJPAS (2023) , 35(1);151-164 .

1. INTRODUCTION:

Small ring heterocycles with nitrogen, sulfur, and oxygen have been the subject of extensive research due to their significant medical benefits (Malipeddi et al., 2012).

Important classes of synthetic organic chemicals include azo compounds and imines, which are used as building blocks for the synthesis of a variety of biological organic molecules (Hussein, 2014). Imines are valuable Structural elements for the synthesis of several heterocyclic compounds, such as azetidinones and thiazolidine-4-ones, and are readily produced from amines and benzaldehydes (Hussein et al., 2013). Thiazolidinones are thiazolidine derivatives with a carbonyl group at position 2, 4, or 5 and an atom of sulfur at position 1, nitrogen at position 3 (Singh et al., 1981, Brown, 1961, Jain et al., 2012, Nirwan et al., 2019). Thiazolidinone and imine derivatives have been studied for a variety of pharmacological indications, including anti-inflammatory (Holota et al., 2019), antitumor, antiviral, antifungal, and antibacterial activities, antihistaminic (Bektaş et al., 2013, Kerim et al., 2003, Veerasamy et al., 2011), anticonvulsant (Almasirad et al., 2022), anti-HIV (Desa et al., 2021), hypnotic, anesthetic, anti-microbial (Mashrai & Mir, 2016) anticancer (Tahmasvand et al., 2020). An amine, a carbonyl molecule, and a mercaptoacetic acid are the three ingredients used most frequently in the main synthesis pathways for 1,3-thiazolidin-4-ones. One-pot, three-component condensation or a stepwise procedure can both be used for the stated classical synthesis. The reactions start with the creation of an imine (the nitrogen of the amine attacks the carbonyl of the aldehyde or ketone), which is subsequently attacked by a sulfur nucleophile. followed by intramolecular cyclization upon elimination of water (Singh et al., 1981). Herein an investigation

* **Corresponding Author:**
Chinar M. Burhan
E-mail: chnar.burhan@student.su.edu.krd
Article History:
Received: 01/08/2022
Accepted: 04/09/2022
Published: 20/02 /2023

of the biological activity and spectroscopic characteristics of some new thiazolidine-4-one derivatives bearing azo and benzyloxy moieties have been conducted.

2. EXPERIMENTAL

2.1. Chemical and devices:

All chemicals were purchased from Sigma-Aldrich Chemical Co (Sigma-Aldrich Corp., St. Louis, MO, USA, and Merck, made in Germany. Melting points were taken by using an (OptiMelt, Sunnyvale, CA, USA). IR spectra were recorded by using FT-IR spectrometer SHIMADZU, Mod IR Affinity-1 Using (KBr) disc. All reactions were monitored using both (Silia plate glass and Silica plate Aluminum) on Backed TLC plates DC-Glasplatten-Kieselgel (Radnor, PA, USA). The mobile phase was a mixture of ethyl acetate with normal hexane (1:1). ^{1}H-NMR, ^{13}C-NMR and ^{13}C-DEPT.135 spectra were recorded on a Bruker Ultra Shield (400 MHz) with TMS and $CDCl_3$ as an internal reference and solvent, respectively in university of Hamadan-Iran.

2.2 Synthesis of azo compound

2-hydroxy-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)benzaldehyde (1): (Ayoob et al., 2020)

Step 1: Preparation of diazonium salt, 4-(6-methylbenzo[d]thiazol-2-yl) aniline (12 gm, 50 mmole) was dissolved in a (40 mL) of 3M hydrochloric acid and put the solution in an ice bath near 0 °C. Quickly prepared 30 mL $NaNO_2$ (1 M), and added it dropwise with stirring to form diazonium salt. The temperature of the solution was kept near 0 °C. The solution was kept in the ice bath and immediately preceded to the next step.

Step 2: 2-Hydroxy benzaldehyde (6.21 gm, 50 mmole) was dissolved in (40 mL, 1M) of sodium hydroxide solution, cooled the solution in the ice bath and added slowly to the solution of diazonium salt (step 1). The mixture allowed in the ice bath with continuous stirring for 15 min. to complete the reaction. The solid azo dye was collected by vacuum filtration, washed several times with water, dried and recrystallized from xylene to give (yellow) crystal of compound (1).

$C_{21}H_{15}N_3O_2S$, percentage yield 98 %, melting point (259-260 ºC). IR (cm^{-1}): str. 2916 (CH_3-Ar), 2866 (CHO), 1653 (C=O), 1622 (-C=N), 1581 (C=C), 1556 (N=N), 1282 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.6 (CH_3, s), 7.04 (1H-Ar, d, C_{19}), 7.23 (1H-Ar, d, C_2), 7.63 (1H-Ar, s, C_6), 7.89 (1H-Ar, s, C_{22}), 7.9 (1H-Ar, d, C_3), 7.93 (1H-Ar, d, C_{18}), 8.1 (2H-Ar, d, $C_{12,16}$), 8.16 (2H-Ar, d, $C_{13,15}$), 10.08 (CHO, s), 11.41 (OH, s). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 21.66: C_{10}, 118.75: C_{19}, 120.35: C_{21}, 121.46: C_6, 122.86: C_3, 123.47: C_{22}, 128.35: $C_{13,15}$, 129.86: C_2, 130.74: $C_{12,16}$,134.04: $C_{18,}$ 135.57: C_1, 136.01: C_5,144.41: C_{11}, 145.97: C_{17}, 151.31: C_4, 153.52: C_{14}, 164.14: C_{20}, 165.89: C_8, 196.57: C_{26} C=O. DEPT ^{13}C NMR (101 MHz, $CDCl_3$) δ; 196.58: C_{26} C=O., 130.74: $C_{12,16}$, 129.86: C_2, 128.36: $C_{13,15}$, 123.47: C_{22}, 122.85: C_3, 121.46: C_6, 118.76: C_{19},, 21.67: C_{10}.

2.3. Synthesis of benzyloxy compound

2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl) phenyl) diazenyl) benzaldehyde (2):

A mixture of 2-hydroxy-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)benzaldehyde (1) (9.35 gm, 0.025 mol), benzyl bromide (8.4 gm, 0.050 mol) and anhydrous K_2CO_3 (9.69 gm, 0.075 mol) in ethanol (200 mL – 96 %) in a R.B.F 250 mL. was refluxed with stirring for 12 hrs. The cooled solution poured into water; solid materials immediately was obtained. The product was filtered off, washed several times with cold water, dried and recrystallized with a mixture (1:2) xylene: ethanol to obtain orange crystals of 2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl) phenyl) diazenyl) benzaldehyde (2) **(**ayoob & Hawaiz, 2017).

$C_{28}H_{21}N_3O_2S$, percentage yield 92 %, melting point (222-223 ºC). IR (cm^{-1}) str. 1687.71 (C=O), 1595 (C=C), 1483 (N=N), 1257 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.52 (CH_3, s), 5.31 (OCH_2, s), 7.2 (1H-Ar, d, C_2), 7.34 (1H-Ar, d, C_{16}), 7.4 (1H-Ar, t, C_{25}), 7.44 (2H-Ar, d, $C_{23,27}$), 7.49 (2H-Ar, t, $C_{24,26}$), 7.72 (1H-Ar, s, C_6), 7.98 (1H-Ar, s, C_{21}), 8.02 (2H-Ar, d, $C_{11,15}$), 8.19 (1H-Ar, d, C_3), 8.24 (2H-Ar, d, $C_{12,14}$), 8.5 (1H-Ar, d, C_{15}), 10.6 (CHO, s). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 21.66: C_{28}, 71.01:C_{32}, 113.50: C_{18}, 121.45: C_6, 122.90:C_3, 123.51: $C_{12,14}$, 123.93: C_{21}, 125.42: C_2, 127.42: $C_{23,27}$, 128.25: C_{25}, 128.28: $C_{11,15}$, 128.59:C_{20}, 128.89: $C_{24,26}$, 130.08: C_{17}, 135.46: C_1, 135.64: C_5, 135.87: C_{22}, 146.66: C_{10}, 148.66:

C_{16}, 152.21: C_4, 153.57: C_{13}, 162.92: C_{19}, 165.91: C_8, 189.22: C_{33} C=O. DEPT ^{13}C NMR (101 MHz, $CDCl_3$) δ; 189.22: C_{33} C=O, 130.08: C_{17}, 128.89: $C_{24,26}$, 128.59: C_{20}, 128.28: $C_{11,15}$, 127.42: $C_{23,27}$, 123.92: C_{21}, 123.51: $C_{12,14}$, 122.89:C_3, 121.45: C_6, 113.50: C_{18}, 71.00:C_{32}, 21.66: C_{28}.

2.4. Synthesis of imines

1-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-substitutedphenylmethanimine (3a-h):-

According to the modified procedure (Hussein, 2014), imines (3a-h) were synthesized by dissolving (0.004 mole) of 2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl) phenyl) diazenyl) benzaldehyde (2) in absolute ethanol (20 mL), and mixed with the solution of an appropriate substituted anilines (0.004 mole) in absolute ethanol (10 mL) with a few drops of acetic acid in R.B.F (50 ml). The mixture was refluxed for (1-3 hr.) until the formation of imines which was monitored by TLC., the cooled mixture was filtered, dried and recrystallized from xylene to give pure crystals of compounds (3a-h).

