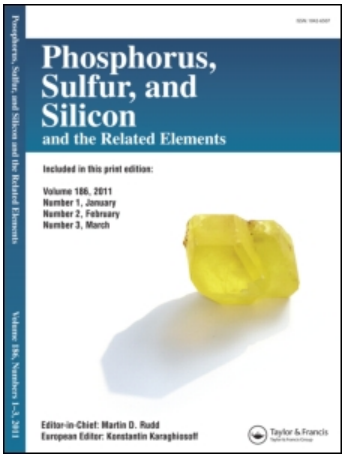

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Reactions of 3-substituted 5-Arylmethylene-1,3-Thiazolidin-2,4-diones with Azide and Cyanide Ions

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*3-substituted-5-arylmethylene-1,3-thiazolidine-2,4-diones **3a–e** react- ed with sodium azide to afford pyrazolinone derivatives **8a–d** as well as 5-(4-chlorophenylmethylene)-1,3-thiazolidine-2,4-dione **7a** in the case of **3d** and 5-(4-methoxyphenylmethylene-1,3-thiazolidin-2,4-dione **7b** as a sole product in the case of **3e**. Reactions of potassium cyanide with **3b–d** gave butyronitrile derivative **9** as well as **7a** and a water soluble adduct that, upon treatment with chloroacetic acid, yielded **10** in the case of **3c** and **3d**. Also, the treatment of **3e** with potassium cyanide afforded a mixture of **7b**, but-3-enonitrile derivative **11** and **10**. Structures of all products were elucidated by microanalytical and spectral data.*

Keywords 5-arylmethylene-1,3-thiazolidin-2,4-diones; 2-oxo-but-3-enonitrile; butyronitrile derivative; pyridazine derivatives; pyrazolinone derivatives

INTRODUCTION

It has been reported[1–4] that 3-substituted-5-arylmethylene-1,3-thiazolidin-2,4-diones react with hydrazines, morpholine, benzylamine, and piperidine to afford pyrazolinones, thiolopropenamides, arylaminocarboxamide, and N-phenylacrylamide derivatives, respectively. However, the 3-unsubstituted derivatives gave, upon treatment with hydrazine hydrate and piperidine, the corresponding triazinone[3,5] and acrylamide derivatives.[6] The latent ability of this ring system to cleave at 1,2- as well as 3,4- bonds encouraged us to synthesize some 3-substituted 5-arylmethylene-1,3-thiazolidin-2,4-diones to investigate the behavior of this ring toward azide and cyanide ions that had previous not be studied.

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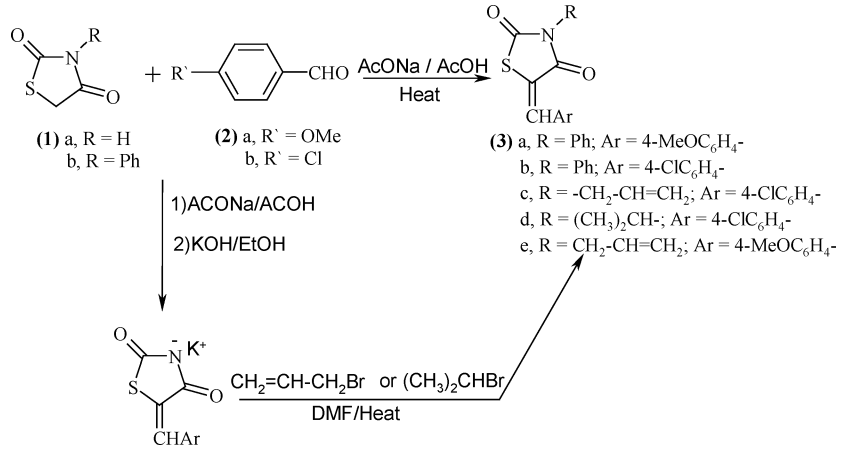
RESULTS AND DISCUSSION

The starting materials (**3a,b**) were synthesized by condensing 3-phenyl-1,3-thiazolidin-2,4-dione (**1b**) with the appropriate aldehyde using sodium acetate-acetic acid.[6] However, (**3c–e**) were prepared following the method of Lo et al.[7] by treating the potassium salt of the respective N-unsubstituted analogues obtained from 1,3-thiazolidin-2,4-dione **1a** and the appropriate aldehyde with allyl or isopropyl bromide in dimethylformamide and were shown to be mixtures of the (E) and (Z)-isomers,[3] as represented in Scheme 1. In the present study, the (E,Z)-mixtures were used without separation.



SCHEME 1

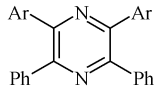
Unfortunately, attempts to prepare new 5-arylidene-1,3-thiazolidin-2,4-diones through the condensation of (**1a,b**) with benzoin (**4a**), 4-methoxybenzoin (**4b**), and benzoylacetone (**4c**) gave a poor yield of adducts.

Thus reacting equimolar amounts of 1,3-thiazolidin-2,4-dione (**1a**) with benzoin (**4a**), 4-methoxybenzoin (**4b**), or benzoylacetone (**4c**) in refluxing toluene in the presence of ammonium acetate as a base afforded a mixture of **5a** (major), and **6a** (minor), **5b**, or **6b**, respectively. Similar treatment of 3-phenyl-1,3-thiazolidin-2,4-dione (**1b**) with **4a** gave a mixture of **5a** (major) and **6c** (minor).

