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Synthesis and Characterization of Some Novel 4-Thiazolidinones and Isoxazolines Derived from Thiosemicarbazones

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Abstract A Novel compounds of 1,3-thiazolidine-4-ones and isoxazolines fused with thiazolidine ring have been synthesized from some thiosemicarbazones. The thiosemicarbazones were prepared by the reaction of thiosemicarbazide with diffrent aldehydes and ketones. A2-substituted-1,3-thiazolidine-4-oneswere synthesized by the reaction of thiosemicarbazones with chloroacetic acid in presence of anhydrous sodium acetate. The 4-thiazolidinones have a double bond at the position -5 of the 4-thiazolidinone ring. The double bond was inserted by the reaction of thiazolidinones with benzaldehyde in piperidine. Hydroxylamine hydrochloride was used to convert the later compounds to isoxazolines fused with thiazolidine ring. Furthermore, 4-thiazolidinones containing N-acetyl group were obtained by the reaction of 4-thiazolidinones with acetic anhydride. The structures of newly synthesized compounds were established on the basis of spectroscopy data.

Keywords 4-Thiazolidinone, FusedIsoxazoline, Amides, Thiosemicarbazone

1. Introduction

Many thiazolidinone and isoxazoline derivatives demonstrated a wide spectrum of biological activities [1-4]. These activities are include anti-bacterial, anti-fungi, anti-convalsant and anti-inflatmmatory. The 4-thiazolidinone class represent an important analogue to thiazolidine heterocyclic compounds [5]. Derivatives of 4-thiazolidinone were synthesized by various methods. However, aconventional method for such synthesis was frequently used. It is involve the cyclo-condensation reaction one-pot method was convenient for synthesis of 4-thiazolidinone. This method includes the reaction of enaminones with ethyl-2-bromopropionate [7]. A common synthetic path for construction of iminothiazolidinones is the cyclization of thiourea or thiosemicarbazide derivatives with halo-esters or thioglycolic acids in presence of inorganic base in polar solvents. The cyclization reaction was carried out by conventional [8-14] or microwave irradiation techniques [15-18]. The classical method for synthesisisoxazoline derivatives involves a base catalyzed condensation of chalcone with hydroxylamine hydrochloride between Schiff-bases and mercaptoacetic acid [6]. The in ethanol [19]. As a part of our interests towards developing novel heterocyclic compounds may be have useful biological activity, we plan to synthesis some new 4-thia -zolidinones and isoxazolines have significant structures derived from different thiosemicarbazides. Schemes (1) and (2).

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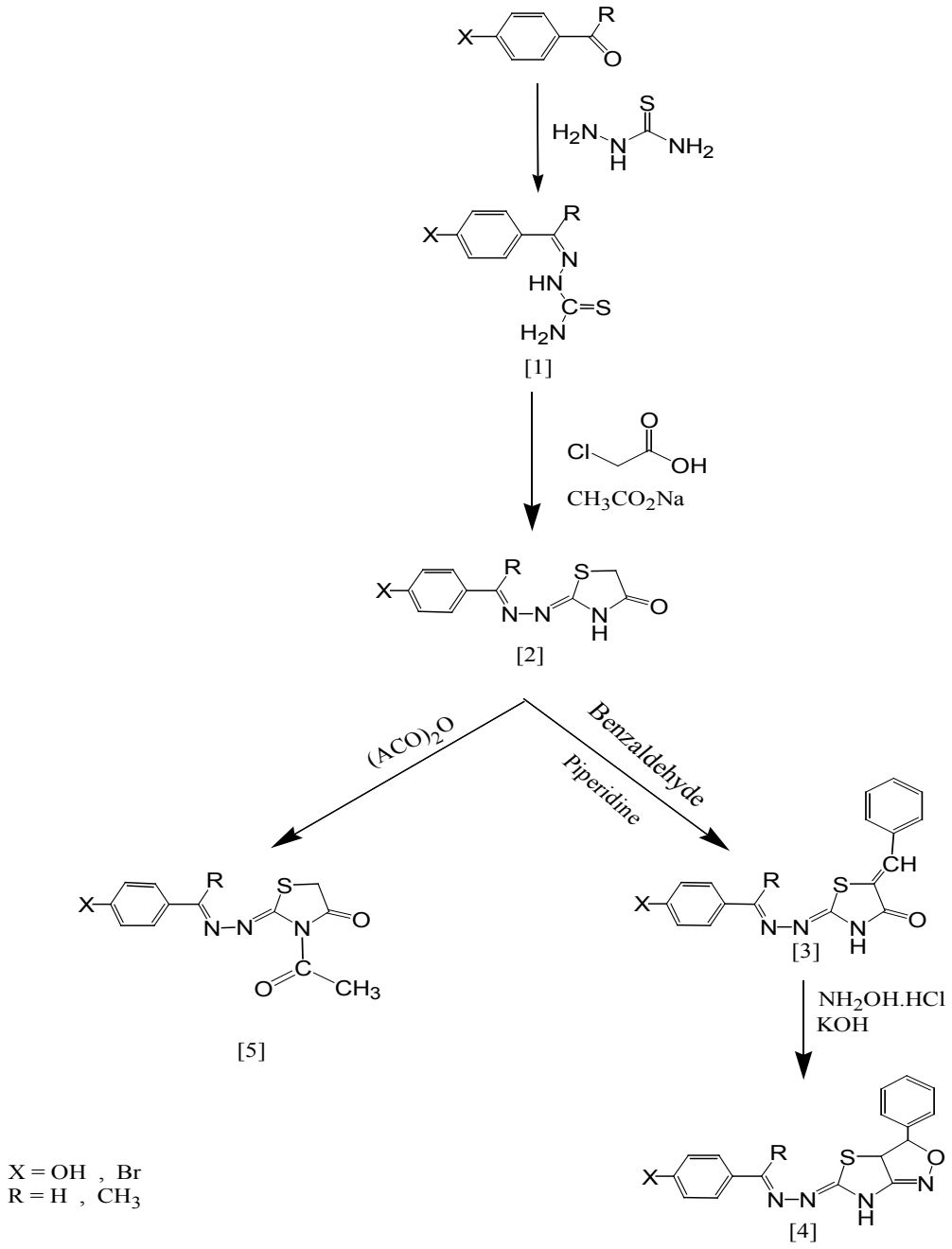
2. Experimental

