SYNTHESIS AND ANTIMICROBIAL ACTIVITIES OF 5-(2', 5'-DISUBSTITUTED1H- INDOL-3'-YL)-5H-THIAZOLO [4,3-b]1,3,4-OXADIAZOLE, -1,3,4-THIADIAZOLE, -1,2,4-TRIAZOLE AND THEIR DERIVATIVES

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Abstract

Several 5-(2', 5'-disubstituted 1H- indol-3'-yl)-5H-thiazolo[4,3-b]1,2,4-triazoles (**5**) -1,3,4-thiadiazoles (**6**) and 1,3,4-oxadiazoles (**7**) and their analogues were synthesized. These compounds were screened for their antimicrobial activity.

INTRODUCTION

Indole and its derivatives have occupied a unique place in the chemistry of nitrogen heterocycles because of their wide spectrum of biological activities such as, anti-microbial[1], anti-inflammatory[2], anti-HIV[3], anti-tubercular[4], CNS dipressant[5], etc. In addition, the indole nucleus is present in a number of physiologically significant compounds, e.g., serotonin isolated from blood serum[6], indole 3-acetic acid (heteroxin) is naturally occurring plant growth hormone and reserpin is an indole alkaloid has been shown to be active in reducing the concentration of serotonin in central tissues[7]. Similarly, thiazole and its derivatives are found to be associated with various biological activities such as, antibacterial, antifungal and anti-inflammatory activities[8]. On the same line, 1,3,4-thiadiazoles, 1,2,4-triazoles and 1,3,4-oxadiazoles possesses wide spectrum of biological activities including anti-tuberculosis, anti-convolusent, anti-inflammatory, insecticidal, antifungal, analgesic and antitumor properties[9-16].

The above observations coupled with the view that, planarity and compactness of a molecule might augment its other biological activities. Encouraged by these investigations and considering the interesting pharmacological profile of these systems and in continuation of our research to synthesize bioactive molecule[17,18], it has been planned to synthesize a molecule which combines these two biolable ring systems together, viz., indole nucleus with thiazolotriazole, thiazolothiadiazole and thiazolooxadiazole to give a compact molecule which may act as a better pharmacophore. Hence, we report herein the synthesis of title compounds with the hope to achieve a compound of better biological activities.

RESULT AND DISCUSSION:

Starting compounds 5-substituted 2-(4-substituted phenyl)indole-3-carboxaldehydes (**2**) were obtained by treatment of 5-substituted 2-(4-substituted phenyl)indoles (**1**) with N,N-dimethyl formamide and phosphorus oxychloride complex (Vilsmeier reagent) following the literature procedure[19] (Scheme-1). **2a** (i.e., R= Cl and R'= CH_3) on reaction with thiosemicarbazide in methanol containing catalytic amount of acetic acid at reflux temperature gave the corresponding thiosemicarbazone (**3a**) (Scheme-1). The structure of which has been established on the basis of its spectral data. Thus, its IR (KBr) spectrum exhibited the absorption peaks at 3400 and 3330 cm^{-1} (doublet of unequal and medium intensities) due to NH_2 group of thiosemicarbazone moiety. The absorption peak at 3252 cm^{-1} is attributed to indole NH, the peak at 3159 cm^{-1} is appeared as broad but medium band due to the NH group of thiosemicarbazone residue, the absorption at 1591 cm^{-1} is appeared due to C=N function, the sharp peak due to C=S group appeared at 1097 cm^{-1} and no absorption in carbonyl region indicating the absence of aldehyde group. Its ^1H NMR spectrum revealed signals at δ 2.40 (s, 3H, *p*-CH_3), 7.07-7.48 (m, 7H, ArH), 7.8 (s, 2H, NH_2), 8.4 (s, 1H, CH=N), 11.0 (s, 1H, NH-CS) and 11.7 (s, 1H, indole NH). In its mass spectrum the isotopic molecular ion is appeared at m/e 342, 344. These data clearly supports the formation of thiosemicarbazone **3a** from **2a**. **3a** on cyclocondensation with thioglycolic acid in presence of anhydrous zinc chloride as a catalyst using N, N-dimethyl formamide as solvent under reflux condition afforded the respective indolyl thiazolidinone (**4a**) (Scheme-1). The structure of this compound has been established on the basis of its spectral data. In IR (KBr) spectrum, it showed peaks at 3411 cm^{-1} (broad medium due to NH_2), at 3215 and 3075 cm^{-1} (broad medium due to NH groups), at 1607 and 1572 cm^{-1} amide-I and amide-II bands, respectively, of cyclic amide and the C=S function appeared at 1094 cm^{-1}. The disappearance of a peak at 1591 cm^{-1} due to C=N absorption and appearance of new peaks due to amide functionality supports the formation of **4a** from **3a**. Also its ^1H NMR spectrum exhibited signals at δ 2.39 (s, 3H, *p*-CH_3), 2.83 (s, 2H, S-CH_2-C=O), 7.09-7.38 (m, 8H, 7-ArH+S-CH-N), 8.38 (s, 2H, NH_2), 8.89 (s, 1H, NH) and 11.53 (s, 1H, indole NH). The mass spectrum of this compound exhibited isotopic molecular ion peak at m/e 416, 418.

