

Synthesis, Evaluation of Substituent Effect and Antimicrobial Activities of Substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one Compounds

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Abstract: A series of ten substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds were synthesized by Crossed-Aldol condensation of 3-bromo-4-morpholino acetophenone with various substituted and unsubstituted benzaldehydes in presence of sodium hydroxide. The entire ten compounds are novel and these have been newly synthesized compounds. The synthesized substituted 3-phenylprop-2-en-1-one were characterized by their physical constants and UV, IR, NMR spectral data. These observed UV absorption maximum (λ_{\max} nm) value. The group frequencies of infrared absorption (cm^{-1}) of ν_{CO} s-cis and s-trans, deformation modes of ν_{CH} out of plane and in-plane, $\nu_{\text{CH}=\text{CH}}$ out of plane, $\nu_{\text{C}=\text{C}}$ out of plane values, ^1H chemical shifts (ppm) vinyl protons, ^{13}C chemical shifts (ppm) carbonyl carbons and vinyl carbons values were correlated with various Hammett substituent constants, and Swain-Lupton parameters using single and multi-regression analyses. From the results of statistical analysis, the effects of substituents on the functional group frequencies were studied. The antimicrobial activities of these synthesized substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones have been screened using Kirby-Bauer method.

Keywords: synthesis; UV; IR; NMR; spectral correlation analysis; substituent effects; antimicrobial activities

1. INTRODUCTION

Prop-2-en-1-ones are α , β -unsaturated ketones consist of two aromatic rings having diverse array of substituent. Aromatic rings are interconnected by a highly electrophilic three carbon α , β -unsaturated carbonyl system, which assumes linear or nearly planar structure [1]. Prop-2-en-1-ones (*trans*-1, 3-diaryl-2-propen-1-ones), belongs to flavanoid family are precursors of open chain flavonoids and isoflavonoids.

Many prop-2-en-1-ones have been used as agrochemicals and drugs [2-6]. Prop-2-en-1-ones are 1, 3 diaryl-2-propen -1-ones are available in the flavonoids family contains medicinal effect like antimicrobial [7], anti-inflammatory [8], analgesic [9], anti-ulcerative [10], immune-modulatory [11], anti-malarial [12], anti-cancer [13], antiviral [14], anti-leishmanial [15], anti-oxidant [16], anti-tubercular [16,17] and anti-hyperglycemic [18].

Since prop-2-en-1-one compounds have anti-

oxidant activity prevents and counteracts the damage of the human issue by the normal effects of physiological oxidation [19]. Presence of the keto ethylenic group ($-\text{CO}-\text{CH}=\text{CH}-$) in the prop-2-en-1-ones [20] and their analogues possesses the antioxidant activity. Prop-2-en-1-one compounds that associated with the antioxidant properties are hydroxyl and phenyl group [21].

Various methods are available for the synthesis of prop-2-en-1-one compounds the most convenient method is the one that involves the Crossed-Aldol condensation method, Crossed-Aldol condensation of equimolar quantities of acetylated aliphatic or aromatic ketone compounds with substituted benzaldehydes in the presence of aqueous alcoholic base [22]. Spectral data values are useful for study of effect of substituents using Hammett substituent constants, *F* and *R* parameters by single and multi-regression analysis. Chemists in recent year have synthesized and studied spectral correlations of pyrazolines [21], some aryl

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prop-2-en-1-ones [23-24] and Schiff bases [25]. In such case, satisfactory correlations were observed with Hammett substituent constants, F and R parameters. Literature survey shows that there is no information available regarding the study of UV, IR and NMR spectral data and correlation of substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds. Therefore, the authors have taken efforts to synthesis (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds from 3-bromo-4-morpholino acetophenone with various substituted and unsubstituted benzaldehydes by crossed-aldol condensation reaction. The various spectral data of these substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have been utilized for studying the quantitative structure activity relationships through Hammett correlations. The antimicrobial activity of the entire synthesized substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones have been screened using Kirby-Bauer [26] method.

2. MATERIAL AND METHODS

2.1. General

All the used chemicals were purchased from Sigma-Aldrich, E-Merck and Himedia Chemical Companies. Melting points of all synthesized substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones were observed in open glass capillaries on Mettler FP51 melting point apparatus and were uncorrected.

