Synthesis, Spectral and Biological Activities of Some Substituted Styryl 2-Phenothiazinyl Ketones

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Abstract: A series of twelve substituted styryl 2-phenothiazinyl ketones have been synthesized and characterized by their physical constants and spectral data. The spectral frequencies, vinyl protons, carbons and carbonyl carbons were correlated with Hammett substituents, F and R parameters. The antimicrobial activities of all chalcones have been studied.

Key words: Substituted styryl 2-phenothiazinyl ketones · Synthesis · IR and NMR spectra · Hammett correlation · Antimicrobial activities

INTRODUCTION

Chalcones (1, 3-diaryl-2-propen-1-ones) constitute an important class of natural products belonging to the flavonoids family, display interesting biological activities including anticancer, anti-inflammatory, antioxidant, cytotoxic, antimicrobial, analgesic and antipyretic, anti-anginal, anti-hepatotoxic, antimalarial, anti-allergic and antifeedant. Chemically they consist of open-chain flavonoids in which the two aromatic rings are joined by a three carbon α,β –unsaturated Carbonyl system [1-3]. From the chemical studies on the structure of clavicin, it was found that the structural feature, responsible for the antibacterial activity was α, β-unsaturated keto functional group [4]. The diverse properties of chalcones have prompted us to synthesize them and study their antimicrobial activity. The Hammett correlation of spectral data of organic compounds are useful for the prediction of their structure, stereo-chemical and physicochemical properties [5, 6]. The quantitative structure- activity relationship and quantitative property relationship of the organic substrates have been studied from the spectral data associated with their molecular equilibration [7]. The electronic transition of n→π* and π→π* obtained in 280-350nm in molecules are exhibited by α,β-unsaturated carbonyl compounds. These absorption maxima λmax (nm) of these chalcones are correlated and studied the effects of substituents [8]. The vibrational stretches of carbonyl groups gave two molecular conformers in unsaturated ketones such as *s-cis* and *s-trans* isomers. The s-cis carbonyl group stretches are higher than those of the *s-trans* carbonyl group. Based on this the structure of molecular equilibration can be predicted in geometrical isomers, keto-enol tautomerism in unsaturated carbonyl compounds [9], alkenes, alkynes, styrenes, nitro-styrenes and naphthyl ketones and their esters [10].

Nuclear magnetic resonance spectroscopy provides the information about the number of protons present in the molecules and their categories either *E* or *Z* in the above molecules. These categories of protons can be identified in the organic molecules, based on their coupling constants. If the molecules possess any substituent in the aromatic ring, corresponding maximum absorption in UV, absorption frequencies in IR and the chemical shift in NMR vary from ketone to ketone depending upon the type of substituents whether they are electron donating or electron withdrawing in nature. From these data the effect of substituents can be studied on the particular functional group of the molecule by means of regression analysis [11]. Now a day's scientists [12] have paid more interest to correlate the group frequencies of spectral data with Hammett substituent constants to explain the substituent effects of organic compounds. Azizi and Esmaili have studied the quantum mechanical linearity of ^{13}C chemical shift values of some cyclic chalcones [13]. Recently Thirunarayanan *et al.* [14],

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investigated elaborately the single and multi-substituent effects on alpha and beta hydrogen and carbons of furyl chalcones. However there is no information available regarding the study of UV, IR, NMR spectral and electrochemical study in literature in the resent past with respect to substituted styryl 2-phenothiazinyl ketones. There is no report available for the correlation of spectral group frequencies of substituted styryl 2-phenothiazinyl ketones with Hammett substituent constants, F and R parameters in literature in the past. Hence the authors have taken efforts to synthesize some substituted styryl-2-phenothizino chalcones by condensation of 2-acetylphenothizine with various *o-*, *m-* and *p-* substituted benzaldehydes and to study the quantitative structure property relationship as well as their antimicrobial activities.

Experimental

General: All chemicals were procured from Sigma-Aldrich and Merck chemical company. The purities of these synthesized chalcones were checked with their physical constants. The physical constants and spectral data of unknown chalcones are presented in Table 1. The Infrared spectra of compounds were recorded in avatar 300 infrared spectrophotometer. The nuclear magnetic spectra

of compounds were recorded in Instrum 300 type nuclear magnetic spectrometer applying 500M Hz frequency for recording ^{1}H and 125.46 MHz frequency for ^{13}C spectrum using DMSO as solvent and TMS is an internal standard. Mass spectra of compounds were recorded in SHIMADZU GC-MS2010 Mass spectrometer.

Synthesis of Substituted Styryl 2-phenothiazinyl Ketones: All substituted styryl 2-phenothiazinyl ketones were synthesized by Green Ground Chemistry method reported in the literature [15]. 2-acetyl phenothiazine (0.02mmol), substituted benzaldehydes (0.02mmol) and sodium hydroxide (0.5g) in a mortar was ground with pestle for 20 minutes (**Scheme-1**). Completion of the reaction was confirmed by thin layer chromatography, the reaction mixture was poured into 25ml of cold water. The obtained brown solid was separated by filtration. The pure brown chalcones were obtained by crystallization of these brown solid with ethanol. Physical constants, analytical, UV and mass spectral data were presented in Table 1. Infrared spectral data of all chalcones were given in Table 2. The NMR data of synthesized styryl 2-phenothiazinyl ketones are tabulated in Table 3.

Table 1: Physical constants, analytical, Ultraviolet and mass spectral data of 2-phenothiazinyl chalcones.

