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MEDICINAL CHEMISTRY RESEARCH

ORIGINAL RESEARCH

Synthesis and antimicrobial activity of newer indole semicarbazones

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Abstract A series of 1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1*H*-indole-3yl)methylene) semicarbazone derivatives (**4a–g** and **6a–c**) were synthesized by the condensation of derivatives of 1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1*H*-indole-3-carbaldehyde and semicarbazide in ethanol under microwave irradiation procedure. Both conventional and microwave-irradiated syntheses have been carried out to compare their yields and reaction time. The structures of the synthesized compounds were confirmed by spectral data. The antimicrobial activities of the synthesized compounds were screened using broth dilution method. Among all the screened compounds some of the compounds exerted good antifungal activity against *C. albicans* and *C. rugosa*. All the compounds exhibited moderate activity against bacteria such as *B. subtilis*, *S. aureus*, *S. epidermidis*, *E. coli*, *P. aeoginosa*, and *K. pneumoniae.*

Keywords 2-phenyl-1*H*-indole-3-carbaldehyde · Semicarbazide · Antimicrobial activity

Introduction

In the recent past, bacterial infections have increased at an alarming rate causing deadly diseases and wide spread epidemics in humans. All types of bacterial diseases have taken a high toll on humanity (Todar's Online Text book of Biotechnology, http://www.textbookofbiotechnology.net/). The resistance of antibiotics to control emerging and pre-emerging bacterial pathogens focused the medicinal chemists to search potential new antimicrobial agents to cure microbial infections effectively (Nagai *et al*., 2002; Joan *et al*., 2002; Nagano *et al*. 2000; John *et al*., 2000). 2-Phenyl indole-3-carbaldehyde is a versatile heterocyclic identified as strong antimitotic agent (Susanne *et al*., 2008). 2-Aryl indole derivatives also displayed diverse biological activities such as antiestrogen (Ismail *et al*., 1997; Fung-Tomc *et al*., 2002) antiinflammatory (Von Angerer *et al*., 1900; Biberger and Von Angerer, 1998) cytotoxic (Stevenson *et al*., 2000) and antimitotic (Doris Kaufmann *et al*., 2007; Mahboobi *et al*., 2005) activities. Semicarbazones also possessed various therapeutic activities (Dimmock and Baker, 1994; Jenny *et al*., 2002. Fedorova *et al*., 1998). Microwave irradiation presents a powerful tool toward organic reactions which offers several advantages including shorter reaction time, cleaner reaction profiles, and simple experimental product isolation procedures (Loupy, 2002). In continuation to our research on biologically important heterocyclics in our laboratory (Suresh Kuarm *et al*., 2010; Venumadhav *et al*., 2009; Rajitha *et al*., 2005), we have synthesized new 2-phenyl indole semicarbazones under conventional and microwave irradiation conditions and investigated their antimicrobial activity. All the new compounds were characterized and identified by IR, ^{1}H-NMR, ^{13}C-NMR.

Results and discussion

The aim of this study is to investigate presence of antimicrobial activities of *N*-substituted-2-phenyl indole semicarbazone moieties (**4a–g**, **6a–c**). The synthesis of these compounds is outlined in Schemes 1 and 2. The alkylation and arylation of compound **1** (2-phenyl-1*H*-indole-3-carbaldehyde) is carried out under microwave (MW) irradiation, conventional, and at room temperature