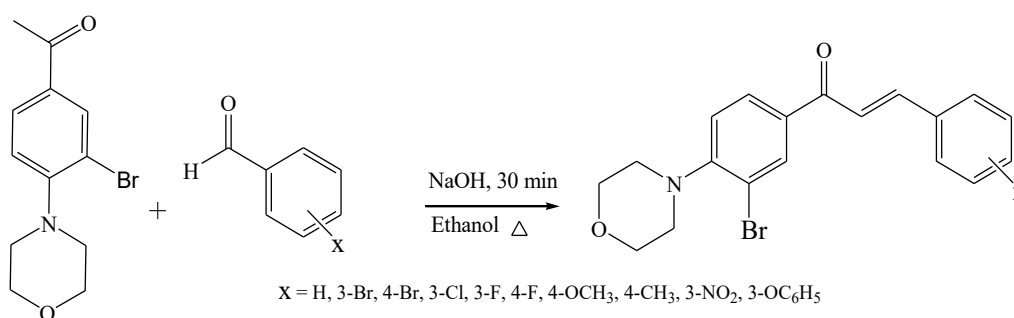
The Shimadzu-1650 ultraviolet spectrophotometer was utilized for recording the absorption maxima (λ_{max} , nm), of all substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones in spectral grade methanol. Infrared spectra (KBr, 4000–400 cm^{-1}) of all substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one were

recorded in Shimadzu-2010 Fourier Transform Spectrophotometer. The NMR spectra of (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one were recorded in Bruker AV500 NMR spectrometer operating at 500 MHz and remaining nine substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones were recorded in Bruker AV400 NMR spectrometer operating at 400 MHz for ^1H and 100 MHz for ^{13}C spectra recorded in CDCl_3 solvent using TMS as internal standard.

2. 2. General procedure for synthesis of (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds

A mixture of 3-bromo-4-morpholino acetophenone (0.05 mol) and benzaldehyde (0.05 mol) was dissolved in 50 mL rectified spirit in a 250mL round-bottom flask equipped with a magnetic stirrer. Then 50 mL NaOH solution (1g in 50 mL H_2O) was added drop wise to the reaction mixture on vigorous stirring for 30 minutes [27]. The reaction mixture was neutralized by the addition of 0.1N HCl, and then the precipitate was obtained. On filtering off, the crude (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compound was obtained and dried in air-oven and recrystallized from rectified spirit to get glittering yellow color solid. Their melting points have been observed. The general reaction is shown in Scheme 1. The same procedure has been followed to synthesise the remaining nine more substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds using different substituted benzaldehydes.

The physical constants and analytical data are presented in Table 1. The UV, IR and NMR spectral value of these prop-2-en-1-ones are presented in Table 2.



Scheme 1. Synthesis of substituted (E)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

Table 1. Physical constants of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones.

Entry	X	M. F.	M. W.	Yield (%)	m.p. (°C)
1	H	C ₁₉ H ₁₈ NO ₂ Br	372	87	139-141
2	3-Br	C ₁₉ H ₁₇ NO ₂ Br ₂	451	82	83-85
3	4-Br	C ₁₉ H ₁₇ NO ₂ Br ₂	451	86	103-105
4	3-Cl	C ₁₉ H ₁₇ NO ₂ ClBr	407	88	142-143
5	3-F	C ₁₉ H ₁₇ NO ₂ FBr	390	93	114-116
6	4-F	C ₁₉ H ₁₇ NO ₂ FBr	390	91	179-181
7	4-OCH ₃	C ₂₀ H ₂₀ NO ₃ Br	402	87	110-112
8	4-CH ₃	C ₂₀ H ₂₀ NO ₂ Br	386	88	163-165
9	3-NO ₂	C ₁₉ H ₁₇ N ₂ O ₄ Br	417	92	109-111
10	3-OC ₆ H ₅	C ₂₅ H ₂₂ NO ₃ Br	464	84	76-78

3. RESULTS AND DISCUSSION

3. 1. Spectral linearity

In The present investigation, the spectral linearity of all the substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones was studied by evaluating the substituent effects [28-29] with respect to various spectral data. The assigned spectral data of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-ones such as absorption maximum λ_{max} (nm), infrared carbonyl stretches of ν_{CO} *s-cis* and ν_{CO} *s-trans*, the deformation modes of CH *out of plane*, *in-plane*, CH=CH and >C=C< *out of planes* (cm⁻¹), NMR chemical shifts δ (ppm) values of H _{α} , H _{β} , C _{α} , C _{β} , CO are assigned and these data are correlated with Hammett substituent constants and *F* and *R* parameters.

