Supplementary data

1. Chemistry

1.1. 4-substituted benzoic acid hydrazide (1,2)[17]

4-Isopropyl-benzoic acid hydrazide 1, Yield 85%, ^{1}H-NMR (DMSO-d_6.δ): 1.21 (d, 6H, 2 CH_3 of isopropyl), 2.93 (q, 1H, CH of isopropyl), 4.45 (s, 2H, NH_2), 7.31 (d, 2H, j= 8, ArH), 7.54 (d, 2H, j= 6.5, ArH), 9.67 (s, 1H, NH).

4-*tert*-Butyl-benzoic acid hydrazide 2, Yield 87%, ^{1}H-NMR (DMSO-d_6.δ): 1.29 (s, 9H, *tert*-butyl), 4.45 (s, 2H, NH_2), 7.45 (d, 2H, j= 8.5, ArH), 7.75 (d, 2H, j= 6.5, ArH), 9.68 (s, 1H, NH).

1.2. General procedure for preparation of 4-substituted benzoyl-N-substituted phenyl thiosemicarbazides (4a-i) [18]

A solution of substituted phenyl isothiocyanate **(3a-i)** (10 mmol) in ethanol (20 mL) was added with continuous stirring to a solution of 4-substituted benzoic acid hydrazide **5,6** (10 mmol) in ethanol (30 mL). For three hours, the reaction mixture was refluxed. The precipitate produced was recovered by filtering after cooling to room temperature and washed with cold ethanol (30 mL) to yield the thiosemicarbazide.

2-(4-Isopropyl-benzoyl)-*N*-(4-chloro-phenyl)hydrazine carbothioamide (4a), Yield 75%, ^{1}H-NMR (DMSO-d6. δ): 1.21 (d, 6H, 2 CH_3 of isopropyl), 2.95 (q, 1H, CH of isopropyl), 7.38 (d, 4H, j= 8, ArH), 7.48 (d, 2H, j=6.5, ArH), 9.88 (d, 2H, j= 8, ArH). 9.7 (s, 2H, NH), 10.47 (s, 1H. NH).

2-(4-(*tert*-Butyl-benzoyl)-*N*-(phenyl)hydrazine carbothioamide (4b), Yield **70**%, ^{1}H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 7.15 (t, 1H, j= 7.5, ArH), 7.32 (t, 2H, j= 7.5, ArH), 7.34 (d, 2H, j= 6.5, ArH), 7.52 (d, 2H, j= 2, ArH), 7.90 (d, 2H, j= 8, ArH), 9.6 (s, 1H, NH), 9.76 (s, 1H, NH), 10.46 (s, 1H. NH).

2-(4-*tert*-Butyl-benzoyl)-*N*-(3-chlorophenyl) hydrazine carbothioamide (4c), Yield 64%, ^{1}H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 7.2 (d, 1H, j= 7.5, ArH), 7.35 (t, 1H, j= 8, ArH), 7.48 (d, 1H, j= 7, ArH), 7.53 (d, 2H, j= 7, ArH), 7.61 (s, 1H, ArH), 7.90 (d, 2H, j= 8.5, ArH), 9.83 (s, 1H, NH), 9.89 (s, 1H, NH), 10.50 (s, 1H. NH).

2-(4-*tert*-Butyl-benzoyl)-*N*-(4-trifluoromethyl-phenyl)hydrazine carbothioamide (4d), Yield 62%, ^{1}H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 7.52 (d, 2H, j= 7, ArH), 7.68 (d, 2H, j= 8.5, ArH), 7.76 (d, 2H, j= 2, ArH), 7.90 (d, 2H, j= 8.5, ArH), 9.96 (s, 2H, NH), 10.53 (s, 1H. NH).