Entry	X	Mol. Formula	m.p.°C	M.W	UVλmax(nm)	Mass (m/z)
1	H	$C_{21}H_{15}NOS$	170	329	286.20	329[M$^+$], 312, 296, 286, 267, 241, 226, 198, 171, 165, 154, 148, 131, 113, 103, 85, 77, 58
2	3-Br	$C_{21}H_{14}BrNOS$	205	408	281.20	408[M$^+$], 410[M+2],390, 376, 328, 310, 299, 281, 267, 241, 226, 211, 148, 182, 171, 164, 148, 127, 113, 102, 97, 73, 58
3	2-Cl	$C_{21}H_{14}ClNOS$	338(D.P)	363	299.00	363[M$^+$], 365[M+2], 328, 310, 296, 286, 267, 254, 241, 226, 211,1 98,1 83, 164, 148,139, 113, 97, 77, 58
4	3–Cl	$C_{21}H_{14}ClNOS$	143	363	307.20	363[M$^+$], 365[M+2], 328, 310, 296, 286, 267, 254, 241, 226, 211, 198, 183,164,148,139,113, 97,77, 58
5	3-F	$C_{21}H_{14}FNOS$	201	347	308.00	347[M$^+$], 347[M+2], 330, 314, 285, 267, 252,226,198, 173,154, 149, 121, 101, 97, 73, 58
6	4-F	$C_{21}H_{14}FNOS$	143	347	314.60	347[M$^+$], 347[M+2], 330, 314, 285, 267, 252, 226, 198, 173, 154, 149, 121, 101, 97, 73, 58
7	3-OH	$C_{21}H_{15}NO_2S$	128	345	280.80	345[M$^+$], 327, 313, 295, 281, 267, 251, 241, 226, 221, 207, 198, 193, 169, 154,135, 113, 99, 73, 69
8	2-OCH$_3$	$C_{22}H_{17}NO_2S$	156	359	342.00	359[M$^+$], 344, 326, 316, 298, 283, 267, 254, 241, 223, 198, 183, 179, 161, 133, 118, 97, 73, 58
9	4-OCH$_3$	$C_{22}H_{17}NO_2S$	162	359	341.20	359[M$^+$], 344, 326, 316, 298, 283, 267, 254, 241, 223, 198, 183, 179, 161, 133, 118, 97, 73, 58
10	4-CH$_3$	$C_{22}H_{17}NOS$	356(D.P.)	343	323.40	343[M$^+$], 328, 310, 300, 281, 267, 252, 241, 223, 198, 164, 145, 127, 115, 102, 91, 77, 58
11	2-NO$_2$	$C_{21}H_{14}N_2O_3S$	324(D.P.)	374	281.80	374[M$^+$], 358, 342, 311, 299, 286, 267, 254, 241, 223, 198, 171, 154, 127, 121, 102, 89, 77, 65
12	3-NO$_2$	$C_{21}H_{14}N_2O_3S$	334(D.P.)	374	298.00	374[M$^+$], 358, 342, 311, 299, 286, 267, 254, 241, 223, 198, 171, 154, 127, 121, 102, 89, 77, 65

Table 2: Infrared spectral data ν(cm^{-1})of 2-phenothiazinyl chalcones

Entry	X	CO*s-cis*	CO*s-trans*	CH*ip*	CH*op*	CH=CH*op*	>C=C<*op*
1	H	1660.60	1627.80	1155.30	736.80	1078.10	680.80
2	3-Br	1664.50	1627.80	1155.30	740.60	1093.60	638.40
3	2-Cl	1656.70	1618.20	1178.40	752.20	1041.50	588.20
4	3–Cl	1649.00	1587.30	1191.90	734.80	1080.10	582.50
5	3-F	1651.00	1585.40	1186.10	777.30	1082.00	584.40
6	4-F	1652.90	1589.20	1184.20	736.80	1083.90	563.20
7	3-OH	1664.50	1635.50	1157.20	740.60	1093.60	638.40
8	2-OCH$_3$	1652.90	1591.20	1172.60	740.60	1080.10	576.70
9	4-OCH$_3$	1651.00	1587.30	1153.40	740.60	1082.00	582.50
10	4-CH$_3$	1652.90	1627.80	1184.20	798.50	1083.90	565.10
11	2-NO$_2$	1658.70	1598.90	1188.10	786.90	1083.90	565.10
12	3-NO$_2$	1656.70	1587.30	1188.10	796.50	1082.00	586.30

Table 3: The NMR spectral chemical shift δ(ppm) of 2-phenothiazinyl chalcones

| Entry | X | ^{1}H NMR | | | | ^{13}C NMR | | | |
		δHα (1H, *d*)	δHβ (1H, *d*)	Substt.	δCO	δCα	δCβ	Substt.
1	H	7.489	7.845	---	188.79	121.89	145.16	---
2	3-Br	6.693	6.932	---	196.76	123.20	141.99	---
3	2-Cl	7.847	8.069	---	187.69	122.07	143.74	---
4	3–Cl	7.678	7.882	---	187.85	122.10	142.14	---
5	3-F	7.656	7.890	---	187.89	122.00	141.14	---
6	4-F	7.045	7.758	---	187.90	122.04	142.46	---
7	3-OH	6.681	6.926	3.336 (1H, *s*)	196.79	123.23	142.01	---
8	2-OCH$_3$	6.708	6.955	3.819 (3H, *s*)	187.82	119.29	143.77	55.36(OCH$_3$)
9	4-OCH$_3$	7.053	7.633	3.820(3H, *s*)	187.95	122.05	142.09	55.37(OCH$_3$)
10	4-CH$_3$	6.956	7.675	2.355(3H, *s*)	187.92	120.76	143.78	21.03
(CH$_3$)11	2-NO$_2$	7.778	7.961	---	187.67	122.78	142.16	---
12	3-NO$_2$	8.008	8.774	---	187.86	122.79	142.29	---
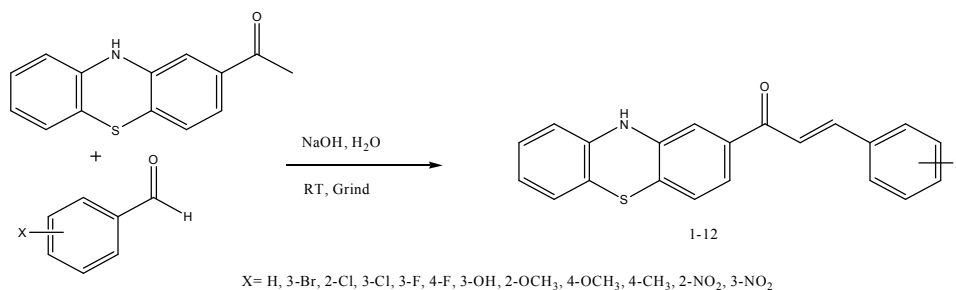
Scheme 1. Synthesis of substituted styryl 2-phenothizenyl ketones

