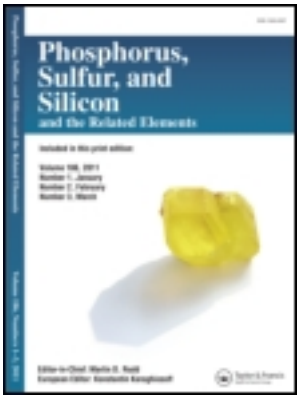

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The Synthesis of 1-(1-Phenyl-1*H*-tetrazole-5-ylthiol)-acetyl-4-aroyl-thiosemicarbazides and 2-Aroylamino-5-(1-phenyl-1*H*-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazoles

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A series of 1-(1-phenyl-1H-tetrazole-5-ylthiol)acetyl-4-aroylthiosemicarbazides were synthesized in good to excellent yields under phase transfer catalytic conditions. By the cyclization of compounds 3a–i in concentrated H_2SO_4 at 0°C,2-aroylamino-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazoles were obtained in high yields. The structures of the products were established by elemental analysis, IR , ^1H NMR, and ^{13}C NMR.

Keywords 2,5-Disubstituted-1,3,4-thiadiazole; aroylthiosemicarbazide; phase transfer catalysis; tetrazole

INTRODUCTION

Many compounds containing tetrazole rings have been found to have a wide range of biological properties.[1] 1H-tetrazole-5-thiol derivatives have been found to have antiviral, antibacterial, anthelmintic, and anti-inflammatory properties.[1,2] These functional groups play important roles in coordination chemistry, material science applications, and especially medicinal chemistry.[1,3] New uses for this unique

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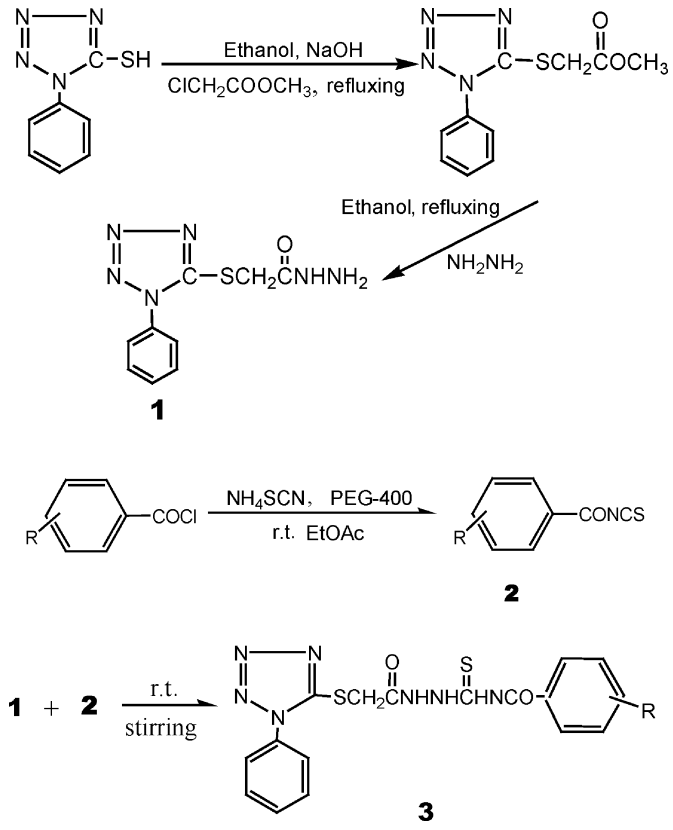
class of heterocyclic derivatives continue to emerge in pharmaceutical applications[3–5] and antibiotics intermediates.[6]

Recently, the importance of N=C=S linkage has been well stressed. The linkage is an essential structural feature, which is responsible for various biological activities in many well-known organic sulphur pesticides, such as dithiocarbamates, thioureas, and thiosemicarbazides.[7,8] The survey of the literature revealed that some thiosemicarbazides containing a tetrazole ring had been used as plant growth regulators.[9–11] Moreover, aroylthiosemicarbazide is also valuable as a synthetic intermediate for the preparation of some thiadiazole derivatives.[12]

It is well established that various substituted 1,3,4-thiadiazoles have become very useful compounds in medicine, agriculture, and many fields of technology.[13,14] Some of these compounds exhibit interesting pharmacological properties, like antitubercular and anti-inflammatory properties.[15] A large number of 1,3,4-thiadiazoles have been patented in the agricultural field as herbicides, fungicides, and bactericides.[16,17]