The Hammett correlation gives positive ρ value some cases and negative ρ value remaining cases. The positive ρ value indicates operation of normal substitution effect and negative ρ value indicates operation of reverse substituent effect.

3. 1. 1. UV spectral study

The absorption maxima (λ_{max} nm) of synthesized substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds were assigned and presented in Table 2. These absorption maxima (λ_{max} nm) of these substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one were correlated with Hammett substituent constants [30-35] and *F* and *R* parameters [36] using single and multi-linear regression analyses. Hammett correlation involving the absorption maxima, form the Hammett equation employed is

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

where λ_0 is the absorption maximum of the unsubstituted system.

These observed absorption maxima (λ_{max} nm) of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have been correlated with Hammett substituent constants and *F* & *R* parameters and the results are shown in Table 3. From the Table-3, it is evident that the UV absorption maximum λ_{max} (nm) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds, except that with 3-NO₂ substituent have shown satisfactory correlations with only *R* ($r = 0.906$) parameter. The 3-NO₂ substituent that has been given exception is included in regression it reduces the correlations considerably. However, UV absorption maximum λ_{max} (nm) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations ($r < 0.900$) with all the Hammett substituent constants σ , σ^+ , σ_I , σ_R and *F* parameter. This is attributed to the weak polar, inductive and field effect of the substituents for predicting their reactivity on the UV absorption maximum values through resonance as per the conjugative structure shown in Figure 1.

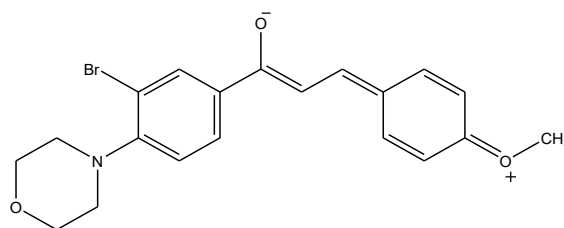


Figure 1. Resonance conjugative structure.

Table 2. The ultraviolet absorption maxima (λ_{max} , nm), infrared frequencies (ν , cm^{-1}) and NMR chemical shifts (δ , ppm) values of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

Entry	δ_{CO}	X	λ_{max}	ν CO(<i>s-cis</i>)	ν CO(<i>s-trans</i>)	ν CH _{ip}	ν CH _{op}	ν CH=CH _{op}	ν C=C _{op}	δ H _{α}	δ H _{β}	δ C _{α}	δ C _{β}
1	188.15	H	357.0	1647.21	1597.06	1192.01	769.60	1035.77	509.21	7.582	7.819	121.99	143.33
2	187.97	3-Br	369.5	1649.14	1597.06	1193.94	759.95	1037.70	518.85	7.473	8.162	124.81	139.08
3	187.63	4-Br	370.5	1649.14	1598.99	1192.01	752.24	1031.92	511.14	7.564	7.730	123.20	141.55
4	187.88	3-Cl	358.5	1647.21	1598.99	1193.94	759.95	1028.06	513.07	7.499	7.773	121.69	141.99
5	187.71	3-F	367.5	1653.00	1597.06	1193.94	796.60	1031.92	513.07	7.559	7.755	123.16	141.79
6	187.79	4-F	353.5	1651.07	1598.99	1195.87	788.89	1029.99	513.07	7.544	7.754	122.40	141.80
7	188.21	4-OCH ₃	369.5	1649.14	1598.99	1197.79	763.81	1031.92	514.99	7.461	7.789	119.66	143.16
8	188.26	4-CH ₃	351.0	1647.21	1595.13	1186.22	783.10	1037.70	516.92	7.537	7.798	120.99	143.40
9	187.12	3-NO ₂	326.5	1653.00	1598.99	1193.94	817.82	1041.56	514.99	7.684	7.961	122.09	140.13
10	188.07	3-OC ₆ H ₅	345.5	1647.21	1583.56	1201.65	777.31	1029.99	493.78	7.531	7.750	121.58	142.62

Table 3. Results of statistical analysis of UV absorption maxima (λ_{max} , nm), IR frequencies (ν , cm^{-1}) and NMR chemical shifts (δ , ppm) values of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds with Hammett σ , σ^+ , σ_I , σ_R and *F* and *R* parameters.