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RESULTS AND DISCUSSION

Ultra Violet Spectral Study: The UV spectra of all synthesized chalcones were recorded in SHIMADZU-1650 SPECTROMETER (λ_{max} nm) in spectral grade methanol. The measured absorption maxima (λ_{max} nm) of these chalcones are presented in Table 1. These values are correlated with Hammett substituent constants and F and R parameters using single and multi-linear regression analysis[10]. Hammett correlation involving the group frequencies and absorption maxima, the form of the Hammett equation employed is

$$\lambda = \rho\sigma + \lambda_{o...} \qquad (1)$$

Where λ_o is the frequency for the parent member of the series.

The results of statistical analysis of these values with Hammett substituent constants are presented in Table 4. From Table 4, Hammett substituent constants σ, σ$^+$,σ$_R$, σ$_I$ and R values gave satisfactory correlations. All constants gave positive ρ values. However resonance parameter produce poor correlation.

This is due to the inductive effects of the substituents were weak for predicting the reactivity on the absorption through resonance. This is evident with resonance conjugative structure shown in Figure 1. The multi regression analysis of these frequencies of all ketones with inductive, resonance and Swain – Lupton's[11] constants produce satisfactory correlations as evident in equations 2 and 3.

$$\lambda_{(nm)} = 300.82(\pm12.731)\text{-}18.167(\pm25.321)$$
$$\sigma_I \text{ - } 49.878(\pm23.227)\sigma_R \qquad (2)$$
$$(R =0.943, n = 12, P \rightarrow 90\%)$$

$$\lambda_{(nm)} = 307.14(\pm14.629) \text{ -}13.329(\pm27.360)$$
$$F \text{ -}10.733(\pm17.987)R \qquad (3)$$
$$(R = 0.952, n = 12, P > 95\%)$$

Infrared Spectral Study: The synthesized chalcones exist as *s-cis* and *s-trans* conformers. These conformers are confirmed by the carbonyl group doublets obtained in the range of 1600-1700cm^{-1}. They are shown in Figure 1 and the corresponding carbonyl frequencies (cm^{-1}) of the conformers are presented in Table 2.
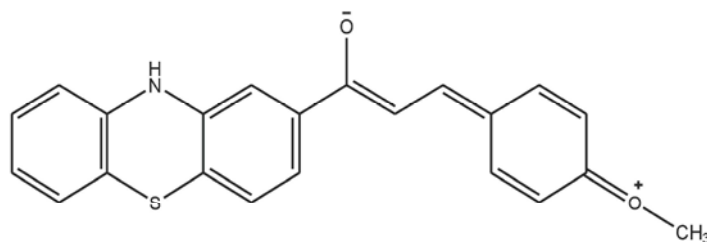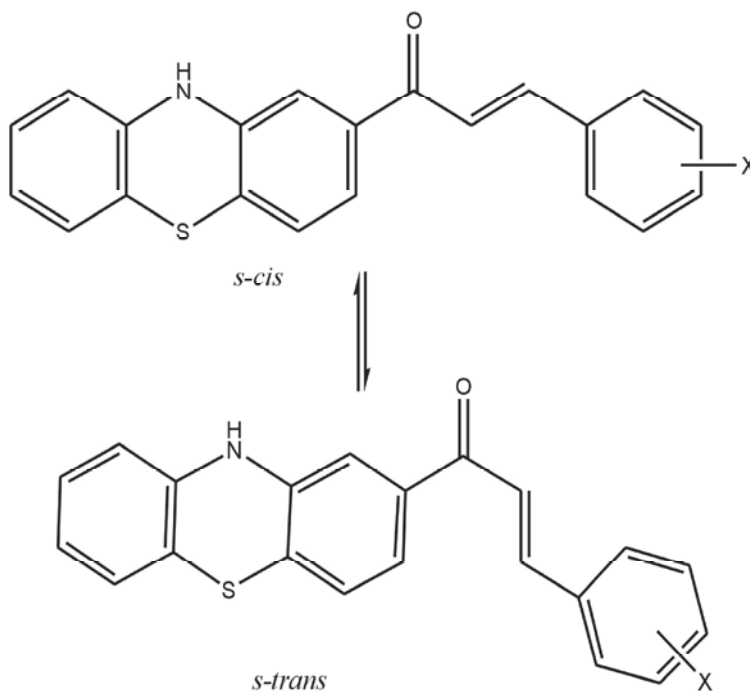
Fig. 1: Resonance-conjugative structure

Fig. 2: *s-cis* and *s-trans* conformers of 2-phenothiasenyl chalcones

The *s-cis* conformers absorbs at higher vibrational frequencies than *s-trans* conformers. Generally carbonyl doublets obtained at lower absorption frequencies for the electron donating substituents in the chalcones whereas the electron withdrawing substituents absorb their doublets at higher frequencies in both the conformers. In the present study also, the same trend was observed. These frequencies are correlated with various Hammett sigma constants and Swain-Lupton's parameters [11] by single and multi linear regression analysis [8, 12, 14, 16]. While seeking Hammett correlation involving group frequencies, the form of the Hammett equation employed is

$$\nu = \rho\sigma + \nu_o \qquad (4)$$

Where ν_o is the frequency for the parent member of the series.

