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Microwave Assisted Synthesis of Biologically Active 7-Benzylideneamino-5*H*-thiochromeno[2,3-b]pyridin-5-one

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Various benzylideneamino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one derivatives were synthesized by using microwave irradiation as well as conventional heating method by the reaction of 7-amino-5*H*-benzothiopyrano[2,3-*b*]pyridin-5-one with different aldehydes. The synthesized compounds were characterized through mass, ^{1}H NMR, IR spectra and elemental analysis. The Schiff's bases were screened for their antibacterial and antioxidant properties.

Key Words: Benzothiopyranopyridine, Antioxidant and antibacterial studies, Microwave assisted synthesis, Schiff's bases.

INTRODUCTION

Synthesis of new heteroaromatic compounds and their derivatives with the aim to enhance their pharmacological properties or to decrease their side effects have received special attention[1-3]. Thiochromones and their analogues possess interesting biological properties which are tested and have been applied as drugs[4]. Schiff's bases an important class of organic compounds[5,6] and have interesting biological properties[7-10], such as anticancer[11-14], diuretic[15], antifungal[16] and anticonvulsant[17] activities. These are also applied as analytical and catalytic reagents[18,19]. Recently 4,5-dihydro-1,2,4-triazole-5-thione and 3-amino-1*H*-1,2,4-triazole Schiff's bases were reported to be good fungicides[20,21].

In continuation of our work on the synthesis of pyridine containing heterocyclic compounds[22-25], 7-amino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one was prepared and condensed with different aldehydes to afford respective Schiff's bases (**Scheme-I**) which were subjected to their DPPH radical scavenging and antibacterial activities.

EXPERIMENTAL

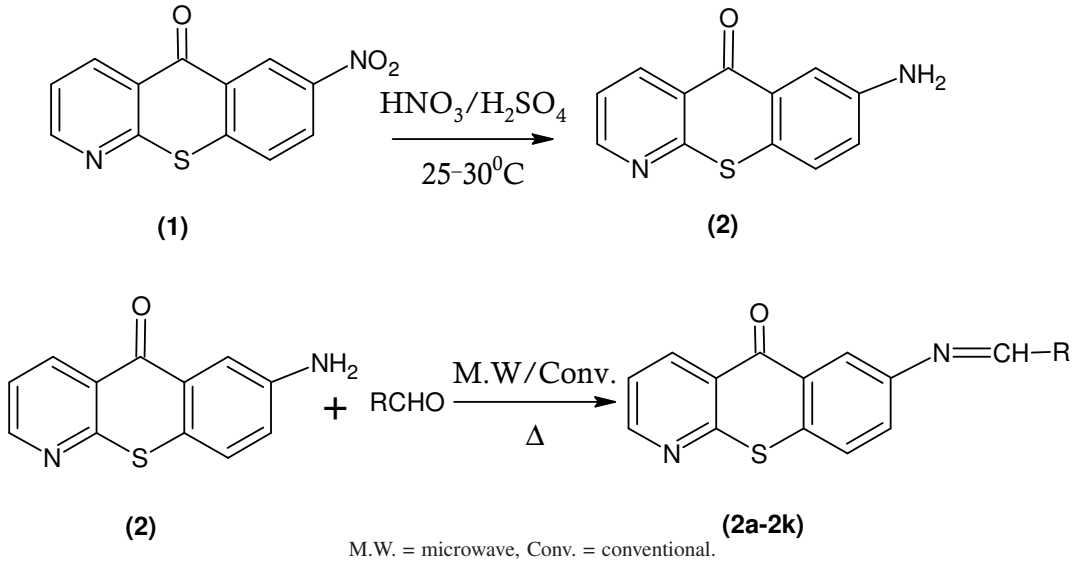
All chemicals were purchased from E. Merck, BDH or Fluka and used without purification. ^{1}H NMR spectra were recorded on Bruker DPX instrument at 400 MHz. Chemical shifts are reported in ppm reference to the residual solvent signal. Mass spectra were recorded on Agilent 6890 spectrometer. IR spectra were recorded on a Bruker Tensor 27. Melting points were taken on a Gallenkamp melting point apparatus and are uncorrected.