The structures of compounds **5** and **6** were elucidated from their analytical and spectral data. The infrared spectra of **5** showed absorption bands corresponding to C═N and/or C═C. However, those of compounds **6** exhibited stretching absorptions assignable to NH and/or OH as well as two strong absorptions, which were characteristic of C═O

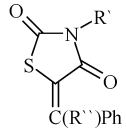
(4)

a, R = -CH(OH)Ph; Ar = Ph
b, R = -CH(OH)Ph; Ar = 4-MeOC$_6$H$_4$-
c, R = -CH$_2$COCH$_3$; Ar = Ph



(5)

a, Ar = Ph
b, Ar = 4-MeOC$_6$H$_4$-

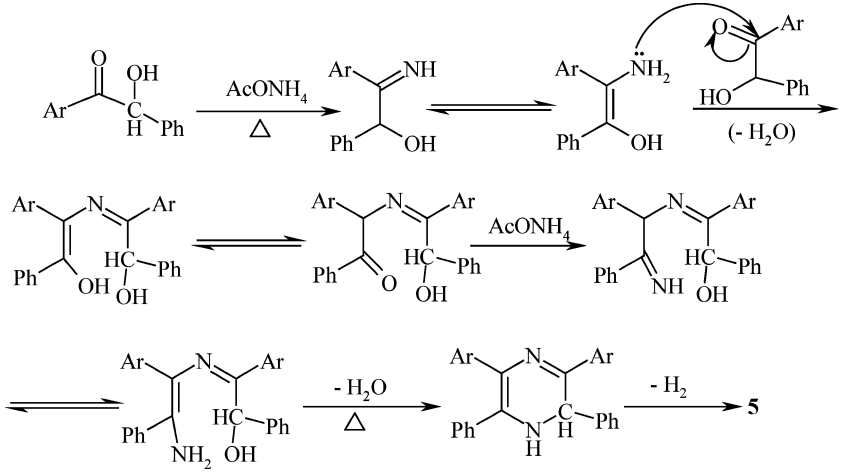


(6)

a, R` = H; R`` = -CH(OH)Ph
b, R` = H; R`` = -CH=C(OH)CH$_3$
c, R` = Ph; R`` = -CH(OH)Ph

SCHEME 2

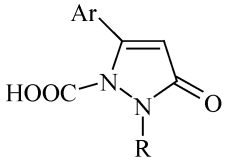
in the respective systems. The ^{1}H NMR spectra of compounds **5** and **6a,c** were in accord with the proposed structures. Compound **5b** exhibited a singlet signal for methoxy protons. However, compounds **6a,c** revealed exchangeable singlets for OH and/or NH protons as well as singlet signals for methine protons. The downfield value for the OH proton signal of compounds **6a,c** suggested the existence of chelation with the 4-oxo group of the heteroring. Further elucidation was gained from EI-MS spectra that showed peaks for compounds **5**. However, the EI-MS spectra of compounds **6a**,**b** did not show the molecular ion peaks; instead they showed ($M^{+\cdot}$ – ) peak for compound **6a** and ($M^{+\cdot}$ –HNCO–CH=C(OH)CH$_3$) peak in the case of **6b**, beside some of abundant peaks.



SCHEME 3

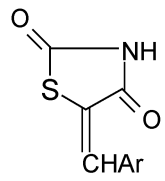
The formation of compounds **5** is shown in Scheme 3.

The treatment of (E,Z)-3-substituted-5-arylmethylene-1,3-thiazolidin-2,4-diones **3a–d** with sodium azide (3 equiv.) in refluxing dimethyl-



(8)

a, R = Ph; Ar = 4-$MeOC_6H_4$-
b, R = Ph; Ar = 4-ClC_6H_4-
c, R = -CH_2-CH=CH_2; Ar = 4-ClC_6H_4-
d, R = $(CH_3)_2$CH-; Ar = 4-ClC_6H_4-



(7)

a, Ar = 4-ClC_6H_4-
b, Ar = 4-$MeOC_6H_4$-

SCHEME 4

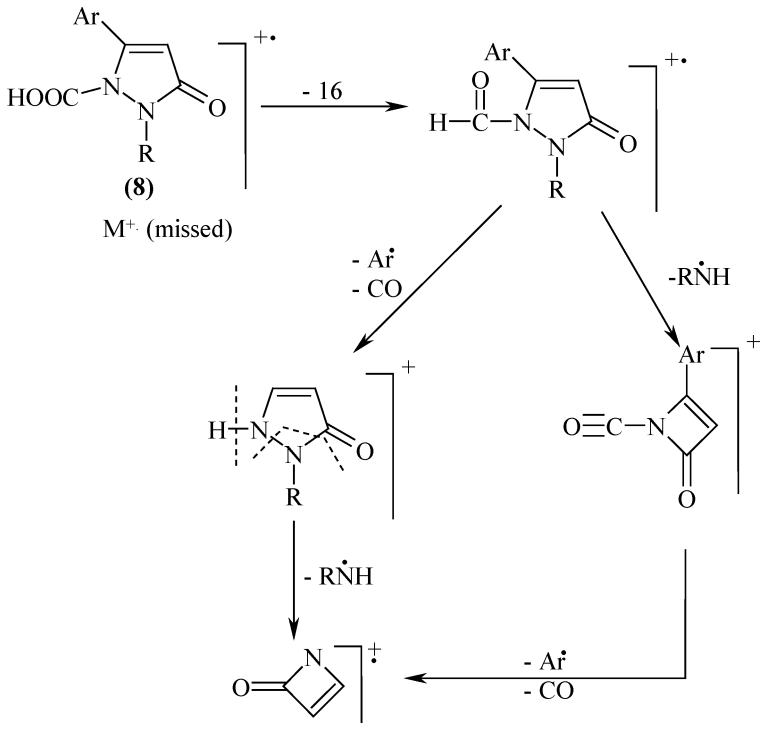
formamide afforded the pyrazolinone derivatives **8a–d** (major) as well as 5-(4-chlorophenylmethylene)-1,3-thiazolidin-2,4-dione (**7a**) in a minor amount in the case of **3d**. Similar treatment of **3e** with sodium azide yielded 5-(4-methoxyphenylmethylene)-1,3-thiazolidin-2,4-dione as sole products.