The results of single parameter statistical analysis of carbonyl frequencies with substituent constants are presented in Table 4. From Table 4, the s-*cis*and s-*trans* conformers the correlation $\nu_{C=O}$ of both conformers fails with Hammett σ constants and F and R parameters. The $\nu_{C=O}$ trans conformers gave negative ρ values and the effects of substituents are reversed. This is due the conjugation between the substituent and the carbonyl group in chalcones as shown in Figure 2.

The correlation of CH *in-plane* modes with Hammett σ+ and $\sigma_I$constants satisfactorily. The satisfactory correlation obtained for CH*out of plane* modes with Hammett σ_I constants. All correlation gave positive ρ values and this reveals that there is a normal substituent effects operated in all ketones. The remaining sigma constants, F and R parameter fails in correlation. This is due to the reason stated earlier and associated with the resonance conjugative structure shown in Fig. 2.

Table 4: Results of statistical analysis of UV λmax (nm), infrared ν(cm^{-1}) of CO$_{s\text{-}cis}$ and CO$_{s\text{-}trans}$,CHip and op, CH=CHop and >C=C<op

Functionality	Constants	r	I	ρ	S	n	Correlated derivatives
λmax	σ	0.965	311.76	-38.465	17.23	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.952	306.59	-21.524	19.47	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.924	314.31	-23.668	22.20	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.958	293.50	-51.564	18.56	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.880	310.84	-13.342	22.63	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.919	301.58	-10.740	22.48	11	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 4-OH,2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
Co$_{s\text{-}cis}$	σ	0.821	1655.44	3.009	5.36	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.807	1655.90	0.700	5.47	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.805	1656.41	-1.211	5.48	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.834	1657.66	7.532	5.13	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.816	1657.30	-3.261	5.42	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.805	1655.71	-0.671	5.48	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
Co$_{s\text{-}trans}$	σ	0.811	1608.89	-6.038	20.43	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.810	1608.13	-4.330	20.42	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.853	1625.53	-46.276	17.34	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.825	1612.47	20.140	19.88	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.863	1627.98	-48.270	15.89	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.806	1606.82	-3.039	20.53	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
Ch$_{ip}$	σ	0.849	1171.24	19.739	13.76	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.900	1173.57	16.243	12.90	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.940	1162.29	32.162	13.80	10	3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$,2-NO$_2$, 3-NO$_2$
	σ$_R$	0.820	1177.36	12.234	15.47	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.805	1161.96	30.242	13.51	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.803	1179.41	14.073	14.69	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
Ch$_{op}$	σ	0.804	751.84	30.723	23.37	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.804	755.82	19.494	23.91	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.916	749.96	18.487	25.93	10	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.705	768.90	52.072	22.53	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.820	748.66	20.041	25.74	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.844	766.81	28.464	23.55	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
CH=CH$_{op}$	σ	0.701	1080.31	0.445	13.82	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.255	1080.77	-6.299	13.36	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.807	1081.95	-4.105	13.79	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.800	1080.45	0.290	13.82	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.802	1079.79	1.425	13.82	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.824	1077.50	-8.386	13.38	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
C=C$_{op}$	σ	0.800	597.61	0.684	37.28	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$^+$	0.804	597.93	-3.297	37.23	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_I$	0.935	618.60	-54.685	34.92	11	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ$_R$	0.802	606.31	37.601	35.97	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.941	621.41	-56.837	33.96	11	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.802	597.17	-1.632	37.27	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$

modes of substituted styryl 2-phenothiazinyl ketones with Hammett σ, σ$^+$, σ$_I$, σ$_R$ constants and F and R parameters

r = Correlation co-efficient; ρ = Slope; I = Intercept; s = Standard deviation; n = Number of substituents.

All correlation were fails with CH=CH *out of plane* modes with Hammett constants, F and R parameters. On the other hand C=C *out of plane* modes with Hammett σ$_I$ constants and F parameters correlated satisfactorily. All correlation gave positive ρ values and this reveals that there is a normal substituent effects operated in all ketones. The remaining sigma constants, F and R parameter fails in correlation. This is due to the reason stated earlier and associated with the resonance conjugative structure shown in Figure 2.

In view of the inability of some of the σ constants to produce individually satisfactory correlations, it was thought that worthwhile to seek multiple correlations involving either σ$_i$and σ$_R$constants or Swain-Lupton's[11, 16], F and R parameters. The correlation equations for s-*cis,*s-*trans and deformation modes* are given equations 5-16.

$\nu CO_{s\text{-}cis}^{(cm-1)} = 1658.50(\pm3.600) - 2.063$
$(\pm7.161)\sigma_I + 7.723(\pm6.568)\sigma_R$ (5)
$\qquad (R = 0.910, n = 12, P> 90\%)$

$\nu CO_{s\text{-}cis}^{(cm-1)} = 1657.07(\pm3.568) - 3.260$
$(\pm6.674)F - 0.670(\pm4.388)R$ (6)
$\qquad (R = 0.942, n = 12, P> 90\%)$

$\nu CO_{s\text{-}trans}^{(cm-1)} = 1623.21(\pm11.364) - 48.999$
$(\pm22.603)\sigma_{I+}24.687(\pm20.734)\sigma_R$ (7)
$\qquad (R = 0.941, n = 12, P> 90\%)$

$\nu CO_{s\text{-}trans}^{(cm-1)} = 1626.94(\pm10.444) - 48.267$
$(\pm19.534)F - 3.015(\pm12.842)R$ (8)
$\qquad (R = 0.900, n = 12, P> 90\%)$

$\nu CH_{ip}^{(cm-1)} = 1164.81(\pm9.580) + 31.131$
$(\pm19.054)\sigma_I + 9.345(\pm17.478)\sigma_R$ (9)
$\qquad (R = 0.942, n = 12, P> 90\%)$

$\nu CH_{ip}^{(cm-1)} = 1166.81(\pm8.052) + 30.226$
$(\pm15.060)F + 14.058(\pm9.901)R$ (10)
$\qquad (R = 0.921, n = 12, P> 90\%)$

