Synthesis, spectral correlations and antimicrobial activities of 2-pyrimidine Schiff's bases

R. Senbagam^a, M. Rajarajan^a, R. Vijayakumar^a, V. Manikandan^a, S. Balaji^a,
G. Vanangamudi^{a,*}, G. Thirunarayana^b

^aPG & Research Department of Chemistry, Government Arts College, C-Mutlur,
Chidambaram- 608 102, India.

^bDepartment of Chemistry, Annamalai University, Annamalainagar-608 002, India.

*E-mail address: drgvsibi@gmail.com

Keywords: Synthesis, 2-pyrimidine Schiff's bases, UV, IR and NMR spectra, regression analysis and antimicrobial activities.

ABSTRACT. In the present study, a series of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been synthesized by condensation reaction with 2-aminopyrimidine and *meta*- and *para*- substituted benzaldehydes. These synthesized Schiff's base compounds are confirmed by their physical constants, UV, IR and NMR spectral data. All the observed UV absorption maximum λ_{max} (nm), IR frequencies $\nu_{C=N}$ (cm⁻¹), NMR δ (ppm) of C-H & C=N chemical shifts have been correlated with Hammett substituent constants and *F* and *R* parameters using single and multi-linear regression analyses in order to study the effect of substituents on these spectral data has been studied. The antimicrobial activities of all the synthesized Schiff's base compounds have been studied using Bauer-Kirby disc diffusion method.

1. INTRODUCTION

Schiff's bases are an important class of organic compounds possessing biological activities and structural significance. It has been proved that the incorporation of this molecule into the biologically active azomethine linkage ($-\text{CH}=\text{N}-$) produces compounds with high pharmacological activity [1]. Schiff's bases are represented by the general formula $\text{RCH}=\text{NR}'$ where $>\text{C}=\text{N}$ is the azomethine group[2]. The colour of the Schiff's bases is due to the presence of this azomethine ($>\text{C}=\text{N}$) linkage and can vary by introducing other auxochromic groups. When functional groups, such as $-\text{OH}$, $-\text{SH}$, $-\text{COOH}$ are present in these ligands in suitably tailored positions, they enable them to be powerful chelating, biological and analytical reagents. On this basis of such groups present, the Schiff's bases may be di, tri, tetra or polydentate in nature. Compounds containing azomethine group are basic in nature, as N atom of this group has a lone pair of electrons and the double bond has electron donating character. Schiff's bases displayed the phenomenon of tautomerism[3], thermochromy and photochromy[4] and geometrical isomerism[5]. They possess both types of hydrogen bonding i.e. intra-molecular as well as inter-molecular [6]. Schiff's bases are widely studied and used in the fields of organic synthesis and metal ion complexation [7] for a number of reasons: their physiological and pharmacological activities [8] their use in ionselective electrodes [9] in the determination of heavy metals ions in environmental samples [10] and in the extraction of metals ions [11,12] and their many catalytic applications (e.g. for epoxidation of olefins, alkene cyclopropanation [13,14] trimethylsilylcyanation of ketones [15] asymmetric oxidation of methyl phenyl sulfide enantioselective epoxidation of silylenol [16] and ring-opening polymerization of lactide [17]. In recent years, correlation analysis has been applied by chemists for solving the effect of substituents on Schiff's bases through spectral data. Literature survey shows that there is no information available regarding the study of UV, IR and NMR spectral correlation and antimicrobial activities of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds. Hence the authors have taken efforts for synthesizing substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds and studying the effect of substituents through the spectral data and their antimicrobial activities.

2. EXPERIMENTAL

2.1. General

All the chemicals used have been purchased from Sigma–Aldrich and E-Merck chemical companies. Melting points of all of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been observed in open glass capillaries on a Mettler FP51 melting point apparatus and are uncorrected. The UV spectra of all synthesized (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been recorded using SHIMADZU-1650 SPECTROMETER in spectral grade methanol. IR spectra (KBr, 4000–400 cm^{-1}) have been recorded on AVATAR-300 Fourier transform spectrophotometer. The NMR spectra of all the substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been recorded in BRUKER 400 spectrometer operating at 400 MHz for ^1H NMR spectra and 100 MHz for ^{13}C NMR spectra in CDCl_3 solvent using TMS as internal standard.

