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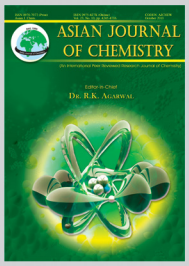

Synthesis of Some New 1,3-Disubstituted-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one: Site Selectivity in Reactions of Nitrilimines with Polyfunctional Dipolarophile

H.M. HASSANEEN[1,*], N.M. ABUNADA[2], O.A. MIQDAD[2] and A.A. FARES[1]

[1]Department of Chemistry, Faculty of Science, Cairo University, Giza, Cairo, Egypt
[2]Department of Chemistry, Faculty of Applied Sciences, Al-Aqsa University, 76888 Gaza, Palestine

*Corresponding author: E-mail:hamdihass@gmail.com

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Some new 1,3-disubstituted-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (**6**, **9** and **11**) were synthesized from the cycloaddition reaction of nitrilimines **2** to 3-phenyl-5-phenylmethylene-2-thiooxothiazolidine-4-one (**1**), 5-phenylmethylene-2-thiooxothiazolidine-4-one (**7**) and 3-phenyl-2-thiooxothiazolidine-4-one (**8**), respectively. The new compounds were characterized using IR, ^{1}H NMR, ^{13}C NMR and mass spectra.

Key Words: Cycloaddition, Nitrilimine, Dipolarophiles.

INTRODUCTION

As a part of our interest in the cycloaddition reaction of nitrilimines with various dipolarophiles[1-8], among of them the heterocyclic thiones, we reported the reaction with 1,3-diphenyl-5-phenylmethylen-2-thione-4-imidazolidinone[7] and 5-arylmethylen-3-phenyl-2-thione-4-thiazolidinone[8], however, the results were contradictory. The nitrilimines cycloadded in the former to the enone/enamine C=C double bond, which led us to consider the C=S double bond to be less reactive than the enone moiety, but in the latter, it cycloadded to the C=S double bond which led us to consider the C=S double bond to be more reactive than both the enamine or enone C=C double bond. In view of these findings we intend here to expand our work on the cycloaddition reaction of nitrilimines with different derivatives of thiazolidinone thiones to shed more light on their reactivity and site selectivity. Moreover, the 1,3,4-thiadiazole derivatives have been found to possess interesting biological activities such as antimicrobial[9,10], analgesic[11], anti-inflammatory[12] and insecticidal activities[13] and thiazolethione derivatives have been suggested to serve as effective photochemical hydroxyl-radical source for photobiological studies[14]. In addition, these findings encourage us to synthesize some new thiadiazolthiazole spiro-derivatives with anticipated biological activities.

EXPERIMENTAL

Melting points were measured on electrothermal melting point apparatus and are uncorrected. The infrared spectra were recorded in potassium bromide disks on a Pye Unicam SP 3-300 and Shimadzu FT-IR 8101 PC infrared spectrophotometer. The ^{1}H NMR (200 MHz) and ^{13}C NMR (50 MHz) spectra were recorded in DMSO-d_6 on a Varian Mercury VX 200 NMR using TMS as the internal reference. Mass spectra were measured on a GCMS-QP 1000 EX spectrometer at 70 eV. Elemental analyses were carried out at the Microanalytical Centre of Cairo University, Giza, Egypt. Hydrazonoyl halides **2a**[15], **2b**[16], **2c**[17], **2d**[18], **2e**[19], **2f**[20], **2g**[21], **2h**[22], **2i**[23], **2j**[24], were prepared according to the methods reported in the literature.

8-Phenylmethylene-6-phenyl-1,3-disubstituted-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6): Triethylamine was added at room temperature to a solution of the appropriate hydrazonoyl halides **2** (5 mmol) and 5-phenylmethylene-3-phenyl-2-thiooxothiazolidin-4-one (**1**) (5 mmol) in chloroform (40 mL). The reaction mixture was refluxed until the reactants disappeared as indicated by TLC analysis. The solvent was evaporated and the residue was triturated with methanol. The solid formed was collected and crystallized from the appropriate solvent to give products **6**.