2-(4-Isopropyl-benzoyl)-*N*-(3-bromophenyl) hydrazine carbothioamide (4e), Yield 70%, ^{1}H-NMR (DMSO-d6. δ): 1.23 (d, 6H, 2 CH_3 of isopropyl), 2.94 (q, 1H, CH of isopropyl), 7.31 (m, 2H, j= 8, ArH), 7.32 (d, 1H, j=4, ArH), 7.39 (d, 1H, j= 8.5, ArH), 7.52 (d, 1H, j= 8.5, ArH), 7.72 (s, 1H, ArH), 7.89 (d, 2H, j= 8, ArH), 9.83 (s, 1H, NH), 9.87 (s, 1H, NH), 10.49 (s, 1H. NH).

2-(4-*tert*-Butyl-benzoyl)-*N*-(4-methoxy-phenyl) hydrazine carbothioamide (4f), Yield 64%, ^{1}H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 3.75 (s, 3H, OCH_3), 6.89 (d, 2H, j= 9, ArH), 7.28 (d, 2H, j= 6.5, ArH), 7.50 (d, 2H, j= 4.5, ArH), 7.89 (d, 2H, j= 6, ArH), 9.58 (s, 1H, NH), 9.66 (s, 1H, NH), 10.43 (s, 1H. NH).

2-(4-*tert*-Butyl-benzoyl)-*N*-(*p*-tolyl) hydrazine carbothioamide (4g), Yield 69%, ^{1}H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 2.28 (s, 3H, CH_3), 7.12 (d, 2H, j= 8.5 ArH), 7.31 (d, 2H, j= 6.5, ArH), 7.51 (d, 2H, j= 8.5, ArH), 7.89 (d, 2H, j= 8, ArH), 9.62 (s, 1H, NH), 9.69 (s, 1H, NH), 10.44 (s, 1H. NH).

2-(4-Isopropyl-benzoyl)-*N*-(4-fluorophenyl) hydrazine carbothioamide (4h), Yield 63 %, ^{1}H-NMR (DMSO-d6. δ): 1.23 (d, 6H, 2 CH_3 of isopropyl), 2.97 (q, 1H, CH of isopropyl), 7.37 (dd, 2H, j= 8, ArH), 7.68 (d, 2H, j= 8.5, ArH), 7.74 (d, 2H, j=6.5, ArH), 7.88 (d, 2H, j= 8, ArH), 9.74 (s, 1H, NH), 9.77 (s, 1H, NH), 10.45 (s, 1H, NH).

2-(4-*tert*-Butyl-benzoyl)-*N*-(4-fluorophenyl) hydrazine carbothioamide(4i), Yield 64%, 1H-NMR (DMSO-d6. δ): 1.31 (s, 9H, *tert*-butyl), 7.16 (t, 2H, j= 9, ArH), 7.42 (d, 2H, j= 7, ArH), 7.53 (d, 2H, j= 5.5, ArH), 7.90 (d, 2H, j= 8.5, ArH), 9.73 (s, 1H, NH), 9.77 (s, 1H, NH), 10.47 (s, 1H. NH).

1.3. General procedure for synthesis of triazole thiol (5a-i) [19]

A solution of 4-substituted benzoyl-*N*-substituted phenyl thiosemicarbazides (10 mmol) **(5a-i)** in 2N NaOH (20 ml) were refluxed for 3 h. After cooling to room temperature, water was added, and the mixture was carefully neutralized with dil HCl. The formed precipitate was filtered, dried, and recrystallized from ethanol to give the corresponding triazole thiol.

4-(4-Chloro-phenyl)-5-(4-isopropyl-phenyl)-4H-[1,2,4]triazole-3-thiol (5a), Yield 76%**.** ^{1}H-NMR (DMSO-$d_{6.}$δ): 1.16 (d, 6H, 2 CH_3 of isopropyl), 2.87 (q, 1H, CH of isopropyl), 7.2 (d, 4H, j=9, ArH), 7.42 (d, 2H, j=5.5, ArH), 7.58 (d, 2H, j=5.5, ArH), 14.10 (s, 1H, SH).