2.2. Synthesis of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds

Equimolar quantities of 2-aminopyrimidine (0.01mol), substituted benzaldehyde (0.01mol) and 0.5ml acetic acid were refluxed for 3h with 20 mL of absolute ethanol [18,19]. The completion of the reaction was monitored by TLC continuously. The resultant mixture was cooled at room temperature. Then the obtained precipitate was filtered and washed several times with cold water. A yellowish solid was obtained as the product. This crude product was recrystallized from ethanol to get glittering colorless solid, and their melting points were been observed. The general reaction is shown in **Scheme 1**.

Scheme 1. X = H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH₃, 4-OCH₃, 3-NO₂, 4-NO₂

All the compounds synthesized in the present investigation have been identified by their physical constants, UV, IR and NMR spectral data and are shown in **Table 1**. The spectral data of all the synthesized substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been correlated with Hammett substituent constants and *F* and *R* parameter and are shown in **Table 2**.

Table 1. The UV, IR and NMR spectroscopic data of substituted (*E*)-*N*-benzylidene-2-aminopyrimidines

Entry	X	M. F.	M. W.	M. p.(°C)	λ_{max} (nm)	$\nu \text{ C=N}$ (cm^{-1})	$\delta^1\text{H}$ CH=N (ppm)	$\delta^{13}\text{C}$ C=N (ppm)
1	H	$\text{C}_{11}\text{H}_9\text{N}_3$	183.21	75-76 (76)[20]	291.50	1645.28	8.564	163.18
2	3-Br	$\text{C}_{11}\text{H}_8\text{BrN}_3$	262.11	117-118	277.50	1643.42	8.668	158.04
3	4-Br	$\text{C}_{11}\text{H}_8\text{BrN}_3$	262.11	121-122	291.50	1643.28	8.374	156.94
4	3-Cl	$\text{C}_{11}\text{H}_8\text{ClN}_3$	217.65	91-92	287.00	1645.35	8.377	162.43
5	4-Cl	$\text{C}_{11}\text{H}_8\text{ClN}_3$	217.65	46-47 (45-46)[21]	292.00	1647.28	8.664	163.55
6	4-F	$\text{C}_{11}\text{H}_8\text{FN}_3$	201.20	96-97	292.50	1653.07	8.610	163.03
7	4-CH ₃	$\text{C}_{12}\text{H}_{11}\text{N}_3$	197.24	159-160	292.50	1647.28	8.527	163.15
8	4-OCH ₃	$\text{C}_{12}\text{H}_{11}\text{N}_3\text{O}$	213.24	173-174 (175)[21]	291.50	1647.28	8.563	163.21
9	3-NO ₂	$\text{C}_{11}\text{H}_8\text{N}_4\text{O}_2$	228.21	183-184	267.50	1654.03	8.748	158.35
10	4-NO ₂	$\text{C}_{11}\text{H}_8\text{N}_4\text{O}_2$	228.21	167-168	269.00	1664.64	8.569	160.60

