3-Aryl-2-sulfanylpropenoic acids as precursors for some novel (*Z*)-5-substituted-2-alkoxy-2-trichloromethyl-4-thiazolidinones

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Abstract

3-Aryl-2-sulfanylpropenoic acids **1a-d** react with trichloroacetonitrile under various reaction conditions to give different products. Thus, reaction of **1a-d** with trichloroacetonitrile in absolute ethanol and in the presence of few drops of triethylamine at room temperature affords 1,3-oxathiolan-5-one derivatives **4a-d**. Whereas, compounds **1a-d** react with trichloroacetonitrile in primary alcohols under reflux to afford the corresponding 2-alkoxy-2-trichloromethylthiazolidin-4-one derivatives **7a-l**. Reaction of compounds **1a-d** with trichloroacetonitrile or other nitriles **11a-c** in refluxing glacial acetic acid gave 5-arylmethylene-2,4-thiazolidinediones **8a-d**. The structures of all the newly synthesized products were confirmed based on elemental and spectral data, and a plausible mechanism is postulated to account for their formation. X-ray crystallography was carried out for the products **4a** and **7b**.

Keywords: 3-Aryl-2-sulfanylpropenoic acids, trichloroacetonitrile, 1,3-oxathiolan-5-ones, 5-substituted-2-alkoxy-2-trichloromethyl-4-thiazolidinones, X-ray crystallography

Introduction

3-Aryl-2-sulfanylpropenoic acids are used as intermediates for the synthesis of a variety of heterocyclic sulfur compounds.[1-5] Additionally, 3-aryl-2-sulfanylpropenoic acids have been found to be useful antidotes for heavy metal poisoning. For example, 3-furyl-2-sulfanylpropenoic acid in particular has been shown to protect against cadmium intoxication in rats.[6] An earlier investigation indicated that post-cadmium exposure treatment with certain 3-aryl-2-sulfanylpropenoic acids is effective in decreasing liver and kidney cadmium burden in rats.[7] 3-Aryl-2-sulfanylpropenoic acids can inhibit neuraminidases.[8] As part of our research interest in developing new routes for the synthesis of new heterocycles,[9-12] we have already reported some of our work on the synthesis, transformations and biological properties of some thiazolidinones and oxathiolanes.[13-15] The biological significance of this class of compounds

impelled us to continue working on synthesis of new oxathiolane and thiazolidinone derivatives. We report here the reaction of 3-aryl-2-sulfanylpropenoic acids with trichloroacetonitrile and other nitriles under various reaction conditions to give new 1,3-oxathiolanes, which were transformed into the corresponding thiazolidin-4-one derivatives.