1-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(4-methoxyphenyl)methanimine (3a) :

$C_{35}H_{28}N_4O_2S$, percentage yield 87 %, melting point (229-230 ºC). IR (cm^{-1}): str. 1620 (-CH=N-), 1602 (C=C), 1575 (N=N), 1249 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.54 (CH_3-Ar, s), 3.87 (O-CH_3, s), 5.31 (O-CH_2, s), 6.96 (2H-Ar,d, $C_{30,32}$), 7.18 (2H-Ar,d, $C_{23,27}$), 7.3 (2H-Ar, d, $C_{29,33}$), 7.4 (1H-Ar, d, C_{18}), 7.45 (1H-Ar,t, C_{25}), 7.5 (2H-Ar, t, $C_{24,26}$), , 7.75 (1H-Ar,s, C_6), 8.00 (1H-Ar,d, C_2), 8.05 (1H-Ar, d, C_3), 8.09 (2H-Ar, d, $C_{11,15}$), 8.25 (2H-Ar, d, $C_{12,14}$), 8.85 (1H-Ar, d, C_{17}), 8.9 (1H-Ar, s, C_{21}), 9.05 (1H, CH=N-). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 166.02: C_8, 160.68: C_{19} ,158.38: C_{31}, 153.46: C_{41}, 152.39: C_{13}, 150.02: C_4, 147.04: C_{28}, 146.66: C_{16}, 144.56: C_{10}, 136.02: C_{22}, 135.72: C_5, 135.41: C_1, 128.82: $C_{24,26}$, 128.37: $C_{11,15}$, 128.22: C_{25}, 127.40: $C_{23,27}$, 127.08: C_2, 125.93: C_{17}, 123.42: $C_{12,14}$, 122.90: C_{21}, 122.78: C_6, 122.51: $C_{29,33}$, 121.45: C_3, 120.58: C_{20}, 114.38: $C_{30,32}$, 112.73: C_{18},70.84: C_{40} ,55.53: C_{36}, 21.63: C_{35}. DEPT ^{13}C NMR (101 MHz, $CDCl_3$) δ; 153.46: C_{41}, 128.82: $C_{24,26}$, 128.37: $C_{11,15}$, 128.22: C_{25}, 127.40: $C_{23,27}$, 127.08: C_2, 125.93: C_{17}, 123.42: $C_{12,14}$, 122.90: C_{21},121.78: C_6,121.51: $C_{29,33}$, 121.45: C_3, 114.38: $C_{30,32}$, 112.7337: C_{18},70.84: C_{40} ,55.53: C_{36}, 21.63: C_{35}.

1-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(p-tolyl)methanimine (3b) :

$C_{35}H_{28}N_4OS$, percentage yield 83 %, melting point (236-239 ºC). IR (cm^{-1}): str. 1620 (-CH=N-), 1602 (C=C), 1570 (N=N), 1257 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.41 (CH_3-Ar, s), 2.54 (CH_3-Ar, s, benzothiazole), 5.3 (O-CH_2, s), 7.18 (1H-Ar,d, C_{19}), 7.24 (4H-Ar, d, $C_{30,31,33,34}$), 7.4 (1H-Ar, d, C_2), 7.45 (1H-Ar,t, C_{26}), 7.49 (2H-Ar, t, $C_{25,27}$), , 7.74 (1H-Ar,s, C_6), 8.01 (1H-Ar,d, C_3), 8.06 (2H-Ar, d, $C_{24,28}$), 8.10 (2H-Ar, d, $C_{12,16}$), 8.26 (2H-Ar, d, $C_{13,15}$), 8.86 (1H-Ar, d, C_{18}), 8.9 (1H-Ar, s, C_{22}), 9.02 (1H, CH=N-). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 166.02: C_8, 160.77: C_{20}, 154.79: C_{40}, 153.78: C_{14}, 152.38: C_4, 147.00: C_{29}, 146.64: C_{11}, 135.97: C_{17}, 135.82: C_{32}, 135.73: C_{23}, 135.45: C_5, 135.41: C_1, 129.79: $C_{31,33}$, 128.82: $C_{25,27}$, 128.22: C_{26}, 128.16: $C_{12,16}$, 127.42: $C_{24,28}$, 127.29: C_{22}, 125.79: C_{18}, 123.51: $C_{13,15}$, 123.43: C_2, 122.90: $C_{30,34}$, 121.43: C_6, 121.09: C_3, 120.64: C_{21}, 112.86: C_{19}, 70.83: C_{39}, 21.66: C_{35}, 21.09: C_{10}. DEPT^{13}C NMR (101 MHz, $CDCl_3$) δ; 154.79: C_{40}, 129.79: $C_{31,33}$, 128.82: $C_{25,27}$, 128.22: C_{26}, 127.42: $C_{24,28}$, 127.29: C_{22}, 125.79: C_8,123.51: $C_{13,15}$, 123.43: C_2, 122.90: $C_{30,34}$, 121.43: C_6, 121.09: C_3, 112.86: C_{19}, 70.83: C_{39}, 21.66: C_{35}, 21.09: C_{10}.

1-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(4-ethoxyphenyl)methanimine (3c) :

$C_{36}H_{30}N_4O_2S$, percentage yield 85 %, melting point (213-214 ºC). IR (cm^{-1}): str. 1620 (-CH=N-), 1602 (C=C), 1570 (N=N), 1247 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6);1.46 (3H, CH_3, t, C_{42}), 2.54 (CH_3-Ar, s, C_{34}), 4.1 (2H, O-CH_2, q, C_{43}), 5.3 (2H, O-CH_2, s, C_{38}), 6.96 (2H-Ar,d, $C_{30,32}$), 7.18 (1H-Ar,d, C_{18}), 7.3 (2H-Ar, d, $C_{29,33}$), 7.4 (1H-Ar, d, C_2), 7.45 (1H-Ar,t, C_{25}), 7.5 (2H-Ar, t, $C_{24,26}$), , 7.75 (1H-Ar,s, C_6), 8.00 (1H-Ar,d, C_3), 8.05 (2H-Ar, d,$C_{23,27}$), 8.09 (2H-Ar, d, $C_{11,15}$), 8.25 (2H-Ar, d, $C_{12,14}$), 8.85 (1H-Ar, d, C_{17}), 8.9 (1H-Ar, s, C_{21}), 9.05(1H, CH=N-). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 166.03: C_8, 160.66: C_{19}, 157.77: C_{31},153.79: C_{13}, 153.32: C_{39}, 152.38; C_4, 147.02:

C_{10}, 146.66: C_{16},144.95: C_{28}, 136.03: C_{22}, 135.72: C_5, 135.39: C_1, 128.82: $C_{24,26}$, 128.36: $C_{11,15}$, 128.21: C_{25}, 127.42: $C_{23,27}$, 127.06: C_2, 125.94: C_{17}, 123.42: $C_{12,14}$, 122.89: C_{21}, 122.76: C_6, 122.52: $C_{29,33}$, 121.45: C_3, 120.59: C_{20}, 114.92: $C_{30,32}$, 112.84: C_{18}, 70.81: C_{38}, 63.69: C_{43}, 21.6581: C_{34}, 14.91: C_{42}. DEPT ^{13}CNMR (101 MHz, $CDCl_3$) δ; 153.32: C_{39}, 128.82: $C_{24,26}$, 128.36: $C_{11,15}$, 128.21: C_{25}, 127.42: $C_{23,27}$, 127.06: C_2, 125.94: C_{17}, 123.42: $C_{12,14}$, 122.89: C_{21}, 122.76: C_6, 122.52: $C_{29,33}$, 121.45: C_3, 114.92: $C_{30,32}$, 112.84: C_{18}, 70.81: C_{38}, 63.69: C_{42},21.6581: C_{34},14.91: C_{32}.

(E)-1-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(4-bromophenyl)methanimine (3d):

$C_{34}H_{25}N_4OSBr$, percentage yield 81 %, melting point (226-227 ºC). IR (cm^{-1}): str. 1618 (-CH=N-), 1595 (C=C), 1575 (N=N), 1261 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.54 (CH_3-Ar, s), 5.3 (O-CH_2, s), 7.16 (2H-Ar,d, $C_{29,33}$), 7.31 (2H-Ar, d, $C_{23,27}$), 7.39 (1H-Ar, d, C_{18}), 7.44 (1H-Ar,t, C_{25}), 7.5 (2H-Ar, t, $C_{24,26}$), , 7.74 (1H-Ar,s, C_6), 8.00 (1H-Ar,d, C_2), 8.09 (1H-Ar, d, C_3), 8.11 (2H-Ar, d, $C_{11,15}$), 8.24 (2H-Ar, d, $C_{12,14}$), 8.51 (1H-Ar, d, C_{17}), 8.78 (1H-Ar, s, C_{21}), 8.83 (2H-Ar, d, $C_{30,32}$), 8.98 (1H, CH=N-). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 165.97: C_8, 160.89: C_{19}, 155.97: C_{40}, 153.72: C_{13}, 152.34: C_4, 151.14: C_{28}, 146.98: C_{16}, 146.64: C_{10}, 135.83: C_{22}, 135.77: C_5, 135.49: C_1, 132.22: $C_{30,32}$, 128.86: $C_{24,26}$, 128.23: $C_{11,15}$, 127.75: C_{25}, 127.42: $C_{23,27}$, 125.32: C_2, 123.91: C_{17}, 123.50: $C_{12,14}$, 123.45: C_{21}, 122.98: $C_{29,33}$, 122.90: C_{31}, 122.86: C_3, 121.45: C_6, 119.49: C_{20}, 112.98: C_{18}, 70.93: C_{39}, 21.66: C_{35}. DEPT ^{13}CNMR (101 MHz, $CDCl_3$) δ; 155.97: C_{40}, 132.22: $C_{30,32}$, 128.86: $C_{24,26}$, 128.23: $C_{11,15}$, 127.75: C_{25}, 127.42: $C_{23,27}$, 125.32: C_2, 123.91: C_{17}, 123.50: $C_{12,14}$, 123.45: C_{31}, 122.98: $C_{29,33}$, 122.90: C_{31}, 122.86: C_3, 121.45: C_6,112.98: C_{18}, 70.93: C_{39}, 21.66: C_{35}.