The structure of compounds **8a–d** was substantiated from their analytical and spectral data. Their infrared spectra showed stretching absorptions assignable to OH, C=O, and C=C groups of pyrazolinones.[8] The ^{1}HNMR spectra of **8** were in good agreement with the suggested structure. Further elucidation was gained from their EI-MS where they did not show the molecular ion peak; instead a peak corresponding to $M^{+\cdot} - 16$. The fragmentation pathway of compounds **8** is shown in Scheme 5.

The structure of compounds **7a** and **7b** was rigidly confirmed by mixture m.p. with authentic samples.[7]

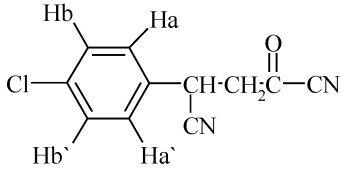
The formation of compounds **7** and **8** (cf. Scheme 6) could be rationalized on the basis of an attack of the azide ion at the allyl or isopropyl group to afford the anion A. Protonation of this anion yielded adducts **7a** and **7b** (route a). The thiazolidine ring opening through an attack of the azide ion at the 2-oxo- group followed by Curtius rearrangement gave the isocyanate intermediate (B). Successive hydrolysis, intramolecular cyclization followed by elimination of hydrogen sulfide, afforded the pyrazolinone salt C. Acidification of (C) gave compounds **8** (route b).

However, treating (E,Z)-3-phenyl-5-(4-chlorophenylmethylene)-(**3b**)-, (E,Z)-3-allyl-5-(4-chlorophenylmethylene)-(**3c**)-, and (E,Z)-3-isopropyl-5-(4-chlorophenylmethylene)-(**3d**)-1,3-thiazolidin-2,4-diones with potassium cyanide in a boiling mixture of methanol and dioxane afforded 4-cyano-4-(4-chlorophenyl)-2-oxobutyronitrile (**9**) as well as (E,Z)-5-(4-chlorophenylmethylene)-1,3-thiazolidin-2,4-dione (**7a**) and a water soluble adduct that, upon treating its methanolic

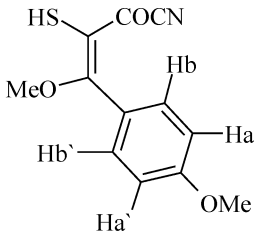


SCHEME 5

solution with chloroacetic acid, gave ammonium chloroacetate (**10**) in the case of **3c** and **3d**. Similar treatment of (E,Z)-3-allyl-5-(4-methoxyphenylmethylene)-1,3-thiazolidin-2,4-dione (**3e**) with potassium cyanide gave a mixture of (E,Z)-5-(4-methoxyphenylmethylene)-1,3-thiazolidin-2,4-dione (**7b**), but-3-enonitrile derivative **11** and a water soluble adduct that yielded compound **10** upon treating its methanolic solution with chloroacetic acid.



(9)



(11)