8-Phenylmethylene-1,3,6-triphenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6a): Yield 75 %, m.p. 191-192 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1692.6 (C=O), 1623.5 (C=N) cm^{-1}. ^{1}H NMR ($CDCl_3$) δ 7.81 (s, 1H, methine H), 7.20-7.81 (m, 20H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.21 (spiro C), 120.34, 121.42, 122.81, 123.80, 126.34, 127.90, 128.56, 128.72, 128.78, 128.93, 129.58, 129.61, 131.29, 135.46, 136.73, 138.91, 139.62, 140.84, 158.66 (C=N), 163.29 (C=O amide). Ms: m/z 491, 381, 362, 329, 194, 135, 91, 77,

51. Anal. Calcd. For $C_{29}H_{21}N_3OS_2$ (491.62) C, 70.85; H, 4.31; N, 13.04. Found C, 71.00; H, 4.30; N, 12.97 %.

1,6-Diphenyl-8-phenylmethylene-3-styryl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6b): Yield 71 %, m.p. 192-194 ºC (dimethylformamide), IR (KBr, ν_{max}, cm^{-1}) 1690.1 (C=O), 1620.9 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.91 (s, 1H, methine H), 6.42-7.80 (m, 22H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.50 (spiro C), 120.81, 122.10, 123.63, 123.91, 124.39, 126.83, 127.87, 128.01, 128.19, 128.53, 128.67, 128.71, 128.80, 129.62, 135.84, 137.74, 138.39, 139.82, 142.31, 142.62, 154.68 (C=N), 163.91 (C=O amide) ppm. Ms: m/z 517, 407, 355, 220, 134, 91, 77, 51. Anal. Calcd. For $C_{31}H_{23}N_3OS_2$ (517.66) C, 71.93; H, 4.48; N, 8.12; S, 12.39. Found C, 72.10; H, 4.42; N, 8.09; S, 12.41 %.

3-(2-Furyl)-1-(4-nitrophenyl)-8-phenylmethylene-6-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6c): Yield 72 %, m.p. 234-236 ºC (dimethylformamide), IR (KBr, ν_{max}, cm^{-1}) 1699.2 (C=O), 1618.4 (C=N). ^1H NMR ($CDCl_3$) δ 7.91 (s, 1H, methine H), 6.81-7.81 (m, 17H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.41 (spiro C), 119.82, 121.41, 123.11, 123.56, 123.78, 124.86, 127.92, 128.31, 128.49, 128.74, 128.82, 135.71, 135.79, 138.90, 139.89, 145.62, 146.58, 151.92, 154.59 (C=N), 163.67 (C=O amide) ppm. Ms: m/z 526, 459, 426, 373, 364, 273, 163, 91, 77, 52. Anal. Calcd. For $C_{27}H_{18}N_4O_4S_2$ (526.58) C, 61.58; H, 3.45; N, 10.64; S, 12.18. Found C, 61.60; H, 3.41; N, 10.61; S, 12.20 %.

1-(4-Nitrophenyl)- 8-phenylmethylene-6-phenyl-3-(2-thienyl)-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6d): Yield 74 %, m.p. 143-144 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1700.3 (C=O), 1613.5 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.83 (s, 1H, methine H), 7.02-8.43 (m, 17H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 95.63 (spiro C), 119.78, 121.62, 122.31, 123.43, 123.52, 124.30, 124.95, 127.89, 128.48, 128.63, 128.74, 135.69, 135.74, 138.91, 139.62, 142.83, 145.60, 146.54, 154.47 (C=N), 164.19 (C=O amide) ppm. Ms: m/z 542, 459, 426, 380, 288, 179, 91, 76, 51. Anal. Calcd. For $C_{27}H_{18}N_4O_3S_3$ (542.65) C, 59.76; H, 3.34; N, 10.32; S, 17.73. Found C, 59.69; H, 3.29; N, 10.40; S, 17.71 %.

3-Acetyl-1,6-diphenyl-8-Phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6e): Yield 70 %, m.p. 177-178 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1710.6 (C=O), 1673 (C=O), 1617.8 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.83 (s, 1H, methine H), 6.98-7.63 (m, 15H, Ar'H), 2.32 (s, 3H, acetyl CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 24.91 (CH_3 acetyl), 96.74 (spiro C), 120.11, 121.75, 123.84, 123.92, 124.78, 127.64, 128.53, 128.76, 128.81, 129.63, 136.18, 138.64, 139.47, 141.95, 156.64 (C=N), 163.68 (C=O amide), 181.74 (C=O acetyl) ppm. Ms: m/z 457, 381, 338, 295, 204, 118, 91, 77, 52. Anal. Calcd. For $C_{25}H_{19}N_3O_2S_2$ (457.56) C, 65.62; H, 4.19; N, 9.18; S, 14.02. Found C, 65.70; H, 4.21; N, 9.22; S, 13.97 %.