Frequency	Constants	r	I	ρ	s	n	Correlated derivatives
$\lambda_{\max}(\text{nm})$	σ	0.900	291.11	-25.026	5.176	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
	σ^+	0.901	287.88	-15.635	7.076	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
	σ_I	0.906	295.29	-25.549	8.389	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
	σ_R	0.907	280.53	-34.474	7.511	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
	F	0.905	293.81	-20.975	9.088	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
	R	0.900	280.09	-27.126	7.961	7	H, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃
$\nu\text{C}=\text{N}(\text{cm}^{-1})$	σ	0.815	1647.09	9.823	5.748	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	σ^+	0.805	1648.52	5.153	6.287	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	σ_I	0.835	1644.99	11.165	6.177	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	σ_R	0.901	1651.25	13.601	6.125	8	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-CH ₃ , 3-NO ₂ , 4-NO ₂
	F	0.842	1644.37	12.302	5.972	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	R	0.905	1651.39	10.513	6.235	8	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-CH ₃ , 3-NO ₂ , 4-NO ₂
$\delta\text{CH}=\text{N}(\text{ppm})$	σ	0.965	8.288	0.246	0.121	7	H, 3-Br, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂
	σ^+	0.984	8.321	0.144	0.139	7	H, 3-Br, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂
	σ_I	0.944	8.243	0.260	0.136	7	H, 3-Br, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂
	σ_R	0.825	8.402	0.409	0.123	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	F	0.795	8.251	0.232	0.139	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	R	0.844	8.408	0.327	0.126	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
$\delta\text{C}=\text{N}(\text{ppm})$	σ	0.904	162.19	-2.999	2.524	7	H, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 4-NO ₂
	σ^+	0.905	161.95	-2.718	2.386	7	H, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 4-NO ₂
	σ_I	0.829	163.11	-4.118	2.548	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	σ_R	0.890	161.06	-3.153	2.672	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	F	0.826	162.73	-3.025	4.639	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂
	R	0.861	161.07	-2.182	4.700	10	H, 3-Br, 4-Br, 3-Cl, 4-Cl, 4-F, 4-CH ₃ , 4-OCH ₃ , 3-NO ₂ , 4-NO ₂

r = correlation coefficient, I = intercept, ρ = slope, s = standard deviation, n = number of correlated derivatives

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3. RESULTS AND DISCUSSION

3.1. UV-Visible spectral correlations

The assigned UV absorption maximum λ_{max} (nm) values of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds are presented in **Table 1**. These UV absorption maximum λ_{max} (nm) values are correlated with different Hammett substituent constants and *F* & *R* parameters using single and multi-linear regression analyses according to the approach of John Shorter [22]. Hammett equation employed, for the correlation analysis, involving the UV absorption maximum is shown in equation (1).

$$\lambda = \rho \sigma + \lambda_0 \quad (1)$$

where λ_0 is the absorption maximum of the parent member of this series.

The results of statistical analyses [18, 23-29] is shown in **Table 2**. The assigned UV absorption maximum λ_{max} (nm) values of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds, except those with 3-Br, 3-NO₂ and 4-NO₂ substituents have shown satisfactory correlations with all the Hammett substituent constants namely, σ ($r = 0.900$), σ^+ ($r = 0.901$), σ_I ($r = 0.906$), σ_R ($r = 0.907$) and Swain-Lupton's [30] *F* ($r = 0.905$) and *R* ($r = 0.900$) parameters. When these substituents that have been given exception are included in regression they reduce the correlations considerably. All the correlations with Hammett constants and *F* and *R* parameters have shown negative ρ values. This indicates the operation of reverse substituent effect with respect to UV absorption maximum λ_{max} (nm) values of all the substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds.

All the correlations have shown satisfactory correlation co-efficient values individually. The multi-regression analyses with Hammett constants σ_I & σ_R and Swain-Lupton's [30] *F* & *R* parameters have also shown satisfactory correlations as shown in the following equations (2) and (3).

$$\lambda_{max} \text{ (nm)} = 289.68 (\pm 3.647) - 22.119 (\pm 3.311) \sigma_I - 31.116 (\pm 4.580) \sigma_R \quad (2)$$

($R = 0.988$, $n = 10$, $P > 95\%$)

$$\lambda_{max} \text{ (nm)} = 288.921 (\pm 3.841) - 22.03 (\pm 2.609) F - 27.995 (\pm 2.761) R \quad (3)$$

($R = 0.986$, $n = 10$, $P > 95\%$)

3.2 IR Spectral correlation

The assigned infrared stretching frequency $\nu_{C=N}$ (cm⁻¹) values of all the substituted (*E*)-*N*-benzylidene 2-amino pyrimidine compounds are presented in **Table 1**. These infrared stretching frequency values are correlated with different Hammett substituent constants and *F* & *R* parameters using single and multi-linear regression analyses according to the approach of Jaffe [31].