7-Amino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one: A mixture of 5*H*-thiochromeno[2,3-*b*]pyridin-5-one[23] (10 g, 0.46 mol), sulfuric acid (30 mL) and potassium nitrate (30 g, 0.29 mol) was stirred slowly maintaining the reaction temperature between 25-30 ºC. After 0.5 h, the reaction mixture was cooled in an ice bath and made alkaline by the addition of liquid ammonia. The precipitates thus obtained were filtered, washed with water and dried. It was recrystallized in hot acetic acid in order to get 7-nitro-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (**1**) (yield 56 %, m.p. 277 ºC)[24], which was reduced by $SnCl_2$/HCl to afford 7-amino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (yield 52 %, m.p. 254-256 ºC) (**2**).

General procedure for the synthesis of 7-benzylideneamino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (2a-2k): Following two methods were used for the synthesis of (**2a-2k**).

Conventional method (A): An equimolar mixture of 7-amino-5*H*-thiochromeno[2,3-*b*]pyridine-5-one (**2**) (0.01 mol), an aldehyde (0.01 mol), 10 mL of methanol and few drops of phosphoric acid, was heated under reflux for about 0.5-3.0 h. On completion (monitored by TLC) the reaction mixture was cooled and the precipitated product was filtered, dried and recrystallised from an appropriate solvent to obtain the following Schiff's bases (**Scheme-I**).

Microwave assisted method (B): An equimolar mixture of 7-amino-5*H*-thiochromeno[2,3-*b*]pyridine-5-one (**2**) (0.01 mol), an aldehyde (0.01 mol), 10 mL of methanol and few



M.W. = microwave, Conv. = conventional.
R = **2a**: $C_6H_5CH{=}C_6H_{11}$, **2b**: 4'-OH, 3'-$OCH_3C_6H_3$, **2c**: CH_3: **2d**: 3'-$CH_3C_6H_4$, **2e**: 4'-$CH_3C_6H_4$, **2f**: C_6H_5
2g: 3'-$CH_3C_6H_4$, **2h**: 4'-$OCH_3C_6H_4$, **2i**: 3'-$NO_2C_6H_4$, **2j**: 4'-$NO_2C_6H_4$, **2k**: C_4H_3O

Scheme-I

drops of phosphoric acid. The reaction flask was irradiated in the modified household microwave oven (900 watt) equipped with the water condenser for the time ranging from 2-5 min. On completion (monitored by TLC) the reaction mixture was cooled and the precipitated product was filtered, dried and recrystallized from an appropriate solvent to obtain the Schiff's bases.

7-(4-Benzylidenenonylideneamino)-5*H*-thiochromeno-[2,3-*b*]pyridine-5-one (2a): Reddish brown powder, yield: **method A:** (0.546 g, 57 %) **method B:** (0.652 g, 68 %), m.p. 234 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.84 (s, 3H, OCH_3) 6.92 (s, 1H, OH), 8.21 (d, *J* = 3.6 Hz, 1H, 6-H), 8.52 (dd, *J* = 2.7, 9.0 Hz, 1H, 9-H), 8.62 (s, 1H, N=CH), 8.68 (d, *J* = 1.8 Hz, 1H, 8-H), 8.74 (m, 3H, 2', 5', 6'-H), 8.89 (dd, *J* = 1.8, 4.8 Hz, 1H, 3-H) 8.93 (dd, *J* = 1.8, 3.4 Hz, 1H, 4-H), 9.07 (d, *J* = 2.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1100 (OCH_3), 1610 (N=CH), 1680 (C=O), 3640 (OH), Ms: m/z 426 [M^+].

7-(4'-Hydroxy-3'-methoxybenzylideneamino)-5*H*-thiochromeno[2,3-*b*]pyridine-5-one (2b): Brown powder, yield: **method A:** 0.571 g, 60 %) **method B:** (0.647 g, 68 %), m.p. 221 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.84 (s, 3H, OCH_3), 6.92 (s, 1H, OH), 8.21 (d, *J* = 3.6 Hz, 1H, 6-H), 8.52 (dd, *J* = 2.7, 9.0 Hz, 1H, 9-H), 8.57 (s, 1H, N=CH), 8.68 (d, *J* = 1.8 Hz, 1H, 8-H), 8.36 (m, 3H, 2', 5', 6'-H), 8.89 (dd, *J* = 1.8, 4.8 Hz, 1H, 3-H) 8.93 (dd, *J* = 1.8, 3.4 Hz, 1H, 4-H), 9.07 (d, *J* = 2.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1100 (OCH_3), 1600 (N=CH), 1680 (C=O), 3640 (OH), Ms: m/z 362 [M^+].