3-Ethoxycarbonyl-1,6-diphenyl-8-phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6f): Yield 75 %, m.p. 168-169 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1719.5 (C=O), 1697.2 (C=O), 1619.2 (C=N) cm^{-1}. ^1H NMR ($CDCl^3$) δ 7.81 (s, 1H, methine H), 7.58-8.27 (m, 15H, Ar'H), 4.78 (q, *J* = 7.1 Hz, 2H, ester CH_2), 1.82 (t, *J* = 7.1 Hz, 3H, ester CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 13.88 (CH_3 ester), 63.29 (CH_2 ester), 97.12 (spiro C), 120.87, 121.64, 122.82, 123.61, 125.19, 127.93, 128.51, 128.82, 128.94, 129.39, 136.90, 138.10, 139.84, 144.38, 157.80 (C=N), 163.31 (C=O amide), 165.45 (C=O ester) ppm. Ms: m/z 488, 378, 328, 234, 134, 118, 91, 77, 51. Anal. Calcd. For $C_{26}H_{21}N_3O_3S_2$ (487.59) C, 64.04; H, 4.34; N, 8.62; S, 13.15. Found C, 64.11; H, 4.41; N, 8.70; S, 13.12 %.

1,6-Diphenyl-3-phenylaminocarbonyl-8-phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6g): Yield 70 %, m.p. 107-108 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3323.4 (NH), 1699.3 (C=O), 1686.5 (C=O), 1624.4 (C=N) cm^{-1}. $_1H$ NMR ($CDCl_3$) δ 7.82 (s, 1H, methine H), 7.09-8.21 (m, 21H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 97.26 (spiro C), 120.28, 121.52, 122.43, 122.67, 122.80, 123.63, 124.58, 127.45, 128.41, 128.68, 128.72, 128.84, 129.13, 135.72, 137.68, 139.72, 140.26, 141.09, 157.62 (C=N), 163.73 (C=O amide), 165.85 (C=O amide) ppm. Ms: m/z 381, 372, 282, 237, 118, 91, 77, 51. Anal. Calcd. For $C_{30}H_{22}N_4O_2S_2$ (534.65) C, 67.39; H, 4.15; N, 10.48; S, 11.99. Found C, 67.43; H, 4.09; N, 10.51; S, 11.90 %.

3-Benzoyl-1,6-diphenyl-8-phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6h): Yield 72 %, m.p. 178-179 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1695.5 (C=O), 1645.6 (C=O), 1622.6 (C=N) cm^{-1}. ^1H NMR ($CDCl^3$) δ 7.91 (s, 1H, methine H), 7.17-8.19 (m, 20H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.41 (spiro C), 120.86, 122.14, 123.56, 123.72, 125.61, 127.95, 128.63, 128.34, 128.82, 129.10, 129.72, 129.87, 133.52, 135.95, 136.63, 137.64, 139.26, 143.10, 154.68 (C=N), 163.46 (C=O amide), 184.38 (C=O benzoyl) ppm. Ms: m/z 519, 381, 357, 266, 117, 91, 77, 51. Anal. Calcd. For $C_{30}H_{21}N_3O_2S_2$ (519.63) C, 69.34; H, 4.07; N, 8.09; S, 12.34. Found C, 69.51; H, 4.00; N, 8.12; S, 12.44 %.

1,6-Diphenyl-8-phenylmethylene-3-(2-naphthoyl)- 4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6i): Yield 72 %, m,p. 200-202 ºC (dimethylformamide), IR (KBr, ν_{max}, cm^{-1}) 1698.2 (C=O), 1640.9 (C=O), 1623.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 8.74 (s, 1H, α-naphthoyl), 7.83 (s, 1H, methine H), 7.23-8.10 (m, 21H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.82 (spiro C), 120.12, 121.83, 123.71, 123.89, 124.65, 125.53, 126.58, 127.21, 127.76, 127.92, 128.05, 128.61, 128.76, 128.87, 129.39, 129.97, 132.42, 132.66, 132.93, 135.60, 136.81, 138.08, 139.32, 142.34, 154.81 (C=N), 163.36 (C=O amide), 182.19 (C=O naphthoyl) ppm. Ms: m/z 414, 407, 381, 316, 272, 135, 117, 91, 52. Anal. Calcd. For $C_{34}H_{23}N_3O_2S_2$ (569.69) C, 71.68; H, 4.07; N, 7.38; S, 11.26. Found C, 71.71; H, 4.10; N, 7.40; S, 11.32 %.

1,6-Diphenyl-8-phenylmethylene-3-(2-thienoyl)- 4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (6j): Yield 73 %, m.p. 200-202 ºC (dimethylformamide), IR (KBr, ν_{max}, cm^{-1}) 1693.6 (C=O), 1640.9 (C=O), 1621.7 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.83 (s, 1H, methine H), 7.12-8.23 (m, 18H, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 96.71 (spiro C), 120.34, 121.38, 123.62, 123.71, 125.01, 127.31, 128.57, 128.60, 128.67, 129.25, 131.31, 136.80, 138.10, 139.12, 139.78, 141.62, 142.10, 145.93, 155.61 (C=N), 163.45 (C=O amide), 175.95 (C=O thienoyl) ppm. Ms: m/z 525, 381, 228, 135, 118, 91, 77, 51. Anal. Calcd. For $C_{28}H_{19}N_3O_2S_3$ (525.66) C, 63.98; H, 3.64; N, 7.99; S, 18.30. Found C, 64.11; H, 3.61; N, 7.90; S, 18.28 %.