Frequency	Const.	<i>r</i>	<i>I</i>	ρ	<i>s</i>	<i>n</i>	Correlated derivatives
λ_{max} nm	σ	0.845	360.62	-21.64	13.06	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.815	357.07	-4.68	14.46	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.791	359.94	-8.11	14.51	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.801	349.66	-29.77	12.88	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>F</i>	0.808	358.77	-4.56	14.59	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>R</i>	0.906	351.72	-25.63	11.65	9	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-OC ₆ H ₅
νCO_{s-cis} (cm^{-1})	σ	0.905	1648.57	4.43	2.03	7	H, 3-Br, 4-Br, 3-Cl, 4-CH ₃ , 3-NO ₂ , 3-O-C ₆ H ₅
	σ^+	0.900	1649.23	2.68	2.05	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.909	1646.72	6.54	1.76	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.805	1646.19	-0.55	2.44	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>F</i>	0.908	1646.41	7.12	1.37	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>R</i>	0.833	1648.77	-2.75	2.25	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
$\nu\text{CO}_{s-trans}$ (cm^{-1})	σ	0.885	1596.46	0.09	5.01	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.841	1596.32	4.21	4.55	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.814	1595.35	3.00	4.96	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.833	1598.22	7.16	4.72	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>F</i>	0.819	1595.07	3.42	4.92	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>R</i>	0.806	1594.6	-9.31	3.84	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
νCH_{ip} (cm^{-1})	σ	0.811	1193.84	1.64	4.22	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.832	1194.23	-2.75	4.02	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.846	1191.09	8.09	3.76	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.905	1191.59	-10.44	3.47	9	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-OC ₆ H ₅
	<i>F</i>	0.838	1191.77	5.75	3.92	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	<i>R</i>	0.816	1194.53	1.99	4.19	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
νCH_{op} (cm^{-1})	σ	0.904	771.49	31.56	19.05	9	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-OC ₆ H ₅
	σ^+	0.829	776.45	12.47	20.44	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.803	766.82	26.95	20.32	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅

	σ_R	0.818	780.98	16.71	21.00	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	F	0.789	762.65	34.80	18.93	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	R	0.807	777.88	4.73	21.3	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
vCH=CH_{op}(cm⁻¹)	σ	0.824	1032.77	3.39	4.85	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.848	1033.17	4.79	4.35	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.814	1034.46	-2.95	4.90	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.917	1037.13	15.56	3.36	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	F	0.817	1034.61	-3.08	4.88	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	R	0.812	1033.71	1.76	4.92	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
vC=C_{op}(cm⁻¹)	σ	0.825	512.40	-2.89	7.30	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.803	511.70	5.38	6.85	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.805	511.84	0.16	7.35	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.803	514.34	10.01	6.97	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	F	0.606	511.22	1.67	7.34	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	R	0.906	509.26	-13.06	5.79	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
δH_α(ppm)	σ	0.906	7.517	0.15	0.048	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.915	7.540	0.077	0.054	9	H, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.795	7.520	0.06	0.065	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.906	7.587	0.174	0.053	9	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-OC ₆ H ₅
	F	0.823	7.520	0.055	0.065	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	R	0.938	7.558	0.074	0.061	7	H, 3-Br, 4-Br, 3-Cl, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂
δH_β(ppm)	σ	0.793	7.810	0.107	0.138	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.804	7.824	0.131	0.125	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_I	0.814	7.790	0.102	0.139	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ_R	0.835	7.881	0.214	0.132	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	F	0.801	7.825	0.008	0.141	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	R	0.814	7.840	0.058	0.140	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
δCO(ppm)	σ	0.958	188.06	-1.065	0.156	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.970	187.90	-0.575	0.221	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅

$\delta C\alpha$(ppm)	σ_I	0.974	188.31	-1.157	0.225	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	σ_R	0.823	187.75	-0.548	0.338	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	F	0.814	188.25	-0.905	0.254	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	R	0.809	187.86	-0.099	0.360	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	σ	0.915	121.73	2.493	1.259	9	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-OC ₆ H ₅	
	σ^+	0.917	122.07	2.249	0.960	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	σ_I	0.900	121.15	2.683	1.319	7	2-Cl, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 3-OC ₆ H ₅	
	σ_R	0.805	122.20	0.179	1.472	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	F	0.839	121.32	2.046	1.353	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	R	0.802	121.14	-0.102	1.473	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	$\delta C\beta$(ppm)	σ	0.966	142.437	-3.209	1.112	9	H, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅
	σ^+	0.967	141.972	-2.291	0.953	9	H, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	σ_I	0.957	143.520	-4.360	1.033	9	H, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	σ_R	0.817	141.614	-1.114	1.461	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	F	0.905	143.084	-2.926	1.229	9	H, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	
	R	0.810	141.858	-0.129	1.484	10	H, 3-Br, 4-Br, 3-Cl, 3-F, 4-F, 4-OCH ₃ , 4-CH ₃ , 3-NO ₂ , 3-OC ₆ H ₅	