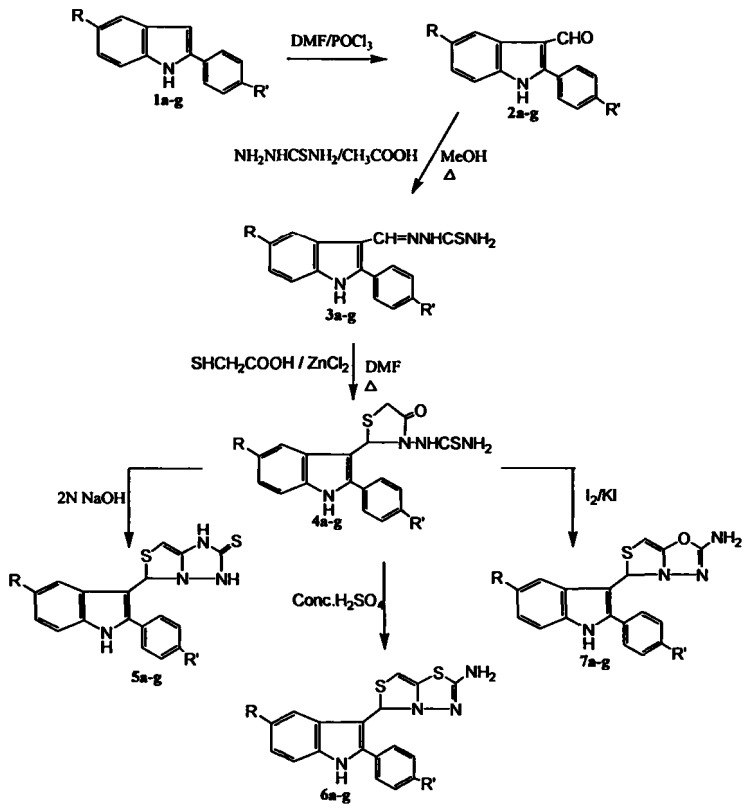
Compounds **5a-g**, **6a-g** and **7a-g** were obtained in good yields by intramolecular chemoselective heterocyclizition of **4a-g** with NaOH, conc. H_2SO_4 and I_2/KI, respectively (Scheme-1). The structures of these compounds were conformed by their spectral studies. The compound **5a** was conformed by disappearance of absorption peaks at 1607 cm^{-1} and 1572 cm^{-1} of amide carbonyl and appearance of new peaks at 3416 and 3216 cm^{-1} (broad medium due to NH), the C=S absorption appeared at 1088 cm^{-1} in its IR (KBr) spectrum. In its ^1H NMR spectrum signals at δ 2.48 (s, 3H, *p*-CH_3), 6.91-7.71 (m, 9H, CH-S-CH+7-ArH), 8.4 (s, 1H, NH), 9.04 (s, 1H, NH), 10.86 (s, 1H, indole NH). The signal at δ 2.83 (s, 2H, S-CH_2-C=O) of **4a** disappeared and presence of new signals at δ 8.4 due to NH and 9.04 due to NH-C-NH conforms the formation of **5a** from **4a**. Further the mass spectrum of this compound exhibited isotopic molecular ion peak at m/e 398, 400.