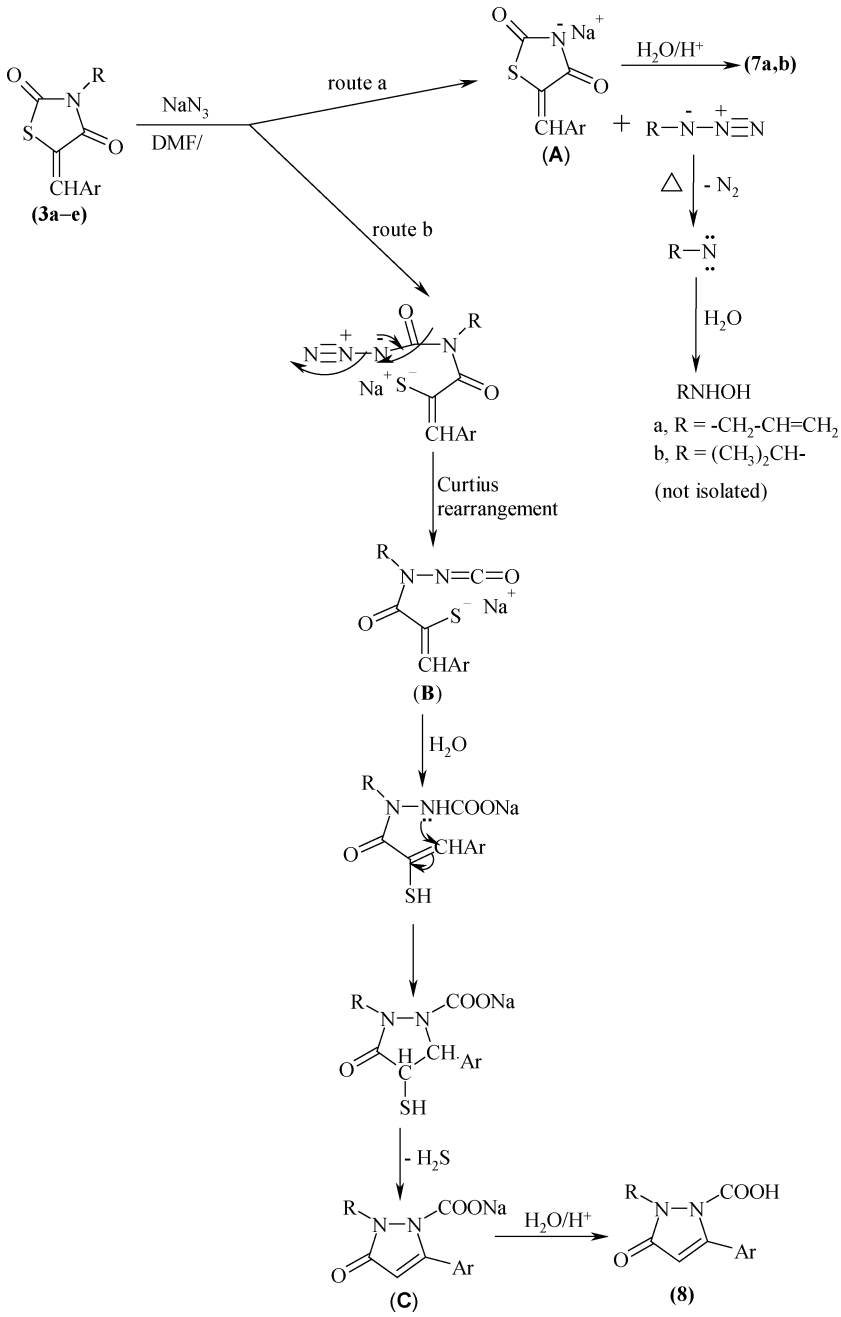


FIGURE 6

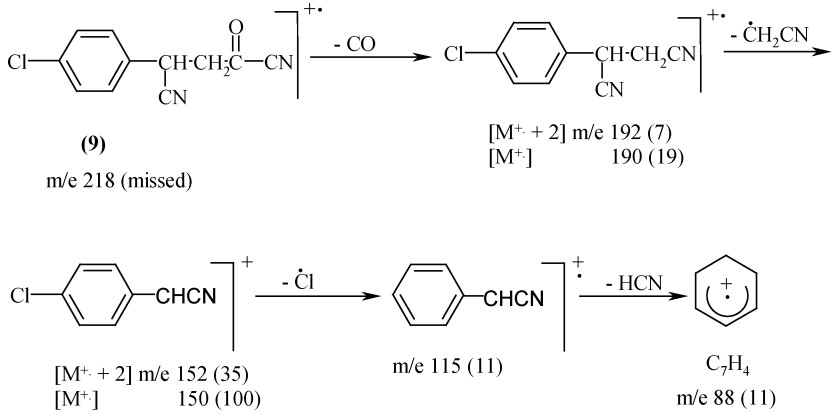


FIGURE 7

The structures of compounds **9** and **11** were substantiated from their analytical and spectral data. Their IR spectra exhibited stretching absorptions for CN and CO groups beside an additional absorption for the SH group in the case of compound **11**.

The ^{1}H NMR spectrum of compound **9** was consistent with the suggested structure as it showed from low to high field the signals of aromatic, methine, and methylene protons. Its EI-MS spectrum did not show the molecular ion peak, but it showed a peak at m/e 190 that corresponds to ($M^{+\cdot}$ – CO). The fragmentation pathway is represented in Scheme 7.

The ^{1}HNMR spectrum of **11** revealed the existence of two closely spaced singlets for protons of two methoxy groups, an exchangeable singlet for the SH proton, as well as two doublet signals for aromatic protons. Moreover, the structure of **11** got further support from its EI-MS as it showed the molecular ion peak beside some abundant peaks. The fragmentation pattern is shown in Scheme 8.

The structures of compounds **7a** and **7b** were rigidly confirmed by m.p. comparison with those reported.[7] However, the structure of **10** was confirmed by mixture m.p. with authentic speciment.

The overall picture for the mode of action of the cyanide ion on 3-aryl and 3-alkyl substituted-5-arylmethylene-1,3-thiazolidin-2,4-diones **3b–e** is easily visualized as represented by type (A) and type (B) (cf. Scheme 9). Type (A) involves an initial attack by the cyanide ion at the allyl or isopropyl group to afford the anion (A). Protonation of this anion yielded the adducts **7a** and **7b**. Thiazolidine ring opening of this anion at the 1,2-bond gave the thiolate anion (B), which underwent 3,4-bond cleavage to give isocyanate (C) and thirane (D). The