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

All the correlations have been shown negative ρ values. This indicates the operation of reverse substituent effect with respect to UV absorption maximum λ_{max} (nm) values in all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds. Since most of the single parameter

correlations poor with all Hammett constants and *F* parameter, so it is decided to go for multi regression analyses. While seeking the multi regression analysis, satisfactory correlations are observed as shown in the following equations (2) and (3).

$$\lambda_{max}(\text{nm}) = 354.370(\pm 9.019) - 14.566(\pm 4.855)\sigma_I - 32.888(\pm 10.962)\sigma_R \quad \dots(2)$$

$$(R = 0.953, n=10, P>95\%)$$

$$\lambda_{max}(\text{nm}) = 357.852(\pm 6.863) - 17.377(\pm 5.792)F - 30.557(\pm 10.185)R \quad \dots(3)$$

$$(R = 0.968, n=10, P>95\%)$$

3. 2. IR spectral study

The measured carbonyl stretching frequencies (cm^{-1}) of *s-cis* and *s-trans* isomers values are presented in Table-2 and the corresponding conformers were shown in Figure 2. The stretching frequencies for carbonyl absorption are assigned based on the

assignments made by Hays and Timmons for *s-cis* and *s-trans* conformers at 1690 and 1670 cm^{-1} , respectively.

The IR frequency values are correlated with Hammett substituent constants [30-35] and Swain-Lupton's parameters [36]. While seeking Hammett

correlation involving group frequencies, the form of the Hammett equation employed is

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

where ν_0 is the carbonyl frequencies of unsubstituted system.

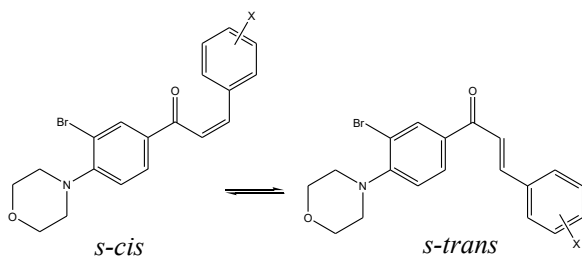


Figure 2. The *s-cis* and *s-trans* conformers of (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one observed compound.

3. 2. 1. IR Spectral Correlation of νCO_{s-cis} (cm^{-1})

The IR frequency νCO_{s-cis} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds except those with 3-F, 4-F and 4- CH_3 substituents have been shown satisfactory correlation with Hammett substituent constant σ ($r = 0.905$) only. When these substituents that have been given exception are included in regression they reduce the correlations considerably. The IR frequency νCO_{s-cis} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown satisfactory correlations with Hammett substituent constant σ^+ ($r = 0.900$), σ_1 ($r = 0.909$) and F ($r = 0.908$) parameter. The remaining Hammett substituent constant σ_R and R parameter have shown poor correlations ($r < 0.900$). This is attributed to the weak resonance effect of the substituents for predicting the reactivity on the IR frequency νCO_{s-cis} (cm^{-1}) values through resonance as per the conjugative structure stated earlier. All the correlations (except σ_R and R) have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency νCO_{s-cis} (cm^{-1}) values in all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

3. 2. 2. IR Spectral Correlation of $\nu\text{CO}_{s-trans}$ (cm^{-1})

The IR frequency $\nu\text{CO}_{s-trans}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations ($r < 0.900$) with all Hammett substituent constants and F and R parameters. All the correlations (except R parameter) have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency $\nu\text{CO}_{s-trans}$ (cm^{-1}) values in all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

3. 2. 3. IR Spectral Correlation of νCH_{ip} (cm^{-1})