7-Ethylideneamino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (2c): Brown powder, yield: **method A:** (0.578 g, 62 %), **method B:** (0.625 g, 67 %), m.p. 211 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.82 (s, 3H, OCH_3), 6.92 (s, 1H, OH), 8.52 (dd, *J* = 2.7, 9.0 Hz, 1H, 8-H), 8.62 (s, 1H, N=CH), 8.68 (d, *J* = 1.8 Hz, 1H, 9-H), 8.54 (m, 2H, 5',6'-H), 8.81 (dd, *J* = 1.8, 4.5 Hz, 1H, 2'-H), 8.75 (d, *J* = 1.5, Hz, 1H, 6-H), 8.78 (d, *J* = 1.5 Hz, 1H, 3-H), 8.93 (dd, *J* = 1.5, 4.5 Hz, 1H, 4-H), 9.06 (d, *J* = 2.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1375 (-CH_3), 1600 (N=CH), 1660 (C=O), Ms: m/z 254 [M^+].

7-(3'-Methoxybenzylideneamino)-5*H*-thiochromeno-[2,3-*b*]pyridin-5-one (2d): Brown powder, yield: **method A:** (0.494 g, 52 %), **method B:** (0.958 g, 63 %), m.p. 190 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.84 (s, 3H, OCH_3), 7.87 (d, *J* = 1.5 Hz, 1H, 4'-H) 7.94 (d, *J* = 1.5 Hz, 2'-H), 8.21 (d, *J* = 2.4 Hz, 1H, 8-H), 8.68 (d, *J* = 1.8 Hz, 1H, 9-H), 8.71 (m, 2H, 5', 6'-H), 8.74 (d, *J* = 1.8, Hz, 1H, 6-H), 8.77 (d, *J* = 1.8, Hz, 1H, 3-H), 8.81 (dd, *J* = 1.8, 4.5 Hz, 1H, 4-H), 8.96 (dd, *J* = 1.8, 4.5 Hz, 1H, 2-H), 9.86 (s, 1H, N=CH), IR (Neat, ν_{max}, cm^{-1}): 1140 (-OCH_3), 1660 (C=O), 1610 (N=CH), Ms: m/z 346 [M^+].

7-(4'-Methylbenzylideneamino)-5*H*-thiochromeno-[2,3-*b*]pyridin-5-one (2e): Brown powder, yield: **method A:** (0.616 g, 65 %), **method B:** (0.692 g, 73 %), m.p. 210 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.29 (s, 3H, CH_3), 7.34 (d, *J* = 7.8 Hz, 2H, 3',5'-H), 7.76 (dd, *J* = 2.4, 8.7 Hz, 1H, 6'-H), 7.88 (d, *J* = 8.1 Hz, 1H, 2'-H), 7.95 (d, *J* = 8.7 Hz, 1H, 9-H) 8.23 (d, *J* = 2.4 Hz, 1H, 8-H), 8.71 (d, *J* = 2.1 Hz, 1H, 6-H), 8.75 (s, 1H, N=CH), 8.81 (dd, *J* = 1.8, 4.5 Hz, 1H, 3-H) 8.96 (dd, *J* = 1.8, 4.5 Hz, 1H, 4-H), 8.89 (dd, *J* = 1.8, 4.5 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1375 (-CH_3), 1600 (N=CH), 1640 (C=O), Ms: m/z 330 [M^+].

7-(Benzylideneamino)-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (2f): Reddish brown, yield: **method A:** (0.652 g, 69 %), **method B:** (0.700 g, 74 %), m.p. 238 ºC, ^{1}H NMR: (DMSO-d_6) δ 7.24 (dd, *J* = 2.4, 6.4 Hz, 1H, 6-H), 7.43 (d, *J* = 2.6 Hz, 1H, 8-H), 7.53 (dd *J* = 4.0, 7.6 Hz, 1H, 4'-H), 7.55 (dd, *J* = 4.2, 7.8 Hz, 2H, 3',5'-H), 7.64 (dd, *J* = 2.4, 8.7 Hz, 1H, 2',6'-H), 7.78 (d, *J* = 2.4 Hz, 1H, 9-H), 7.97 (dd, *J* = 8.4 Hz, 1H, 3-H), 8.46 (s, 1H, N=CH), 8.79 (d, *J* = 6.6 Hz, 1H, 4-H), 8.90 (d, *J* = 1.8 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1610 (N=CH), 1700 (C=O), MS: m/z 316 [M^+].