The structure parameter correlation involving group frequencies, the employed Hammett equation is shown in equation (4).

$$\nu = \rho \sigma + \nu_0 \quad (4)$$

where ν_0 is the frequency of the parent member of this series

The results of the statistical analyses [18, 23-29] are presented in **Table 2**. From this table, it is evident that the infrared stretching frequency $\nu_{C=N}$ (cm⁻¹) values of all the substituted (*E*)-*N*-benzylidene 2-amino pyrimidine compounds, except those with 4-F and 4-OCH₃ substituents have shown satisfactory correlations with Hammett constant σ_R ($r = 0.901$) and Swain-Lupton's *R* ($r = 0.905$) parameter. When these substituents that have been given exception are included in regression they reduce the correlations considerably.

However the infrared stretching frequency $\nu_{C=N}$ (cm⁻¹) values of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds, have shown poor correlations ($r < 0.900$) with the Hammett constants σ , σ^+ & σ_I and *F* parameter. This is attributed to weak polar, inductive and field effect of the substituents to predict their electronic effects through resonance as per conjugative structure shown in **Figure 1**.

Figure 1. The resonance-conjugative structure

All the correlations have shown positive ρ values. It indicates the operation of normal substituent effect with respect to infrared stretching frequency $\nu_{\text{C=N}}$ (cm^{-1}) values of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds.

Since some of the single regression analyses, have shown poor correlations with Hammett constant and *F* & *R* parameters. It is decided to go for multi regression analysis. The multi regression analyses of the stretching frequency $\nu_{\text{C=N}}$ (cm^{-1}) values of all aryl imine compounds with inductive, resonance and Swain-Lupton's [30] parameters produce satisfactory correlations as shown in equations (5) and (6).

$$\nu_{\text{C=N}} (\text{cm}^{-1}) = 1647.18 (\pm 4.121) + 9.830 (\pm 1.260) \sigma_{\text{I}} + 12.108 (\pm 2.694) \sigma_{\text{R}} \quad (5)$$

($R = 0.957$, $n = 10$, $P > 95\%$)

$$\nu_{\text{C=N}} (\text{cm}^{-1}) = 1649.29 (\pm 3.742) + 12.719 (\pm 2.715) F + 11.015 (\pm 1.562) R \quad (6)$$

($R = 0.964$, $n = 10$, $P > 95\%$)

3.3 NMR spectral correlation

The observed chemical shift values (ppm) of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds are presented in Table 1. These chemical shift values (ppm) are correlated with different Hammett substituent constants and *F* & *R* parameters using single and multi-linear regression analyses according to the approach of Reynolds [32,33]. In this correlation, the structure-parameter equation employed is shown in equation (7).

$$\delta = \rho \sigma + \delta_0 \quad (7)$$

where δ_0 is the chemical shift of the corresponding parent compound.

3.3.1 ^1H NMR spectral correlation:

From the results of the statistical analyses [18, 23-29] in Table-2, it is evident that the ^1H NMR chemical shift $\delta_{\text{CH=N}}$ (ppm) values of all the substituted (*E*)-*N*-benzylidene-2-amino pyrimidine compounds except that with 4-Br, 3-Cl and 4- NO_2 substituents have shown satisfactory correlations with σ ($r = 0.965$), σ^+ ($r = 0.984$) and σ_{I} ($r = 0.944$). The remaining Hammett constant σ_{R} and Swain-Lupton's *F* & *R* parameters.