-1-(2-(benzyloxy)-5-((E)-(4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(2-ethoxyphenyl)methanimine (e):

$C_{36}H_{30}N_4O_2S$, percentage yield 80 %, melting point (171-172 ºC). IR (cm^{-1}): str. 1616 (-CH=N-), 1591 (C=C), 1485 (N=N), 1249 (C-O).

-1-(2-(benzyloxy)-5-((E)-(4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(2-chloro-4-methylphenyl)methanimine (f):

$C_{35}H_{27}N_4OSCl$, percentage yield 77 %, melting point (206-207 ºC). IR (cm^{-1}): str. 1620 (-CH=N-), 1593 (C=C), 1485 (N=N), 1257 (C-O).

-1-(2-(benzyloxy)-5-((E)-(4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(2-methoxyphenyl)methanimine (g):

$C_{35}H_{28}N_4O_2S$, percentage yield 81 %, melting point (173-174 ºC). IR (cm^{-1}): str. 1618 (-CH=N-), 1593 (C=C), 1487 (N=N), 1247 (C-O).

-1-(2-(benzyloxy)-5-((E)-(4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-N-(m-tolyl)methanimine (h):

$C_{35}H_{28}N_4OS$, percentage yield 79 %, melting point (188-189 ºC). IR (cm^{-1}): str. 1623 (-CH=N-), 1602 (C=C), 1483 (N=N), 1261 (C-O).

2.5. Synthesis of 4-thiozolidinone

2.5.1. Stepwise method

Synthesis of 4-Thiazolidinones: (2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-substitutedphenylthiazolidin-4-one (4a-h):

According to the modified procedure (Patel et al., 2012), a mixture of imine (0.001 mole) and mercaptoacetic acid (0.0012 mole) in benzene (20 mL) was refluxed with stirring for (48 hr.). The solvent was evaporated by using rotary evaporator. The remained solid compound was neutralized by adding cold saturated sodium bicarbonate and allowed to stand overnight. The solid products were isolated by suction filtration, washed with water, dried and purified by recrystallization from xylene.

2.5.2. One pot technique

azo-thiazolidin-4-one (4a-e) was prepared by one pot three component reaction as follows: 1mmole of compound 2 was dissolved in 20mL xylene then added 1 mmole of (p-tolidine, p-

anisidine, p-phenetidine, p-bromo aniline, o-phenetidine) and 1.2 mmole of mercaptoacetic acid in R.B.F (50 ml). The mixture was refluxed for (15-20 hr.) and processed as in the method 2.5.1

(-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(4-methoxyphenyl)thiazolidin-4-one (4a) :

$C_{37}H_{30}N_4O_3S_2$, percentage yield method 2.5.1 93 % and method 2.5.2 96 %, melting point (193-194 ºC). IR (cm^{-1}): str. 1689.64 (C=O), 1602 (C=C), 1510 (C=N), 1249 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.54 (CH_3-Ar, s), 3.76 (OCH_3, s), 4.25 (CH_2, thiazolidine-4-one, dd), 5.23 (OCH_2, s), 6.47 (1H, CH thiazolidine-4-one, s,), 6.85 (2H-Ar, d, $C_{35,37}$),7.02 (1H-Ar, d, C_{18}), 7.06 (2H-Ar, d, $C_{24,28}$), 7.23 (1H-Ar, d, C_2), 7.36 (1H-Ar, t, C_{26}), 7.42 (2H-Ar, t, $C_{25,27}$), 7.46 (2H-Ar, d, $C_{34,38}$), 7.61 (1H-Ar, s, C_6), 7.75 (1H-Ar, s, C_{21}), 7.90 (1H-Ar, d, C_3), 7.92 (1H-Ar, d, C_{17}), 8.01 (2H-Ar, d, $C_{11,15}$), 8.23 (2H-Ar, d, $C_{12,14}$). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 171.55: C_{30}, 165.96: C_8, 160.72: C_{19}, 158.32: C_{36}, 153.69: C_{13}, 152.33: C_4, 146.76: C_{10}, 143.83: C_{16}, 135.78: C_{23}, 135.69: C_{33}, 135.46: C_5, 135.43: C_1, 128.86: $C_{25,27}$, 128.55: $C_{11,15}$, 128.22: C_{26}, 127.57: $C_{24,28}$, 126.86: C_2, 126.41: C_{21}, 125.51: $C_{12,14}$, 123.39: $C_{34,38}$, 122.90: C_{17}, 121.92: C_3, 121.45: C_6, 120.44: C_{20}, 114.49: $C_{35,37}$, 112.49: C_{18}, 70.87: C_{44}, 55.39: C_{46}, 54.27: $C_{22,}$ 33.13: C_{31}, 21.65: $C_{40.}$ DEPT^{13}C NMR (101 MHz, $CDCl_3$) δ; 128.86: $C_{25,27}$, 128.55: $C_{11,15}$, 128.22: C_{26}, 127.57: $C_{24,28}$, 126.86: C_2, 126.41: C_{21}, 125.51: $C_{12,14}$, 123.39: $C_{34,38}$, 122.90: C_{17}, 121.92: C_3, 121.45: C_6, 114.49: $C_{35,37}$, 112.49: C_{18}, 70.87: C_{44}, 55.39: C_{46}, 54.27: $C_{22,}$ 33.13: C_{31}, 21.65: $C_{40.}$

(-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(p-tolyl)thiazolidin-4-one (4b) :

$C_{37}H_{30}N_4O_2S_2$, method 2.5.1 88 % and method 2.5.2 92 %, melting point (119-120 ºC). IR (cm^{-1}): str. 1689 (C=O), 1600 (C=C), 1512 (C=N), 1251 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.29 (CH_3-Ar, s, C_{13}), 2.55 (CH_3-Ar, s, benzothiazole), 3.8 (CH_2 thiazolidin-4-one, dd), 5.23 (OCH_2, dd), 6.51 (1H, CH thiazolidine-4-one, s, C_2), 7.02 (1H-Ar, d, C_{16}), 7.08 (2H-Ar, d, $C_{11,12}$), 7.14 (2H-Ar, d, $C_{8,10}$), 7.23 (1H-Ar, d, C_{35}), 7.35 (1H-Ar, t, C_{43}), 7.45 (1H-Ar, t, $C_{42,44}$), 7.63 (2H-Ar, d, $C_{41,45}$), 7.75 (1H-Ar, s, C_{33}), 7.83 (1H-Ar, d, C_{17}), 7.9 (1H-Ar, d, C_{36}), 8.02 (2H-Ar, d, $C_{24,26}$), 8.24 (2H-Ar, d, $C_{23,27}$), 8.6 (1H-Ar, s, C_{19}) . ^{13}CNMR (101 MHz, $CDCl_3$) δ; 171.51: C_4, 165.98: C_{29}, 160.72: C_{15}, 153.71: C_{22}, 152.18: C_{31}, 146.80: C_{18}, 144.62: C_{25}, 140.10: $C_{7,}$ 136.90: C_9, 135.81: C_{40}, 135.73: C_{32}, 135.41: C_{34}, 135.12: $C_{8,10}$,129.85: $C_{11,12}$, 128.86: $C_{42,44}$, 128.54: $C_{24,26}$, 128.23: C_{43}, 127.56: $C_{41,45}$, 125.39: C_{35}, 124.95: $C_{23,27}$,123.51: C_{19}, 123.39: C_{17}, 122.88: C_{36}, 121.45: C_{33}, 113.36: C_{14}, 112.48: C_{16}, 70.86: C_{39}, 56.83: C_2 33.18: C_5, 21.63: C_{13}, 21.03: C_{37}. DEPT^{13}CNMR (101 MHz, $CDCl_3$) δ; 135.12: $C_{8,10}$,129.85: $C_{11,12}$, 128.86: $C_{42,44}$, 128.54: $C_{24,26}$, 128.23: C_{43}, 127.56: $C_{41,45}$, 125.39: C_{35}, 124.95: $C_{23,27}$,123.51: C_{19}, 123.39: C_{17}, 122.88: C_{36}, 121.45: C_{33}, 112.48: C_{16}, 70.86: C_{39}, 66.51: C_2, 33.18: C_5, 21.63: C_{13}, 21.03: C_{37}.

2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(4-ethoxyphenyl)thiazolidin-4-one (4c) :

$C_{38}H_{32}N_4O_3S_2$, method 2.5.1 90 % and method 2.5.2 94 %, (melting point (113-114 ºC). IR (cm^{-1}): str. 1685.79 (C=O), 1602.85 (C=C), 1512 (C=N), 1249 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.54 (CH_3-Ar, s, C_{10}), 1.5 (3H,CH_3,t, C_{46}), 3.8 (CH2, thiazolidine-4-one, dd), 4.00 (2H-OCH_2, q, C_{47}), 5.23 (OCH_2, s, C_{44}), 6.47 (1H, CH thiazolidine-4-one, s, C_{23}), 6.84 (2H-Ar, d, $C_{36,38}$),7.02 (1H-Ar, d, C_{19}), 7.05 (2H-Ar, d, $C_{25,29}$), 7.24 (1H-Ar, d, C_2), 7.35 (1H-Ar, t, C_{27}), 7.41 (2H-Ar, t, $C_{26,28}$), 7.45 (2H-Ar, d, $C_{35,39}$), 7.63 (1H-Ar, s, C_6), 7.76 (1H-Ar, s, C_{22}), 7.91 (1H-Ar, d, C_3), 7.93 (1H-Ar, d, C_{18}), 8.00 (2H-Ar, d, $C_{12,16}$), 8.22 (2H-Ar, d, $C_{13,15}$). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 171.58: C_{31}, 165.95: C_8, 160.66: C_{20}, 157.75: C_{37}, 153.78: C_{14}, 152.36: C_4, 147.02: C_{11}, 146.64: C_{17}, 135.78: C_{24}, 135.72: C_5, 135.44: C_1, 129.93: C_{34}, 128.85: $C_{26,28}$, 128.58: $C_{12,16}$, 128.21: C_{27}, 127.30: $C_{25,29}$, 127.04: C_2, 126.52: C_{22}, 126.04: $C_{13,15}$, 123.41: $C_{35,39}$, 122.89: C_{18}, 121.82: C_3, 121.45: C_6, 121.24: C_{21}, 114.94: $C_{36,38}$, 112.16: C_{19}, 70.85: C_{44}, 63.70: C_{47}, 54.09: C_{23}, 33.24:C_{32} 21.65: C_{10}, 14.92: $C_{46.}$ DEPT^{13}CNMR (101 MHz, $CDCl_3$) δ; 128.85: $C_{26,28}$, 128.58: $C_{12,16}$, 128.21: C_{27}, 127.30: $C_{25,29}$,