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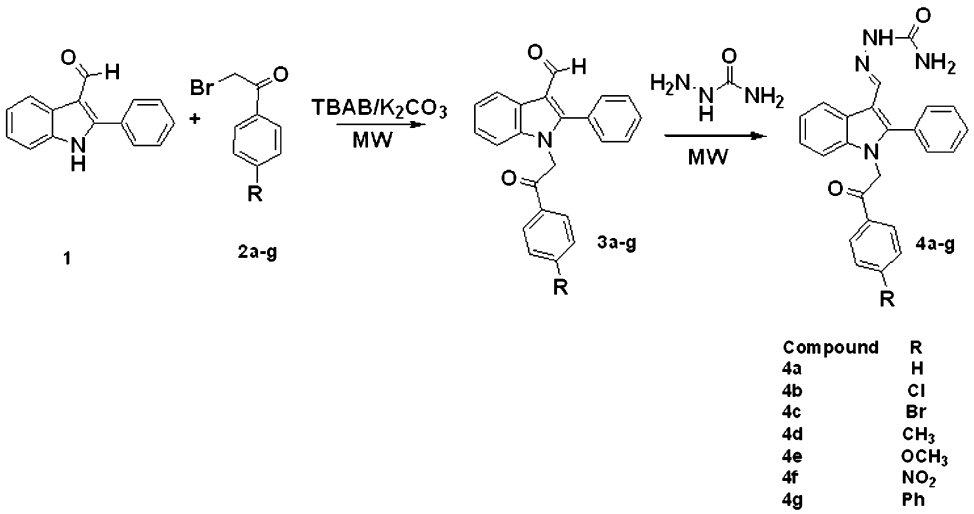
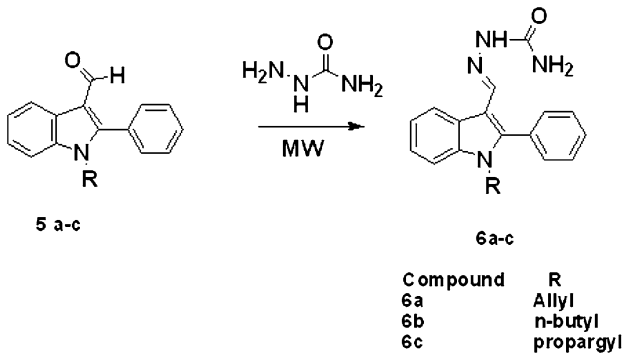
Scheme 1 Synthesis of target compounds **4a**–**g**



(RT) in the presence of K_2CO_3 and Tetra-*n*-butylammonium bromide (TBAB) in *N*,*N*-dimethylformamide (DMF). A comparative study of the above three methods has been critically conducted to evaluate the yields of the products, the time taken for the completion of the reaction, and conditions favorable for the smooth conduct of the reactions. The data is presented in Table 1.

Further, compounds **3a**–**g** and **5a**–**c** are condensed with semicarbazide in microwave and conventional methods in ethanol furnished (**4a**–**g** and **6a**–**c**).Good yields were observed within minutes only under microwave irradiation condition, results are depicted in Table 2. Formation of the semicarbazones (**4a**–**g** and **6a**–**c**) is confirmed due to the absence of aldehydic signal at δ 9.93. The signals at δ ppm 8.3, 6.2, and 9.8 confirm C=C–H, NH_2, and NH protons of semicarbazone, respectively. Further, C=O signal of semicarbazone is confirmed by ^{13}C-NMR at 156.6–156.7-ppm range. And IR signal of both C=O and NH_2 was observed at 1687, 3434 cm^{-1}, respectively. EIMS of the given compounds displayed the molecular ion (m^{+1}) which confirmed their molecular weights. Spectral data ^{1}H-NMR, IR, ^{13}C-NMR of the synthesized compounds were in full agreement with the proposed structures.



Scheme 2 Synthesis of target compounds **6a**–**c**

Table 1 Results of the synthesized compounds **3a**–**f** and **5a**–**c**

Entry	Product	Mw 2–5 min	Δ 2–3 h	Rt 6–8 h
1	**3a**	85	70	58
2	**3b**	88	72	56
3	**3c**	87	75	60
4	**3d**	75	63	50
5	**3e**	75	64	50
6	**3f**	86	70	60
7	**3g**	82	73	54
8	**5a**	77	65	60
9	**5b**	74	64	49
10	**5c**	73	60	55

Table 2 Results of the synthesized compounds **4a**–**g** and **6a**–**c**

Entry	Product	Mw 1–2 min	Δ 1–3 h
1	**4a**	82	77
2	**4b**	86	72
3	**4c**	86	73
4	**4d**	72	76
5	**4e**	75	77
6	**4f**	82	70
7	**4g**	74	73
8	**6a**	72	66
9	**6b**	75	59
10	**6c**	72	60

Antimicrobial activity

All the prepared compounds were evaluated in vitro for their antifungal and antibacterial activities (Villanova, 1982; Linday, 1962).