1,3-disubstituted-8-Phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one 9 and 1,3-disubstituted-6-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11): These compounds were prepared following the same procedure described above using 5-phenylmethylene-2-thioxothiazolidin-4-one (**7**) and 3-phenyl-2-thioxothiazolidin-4-one 8 instead of **1**.

1,3-diphenyl-8-phenylmethylene-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9a): Yield 72 %, m.p. 107-108 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3424.1 (NH), 1730.3 (C=O), 1623.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) d 6.96-8.22 (m, 17H, NH, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 98.11 (spiro C), 120.14, 123.80, 124.16, 127.90, 128.53, 128.62, 128.81, 129.29, 129.51, 131.08, 135.21, 135.83, 138.81, 143.82, 153.64 (C=N), 165.85 (C=O amide) ppm. Ms: m/z 415, 194, 134, 91, 77, 51. Anal. Calcd. For $C_{23}H_{17}N_3OS_2$ (415.53) C, 66.48; H, 4.12; N, 10.11; S, 15.43. Found C, 66.40; H, 4.12; N, 10.00; S, 15.41 %.

3-Acetyl-8-phenylmethylene-1-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9b): Yield 72 %, m.p. 112-114 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3524 (NH), 1628.2 (C=O), 1701 (C=O), 1619.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.17-8.09 (m, 12H, NH, Ar'H), 2.7 (s, 3H, acetyl CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 24.83 (CH_3 acetyl), 98.03 (spiro C), 120.09, 123.78, 125.32, 127.74, 128.49, 128.65, 129.48, 135.10, 138.78, 143.86, 153.74 (C=N), 166.91 (C=O amide), 188.63 (C=O acetyl) ppm. Ms: m/z 381, 219, 160, 134, 117, 91, 77, 51. Anal. Calcd. For $C_{19}H_{15}N_3O_2S_2$ (381.47) C, 59.82; H, 3.96; N, 11.02; S, 16.81. Found C, 59.90; H, 3.89; N, 10.95; S, 16.90 %.

3-Ethoxycarbonyl-8-phenylmethylene-1-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9c): Yield 70 %, m.p. 86-87 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3473.2 (NH), 1747.5 (C=O), 1720.1 (C=O), 1621.5 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.18-8.09 (m, 12H, NH, Ar'H), 4.61 (q, J = 7.1 Hz, 2H, ester CH_2), 1.45 (t, J = 7.1 Hz, 3H, ester CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 13.64 (CH_3 ester), 63.34 (CH_2 ester), 99.17(spiro C), 120.37, 123.77, 125.03, 127.88, 128.56, 128.62, 128.97, 135.34, 138.79, 143.92, 159.80 (C=N), 165.93 (C=O amide), 166.12 (C=O ester) ppm. Ms: m/z 411, 322, 250, 161, 134, 118, 91, 51. Anal. Calcd. For $C_{20}H_{17}N_3O_3S_2$ (411.49) C, 58.38; H, 4.16; N, 10.21; S, 15.58. Found C, 58.43; H, 4.20; N, 10.20; S, 15.70 %.

3-Phenylaminocarbonyl-8-phenylmethylene-1-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9d): Yield 70 %, m.p. 124-126 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3391.2 (NH), 3318.2 (NH), 1686.3 (br. C=O), 1622.8 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 6.98-7.99 (m, 18H, NH, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 99.07 (spiro C), 121.06, 122.39, 122.81, 123.86, 124.96, 127.78, 128.51, 128.68, 128.74, 129.48, 135.18, 138.66, 140.68, 142.97, 156.34 (C=N), 165.57 (C=O amide), 166.85 (C=O amide) ppm. Ms: m/z 458, 368, 326, 296, 162, 132, 117, 91, 77, 51. Anal. Calcd. For $C_{24}H_{18}N_4O_2S_2$ (458.55) C, 62.86; H, 3.96; N, 12.22; S, 13.99. Found C, 62.80; H, 3.88; N, 12.30; S, 14.13 %.