Compound **6a** in its IR (KBr) spectrum exhibited absorption peaks at 1610 cm^{-1} due to C=N function of 1,3,4-thiadiazole moiety and absorption at 3413 and 3219 cm^{-1} appeared due to NH/NH_2 groups. In its ^1H NMR spectrum various protons were resonated at δ 2.43 (s, 3H, *p*-CH_3), 7.26-7.56 (m, 9H, CH-S-CH+7-ArH), 8.6 (s, 2H, NH_2), 10.91 (s, 1H, indole NH). The signals at δ 8.3 due to (s, 2H, NH_2) and at 2.83 due to (s, 2H, S-CH_2-C=O) of **4a** were disappeared which conforms the formation of **6a** from **4a**. The mass spectrum of this compound exhibited isotopic molecular ion peak at m/e 398, 400.

The compound **7a** exhibited in its IR (KBr) spectrum absorption at 3420, 3383 cm^{-1} (broad medium due to NH_2 and NH, respectively) and 1607 cm^{-1} due to C=N function of 1,3,4-oxadiazole. The ^1H NMR spectrum showed signals at δ 2.13 (s, 3H, *p*-CH_3), 6.9-7.56 (m, 9H, CH-S-CH+7-ArH), 8.61 (s, 2H, NH_2) and 10.96 (s, 1H, indole NH).

The mass spectrum of this compound exhibited isotopic molecular ion peak at m/e 382, 384. Thus the formation of **7a** from **4a** was conformed.

All the spectral data of the synthesized compounds were given in table-2.



	a	b	c	d	e	f	g
Where R=	Cl	Cl	H	H	Cl	CH_3	H
R'=	CH_3	Cl	CH_3	Cl	H	H	H

Scheme - 1

Antimicrobial activity:

All the newly synthesized compounds (**3-7**) were evaluated for their antibacterial and antifungal activities by cup-plate method at a concentration 1mg/ml following reported procedure[20]. The zone of inhibition was compared with the standard gentamycin and flucanozole for antibacterial and antifungal activity, respectively. The investigation of antibacterial screening revealed that, all the compounds exhibited moderate to good zone of inhibition against *Staphylococcus aureus*, *Pseudomonos aeruginosa* and *Klebsella pneumonia*. Compounds **4b**, **6c** and **6e** showed good activity against *P.aeruginosa*, compound **4e**, **4f**, **4g**, **5c**, **6f** and **7c** exhibited good activity against *K.Pneumonia* and compound **3b**, **4b**, **4e**, **5c**, **6c** and **7c** showed good inhibition against *S.Aureus.* In antifungal screening, compounds **4d**, **4f**, **7e** and **7g** exhibited maximum zone of inhibition against *Aspergillus oryzae,* compounds **3e**, **3f**, **4e**, **6e**, **6f** and **6g** showed good activity against *Aspergillus terrus* and compounds **3e**, **3f**, **3g**, **4e**, **4f**, **5d**, **7e** and **7f** exhibited good activity against *Aspergillus niger.*

Experimental section:

All the reagents were obtained commercially and used with further purification. Melting points were determined by an open capillary method and are uncorrected. The IR spectra (KBr) were recorded with a Perkin-Elmer spectrum one FTIR spectrometer. The ^{1}H NMR spectra were recorded ($CDCl_3$+DMSO) with an AMX-400AV III solids NMR. The chemical shifts were expressed in ppm (δ-scale) downfield from TMS. Mass spectra were recorded with a 2010A Data Report-Shimadzu. Elemental analysis carried out using Flash EA 1112 series elementar analyzer.

Preparation of 2-phenyl indole 3-carboxaldehyde (2a-g):

These compounds were prepared by following literature procedure[19].

Preparation of thiosemicarbazone (3a-g):

To a solution of 2 (0.01 mole) and thiosemicarbazide (0.01 mole) in methanol (20 ml), few drops of acetic acid were added and the mixture refluxed for 5 hrs. At the end of this period, the solution was cooled to room temperature and poured into ice cold water, then neutralized with solid $NaHCO_3$, the separated solid was filtered and dried to obtain **(2a-g).** The crude products were recrystallized from ethanol. Physical data were tabulated in table 1.