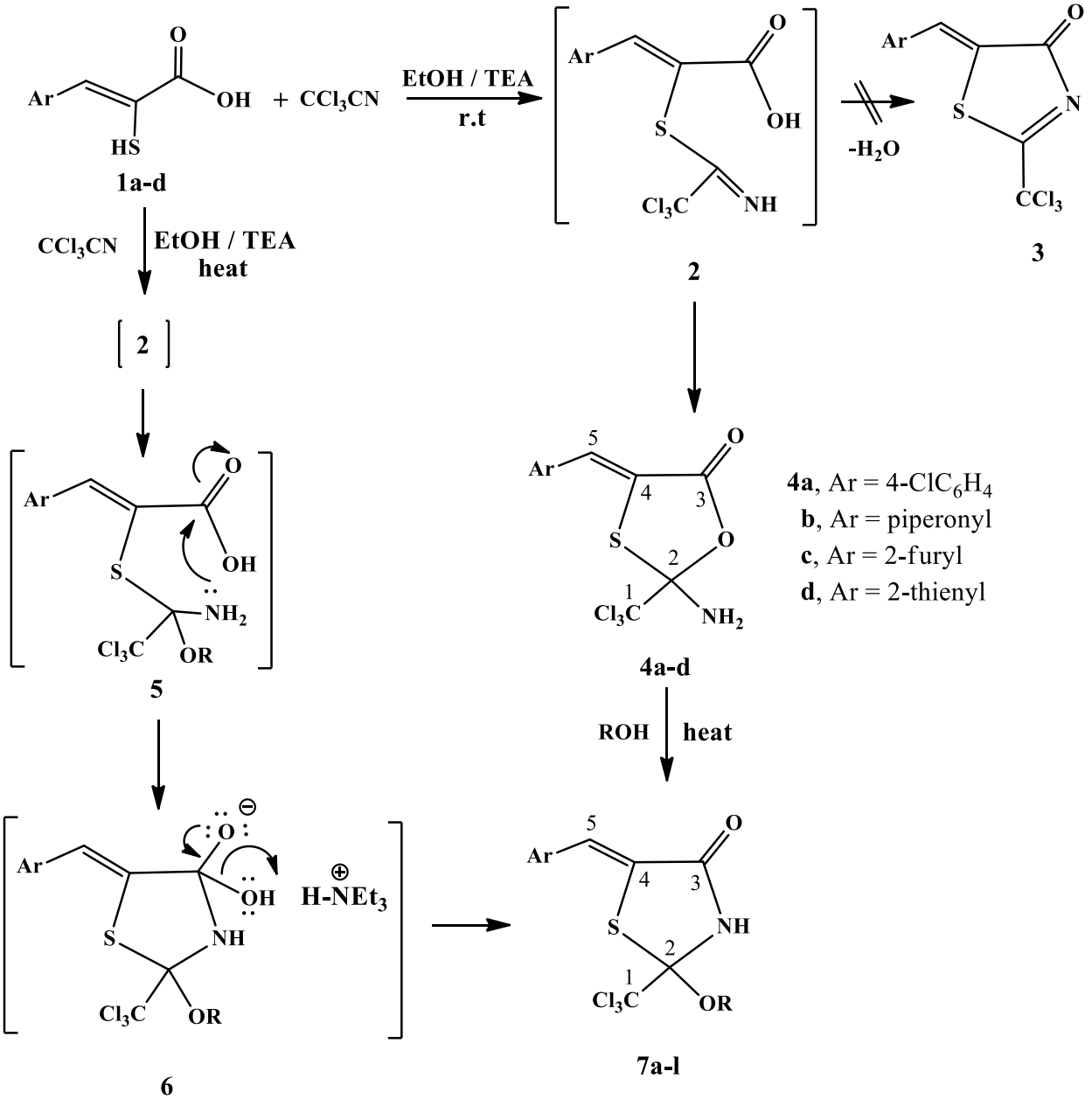
Results and Discussion

The reaction of 3-aryl-2-sulfanylpropenoic acids **1a-d** with trichloroacetonitrile in absolute ethanol and in the presence of a few drops of triethylamine as basic catalyst at room temperature afforded the products **4a-d**. The structures of the products were confirmed by elemental analyses and spectral data (IR, ^{1}H NMR, ^{13}C NMR, MS and X-ray). For example, the IR spectrum of the isolated product **4a** taken as a typical example of the series showed two absorption bands at ν 3388 and 3309 cm^{-1} corresponding to the amino group and one absorption band at 1751 cm^{-1} corresponding to lactone carbonyl group. The ^{1}H NMR spectrum of the same product revealed a broad singlet signal (2H, D_2O exchangeable) at δ = 4.51 ppm attributable to NH_2, and a singlet signal at δ = 7.81 ppm due to a vinylic proton and the aromatic proton signals. The ^{13}C NMR spectrum of **4a** exhibited the following signals: 113.0 ppm for C-1, 115.5 ppm for C-2, 175.5 ppm for C-3, 133.0 ppm for C-4 and 138.7 ppm for C-5, beside the aromatic carbons. Its mass spectrum showed molecular ion peaks at *m/z* 360 $(M+1)^+$ and 361 $(M+2)^+$ consistent with the assigned structure.

Based on these spectral data the oxathiolane structures **4a-d** were assigned to the above reaction products and alternative structure **3** could be dismissed (Scheme 1). X-ray analysis of compound **4a** (Figure 1, Table 1) gives conclusive evidence for the assigned structure **4**. The formation of **4** is assumed to proceed first *via* addition of the thiol moiety in sulfanylpropenoic acid derivative **1a** to the cyano carbon in trichloroacetonitrile, affording the non-isolable acyclic imine **2**. This, in turn cyclizes to the final isolated product **4** *via* addition of the oxygen nucleophile to the activated azomethine group.

On the other hand, it was found that compounds **1a-d** react with trichloroacetonitrile in absolute ethanol in the presence of few drops of triethylamine at refluxing temperature to afford pale yellow crystalline products. It was expected that this reaction would afford thiazole derivatives **3**. The IR spectrum of **7b** taken as a typical example of the reaction products showed an absorption band at ν 1680 cm^{-1} attributable to a lactam carbonyl group. The ^{1}H NMR spectrum of the same product revealed a triplet signal at δ = 1.22 ppm and a quartet signal at δ = 3.70 attributable to ethoxy protons. A singlet signal (1H, D_2O exchangeable) appeared at δ = 10.46 ppm, attributable to an NH, a singlet signal at δ = 7.47 ppm due to vinylic proton and a singlet signal at δ = 6.10 due to methylene (O-CH_2-O) protons, besides the aromatic protons. The ^{13}C NMR spectrum of **7b** exhibited the following signals: 113.0 ppm for C-1, 115.7 ppm for C-2, 176.6 ppm for C-3, 133.8 ppm for C-4, 137.5 ppm for C-5, 111.1 for methylene (O-CH_2-O), and

aromatic carbon signals. The mass spectrum showed molecular ion peaks at *m/z* 395 $(M)^+$ and 397 $(M+2)^+$ consistent with the assigned structure.



4a, Ar = 4-ClC_6H_4
b, Ar = piperonyl
c, Ar = 2-furyl
d, Ar = 2-thienyl

7a, Ar = 4-ClC_6H_4, R = Et
b, Ar = piperonyl, R = Et
c, Ar = 2-furyl, R = Et
d, Ar = 2-thienyl, R = Et
e, Ar = 4-ClC_6H_4, R = Me
f, Ar = piperonyl, R = Me
7g Ar = 2-furyl, R = Me
h, Ar = 2-thienyl, R = Me
i, Ar = 4-ClC_6H_4, R = n-propyl
j, Ar = piperonyl, R = n-propyl
k, Ar = 2-furyl, R = n-propyl
l, Ar = 2-thienyl, R = n-propyl

Scheme 1

An X-ray crystallographic study of a single crystal of **7b** (Figure 2, Table 2) confirmed the structure deduced from NMR studies. Compounds **7a-d** can also be obtained by refluxing **4a-d** in absolute ethanol in the presence of triethylamine. Similarly, refluxing of **4a-d** in other alcohols like methanol or *n*-propanol in the presence of few drops of triethylamine afforded 2-alkoxy-2-trichloromethyl-4-thiazolidinone derivatives **7e-l**. Transformation of **4a-d** into **7a-l** is assumed to proceed *via* ring opening of lactone ring by alcohol to afford the non-isolable acyclic intermediates, then cyclization with elimination of water to afford the final isolated products **7**.