5-(4-*tert*-butyl-phenyl)-4-phenyl-4H-[1,2,4]triazole-3-thiol (5b), Yield 85%**,** ^{1}H-NMR (DMSO-$d_{6.}$δ): 1.22 (s, 9H, *tert*-butyl), 7.22 (d, 2H, j= 8.5, ArH), 7.36 (m, 4H, j= 9.5, ArH), 7.53 (m, 3H, j= 10 , ArH), 14.09 (s, 1H, SH).

5-(4-*tert*-butyl-phenyl)-4-(3-chloro-phenyl)-4H-[1,2,4]triazole-3-thiol (5c), Yield 73%, ^{1}H-NMR (DMSO-d_6 .δ): 1.23 (s, 9H, tert-butyl), 7.24 (d , 2H, j= 6, ArH), 7.38 (d, 2H, j= 5.5, ArH), 7.64 (d, 2H, j= 8.5 , ArH), 7.92 (d, 2H, j= 8, ArH), 14.14 (s, 1H, SH).

5-(4-*tert*-butyl-phenyl)-4-(4-trifluoromethyl-phenyl)-4H-[1,2,4]triazole-3-thiol (5d), Yield 72%**,** ^{1}H-NMR (DMSO-d_6 .δ): 1.23 (s, 9H, *tert*-butyl), 7.25 (d , 2H, j= 9.5, ArH), 7.34 (d, 1H, j= 6.5, ArH), 7.39 (d, 2H, j= 6.5 , ArH), 7.55 (t, 1H, j= 8, ArH), 7.60 (m, 2H, j= 9, ArH), 14.20 (s, 1H, SH).

5-(4-*tert*-butyl-phenyl)-4-(4-methoxy-phenyl)-4H-[1,2,4]triazole-3-thiol (5e), Yield 65%, ^{1}H-NMR (DMSO-d_6 .δ): 1.22 (s, 9H, *tert*-butyl), 3.76 (s, 3H, OCH_3), 7.24 (d , 2H, j= 6.5, ArH),

7.32 (d, 2H, j= 8.5, ArH), 7.43 (t, 1H, j= 9 , ArH) 7.54 (d, 2H, j= 5 , ArH), 7.67 (s, 1H, ArH), 14.0 (s, 1H, SH).

5-(4-*tert*-butyl-phenyl)-4-*p*-tolyl-4H-[1,2,4]triazole-3-thiol (5f), Yield 68%, ^{1}H-NMR (DMSO-d_6 .δ): 1.22 (s, 9H, *tert*-butyl), 2.37 (s, 3H, CH_3), 7.24 (m , 4H, j= 8.25, ArH), 7.32 (d, 2H, j= 8, ArH), 7.37 (d, 2H, j= 8.5 , ArH), 14.0 (s, 1H, SH).

4-(4-Fluorophenyl)-5-(4-isopropyl-phenyl)-4H-[1,2,4]triazole-3-thiol (5g), Yield 64%**.** ^{1}H-NMR (DMSO-d_6.δ): 1.16 (d, 6H, 2 CH_3 of isopropyl), 2.87 (q, 1H, CH of isopropyl),), 7.2 (d, 4H, j=9, ArH), 7.42 (d, 2H, j=5.5, ArH), 7.58 (d, 2H, j=5.5, ArH), 14.10 (s, 1H, SH).

5-(4-*tert*-Butyl-phenyl)-4-(4-fluoro-phenyl)-4H-[1,2,4]triazole-3-thiol (5i), Yield 59%, ^{1}H-NMR (DMSO-d_6 .δ): 1.22 (s, 9H, tert-butyl), 7.25 (d , 2H, j= 6.5, ArH), 7.36 (m, 4H, j= 12, ArH), 7.44 (m, 2H, j= 12 , ArH), 14.11 (s, 1H, SH).