2.1. Instruments

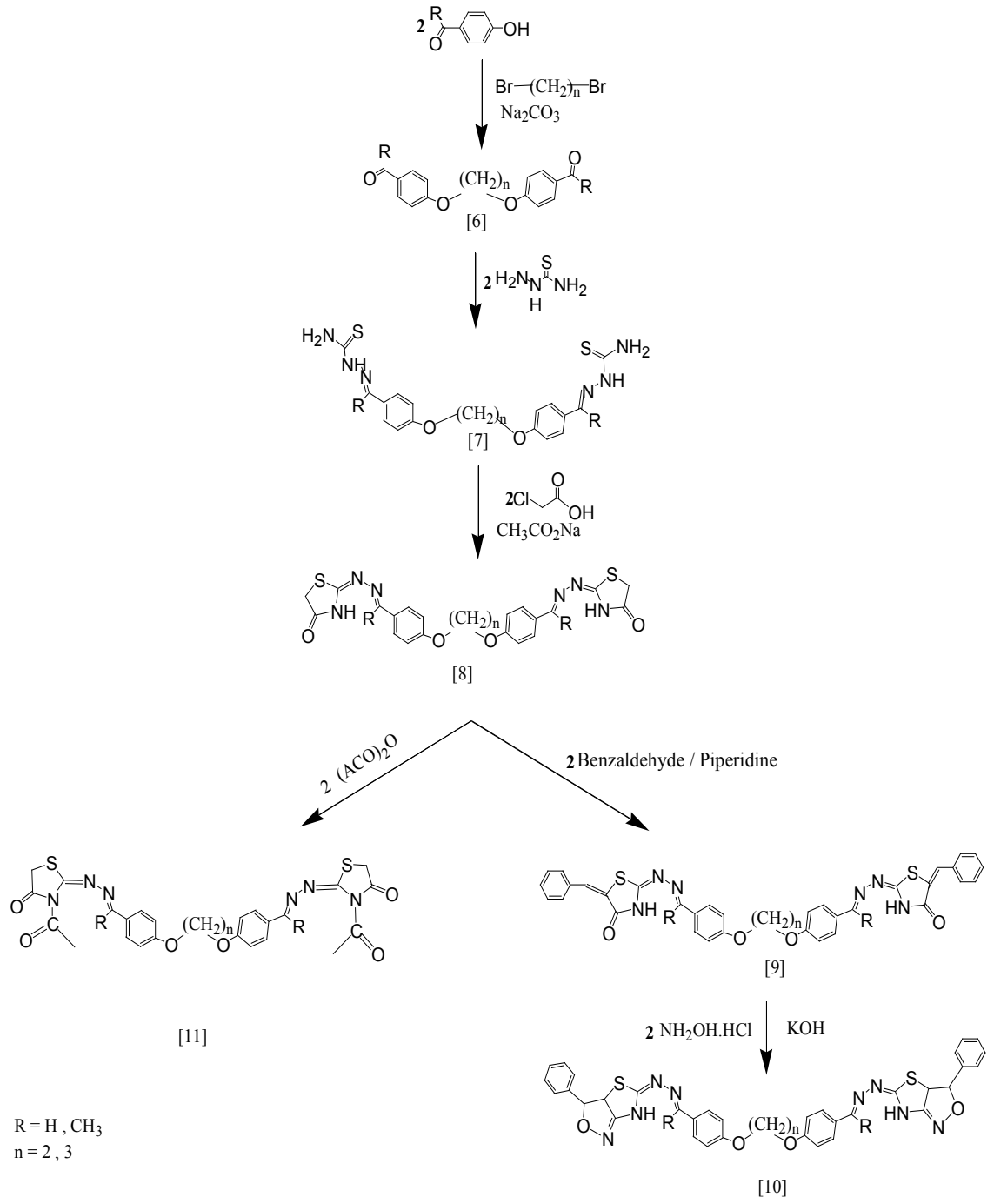
Melting points were recorded using SMP 30 melting point instrument (Stuart, Germany), and they are uncorrected. ^{1}HNMR spectra were recorded in DMSO-d_6 on Bruker (400 MH_Z) DMX-500 NMR spectrophotometer, at Al-albayt university, Jordan. The chemical shifts were recorded as values in ppm using tetramethylsilane (TMS) as internal standerd. FT-IR spectra were recorded as KBr discs on Shimadzu FT-IR 8400S spectrophotometer. All reactions and the purity of the synthesized compounds were monitored by using TLC (silica gel). The mass spectra were recorded on Shimadzu model GCMS QP 1000EX gas chromatography-MS apparatus (Japan) at the department of chemistry college of science, university of Al-Mustansiriya (Baghdad-Iraq).