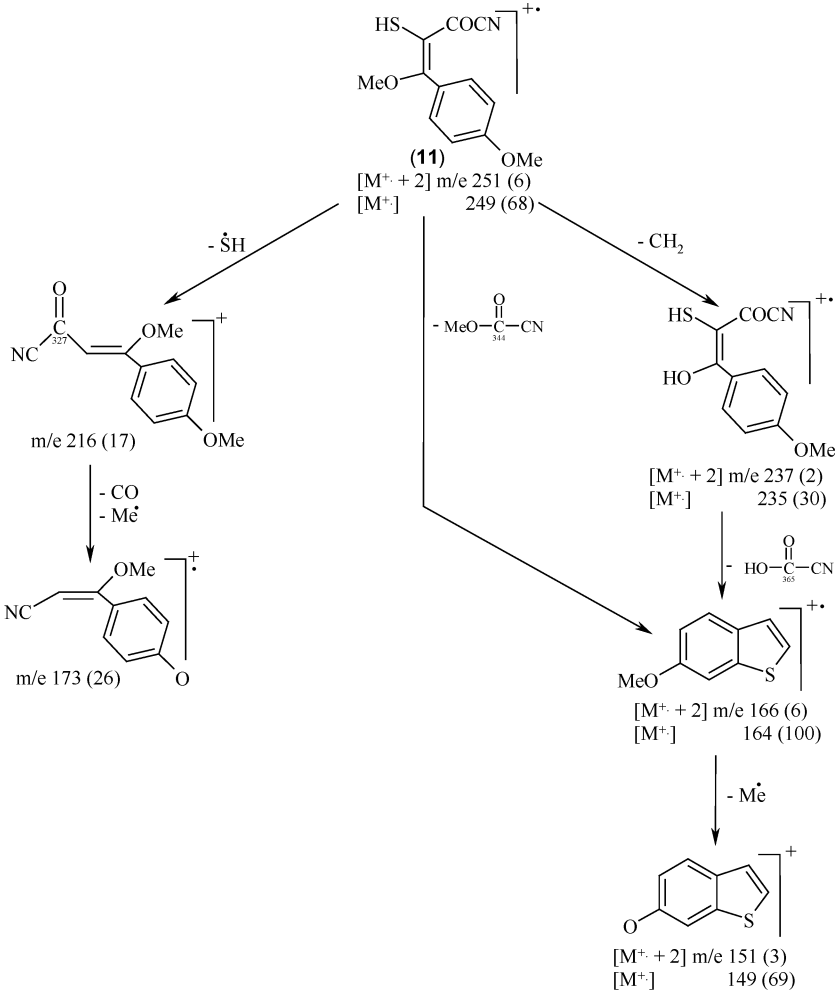


FIGURE 8

addition of water to (C) gave the carbamate (E), which, on treatment of its methanolic solution with chloroacetic acid, afforded **10**. A thirane ring opening through attack by the CN^- ion at the 2-oxo group followed by the addition of the solvent molecule (MeOH)[9] at the β-carbon of the exocyclic double bond gave the methoxy adduct (F). Oxidation of the methoxy adduct (F) afforded (G), which, upon protonation, yielded **11**.

Type (B) involves the thiazolidine ring opening through successive cleavage at the 1,2- as well as the 3,4-bonds to give the isocyanate (H) and the thirane (D). The thirane ring opening through attack by

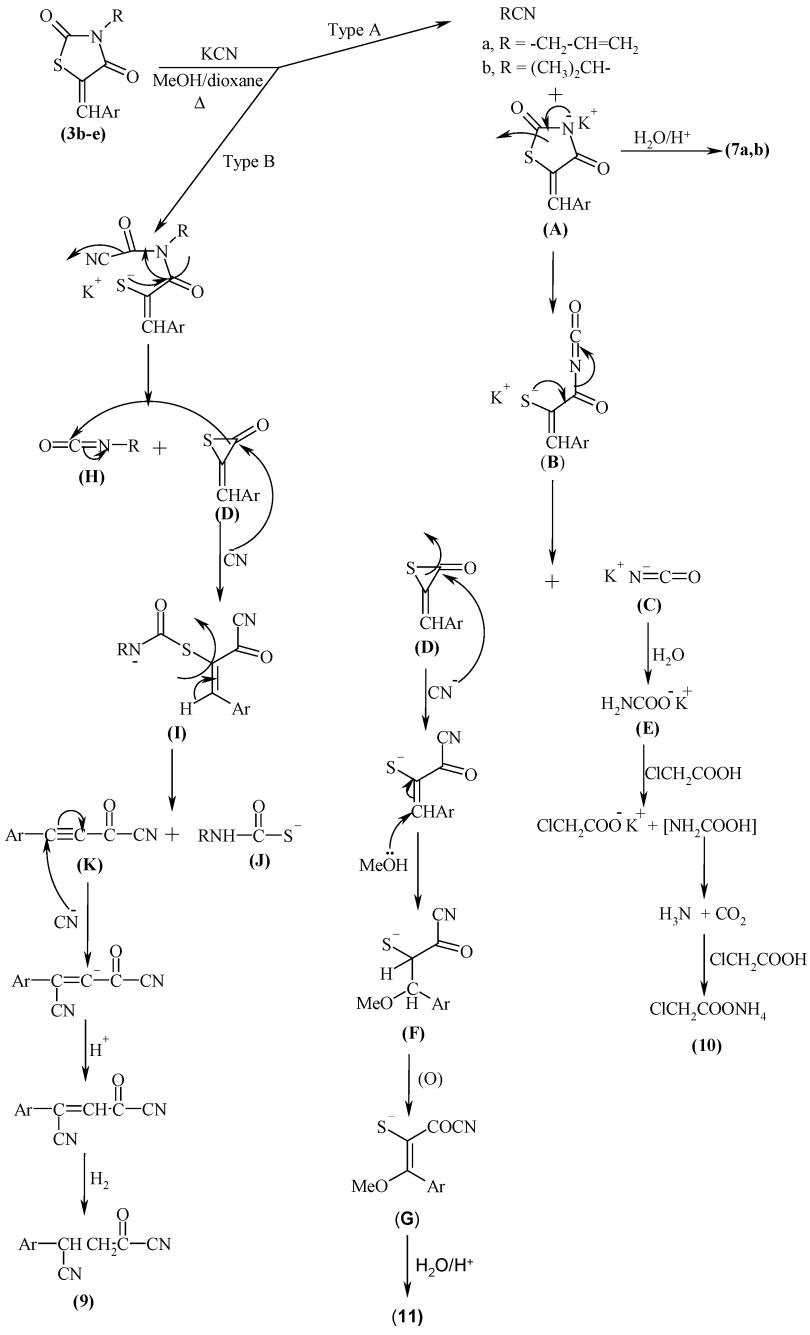


FIGURE 9

the cyanide ion at the 2-oxo group followed by reaction of the formed thiolate ion with the isocyanate (H) gave (I). Cleavage of (I) yielded the thiocarbamate (J) and the acetylenic ketone (K). Attack by another cyanide ion at the β-acetylenic carbon of (K) followed by reduction afforded **9**.

CONCLUSION

It is inferred that reactions of 3-substituted-5-arylmethylene-1,3-thiazolidine-2,4-diones with azide and cyanide iones proceed through 1,2- as well as 3,4- bond cleavage, as reported[1–4] before with hydrazines, morpholine, benzyl amine, and piperidine, and not through an attack at the β-carbon of the exocyclic double bond as reported[10] in the reaction of 4-methoxyphenylazide with 3-substituted-5-arylmethylene-4-oxo-2-thioxo-1,3-thiazolidine.