Antibacterial activity

Determination of minimum inhibitory concentration (MIC) of synthetic compounds

The MIC was measured by broth dilution method (Villanova, 1982). A set of sterile test tubes with nutrient broth media was capped with cotton plugs (test tube numbers 1–9). The test compound was dissolved in dimethyl sulfoxide (DMSO) and concentration of 100 μg/ml of the test compound was added to the first tube, which was serially diluted from 1 to 9. A fixed volume of 0.5 ml overnight culture is added in all the test tubes and incubated at 37°C for 24 h. After incubation period, the tubes were measured for turbidity with spectrophotometer.

Antifungal activity

The ready-made Potato Dextrose Agar (PDA) medium (Himedia, 39 g) was suspended in distilled water (1000 ml) and heated to boiling until completely dissolved. The medium and petri dishes were autoclaved at pressure of 15 lb/inc^2 for 20 min. Agar cup bioassay was employed for testing antifungal activity. The medium was poured into sterile petri dishes under aseptic conditions in a laminar flow chamber. When the medium in the plates solidified, 0.5 ml of (1 week old) culture of test organism was inoculated and uniformly spread over the agar surface with a sterile L-shaped rod. Solutions were prepared by dissolving the compound in methanol and different concentrations were made (30 and 100 μg/ml). After inoculation, cups were scooped out with 6-mm sterile cork borer and the lids of the dishes were replaced. To each cup different concentrations of test solutions (30,100 μg/ml) were added. Control solutions were maintained with methanol and fluconazole (30 μg/ml). The treated and the control solutions were kept at 27°C for 48 h. Zones of inhibition were measured and the diameter was measured in millimeter. Three to four replicates were maintained for each treatment.

Antibacterial activity

Antibacterial activities were evaluated against *B. subtilis*, *S. aureus*, *S. epidermidis*, *E. coli*, *P. aeoginosa*, and *K. pneumoniae*. The MICs (μg/ml) of tested compounds against bacteria are shown in Table 3. From the data, the MIC values indicate that all the compounds exhibited a varied range (37.5–150 μg/ml) of antibacterial activity against all the tested bacterial strains.

It is observed that the antibacterial activity in the series decreased with the introduction of alkyl substituents (**6b**, **6c**). When compared, the phenacyl moiety enhanced the antibacterial activity. Among the all compounds, **4f** displayed promising activity on *P. aeoginosa* and *K. pneumoniae* bacteria at 75 and 37.5 μg/ml (MIC), respectively, due to the introduction of NO_2 group at *para* position. The electron-withdrawing nature of nitro group might be responsible for the enhanced activity in the series. Hence, we propose that **4f** can be considered as a lead analog for subsequent optimization in the ongoing search for novel antibacterial agents.

Antifungal activity

The in vitro antifungal activities of the novel compounds were examined against two fungal strains *C. albicans and C. rugosa.* Here, amphotericin B was used as standard drug. No zone of inhibition was observed for the

Table 3 In vitro antibacterial activity (MIC) values for compounds **4a–g** and **6a–c**

Compounds	MIC (μg/ml)					
	B. subtilis	*S. aureus*	*S. epidermidis*	*E. coli*	*P. aeroginosa*	*K. pneumoniae*
4a	125	130	110	100	100	115
4b	110	130	140	125	115	120
4c	105	125	130	120	135	130
4d	>150	130	125	130	>150	>150
4e	140	110	130	140	145	120
4f	120	125	110	130	75	37.5
4g	>150	110	130	120	105	135
6a	140	125	115	120	125	>150
6b	>150	125	135	140	120	110
6c	125	>150	>150	>150	>150	110
Ciprofloxacin	24	25	22	20	12.5	25

Table 4 In vitro antifungal activity (MIC) values for compounds **4a–f** and **6a–c**