Preparation of 1-[2-(2,5-disubstituted-1H-indol-3-yl)-4-oxothiazolidin-3-yl]thiourea (4a-g):

Thiosemicarbazone **3** (0.01 mole) was refluxed in DMF (30 ml) containing a pinch of anhydrous zinc chloride and thioglycolic acid (0.01 mol) for 8 hrs. The mixture was cooled and poured into ice cold water, the separated solid was filtered, washed with water and recrystallized from ethanol. Physical data were tabulated in table 1.

Preparation of 2-amino-(2', 5'-substituted -1H-indol-3'-yl)-5H-thiazolo[4,3-b]1,3,4-oxadiazole (7a-g):

To a solution of 1-[2-(2,5-disubstituted-1H-indol-3-yl)-4-oxothiazolidin-3-yl]thiourea, **4** (0.01 mole) in ethanol (10 ml), NaOH (8 ml, 2N) was added followed by the addition of I_2 in KI solution (5%) till permanent tinge of iodine persisted. The reaction mixture was refluxed for 2 hrs, cooled to room temperature and poured into ice cold water. The desired product thus obtained was filtered, washed with water and recrystallized from ethanol. Physical data were tabulated in table 1.

Preparation of 2-amino 5'-(2', 5'-substituted-1H-indol-3'-yl)-5H-thiazolo[4,3-b]-1,3,4-thiadiazole (6a-g):

To a solution of 1-[2-(2,5-disubstituted-1H-indol-3-yl)-4-oxothiazolidin-3-yl]thiourea **4** (0.01 mole) in ethanol (10 ml), concentrated sulphuric acid (8 ml) was added drop wise with stirring in an ice bath at 0-2^0 C. After 45 min. the reaction mixture was poured into ice cold water and then neutralized with ammonia solution. The product thus separated was filtered, washed with water, dried and recrystallized from ethanol. Physical data were tabulated in table 1.

Preparation of 5-(2', 5'-substituted-1H-indol-3'-yl)-2-mercapto-1,5-dihydrothiazolo [3,4-b]-1,2,4-triazole (5a-g):

1-[2-(2,5-disubstituted-1H-indol-3-yl)-4-oxothiazolidin-3-yl]thiourea **4** (0.01 mole) was dissolved in NaOH (2N , 10 ml) and ethanol (5 ml). The reaction mixture was refluxed for 8 hrs. The resulting mixture was cooled and poured on to crushed ice, on acidification with dil.HCl gave the crude product which was filtered, washed with water, dried and recrystallized from ethanol. Physical data were tabulated in table 1.

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Table-1: Physical data of compounds (3-7):