EXPERIMENTAL

All melting points are uncorrected. IR spectra were measured on a Unicam SP1200 spectrometer as KBr discs. Unless otherwise stated, the ^{1}HNMR spectra were measured in $CDCl_3$ solution on Varian Gemini 200 MHz or Brucker ES 200 MHz instruments with chemical shift (δ) expressed in ppm downfield from Me_4Si. Mass spectra were recorded on Shimadzu GC-MS-QP 1000 Ex or Finnigan GCQ instruments operating at 70 eV. Column chromatography and TLC[10,11] were run using Silica Gel Voein, activity III/30 mm according to Brockmann and Schodder and TLC aluminium sheets Silica Gel 60 F_{254} (Merck).

Reactions of (1a,b) with (4a–c)

A solution of (**1a**) or (**1b**) (10 mmoles) and (**4a–c**) (10 mmoles) in 25 mL toluene in the presence of ammonium acetate (2.31 g, 30 mmoles) was refluxed for 15 h. The reaction mixture was cooled and then poured into cold water. The toluene layer was dried over anhydrous calcium chloride, concentrated, and left to stand over night at room temperature. The precipitated solid was recrystallized from a proper solvent to give the adducts **5b** and **6b** in the case of reactions of **1a** with **4b** and **4c**. The adduct **5a** was isolated from the reaction of **1a** with **4a**, and the residual oil was chromatographed over silica gel. Elution with petroleum ether (b.p. 40–60)/ ether (4 : 1 V / V) gave **6a**. The precipitated solid in the case of the reaction of **1b** with **4a** was fractionally crystallized to give first **6c** as yellow crystals (ethanol). The insoluble part in boiling ethanol was recrystallized from benzene to give **5a** as white crystals.

2,3,5,6-Tetraphenyl-1,4-diazine (5a)

1.5 g (30%) white crystals (benzene), m.p. 241–243 °C; IR: $\nu_{max} = 3080$ (aryl-H), 1615 (C=C and/or C=N), 760, 690 cm^{-1}. ^{1}HNMR: δ 7.31–7.68 (m, 20, ArH). EI-MS m/z (%) 384 ($M^{+\cdot}$, 77), 383 (68), 179 (14), 178 (base), 177 (20), 176 (35), 152 (20), 151 (14), 103 (13), 77 (10), 76 (13), 51 (11). Anal. calcd. for $C_{28}H_{20}N_2$: C, 87.47; H, 5.24; N, 7.29. Found : C, 87.21; H, 5.49; N, 7.10%.

2,6-Diphenyl-3,5-di-(4-methoxyphenyl)-1,4-diazine (5b)

1.1 g (25%), white crystals (methanol-benzene), m.p. 190–192°C; IR: $\nu_{max} = 3020$ (aryl-H), 2920, 2830 (alkyl-H), 1610 (C=C and/or C=N), 835, 760, 700 cm^{-1}. ^{1}HNMR: δ 3.83 (s, 6, $2OCH_3$), 6.83–7.69 (m, 18, ArH). EI-MS m/z (%) 444 ($M^{+\cdot}$, base), 443 (53), 208 (31), 193 (54), 165 (50), 164 (17), 163 (11), 139 (11), 104 (25). Anal. calcd. for $C_{30}H_{24}N_2O_2$: C, 81.06; H, 5.44; N, 6.30. Found: C, 81.22; H, 5.11; N, 6.45%.

5-(1,2-Diphenyl-2-hydroxy)ethylene-1,3-thiazolidin-2,4-dione (6a)

0.37 g (12%), yellow crystals (ethanol), m.p. 314-316 °C; IR: $\nu_{max} = 3340$, 3130 (OH and/or NH), 3055 (aryl-H), 2930, 2860 (alkyl-H), 1740, 1690 (C=O), 765, 690 cm^{-1}. ^{1}HNMR: δ 4.02 (s, 1, CH), 7.24-7.42 (m, 10, ArH), 10.01 (br.s, 1, OH exchangeable), 10.15 (br.s, 1, NH exchangeable). EI-MS m/z (%) 311 ($M^{+\cdot}$, missed), 236 ($M^{+\cdot}$ –  , 88), 165 (16), 105 (63), 104 (base), 103 (16), 77 (51), 76 (12), 51 (35). Anal. calcd. for $C_{17}H_{13}NO_3S$: C, 65.58; H, 4.21; N, 4.49. Found: C, 65.41; H, 4.46; N, 4.19%.

5-(1-Phenyl-3-hydroxy)-but-2-en-1-ylene-1,3-thiazolidin-2,4-dione (6b)

0.39 g (15%), pale yellow crystals (ethanol), m.p. 140-142 °C; IR: $\nu_{max} =$ 3314, 3160 (OH and/or NH), 3060 (aryl–H), 2983, 2875 (alkyl-H), 1743, 1635 (C=O), 1595 (C=C), 641, 754 cm^{-1}. EI-MS m/z (%) 261 ($M^{+\cdot}$, missed), 161 ($M^{+\cdot}$ – HNCO–CH=C(OH)CH_3, 38), 160 (88), 84 (base), 77 (33), 51 (29). Anal. calcd. for $C_{13}H_{11}NO_3S$: C, 59.76; H, 4.24; N, 5.36. Found: C, 59.42; H, 4.39; N, 5.29%.

3-Phenyl-5-(1,2-diphenyl-2-hydroxy)ethylene-1,3-thiazolidin-2,4-dione (6c)

0.77 g (20%), yellow crystals (ethanol), m.p. 138–140°C, IR: $\nu_{max} = 3380$, 3210 (OH and/or NH), 3070 (aryl–H), 2985, 2874 (alkyl-H), 1728, 1676 (C=O), 752, 692 cm^{-1}. ^{1}HNMR: δ 4.1 (s, 1, CH) 7.18–7.51 (m, 15, ArH), 10.12 (br.s, 1, OH exchangeable) Anal. calcd. for $C_{23}H_{17}NO_3S$: C, 71.29; H, 4.42; N, 3.62. Found: C, 71.48; H, 4.23; N, 3.79%.