2.2. General Procedures

All new heterocyclic derivatives were synthesized according to schemes (1) and (2).



Scheme (1). Synthetic route for target compounds [4] and [5]



Scheme (2). Synthetic route for target compounds [10] and [11]

2.2.1. Preparation of thiosemicarbazones $[1]_{a-d}$ [20]

Thio- semicarbazide (0.01mol) was added to a solution of 4-substitutedacetophenone (0.01mol) or 4-substituted-enzaldehyde(0.01mol) in absolute ethanol (20mL) and three drops of glacial acetic acid. The reactants were heated under reflux for 5 hrs .The product was cooled to room temperature and the solid was filtered, dried and recrystallized from ethyl acetate.

2.2.2. Synthesis of 2-(4-substituted-benzylidenehydrazono)-1,3-thiazolidine-4-one $[2]_{a-d}$

A mixture consists of thiosemicarbazone [1] (0.01mol) in absolute ethanol (10mL) containing chloroacetic acid (0.01mol) and fused sodium acetate (0.03mol) was refluxed for 6 hrs. The resulted product was poured onto ice-water (100mL) and the formed precipitate was filtered, washed with water, dried and recrystallized from ethanol.

2.2.3. Synthesis of (5-benzylidene)-2-(4-substituted-benzylidenehydrazono)-1,3-thiazolidine-4-one $[3]_{a-d}$

A mixture of compound [2] (0.01mol) and benzaldehyde(0.015mol) was fused in presence of piperidine(0.5 mL)

for 3 hrs. The crude product was cooled to room temperature, and poured onto ice- water. The separated solid was filtered, washed, dried and recrystallized from acetone. The physical data of compounds [1]a-d – [3]a-d are listed in Table (1).

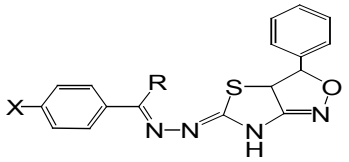
Table (1). Physical properties of compounds [1] to [3]

Comp. No.	X	R	Color	Yield %	m.p. C^0	Name
[1]a	Br	H	White	88	217-220	4-bromobenzaldehydethiosemicarbazone
[1]b	Br	CH_3	White	73	189-191	4-bromoacetophenonethiosemicarbazone
[1]c	OH	H	White	82	233-234	4-hydroxybenzaldehydethiosemicarbazone
[1]d	OH	CH_3	White	78	219-221	4-hydroxyacetophenonethiosemicarbazone
[2]a	Br	H	Brown	87	289-290	2-(4-bromodbenzylidenehydrazono)-1,3-thiazolidine-4-one
[2]b	Br	CH_3	Brown	79	198-200	2 [(4-bromobenzylidenehydrazono)-α-methyl-thiazolidine-4-one
[2]c	OH	H	Yellow	71	314-318	2-(4-hydroxybenzylidenehydrazono)-thiazolidine-4-one
[2]d	OH	CH_3	Yellow	67	254-256	2-(4-hydroxybenzylidenehydrazono)- α-methyl-thiazolidine-4-one
[3]a	Br	H	Orange	74	243-246	(5-benzylidene)-2-(4-bromobenzylidenehydrazono)-1,3-thiazolidine-4-one
[3]b	Br	CH_3	Yellow	65	210-213	(5-benzylidene)-2-(4-bromobenzylidenehydrazono)- α-methyl-thiazolidine-4-one
[3]c	OH	H	Yellow	76	112-115	(5-benzylidene)-2-(4-hydroxybenzylidenehydrazono)-1,3-thiazolidine-4-one
[3]d	OH	CH_3	Brown	72	177-181	(5-benzylidene)-2-(4-hydroxybenzylidenehydrazono)-α-methyl-thiazolidine-4-one

2.2.4. Synthesis of 2-(4-substitutedbenzylidenehydra- zono)-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazo -le $[4]_{a-d}$

A mixture of compound [3] (0.01mol), hydroxylamine hydrochloride(0.01mol) and potass -ium hydroxide(0.02 mol) in absolute ethanol (15mL) was heated under reflux for 16-18 hrs., (Monitored by TLC). The crude product was left to cooled to room temperature, then poured onto ice- water. The formed solid wasfiltered, washed with water, dried and recrystallized from ethanol. The physical properties of these compounds are listed in Table (2).