3-Benzoyl-8-phenylmethylene-1-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9e): Yield 69 %, m.p. 130-131 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3420.9 (NH), 1653.4 (br. C=O), 1623.2 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.00-8.61 (m, 17H, NH, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 99.13 (spiro C), 120.93, 123.90, 125.26, 127.27, 128.46, 128.69, 129.13, 129.37, 129.77, 135.26, 136.48, 138.79, 143.11, 155.62 (C=N), 166.71 (C=O amide), 183.65 (C=O benzoyl) ppm. Ms: m/z 443, 353, 282, 162, 132, 117, 105, 91, 77, 51. Anal. Calcd. For $C_{24}H_{17}N_3O_2S_2$ (443.54) C, 64.99; H, 3.86; N, 9.47; S, 14.46. Found C, 65.05; H, 3.80; N, 9.52; S, 14.51 %.

3-(2-Naphthoyl)-8-phenylmethylene-1-phenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (9f): Yield 71 %, m.p. 97-98 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 3469.1 (NH), 1647.2 (br. C=O), 1622.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 9.20 (s, 1H), 7.31-8.20 (m, 18H, NH, Ar'H) ppm. ^{13}C NMR ($CDCl_3$) δ 98.97 (spiro C), 120.13, 123.62, 124.64, 125.51, 126.57, 127.32, 127.63, 127.86, 128.00, 128.54, 128.71, 129.28, 129.88, 132.29, 132.52, 132.84, 135.48, 135.51, 138.78, 142.28, 155.64 (C=N), 165.92 (C=O amide), 183.62 (C=O naphthoyl) ppm. Ms: m/z 403, 332, 272, 162, 155, 117, 91, 77, 51. Anal. Calcd. For $C_{28}H_{19}N_3O_2S_2$ (493.59) C, 68.13; H, 3.88; N, 8.51; S, 12.99. Found C, 68.15; H, 3.92; N, 8.49; S, 13.00 %.

1,3,6-Triphenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11a): Yield 76 %, m.p. 180-181 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1701.2 (C=O), 1621.7 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.21-7.72 (m, 15H, NH, Ar'H), 3.82 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.81 (CH_2), 101.93(spiro C), 120.32, 121.61, 123.29, 128.74, 128.90, 129.48, 129.53, 131.19, 133.79, 136.54, 139.48, 142.27, 157.32 (C=N), 167.63 (C=O amide) ppm. Ms: m/z 403, 329, 280, 194, 135, 91, 77, 51. Anal. Calcd. For $C_{22}H_{17}N_3OS_2$ (403.52) C, 65.48; H, 4.25; N, 10.41; S, 15.89. Found C, 65.53; H, 4.24; N, 10.42; S, 15.82 %.

1,6-Diphenyl-3-styryl-4,9-dithia-1,2,6-triazaspiro[4,4]-nonan-2-ene-7-one (11b): Yield 76 %, m.p. 127-129 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1702.5 (C=O), 1621.2 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 6.51-7.72 (m, 17H, NH, Ar'H), 3.91 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.84 (CH_2), 102.87 (spiro C), 120.82, 122.13, 123.55, 123.84, 126.78, 128.03, 128.23, 128.59, 128.73, 129.57, 137.74, 139.78, 142.10, 142.61, 154.59 (C=N), 167.70 (C=O amide) ppm. Ms: m/z 429, 355, 281, 222, 135, 117, 91, 51. Anal. Calcd. For $C_{24}H_{19}N_3OS_2$ (429.55) C, 67.11; H, 4.46; N, 9.78; S, 14.93. Found C, 67.15; H, 4.52; N, 9.81; S, 14.89 %.

1-(4-Nitrophenyl)-6-phenyl-3-(2-thienyl)-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11c): Yield 71 %, m.p. 203-204 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1700.2 (C=O), 1623.4 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 6.98-8.82 (m, 12H, NH, Ar'H), 4.18 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.78 (CH_2), 102.21 (spiro C), 118.79, 121.62, 122.23, 123.39, 123.61, 124.58, 128.71, 137.63, 138.96, 142.76, 144.53, 146.33, 154.48 (C=N), 167.71 (C=O amide) ppm. Ms: m/z 454, 380, 327, 245, 162, 135, 91, 77, 51. Anal. Calcd. For $C_{20}H_{14}N_4O_3S_3$ (454.54) C, 52.85; H, 3.10; N, 12.33; S, 21.16. Found C, 52.80; H, 3.12; N, 12.41; S, 21.22 %.

3-Acetyl-1,6-diphenyl-4,9-dithia-1,2,6-triazaspiro-[4,4]nonan-2-ene-7-one (11d): Yield 71 %, m.p. 184-186 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 1715.2 (C=O), 1684.5 (C=O), 1622.5 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.19-7.58 (m, 10H, NH, Ar'H), 3.91 (s, 2H, CH_2), 2.15 (s, 3H, acetyl CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 23.67 (CH_3 acetyl), 29.77 (CH_2), 102.26

(spiro C), 120.11, 121.69, 123.29, 123.76, 128.77, 129.71, 139.45, 140.23, 156.74 (C=N), 167.73 (C=O amide), 188.92 (C=O acetyl) ppm. Ms: m/z 369, 295, 280, 160, 135, 117, 91, 77, 52. Anal. Calcd. For $C_{18}H_{15}N_3O_2S_2$ (369.46) C, 58.52; H, 4.09; N, 11.37; S, 17.36. Found C, 58.51; H, 3.97; N, 11.36; S, 17.37 %.