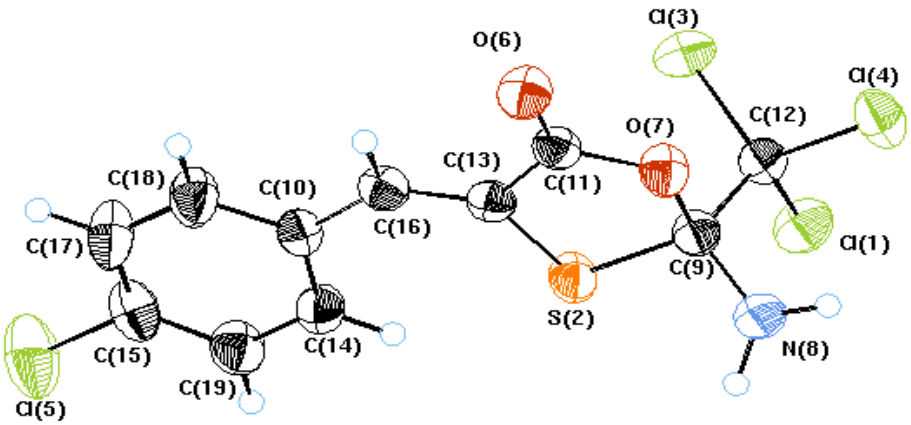


Figure 1. ORTEP drawing of compound **4a**.

Table 1. Selected bond lengths of compound **4a**

Bond	Length (Å)
C9—S2—C13	92.03 (8)
C9—O7—C11	116.09 (13)
O7—C9—C12	105.30 (13)
N8—C9—C12	109.7 (2)
Cl1—C12—C9	110.55 (12)
Cl3—C12—C9	110.45 (13)
Cl4—C12—C9	108.62 (13)
N8—C9	1.399 (2)
O7—C9	1.449 (2)
O7—C11	1.360 (2)
S2—C9	1.828 (2)
C9—C12	1.572 (3)

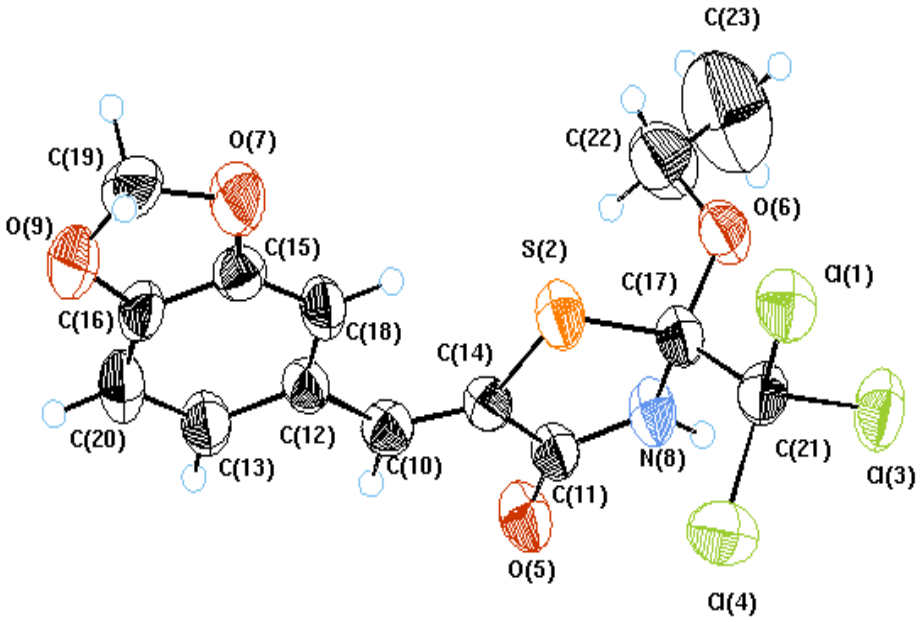


Figure 2. ORTEP drawing of compound **7b**.

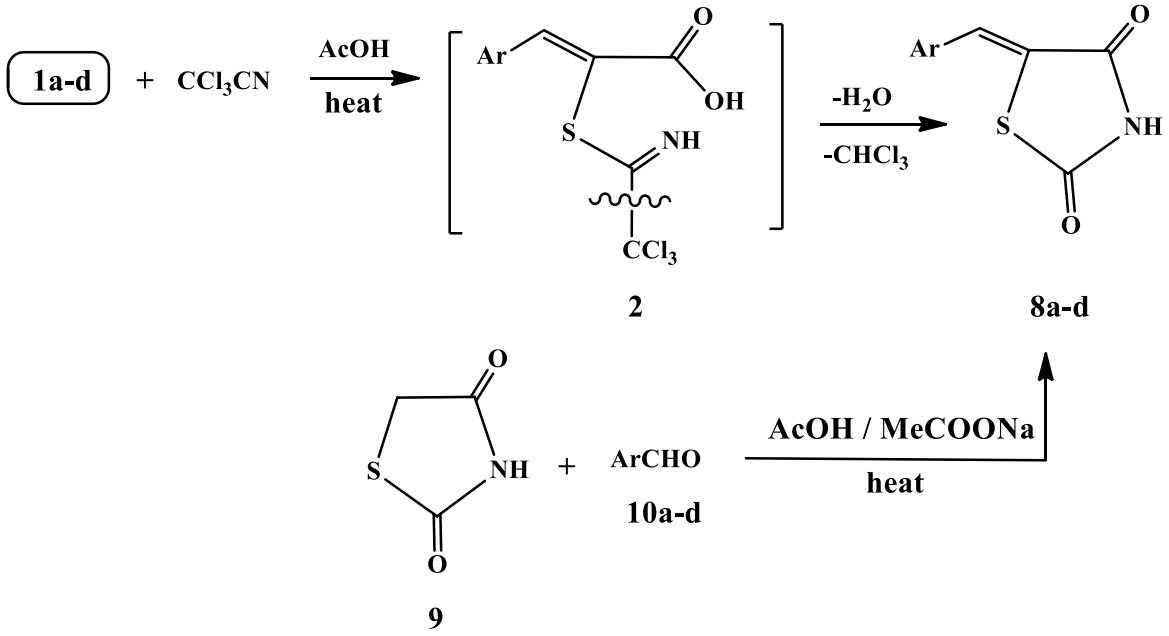
Table 2. Selected bond lengths of compound **7b**