Compounds	Zone of inhibition in mm			
	C. albicans		*C. rugosa*	
	100 μg	150 μg	100 μg	150 μg
4a	0	8	0	8
4b	4	10	5	12
4d	7	10	7	10
4e	8	10	8	10
4f	9	14	10	14
6a	10	15	7	12
6b	9	12	9	10
6c	8	13	10	15
Amphotericin B (50 μg)	23.5		21	

compounds **4c** and **4g**. Remaining compounds exhibited zone of inhibition range from 4 to 15 mm. In both **4a–g** and **6a–c** series, alkyl-substituted compounds **6a–c** have shown significant activity when compared with aryl substituents. The zone of inhibition (mm) and concentration (μg/ml) of the tested compounds are illustrated in Table 4

Experimental protocols

Chemistry

Chemicals were purchased from Merck (purity 98%). All melting points were determined with Quimis apparatus (Model Q-340 s 13) and were uncorrected. TLC was performed on 2.0 × 6.0 cm aluminum sheets covered with silica gel (Sorbent, with 200 μm thickness) under ultraviolet radiation. Ethyl acetate:hexane (2:8) is used as a mobile phase. Infrared (IR) spectra were obtained with ABB spectro photometer (Model: FTLA 2000-100) using KBr pellets. ^{1}H-NMR, was measured on Brucker 300-MHz spectrometer using DMSO as a solvent and TMS as internal standard. Mass spectra were recorded on a Jeol JMSD-300 spectrometer.

*Synthesis procedure for the derivatives of 1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1H-indole-3-carbaldehyde (**3a–g**) and derivatives of 1-alkyl-2-phenyl-1H-indole-3-carbaldehyde (**5a–c**)*

A mixture of 2-phenyl-1*H*-indole-3-carbaldehyde (1 mmol), derivatives of four substituted phenacylbromide (1 mmol) or alkyl bromides (1 mmol), K_2CO_3 and TBAB were dissolved in DMF and irradiated the reaction mixture for 2–3 min at 300 W in domestic microwave oven. Progress of the reaction was monitored by TLC. After completion of the reaction, the reaction mixture was cooled to room temperature and then treated with water. The precipitate was filtered and recrystallized from ethanol which furnished the compounds **3a–g** and **5a–c**. The ^{1}H-NMR data of compounds **3a–g**, **5a–c** are given below.

*1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1H-indole-3-carbaldehyde (**3a**)* m.p.:185–190°C; ^{1}H-NMR (DMSO, δ, ppm): 5.87 (s, 2H), 7.32–8.27 (m, 14H), 9.60 (s, 1H). MS EIMS: 70 eV (m^{+1}) 340 (100%). For the M.F $C_{23}H_{17}NO_2$, M.Wt 339.

*1-[2-(4-Chloro-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3-carbaldehyde (**3b**)* m.p.: 150–155°C; ^{1}H-NMR (DMSO, δ, ppm): 5.86 (s, 2H), 7.33–8.25 (m, 13H), 9.62 (s, 1H). MS EIMS: 70 eV (m^{+1}) 374. For the M.F $C_{23}H_{16}ClNO_2$, M.Wt 373.

*1-[2-(4-Bromo-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3-carbaldehyde (**3c**)* m.p.: 160–163°C; ^{1}H-NMR (DMSO, δ, ppm): 5.87 (s, 2H), 7.36–8.29 (m, 13H), 9.65 (s, 1H).

*1-(2-Oxo-2-p-tolyl-ethyl)-2-phenyl-1H-indole-3-carbaldehyde (**3d**)* m.p.: 180–183°C; ^{1}H-NMR (DMSO, δ, ppm): 5.8 (s, 2H), 2.3 (s, 3H), 7.33–8.25 (m, 13H), 9.60 (s, 1H).

*1-[2-(4-Methoxy-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3-carbaldehyde (**3e**)* m.p.: 190–194°C; ^{1}H-NMR (DMSO, δ, ppm): 5.86 (s, 2H), 3.8(s, 3H), 7.35–8.27 (m, 13H), 9.61 (s, 1H).