127.04: C_2, 126.52: C_{22}, 126.04: $C_{13,15}$, 123.41: $C_{35,39}$, 122.89: C_{18}, 121.82: C_3, 121.45: C_6, 114.94: $C_{36,38}$, 112.16: C_{19}, 70.85: C_{44}, 63.70: C_{47}, 54.09: C_{23}, 33.24:C_{32} 21.65: C_{10}, 14.92: C_{46}.

(-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(4-bromophenyl)thiazolidin-4-one (4d):

$C_{36}H_{27}N_4O_2S_2Br$, method 2.5.1 86 % and method 2.5.2 87 %, melting point (101-102 ºC). IR (cm^{-1}): str. 1691 (C=O), 1598 (C=C), 1489 (C=N), 1251 (C-O). ^{1}H NMR (400 MHz, DMSO-d_6); 2.51 (CH_3-Ar, s), 3.85 (CH_2, thiazolidine-4-one, dd), 5.24 (OCH_2, s), 6.47 (1H, CH thiazolidine-4one, s, C_{22}), 6.99 (2H-Ar, d, $C_{24,28}$), 7.12 (1H-Ar, d, C_{18}), 7.24 (1H-Ar, d, C_2), 7.37 (1H-Ar, t, C_{26}), 7.44 (2H-Ar, t, $C_{25,27}$), 7.65 (1H-Ar, s, C_6), 7.78 (1H-Ar, s, C_{21}), 7.95 (1H-Ar, d, C_{17}), 8.02 (1H-Ar, d, C_3), 8.09 (2H-Ar, d, $C_{12,14}$), 8.12 (2H-Ar, d, $C_{11,15}$), 8.15 (2H-Ar, d, $C_{35,37}$), 8.23 (2H-Ar, d, $C_{34,38}$). ^{13}CNMR (101 MHz, $CDCl_3$) δ; 171.43: C_{30}, 165.91: C_8, 158.06: C_{19}, 153.63: C_4, 152.36: C_{13}, 146.83: C_{10}, 137.81: C_{16},136.83: C_{33}, 135.80: C_{23}, 135.60: C_5, 135.44: C_1, 132.27: $C_{34,38}$, 129.92: $C_{35,37}$, 128.92: $C_{25,27}$, 128.90: $C_{11,15}$, 128.66: C_{26}, 128.21: $C_{24,28}$, 127.64: C_2, 126.15: C_{21}, 126.04: $C_{12,14}$, 125.48: C_{17}, 123.41: C_{36}, 122.91: C_3, 121.45: C_6, 120.23: C_{20}, 112.64: C_{18}, 70.97: C_{45}, 59.82: C_{22}, 33.18: C_{31}, 21.65: C_{41}. DEPT ^{13}C NMR (101 MHz, $CDCl_3$) δ; 132.27: $C_{34,38}$, 129.92: $C_{35,37}$, 128.92: $C_{25,27}$, 128.90: $C_{11,15}$, 128.66: C_{26}, 128.21: $C_{24,28}$, 127.64: C_2, 126.15: C_{21}, 126.04: $C_{12,14}$, 125.48: C_{17}, 122.91: C_3, 121.45: C_6, 120.23: C_{20}, 70.97: C_{45}, 59.82: C_{22}, 33.18: C_{31}, 21.65: C_{41}.

-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(2-ethoxyphenyl)thiazolidin-4-one (e):

$C_{36}H_{30}N_4O_2S$, method 2.5.1 86.5 % and method 2.5.2 89 %, melting point (124-125 ºC). IR (cm^{-1}): str. 1689 (C=O), 1598 (C=C), 1500 (C=N), 1253 (C-O)

-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(2-chloro-4-methylphenyl)thiazolidin-4-one (f):

$C_{35}H_{27}N_4OSCl$, percentage yield 87 %, melting point (96-97 ºC). IR (cm^{-1}): str. 1686 (C=O), 1602 (C=C), 1489 (C=N), 1253 (C-O).

-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(2-methoxyphenyl)thiazolidin-4-one (g):

$C_{35}H_{28}N_4O_2S$, percentage yield 89 %, melting point (110-111 ºC). IR (cm^{-1}): str. 1679 (C=O), 1598 (C=C), 1527 (C=N), 1253 (C-O).

-2-(2-(benzyloxy)-5-((4-(6-methylbenzo[d]thiazol-2-yl)phenyl)diazenyl)phenyl)-3-(m-tolyl)thiazolidin-4-one (h):

$C_{35}H_{28}N_4OS$, percentage yield 84 %, melting point (100-101 ºC). IR (cm^{-1}): str. 1685 (C=O), 1604 (C=C), 1487 (C=N), 1251 (C-O).

1.1. Antibacterial Activity

Antibacterial activities of the synthesized compounds in different concentrations (200, 400, 600, 800, and 1000 ppm in DMSO) were screened against two different type of bacteria *S. aureus* Gram-positive and *E. coli* Gram-negative bacteria using well diffusion method on Mueller-Hinton agar (MHA). The inhibition zones were reported in millimeters (mm). As controls, *S. aureus* (ATCC 25923) and *E. coli* (ATCC 25922) were employed. MHA agar plates were infected with the bacteria under aseptic circumstances, and 50 µL of the test samples were added to wells (diameter = 8 mm), which were then incubated at 37 °C for 24 hrs. The diameter of the growth inhibition zone was evaluated following the incubation time. Ciprofloxacin was a commonly prescribed medication for its antibacterial effects.

3. RESULTS AND DISCUSSION

The target compounds (4a-h) were prepared by two methods stepwise and one pot three component technique. The reaction begins by formation of imine (3a-h) from the reaction of azo-benzyloxy benzaldehyde (2) with substituted amines then followed by reaction with

mercaptoacetic acid as shown in Scheme (1). The structure of the synthesized compounds were confirmed by spectroscopic techniques FT-IR, ^{1}H-NMR, ^{13}C-NMR and DEPT-135).

The IR spectrum of azo compound have a strong absorption band of carbonyl group at 1651.07 cm^{-1} due to the present of intramolecular hydrogen bond between carbonyl group and hydroxy group the absorption band of hydroxy group not appeared at 3200-3400 cm^{-1}. The ^{1}H-NMR spectrum of the azo compound shows a signal at 10.08 ppm for (CHO), signal at 11.41ppm for hydroxy group, signal at 2.53 ppm for methyl group (CH_3-Ar) (Figure 1). ^{13}C-NMR showed the present of nineteen signals for nineteen different types of carbon atoms. Signal at 196.57 ppm for (CHO), 164.1344 ppm for hydroxy group, and 21.6579 ppm for methyl group and the rest of 14 signals belong to aromatic carbons as described in experimental part. ^{13}C-Dept spectrum show 9 signals for protonated carbons of (CH, CH_2, CH_3), so signals of (-CH_3 and -CH-) groups pointed upwards (+) while signals of (-CH_2-) group pointed downwards (-). The spectrum shows that all 9 signals pointed upwards (+) the signal at 21.67 ppm (CH_3-Ar, C_{10}), signal at 196.58 ppm for (CHO, C_{26}), the remains 7 signals is the signal of CH of aromatic.

The IR spectra of benzyloxy compound has a significant shift of carbonyl group to higher wave number than the azo compound approximately 1687.71 cm^{-1}. The ^{1}H-NMRspectra of benzyloxy shows deshielding of carbonyl group of aldehydes from 10.08ppm to 10.61ppm and the signal of hydroxyl group disappeared in 11.41 ppm due to reaction of hydroxyl group with benzyl bromide instead of the singlet peak of (-O-CH_2) was appeared at 5.31 ppm and singlet peak at 71.01 ppm in. (Figure 2). ^{13}C-NMR spectrum and shift of carbonyl group to 189.2263 ppm are further supports for occurring benzylation process. In ^{13}C-Dept spectrum include 13 signals. Signal at 21.66 ppm for (CH_3-Ar), appeared signal at 71.00 ppm for (OCH_2) pointed to downward (-), signal of aldehyde shifted two lower energy 189.22 ppm other remaining signals pointed to upward were the CH of aromatic.