Bond	Length (Å)
S2—C17—O6	112.85 (10)
S2—C17—N8	105.16 (9)
S2—C17—C21	109.75 (10)
O6—C17—N8	113.78 (12)
N8—C17—C21	111.13 (12)
Cl1—C21—C17	110.19 (10)
Cl3—C21—C17	109.68 (10)
Cl4—C21—C17	110.82 (11)
O6—C17	1.385 (2)
S2—C17	1.8469 (14)
N8—C17	1.434 (2)
C17—C21	1.555 (2)

It was of interest to extend this study to reactions conducted in acetic acid and we found that heating **1a-d** with trichloroacetonitrile in acetic acid at reflux afforded coloured solid products. The structure of the isolated products was confirmed by elemental analysis and spectral data (IR, ^{1}H NMR and MS). The IR spectra of the isolated products showed in each case absorption at ν_{max} 3176-3216 due to NH group and absorption at $\nu_{max.}$ 1753-1679 cm^{-1} due to carbonyl groups.

The ^{1}H NMR spectra of these products revealed in each case a broad singlet signal (1H, D_2O exchangeable) at δ ~ 11.25-12.90 attributable to NH, besides a vinylic CH proton at δ ~ 7.56-7.71 ppm. The mass spectra together with elemental analyses confirmed the structures **8a-d**. These structures were chemically confirmed by an alternative method *via* condensation of 2,4-thiazolidinedione (**9**) with aromatic aldehydes **10a-d** in glacial acetic acid in the presence of anhydrous sodium acetate to give products corresponding in all respects (mp, mixed mp and IR) with products[16,17] **8a-d**.

The formation of structure **8** is assumed to proceed via addition of the thiol moiety in the sulfanylpropenoic acid to the cyano carbon in trichloroacetonitrile, then cyclization with elimination of water to give non-isolable product **2**. Acid hydrolysis then affords the 5-arylidene-2,4-thiazolidinediones **8**.

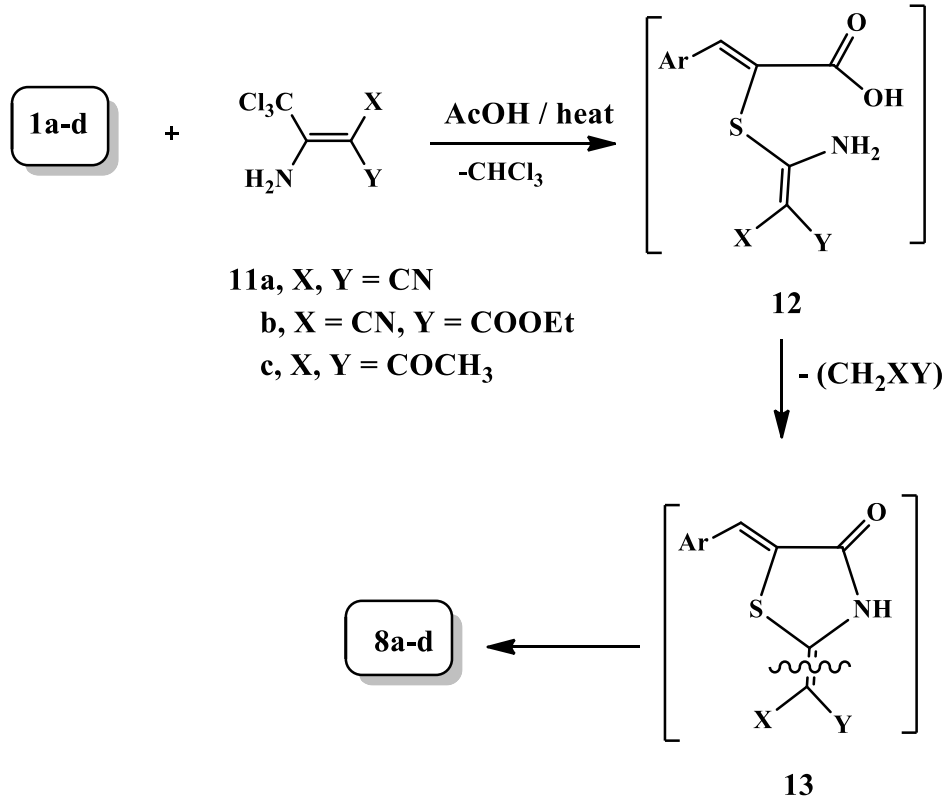


1, 8, 10a, Ar = 4-ClC_6H_4
b, Ar = piperonyl
c, Ar = 2-furyl
d, Ar = 2-thienyl

Scheme 2

The reaction of **1a-d** with other nitriles such as 2-(1-amino-2,2,2-trichloroethylidene)malononitrile **11a** in refluxing acetic acid, afforded products identical in all respects (TLC, mp, mixed mp, IR) with **8a-d**. Similarly, compounds **1a-d** were allowed to react with ethyl 3-amino-4,4,4-trichloro-2-cyanobut-2-enoate **11b** or 3-(1-amino-2,2,2-trichloroethylidene)pentane-2,4-dione **11c** under the same reaction conditions to afford products completely identical (TLC, mp, mixed mp, IR) with **8a-d**.