*1-[2-(4-Nitro-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3-carbaldehyde (**3f**)* m.p.: 200–205°C; ^{1}H-NMR (DMSO, δ, ppm): 5.88 (s, 2H), 7.3–8.25 (m, 14H), 9.64 (s, 1H).

*1-[2-Biphenyl-4-yl-2-oxo-ethyl)-2-phenyl-1H-indole-3-carbaldehyde (**3g**)* m.p.: 167–170°C; ^{1}H-NMR (DMSO, δ, ppm): 5.86 (s, 2H), 7.2–8.25 (m, 18H), 9.62 (s, 1H).

*1-Allyl-2-phenyl-1H-indole-3-carbaldehyde (**5a**)* m.p.: 150–153°C; ^{1}H-NMR (DMSO, δ, ppm): 4.6 (d, 2H), 5.04, 5.06 (d, 2H), 5.89 (m, 1H), 7.2–8.2(9H, m), 9.64 (s, 1H).

*1-Butyl-2-phenyl-1H-indole-3-carbaldehyde (**5b**)* m.p.: 230–235°C; ^{1}H-NMR (DMSO, δ, ppm): 0.98 (t, 3H), 1.44 (m, 2H), 1.78 (m, 2H), 3.5(t, 2H), 7.20–8.1(m, 9H) 9.61 (s, 1H).

*2-Phenyl-1-(propyl-2-ynyl)-1H-indole-3-carbaldehyde (**5c**)* m.p.: 220–225°C; ^{1}H-NMR (DMSO, δ, ppm): 1.9 (s, 1H), 4.61 (s, 2H), 7.20–8.1 (m, 9H), 9.63 (s, 1H).

*Synthesis procedure for the derivatives of 1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1H-indole-3yl)methylene) semicarbazone (**4a–g**) and derivatives of 1-alkyl-2-phenyl-1H-indole-3yl) methylene)semicarbazone (**6a–c**)*

Derivatives of 1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1*H*-indole-3-carbaldehyde (**3a**–**g**) or derivatives of 1-alkyl-2-phenyl-1*H*-indole-3-carbaldehyde (**5a**–**c**) (1.0 mmol) was dissolved in absolute ethanol. An equal molar amount of semicarbazide was added to it and the mixture was irradiated under microwave for 1–2 min. On cooling the solid was found to separate. The precipitate was filtered and washed with rectified spirit. This procedure often resulted in a pure product without the need for further purification. The characterization data of compounds **4a**–**g**, **6a**–**c** are given below.

*1-(2-Oxo-2-phenyl-ethyl)-2-phenyl-1H-indole-3yl)methylene) semicarbazone (**4a**)* m.p.: 217–220°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2923, 1687 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 749, 691, 566; ^{1}H-NMR (DMSO, δ, ppm): 5.73 (s, 2H), 6.22 (s, 2H, NH_2), 7.21–8.32 (m, 14H), 8.34 (s, 1H, C=C–H) 9.81 (s, 1NH). MS EIMS:70 eV (m + 1) 397(100%). For the M.F $C_{24}H_{20}N_4O_2$, M.Wt 396. ^{13}C-NMR (DMSO, δ, ppm): 50.5, 109.7, 110.2, 121.2, 122.2, 124.2, 128.7, 128.6, 129, 129.1, 129.4, 129.9, 130.4, 132.8, 137.3, 137.6, 139, 142.7, 156.6, 192.4.

*1-[2-(4-Chloro-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3yl)methylene)semicarbazone (**4b**)* m.p.: 205–210°C; IR (KBr) (cm^{-1}): 3434(N–H), 2923, 1687 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 749, 695. ^{1}H-NMR (DMSO, δ, ppm): 5.7 (s, 2H), 6.3 (s, 2H, NH_2), 7.23–8.32 (m, 13H), 8.33(s, 1H, C=C–H), 9.82 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 50.5, 109.9, 110.3, 121.2, 122.2, 124.2, 128.7, 129, 129.1, 129.4, 129.9, 130.4, 132.8, 137.3, 137.5, 139, 142.8, 156.6, 193.4.