The IR frequency νCH_{ip} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds except that with 3- NO_2 substituent have shown satisfactory correlations with Hammett substituent constant σ_R ($r = 0.905$). When the substituent that has been given exception is included in regression it reduces the correlations considerably. The IR frequency νCH_{ip} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations with the remaining Hammett substituent constants σ , σ^+ , σ_1 and F and R parameters. All the correlations (except σ^+ and σ_R) have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency νCH_{ip} (cm^{-1}) values in all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

3. 2. 4. IR Spectral Correlation of νCH_{op} (cm^{-1})

The IR frequency νCH_{op} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds, except that with the 4-Br substituent have shown satisfactory correlation with Hammett substituent constant σ ($r = 0.904$). When the substituent that has been given, exception is included in regression it reduces the correlation considerably. The IR frequency νCH_{op} (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations with remaining Hammett substituent constant σ^+ , σ_1 , σ_R and F and R parameters. All the correlations have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency νCH_{op} (cm^{-1}) values in all substituted (*E*)-1-(3-bromo-

4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

3. 2. 5. IR Spectral Correlation of $\nu\text{CH}=\text{CH}_{OP}$ (cm^{-1})

The IR frequency $\nu\text{CH}=\text{CH}_{OP}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown satisfactory correlations with Hammett substituent constant σ_R ($r = 0.917$). The IR frequency $\nu\text{CH}=\text{CH}_{op}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations with the remaining Hammett substituent constant, σ , σ^+ , σ_I and *F* and *R* parameters. All the correlations (except σ_R and σ_I) have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency $\nu\text{CH}=\text{CH}_{OP}$ (cm^{-1}) values in all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

3. 2. 6. IR Spectral Correlation of $\nu\text{C}=\text{C}_{OP}$ (cm^{-1})

The IR frequency $\nu\text{C}=\text{C}_{OP}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown satisfactory correlations with Hammett substituent constant *R* ($r = 0.906$). The IR frequency $\nu\text{C}=\text{C}_{OP}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have shown poor correlations with the remaining Hammett substituent constant and *F* parameter. All the correlations (except σ and *R*) have shown positive ρ values. This indicates the operation of normal substituent effect with respect to IR frequency $\nu\text{C}=\text{C}_{OP}$ (cm^{-1}) values of all substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds. Most of the single regression analyses have shown poor correlation, so it is decided to go for multi-regression analysis. The multi-regression produced satisfactory correlations with Hammett substituent constants and *F* and *R* parameters [36]. The multi correlation equations are given in (5)-(16).

$$\nu\text{CO}_{s-cis}(\text{cm}^{-1}) = 1646.886(\pm 1.271) + 7.154(\pm 2.762)\sigma_I + 0.969(\pm 0.301)\sigma_R \quad \dots(5)$$

$$(R = 0.971, n=10, P>95\%)$$

$$\nu\text{CO}_{s-cis}(\text{cm}^{-1}) = 1646.389(\pm 0.867) + 6.770(\pm 1.912)F + 0.834(\pm 0.278)R \quad \dots(6)$$

$$(R = 0.983, n=10, P>95\%)$$

$$\nu\text{CO}_{s-trans}(\text{cm}^{-1}) = 1596.735(\pm 3.341) + 4.606(\pm 1.535)\sigma_I + 8.148(\pm 2.716)\sigma_R \quad \dots(7)$$

$$(R = 0.940, n=10, P>90\%)$$

$$\nu\text{CO}_{s-trans}(\text{cm}^{-1}) = 1594.793(\pm 2.463) - 0.545(\pm 0.186)F - 9.468(\pm 3.121)R \quad \dots(8)$$

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

$$\nu\text{CH}_{ip}(\text{cm}^{-1}) = 1189.554(\pm 2.278) + 6.313(\pm 1.950)\sigma_I - 9.092(\pm 3.030)\sigma_R \quad \dots(9)$$

$$(R = 0.967, n=10, P>95\%)$$

$$\nu\text{CH}_{ip}(\text{cm}^{-1}) = 1191.896(\pm 2.369) + 7.475(\pm 2.491)F + 4.107(\pm 1.369)R \quad \dots(10)$$

$$(R = 0.949, n=10, P>90\%)$$

$$\nu\text{CH}_{op}(\text{cm}^{-1}) = 770.794(\pm 14.249) + 31.550(\pm 10.516)\sigma_I + 23.454(\pm 7.818)\sigma_R \quad \dots(11)$$