Comp. No	Substitution R	Substitution R'	Molecular formula	Yield (%)	M.P (^{0}C)	Elemental Analysis. Calculated(found) C	H	N
3a	Cl	CH_3	$C_{17}H_{15}N_4ClS$	61	258-60	59.56(59.59)	4.41(4.40)	16.34(16.33)
3b	Cl	Cl	$C_{16}H_{12}N_4Cl_2S$	71	238-40	52.90(52.88)	3.33(3.29)	15.42(15.48)
3c	H	CH_3	$C_{17}H_{16}N_4S$	68	244-46	66.24(66.30)	5.23(5.29)	18.17(18.15)
3d	H	Cl	$C_{16}H_{13}N_4ClS$	66	210-14	58.44(58.43)	3.98(3.40)	17.04(17.00)
3e	Cl	H	$C_{16}H_{13}N_4ClS$	63	249-50	58.44(58.50)	3.98(3.87)	17.04(16.98)
3f	CH_3	H	$C_{17}H_{16}N_4S$	79	255-56	66.24(66.28)	5.23(5.18)	18.17(18.18)
3g	H	H	$C_{16}H_{14}N_4S$	73	220-22	65.28(65.25)	4.79(4.83)	19.03(19.15)
4a	Cl	CH_3	$C_{19}H_{17}N_4OClS_2$	66	140-42	54.73(54.60)	4.11(4.23)	13.44(13.25)
4b	Cl	Cl	$C_{18}H_{14}N_4OCl_2S_2$	68	120-24	49.43(49.32)	3.23(3.19)	12.81(12.85)
4c	H	CH_3	$C_{19}H_{18}NOS_2$	66	180-85	59.66(59.32)	4.74(4.69)	14.65(14.51)
4d	H	Cl	$C_{18}H_{15}N_4OClS_2$	70	210-13	53.66(53.59)	3.75(3.82)	13.91(14.03)
4e	Cl	H	$C_{18}H_{15}N_4OClS_2$	63	220-22	53.66(53.62)	3.75(3.90)	13.91(13.95)
4f	CH_3	H	$C_{19}H_{18}NOS_2$	71	93-96	59.66(59.78)	4.74(4.92)	14.65(14.86)
4g	H	H	$C_{18}H_{16}N_4OS_2$	69	235-39	58.67(58.72)	4.38(4.29)	15.21(15.29)
5a	Cl	CH_3	$C_{19}H_{15}N_4ClS_2$	65	118-21	57.20(57.32)	3.79(3.96)	14.04(14.20)
5b	Cl	Cl	$C_{18}H_{12}N_4Cl_2S_2$	63	185-88	51.55(51.35)	2.88(2.76)	13.36(13.41)
5c	H	CH_3	$C_{19}H_{16}N_4S_2$	66	165-68	62.61(62.56)	4.42(4.51)	15.37(15.29)
5d	H	Cl	$C_{18}H_{13}N_4ClS_2$	64	186-87	56.17(56.09)	3.40(3.38)	14.56(14.61)
5e	Cl	H	$C_{18}H_{13}N_4ClS_2$	60	250-52	56.17(56.29)	3.40(3.45)	14.56(14.49)
5f	CH_3	H	$C_{19}H_{16}N_4S_2$	54	120-23	62.61(62.53)	4.42(4.38)	15.37(15.26)
5g	H	H	$C_{18}H_{13}N_4S_2$	65	193-95	61.69(61.82)	4.03(4.29)	15.99(16.12)
6a	Cl	CH_3	$C_{19}H_{15}N_4ClS_2$	71	240-42	57.20(57.32)	3.79(3.96)	14.04(13.95)
6b	Cl	Cl	$C_{18}H_{12}N_4Cl_2S_2$	66	166-68	51.55(51.32)	2.88(2.96)	13.36(13.42)
6c	H	CH_3	$C_{19}H_{16}N_4S_2$	67	213-15	62.61(62.32)	4.42(4.29)	15.37(15.43)
6d	H	Cl	$C_{18}H_{13}N_4ClS_2$	69	201-03	56.17(56.06)	3.40(3.52)	14.56(14.62)
6e	Cl	H	$C_{18}H_{13}N_4ClS_2$	64	116-20	56.17(56.08)	3.40(3.29)	14.56(14.48)
6f	CH_3	H	$C_{19}H_{16}N_4S_2$	68	183-85	62.61(62.32)	4.42(4.52)	15.37(15.45)
6g	H	H	$C_{18}H_{14}N_4S_2$	61	160-63	61.69(61.72)	4.03(4.23)	15.99(16.09)
7a	Cl	CH_3	$C_{19}H_{15}N_4ClS_2$	68	282-85	59.60(59.20)	3.95(4.23)	14.63(14.49)
7b	Cl	Cl	$C_{18}H_{12}N_4OCl_2S_2$	68	210-13	53.61(53.35)	3.00(3.25)	13.89(13.68)
7c	H	CH_3	$C_{19}H_{16}N_4OS_2$	61	233-36	65.50(65.80)	4.63(4.71)	16.08(16.23)
7d	H	Cl	$C_{18}H_{13}N_4OClS_2$	70	261-63	58.61(58.38)	3.55(3.60)	15.19(15.08)
7e	Cl	H	$C_{18}H_{13}N_4OClS_2$	61	128-30	58.61(58.39)	3.55(3.72)	15.19(15.23)
7f	CH_3	H	$C_{19}H_{16}N_4OS_2$	65	120-24	65.50(65.86)	4.63(4.72)	16.08(15.95)
7g	H	H	$C_{18}H_{14}N_4OS_2$	69	238-39	64.65(64.36)	4.22(4.39)	16.75(19.98)

Table-2: Spectral data of compounds (3-7):