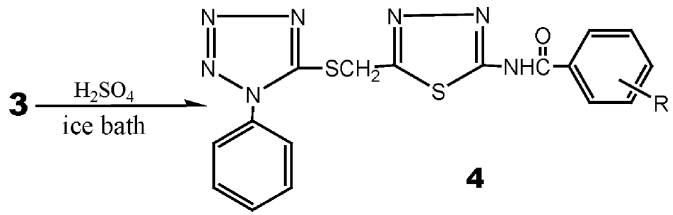
These observations prompted us to synthesize some new compounds wherein biologically active moieties are present. In addition, in order to improve the biological ability of compounds, much attention has been paid to the development of the functional group in the ring. It is significant that the combined effect of all the entities will result in increased biological activity. In view of these and in continuation of our earlier work on the synthesis of thiosemicarbazide and thiourea derivatives,[18–21] we report some new compounds containing tetrazole rings and thiadiazole rings. All of these compounds have never been reported before.

The reaction sequences leading to the formation of different title compounds are outlined in Schemes 1 and 2. Our synthetic approach was aimed at creating hydrazide **1** and a series of aroyl isothiocyanates **2**. They were key intermediates in producing title compounds. Hydrazide **1** was prepared according to the procedure available in the literature.[2] Aroyl isothiocyanates are versatile reagents, and their chemistry has received considerable recent interest.[23] We could employ them as good intermediates to prepare easily various thiosemicarbazides. In this procedure, aroyl chloride was treated with ammonium thiocyanate (NH_4SCN) in ethyl acetate under the condition of solid–liquid phase transfer catalysis using PEG-400 as the catalyst to give the corresponding aroyl isothiocyanate in quantitative yields. On the contrary, we could not get any products or good yields when no PEG-400 or other PTC participated in the reaction. The target products **3a–i** could be obtained by the addition reaction between aroyl isothiocycanates with hydrazide. Since terazole hydrazide is insoluble in ethyl acetate, we added it portionwise into a solution of **2** in a flask with rigorous stirring



SCHEME 1

for 1–2 h at a refluxing temperature. The precipitate was separated out and recrystallized from DMF-EtOH-H_2O to give **3a–i**. Compound **3** was treated with concentrated sulphuric acid at 0°C in an ice bath with constant stirring for 1–2 h. Then, the reaction mixture was poured into 150 mL of ice water. The precipitate formed was filtered and washed



SCHEME 2 R: a: o-Cl, b: p-Cl, c: m-Cl, d: p-F, e: H, f: p-Br, g: p-CH_3,h: p-OCH_2CH_3,i: p-I.

with water and recrystallized from DMF-EtOH-H_2O to give **4a–i** in good to excellent yields.

In this procedure, we employed concentrated sulphuric acid instead of using acetic acid as a dehydration reagent. As a rule, using acetic acid as a dehydration reagent had the disadvantages of relatively longer reaction times (5–6 h), and the reaction mixture had to reflux at a high temperature. Furthermore, since acetic acid was not a good solvent, for compound **3**, in order to dissolve the reactant, we had to employ some other solvent, such as DMF or DMSO, although it was not easily removed due to its high boiling point. The use of concentrated H_2SO_4 could overcome these shortcomings. It is not only a good dehydration reagent but also a useful solvent for many organic compounds. Here we used it to successfully prepare the title compounds.

In conclusion, this is a facile and convenient method for the synthesis of title compounds under solid–liquid phase transfer catalytic conditions. This method possesses the advantages of mild conditions, a simple operation, short reaction times, and high yields; also, the catalyst PEG-400 is inexpensive, relatively nontoxic, highly stable, and easily available. The biological properties of title compounds are under investigation.

EXPERIMENTAL

All reagents were purchased and without further purification. Melting points were determined in open capillaries and are uncorrected. IR spectra were recorded as KBr discs on an Alpha Centauri FT-IR spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian Mercury Plus-400 instrument (400 MHz) using DMSO-d_6 as a solvent and TMS as an internal reference. Elemental analysis was determined on a PE-2400 CHN instrument.