Reactions of 3-Substituted-5-arylmethylene-1,3-thiazolidin-2,4-diones (3a–e) with Sodium Azide

A mixture of (**3a–e**) (10 mmoles) and sodium azide (1.95 g, 30 mmoles) was refluxed in dimethylformamide (20 mL) for 20 h. The color of the reaction mixture changed from yellow to brown to orange, and then to yellow again. The precipitated solid during the reaction was filtered off; part of it was dissolved in water and then acidified with ice cold HCl, where no precipitate was obtained. This solid was not identified due to its very poor yield and the difficulty of doing detailed characterization as it is insoluble in all organic solvents and its m.p. is >300°C . The reaction mixture was cooled, concentrated, and then poured into ice cold water. The precipitated solid was recrystallized from a proper solvent to give (10–15%) of unreacted starting materials **3a–e**. The filtrate was acidified with ice cold HCl. The solid obtained was fractionally crystallized to afford **7a** and **7b** in the case of **3d** and **3e** (identical m.p. with the reported[7]), and **8a–d**, respectively.

E,Z-5-(4-Chlorophenylmethylene)-1,3-thiazolidin-2,4-dione (E,Z-7a)

0.6 g (10%); yellow crystals (ethanol-benzene), m.p. 224–226°C, Lit.[7], m.p. 223–225°C.

E,Z-5-(4-Methoxyphenylmethylene)-1,3-thiazolidin-2,4-dione (E,Z-7b)

0.7 g (12%), yellow crystals (ethanol), m.p. 208–210°C, Lit.,[7] m.p. 212–214°C.

1-Carboxy-2-phenyl-3-oxo-5-(4-methoxyphenyl)-2,3-dihydropyrazole (8a)

1.55 g (50%), colorless crystals (ethanol-benzene), m.p. 152–154°C; IR: $\nu_{max} = 3400$, 3150 (br.) (OH), 1665 (C=O), 1600 (C=C), 1550 (pyrazole

ring), 830, 690 cm^{-1}. ^{1}HNMR : δ 3.77 (s, OMe), 6.89–7.97 (m, 10, ArH + CH=), 9.1 (br.s, 1, OH exchangeable). EI-MS m/z (%) 310 ($M^{+\cdot}$, missed), 294 ($M^{+\cdot}$ – 16, 23), 202 (26), 146 (15), 135 (24), 134 (19), 119 (25), 93 (base), 77 (20), 76 (15), 65 (16), 51 (17). Anal. calcd. for $C_{17}H_{14}N_2O_4$: C, 65.80; H, 4.55; N, 9.03. Found: C, 65.97; H, 4.35; N, 8.89%.

1-Carboxy-2-phenyl-3-oxo-5-(4-chlorophenyl)-2,3-dihydropyrazole (8b)

1.73 g (55%), colorless crystals (xylene), m.p. 208–210°C; IR: ν_{max} = 3389, 3196 (br.) (OH), 1671 (C=O), 1601 (C=C), 1548 (pyrazole ring), 829, 747, 684 cm^{-1}. ^{1}HNMR : δ 7.37–7.98 (m, 10, ArH + CH=), 8.92 (br.s, 1, OH exchangeable). EI-MS m/z (%) 314 ($M^{+\cdot}$, missed), 300 ($M^{+\cdot}$ + 2 − 16, 5), 298 ($M^{+\cdot}$ − 16, 15), 206 (19), 139 (12), 123 (15), 93 (base) 77 (12), 65 (12), 51 (10). Anal. calcd. for $C_{16}H_{11}ClN_2O_3$: C, 61.06; H, 3.52; N, 8.90. Found: C, 61.20; H, 3.39; N, 8.74%.

1-Carboxy-2-allyl-3-oxo-5-(4-chlorophenyl)-2,3-dihydropyrazole (8c)

1.33 g (48%), metallic needles (ethanol), m.p. 130–132°C; IR: ν_{max} = 3400, 3118 (br.) (OH), 2980, 2906 (alkyl-H), 1668 (C=O), 1637, 1612 (C=C), 1559 (pyrazole ring), 824 cm^{-1}. ^{1}HNMR: δ 4.08 (m, 2, N—CH_2), 5.22 (m, 2, C$\underline{H}_2$=CH—), 5.91 (m, 1, CH_2=C$\underline{H}$—), 7.28–7.87 (m, 5, ArH + CH=), 13.05 (br.s, 1, OH exchangeable). EI-MS m/z (%) 278 ($M^{+\cdot}$, missed), 264 ($M^{+\cdot}$ + 2 − 16, 13), 262 ($M^{+\cdot}$ − 16, 37), 247 (14), 208 (16), 206 (46), 138 (14), 123 (19), 114 (10), 57 (81), 56 (base). Anal. calcd. for $C_{13}H_{11}ClN_2O_3$: C, 56.03; H, 3.98; N, 10.05. Found: C, 55.84; H, 4.12; N, 10.21%.