The failure in correlation is due to the reason that has been stated earlier with resonance conjugative structure as shown in Figure 1. All the correlations with Hammett substituent constants *F* & *R* parameters have shown positive ρ values. It indicates the operation of normal substituent effect with respect to ^1H NMR spectral data of all the compounds.

Some of the single regression analyses have shown poor correlations. Hence, it is decided to go for multi-regression analysis. While seeking the multi-correlation collectively the inductive, resonance and field effects [30] have shown satisfactory correlation as shown in the equations (8) and (9).

$$\delta_{\text{C=N}} (\text{ppm}) = 8.311 (\pm 0.080) + 0.219 (\pm 0.016) \sigma_{\text{I}} + 0.376 (\pm 0.021) \sigma_{\text{R}} \quad (8)$$

($R = 0.989$, $n = 10$, $P > 95\%$)

$$\delta_{\text{C=N}} (\text{ppm}) = 8.309 (\pm 0.077) + 0.245 (\pm 0.015) F + 0.337 (\pm 0.016) R \quad (9)$$

($R = 0.970$, $n = 10$, $P > 95\%$)

3.3.2 ^{13}C NMR spectral correlation

The results of the statistical analyses [18, 23-29] are presented in Table 2. From Table 2, it is evident that the ^{13}C NMR chemical shift $\delta_{\text{C=N}}$ (ppm) values of all the substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds except those with 3-Br, 4-Br and 3- NO_2 substituents have shown satisfactory correlations with Hammett constants σ ($r = 0.904$) and σ^+ ($r =$

0.905). The remaining Hammett constants σ_I , σ_R and Swain-Lupton's [30] F & R parameters have shown poor correlations ($r < 0.900$). The failure in correlation is due to the reason that has been stated earlier with resonance conjugative structure as shown in Figure 1. All the correlations with Hammett substituent constants F & R parameters have shown negative ρ values. It indicates the operation of reverse substituent effect with respect to ^{13}C NMR spectral data of all the compounds.

Some of the single regression analyses have shown poor correlations. Hence, it is decided to go for multi-regression analysis. While seeking the multi-correlation collectively the inductive, resonance and field effects[30] have shown satisfactory correlation as shown in the equations(10) and (11).

$$\delta\text{C} = \text{N(ppm)} = 162.64(\pm 1.834) - 3.834(\pm 0.013)\sigma_I - 2.570(\pm 0.135)\sigma_R \quad (10)$$

$$(R = 0.943, n = 10, P > 90\%)$$

$$\delta\text{C} = \text{N(ppm)} = 162.32(\pm 1.838) - 3.112(\pm 0.642)F - 2.305(\pm 0.715)R \quad (11)$$

$$(R = 0.936, n = 10, P > 90\%)$$

4. ANTIMICROBIAL ACTIVITIES

4.1. Antibacterial sensitivity assay

The antibacterial activities of all synthesized substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been studied against three gram positive pathogenic strains *B. subtilis*, *M. lutes*, *S. aureus* and two gram negative strains *E. coli* and *P. aeruginosa*. The disc diffusion technique has been followed using the Kirby-Bauer method [34], at a concentration of 250 $\mu\text{g/mL}$ and ciprofloxacin was used as standard. The antibacterial screening effect of prepared substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds is shown in **Figure 2** (Plates 1–10). The measured zone of inhibition values are given in **Table 3** and the corresponding clustered column chart is shown in **Figure 3**. Zone of inhibition (mm) values of antibacterial activity of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds reveals that all the compounds have shown moderate to good activity against all the five microorganisms evaluated in the present investigation. The 3-Cl and 4-CH₃ substituted Schiff's bases have shown good activity against *B. subtilis*. The 4-Br substituted compound has shown good activity against *M. luteus* and *S. aureus*. The 4-F substituted compound has shown good activity against *P. aeruginosa* and the remaining compounds have shown moderate activity.