Table (2). Physical properties of compounds [4] a -c

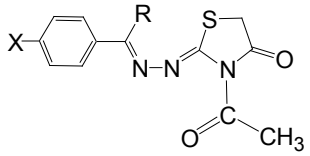


Comp. No.	X	R	Color	Yield %	m.p. C^0	Name
[4]a	Br	H	Yellow	56	282-284	2-(4-bromobenzylidenehydrazono)-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole
[4]b	Br	CH_3	Orange	54	160-163	2 [(4-bromobenzylidenehydrazono)- α-methyl]-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole
[4]c	OH	H	Orange	66	214-218	2-(4-hydroxybenzylidenehydrazono)-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole
[4]d	OH	CH_3	Brown	48	193-195	2 [(4-hydroxybenzylidenehydrazono)- α-methyl]-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole

2.2.5. Synthesis of 3-acetyl-2-(4-substitutedbenzyli- denehydrazono)-1,3-thiazolidine-4-one $[5]_{a-d}$

Asolution of compound [4] (0.001mol) in acetic anhydride (3mL) was heated under reflux for 4 hrs. The mixture was cooledtoroom temperature, then poured onto ice-water. The separated solid was filtered, washed with excess water, dried andrecrystallized from ethanol. The physical properties of these compounds are given in Table (3).

Table (3). Physical properties of compounds [**5] a–d**



Comp. No.	X	R	Color	Yield %	m.p. C^0	Name
[5]a	Br	H	Brown	78	200-204	3-acetyl- 2-(4-bromobenzylidenehydrazono)-1,3-thiazolidine-4-one
[5b	Br	CH_3	Orange	71	172-174	3-acetyl- 2 [(4-bromobenzylidenehydrazono)- α-methyl] -1,3-thiazolidine-4-one
[5]c	OH	H	Pale-yellow	84	184-187	3-acetyl- 2-(4-hydroxybenzylidenehydrazono)-1,3-thiazolidine-4-one
[5]d	OH	CH_3	Brown	68	164-168	3-acetyl- 2 [(4-hydroxybenzylidenehydrazono)- α-methyl] -1,3-thiazolidine-4-one

2.2.6. Synthesis of polymethylene-bis-4-oxybenzal-dehydes and polymethylene-bis-4-oxyacetophenones $[6]_{a-d}$

To a mixture of 4-hydroxylbenzaldehyde (0.02mol) or 4-hydroxyacetophenone (0.02mol) and 1,2-butane or 1,3-dibromopropane (0.01mol) in N,N-dimethylformamide (15mL), anhydrous sodium carbonate (0.025mol)was added. The mixture was heated under reflux with continuous stirring for 4hrs. The crude product was cooled to room temperature, then poured onto ice-cold water and left in therefrigerator overnight. The resulted solid was filtered, washed with water, and recrystallized from ethanol.

2.2.7. Synthesis of polymethylene-bis-4-oxyphenyl –thiosemicarbazons $[7]_{a-d}$

Thiosemicarbazide(0.02mol) was added to a solution of compound [6] (0.01 mol) in absolute ethanol (20mL). Afew drops of glacial acetic acid was added and the reactants were heated under reflux for 5 hrs. The crude product was cooled to room temperature and the resulted solid was filtered, washed with water, dried and recrystallized from ethyl acetate.

2.2.8. Synthesis of polymethylene-bis- [2-(4-oxybenz-ylidenehydrazono)-1,3-thiazolidine-4-one] $[8]_{a-d}$

A mixture of thiosemicarbazone [7] (0.01mol), chloro-acetic acid (0.02mol) and fused sodium acetate (0.04mol) in absolute ethanol (10mL) was refluxed for 6 hrs. The crude product was cooled to room temperature, then poured onto ice-water. The resulted precipitate was filtered, washed with water, dried, and recrystallized from ethanol.

2.2.9. Synthesis of polymethylene-bis-[5-benzylidene-4-(2-imino-1,3-thiazolidine-4-one)-benzyledenehydra -zono-oxy] $[9]_{a-d}$

A mixture of compound [8] (0.01mol) and benzaldehyde (0.025mol) in piperidine (1mL) was heated in fusion temperature for 3 hrs. The crude product was cooled to room temperature, then poured onto- ice water. The separated solid was filtered, washed with water, dried, and recrystallized from acetone. The physical properties of the synthesized compounds [6]a-d- [9]a-d are listed in Table (4).

2.2.10. Synthesis of polymethylene-bis [4-(5-imino-3-phenyl-3,3a-dihydro-thiazolo [3,4c]isoxazole)-benzy- lidenehydrazono)-oxy]alkane $[10]_{a-d}$

A mixture of compound [9] (0.01mol), hydroxylaminehydro- chloride (0.02mol) and potassium hydroxide (0.04 mol) was dissolved in absolute ethanol(15 mL). The mixture was heated by reflux for 16-18 hrs., and the progress of the reaction was monitored by TLC. The crude product was left to cooled to room temperature and then poured into ice-cold water. The resulted solid was filtered, washed with water, dried, and recrystallized from ethanol. The physical data of these compounds are given in Table (5).