$$(R = 0.939, n=10, P>90\%)$$

$$\nu\text{CH}_{op}(\text{cm}^{-1}) = 763.153(\pm 11.651) + 41.748(\pm 13.916)F + 16.548(\pm 5.516)R \quad \dots(12)$$

$$(R = 0.952, n=10, P>95\%)$$

$$\nu\text{CH}=\text{CH}_{op}(\text{cm}^{-1}) = 1037.103(\pm 2.445) + 0.103(\pm 0.034)\sigma_I + 15.591(\pm 5.197)\sigma_R \quad \dots(13)$$

$$(R = 0.973, n=10, P>95\%)$$

$$\nu\text{CH}=\text{CH}_{op}(\text{cm}^{-1}) = 1034.648(\pm 3.127) - 2.657(\pm 0.885)F + 1.016(\pm 0.338)R \quad \dots(14)$$

$$(R = 0.925, n=10, P>90\%)$$

$$\nu_{\text{C}=\text{C}_{op}}(\text{cm}^{-1}) = 513.625(\pm 5.053) + 2.223(\pm 0.741)\sigma_{\text{I}} + 10.493(\pm 3.497)\sigma_{\text{R}} \quad \dots(15)$$

$$(R = 0.935, n=10, P>90\%)$$

$$\nu_{\text{C}=\text{C}_{op}}(\text{cm}^{-1}) = 510.794(\pm 3.647) - 4.320(\pm 1.440)F - 14.288(\pm 4.762)R \quad \dots(16)$$

$$(R = 0.963, n=10, P>95\%)$$

3. 3. NMR Spectral Study

In nuclear magnetic resonance spectra, the proton and the carbon chemical shifts (δ) depends on the electronic environment of the nuclei concerned. The assigned proton and carbon chemical shifts value (ppm) have been correlated with Hammett substituent constants and F and R parameters using Hammett equation in the form of

$$\delta = \rho\sigma + \delta_0 \quad \dots (17)$$

where δ_0 is the chemical shift of unsubstituted system.

3. 3. 1. ^1H NMR Spectral correlation

3. 3. 1.1. ^1H NMR Spectral Correlations of H_α (ppm)

The assigned H_α chemical shift (δ , ppm) values are correlated with Hammett substituted constants [30-35] and F and R parameters, all substituents have shown satisfactory correlation with Hammett substituent constant σ ($r = 0.906$) except that with 3-Br substituent have shown satisfactory correlation with Hammett substituent constant σ^+ ($r = 0.915$) and except that with 3- NO_2 substituent have shown satisfactory correlation with Hammett substituent constant σ_{R} ($r = 0.906$) and expect those with 3-F, 4-F and 3- C_6H_5 substituents have shown satisfactory correlation with R ($r=0.938$) parameter. When the

substituent that has been given exception is included in regression it reduces the correlation considerably. The remaining few Hammett substituent constants σ_{I} , σ_{R} and F parameter [36] have shown poor correlations ($r < 0.900$). This is attributed to weak inductive, resonance and field effects of the substituents for predicting the reactivity on the chemical shifts through resonance as per the conjugative structure shown in Figure 1. All the correlations have shown positive ρ values. This indicates the operation of normal substituent effect.

3. 3. 1.2. ^1H NMR Spectral Correlations of H_β (ppm)

The assigned H_β chemical shifts (δ , ppm) values are correlated with Hammett substituted constants and F and R parameters, all substituent have shown poor correlation with all Hammett substituent Constants and F and R parameters. This is due to incapability to the polar, inductive, resonance and field effect of the substituents. All the correlations have shown positive ρ values. This indicates the operation of normal substituent effect.

Some of the single regression analysis has shown poor correlations with Hammett substituent constants and Swain-Lupton's parameters [36]. It is decided to go for multi-regression, the multi-regression analysis produced satisfactory correlations with the chemical shifts of (δ , ppm) H_α and H_β . The multi-correlation equations are given in (18)-(21).

$$\delta_{\text{H}_\alpha}(\text{ppm}) = 7.553(\pm 0.0344 + 0.099(\pm 0.033)\sigma_{\text{I}} + 0.195(\pm 0.078)\sigma_{\text{R}} \quad \dots(18)$$