Comp	IR(KBr) cm^{-1}	^{1}HNMR ($CDCl_3$+DMSO) δ ppm	MS m/z[M^+]
3a	3400(NH_2), 3330(NH), 3252 (NH), 3159(NH), 1591(C=N), 1097 (C=S).	2.40 (s, 3H, *p*-CH_3), 7.07-7.48 (m, 7H, ArH), 7.8 (s, 2H, CS-NH_2), 8.4 (s, 1H, CH=N-N-), 11.01 (s, 1H, N-NH-CS), 11.7 (s, 1H, indole NH).	344[M^++2]
3b	3423 (NH_2), 3372 (NH), 3265 (NH), 1597 (C=N), 1105 (C=S).	6.95-7. 40 (m, 7H, Ar H), 7.72 (s, 2H, CS-NH_2), 8.16 (s, 1H, CH=N-N-), 10.45 (s, 1H, N-NH-CS), 11.09 (s, 1H, indole NH).	364 [M^++4]
3c	3450(NH_2), 3379 (NH), 3274 (NH), 1602 (NH), 1110 (C=S).	2.31(s, 3H, *p*-CH_3), 6.93-7.35 (m, 8H, ArH), 7.69 (s, 2H, CS-NH_2), 8.1 (s, 1H, CH=N-N-), 10.4 (s, 1H, N-NH-CS), 10.92 (s, 1H, indole NH).	309 [M^+]
3d	3436 (NH_2), 3365 (NH), 3269 (NH), 1615(NH), 1110 (C=S).	7.01-7.49 (m, 8H, Ar H), 7.72 (s, 2H, CS-NH_2), 8.13 (s, 1H, CH=N-N-), 10.39 (s, 1H, N-NH-CS), 10.92 (s, 1H, indole NH).	330 [M^++2]
3e	3429 (NH_2), 3381 (NH), 3278 (NH), 1591 (C=N), 1091 (C=S).	6.87-7.34 (m, 8H, Ar H), 7.82 (s, 2H, CS-NH_2), 8.12 (s, 1H, CH=N-N-), 10.6 (s, 1H, N-NH-CS), 11.12 (s, 1H, indole NH).	330 M^++2]
3f	3445 (NH_2), 3355 (NH), 3256 (NH), 1601(C=N), 1101(C=S).	2.1(s, 3H, 5-CH_3), 7.09-7.48 (m, 8H, ArH), 7.59 (s, 2H, CS-NH_2), 8.21(s, 1H, CH=N-N-), 10.41 (s, 1H, N-NH-CS), 10.98 (s, 1H, indole NH).	309 [M^+]
3g	3449 (NH_2), 3356 (NH), 3279 (NH), 1605(C=N), 1098 (C=S).	7.01-7.4 (m, 9H, Ar H), 7.71 (s, 2H, CS-NH_2), 8.29 (s, 1H, CH=N-N-), 10.39 (s, 1H, N-NH-CS), 11.02 (s, 1H, indole NH).	295 [M^+]
4a	3411 (NH_2), 3215 (NH), 3075 (NH), 1607 (N-C=O), 1591 (C=S).	2.39 (s, 3H, *p*-CH_3), 2.83 (*s*, 2H, CO-CH_2-S), 7.09-7.38 (m, 7H, ArH), 8.37 (s, 1H, S-CH-N), 8.38 (*s*, 1H, S-CH-N), 8.89 (*s*, 2H, NH_2), 11.51 (*s*, 1H, indole NH).	418M^++2]
4b	3415 (NH_2), 3225 (NH), 3115 (NH), 1605 (N-C=O), 1104 (C=S).	2.84 (*s*, 2H, CO-CH_2-S), 7.01-7.41 (m, 7H, ArH), 8.37 (*s*, 1H, S-CH-N), 8.87 (*s*, 2H, NH_2), 9.89 (*s*, 1H, NH), 10.96 (*s*, 1H, indole NH).	441 [M^++4]
4c	3419 (NH_2), 3224 (NH), 3118 (NH), 1603 (N-C=O), 1098 (C=S).	2.11 (s, 3H, *p*-CH_3), 2.84 (*s*, 2H, CO-CH_2-S), 7.03-7.45 (m, 8H, ArH), 8.38 (*s*, 1H, S-CH-N), 8.88 (*s*, 2H, NH_2), 9.87 (*s*, 1H, NH), 10.86 (*s*, 1H, indole NH).	383 [M^+]
4d	3422 (NH_2), 3225 (NH), 3115 (NH), 1610 (N-C=O), 1109 (C=S).	2.81 (*s*, 2H, CO-CH_2-S), 6.97-7.35 (m, 8H, ArH), 8.36 (*s*, 1H, S-CH-N), 8.91 (*s*, 2H, NH_2), 9.89 (*s*, 1H, NH), 10.98 (*s*, 1H, indole NH).	404[M^++2]
4e	3414 (NH_2), 3223 (NH), 3110 (NH), 1608 (N-C=O), 1098 (C=S)	2.8 (*s*, 2H, CO-CH_2-S), 7.03-7.59 (m, 8H, ArH), 8.4 (*s*, 1H, S-CH-N), 8.9 (*s*, 2H, NH_2), 9.89 (*s*, 1H, NH), 10.95 (*s*, 1H, indole NH).	404[M^++2]
4f	3429 (NH_2), 3219 (NH), 3113 (NH), 1612 (N-C=O), 1095 (C=S).	2.19 (s, 3H, 5-CH_3), 2.81 (*s*, 2H, CO-CH_2-S), 7.02-7.50 (m, 8H, ArH), 8.29 (*s*, 1H, S-CH-N), 8.79 (*s*, 2H, NH_2), 9.86 (*s*, 1H, NH), 10.91 (*s*, 1H, indole NH).	383 [M^+]
4g	3427 (NH_2), 3226 (NH), 3117 (NH), 1607 (N-C=O), 1099 (C=S).	2.89 (*s*, 2H, CO-CH_2-S), 7.06-7.47 (m, 9H, ArH), 8.32 (*s*, 1H, S-CH-N), 8.82 (*s*, 2H, NH_2), 9.88 (*s*, 1H, NH), 10.94 (*s*, 1H, indole NH).	369 [M^+]