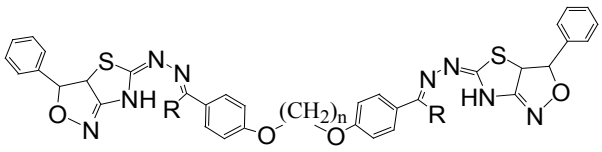
2.2.11. Synthesis of polymethylene-bis-{4-[2-imino-N-acetyl-1,3-thiazolidine-4-one)benzyleden ehydra- zono]-4-oxy}alkane $[11]_{a-d}$

A solution of compound [7] (0.001 mol) was dissolved in acetic anhydride (6 mL) and heated by reflux for 4 hrs. The crude product was left to cooled to room temperature, then poured onto ice-cold water. The separated solidwas filtered, washed with water, dried and recrystallized from ethanol. The physical data of these compounds are listed in Table (6).

Table (4). Physical properties of compounds [6] to [9]

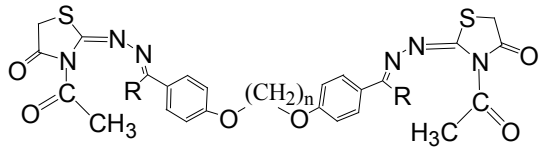
Comp. No.	n	R	Color	Yield %	m.p. C^0	Name
[6]a	2	H	Pale-yellow	88	118-120	1,2-bis [4-oxybenzaldehyde]ethane
[6]b	3	H	Yellow	86	97-98	1,3-bis [4-oxybenzaldehyde] propane
[6]c	2	CH_3	Yellow	83	154-158	1,2-bis [4-oxyacetophenone] ethane
[6]d	3	CH_3	Yellow	77	98-100	1,3-bis [4-oxyacetophenone]propane
[7]a	2	H	Pale-yellow	78	>300dec.	1,2-bis [4-oxybenzaldehydethiosemicarbazone]ethane
[7]b	3	H	Yellow	75	214-217	1,3-bis [4-oxybenzaldehydethiosemicarbazone] propane
[7]c	2	CH_3	Pale-yellow	69	>300dec.	1,2-bis [4-oxyacetophenone thiosemicarbazone] ethane
[7]d	3	CH_3	Pale-yellow	66	151-154	1,3-bis [4-oxyacetophenone thiosemicarbazone]propane
[8]a	2	H	White	54	>300dec.	1,2-bis- [2-(4-oxybenzylidenehydrazono)-1,3-thiazolidine-4-one]ethane
[8]b	3	H	White	58	260-264	1,3-bis- [2-(4-oxybenzylidenehydrazono)-1,3-thiazolidine-4-one]propane
[8]c	2	CH_3	Pale-yellow	45	>300dec.	1,2-bis- [2-(4-oxybenzylidenehydrazono-α-methyl)-1,3-thiazolidine-4-one]ethane
[8]d	3	CH_3	Pale-yellow	55	158-160	1,3-bis- [2-(4-oxybenzylidenehydrazono-α-methyl)-1,3-thiazolidine-4-one]propane
[9]a	2	H	Yellow	61	291-293	1,2-bis-[5-benzylidene-4(2-imino-1,3-thiazolidine-4-one)-benzyledenehydrazono -4-oxy]ethane
[9]b	3	H	Yellow	64	241-244	1,3-bis-[5-benzylidene-4(2-imino-1,3-thiazolidine-4-one)-benzyledenehydrazono -4-oxy]propane
[9]c	2	CH_3	Brown	49	118-123	1,2-bis- [5-benzylidene-4(2-imino-1,3-thiazolidine-4-one)-benzyledenehydrazono -α-methyl -4-oxy]ethane
[9]d	3	CH_3	Orange	51	135-138	1,3-bis- [5-benzylidene-4(2-imino-1,3-thiazolidine-4-one)-benzyledenehydrazono -α-methyl -4-oxy]propane