The General Procedure

1-phenyl-1H-5-mercapto-tetrazole was prepared by methods in the literature.[22] (1-phenyl-1H-tetrazole-5-ylthiol) acetic acid hydrazide (compound **1**) was prepared by methods in the literature.[2]

The General Procedure for the Preparation of 3a–i

A mixture of 0.91 g dried and powdered NH_4SCN (12 mmol), Aroyl chloride (11 mmol), and PEG-400 (0.1 mL) in ethyl acetate (15 mL) was stirred in a flask at r.t. for 1–2 h. The mixture was filtered to isolate inorganic salt NH_4Cl and washed with 3×10 mL EtOAc to

acquire a solution of **2**. Then, (1-phenyl-1H-tetrazole-5-ylthiol) acetic acid hydrazide **1** (10 mmol) was slowly added into it with constant stirring at a refluxing temperature for 1–2 h. The precipitate formed was filtered and recrystallized from DMF-EtOH-H_2O to give pure products **3a–i**.

The General Procedure for the Preparation of 4a–i

A portion of **3** (5 mmoL) was dissolved in concentrated sulphuric acid (2.5 mL) in ice bath; the solution was kept at 0°C for 2 h with constant stirring and then poured into 150 mL of water with an excess of crushed ice. It was stirred well and allowed to stand for 1–2 h. The residue was filtered and washed with ice water and then recrystallized from DMF-EtOH-H_2O to give pure products **4a–i**.

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(2-chlorobenzoyl)thiosemicarbazide (3a)

Yield 76%, m.p. 158–160°C. IR(KBr) υ (cm^{-1}): 3203, 1687, 1593, 1313, 1183. Anal. calc. for $C_{17}H_{14}O_2S_2ClN_7$: C, 45.59; H, 3.15; N, 21.90. Found: C, 45.76; H, 3.01; N, 21.69. ^{1}H NMR(DMSO-d_6): $\delta = 12.46$ (s, 1H, N—NH—CS), 12.19(s, 1H, CS—NH —CO), 11.44 (s, 1H, CO—NH—N), 7.43–7.73 (m, 9H, Ar-H), 4.41(s, 2H, —SCH_2—). ^{13}C NMR (DMSO-d_6): $\delta = 176.26$ (C=S), 167.39 (O=C-Ar), 163.64 (—CONH), 153.68 (N=C—N), 134.03, 133.04, 132.20, 130.75, 130.11, 129.97, 129.6, 129.30, 127.15, 124.56(Ar-C), 34.72 (—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-chlorobenzoyl)-thiosemicarbazide (3b)

Yield 92%, m.p. 213–214°C. IR(KBr) υ (cm^{-1}): 3172, 1666, 1595, 1311, 1171. Anal. calc. for $C_{17}H_{14}O_2S_2ClN_7$: C, 45.59; H, 3.15; N, 21.90. Found: C, 45.64; H, 2.90; N, 21.71. ^{1}H NMR(DMSO-d_6): $\delta = 12.62$ (s, 1H, N—NH—CS), 11.87(s, 1H, CS—NH—CO), 11.40(s, 1H, CO—NH—N), 7.56–8.00(m, 9H, Ar-H), 4.38 (s, 2H, —SCH_2—). ^{13}C NMR (DMSO-d_6): $\delta = 176.80$(C=S), 167.05(O=C-Ar), 163.63(—CONH), 153.68(N=C—N), 138.13, 133.05, 132.15, 130.76, 130.65, 130.11, 128.56, 124.55(Ar-C), 34.78(—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(3-chlorobenzoyl)thiosemicarbazide (3c)

Yield 79%, m.p. 188–190°C. IR(KBr) υ (cm^{-1}): 3130, 1675, 1572, 1302, 1170. Anal. calc. for $C_{17}H_{14}O_2S_2ClN_7$: C, 45.59; H, 3.15; N, 21.90. Found: C, 45.72; H, 3.15; N, 21.95. ^{1}H NMR (DMSO-d_6): $\delta = 12.62$(s, 1H, N—NH—CS), 11.91(s, 1H, CS—NH—CO), 11.42 (s,1H, CO—NH—N),

7.50–7.99(m, 9H, Ar-H), 4.39(s, 2H, —SCH_2—). ^{13}C NMR (DMSO-d_6): δ = 176.64(C=S), 166.68(O=C-Ar), 163.63 (—CONH), 153.68 (N=C—N), 133.84, 133.18, 133.05, 132.85, 130.71, 130.36, 130.10, 128.55, 127.5, 124.5(Ar-C), 34.81(—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-fluorobenzoyl)thiosemicarbazide (3d)