$CH_{op}^{(cm-1)} = 763.71(\pm15.742) + 12.876$
$(\pm31.309)\sigma_I + 50.877(\pm28.720)\sigma_R$ (11)
$\qquad (R = 0.930, n = 12, P> 90\%)$

$\nu CH_{op}^{(cm-1)} = 758.42(\pm15.110) + 20.009$
$(\pm28.259)F + 28.454(\pm18.578)R$ (12)
$\qquad (R = 0.907, n = 12, P> 90\%)$

$\nu CH=CH_{op}^{(cm-1)} = 1082.14(\pm9.722) - 4.179$
$(\pm19.333)\sigma_I + 0.678(\pm17.737)\sigma_R$ (13)
$\qquad (R = 0.934, n = 12, P> 90\%)$

$\nu CH=CH_{op}^{(cm-1)} = 1076.90(\pm8.820) + 1.435$
$(\pm16.496)F - 8.387(\pm10.845)R$ (14)
$\qquad (R = 0.926, n = 12, P> 90\%)$

$\nu C=C_{op}^{(cm-1)} = 630.26(\pm23.324) - 59.440$
$(\pm46.390)\sigma_I + 43.117(\pm42.553)\sigma_R$ (15)
$\qquad (R = 0.948, n = 12, P> 90\%)$

$\nu C=C_{op}^{(cm-1)} = 620.862(\pm22.384) - 56.836$
$(\pm41.864)F - 1.604(\pm27.523)R$ (16)
$\qquad (R = 0.945, n = 12, P> 90\%)$

¹H NMR Spectral Study: The ¹H NMR spectra of synthesized chalcones were recorded in deuterated DMSO solutions employing tetramethylsilane (TMS) as internal standard. The signals of the ethylenic protons were assigned from their spectra. They were calculated as AB or AA' or BB' systems respectively. The lower chemical shifts(ppm) obtained for H_α and higher chemical shifts(ppm) obtained for H_β in this series of ketones. The vinyl protons give an AB pattern and the β-proton doublets were well separated from the signals of the aromatic protons. The assigned vinyl proton chemical shiftsδ(ppm) of all ketones were presented in Table 3.

In nuclear magnetic resonance spectra, the proton or the ¹³C chemical shifts (δ) depends on the electronic environment of the nuclei concerned. The assigned vinyl proton chemical shifts(ppm) have been correlated with reactivity parameters using Hammett equation in the form of

$$\text{Log } \delta = \text{Log } \delta_0 + \rho\sigma... \qquad (17)$$

Where δ_0 is the chemical shift of unsubstitued ketones.

The assigned H_α and H_β proton chemical shifts (ppm) are correlated with various Hammett sigma constants. The results of statistical analyses[11,16] are presented in Table 5. The positive ρ values were obtained in all correlation and are evident for the normal substituent effect operates in all chalcones. A satisfactory correlation obtained for the H_α proton chemical shifts(ppm) with Hammett σ, σ^+, σ_I, constants. Remaining Hammett σ_R and F and R parameters were correlated poorly in all synthesized ketones. Similarly, the Hammett σ, σ_R and F and R parameters correlated satisfactorily with H_β proton chemical shifts(ppm) of all ketones. The polar and inductive effects were fail in correlation. This is due to the reasons stated in earlier and the conjugative structure shown in Figure 2.

Application of Swain-Lupton [11] treatment to the relative chemical shifts of H_α and H_β with F and R values is successful with resonance, inductive and fail with F & R parameter generates the multi regression equations 18-21.

$\delta H_\alpha(ppm) = 7.186(\pm0.265) + 0.897$
$(\pm0.527) \sigma_I + 1.007(\pm0.484)\sigma_R$ (18)
$\qquad (R = 0.945, n = 12, P> 90\%)$

$\delta H_\alpha (ppm) = 7.259(\pm0.230) + 0.745$
$(\pm0.431)F + 0.787(\pm0.283)R$ (19)
$\qquad (R = 0.961, n = 12, P> 95\%)$

$\delta H_\beta(ppm) = 7.671(\pm0.309) + 0.727$
$(\pm0.615) \sigma_I + 1.131(\pm0.564)\sigma_R$ (20)
$\qquad (R = 0.927, n = 12, P> 90\%)$

$\delta H_\beta(ppm) = 7.694(\pm0.260) + 0.708$
$(\pm0.487)F + 0.866(\pm0.320)R$ (21)
$\qquad (R = 0.951, n = 12, P> 95\%)$

Table 5: Results of statistical analysis of ^{1}H NMR of δH_α, δH_β (ppm), ^{13}C NMR of δC_α, δC_β and δCO (ppm) of substituted styryl 2-phenothiazinyl ketones with Hammett σ, σ^+, σ_I, σ_R constants and F and R parameters