The IR spectra of Schiff base derivatives show disappearance of the absorption band of carbonyl group at 1687.71 cm^{-1} and appearance of the absorption band of imine group (-N=CH-) around 1620 cm^{-1} also the ^{1}H-NMR spectra confirm the reaction by vanish a peak of (CHO) group at 10.61ppm and show the singlet peak of imine (-N=CH-) at 9.04 ppm. compounds 3a and 3b show signals at (3.87, 2.41) of three protons belong to methoxy and methyl groups attaching $C_{35,36}$ and compound 3c (Figure.3) shows a distinct two peaks, a triplet at (1.45) and quartet at (4.09) for CH_3 andCH_2 in side chain (OCH_2CH_3) respectively. ^{13}C-NMR spectra show peak of imine group at 154 ppm and vanish peak of carbonyl group at 189.2263 ppm (Figure 5) According to ^{13}C-Dept, present 18 signals two signal pointed to upward at (14.93 ppm, 21.67 ppm) belongs to (CH3, C_{42}) and (CH_3, C_{34}) respectively, two signal pointed to downward refer to two protons of CH_2 of benzyloxy at 70.81 ppm and CH_2 of ethyl group at 63.69 ppm, signal at 154 ppm belong to the proton of imine and all remaining signal pointed to upward belongs to protons of (CH-Ar) as the shown in experimental data .

The synthesis of thiazolidine-4-one derivatives were confirmed by disappearance absorption band of (-CH=N-) around 1620 cm^{-1} and appearance absorption band of carbonyl of thiazolidi-4-none around 1672-1685 cm^{-1} in IR spectroscopy. While the ^{1}H-NMR show doublet of doublet for (CH_2) of thiazolidine-4-one around 4 ppm and CH of thiazolidine-4-one at 6.47 ppm were appeared in 4c the CH_2 of thiazolidine-4-one is multiplet with total of protons CH2 of thiazolidine-4-one and methyl OCH_2. 3.8 (CH_2, thiazolidine-4-one, dd), 4.00 (2H-OCH_2, q, C_{47}) (Figure.4), In the ^{13}C NMR spectrum of the thiazolidine-4-one ring, there are two distinct picks for two carbons of CH_2 and CH of thiazolidine-4-one approximately around (33-40 ppm) and (54-64 ppm) and peak of carbonyl at 171 ppm compound 4c show are two distinct picks for two carbons of CH_2 and CH of thiazolidine-4-one (C_{32} and C_{23}) approximately at (33.24 ppm) and (54 ppm) and peak of carbonyl at 171 ppm (Fig. 6). In the ^{13}C-Dept show the signal of (CH_2) of thiazolidine-4-one at (33-40 ppm) and peak of (CH) of thiazolidine-4-one around (54-64 ppm) (Figure. 7).

The antibacterial activities of these compounds were evaluated by the well diffusion assay against *S. aureus* Gram-positive and *E. coli* Gram-negative bacteria at 37 ºC for 24 hrs. The results showed that the synthesized compounds are better

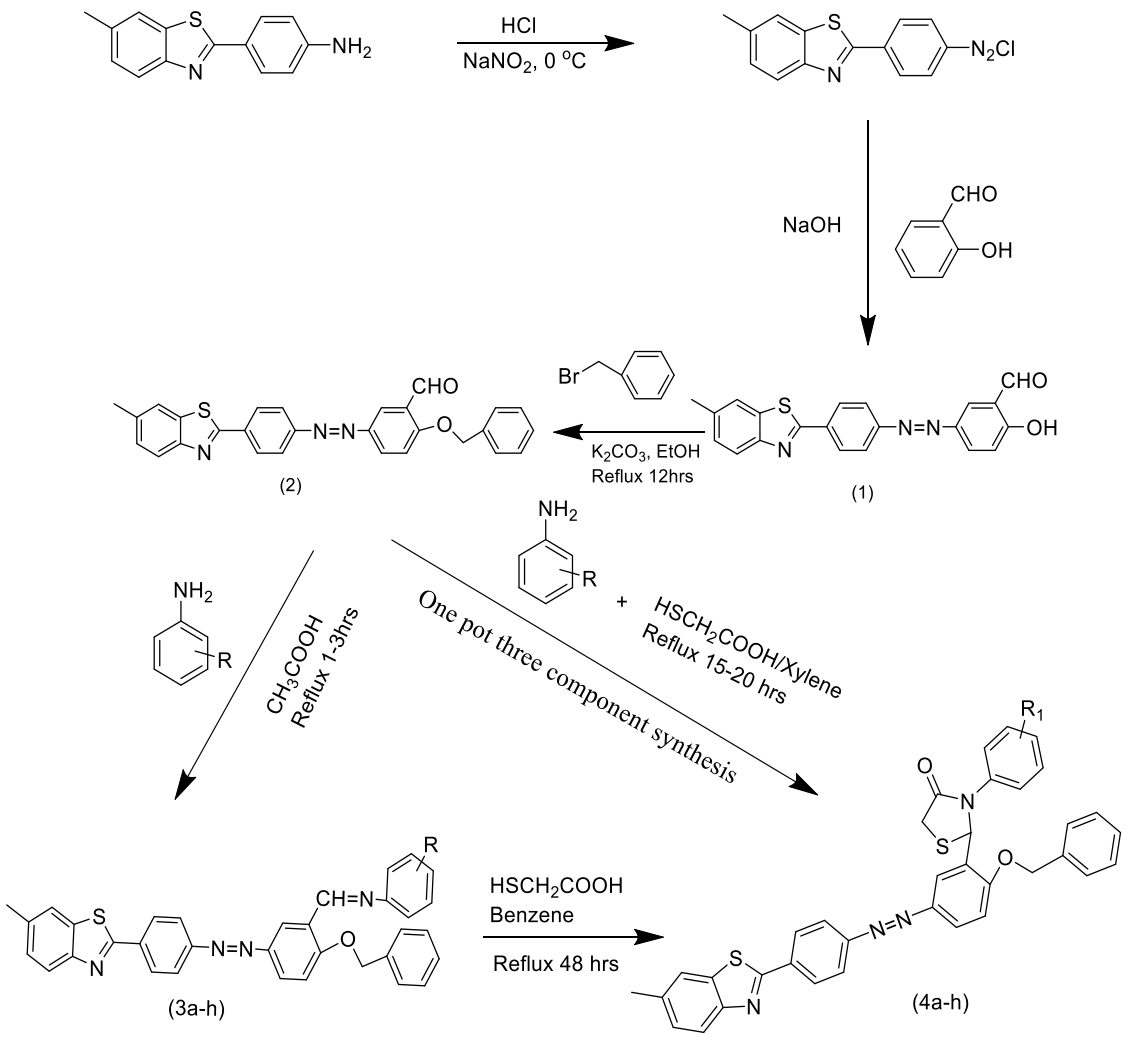
in inhibiting the growth of *E. coli* Gram-negative bacteria as compared to against *S. aureus* Gram-positive as shown in Table 1, 2 and (Figure. 8).

Table 1: Antibacterial activity of some prepared with inhibition zone diameters in (mm) scale against *E. coli* as gram negative.

concentration	200 ppm	400 ppm	600 ppm	800 ppm	1000 ppm
1	21	22	23	24.5	28
2	17	21	16	22	16.5
3a	21	116.5	15	16	14
3b	16	15	18	19	20
3c	21	19	27	14	26
3d	16	17	23	13	20
3h	16	17	16.5	17.5	25
4a	19	14	15	15	15.5
4b	17	15	15.5	15	14.5
4c	19	16	15	15.5	14.5
4d	16	21	17.5	17	15
4h	18	17.5	22	26	25

Table 2: Antibacterial activity of some prepared with inhibition zone diameters in (mm) scale against S. aureus as gram positive.

concentration	200 ppm	400 ppm	600 ppm	800 ppm	1000 ppm
1	18	19	20	19.5	21
2	16	Zero	14	Zero	Zero
3a	Zero	Zero	16	Zero	Zero
3b	19.5	Zero	Zero	Zero	22
3c	Zero	Zero	23	14	Zero
3d	16	17	23	13	20
3h	21	Zero	Zero	Zero	23
4a	17	Zero	15	Zero	Zero
4b	14	Zero	Zero	Zero	Zero
4c	22	18	19	23	25
4d	13	20	22	17	25
4h	18.5	19	18	16	26



R1= 4-OCH_3,, 4-CH_3, 4-OCH_2CH_3, 4-Br, 2-OC_2H_5, 2-Cl, 4-CH_3, 2-OCH_3, 3-CH_3

Scheme 1. Synthesis route of thiazolidine-4-one derivatives (4a-h)

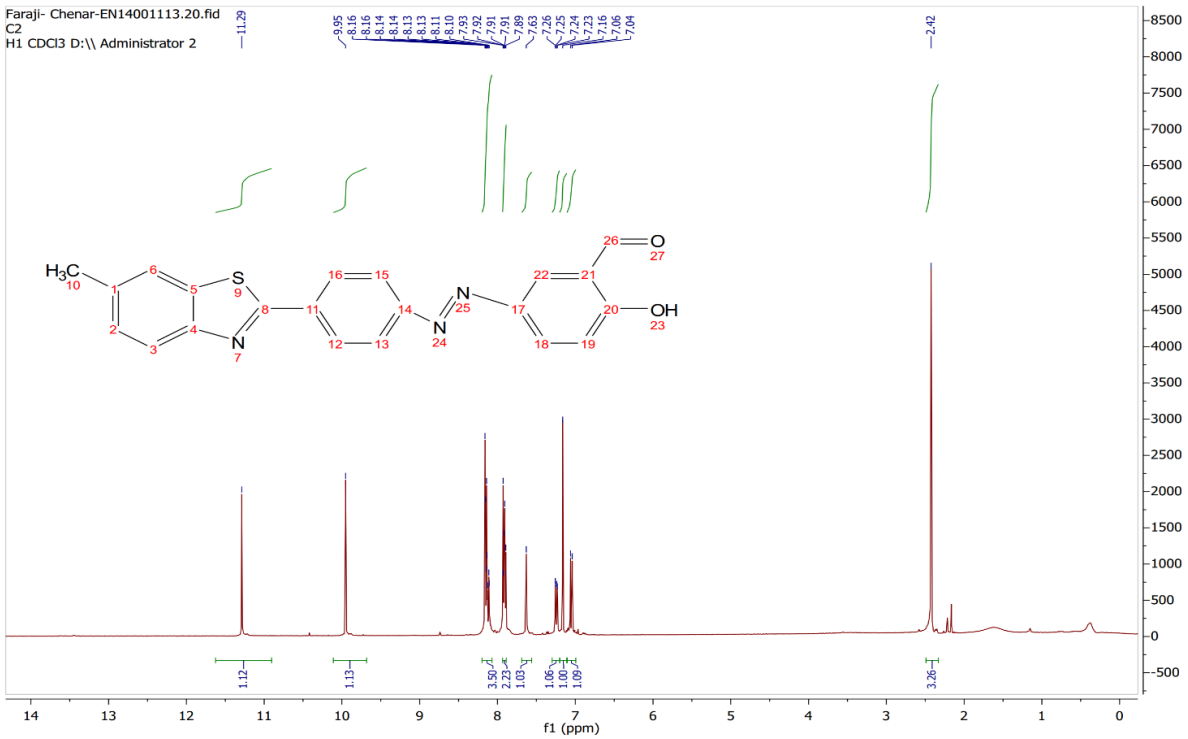


Figure (1): ^{1}H-NMR of compounds (1).