Compounds **8a-d** are assumed to be formed *via* elimination of chloroform, followed by cyclization with elimination of water, then acid hydrolysis with elimination of active nitrile molecule to afford **8** (Scheme 3).



Scheme 3

Experimental Section

General. Melting points were determined on an Electrothermal 9100 apparatus. The IR spectra were recorded as KBr pellets on a Perkin-Elmer 1430 spectrophotometer. The ^{1}H NMR spectra were taken on a Varian Gemini 300-MHz spectrometer in DMSO-d_6 using TMS as internal standard. Mass spectra were measured on a Shimadzu GCMS-GB 1000 PX (70 ev). Elemental analyses were obtained using an Elementar CHNS analyzer Vario EL III (Germany), at the Microanalyses Center of Cairo University, Giza, Egypt. The X-ray crystal analysis was carried out at Dokki National Centre (NRC) at Dokki, Giza, Egypt. 3-Aryl-2-sulfanylpropenoic acids were synthesized according to literature procedures.[18]

Synthesis of 2-amino-2-trichloromethyl-4-arylmethylene-1,3-oxathiolan-5-one derivatives (4a-d). General procedure

To a mixture of **1a-d** (10 mmol) and trichloroacetonitrile (10 mmol) in 20 ml of absolute ethanol, 0.2 ml of triethylamine was added. The reaction mixture was stirred at room temperature for 1 h (TLC). The solid formed was filtered off, washed with ethanol, and recrystallized from the appropriate solvent to afford the 1,3-oxathiolan-5-ones **4a-d**.

(*Z*)-2-Amino-4[(4-chlorophenylmethylene)-2-trichloromethyl]-1,3-oxathiolan-5-one (4a). Pale yellow crystals; (84%); mp 202-204 ºC; (EtOH/dioxane); IR (KBr): 3388, 3309 (NH_2), 1751 cm^{-1} (CO). ^1H NMR (DMSO-d_6): δ = 4.51 (s, 2H, NH_2), 7.45 (d, 2H, *J* = 8.2 Hz, Ar), 7.71 (d, 2H, *J* = 8.1 Hz, Ar), 7.81 (s, 1H); ^{13}C NMR (DMSO-d_6): δ = 113.0, 115.5, 133.0, 138.7, 140.7, 141.7, 148.7, 175.5; MS: *m/z* (%), 360 $(M+1)^+$ (1.3), 361 $(M+2)^+$ (0.8), 315 (2.2), 278 (5.3), 250 (5.9), 214 (5.6), 213 (4.9), 205 (1.4), 198 (4.1), 170 (42.9), 168 (100), 149 (3.2), 136 (5.6), 120 (5.6), 108 (29.4), 98 (3.8), 84 (26.2), 75 (11.4), 69 (10.3). Anal. Calcd. for $C_{11}H_7Cl_4NO_2S$: calcd. C, 36.80; H, 1.97; Cl, 39.50; N, 3.90; S, 8.93; found: C, 36.59; H, 2.15; Cl, 39.30; N, 4.12; S, 8.73.

(*Z*)-2-Amino-2-trichloromethyl-4-(1,3-benzodioxol-5-ylmethylene)-1,3-oxathiolan-5-one (4b). Pale yellow crystals; (80%); mp 168-170 ºC; (EtOH/dioxane); IR (KBr): 3376, 3309 (NH_2), 1743 cm^{-1} (CO). ^1H NMR (DMSO-d_6): δ = 4.50 (s, 2H, NH_2), 6.09 (s, 2H), 7.25-7.63 (m, 3H), 7.76 (s, 1H); MS: *m/z* (%), 367 $(M-1)^+$ (0.15), 369 $(M+1)^+$ (0.12), 315 (0.2), 224 (3.9), 206 (8.1), 178 (100), 149 (6.6), 120 (15.6), 108 (20.2), 76 (4.2), 69 (5.4), 55 (3.1). Anal. Calcd. for $C_{12}H_8Cl_3NO_4S$: C, 39.10; H, 2.19; Cl, 28.85; N, 3.80; S, 8.70; found: C, 39.29; H, 1.97; Cl, 28.64; N, 3.57; S, 8.86.

(*Z*)-2-Amino-2-trichloromethyl-4-(furyl-2-ylmethylene)-1,3-oxathiolan-5-one (4c). Whitish brown crystals; (75%); mp 144-146 ºC (toluene); IR (KBr): 3391, 3143 (NH_2) and 1698 cm^{-1} (CO). ^1H NMR (DMSO-d_6) δ = 4.47 (s, 2H, NH_2), 7.19-7.99 (m, 3H), 8.22 (s, 1H); Anal. Calcd. for $C_9H_6Cl_3NO_3S$: C, 34.36; H, 1.92; Cl, 33.81; N, 4.45; S, 10.19. Found: C, 34.18; H, 1.70; Cl, 33.62; N, 4.64; S, 10.40.