Functionality	Constants	r	I	ρ	s	n	Correlated derivatives
$\delta_{H\alpha}$(ppm)	σ	0.968	7.146	0.904	0.37	11	H, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH3, 4-OCH3, 4-CH3, 2-NO2, 3-NO2
	σ^+	0.975	7.256	0.696	0.33	11	H, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH3, 4-OCH3, 4-CH3, 2-NO2, 3-NO2
	σ_I	0.946	6.913	1.009	0.45	11	H, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH3, 4-OCH3, 4-CH3, 2-NO2, 3-NO2
	σ_R	0.548	7.548	1.090	0.43	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.389	6.988	0.746	0.47	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.825	7.570	0.787	0.40	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
$\delta_{H\beta}$(ppm)	σ	0.956	7.554	0.814	0.46	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ^+	0.613	7.653	0.617	0.44	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_I	0.836	7.365	0.852	0.52	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_R	0.955	7.965	1.198	0.47	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.933	7.395	0.709	0.53	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.963	7.989	0.867	0.43	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F,3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
δCO(ppm)	σ	0.808	189.42	-0.074	3.62	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ^+	0.820	189.48	-1.345	3.54	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_I	0.807	189.84	-1.143	3.61	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_R	0.705	189.84	-1.143	3.36	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.710	190.08	-1.619	3.59	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.847	188.02	-4.016	3.22	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
δC_α(ppm)	σ	0.864	121.69	1.887	0.87	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ^+	0.838	121.96	0.777	1.05	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_I	0.843	121.21	2.089	1.03	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_R	0.434	122.45	1.909	1.03	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.376	121.35	1.594	1.06	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.804	122.04	0.075	1.14	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
δC_β(ppm)	σ	0.434	142.94	-1.310	1.06	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ^+	0.175	142.74	-0.371	1.16	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_I	0.906	143.99	-3.316	0.88	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	σ_R	0.816	142.89	0.755	1.16	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	F	0.907	144.05	-3.188	0.81	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$
	R	0.830	143.03	0.890	1.12	12	H, 3-Br, 2-Cl, 3–Cl, 3-F, 4-F, 3-OH, 2-OCH$_3$, 4-OCH$_3$, 4-CH$_3$, 2-NO$_2$, 3-NO$_2$

r = Correlation co-efficient; ρ = Slope; I = Intercept; s = Standard deviation; n = Number of substituents.

^{13}C NMR spectral study: Spectral analysts and chemists and scientists[11, 16-18] have made extensive study of ^{13}CNMR spectra for a large number of different ketones and styrenes. The assigned vinyl C_α, C_β and carbonyl carbon chemical shifts are presented in Table 3. The results of statistical analysis are given in Table 5. They have been observed a poor correlation linearfor the chemical shifts(ppm) of c$_\alpha$carbon with hammett s constants. A satisfactory correlation obtained for c$_\beta$ carbon with inductive and filed parameters. Remaining substituent constants fail in correlation. This is due to reasons stated earlier with the resonance conjugative structure shown in Figure 2.

The assigned carbonyl carbon chemical shifts (ppm) were correlated with hammett constants using single and multi linear regression analysis and it presented in Table 5. All correlations gave positive ρ values and it is evident for the normal substituent effects operated in all ketones. The correlation of Hammett substituent constants and F and R parameters fail in$\delta_{C=O}$ (ppm) values. This is due to the conjugation exists between the substituent and the carbonyl group shown in Figure 2.

The Swain Luptons' [11] parameter correlations were satisfactorily obtained within these carbon chemical shifts and the regression equations are given in 22-27.

$$\delta C_\alpha \text{ (ppm)} = 121.68 \, (\pm 0.654) + 1.897$$
$$(\pm 1.301)\sigma_I + 1.733(\pm 1.193)\sigma_R \tag{22}$$
$$(R = 0.972, \text{ n} = 12, P > 95\%)$$

$$\delta C_\beta \text{ (ppm)} = 144.36(\pm 0.478) - 3.189$$
$$(\pm 0.895)F + 0.891(\pm 0.588)R \tag{25}$$
$$(R = 0.927, \text{ n} = 12, P > 90\%)$$

$$\delta C_\alpha \text{ (ppm)} = 121.37(\pm 0.699) + 1.593$$
$$(\pm 1.307)F + 0.074(\pm 0.859) \text{ R} \tag{23}$$
$$(R = 0.917, \text{ n} = 12, P > 90\%)$$

$$\delta CO(\text{ppm}) = 189.66(\pm 2.543) - 1.068$$
$$(\pm 5.058)\sigma_I - 0.680(\pm 4.639)\sigma_R \tag{26}$$
$$(R = 0.900, \text{ n} = 12, P > 90\%)$$

$$\delta C_\beta(\text{ppm}) = 144.28(\pm 0.589) - 3.435$$
$$(\pm 1.173)\sigma_I + 1.074(\pm 1.076)\sigma_R \tag{24}$$
$$(R = 0.935, \text{ n} = 12, P > 90\%)$$

$$\delta CO(\text{ppm}) = 188.69(\pm 2.104) - 1.615$$
$$(\pm 3.936)F - 4.016(\pm 2.587)R \tag{27}$$
$$(R = 0.921, \text{ n} = 12, P > 90\%)$$