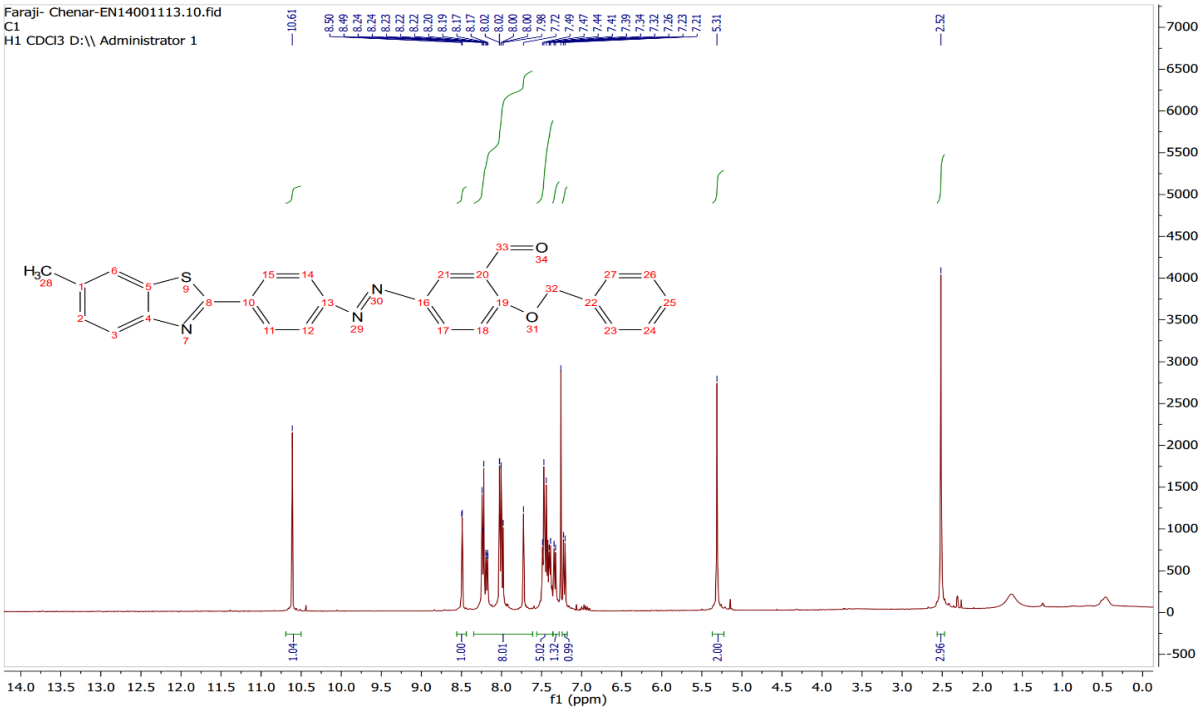


Figure (2): ^{1}H-NMR of compounds (2).

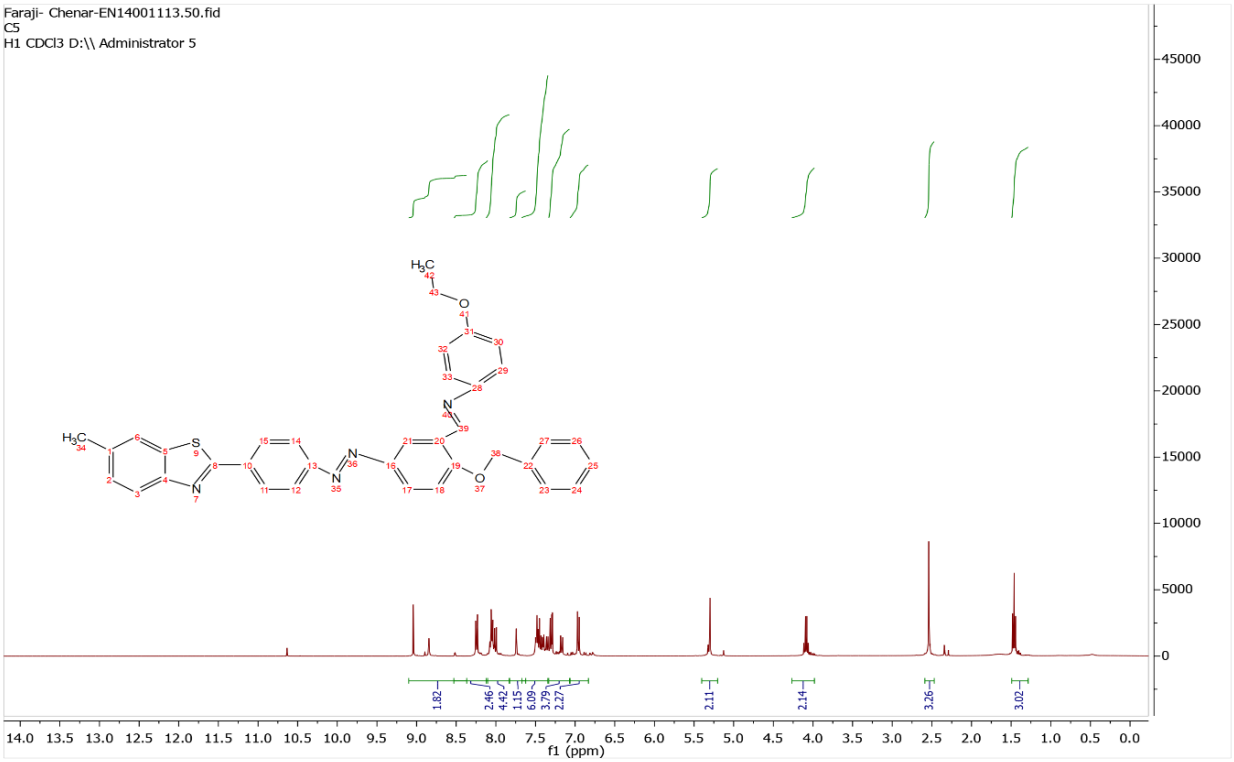


Figure (3): ^{1}H-NMR of compounds (3c).

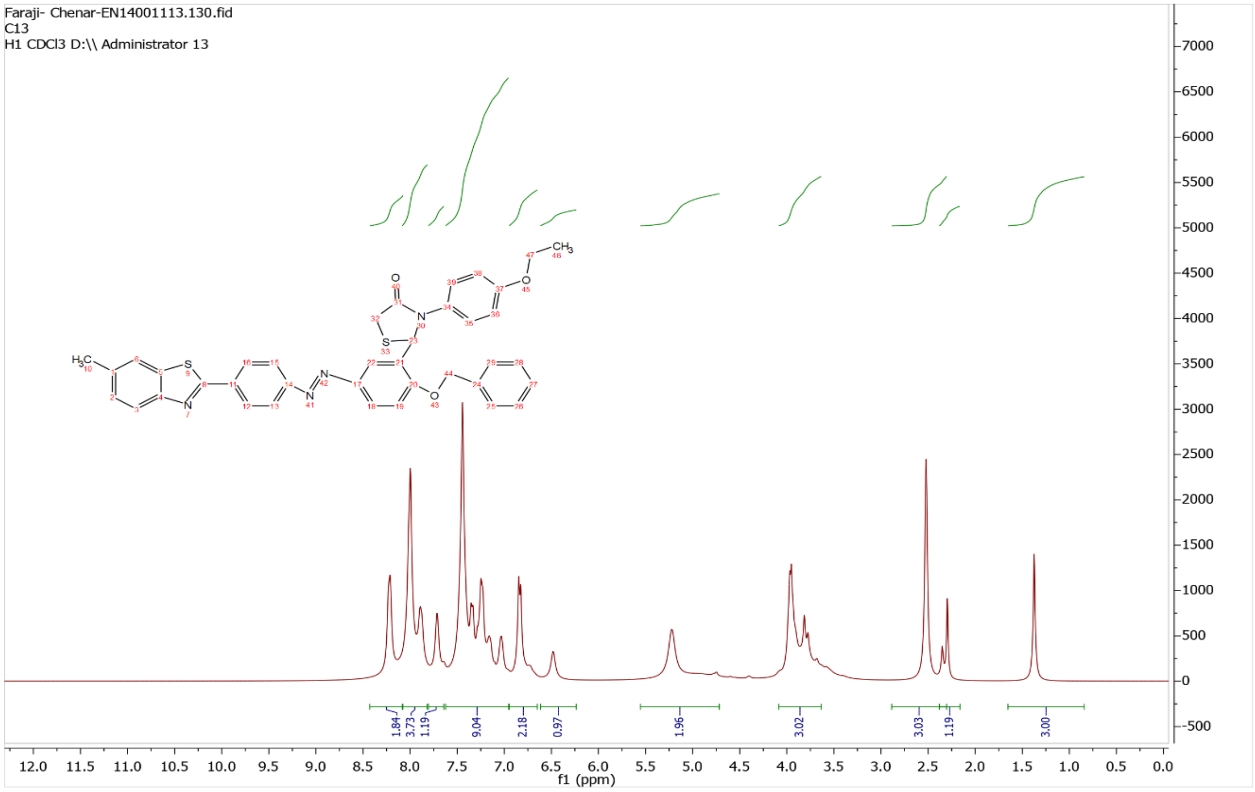


Figure (4): ^{1}H-NMR of compounds (4c).