Yield 89%, m.p. 214–215°C IR(KBr) υ (cm^{-1}): 3169, 1668, 1601, 1311, 1170. Anal. calc. for $C_{17}H_{14}O_2S_2FN_7$: C, 47.12; H, 3.34; N, 22.79. Found: C, 47.33; H, 3.25; N, 22.74. ^{1}H NMR (DMSO-d_6): δ = 12.62 (s, 1H, N—NH—CS), 11.82(s, 1H, CS—NH—CO), 11.40 (s, 1H, CO—NH—N), 7.31–8.04 (m, 9H, Ar-H), 4.38(s, 2H, —SCH2—). ^{13}C NMR(DMSO-d_6):δ = 176.84(C=S), 166.6(O=C-Ar), 163.67 (—CONH), 153.68 (N=C—N), 133.05, 131.87, 131.77, 130.73, 130.1, 128.31, 124.55, 115.64, 115.42 (Ar-C), 34.77(—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-benzoylthiosemicarbazide (3e)

Yield 90%, m.p. 197–199°C IR(KBr) υ (cm^{-1}): 3125, 1672, 1573, 1300, 1166. Anal. calc. for $C_{17}H_{15}O_2S_2FN_7$: C 49.39; H 3.63; N 23.73. Found: C 49.35; H 3.58; N 23.62. ^{1}H NMR(DMSO-d_6): δ = 4.38(s, 2H, —CH_2—), 7.49–7.95(m, 10H, Ar-H), 12.70(s, 1H, N—NH—CS), 11.78(s, 1H, CS—NH—CO), 11.39(s, 1H, CO—NH—N). ^{13}C NMR(DMSO-d_6): δ = 176.93 (C=S), 168.1(O=C—Ar), 163.58 (—CONH), 153.69(N=C—N), 133.2, 133.04, 131.80, 130.75, 130.11, 128.77, 128.47, 124.57(Ar-C), 34.76(—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-bromobenzoyl)-thiosemicarbazide (3f)

Yield 88%, m.p. 206–208°C. IR(KBr) υ (cm^{-1}): 3169, 1670, 1589, 1313, 1170. Anal. calc. for $C_{17}H_{14}O_2S_2BrN_7$: C, 41.47; H, 2.85; N, 19.92. Found: C, 41.30; H, 2.40; N, 19.94.^{1}H NMR (DMSO-d_6): δ = 12.62(s, 1H, N—NH—CS), 11.87(s, 1H, CS—NH—CO), 11.39 (s, 1H, CO—NH—N), 7.62–7.91(m, 9H, Ar-H), 4.37(s, 2H, —SCH_2—). ^{13}C NMR (DMSO-d_6): δ = 176.79 (C=S),167.2(O=C-Ar), 163.63(—CONH), 153.68 (N=C—N), 133.05, 131.51, 131.03, 130.9, 130.75, 130.1, 127.2, 124.56(Ar-C), 34.78(—SCH_2—).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-methylbenzoyl)thiosemicarbazide (3g)

Yield 91%, m.p. 196–198°C. IR(KBr) υ (cm^{-1}): 3180, 1668, 1613, 1300, 1172. Anal. calc. for $C_{18}H_{17}O_2S_2N_7$: C, 50.59; H, 3.98; N, 22.95.

Found: C, 50.70; H, 3.94; N, 22.95. ^{1}H NMR(DMSO-d_6): $\delta = 2.36$(s, 3H, $-CH_3$), 4.42(s, 2H, $-SCH_2-$), 12.78(s, 1H, N—NH—CS), 11.72 (s, 1H, CS—NH—CO), 11.43(s, 1H, CO—NH—N), 7.33–7.91 (m, 9H, Ar-H); ^{13}C NMR (DMSO-d_6): $\delta = 177.0$(C=S), 167.9(O=C-Ar), 163.58 (—CONH), 153.7 (N=C—N), 143.7, 133.1, 130.73, 130.1, 129.06, 128.88, 128.84, 124.54(Ar-C), 34.80($-SCH_2-$), 21.19(Ar-CH_3).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-ethyloxylbenzoyl) thiosemicarbazide (3h)