3-Ethoxycarbonyl-1,6-diphenyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11e): Yield 80 %, m.p. 172-174 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 1738.4 (C=O), 1710.3 (C=O), 1621.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.18-7.67 (m, 10H, NH, Ar'H), 4.31 (q, *J* = 7.1 Hz, 2H, ester CH_2), 3.91 (s, 2H, CH_2), 1.32 (t, *J* = 7.1 Hz, 3H, ester CH_3) ppm. ^{13}C NMR ($CDCl_3$) δ 15.21 (CH_3 ester), 29.61 (CH_2), 64.26 (CH_2 ester), 102.16 (spiro C), 120.76, 121.67, 122.78, 123.52, 128.87, 129.26, 139.78, 142.38, 157.64 (C=N), 165.94 (C=O amide), 167.82 (C=O ester) ppm. Ms: m/z 399, 325, 276, 135, 117, 91, 51. Anal. Calcd. For $C_{19}H_{17}N_3O_3S_2$ (399.48) C, 57.12; H, 4.29; N, 10.52; S, 16.05. Found C, 57.20; H, 4.30; N, 10.50; S, 16.06 %.

1,6-Diphenyl-3-phenylaminocarbonyl-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11f): Yield 78 %, m.p. 190-192 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1741.5 (br. C=O), 1623.6 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.23-7.69 (m 16H, NH, Ar'H), 4.43 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.68 (CH_2), 102.13(spiro C), 120.35, 121.63, 122.51, 122.71, 122.91, 123.59, 128.58, 128.74, 129.26, 139.69, 140.29, 140.36, 157.31 (C=N), 164.78 (C=O amide), 167.84 (C=O amide) ppm. Ms: m/z 446, 372, 281, 237, 135, 117, 99, 77, 51. Anal. Calcd. For $C_{23}H_{18}N_4O_2S_2$ (446.54) C, 61.86; H, 4.06; N, 12.55; S, 14.36. Found C, 61.79; H, 3.94; N, 12.50; S, 14.32 %.

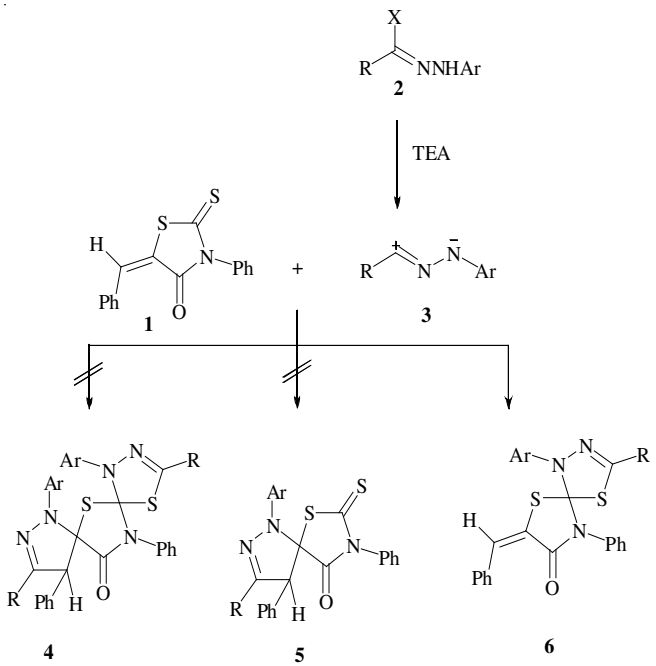
3-Benzoyl-1,6-diphenyl-4,9-dithia-1,2,6-triazaspiro [4,4]nonan-2-ene-7-one (11g): Yield 73 %, m.p. 180-181 ºC (acetic acid), IR (KBr, ν_{max}, cm^{-1}) 1718.2 (C=O), 1700.6 (C=O), 1620.8 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.21-8.08 (m, 15H, NH, Ar'H), 3.88 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.87 (CH_2), 102.16 (spiro C), 120.81, 122.19, 123.48, 123.73, 128.67, 129.03, 129.58, 129.69, 133.51, 136.96, 139.73, 142.92, 155.78 (C=N), 168.01 (C=O amide), 185.21 (C=O benzoyl) ppm. Ms: m/z 431, 357, 281, 135, 91, 77, 51. Anal. Calcd. For $C_{23}H_{17}N_3O_2S_2$ (431.53) C, 64.02; H, 3.97; N, 9.74; S, 14.86. Found C, 64.11; H, 3.90; N, 9.81; S, 14.88 %.