*1-[2-(4-Bromo-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3yl) methylene)semicarbazone (**4c**)* m.p.: 210–215°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2923, 1687 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 749, 691. ^{1}H-NMR (DMSO, δ, ppm): 5.7 (s, 2H), 6.3 (s, NH_2), 7.20–8.32 (m, 13H), 8.34 (s, 1H C=C–H) 9.82 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 50.5, 109.9, 110.3, 121.2, 122.2, 123, 124.3, 128.3, 128.7, 129.1, 129.4, 130, 130.4, 131.9, 133.2, 137.4, 137.6, 142.9, 156.7, 193.6.

*1-(2-Oxo-2-p-tolyl-ethyl)-2-phenyl-1H-indole-3yl)methylene) semicarbazone (**4d**)* m.p.: 190–200°C; IR (KBr) (cm^{-1}): 3434 (N–H), 3010 (C–H), 2923, 1687 (C=O), 1579, 1463, 1446, 1228, 1098, 986, 749. ^{1}H-NMR (DMSO, δ, ppm): 2.3 (s, 3H CH_3) 5.7 (s, 2H), 6.3 (s, 2H, NH_2), 7.20–8.32 (m, 13H), 8.34 (s, 1H C=C–H) 9.82 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 20.1, 50.5, 109.9, 110.3, 121.2, 122.2, 123, 124.3, 128.3, 128.7, 129.1, 129.4, 130, 130.4, 131.9, 133.2, 137.4, 137.6, 142.9, 156.7, 193.6.

*1-[2-(4-Methoxy-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3yl)methylene)semicarbazone (**4e**)* m.p.: 160–165°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2923, 1687 (C=O), 1579, 1425, 1228, 1120 (C–O), 1098, 986, 749, ^{1}H-NMR (DMSO, δ, ppm): 3.84 (s, 3H, OCH_3) 5.7 (s, 2H), 6.23 (s, 2H NH_2), 7.20–8.25 (m, 13H), 8.27 (s, 1H C=C–H) 9.88 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 50.1, 55.6, 109.7, 110.2, 111.3, 114.1, 121.1, 122.1, 122.8, 124.2, 127.1, 128.6, 128.8, 129, 130.4, 137.3, 137.6, 140.2, 156.6, 192.3.

*1-[2-(4-Nitro-phenyl)-2-oxo-ethyl]-2-phenyl-1H-indole-3yl) methylene)semicarbazone (**4f**)* m.p.: 150–155°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2923, 1687 (C=O), 1579, 1525 (N–O), 1463, 1446, 1425, 1228, 1098, 986, 750. ^{1}H-NMR (DMSO, δ, ppm): 5.69 (s, 2H), 6.29 (s, 2H NH_2), 7.20–8.4 (m, 13H), 8.36 (s, 1H C=C–H) 9.82 (s, 1NH)). ^{13}C-NMR (DMSO, δ, ppm): 50.1, 109.7, 110.2, 111.3, 114.1, 121.1, 122.1, 122.8, 123.4, 123.4, 124.2, 127.1, 129, 137.3, 137.6, 140.2, 142.7, 148.3, 156.6, 192.3.

*1-[2-Biphenyl-4-yl-2-oxo-ethyl)-2-phenyl-1H-indole-3yl) methylene)semicarbazone (**4g**)* m.p.: 170–173°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2923, 1687 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 749, 691, 566; ^{1}H-NMR (DMSO, δ, ppm): 5.86 (s, 2H), 6.3(s, 2H, NH_2) 7.2–8.3 (m, 18H), 8.37 (s, 1H C=CH) 9.82 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 50.1, 109.7, 110.2, 111.3, 114.1, 121.1, 122.1, 122.8, 123.4, 123.4, 124.2, 126.2, 127.2127.3, 128, 129, 137.3, 137.6, 140.2, 142.7, 148.3, 156.6, 192.3.