Yield 95%, m.p. 190–192°C. IR(KBr) υ (cm^{-1}): 3163, 1671, 1603, 1310, 1180. Anal. calc. for $C_{19}H_{19}O_3S_2N_7$: C, 49.60; H, 4.25; N, 21.21. Found: C, 49.90; H, 4.16; N, 21.44. ^{1}H NMR (DMSO-d_6): $\delta = 12.77$(N—NH—CS), 11.58(s, 1H, CS—NH—CO), 11.36 (s, 1H, CO—NH—N), 7.00–7.97(m, 9H, Ar-H), 4.35(s,2H,—SCH_2-), 4.10(q, 2H, —OCH_2-), 1.33 (t, 3H,—CH_3). ^{13}C NMR(DMSO-d_6): $\delta = 177.11$ (C=S), 167.30(O=C-Ar), 163.51(—CONH), 153.68(N=C—N), 162.45, 133.04, 131.1, 130.75, 130.1, 124.57, 123.31, 114.17(Ar-C), 34.75($-SCH_2-$), 30.79($-OCH_2-$), 63.64($-CH_3$).

1-(1-Phenyl-1H-tetrazole-5-ylthiol)acetyl-4-(4-iodobenzoyl) thiosemicarbazide (3i)

Yield 70%, m.p. 198–200°C. IR(KBr) υ (cm^{-1}): 3195, 1671, 1577, 1305, 1162. Anal. calc. for $C_{17}H_{14}O_2S_2N_7I$: C, 37.85; H, 2.60; N, 18.19. Found: C, 38.06; H, 2.73; N, 18.08. ^{1}H NMR (DMSO-d_6):$\delta = 12.63$ (N—NH—CS), 11.84(s, 1H, CS—NH—CO), 11.38 (s, 1H, CO—NH—N), 7.63–7.94 (m, 9H, Ar-H), 4.37(s, 2H, $-SCH_2-$). ^{13}C NMR(DMSO-d_6): $\delta = 176.78$ (C=S), 167.48(O=C-Ar), 162.97 (—CONH), 153.67(N=C—N), 137.48, 133.02, 131.27, 131.19, 130.69, 130.55, 130.10, 124.55(Ar-C), 34.77($-SCH_2-$).

2-(2-Chlorobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4a)

Yield 78%, m.p. 163–164°C. IR(KBr) υ (cm^{-1}): 3145, 1679, 1592, 1389, 1309, 689. Anal. calc. for $C_{17}H_{12}OS_2N_7Cl$: C, 47.50; H, 2.79; N, 22.82. Found: C, 47.75; H, 2.78; N, 23.10. ^{1}H NMR(DMSO-d_6): $\delta = 13.25$(s, 1H, —NH—), 7.48–7.71(m, 9H, Ar-H), 5.04(s, 2H, $-SCH_2-$) ^{13}C NMR(DMSO-d_6):$\delta = 165.02$, 160.52, 159.64, 153.33, 133.74, 132.90, 132.31, 130.78, 130.37, 130.06, 129.89, 129.63, 127.32, 124.61, 30.96.

2-(4-Chlorobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4b)

Yield 86%, m.p. 208–210°C. IR(KBr) υ (cm^{-1}): 3179, 1674, 1594, 1390, 1314, 682. Anal. calc. for $C_{17}H_{12}OS_2N_7Cl$: C, 47.50; H, 2.79; N, 22.82.

Found: C, 47.74; H, 2.51; N, 22.82. ^{1}H NMR (DMSO-d_6): $\delta = 13.13$ (s, 1H, —NH—), 7.53–8.10 (m, 9H, Ar-H), 4.99 (s, 2H, —SCH_2—).

2-(3-Chlorobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4c)

Yield 87%, m.p. 228–230°C. IR(KBr) υ (cm^{-1}): 3165, 1670, 1595, 1402, 1313, 692. Anal. calc. for $C_{17}H_{12}OS_2N_7Cl$: C, 47.50; H, 2.79; N, 22.82. Found: C, 47.56; H, 2.69; N, 22.92. ^{1}H NMR(DMSO-d_6):$\delta = 13.11$ (s, 1H, —NH—), 7.55–8.14 (m, 9H, Ar-H), 4.98(s,2H,—SCH^2—).

2-(4-Fluorobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4d)

Yield 90%, m.p. 232–234°C. IR(KBr) υ (cm^{-1}): 3177, 1675, 1601, 1413, 1315, 684. Anal. calc. for $C_{17}H_{12}OS_2N_7F$: C, 49.39; H, 2.91; N, 23.73. Found: C, 49.62; H, 2.53; N, 23.66. ^{1}H NMR (DMSO-d_6): $\delta = 13.08$ (s, 1H, —NH—), 7.36–8.18 (m, 9H, Ar-H), 4.98(s, 2H, —SCH_2—). ^{13}C NMR(DMSO-d_6): $\delta = 164.17$, 163.65, 160.16, 153.33, 132.90, 131.43, 131.33, 130.78, 130.07, 128.00, 124.63, 115.80, 30.96.