(*Z*)-2-Amino-2-trichloromethyl-4-(thienyl-2-ylmethylene)-1,3-oxathiolan-5-one (4d). pale yellow crystals; (72%), mp 148-150 ºC (EtOH/dioxane). IR (KBr: 3387, 3138 (NH_2) and 1696 cm^{-1} (CO). ^1H NMR (DMSO-d_6) δ = 4.65 (s, 2H, NH_2), 7.19-7.99 (m, 3H), 8.22 (s, 1H); Anal. Calcd. for $C_9H_6Cl_3NO_2S_2$: C, 32.69; H, 1.83; Cl, 32.17; N, 4.24; S, 19.40. Found: C, 32.90; H, 1.62; Cl, 32.37; N, 4.64; S, 19.56.

Synthesis of (*Z*)-5-arylmethylene-2-alkoxy-2-trichloromethyl-1,3-thiazol-4-ones (7a-l). To a mixture of **1a-d** (10 mmol) and trichloroacetonitrile (10 mmol) in absolute ethanol (20 ml) or methanol or *n*-propanol, 0.2 ml of triethylamine was added. The reaction mixture was refluxed for 2-5 h (TLC), whereby a solid precipitated, was filtered off, and recrystallized from the appropriate solvent to give 2-alkoxy-2-trichloromethyl-5-arylmethylene-4-thiazolidinones **7a-l**, respectively.

Conversion of (4a-d) into (7a-l)

To **4a-d** (10 mmol) of absolute ethanol or methanol or *n*-propanol (20 ml), 0.2 ml of triethylamine was added. The reaction mixture was refluxed for 2-3 h (TLC), whereby a solid precipitated, was filtered off, and recrystallized from the appropriate solvent to give compounds **7a-l**, respectively.

(*Z*)-5-[4-(Chlorophenylmethylene)-2-ethoxy-2-(trichloromethyl)]thiazolidin-4-one (7a). Yellow crystals; (80%); mp 208-210 ^{o}C; (EtOH/dioxane); IR (KBr): 3138, 3035 (NH), 1685 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 1.17 (t, 3H, *J* = 6.3 Hz, CH_3), 4.03 (q, 2H, *J* = 7.5 Hz, CH_2), 7.48 (d, 2H, *J* = 8.0 Hz, Ar), 7.80 (d, 2H, *J* = 8.0 Hz, Ar), 7.83 (s, 1H), 10.44 (s, 1H, NH). Anal. Calcd. for $C_{13}H_{11}Cl_4NO_2S$: C, 40.33; H, 2.86; Cl, 36.63; N, 3.62; S, 8.28; found: C, 36.59; H, 2.15; Cl, 36.79; N, 3.86; S, 8.64.

(*Z*)-5-(1,3-Benzodioxol-5-ylmethylene)-2-ethoxy-2-(trichloromethyl)thiazolidin-4-one (**7b**). Pale yellow crystals; (80%); mp 190-192 ^{o}C; (EtOH); IR (KBr): 3143, 3047 (NH) and 1682 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6) δ = 1.22 (t, 2H, *J* = 6 Hz), 3.70 (q, 3H, *J* = 7.2 Hz), 6.10 (s, 2H), 7.08-7.13 (m, 3H), 7.47 (s, 1H), 10.46 (s, 1H, NH). ^{13}C NMR (DMSO-d_6) δ = 24.0, 71.2, 111.1, 113.0, 115.7, 118.3, 118.4, 132.6, 133.8, 136.0, 137.5, 157.3, 157.5, 176.6. Anal.Calcd. for $C_{14}H_{12}Cl_3NO_4S$: C, 42.39; H, 3.05; Cl, 26.81; N, 3.53; S, 8.08. Found: C, 42.18; H, 3.25; Cl, 26.58; N, 3.75; S, 8.29.

(*Z*)-5-(Furyl-2-ylmethylene)-2-ethoxy-2-(trichloromethyl)thiazolidin-4-one (7c). Brown crystals; (71%); mp 165-167 ^{o}C (EtOH); IR (KBr): 3130, 3035 (NH) and 1684 cm^{-1} (CO); ^{1}H NMR (DMSO-d_6) δ = 1.21 (t, 2H, *J* = 6.2 Hz), 3.73 (q, 3H, *J* = 7.4 Hz), 6.91–8.21 (m, 3H), 7.36 (s, 1H), 10.37 (s, 1H, NH); Anal.Calcd. for $C_{11}H_{10}Cl_3NO_3S$: C, 38.56; H, 2.94; Cl, 31.04; N, 4.09; S, 9.36. Found: C, 38.78; H, 2.73; Cl, 31.26; N, 4.32; S, 9.14.

(*Z*)-5-(Thienyl-2-ylmethylene)-2-ethoxy-2-(trichloromethyl)thiazolidin-4-one (7d). Brownish yellow crystals; (74%); mp 169-171 ^{o}C (EtOH); IR (KBr): 3135, 3040 (NH) and 1687 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6) δ 1.19 (t, 2H, *J* = 6.1 Hz), 3.70 (q, 3H, *J* = 7.3 Hz), 7.64–8.15 (m, 3H), 7.40 (s, 1H), 10.38 (s, 1H, NH). Anal.Calcd. for $C_{11}H_{10}Cl_3NO_2S_2$: C, 36.83; H, 2.81; Cl, 29.65; N, 3.90; S, 17.88. Found: C, 37.04; H, 2.63; Cl, 29.42; N, 3.67; S, 17.67.