*1-Allyl-2-phenyl-1H-indole-3yl)methylene)semicarbazone (**6a**)* m.p.: 205–210°C; IR (KBr) (cm^{-1}): 3434 (N–H), 3080 (C=C–H of allyl) 2923, 1687 (C=O), 1640 (C=C of allyl) 1579, 1463, 1446, 1425, 1228, 1098, 986, 749; ^{1}H-NMR (DMSO, δ, ppm): 4.6 (d, 2H), 5.04, 5.06 (d, 2H), 5.89 (m, 1H), 6.18 (s, 2H, NH_2), 7.17–8.27(m, 9H), 8.28 (s, 1H C=CH) 9.78 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 40.2, 109.3, 110.3, 115, 120.9, 122.2, 122.7, 124.2, 128.6, 128.9, 129, 129.9, 130, 130.7, 136.4, 137.4, 142.5, 156.7.

*1-Butyl-2-phenyl-1H-indole-3yl)methylene)semicarbazone (**6b**)* m.p.: 210–212°C; IR (KBr) (cm^{-1}): 3434 (N–H), 2970 (CH_3, C–H stre), 2923, 1687 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 749, ^{1}H-NMR (DMSO, δ, ppm): 0.98 (t, 3H), 1.44 (m, 2H), 1.78 (m, 2H), 3.5(t, 2H), 6.2 (s, 2NH) 7.20-8.1(m, 9H) 8.3 (s, 1H C=CH) 9.8 (s,

1NH). ^{13}C-NMR (DMSO, δ, ppm): 13.2, 19.1, 31.2, 42.8, 109.3, 110.3, 120.9, 122.2, 122.7, 124.2, 128.6, 128.9, 129, 129.9, 130.7, 136.4, 137.4, 142.5, 156.6.

*2-Phenyl-1-(propyl-2-ynyl)-1H-indole-3yl)methylene)semicarbazone (**6c**)* m.p.: 215–217°C; IR (KBr) (cm^{-1}): 3433 (N–H), 3305(sp hybridized C–H), 2923, 1686 (C=O), 1579, 1463, 1446, 1425, 1228, 1098, 986, 748. ^{1}H-NMR (DMSO, δ, ppm): 1.9 (s, 1H), 4.61 (s, 2H), 6.2 (s, 2H, NH_2) 7.20–8.1(m, 9H), 8.3 (s, 1H C=C–H) 9.8 (s, 1NH). ^{13}C-NMR (DMSO, δ, ppm): 30.7, 60.7, 70.5, 109.3, 110.3, 120.9, 122.3, 122.9, 124.2, 128.4, 128.9, 129, 129.9, 130.7, 136.4, 137.4, 142.5, 156.6.

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Conflicts of interest The author reports no conflicts of interest.

References

Biberger C, Von Angerer EJ (1998) 1-Benzyl-2-phenylindole- and 1, 2-diphenylindole-based antiestrogens. Estimation of agonist and anatagonist activities in transfection assays. Steroid Biochem Mol Biol 64:277–281

Capobianco JO, Cao Z, Shortridge VD, Ma Z, Flamm RK, Zhong P (2000) Studies of the novel ketolide ABT-773: transport, binding to ribosomes, and inhibition of protein synthesis in *Streptococcus pneumonia*. Antimicrob Agents Chemother 44:1562–1567

Dimmock JR, Baker GB (1994) Anticonvulsant activities of 4-bromobenzaldehyde semicarbazone. Epilepsia 35:648–655

Fedorova OV, Mordovskoi GG, Rusinov GL, Ovchinnikova IG, Zueva MN, Kravchenko MA, Chupakhin ON (1998) Synthesis and in vitro tuberculostic activity of podands containing semicarbazide or thiosemicarbazide fragments. Pharm Chem J 32:64–66

Fung-Tomc JC, Clark J, Minassian B, Pucci M, Tsai Y-H, Gradelski E, Lamb L, Medina I, Huczko E, Kolek B, Chaniewski S, Ferraro C, Washo T, Bonner DP (2002) In vitro and in vivo activities of a novel cephalosporin, BMS-247243, against methicillin-resistant and susceptible staphylococci. Antimicrob Agents Chemother 46:971–976