7-(3'-Methylbenzylideneamino)-5*H*-thiochromeno [2,3-*b*]pyridin-5-one (2g): Dark brown powder, yield: **method A:** (0.644 g, 68 %), **method B:** (0.633 g, 70 %), m.p. 205 ºC, ^{1}H NMR: (DMSO-d^6) δ 3.45 (s, 3H, CH_3), 7.09 (dd, *J* = 2.7, 8.7 Hz, 1H, 2'-H), 7.53 (dd, *J* = 3.0, 8.4 Hz, 1H, 5'-H), 7.70 (dd, *J* = 4.5, 8.4 Hz, 1H, 6'-H), 7.96 (d, *J* = 8.7 Hz, 1H, 9-H)

8.23 (d, *J* = 3.9 Hz, 1H, 8-H), 8.53 (dd, *J* = 2.4, 9.0 Hz, 1H, 6-H), 8.69 (s, 1H, N=CH), 8.76 (d, *J* = 1.8 Hz, 1H, 3-H), 8.94 (dd, *J* = 1.8, 4.5 Hz, 1H, 4-H), 9.08 (d, *J* = 2.7 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1375 (-CH_3), 1610 (N=CH), 1680 (C=O), MS: m/z 330 [M^+].

7-(4'-Methoxybenzylideneamino)-5*H*-thiochromeno-[2,3-*b*]pyridin-5-one (2h): Reddish brown powder, yield: **method A:** (0.655 g, 69 %), **method B:** (0.712 g, 75 %), m.p. 182 ºC, ^{1}H NMR: (DMSO-d_6) δ 3.84 s, 3H, OCH_3), 7.08 (dd, *J* = 8.7 Hz, 2H, 3',5'-H), 7.56 (d, *J* = 1.8 Hz, 1H, 9-H), 7.63 (dd, *J* = 1.5, 8.1 Hz, 1H, 8-H), 7.75 (dd, *J* = 2.4, 8.4 Hz, 1H, 6-H), 7.94 (d, *J* = 2.0 Hz, 1H, 6'-H), 7.97 (d, *J* = 1,2 Hz, 1H, 2'-H), 8.71 (s, 1H, N=CH), 8.76 (d, *J* = 1.8 Hz, 1H, 3-H), 8.75 (dd, *J* = 1.8, 8.1 Hz, 1H, 4-H), 8.89 (dd, *J* = 1.8, 4.5 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1160 (-OCH_3), 1600 (N=CH), 1680 (C=O), MS: m/z 346 [M^+].

7-(3'-Nitrobenzylideneamino)-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (2i): Yellow powder, yield: **method A:** (0.694 g, 73 %), **method B:** (0.723 g, 76 %), m.p. 290 ºC, ^{1}H NMR: (DMSO-d_6) δ 7.62 (dd, *J* = 4.5, 8.1 Hz, 1H, 5'-H), 7.69 (dd, *J* = 4.5, 8.1 Hz, 1H, 8-H), 7.91 (d, *J* = 2.1 Hz, 1H, 4'-H) 8.19 (d, *J* = 9.0 Hz, 1H, 9-H), 8.30 (s, 1H, N=CH), 8.43 (m, 2H, 2', 6'-H), 8.52 (dd, *J* = 2.7, 8.7 Hz, 1H, 6-H), 8.88 (dd, *J* = 1.8, 3.4 Hz, 1H, 3-H), 8.93 (dd, *J* = 1.8, 4.5 Hz, 1H, 4-H), 9.07 (d, *J* = 2.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1520, 1340 (-NO_2), 1600 (N=CH), 1700 (C=O), MS: m/z 361 [M^+].

7-(4'-Nitrobenzylideneamino)-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (2j): Brown powder, yield: **method A:** (0.673 g, 67 %), **method B:** (0.675 g, 71 %), m.p. 267 ºC, ^{1}H NMR: (DMSO-d_6) δ 7.65 (d, *J* = 4.0 Hz, 1H, 5'-H), 7.83 (d, *J* = 8.4 Hz, 1H, 8-H) 7.99 (t, *J* = 8.4 Hz, 1H, 3'-H), 8.35 (d, *J* = 2.3 Hz, 1H, 9-H), 8.42 (dd, *J* = 2.0, 4.5 Hz, 2H, 2',6'-H), 8.76 (d, *J* = 4.4 Hz, 1H, 6-H), 8.83 (d, *J* = 3.2 Hz, 1H, 3-H), 8.92 (d, *J* = 4.0 Hz, 1H, 4-H), 9.02 (s, 1H, N=CH), 9.08 (d, *J* = 6.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1525, 1350 (-NO_2), 1610 (N=CH), 1640 (C=O), MS: m/z 361 [M^+].