1.5. General procedure for synthesis of S-alkylation triazole thiol **(T 1-10) [19]**

To a solution of triazole thiol (**8a-i)** (10 mmol) in 70 % ethanol containing KOH (10 mmol), a solution of 3-trifluoro benzyl chloride (10mmol) in ethanol was added dropwise. The reaction mixture was left stirring at room temperature for 16 h. The formed precipitate was collected by filtration and recrystallized from ethanol to give pure product of compounds **(T 1-10).**

4-(3-Bromo-phenyl)-3-(4-isopropyl-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T1), Yield 60%, mp:201-203, ^{1}H-NMR (DMSO-d_6 .δ): 1.15 (d, 6H, 2 CH_3 of isopropyl), 2.84 (q, 1H, CH of isopropyl), 4.5 (s, 2H, CH_2), 7.24 (m, 5H, j=9.5, ArH), 7.43 (t, 1H, j=8, ArH), 7.54 (t, 1H, j=9, ArH), 7.57 (t, 1H, j= 7.5, ArH), 7.62 (d, 2H, j=10, ArH), 7.67 (s, 1H, ArH), 7.73 (dd, 1H, j=8, ArH). ^{13}C-NMR (DMSO-d_6.δ): 23.51, 33.19, 36.05, 122.03, 123.00, 123.98, 124.11, 125.49, 126.63, 127.08, 127.87, 127.89, 129.21, 129,52, 130.60, 133.16, 135.28, 139.09, 150.03, 151.11, 154.40. MS analysis for $C_{25}H_{21}BrF_3N_3S$: Calcd mass: 532.04, found (m/z, ES+): 532.01.

3-(4-Isopropyl-phenyl)-4-(4-fluorophenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T2), Yield 56%, mp: 203-205, ^{1}H-NMR (DMSO-d_6 .δ): 1.23 (d, 6H, 2 CH_3 of isopropyl), 2.97 (q, 1H, CH of isopropyl), 4.95 (s, 2H, CH_2), 7.23 (d, 2H, j=8.5, ArH), 7.38 (m, 3H, j=10, ArH), 7.54 (d, 2H, j= 7.5 , ArH), 7.67 (d, 2H, j=8, ArH), 7.72 (d, 1H, j= 5, ArH), 7.87 (d, 2H, j= 5, ArH).^{13}C-NMR (DMSO-d_6.δ): 23.02, 33.19, 36.04, 122.52, 123.88, 124.41, 125.45, 125.58, 125.66, 126.89, 127.88, 128.13, 129.19, 129.44, 130.14, 132.89, 135.27, 139.17, 150.69, 151.05, 154.39. MS analysis for $C_{25}H_{21}F_4N_3OS$: Calcd mass: 471.14, found (m/z, ES+): 472.04.

4-(4-Chloro-phenyl)-3-(4-isopropyl-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T3), Yield 60%**,** mp: 210-212, ^{1}H-NMR (DMSO-d_6 .δ): 1.15 (d, 6H, 2 CH_3 of isopropyl), 2.85 (q, 1H, CH of isopropyl), 4.44 (s, 2H, CH_2), 7.23 (d, 2H, j=8.5, ArH), 7.25 (d, 2H, j=2.5, ArH), 7.26 (d, 2H, j=2, ArH), 7.54 (m, 2H, j= 9.5, ArH), 7.56 (d, 1H, j=2, ArH), 7.62 (m, 2H, j= 9, ArH), 7.64 (s, 1H, ArH). ^{13}C-NMR (DMSO-d_6.δ): 23.71, 33.39, 36.19, 123.97, 124.38, 124.41, 125.35, 125.68, 125.71, 126.89, 128.13, 129.19, 129.44, 129.76, 129,77, 130.14, 132.89, 133.33, 134.90, 139.17, 150.69, 151.05, 154.75. MS analysis for $C_{25}H_{21}ClF_3N_3S$: Calcd mass: 487.97, found (m/z, ES+): 488.27.