1-Carboxy-2-isopropyl-3-oxo-5-(4-chlorophenyl)-2,3-dihydropyrazole (8d)

1.49 g (53%), colorless crystals (benzene-ethanol), m.p. 145–147°C; IR: ν_{max} = 3406, 3104 (br.) (OH), 3050 (aryl-H), 2948, 2899 (alkyl-H), 1669 (C=O), 1550 (pyrazole ring), 820 cm^{-1}. ^{1}HNMR: δ 1.26 (d, $2CH_3$, J = 6.5 Hz), 4.26 (m, 1, C$\underline{H}(CH_3)_2$, J = 6.6 Hz), 7.25–7.79 (m, 5, ArH + CH=), 12.41 (br.s, 1, OH exchangeable). EI-MS m/z (%) 280 ($M^{+\cdot}$, missed), 266 ($M^{+\cdot}$ + 2 − 16, 5) 264 ($M^{+\cdot}$ − 16, 16), 249 (16), 208 (14), 206 (43), 138 (13), 123 (19), 58 (base). Anal. calcd. for $C_{13}H_{13}ClN_2O_3$: C, 55.62; H, 4.67; N, 9.98. Found: C, 55.41; H, 4.81; N, 9.66%.

Reactions of (3b–e) with Potassium Cyanide

A solution of (25 mL) dioxane containing **3a–e** (10 mmoles) and potassium cyanide (1.95 g, 30 mmoles) was heated to 90°C for 25 min. During the reflux, 30 mL of methanol was added in five equal portions. The mixture was refluxed for 4 h. The precipitated solid during heating was filtered off and dissolved in water. Acidification with ice cold HCl was accompanied by effervescence without precipitation of a solid. Treatment of a methanolic solution of this solid with chloroacetic acid afforded **10**. The reaction mixture was concentrated and left to stand at room temperature for 2 h. The precipitated solid was filtered off, dissolved in water, and acidified with ice cold HCl to give a solid. Crystallization from ethanol–benzene afforded **7a** in the case of **3c** and **3d**, in a yield of 8%, m.p. 225–227°C (identical with the reported[7]), and **7b** as an E/Z mixture in a ratio of 35:65 in the case of **3e**, with a yield of 10%, m.p. 208–210°C (identical with the reported[7]). On leaving the mother liquor over night at room temperature, afforded compound **9** in the case of **3b**, **3c**, & **3d**, while **11** was obtained in the case of **3e**.

Ammonium Chloroacetate (10)

0.12 g (11%), white crystals (methanol), m.p. 137–139°C (undepressed on an admixture with an authentic sample prepared by passing ammonia gas over a methanolic solution of chloroacetic acid); IR: $\nu_{max} = 3401$ (NH), 2962, 2942, 2855 (alkyl-H), 1648 cm^{-1} (C=O). ^{1}HNMR (DMSO-d_6): δ 4.04 (s, 2, CH_2) , 4.83 (br.s, 4, NH_4 exchangeable). EI-MS m/z (%) 111 ($M^{+\cdot}$, missed), 96 ($M^{+\cdot}$ + 2 $-NH_3$, 1.4), 94 ($M^{+\cdot}$ $-NH_3$, 4.2), 79 ($ClCH_2-C\equiv O^+$, 1.3), 78 (ClCH=C=O, 0.5), 77 ($ClCH_2C\equiv O^+$, 4.3), 76 (ClCH=C=O, 1), 58 ($M^{+\cdot}$ $-NH_3-HCl$, 1), 50 ($M^{+\cdot}$ $-NH_3$ $-CO_2$, base).

4-Cyano-4-(4-chlorophenyl)-2-oxobutyronitrile (9)

0.87–1.31 g (40–60%), creamy crystals (ethanol), m.p. 87–89°C; IR: $\nu_{max} = 3050$ (aryl-H), 2973, 2945 (alkyl-H), 2247 (CN), 1657 (C=O), 825 cm^{-1}. ^{1}HNMR: δ 2.97 (m, 2, CH_2, J = 6.4 Hz), 4.15 (t, 1, CH, J = 6.8 Hz), 7.37 (d, 2, H_a, $H_{a'}$, J_o = 6.8 Hz), 7.46 (d, 2, H_b, $H_{b'}$, J_o = 6.8 Hz). EI-MS m/z (%) 218 ($M^{+\cdot}$, missed), 192 ($M^{+\cdot}$ + 2 $-CO$, 7), 190 ($M^{+\cdot}$ $-CO$, 19), 152 ($M^{+\cdot}$ + 2 $-CH_2COCN$, 36), 150 ($M^{+\cdot}$ $-CH_2COCN$, base), 115 (11), 88 (11), 75 (22), 74 (14), 63 (20), 62 (13), 61 (11), 51 (21), 50 (34). Anal. calcd. for $C_{11}H_7ClN_2O$: C, 60.43; H, 3.23; N, 12.81. Found: C, 60.25; H, 3.31; N, 12.56%.

3-Mercapto-4-methoxy-4-(4-methoxyphenyl)-2-oxo-but-3-enonitrile (11)

1.2 g (48%), pale brown crystals (ethanol), m.p. 279–281°C; IR: ν_{max} = 3001 (aryl-H), 2929, 2840 (alkyl-H), 2423 (SH), 2056 (CN), 1673 (C=O), 1607 (C=C), 817 cm^{-1}. ^{1}HNMR (DMSO-d_6): δ 3.76, 3.77 (two singlets, 2OCH_3), 2.49 (br.s, 1, SH exchangeable), 7.01 (d, 2, H_a, $H_{a'}$, J_o = 8.8 Hz), 7.47 (d, 2, H_b, $H_{b'}$, J_o = 8.6 Hz). EI-MS m/z (%) 251 ($M^{+\cdot}$ + 2, 6), 249 ($M^{+\cdot}$, 68), 237 (2), 235 (30), 216 (17), 191 (13), 174 (18), 173 (26), 165 (11), 164 (base), 163 (49), 149 (69), 148 (18), 145 (25), 121 (22), 120 (22), 119 (12), 94 (12), 89 (14), 82 (10), 77 (25), 69 (13), 63 (14), 62 (13), 51 (17), 50 (11). Anal. calcd. for $C_{12}H_{11}NO_3S$: C, 57.82; H, 4.45; N, 5.62. Found: C, 57.52; H, 4.62; N, 5.74%.

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