Table (5). Physical properties of compounds [10] a-d

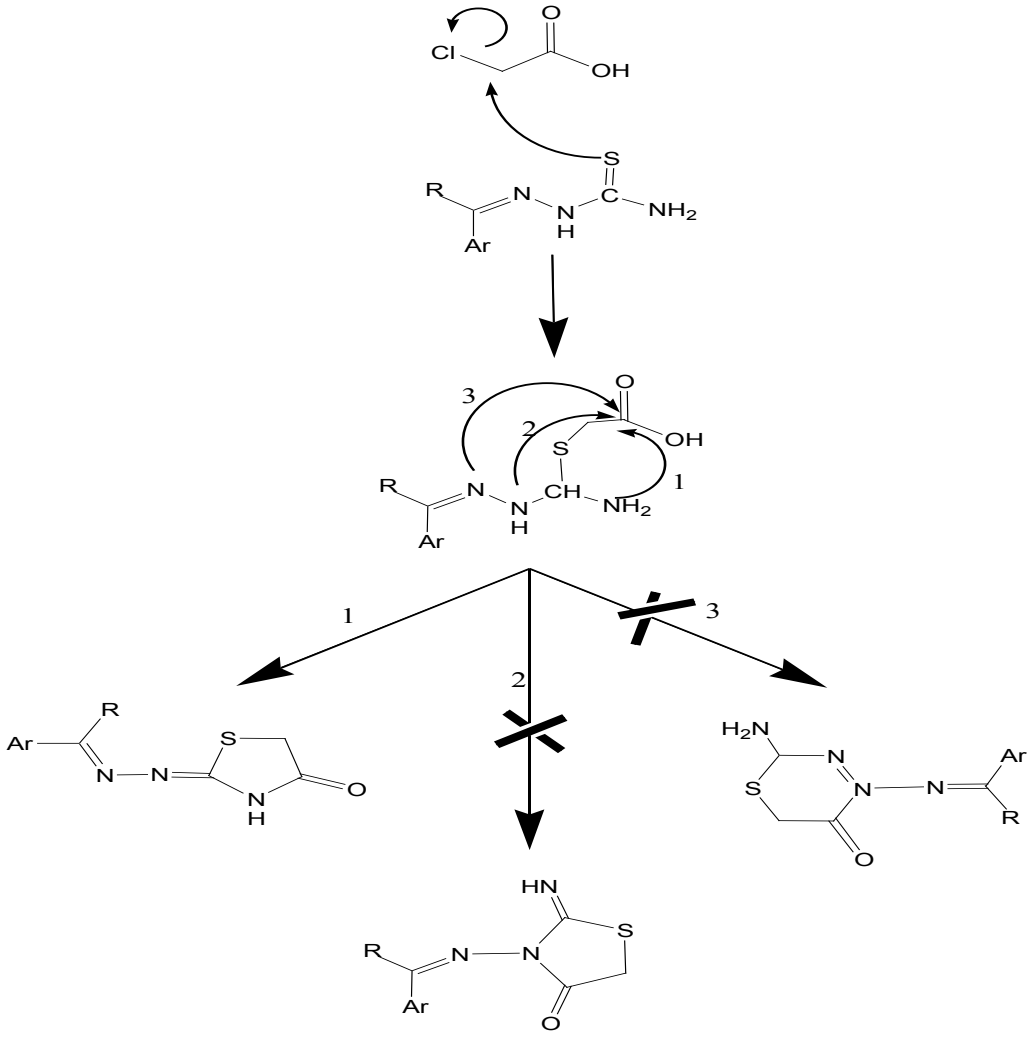


Comp. No.	n	R	Color	Yield %	m.p. C^0	Name
[10]a	2	H	Yellow	65	> 280dec.	1,2-bis [4-(5-imino-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole)benzylidenehydrazono)-oxy]ethane
[10]b	3	H	Yellow	47	289-291	1,3-bis [4-(5-imino-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole)benzylidenehydrazono)-oxy]propane
[10]c	2	CH_3	Brown	59	267-270	1,2-bis [4-(5-imino-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole)benzylidenehydrazono-α-methyl)-oxy]ethane
[10]d	3	CH_3	Yellow	54	290dec.	1,3-bis [4-(5-imino-3-phenyl-3,3a-dihydro-thiazolo [3,4-c]isoxazole)benzylidenehydrazono-α-methyl)-oxy]propane

Table (6). Physical properties of compounds [11] a-d



Comp. No.	N	R	Color	Yield %	m.p. C^0	Name
[11]a	2	H	Yellow	71	156-159	1,2-bis-{4- [2-imino-N-acetyl-1,3-thiazolidine-4-one)-benzyledenehydrazono] -oxy}ethane
[11]b	3	H	Brown	68	>280dec.	1,3-bis-{4-[2-imino-N-acetyl-1,3-thiazolidine-4-one)-benzyledenehydrazono] -oxy}propane
[11]c	2	CH_3	Orange	59	177-180	1,2-bis-{4-[2-imino-N-acetyl-1,3-thiazolidine-4-one)-benzyledenehydrazono -α-methyl]-oxy}ethane
[11]d	3	CH_3	Brown	61	> 278dec.	1,3-bis-{4-[2-imino-N-acetyl-1,3-thiazolidine-4-one)-benzyledenehydrazono -α-methyl]-oxy}propane



Scheme (3). The suggested mechanism for synthesis 4-thiozolidinones

3. Results and Discussion

In the present work, we report the synthesis of new derivatives of novel 4-thiazolidinone and isoxazoline fused with thiazoline ring. The target compounds were derived from thiosemicarbazone [1] and [7] which obtained from the reaction of different aldehydes and ketones with thiosemicarbazide in a good yields, schemes (1) and (2). The thiosemi-carbazones [1] and [7] were characterized by FT-IR spectroscopy and the characteristic absorption bands are listed in table (7). Three new stretching absorption bands at (3165- 3441 cm^{-1}) are due to NH_2 and NH groups, while the stretching absorption band due to C=N group appeared at (1650 cm^{-1}). However, the spectra of these compounds showed the disappearances of carbonyl stretching absorption of the starting material (aldehydes and ketones). The resulted thiosemicarbazones [1] and [7] were cyclized successfully to 4-thiazolidinones [2] and [8] respectively, in good to moderate yields. The procedure includes the reaction of thiosemi-carbazones with chloroacetic acid and anhydrous sodium acetate in ethanol under reflux for 6 hrs. The disappearances of the starting materials was monitored by TLC. The cyclization mechanism may proceed as in scheme (3). The first step of the reaction includes the removal of proton from NH by sodium acetate resulted in conversion of the resulted intermediate to partially or totally to thiol form [21, 22]. The second step represent anucleophilic attack by thiol on carbon atom that bears a good leaving group (CH-Cl) will result in formation of new S-C bond. This step is followed by a nucleophilic attack by NH_2 on carbon atom of carbonyl group resulted in formation of five member heterocyclic ring. The carbonyl group at position 4 of the hetrocyclic ring may be formed by losing one molecule of water. The FT-IRspectra of the products confirmed the formation of the 4-thiazoldinones [2] and [8], table (9). The spectra showed the disappearances of NH_2 group bands of thiosemicarbazons [1] and [7] and the appearances of newcharacteristic bands at (3290-3483 cm^{-1}) and (1683-1724 cm^{-1}) belonging to the stretching vibration of N-H and C=O of lactam groups, respectively.