(*Z*)-5-[4-(Chlorophenylmethylene)-2-methoxy-2-(trichloromethyl)]-thiazolidin-4-one (7e). Yellow crystals; (77%); mp 210-212 ^{o}C; (EtOH/dioxane); IR (KBr): 3110, 3027 (NH), 1686 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 3.44 (s, 3H, CH_3), 7.61 (d, 2H, *J* = 8.2 Hz, Ar), 7.78 (s, 1H), 7.82 (d, 2H, *J* = 8.2 Hz, Ar), 10.57 (s, 1H, NH). Anal. Calcd. for $C_{12}H_9Cl_4NO_2S$: C, 38.63; H, 2.43; Cl, 38.01; N, 3.75; S, 8.59; found: C, 38.21; H, 2.26; N, 3.98; S, 8.40.

(*Z*)-5-(1,3-Benzodioxol-5-ylmethylene)-2-methoxy-2-(trichloromethyl)thiazolidin-4-one (7f). Yellowish-white crystals; (65%); mp 138-140 ^{o}C (EtOH); IR (KBr): 3140 (NH), 1680 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 3.66 (s, 3H), 6.09 (s, 2H), 6.93-7.57 (m, 3H), 7.77 (s, 1H) 10.47 (br., 1H, NH); MS: *m/z* (%); 381 (M^+, 9.5), 368 (10.7), 356 (19), 324 (16.7), 233 (11.9), 220 (25), 209 (22.6), 189 (21.4), 177 (100), 144 (38.1), 120 (28.6), 107 (35.7), 89 (38.1), 68 (50). Anal. Calcd. for $C_{13}H_{10}Cl_3NO_4S$: C, 40.81; H, 2.63; Cl, 27.80; N, 3.66; S, 8.38. Found: C, 40.60; H, 2.35; Cl, 28.03; N, 3.43; S, 8.65.

(*Z*)-5-(Furyl-2-ylmethylene)-2-methoxy-2-(trichloromethyl)thiazolidin-4-one (7g). Brown crystals; (60%); mp 134-136 ºC (EtOH); IR (KBr): 3130, 3035 (NH), 1684 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 3.53 (s, 3H), 6.81-8.18 (m, 3H), 7.35 (s, 1H), 10.41 (s, 1H, NH); Anal.Calcd. for $C_{10}H_8Cl_3NO_3S$: C, 36.55; H, 2.45; Cl, 32.37; N, 4.26; S, 9.76. Found: C, 36.76; H, 2.67; Cl, 32.16; N, 4.60; S, 9.55.

(*Z*)-5-(Thienyl-2-ylmethylene)-2-methoxy-2-(trichloromethyl)thiazolidin-4-one (7h). Yellowish-brown crystals; (62%); mp 138-140 ºC (EtOH); IR (KBr): 3137, 3044 (NH), 1684 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 3.48 (s, 3H), 6.78–8.08 (m, 3H), 7.37 (s, 1H), 10.44 (s, 1H, NH). Anal.Calcd. for $C_{10}H_8Cl_3NO_2S_2$: C, 34.85; H, 2.34; Cl, 30.86; N, 4.06; S, 18.61. Found: C, 34.64; H, 2.54; Cl, 30.67; N, 4.28; S, 18.41.

(*Z*)-5-[4-(Chorophenylmethylene)-2-propoxy-2-(trichloromethyl)]-thiazolidin-4-one (7i). Pale yellow crystals; (67%); mp 196-198 ºC (EtOH/dioxane); IR (KBr): 3126, 3033 (NH), 1686 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 1.11 (t, 3H, *J* = 6.8), 1.61 (m, 2H), 3.61 (t, 2H, *J* = 6.2 Hz), 7.54 (d, 2H, *J* = 8.0 Hz, Ar), 7.78 (s, 1H), 7.79 (d, 2H, *J* = 8.0 Hz, Ar) 10.51 (s, 1H, NH). Anal. Calcd. for $C_{14}H_{13}Cl_4NO_2S$: C, 41.92; H, 3.27; Cl, 35.35; N, 3.49; S, 7.99; found: C, 41.74; H, 3.46; N, 3.71; S, 7.81.

(*Z*)-5-(1,3-Benzodioxol-5-ylmethylene)-2-propoxy-2-(trichloromethyl)-thiazolidin-4-one (7j). Yellow crystals; (66%); mp 173-175 ºC (EtOH/dioxane); IR (KBr): 3142, 3028 (NH), 1685 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 0.92 (t, 3H, *J* = 7.2 Hz), 1.58 (m, 2H), 3.58 (t, 2H, *J* = 6.2 Hz), 6.10 (s, 2H, CH_2), 7.06-7.12 (m, 3H), 7.47 (s, 1H), 10.43 (br., 1H, NH). Anal.Calcd. for $C_{15}H_{14}Cl_3NO_4S$: C, 43.87; H, 3.44; Cl, 25.90; N, 3.41; S, 7.81. Found: C, 43.66; H, 3.25; Cl, 25.68; N, 3.64; S, 7.60.