1,6-Diphenyl-3-(2-naphthoyl)-4,9-dithia-1,2,6-triazaspiro[4,4]nonan-2-ene-7-one (11h): Yield 70 %, m.p. 136-138 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 1716.5 (C=O), 1684.6 (C=O), 1621.1 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.19-8.20 (m, 17H, NH, Ar'H), 3.90 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.91 (CH_2), 102.20 (spiro C), 120.31, 121.29, 123.53, 123.68, 125.54, 126.59, 127.72, 127.93, 128.07, 128.69, 129.29, 129.94, 132.50, 132.76, 132.84, 135.57, 139.41, 142.31, 155.67 (C=N), 167.80 (C=O amide), 183.31 (C=O naphthoyl) ppm. Ms: m/z 481, 407, 282, 271, 195, 155, 135, 117, 91, 51. Anal. Calcd. For $C_{27}H_{19}N_3O_2S_2$ (481.58) C, 67.34; H, 3.98; N, 8.73; S, 13.32. Found C, 67.38; H, 4.05; N, 8.80; S, 13.35 %.

1,6-Diphenyl-3-(2-thienoyl)-4,9-dithia-1,2,6-triazaspiro [4,4]nonan-2-ene-7-one (11i): Yield 77 %, m.p. 162-164 ºC (ethanol), IR (KBr, ν_{max}, cm^{-1}) 1706.1 (C=O), 1664.5 (C=O), 1621.3 (C=N) cm^{-1}. ^1H NMR ($CDCl_3$) δ 7.08-8.21 (m, ^{13}H, NH, Ar'H), 3.89 (s, 2H, CH_2) ppm. ^{13}C NMR ($CDCl_3$) δ 29.73 (CH_2), 102.26 (spiro C), 120.29, 121.29, 123.26, 123.70, 128.58, 129.13, 131.42, 138.96, 139.31, 141.58, 142.08, 145.94, 155.92, 167.84 (C=O amide), 175.88 (C=O thienoyl) ppm. Ms: m/z 437, 363, 282, 228, 135, 117, 91, 77, 51. Anal. Calcd. For $C_{21}H_{15}N_3O_2S_3$ (437.55) C, 57.64; H, 3.46; N, 9.60; S, 21.98. Found C, 57.66; H, 3.48; N, 9.58; S, 22.02 %.

RESULTS AND DISCUSSION

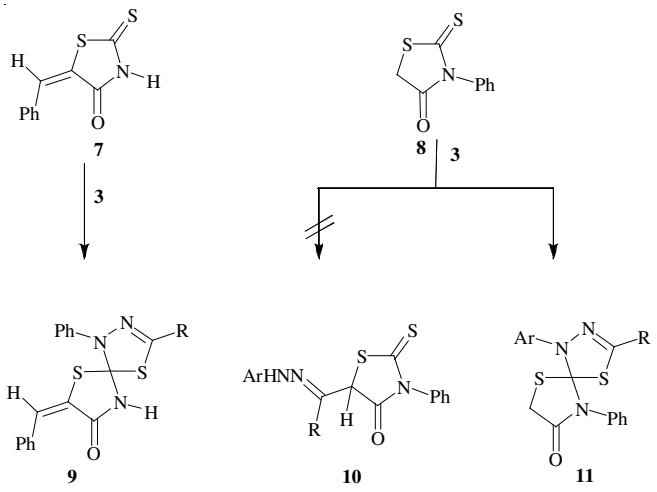
The reaction of 3-phenyl-5-phenylmethylene-2-thiooxothiazolidine-4-one **1** with nitrilimines **3**, generated *in situ* by the action of triethylamine on the corresponding hydrazonoyl halides **2** in refluxing chloroform, (**Scheme-I**) was completed in 18 h as shown by TLC analysis and gave, in each case, a single product. Elemental analyses and mass spectra of the products isolated confirmed that all of them are 1:1 cycloadduct. The 1:2 cycloadducts of type **4** were not detected in any case. Also, the cycloaddition product on the exocyclic carbon-carbon double bond **5** was discarded on the basis of IR and ^1H NMR spectra. Since each of the products isolated exhibits a carbonyl absorption band at 1692 cm^{-1} assignable to α,β-unsaturated carbonyl group, similar to the starting dipolarophile **1** (1690 cm^{-1}). The structure **5** also rejected on the basis of the absence of methine proton signal near δ 5.3-5.5 ppm in their ^1H NMR spectra. Spiropyrazoline of type **5** was reported to exhibit characteristic methine proton signal at δ 5.3-5.5 ppm[25,26]. Furthermore, the ^1H NMR spectra of the isolated products showed a common singlet signal near δ 7.8 ppm assignable to vinylic proton resonance similar to the starting thiazolidine **1**. This finding confirms that the cycloaddition reaction occurs on the carbon-sulfur double bond rather than the carbon-carbon double bond[7] and assigned[8] structure **6**.