2-Benzoylamino-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4e)

Yield 93%, m.p. 214–216°C IR(KBr) υ (cm^{-1}): 3167, 1660, 1597, 1410, 1304, 702. Anal. calc. for $C_{17}H_{13}OS_2N_7$: C, 51.64; H, 3.29; N, 24.81. Found: C, 51.60; H, 2.98; N, 24.67. ^{1}H NMR (DMSO-d_6): $\delta = 4.99$(s, 2H, —CH_2—), 13.07(s, 1H, —NH—), 7.52–8.10(m, 10H, Ar-H). ^{13}C NMR (DMSO-d_6): $\delta = 165.22$, 160.60, 160.13, 153.32, 133.07, 132.90, 131.40, 130.77, 130.05, 128.70, 128.42, 124.62, 30.96.

2-(4-Bromobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4f)

Yield 79%, m.p. 230–232°C IR(KBr) υ (cm^{-1}): 3181, 1674, 1589, 1389, 1311, 690. Anal. calc. for $C_{17}H_{13}OS_2N_7Br$: C, 43.04; H, 2.53; N, 20.68. Found: C, 43.08; H, 2.43; N, 20.62. ^{1}H NMR (DMSO-d_6): $\delta =$ 13.14(s, 1H, —NH—), 7.57–8.02 (m, 9H, Ar-H), 4.99(s, 2H, —SCH_2—). ^{13}C NMR(DMSO-d_6): $\delta = 164.46$, 160.68, 160.12, 153.29, 132.90, 131.70, 130.71, 130.60, 130.45, 130.04, 127.10, 124.50, 30.99.

2-(4-Methylbenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4g)

Yield 82%, m.p. 205–206°C IR(KBr) υ (cm^{-1}): 3165, 1651, 1607, 1398, 1302, 683. Anal. calc. for $C_{18}H_{15}OS_2N_7$: C, 49.60; H, 4.25; N, 21.21. Found: C, 49.90; H, 4.16; N, 21.44. ^{1}H NMR (DMSO-d_6): $\delta = 13.08$ (s,

1H, —NH—), 7.45–8.13 (m, 9H, Ar-H), 5.10(s, 2H, —SCH2—), 2.60(s, 3H, —CH_3). ^{13}C NMR(DMSO-d_6): δ = 164.93, 160.60, 160.05, 153.31, 143.46, 132.89, 131.90, 130.75, 130.04, 129.24, 128.45, 124.61, 30.94, 21.13.

2-(4-Ethyloxylbenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4h)

Yield 86%, m.p. 197–199°C IR(KBr) υ (cm^{-1}): 3167, 1659, 1605, 1391, 1299, 684. Anal. calc. for $C_{19}H_{17}O_2S_2N_7$: C, 51.92; H, 3.90; N, 22.31. Found: C, 51.64; H, 3.72; N, 22.29. ^{1}H NMR(DMSO-d_6):δ = 12.85(s, 1H, —NH—), 4.97(s, 2H, —SCH_2—), 4.09(q,2H,—OCH_2—), 1.33(t, 3H, —CH_3), 7.02–8.09 (m, 9H, Ar-H). ^{13}C NMR(DMSO-d_6): δ = 164.23, 160.23, 159.90, 153.33, 132.90, 130.75, 130.56, 130.04, 124.60, 123.14, 122.63, 114.34, 63.60, 30.95, 14.51.

2-(4-Iodobenzoylamino)-5-(1-phenyl-1H-tetrazole-5-ylthiolmethylene)-1,3,4-thiadiazole (4i)

Yield 78%, m.p. 229–230°C IR(KBr) υ (cm^{-1}): 3167, 1671, 1587, 1390, 1310, 689. Anal. calc. for $C_{17}H_{12}OS_2N_7I$: C, 39.16; H, 2.32; N, 18.81. Found: C, 38.95; H, 2.09; N, 18.89. ^{1}H NMR(DMSO-d_6): δ = 13.11(s, 1H, —NH—), 7.57–7.92 (m, 9H, Ar-H), 4.98 (s, 2H, —SCH_2—).

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