Plate-1

Plate-2

Plate-3

Plate-4

Plate-5

Plate-6

Plate-7

Plate-8

Plate-9

Plate-10

Figure 2. Antibacterial activity of substituted (*E*)-*N*-benzylidene-2-aminopyrimidines (petri-plates)

Table 3. Zone of inhibition (mm) values of antibacterial activity of substituted (*E*)-*N*-benzylidene-2-aminopyrimidines.

S.No.	Substituents	Zone of inhibition(mm)				
		Gram positive Bacteria			Gram negative Bacteria	
		<i>B.subtilis</i>	<i>M.luteus</i>	<i>S.aureus</i>	<i>E. coli</i>	<i>P. aeruginosa</i>
1	H	7	10	7	10	7
2	3-Br	7	9	8	8	9
3	4-Br	9	14	12	9	7
4	3-Cl	12	7	9	10	10
5	4-Cl	8	7	9	11	7
6	4-F	8	9	10	8	12
7	4-CH ₃	13	10	9	8	9
8	4-OCH ₃	7	9	10	7	10
9	3-NO ₂	10	10	12	7	9
10	4-NO ₂	7	8	9	7	8
Standard	Ciprofloxacin	13	14	10	12	12
Control	DMSO	0	0	0	0	0

Figure 3. Antibacterial activity of substituted (*E*)-*N*-benzylidene-2-aminopyrimidines (clustered column chart)

4.2 Antifungal sensitivity assay

The antifungal activities of all synthesized substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been studied against three fungal species namely *A. niger*, *M. species* and *T. species*. The disc diffusion technique has been followed using the Kirby-Bauer method [34], at a concentration of 250 µg/mL and Ciprofloxacin was used as standard. The antifungal screening effect of prepared substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds is shown in **Figure 4**. (Plates 1–4). The measured zone of inhibition values are given in Table 4 and the corresponding Clustered column chart is shown in **Figure 5**. All the compounds have shown moderate to good activity against all the three fungal species evaluated in general. The 4-Cl, 4-Br, 4-CH₃, 4-OCH₃ and 4-NO₂ substituted compounds have shown good activity against

A. niger. The parent compound (H) and 3-Br substituted compounds have shown good activity against *M. species*. The 4-Br substituted compound has also shown good activity against *T. viride*.

Table 4. Zone of inhibition (mm) values of antifungal activities of substituted (E)-N-benzylidene-2-aminopyrimidines

Entry	Substituents	Zone of inhibition (mm)		
		<i>A. niger</i>	<i>M. species</i>	<i>T. viride</i>
1	H	9	13	10
2	3-Br	9	15	11
3	4-Br	10	10	13
4	3-Cl	11	10	12
5	4-Cl	10	11	11
6	4-F	10	13	10
7	4-CH ₃	11	8	9
8	4-OCH ₃	11	10	12
9	3-NO ₂	9	12	10
10	4-NO ₂	10	9	11
Standard	Ciprofloxacin	10	15	14
Control	DMSO	0	0	0

Plate-1

Plate-2

Plate-3

Plate-4

Plate-5

Plate-6

Figure 4. Antifungal activity of substituted (E)-N-benzylidene-2-aminopyrimidines (petri-plates)

Figure 5. Antifungal activity of substituted (*E*)-*N*-benzylidene-2-aminopyrimidines (clustered column chart)

5. CONCLUSIONS

A series of substituted (*E*)-*N*-benzylidene-2-aminopyrimidine compounds have been synthesized by condensation method. These compounds were confirmed by their physical constants and spectral data. The spectral data of these compounds have been correlated with Hammett sigma constants and *F* & *R* parameters using single and multi-linear regression analysis. Most of the single linear regression analyses have been satisfactory correlations for all the substituents with UV, IR and NMR spectral data. Some of the compounds have been shown good antibacterial and antifungal activities. Most of the compounds have been shown moderate activity.

Acknowledgement

The authors thank DST NMR Facility, Department of Chemistry, Annamalai University, Annamalai-nagar-608 002, for recording NMR spectra of all compounds.

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