3-(4-*tert*-Butyl-phenyl)-4-phenyl-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T4) , Yield 70%, mp: 198-200 ^{1}H-NMR (DMSO-d_6 .δ): 1.22 (s, 9H, tert-butyl), 4.46 (s, 2H, CH_2), 7.24 (m , 3H, j= 8.25, ArH), 7.34 (d, 2H, j= 8, ArH), 7.51 (m, 4H, j= 8.5 , ArH), 7.63 (t, 2H, j=9.5, ArH), 7.70 (s, 1H, ArH). ^{13}C-NMR (DMSO-d_6.δ): 30.95, 34.62, 35.90, 120.97, 123.13, 123.81, 124.29, 125.50, 125. 56, 125.63, 125.67, 127.67, 127.77, 128.86, 129.12, 129.37, 129.65, 130.25, 133.28, 133.97, 139.18, 151.129, 152.69, 154.53. MS analysis for $C_{26}H_{24}F_3N_3S$: Calcd mass: 467.16, found (m/z, ES+): 468.23.

3-(4-*tert*-Butyl-phenyl)-4-p-tolyl-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T5), Yield 47%, mp: 184-186, ^{1}H-NMR (DMSO-d_6 .δ): 1.22 (s, 9H, tert-butyl), 2.36 (s, 3H,

CH_3), 4.45 (s, 2H, CH_2), 7.11 (d, 2H, j= 6.5, ArH), 7.29 (m, 4H, j= 9 , ArH), 7.36 (d, 2H, j= 4.5, ArH), 7.54 (t, 1H, j=7.5 , ArH), 7.63 (m, 2H, j= 8.5, ArH), 7.68 (s, 1H, ArH). ^{13}C-NMR (DMSO-d_6.δ): 20.86, 30.96, 34.62, 35.79, 123.13, 123.87, 124.24, 124.26, 125.57, 125.61, 125.64, 127.49, 127.55, 128.83, 129.09, 129.34, 129.63, 130.52, 131.38, 133.27, 139.97, 151.29, 152.64, 154.51. MS analysis for $C_{27}H_{26}F_3N_3S$: Calcd mass: 481.18, found (m/z, ES+): 482.22.

3-(4-*tert*-Butyl-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4-(4-trifluoromethyl-phenyl)-4H- [1,2,4] triazole (T6). Yield 70%, mp: 224-226, ^{1}H-NMR (DMSO-d_6 .δ): 1.24 (s, 9H, tert-butyl), 4.43 (s, 2H, CH2), 7.26 (dd, 2H, j= 7.5, ArH), 7.39 (dd, 2H, j= 7.5 , ArH), 7.48 (d, 2H, j= 9 , ArH), 7.53 (m, 1H, j=8.5 , ArH), 7.62 (m, 2H, j= 8, ArH), 7.65 (s, 1H, ArH), 7.87 (d, 2H, j= 8.5, ArH). ^{13}C-NMR (DMSO-d_6.δ): 30.827, 34.54, 36.12, 123.44, 124.156, 124.18, 125.56, 126.99, 127.02, 127.65, 128.83, 128.98, 129.23, 129.49, 129.97, 130.22, 133.10, 137.50, 138.99, 150.64, 152.71, 154.33. MS analysis for $C_{27}H_{23}F_6N_3S$: Calcd mass: 535.15, found (m/z, ES+): 536.28.

3-(4-*tert*-Butyl-phenyl)-4-(4-methoxy-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T7), Yield 47%, mp: 204-206, ^{1}H-NMR (DMSO-d_6 .δ): 1.21 (s, 9H, tert-butyl), 3.79 (s, 3H, OCH_3), 4.44 (s, 2H, CH2), 7.02 (d, 2H, j= 9, ArH), 7.13 (d, 2H, j= 8.5 , ArH), 7.29 (d, 2H, j= 8.5 , ArH), 7.36 (d, 2H, j=8.5 , ArH), 7.55 (t, 1H, j= 8, ArH), 7.65 (m, 3H, j=11 ArH). ^{13}C-NMR (DMSO-d_6.δ): 30.02, 32.54, 36.12, 55.52, 123.14, 124.56, 124.86, 126.56, 126.99, 127.22, 127.75, 128.23, 129.00, 129.23, 129.54, 129.67, 131.22, 132.10, 136.45, 139.39, 150.64, 151.72, 154.33. MS analysis for $C_{27}H_{26}F_3N_3OS$: Calcd mass: 497.17, found (m/z, ES+): 498.30.