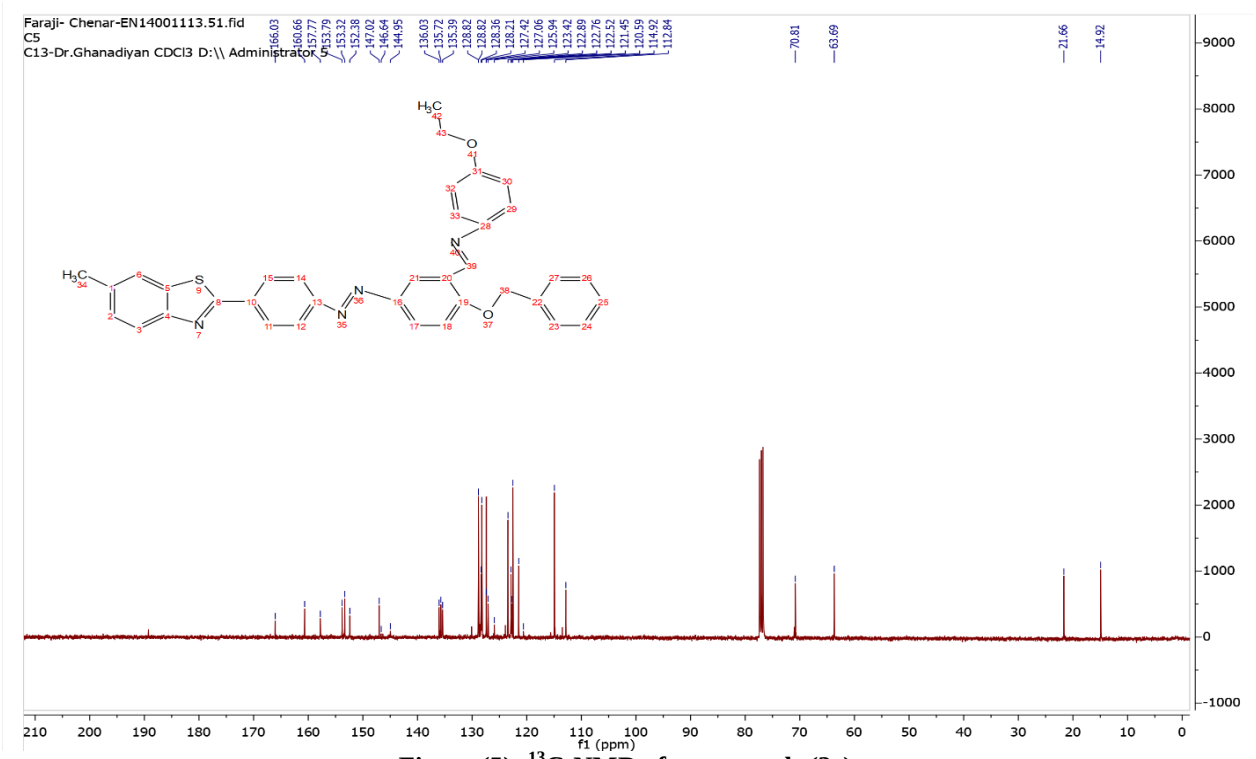


Figure (5): ^{13}C-NMR of compounds (3c).

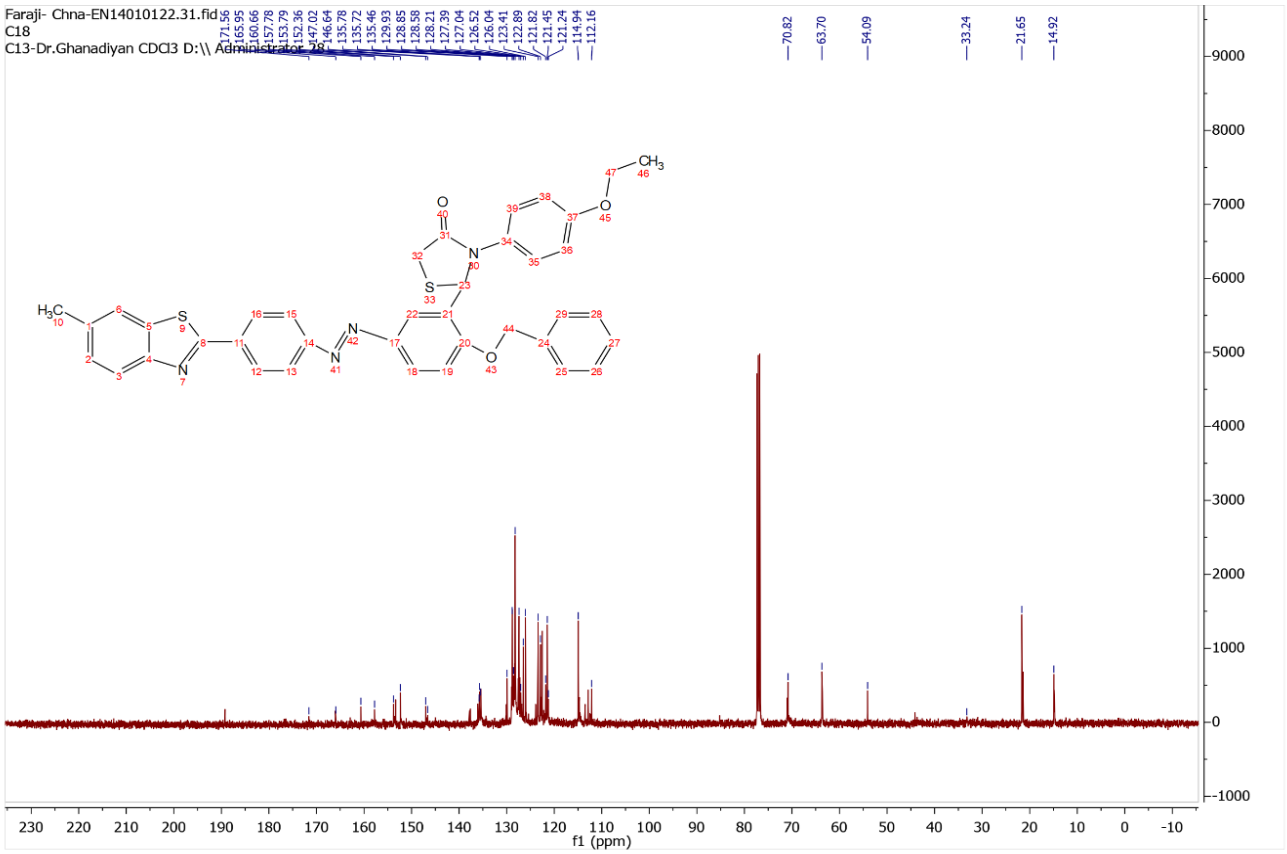


Figure (6): ^{13}C-NMR of compounds (4c).

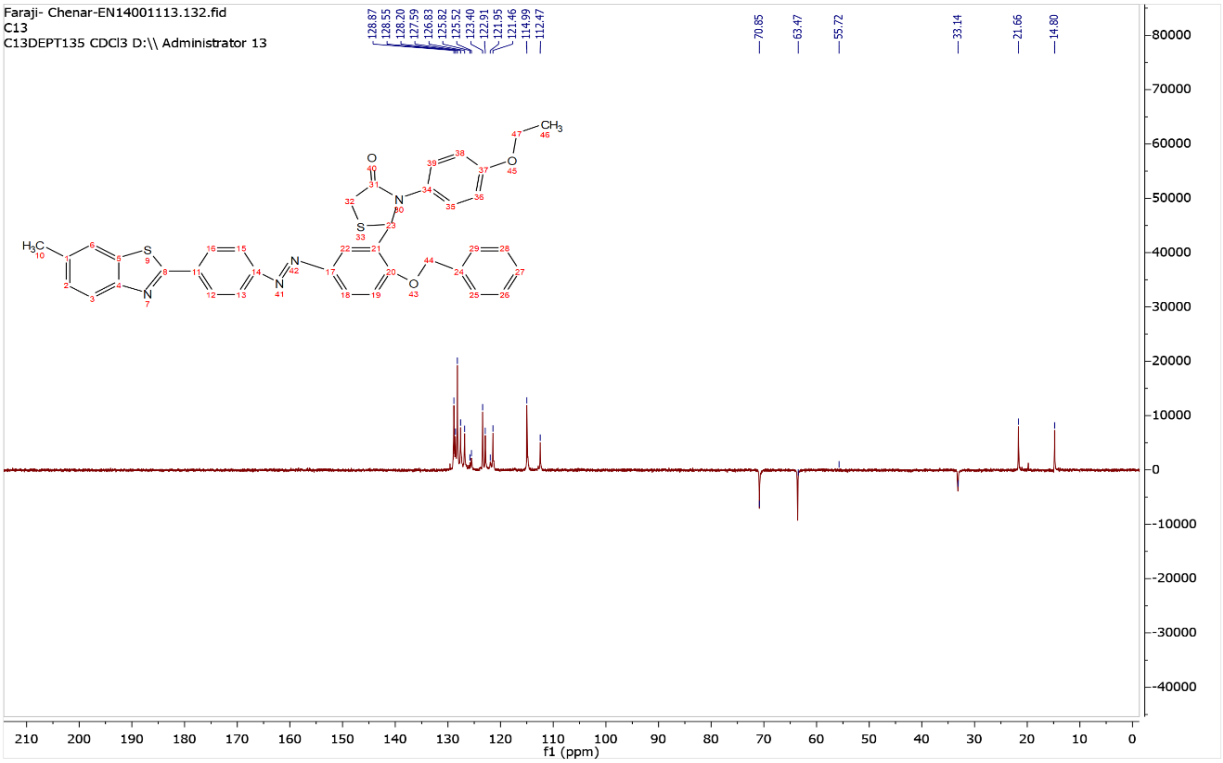


Figure (7): ^{13}C-Dept of compounds (4c).