^{1}HNMR spectrum of compound [8]b (in DMSO as solvent) showed signal of eight aromatic protons in the region δ 7.9-7.0 ppm, and two sharp singlet signals at δ 11.30 ppm and δ 8.3 ppm could be attributed to protons of NH group and CH=N group respectively. Also the spectrum showed two signals at δ 4.21 ppm and δ3.90 ppm for four protons of two oxymethylene groups ($OC\underline{H_2}CH_2C\underline{H_2}O$) and two protons at C-5 of the five member ring, respectively. A third signal at δ (2.20) ppm due to two protons of methylene group ($OCH_2\ C\underline{H_2}\ CH_2O$). ppm. The mass spectrum of 4-thiazolidinone [2] a exhibited m/z = 298(M^+) in addition to most significant fragments of this compounds are: 299(M+1), 198, 184, 170, 157, 142, 116, 102, 89 (base peak), 62.

The second step of our plan is to introducea double bond at position 5 of the thiazolidinone ring. to give alkene compounds [3] and [9]. This step was carried out by fusion reaction of thiazolidinone [2] or [8] with benzaldehyde in presence of piperidine. The piperidinerole as a base was to remove the most acidic proton at position 5 of the ring. The resulted carbanion would easy attack the carbon of the carbonyl group of the benzaldehyde to produce the alkene [3] or [9]. The structure of the resulted products were confirmed by their FTIR spectra which showed a stretching vibration band for olefinic double bond (C=C) in the region (1624-1662 cm^{-1}). The most characteristic absorption bands of the products are listed in table (10). furthermore, ^{1}HNMR spectra of compound [3]d (in DMSO as solvent) showed signals at δ7.0-7.9 ppm due to nine aromatic protons and one olefinicproton of CH = group, three sharp singlet singals at δ (12.6) ppm and δ (7.84) ppm could be attributed to a proton of OH group, and NHgroup, respectively. ^{1}HNMR spectrum of compound [9] b (in DMSO as solvent) showed acomplicatedsignals between in the region δ 7.02-8.54 ppm due to 22 protons. Eighteen of them are aromatic protons, two olefinicprotons (CH=) and two protons of imine groups (CH=N). Also the spectrum showed a triplet signal at δ 4.24-4.28equivalent to four protons of two alkoxy group ($OC\underline{H_2}CH_2\ C\underline{H_2}O$). A multiple signal appeared at δ2.14-2.24 ppm due to two aliphatic protons ($OCH_2\ C\underline{H_2}CH_2O$). The mass spectrum of 4-thiazolidinoe [3] a exhibited m/z=287(M^+) and another characteristic fragments of this compounds are an: 307,230, 214,203,184, 134(base peak), 102,89,51. The second line of the present work is the synthesis of isoxazolines fused with thiazoline ring. This was achieved by cyclization of [3] or [9] with hydroxylaminehydrochloride in presence of base. The FTIR spectra of the products [4] and [10] confirmed the formation of these products and the data are listed in table (11). The significant remarks of these spectra are the disappearances of stretching vibration bands of C=CH and C=O groups of compounds [3] and [9]. A new bands appeared at 1662-1684 cm^{-1} and 1030-1068 cm^{-1} due to C=N and C-O respectively.

^{1}HNMR spectrum of compound [10]a (in DMSO as solvent) showed signals in the region δ 7.10-7.59 ppm and δ 8.7 ppm due to eighteen aromatic protons and two protons of N-H groups , respectively. Also the spectrum showed a signal at δ 4.29 due to four protons of $OC\underline{H_2}C\underline{H_2}O$ group and a signal at ppm δ 5.38 ppm for two protons of imine groups HC=N-. A singlet signal appear at δ 2.8 ppm are due to two protons at C-4. The mass spectrum of compound [10] b exhibited m/z=714(M^+-2H) and another most characteristicfragments of this compounds are: 338, 312 (base peak), 307, 298, 230, 161, 134, 121, 102, 90, 51.