5a	3416 (NH), 3216 (NH), 1088 (C=N).	2.48 (s, 3H, *p*-CH_3), 6.91-7.71 (*m*, 9H, 7-ArH, CH-S-CH), 8.4 (*s*, 1H, NH), 9.04 (s, 1H, NH) 10.86 (*s*, 1H, indole NH).	400 [M^++2]
5b	3380 (NH), 3145 (NH), 1079 (C=S).	6.98-7.50 (*m*, 9H, 7-ArH, CH-S-CH), 8.80 (*s*, 1H, NH), 9.01(s, 1H, SH) 11.15 (*s*, 1H, indole NH).	423 [M^++4]
5c	3382 (NH), 3149 (NH), 1085 (C=S).	2.19 (s, 3H, *p*-CH_3), 6.97-7.51 (*m*, 10H, 8-ArH, CH-S-CH), 8.72 (*s*, 1H, NH), 9.02 (s, 1H, SH) 10.97 (*s*, 1H, indole NH).	365 [M^+]
5d	3386 (NH), 3146 (NH), 1087 (C=S).	6.98-7.48(*m*, 10H, 8-ArH, CH-S-CH), 8.76 (*s*, 1H, NH), 9.03 (s, 1H, SH), 11.04 (*s*, 1H, indole NH).	386 [M^++2]
5e	3383 (NH), 3142 (NH), 1049 (C=S).	6.96-7.53 (*m*, 10H, 8-ArH, CH-S-CH), 8.31 (*s*, 1H, NH) 8.82 (*s*, 1H, NH), 11.15 (*s*, 1H, indole NH).	386 [M^++2]
5f	3387 (NH), 3148 (NH), 1101 (C=S).	2.24 (s; 3H, 5-CH_3), 6.99-7.41 (*m*, 10H, 8-ArH, CH-S-CH), 8.73 (*s*, 1H, NH), 9.03 (s, 1H, SH), 10.93 (*s*, 1H, indole NH).	365 [M^+]
5g	3384 (NH), 3140 (NH), 1097 (C=S).	7.03-7.52(*m*, 11H, 9-ArH, CH-S-CH), 8.69 (*s*, 1H, NH), 9.01 (s, 1H, SH), 10.95 (*s*, 1H, indole NH).	351 [M^+]
6a	3413 (NH_2), 3219 (NH), 1610 (C=N)	2.43 (s, 3H, *p*-CH_3), 7.26-7.56 (*m*, 9H, 7- ArH, CH-S-CH), 8.6 (*s*, 2H, NH_2), 10.91 (*s*, 1H, indole NH).	400 [M^++2]
6b	3382 (NH_2), 2916 (NH), 1619 (C=N)	7.16-7.54 (*m*, 9H, 7- ArH, CH-S-CH), 8.61(*s*, 2H, NH_2), 10.86 (*s*, 1H, indole NH).	423 [M^++4]
6c	3380 (NH_2), 2945 (NH), 1610(C=N)	2.14 (s, 3H, *p*-CH_3), 7.09-7.51 (*m*, 10H, 8- ArH, CH-S-CH), 8.60(*s*, 2H, NH_2), 10.84 (*s*, 1H, indole NH).	365 [M^+]