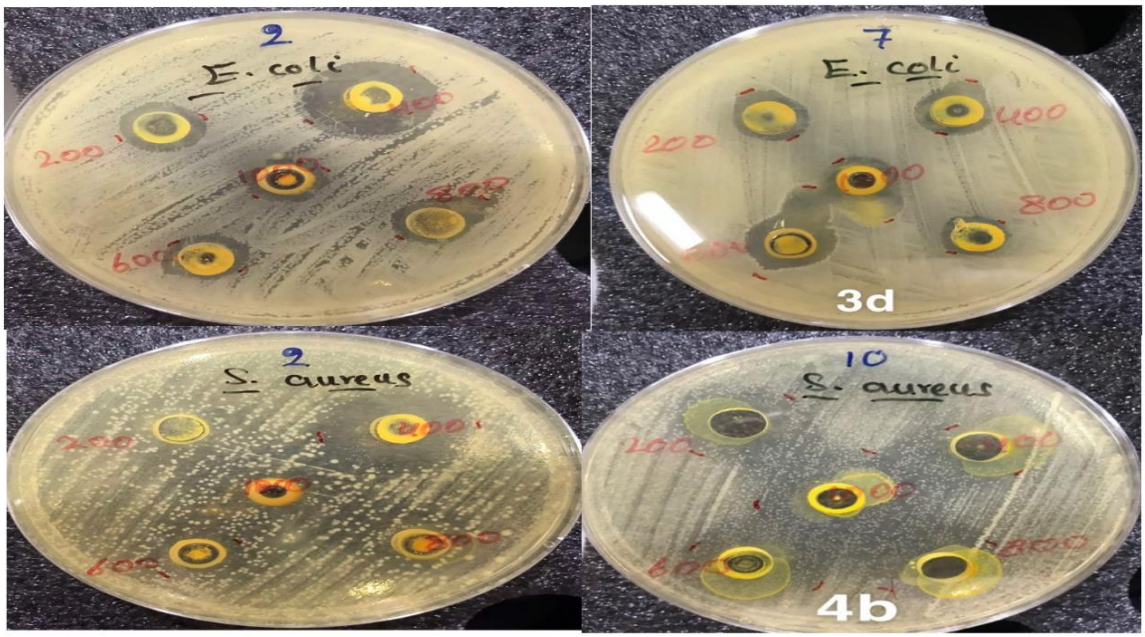


Figure 8: Inhibition zone of solution of some synthesized compounds on E. coli and S.aureus.

4. CONCLUSIONS

Based on the results from this study, one-pot multi-component synthesis is extremely useful for the synthesis of thiazolidine-4-one derivatives since it is less time consuming, less costly, less wasteful, more yielding, and more accurate than other methods. A biological screening study performed in vitro revealed that certain newly synthesized compounds are more active against gram negative, *S. Aureus* than gram positive *E. coli*.

References

ALMASIRAD, A., GHADIMI, M., MIRAHMADI, S., AHMADIAN KODAKAN, P., JAHANI, R., NAZARI, M., REZAEE, E.,AZIZIAN, H., RABIZADEH, P., TABATABAI, S.A. AND FAIZI, M., 2022. Design, synthesis, and preliminary pharmacological evaluation of novel thiazolidinone derivatives as potential benzodiazepine agonists. Molecular Diversity, 26(2), pp.769-780.

AYOOB, M.M., HAWAIZ, F.E., HUSSEIN, A., SAMAD, M.K., HUSSAIN, F. AND MOHAMED, S.K., 2020. Synthesis, Spectroscopic Investigation, Anti-Bacterial and Antioxidant Activites of Some New Azo-Benzofuran Derivatives. Egyptian Journal of Chemistry, 63(7), pp.2617-2629.

AYOOB, MZGIN MOHAMMED; HAWAIZ, FAROUQ EMAM (2017). AIP Conference Proceedings [Author(S) 6th International Conference And Workshops On Basic And Applied Sciences - Erbil, Kurdistan, Iraq (18–19 March 2017)] - Design, Synthesis, And Spectroscopic Study Of Some New Flavones Containing Two Azo Linkages. , 1888(), 020017–.

BROWN, F.C., 1961. 4-Thiazolidinones. Chemical Reviews, 61(5), pp.463-521.

DESAI, N.C., JADEJA, K.A., JADEJA, D.J., KHEDKAR, V.M. AND JHA, P.C., 2021. Design, synthesis, antimicrobial evaluation, and molecular docking study of some 4-thiazolidinone derivatives containing pyridine and quinazoline moiety. Synthetic Communications, 51(6), pp.952-963.

BEKTAŞ, H., CEYLAN, Ş., DEMIRBAŞ, N., ALPAY-KARAOĞLU, Ş. AND SÖKMEN, B.B., 2013. Antimicrobial and antiurease activities of newly synthesized morpholine derivatives containing an azole nucleus. Medicinal Chemistry Research, 22(8), pp.3629-3639.

HOLOTA, S., KRYSHCHYSHYN, A., DERKACH, H., TRUFIN, Y., DEMCHUK, I., GZELLA, A., GRELLIER, P. AND LESYK, R., 2019. Synthesis of 5-enamine-4-thiazolidinone derivatives with trypanocidal and anticancer activity. Bioorganic chemistry, 86, pp.126-136.

HUSSEIN, A.J., 2014. Synthesis and characterization of some new pyrazoline compounds derived from azo-benzaldehyde. ZANCO Journal of Pure and Applied Sciences, 27(1), pp.51-58.

HUSSEIN, AWAZ JAMIL; JALAL AZEEZ, HASHIM (2013). Synthesis and Antimicrobial Activity of Some New Thiazolidin-4-one Derivatives of 4-(6-methylbenzo[d]thiazol-2-yl)benzamine. Journal of Chemistry, 2013(), 1–6.

JAIN, A.K., VAIDYA, A., RAVICHANDRAN, V., KASHAW, S.K. AND AGRAWAL, R.K., 2012. Recent developments and biological activities of thiazolidinone derivatives: A review. Bioorganic & medicinal chemistry, 20(11), pp.3378-3395.

KERIM BABAOGLU; MARK A. PAGE; VICTORIA C. JONES; MICHAEL R. MCNEIL; CHANGJIANG DONG; JAMES H. NAISMITH; RICHARD E. LEE (2003). Novel inhibitors of an emerging target in Mycobacterium tuberculosis; substituted thiazolidinones as inhibitors of dTDP-rhamnose synthesis. , 13(19), 3227–3230.

MALIPEDDI, H., KARIGAR, A.A., MALIPEDDI, V.R. AND SIKARWAR, M.S., 2012. Synthesis and antitubercular activity of some novel thiazolidinone derivatives. Tropical Journal of Pharmaceutical Research, 11(4), pp.611-620.

MASHRAI, A., DAR, A. AND MIR, S., 2016. SHAMSUZZAMAN (2016). Strategies for the Synthesis of Thiazolidinone Heterocycles. Med. Chem. (Los Angeles), 6, pp.280-291.

NIRWAN, S., CHAHAL, V. AND KAKKAR, R., 2019. Thiazolidinones: Synthesis, reactivity, and their biological applications. Journal of Heterocyclic Chemistry, 56(4), pp.1239-1253.

OUBELLA, A., EL MANSOURI, A.E., FAWZI, M., BIMOUSSA, A., LAAMARI, Y., AUHMANI, A., MORJANI, H., ROBERT, A., RIAHI, A. AND ITTO, M.Y.A., 2021. Thiazolidinone-linked1, 2, 3-triazoles with monoterpenic skeleton as new potential anticancer agents: Design, synthesis and molecular docking studies. Bioorganic Chemistry, 115, p.105184.

PATEL, D., KUMARI, P. AND PATEL, N., 2012. Synthesis and biological evaluation of some thiazolidinones as antimicrobial agents. European journal of medicinal chemistry, 48, pp.354-362.

SINGH, SHIVA P.; PARMAR, SURENDRA S.; RAMAN, KRISHNA; STENBERG, VIRGIL I. (1981). Chemistry and biological activity of thiazolidinones., 81(2), 175–203.

TAHMASVAND, R., BAYAT, P., VAHDANIPARAST, S.M., DEHGHANI, S., KOOSHAFAR, Z., KHALEGHI, S., ALMASIRAD, A. AND SALIMI, M., 2020. Design and synthesis of novel 4-thiazolidinone derivatives with promising anti-breast cancer activity: Synthesis, characterization, in vitro and in vivo results. Bioorganic Chemistry, 104, p.104276.

VEERASAMY, R., RAJAK, H., SURESH KUMAR, K. AND KISHORE AGRAWAL, R., 2011. Synthesis and evaluation of antimicrobial activity of thiazolidinone derivatives. Letters in Drug Design & Discovery, 8(1), pp.82-86