Ismail MF, Shmeiss NAMM, El-Diwani HI, Arbid MS (1997) Synthesis and pharmacological activity of some 2,3-diphenylindole derivative. Indian J Chem Sect 36:288–292

Jenny L, Nordquist E, Gokturk C, Oreland L (2002) Semicarbazide-sensitive amine oxidase gene expression in alloxan-induced diabetes in mice. Mol Med 8:824–829

Kaufmann D, Pojarová M, Vogel S, Liebl R, Gastpar R, Gross D, Nishino T, Pfaller T, von Angerer E (2007) Antimitotic activities of 2-phenylindole-3-carbaldehydes in human breast cancer cells. Bioorg Med Chem 15:5122–5136

Linday ME (1962) Practical introduction to microbiology. E & F.N. Spon Ltd, London, p 177

Loupy A (2002) Microwave in organic synthesis. Wiley-VCH, Weinheim

Mahboobi S, Sellmer A, Eichhorn E, Beckers T, Fiebig HH, Kelter G (2005) Synthesis and cytotoxic activity of 2-acyl-1H-indole-4,7-diones on human cancer cell lines. Eur J Med Chem 40:85–92

Nagai K, Davies TA, Jacobs MR, Appelbaum PC (2002) Effects of amino acid alterations in penicillin-binding proteins (PBPs) 1a, 2b, and 2x on PBP affinities of penicillin, ampicillin, amoxicillin, cefditoren, cefuroxime, cefprozil, and cefaclor in 18 clinical isolates of penicillin-susceptible, intermediate, and resistant pneumococci. Antimicrob Agents Chemother 46:1273–1280

Nagano R, Shibata K, Adachi Y, Imamura H, Hashizume T, Morishima H (2000) In vitro activities of novel trans-3, 5-disubstituted pyrrolidinylthio-1β-methylcarbapenems with potent activities against methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Antimicrob Agents Chemother 44:489–495

Rajitha B, Thirupathi Reddy Y, Narasimha Reddy P (2005) Sulfamic acid a novel and efficient catalyst for the synthesis of aryl-14-H-dibenzo[a, f]Xanthenes in conventional heating and microwave irradiation. Tetrahedron Lett 46:8691–8693

Stevenson GI, Smith AL, Lewis S, Michie SG, Neduvelil JG, Patel S, Marwood R, Castro JL (2000) Solid-phase synthesis of 2,3-disubstituted indoles: discovery of a novel, high-affinity, selective h5-HT2A antagonist. Bioorg Med Chem Lett 10:2697–2699

Suresh Kuarm B, Venu Madhav J, Vijaya Laxmi S, Rajitha B, Thirupathi Reddy Y, Narsimha Reddy P, Crooks PA (2010) Expeditious pechmann condensation by using biodegradable cellulose sulfuric acid as a solid acid catalyst. Synth Commun 40:3358–3364

Todar's Online Text book of Biotechnology. http://www.textbookofbiotechnology.net/

VenuMadhav J, Thirupathi Reddy Y, Narasimha Reddy P, Nikhil Reddy M, Suresh Kuarm B, Crooks PA, Rajitha B (2009) Cellulose sulfuric acid: an efficient biodegradable and recyclable solid acid catalyst for the one-pot synthesis of aryl-14H-dibenzo[a.j]xanthenes under solvent-free conditions. J Mol Catal 304:85–87

Villanova (1982) National Committee for Clinical Laboratory Standards (NCCLS). Standard methods for dilution antimicrobial susceptibility tests for bacteria, which grows aerobically. National Committee for Clinical Laboratory Stands 24

Vogel S, Kaufmann D, Pojarová M, Müller C, Pfaller T, Kühne S, Bednarski PJ, von Angerer E (2008) Aroyl hydrazones of 2-phenylindole-3-carbaldehydes as novel antimitotic agents. Bioorg Med Chem 16:6436–6447

Von Angerer E, Knebel N, Kager M, Ganss BJ (1900) 1-(Aminoalkyl)-2-phenylindoles as novel pure estrogen antagonists. Med Chem 33:2635–2640