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5
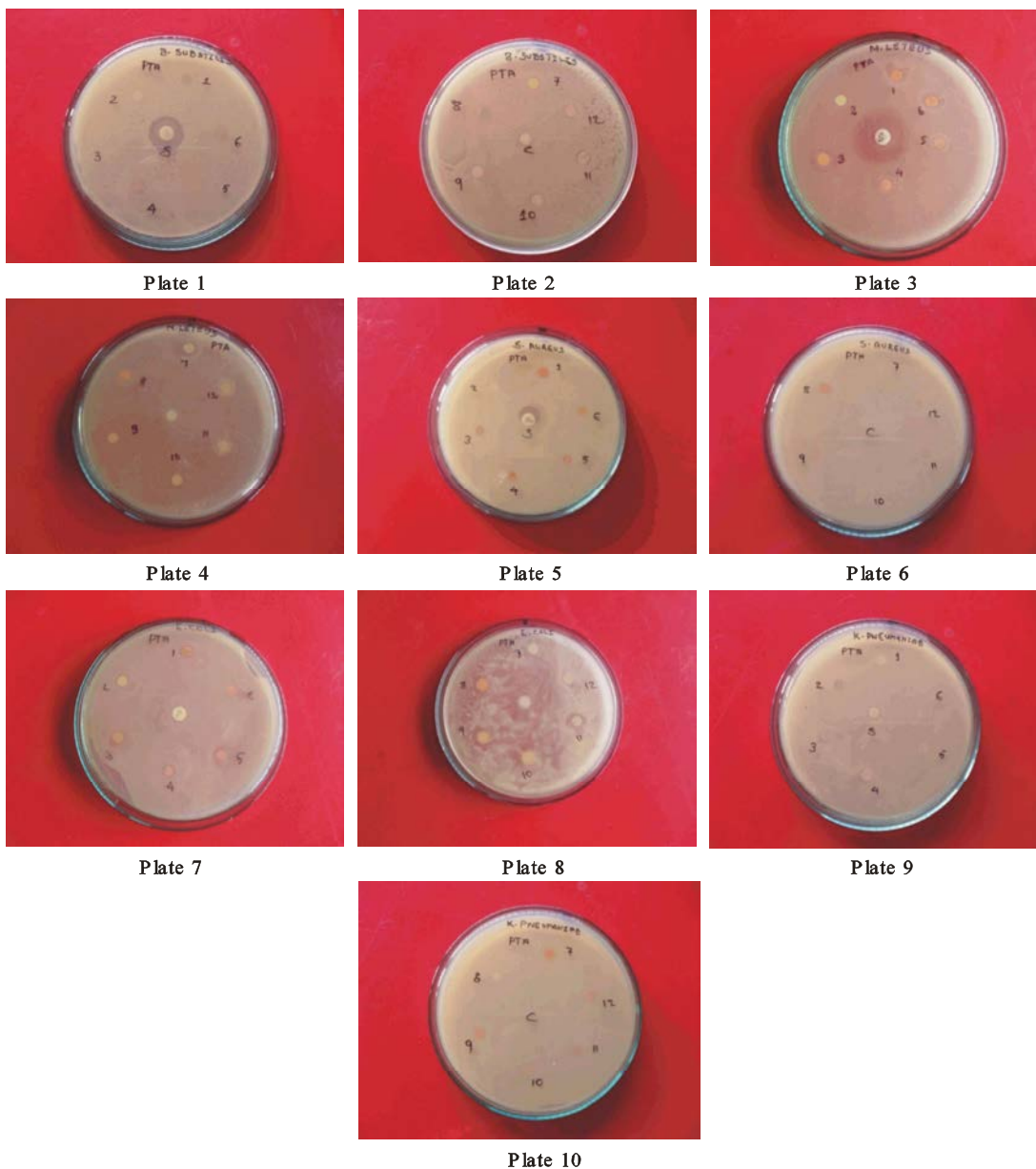
Plate 6

Plate 7

Plate 8

Plate 9

Plate 10

Fig. 3: Antibacterial activities of 2-phenothiazinyl ketones-petri-dishes
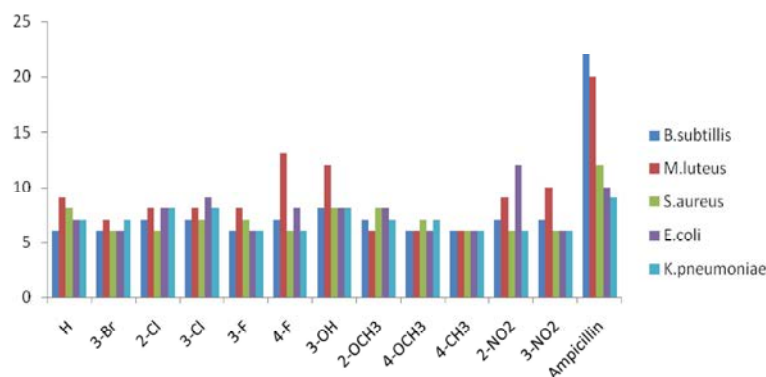
Fig. 4: Antibacterial activities of substituted styryl 2-phenothiazinyl ketones-Clustered column chart.

Table 6: Antibacterial activities of substituted styryl 2-phenothiazinylketones

		Zone of Inhibition (mm)				
		Gram positive Bacteria			Gram negative Bacteria	
Entry	X	*B.subtilis*	*M.luteus*	*S.aureus*	*E.coli*	*K.pneumoniae*
1	H	6	9	8	7	7
2	3-Br	6	7	6	6	7
3	2-Cl	7	8	6	8	8
4	3–Cl	7	8	7	9	8
5	3-F	6	8	7	6	6
6	4-F	7	13	6	8	6
7	3-OH	8	12	8	8	8
8	2-OCH$_3$	7	6	8	8	7
9	4-OCH$_3$	6	6	7	6	7
10	4-CH$_3$	6	6	6	6	6
11	2-NO$_2$	7	9	6	12	6
12	3-NO$_2$	7	10	6	6	6
Standard	Ampicillin	22	20	12	10	9
Control	DMSO	-	-	-	-	-

Microbial activities: Chalcones possess a wide range of biological activities such as antibacterial [19, 20], antifungal [19], antiviral[21], antifeedant [3, 15, 22], anticancer [19], antimalarial [23], antituberculosis [24], antiAIDS [25], anti-inflammatory and antioxidant [26, 27] Hepatoprotectiv activity [28], anti-plasmodial [29] activities. These multipronged activities present in different chalcones are examined against respective microbes-bacteria's and fungi.

Antibacterial Sensitivity Assay: Antibacterial sensitivity assay was performed using Kirby-Bauer [30] disc diffusion technique. In each Petri plate about 0.5 ml of the test bacterial sample was spread uniformly over the solidified Mueller Hinton agar using sterile glass spreader. Then the discs with 5mm diameter made up of Whatman No.1 filter paper, impregnated with the solution of the compound were placed on the medium using sterile forceps. The plates were incubated for 24 hours at 37°C by keeping the plates upside down to prevent the collection of water droplets over the medium. After 24 hours, the plates were visually examined and the diameter values of the zone of inhibition were measured. Triplicate results were recorded by repeating the same procedure.

The antibacterial screening effect of synthesized chalcones is shown in Figure 3. (Plates1-10). The zone of inhibition is compared using Table 6 and the Clustered column Chart is shown in Figure 4. A very good antibacterial activity was possessed by all substituents on the microorganisms in general. All the compounds showed excellent activities on *E.coli*and *M.luteus* species. The substituent H, 2-Cl, 3-Cl, 4-F, 3-OH and 2-NO$_2$ have high activity against *Bacillussubstilis, Micrococcus luteus, Staphylococcus aureus, Escherichia Col*i and *KlebsillaPneumoniae*. The substituents 4-F, 3-OH in the chalcones has improved the antibacterial activity against *M.luteus*.