6	R/Ar	6	R/Ar
a	C_6H_5/C_6H_5	**f**	C_2H_5OCO/C_6H_5
b	$C_6H_5CH=CH/C_6H_5$	**g**	C_6H_5NHCO/C_6H_5
c	2-furyl/4-$NO_2C_6H_4$	**h**	C_6H_5CO/C_6H_5
d	2-thienyl/4-$NO_2C_6H_4$	**i**	2-naphthyol/C_6H_5
e	CH_3CO/C_6H_5	**j**	2-thienoyl/C_6H_5

Scheme-I

Similarly, 5-phenylmethylene-2-thiooxothiazolidin-4-one (**7**) reacts with hydrazonoyl halides (**2**) in refluxing chloroform in the presence of triethylamine and afforded, in each case, a single product as evidenced by TLC analysis (**Scheme-II**). The isolated products were assigned structure **9**. The structures of the products were deduced from their spectral analyses data. The IR spectrum of **9c** taken as example, revealed three absorption bands at 3473, 1747 and 1720 cm^{-1} assignable to NH, ester carbonyl and cyclic amide carbonyl, respectively. Its ^1H NMR spectrum showed the ethyl pattern signals, triplet (3H) at d 1.45 ppm and quartet (2H) at δ 4.61 ppm, in addition to a multiplet signals at δ 7.18-8.09 ppm (12 Ar'H).

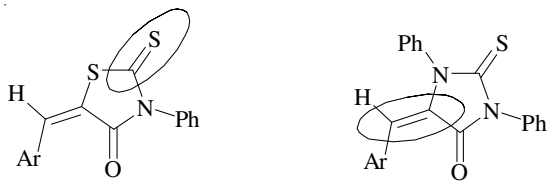


9	R	11	R/Ar	11	R/Ar
a	C_6H_5	a	C_6H_5/C_6H_5	f	C_6H_5NHCO/C_6H_5
b	CH_3CO	b	$C_6H_5CH{=}CH/C_6H_5$	g	C_6H_5CO/C_6H_5
c	C_2H_5OCO	c	2-thienyl/4-$NO_2C_6H_4$	h	2-naphthoyl/C_6H_5
d	C_6H_5NHCO	d	CH_3CO/C_6H_5	i	2-thienoyl/C_6H_5
e	C_6H_5CO	e	C_2H_5OCO/C_6H_5		
f	2-naphthoyl				

Scheme-II

As the cycloaddition reactions of nitrilimines with dipolarophiles are known to be controlled by HOMO (nitrilimines)-LUMO (dipolarophile) interaction, it would be expected that the reactivity of the dipolarophile would increase with decrease of its LUMO energy. The difference of the site selectivity of the nitrilimines in the cycloaddition reaction to **1** and **12** could be attributed to the presence of different groups attached directly to the site of the reaction. Thus, attachment of the enone site of **12** to the more electronegative nitrogen atom lowers the LUMO energy of it rather than the thione one and the attachment of the enone site of **1** to the less electronegative sulfur atom raises the LUMO energy of it rather than the thione one (Fig. 1). Consequently, it would be expected that the nitrilimines would preferably attack the C=C of the enone site of **12** rather than the C=S site[7] and preferably attack the thione site of **1** rather than the other enone site leading[8] to the product **6**.

Treatment of hydrazonoyl halides **2** with 3-phenyl-2-thiooxothiazolidin-4-one (**8**) in refluxing chloroform in the presence of triethylamine afforded only a single product, in each case, as evidenced by TLC analysis and the ^1H NMR spectra of the crude product (**Scheme-II**). The products identified as spirothiadiazoline **11**. Both mass spectra and



1 **12**

Fig. 1.

elemental analyses data for the products agreed with the two isomeric structurs **10, 11**. The structure **10** was discarded on the basis of ^1H NMR, since it is expected to exhibit a singlet signal at δ 5.4 ppm corresponding to a methine proton at C-5 while instead a singlet signal at δ 3.9 ppm assignable to methylene protons (2H) at position 8 of structure **11** appeared. Also, structure **10** was discarded since its IR spectrum didn't show any band assignable to NH group at *ca.* 3200 cm^{-1}.

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