(*Z*)-5-(Furyl-2-ylmethylene)-2-propoxy-2-(trichloromethyl)thiazolidin-4-one (7k). Brown crystals; (58%); mp 155-157 ºC (MeOH); IR (KBr): 3309 (NH), 1684 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 0.91 (t, 3H, *J* = 6.3 Hz), 1.58 (m, 2H), 3.61 (t, 2H, *J* = 7.0 Hz), 7.28-7.75 (m, 3H), 7.92 (s, 1H), 10.44 (br., 1H, NH). Anal.Calcd. for $C_{12}H_{12}Cl_3NO_3S$: C, 40.41; H, 3.39; Cl, 29.82; N, 3.93; S, 8.99. Found: C, 40.18; H, 3.17; Cl, 29.61; N, 3.69; S, 9.28.

(*Z*)-5-(Thienyl-2-ylmethylene)-2-propoxy-2-(trichloromethyl)thiazolidin-4-one (7l). Yellowish-brown crystals; (67%); mp 165-167 ºC (toluene); IR (KBr): 3309 (NH), 1687 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ = 0.99 (t, 3H, *J* = 6.6 Hz), 1.62 (m, 2H), 3.62 (t, 2H, *J* = 7.7 Hz), 7.23-7.82 (m, 3H), 7.79 (s, 1H), 10.47 (br., 1H, NH). Anal.Calcd. for $C_{12}H_{12}Cl_3NO_2S_2$: C, 38.67; H, 3.25; Cl, 28.54; N, 3.76; S, 17.21. Found: C, 38.38; H, 3.45; Cl, 28.75; N, 3.52; S, 17.42.

Reaction of 1a-d with nitriles: Synthesis of 5-arylidene-2,4-thiazolidine derivatives (8a-d)

A mixture of **1a-d** (10 mmol) and trichloroacetonitrile or 2-(1-amino-2,2,2-trichloroethylidene)malononitrile **11a** or ethyl 3-amino-4,4,4-trichloro-2-cyanobut-2-enoate **11b** or 3-(1-amino-2,2,2-trichloroethylidene)pentane-2,4-dione **11c** (10 mmol) in 20 ml of glacial acetic acid was refluxed for 2 h (TLC). The coloured solid precipitated, was filtered off, and recrystallized from the proper solvent.

5-(4-Chlorophenylmethylene)-2,4-thiazolidinedione (8a). Yellow crystals; (82%), mp, 241-243 ºC (AcOH); IR (KBr): 3146 (NH), 1753 (CO), 1721 cm^{-1} (CO). ^{1}H NMR (DMSO-d_6): δ =

7.37 (d, 2H, *J* = 7.8 Hz, Ar.), 7.71 (s, 1H), 7.97 (d, 2H, *J* = 7.8 Hz, Ar), 10.25 (s, 1H, NH). Anal. Calcd. for $C_{10}H_6ClNO_2S_2$: C, 50.11; H, 2.52; Cl, 14.79; N, 5.84; S, 13.38. Found: C, 50.20; H, 2.34; N, 5.60; S, 13.56.

5-(1,3-Benzodioxol-5-ylmethylene)-2,4-thiazolidinedione (8b). Yellow crystals; (84%); mp 246-248 ºC (AcOH); IR (KBr): 3141 (NH), 1739 (CO), 1697 cm^{-1} (CO). ^1H NMR (DMSO-d_6): δ = 6.10 (s, 2H), 6.93 (d, 1H, *J* = 8.2 Hz), 7.25 (d, 1H, *J* = 9.6 Hz), 7.58 (s, 1H), 7.77 (s, 1H), 12.90 (s, 1H, NH); MS: *m/z* (%); 249 (M^+, 0.21), 224 (22.79), 206 (1.96), 193 (2.38), 178 (100), 165 (4.26), 149 (13.05), 135 (10.81), 120 (18.21), 105 (2.09), 93 (4.65), 77 (11.09), 69 (7.59), 50 (4.38). Anal.Calcd. for $C_{11}H_7NO_4S$: C, 53.01; H, 2.83; N, 5.62; S, 12.86. Found: C, 53.22; H, 2.61; N, 5.95; S, 12.63.

5-(Furyl-2-ylmethylene)-2,4-thiazolidinedione (8c). Brown crystals; (68%); mp 235-237 ºC (AcOH); IR (KBr): 3133 (NH) and 1725 (CO), 1685 cm^{-1} (CO). ^1H NMR (DMSO-d_6): δ = 6.90-8.21 (m, 3H), 7.56 (s, 1H), 11.48 (s, 1H, NH). Anal.Calcd. for $C_8H_5NO_3S$: C, 49.23; H, 2.58; N, 7.18; S, 18.43. Found: C, 49.45; H, 2.81; N, 7.42; S, 18.24.

5-(Thienyl-2-ylmethylene)-2,4-thiazolidinedione (8d). Yellow crystals; (70%); mp 230-232 ºC (EtOH); IR (KBr): 3125 (NH) and 1733 (CO), 1679 cm^{-1} (CO). ^1H NMR (DMSO-d_6): δ = 7.50-8.16 (m, 3H), 7.61 (s, 1H), 11.44 (s, 1H, NH). Anal.Calcd. for $C_8H_5NO_2S_2$: C, 45.48; H, 2.39; N, 6.63; S, 30.36. Found: C, 45.66; H, 2.18; N, 6.86; S, 30.57.

Crystallographic data for the structural analysis of compounds **4a** and **7b** has been deposited with the Cambridge Crystallographic Data centre (CCDC) under the numbers 808332 and 808807, respectively. Copies of the information may be obtained free of charge from the Director, CCDC, 12 Union Road, Cambridge CB2 IEZ, UK (Fax: +44-01223-336033; e-mail: deposit@ccdc.cam.ac.uk or www: http://www.ccdc.cam.ac.uk).

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