6d	3381 (NH_2), 2949 (NH), 1613 (C=N)	7.11-7.49 (*m*, 10H, 8-ArH, CH-S-CH), 8.62(*s*, 2H, NH_2), 10.91 (*s*, 1H, indole NH).	386 [M^++2]
6e	3383 (NH_2), 2916 (NH), 1616 (C=N)	6.93-7.51 (*m*, 10H, ArH), 8.8 (*s*, 2H, NH_2), 11.17 (*s*, 1H, indole NH).	386 [M^++2]
6f	3385 (NH_2), 2948 (NH), 1615 (C=N)	2.13 (s, 3H, 5-CH_3), 7.06-7.52 (*m*, 10H, 8- ArH, CH-S-CH), 8.60 (*s*, 2H, NH_2), 10.82 (*s*, 1H, indole NH).	365 [M^+]
6g	3384 (NH_2), 2946 (NH), 1612 (C=N).	7.10-7.51 (*m*, 11H, 9-ArH, CH-S-CH), 8.61(*s*, 2H, NH_2), 10.80 (*s*, 1H, indole NH).	351 [M^+]
7a	3420 (NH_2), 3383 (NH), 1607 (C=N).	2.13 (s, 3H, *p*-CH_3), 6.9-7.56 (*m*, 9H, 7-ArH, CH-S-CH), 8.61 (*s*, 2H, NH_2), 10.06 (*s*, 1H, indole NH).	384 [M^++2]
7b	3425 (NH_2), 3380 (NH), 1610 (C=N).	6.97-7.50 (*m*, 9H, 7-ArH, CH-S-CH), 8.51 (*s*, 2H, NH_2), 10.46 (*s*, 1H, indole NH).	407 [M^++4]
7c	3416 (NH_2), 3376 (NH), 1612 (C=N).	2.12 (s, 3H, *p*-CH_3), 6.99-7.46 (*m*, 10H, 8-ArH, CH-S-CH), 8.54 (*s*, 2H, NH_2), 10.41 (*s*, 1H, indole NH).	349 [M^+]
7d	3424 (NH_2), 3371 (NH), 1609 (C=N).	7.01-7.51 (*m*, 10H, 8-ArH, CH-S-CH), 8.50(*s*, 2H, NH_2), 10.78 (*s*, 1H, indole NH).	370 [M^++2]
7e	3383 (NH_2), 2966 (NH), 1616 (C=N).	6.93-7.51 (*m*, 10H, ArH), 8.54 (*s*, 2H, NH_2), 10.86 (*s*, 1H, indole NH).	370 [M^++2]
7f	3429 (NH_2), 3374 (NH), 1614 (C=N).	2.15 (s, 3H, 5-CH_3), 7.10-7.55 (*m*, 10H, 8- ArH, CH-S-CH), 8.80 (*s*, 2H, NH_2), 10.87 (*s*, 1H, indole NH).	349 [M^+]
7g	3428 (NH_2), 3370 (NH), 1611 (C=N).	7.02-7.52 (*m*, 11H, 9- ArH, CH-S-CH), 8.51 (*s*, 2H, NH_2), 10.77 (*s*, 1H, indole NH).	335 [M^+]