Finally, the amide derivatives of 4-thiazolidinone [5] or [11] were produced from reaction under reflux between thiazolidinones [4] or [10] and acetic anhydride, respectively. The FT-IR data of compounds [5] and [11] are confirmed the structures of the products. The stretching vibration of amidic carbonyl (C=O) appeared at (1640-1685 cm^{-1}), and the disappearances of absorption band of NH Lactam, table (12). ^{1}HNMR spectrum of compound [5]a (in

DMSO as solvent) showed pair of doublets signals in the region δ 7.62-7.38 ppm due to four aromatic protons, two sharp singlet signls at δ 6.74 ppm and δ 2.11 ppm could be attributed to proton of CH=N group and three protons of CH_3 group, respectively. Also the spectrum showed a signals at δ 4.35 ppm due to two protons at C-5 of thiazolidinone ring. The mass spectrum of compound [5]b exhibited m/z = 354 (M^+) and another most characteristic fragments of this compounds are :353 (M^+-H) base peak, 340, 313, 298, 268, 240, 198 (base peak), 184, 156, 128, 102, 77, 51.

Table (7). FT-IR data of compounds [1] a-d – [7] a-d

Comp. No.	υ NH_2, NH asym, sym	υC-H aliph.	υ C=N	υ C=C arom.	υ C=S	Other
[1]a	3437-3196	2958,2879	1651	1600	1222	C-Br : 696
[1]b	3410-3194	2976,2920	1652	1587	1228	C-Br : 661
[1]c	3466-3186	2930,2806	1606	1581	1227	O-H :3376
[1]d	3356-3174	2935,2808	1653	1599	1222	O-H :3225
[7]a	3481-3273	2933,2877	1678	1600	1234	C-O :1242
[7]b	3423-3259	2972,2877	1610	1537	1235	C-O :1249
[7]c	3410-3242	2982,2885	1653	1599	1238	C-O :1242
[7]d	3371-3176	2960,2883	1668	1602	1240	C-O :1249

Table (8). FT-IR data of compounds [6] a-d

Comp. No.	υ C-H arom.	υ C-H aliph.	υ C=O	υ C=C arom	υ C-O
[6]a	3063	2943,2922	1697	1600	1246
[6]b	3074	2953,2883	1693	1602	1249
[6]c	3045	2955,2891	1676	1593	1251
[6]d	3001	2955,2922	1674	1602	1253

Table (9). FT-IR data of compounds [2] a-d – [8] a-d

Comp. No.	υ N-H	υ C-H aliph	υ C=O Lactam	υ C=N	υ C=C	υ C-S
[2]a	3435	2951,2937	1712	1647	1595	736
[2]b	3412	2982,2931	1716	1614	1589	707
[2]c	3290	2968,2924	1705	1639	1599	738
[2]d	3304	2974,2933	1710	1627	1572	725
[8]a	3483	2945,2933	1714	1639	1600	734
[8]b	3433	2955,2883	1712	1641	1604	734
[8]c	3410	2983,2885	1714	1645	1602	707
[8]d	3437	2955,2883	1724	1672	1602	725

Table (10). FT-IR data of compounds [3]a-d – [9]a-d

Comp. No.	υ CH=C	υ C-H aliph.	υ C=O	υ C=C Exo.	υ C=C arom.
[3]a	3100	2937,2852	1710	1647	1591
[3]b	3136	2976,2916	1705	1624	1593
[3]c	3159	2935,2858	1710	1651	1604
[3]d	3157	2939,2854	1710	1626	1602
[9]a	3120	2935,2874	1715	1651	1600
[9]b	3127	2933,2833	1712	1647	1599
[9]c	3160	2935,2856	1734	1662	1599
[9]d	3129	2939,2867	1701	1647	1600

Table (11). FT-IR data of compounds [4] a-d – [10] a-d

Comp. No.	υ N-H	υ CH at C-3 of isoxazoline	υ C-H aliph.	υ C=N (indocyclic)	υ C=C arom.	υ C-O (indocyclic)	υ N-O (indocyclic)
[4]a	3420	3059	2941	1683	1610	1068	759
[4]b	3421	3060	2993,2918	1683	1602	1030	758
[4]c	3360	3070	2976,2896	1679	1605	1030	790
[4]d	3410	3061	2937,2856	1684	1604	1074	761
[10]a	3380	3055	2931,2875	1681	1604	1068	781
[10]b	3390	3059	2953,2887	1684	1600	1047	752
[10]c	3360	3061	2972,2883	1683	1605	1047	758
[10]d	3248	3061	2922,2893	1662	1600	1045	761

Table (12). FT-IR data of compounds [5] a-d – [11] a-d

Comp. No.	υ C-H aliph.	υC=O Lactam	υC=O Amide	υC=C arom.	υC-N
[5]a	2935,2887	1726	1660	1597	1373
[5]b	2978,2929	1718	1684	1599	1363
[5]c	2920,2800	1726	1685	1599	1321
[5]d	2956,2910	1720	1683	1604	1307
[11]a	2962,2949	1714	1660	1608	1307
[11]b	2935,2879	1728	1647	1604	1313
[11]c	2933,2910	1730	1663	1610	1296
[11]d	2939,2881	1724	1640	1599	1298

4. Conclusions

In conclusion, new compounds of 4-thiazolidinone derivatives and fused-isoxazolines were synthesized in good yield derived from different thiosemicarbazones and they were characterized by different spectral studies.

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