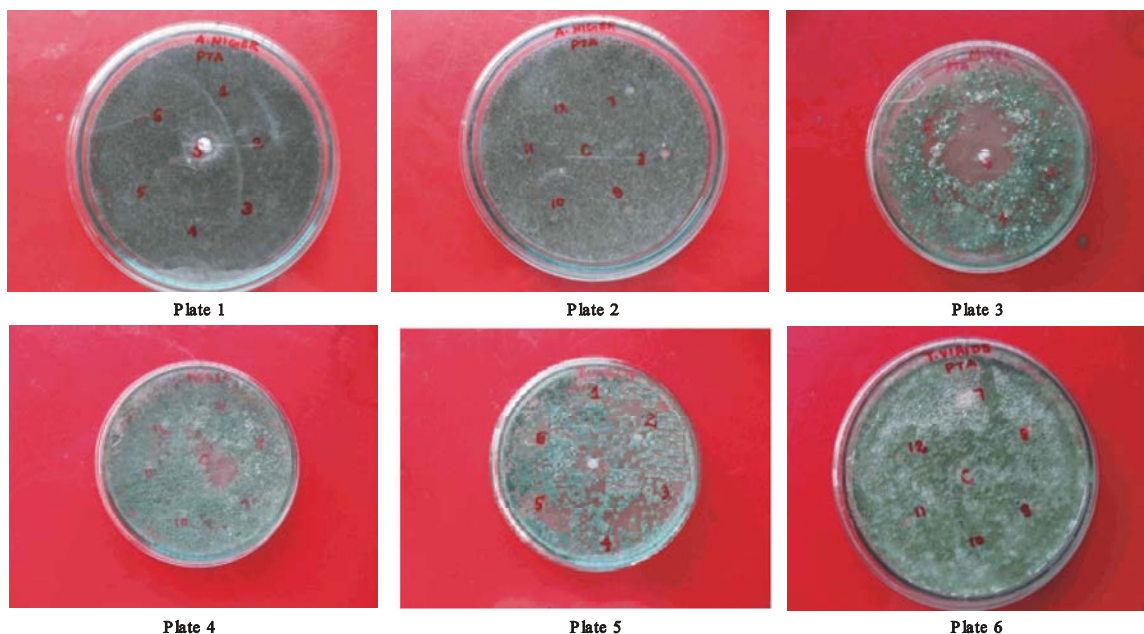| Plate 1 | Plate 2 | Plate 3 |
| Plate 4 | Plate 5 | Plate 6 |

Fig. 5: Antifungal activities of substituted styryl 2-phenothiazinyl ketones -Perti-dishes.
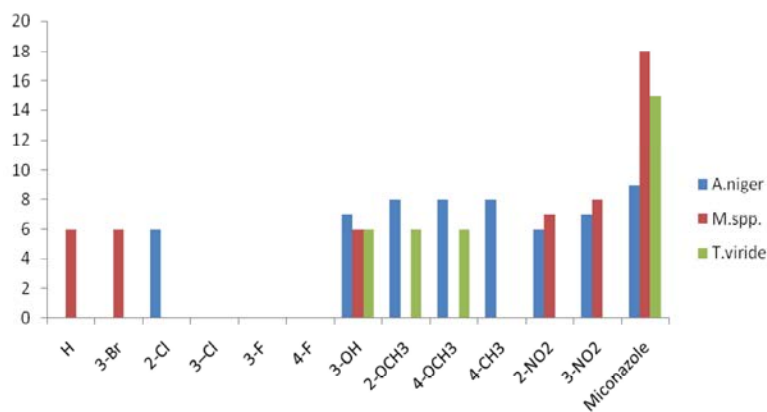

Fig. 6: Antifungal activities of substituted styryl 2-phenothiazinyl ketones-Clustered column chart.

Table 7: Antifungal activities of substituted styryl 2-phenothiazinyl ketones

| | | Zone of Inhibition (mm) | | |
Entry	X	*A.niger*	*M.spp.*	*T.viride*
1	H	-	6	-
2	3-Br	-	6	-
3	2-Cl	6	-	-
4	3–Cl	-	-	-
5	3-F	-	-	-
6	4-F	-	-	-
7	3-OH	7	6	6
8	2-OCH$_3$	8	-	6
9	4-OCH$_3$	8	-	6
10	4-CH$_3$	8	-	-
11	2-NO$_2$	6	7	-
12	3-NO$_2$	7	8	-
Standard	Miconazole	9	18	15
Control	DMSO	-	-	-

Antifungal Sensitivity Assay: Antifungal sensitivity assay was performed using Kirby-Bauer [30]disc diffusion technique. PDA medium was prepared and sterilized as above. It was poured (ear bearing heating condition) in the Petri-plate which was already filled with 1 ml of the fungal species. The plate was rotated clockwise and counter clock-wise for uniform spreading of the species. The discs were impregnated with the test solution. The test solution was prepared by dissolving 15mg of the Chalcone in 1ml of DMSO solvent. The medium was allowed to solidify and kept for 24 hours. Then the plates were visually examined and the diameter values of zone of inhibition were measured. Triplicate results were recorded by repeating the same procedure.

The antifungal activity of substituted chalcones synthesized in the present study are shown in Figure 5 for Plates (1-6) and the zone of inhibition values of the effect is given in Table 7. The clustered column chart, shown in Figure-6 reveals that all the compounds have good antifungal activity against all the three fungal species namely *Aspergillusniger, Muger species* and *Trichodermaviride.* The chalcones with 2-OCH$_3$, 4-OCH$_3$ and 4-CH$_3$ substituents have shown greater antifungal activity against *A.niger* than those with the other substituents present in the series.

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