3-(4-*tert*-Butyl-phenyl)-4-(3-chloro-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T8), Yield 70%, mp: 230-232, ^{1}H-NMR (DMSO-d_6 .δ): 1.23 (s, 9H, tert-butyl), 4.45 (s, 2H, CH_2), 7.21 (dd, 1H, j= 2, ArH), 7.28 (dd, 2H, j= 2, ArH), 7.38 (dd, 2H, j=

2.5 , ArH), 7.43 (t, 1H, j=4 , ArH), 7.54 (m, 2H, j=4 , ArH), 7.60 (m, 1H, j= 3, ArH), 7.63 (m, 2H, j=5, ArH), 7.66 (s, 1H, ArH). ^{13}C-NMR (DMSO-d_6.δ): 30.93, 34.64, 36.20, 123.10, 123.59, 124.28, 124.30 125.27, 125.58, 125.61, 125.64, 126.83, 127.69, 127.84, 129.11, 129.37, 131.56, 133.24, 133.98, 135.29, 139.17, 150.92, 152.84, 154.46. MS analysis for $C_{26}H_{23}ClF_3N_3S$: Calcd mass: 501.13, found (m/z, ES+): 502.25.

3-(4-Isopropyl-phenyl)-4-(4-methoxy-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T9), Yield 47%, mp: 214-216, ^{1}H-NMR (DMSO-d_6 .δ): 1.13 (d, 6H, 2 CH_3 of isopropyl), 2.85 (q, 1H, CH of isopropyl), 3.75 (s, 3H, OCH_3), 4.45 (s, 2H, CH_2), 6.74 (dd, 1H, j=8.5, ArH), 6.90 (t, 1H, j=6.5, ArH), 7.09 (dd, 1H, j=6.5, ArH), 7.21 (d, 2H, j= 5, ArH), 7.29 (d, 2H, j= 5, ArH), 7.38 (t, 1H, j= 7.5, ArH), 7.54 (t, 1H, j= 7.5 , ArH), 7.61 (d, 1H, j= 8.5, ArH), 7.67 (d, 1H, j= 7, ArH), 7.72 (s, 1H, ArH).^{13}C-NMR (DMSO-d_6.δ): 23.51, 33.18, 35.66, 55.52, 113.61, 115.44, 119.58, 124.08, 124.11, 125.52, 125.55, 126.52, 127.69, 128.95, 129.20, 129.45, 130.69, 133.15, 134.91, 139.13, 150.20, 154.35, 159.94. MS analysis for $C_{26}H_{24}F_3N_3OS$: Calcd mass: 483.16, found (m/z, ES+): 484.23.

3-(4-*tert*-Butyl-phenyl)-4-(4-fluoro-phenyl)-5-(3-trifluoromethyl-benzylsulfanyl)-4H-[1,2,4]triazole (T10), Yield 65%, mp: 223-225 , ^{1}H-NMR (DMSO-d_6 .δ): 1.23 (s, 9H, tert-butyl), 4.45 (s, 2H, CH_2), 7.26 (d, 2H, j= 6.5, ArH), 7.34 (m, 6H, j= 9.5 , ArH), 7.54 (t, 1H, j= 8 , ArH), 7.63 (m, 2H, j= 7.5, ArH), 7.68 (s, 1H, ArH). ^{13}C-NMR (DMSO-d_6.δ): 30.67, 34.51, 35.75, 116.79 116.98, 123.67, 124.11, 125.46, 125.51, 125.54, 127.49, 128.96, 129.20, 129.49, 130.13, 130.24, 133.16, 139.08, 151.08, 152.52, 161.38. MS analysis for $C_{26}H_{23}F_4N_3S$: Calcd mass: 485.18, found (m/z, ES+): 486.22.