7-(Furan-2'-ylmethyleneamino)-5*H*-thiochromeno-[2,3-*b*] pyridin-5-one (2k): Black powder, yield: **method A:** (0.566 g, 60 %), **method B:** (0.670 g, 71 %), m.p. 293 ºC, ^{1}H NMR: (DMSO-d_6) δ 7.12 (dd, *J* = 2.4, 4.6 Hz, 1H, 9-H), 6.49 (d, *J* = 6.0 Hz, 1H, 6-H), 7.44-7.55 (m, 3H, 2',3',4'-H), 7.63 (d, *J* = 6.8 Hz, 1H, 8-H), 7.78 (d, *J* = 6.4 Hz, 1H, 6-H), 8.53 (d, *J* = 8.0 Hz, 1H, 3-H), 8.73 (s, 1H, N=CH), 8.83 (d, *J* = 5.6 Hz, 1H, 4-H), 8.89 (d, *J* = 6.4 Hz, 1H, 2-H), IR (Neat, ν_{max}, cm^{-1}): 1670 (C=O), 1600 (N=CH), Ms: m/z 306 [M^+].

RESULTS AND DISCUSSION

Synthesis: Scheme-I gives method for the synthesis of target compounds. All the synthesized compounds are solids which are soluble in DMSO and stable at room temperature. Nitration of 5*H*-thiochromeno[2,3-*b*]pyridin-5-one with KNO_3 in H_2SO_4 afforded a mixture of 7-nitro-5*H*-thiochromeno[2,3-*b*]pyridin-5-one (**1**). The 7-nitro-5*H*-thiochromeno[2,3-*b*]-pyridin-5-one (**1**) was isolated as CH_3COOH soluble part[24]. This was reduced by $SnCl_2$ in HCl to afford 7-amino-5*H*-thiochromeno[2,3-*b*]pyridin-5-one[26] (**2**). This reduction can also be done by iron in good yield. The product (**2**) was treated with different aldehydes by means of microwave irradiation and by conventional method of heating to afford the respective Schiff's bases (**2a-2k**) (**Scheme-I**).

Schiff's bases synthesis is generally carried out by refluxing the reaction mixture in presence of acid as a catalyst[27]. Microwave assisted organic synthesis (MAOS) has been intensively used in different reactions due to its environmental impacts and efficiency[28]. In present work, it was observed that reaction time in most of the reaction was considerably decreased and yield of product was found somewhat better. An overall comparison between reaction time and percentage yield of these two techniques is given in Table-1.

Spectral characterization of synthesized compounds: ^{1}H NMR spectra of compounds have shown the presence of a doublet at δ 8.89-9.08 and 8.81-8.94 due to a single proton at 2 and at 4 position of the pyridine ring, respectively. The signals appearing between δ 8.46-9.86 as a singlet was due to N=CH, while all the aromatic protons signals are observed between δ 7.34-8.74 as multiplets and double doublets. The IR spectra of compounds have absorbance peaks for N=CH between 1610-1600 cm^{-1}. The absorbance at 1700-1640 cm^{-1} are due to the presence of C=O group of the thiochromone moiety. Elemental analysis of compounds also confirm their structures.

Biological activities

DPPH radical scavenging activities: DPPH assay is a well known technique, used for the analysis of free radical scavenging activity of different antioxidant compounds[29]. Compounds **2a-2k** were subjected to their DPPH radical scavenging activity using the procedure of Shaheen *et al.*[30] and Mahajan *et al.*[31]. A stock solution of DPPH 0.1 mM was prepared by dissolving 3.94 mg in 100 mL of methanol: water (50:50), sample and standard antioxidant butylated hydroxy-

TABLE-1
REACTION PARAMETERS AND CHN ANALYSIS OF 7-BENZYLIDENEAMINO-5*H*-THIOCHROMENO[2,3-*b*]PYRIDIN-5-ONE (**2a-2k**)

Product	Reaction time (min)		Yield (%)		CHN Analysis (%): calcd. (found)		
	m.w.	Conv.	m.w.	Conv.	C	H	N
2a	02	45	68	57	76.05 (75.72)	6.10 (5.83)	6.58 (6.21)
2b	02	60	68	60	66.30 (66.11)	3.87 (3.02)	7.73 (7.09)
2c	04	30	67	62	66.14 (66.31)	3.94 (3.02)	11.02 (10.79)
2d	02	90	63	52	69.36 (68.81)	4.05 (3.72)	8.09 (7.69)
2e	04	60	73	65	72.73 (72.31)	4.24 (3.92)	8.48 (7.99)
2f	03	120	69	74	72.15 (71.91)	3.79 (3.02)	8.86 (8.09)
2g	05	150	68	70	72.73 (72.21)	4.24 (4.02)	8.48 (8.11)
2h	04	120	69	75	69.36 (68.91)	4.05 (3.72)	8.09 (7.79)
2i	02	120	76	73	63.15 (62.67)	3.04 (2.83)	11.63 (11.38)
2j	03	30	71	67	63.15 (62.93)	3.04 (2.91)	11.63 (11.41)
2k	05	60	71	60	66.66 (66.09)	3.26 (3.09)	9.15 (9.01)

anisole (BHA) in DMSO (50 mg). Absorbance was recorded at 517 nm after 0.5 h incubation. Per cent radical scavenging activity was determined by comparison with DMSO containing standard butylated hydroxyanisole (BHA). Results of studies have revealed significant activity for almost all the compounds (Table-2). As for as the structure-activity relationship (SAR) is concerned, it has been reported that the free radical scavenging activity may increase by an increase in number and strength of electron donating groups such as hydroxyl[29] and methoxy[32]. In the present work we have also noted that compounds having substitution of methoxy and hydroxyl groups (electron donating) in their structures have shown better activity (**2b**, **2d**, **2h**) as compared to compounds having electron withdrawing (nitro) group (**2i**, **2j**) *e.g.*, compound **2b**, **2d** and **2h** due to the presence of methoxy and hydroxyl. It is interesting that compounds **2e** and **2g** were found somewhat active which may be due to presence of methyl group, while the rest of the compounds have not shown significant radical scavenging activity.

TABLE-2
PER CENT RADICAL SCAVENGING ACTIVITY **2a-2k**

Comp.	Radical scavenging activity (%)	Comp.	Radical scavenging activity (%)
2a	7.80	**2g**	31.49
2b	51.23	**2h**	39.78
2c	5.69	**2i**	9.10
2d	42.68	**2j**	8.34
2e	29.32	**2k**	6.23
2f	5.41	BHA (std. antioxidants)	40.97

Antibacterial studies: Compounds **2a-2k** were also subjected to antibacterial studies using the Agar Well Diffusion method[33,34]. The *in vitro* antimicrobial activity of compounds against gram negative and gram positive bacteria *Escerichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis* was checked by preparing suspensions of microorganism which contain *ca.* 10^5-10^6 colony forming units/well (CFU). The compounds were applied to the wells of 6.0 mm diameter at 1.0 mg/mL of DMSO (dimethylsul sulphoxide) in addition to zero (control) and the standard tetracycline (20.0 mg/disc). The inoculated plates were placed in an incubator at 37 ºC for 24 h and growth was assessed by visual inspection. The inhibition zones were measured in mm and compared with the standard drug.

Results show (Table-3) that the compounds **2b** (containing OH and OCH_3 groups) and **2d** (containing OCH_3 group) were found to be the most active against *P. aeruginosa* (30.4 mm), *E. coli*, (28.2 mm), *S. aureus* (25.2 mm) and *B. subtilis* (24.5 mm), respectively. Compounds **2g** and **2k** have also shown moderate activities against *P. aeruginosa* (25.1 mm), and *E. coli*, (22.1 mm), *S. aureus* (24.2 mm) and *B. subtilis* (14.6 mm). The remaining compounds were also found somewhat active against these bacteria. Keeping in view the structure-activity relationship, it was noted that the compounds with electron donating groups are generally found to be more active as compared to electron withdrawing groups.

TABLE-3
ANTIBACTERIAL ACTIVITY OF COMPOUNDS **2a-2k**. (ZONE OF INHIBITION IN mm)

Comp.	*P. aeruginosa*	*E. coli*	*S. aureus*	*B. subtilis*
2a	19.4	24.2	20.2	20.8
2b	34.2	28.9	25.2	24.5
2c	23.0	12.0	18.2	22.3
2d	25.2	29.3	22.3	20.4
2e	20.2	21.3	15.4	18.5
2f	22.3	27.5	12.8	21.7
2g	25.1	22.1	24.5	14.6
2h	17.2	34.5	19.8	19.2
2i	21.4	29.3	21.2	26.8
2j	14.2	18.7	31.4	22.4
2k	24.5	14.7	22.2	21.7
Tetracycline	24.0	29.0	32.0	24.0

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