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

$$\delta_{\text{H}_\alpha}(\text{ppm}) = 7.523(\pm 0.035) + 0.098(\pm 0.032)F + 0.102(\pm 0.034)R \quad \dots(19)$$

$$(R = 0.955, n=10, P>95\%)$$

$$\delta_{\text{H}_\beta}(\text{ppm}) = 7.832(\pm 0.092) + 0.150(\pm 0.050)\sigma_{\text{I}} + 0.247(\pm 0.082)\sigma_{\text{R}} \quad \dots(20)$$

$$(R = 0.940, n=10, P>90\%)$$

$$\delta_{\text{H}_\beta}(\text{ppm}) = 7.827(\pm 0.089) + 0.037(\pm 0.012)F + 0.069(\pm 0.023) \quad \dots(21)$$

$$(R = 0.915, n=10, P>90\%)$$

3. 3. 2. ^{13}C NMR spectral correlation

3. 3. 2.1. ^{13}C NMR spectral correlation of δC_α carbon

The assigned C_α chemical shifts values (δ , ppm) correlated with Hammett substituent constants [30-35] and F and R parameters, except that with 3- NO_2 substituent have shown satisfactory correlation with Hammett substituent constant σ ($r = 0.915$). Except that with H (parent), and those with 4- CH_3 and 3- NO_2 substituents have shown satisfactory correlation with Hammett substituent constant σ_1 ($r = 0.900$). When the substituent that has been given exception is included in regression it reduces the correlation considerably. The remaining few Hammett substituent constants σ^+ , σ_R and F and R parameters have shown poor correlations ($r < 0.900$). This is attributed to weak inductive and resonance and field effects of the substituent. This is due to the reason stated earlier and associated with resonance- conjugative structure shown in Figure 2. All the correlations (except R) have shown positive ρ values. This indicates the operation of normal substituent effect.

3. 3. 2. 2. ^{13}C NMR spectral correlation of δC_β carbon

The assigned C_β chemical shifts values (δ , ppm) have correlated with Hammett substituent constants and F and R parameters. All the compounds expect that with 3-Br substituent have shown satisfactory correlation with Hammett substituent constant σ ($r = 0.966$), σ^+ ($r = 0.967$), σ_1 ($r = 0.957$) and F ($r = 0.905$)

parameter. When the substituent that has been given exception is included in regression it reduces the correlation considerably. The remaining one Hammett substituent constants σ_R and R parameter [36] have shown poor correlations ($r < 0.900$). This is attributed to the resonance effect of the substituents. This is due to the reason stated earlier and associated with resonance- conjugative structure shown in Figure 1. All the correlations have shown negative ρ values. This indicates the operation of reverse substituent effect.

3. 3. 2.3. ^{13}C NMR spectral correlation of δCO carbon

The assigned CO chemical shifts values (δ , ppm) are correlated with Hammett substituent constants and F and R parameters, all the substituent have shown satisfactory correlation with Hammett substituent constants σ ($r = 0.958$), σ^+ ($r = 0.970$), σ_1 ($r = 0.974$). The remaining one Hammett substituent constants σ_R and F and R parameters have shown poor correlations ($r < 0.900$). This is attributed to the resonance and field effect of the substituents. All the correlations have shown negative ρ values. This indicates the operation of reverse substituent effect. Some of the single regression analysis have shown poor correlations with Hammett substituent constants and Swain-Lupton's parameters [36]. So it is decided to go for multi-regression, the multi-regression analysis produce satisfactory correlations with the chemical shifts of (δ , ppm) C_α , C_β and CO. The multi correlation equations are given in (22)-(27).

$$\delta\text{C}_\alpha \text{ (ppm)} = 121.283(\pm 0.950) + 2.837(\pm 0.945)\sigma_1 + 0.785(\pm 0.261)\sigma_R \quad \dots(22)$$

$$(R = 0.946, n=10, P>90\%)$$

$$\delta\text{C}_\alpha \text{ (ppm)} = 121.334(\pm 0.861) + 2.273(\pm 0.757)F + 0.540(\pm 0.180)R \quad \dots(23)$$

$$(R = 0.941, n=10, P>90\%)$$

$$\delta\text{C}_\beta \text{ (ppm)} = 143.158(\pm 0.661) + 4.778(\pm 1.592)\sigma_1 - 2.134(\pm 0.713)\sigma_R \quad \dots(24)$$

$$(R = 0.978, n=10, P>95\%)$$

$$\delta\text{C}_\beta \text{ (ppm)} = 143.052(\pm 0.755) - 3.381(\pm 1.127)F - 1.086(\pm 0.362)R \quad \dots(25)$$

$$(R = 0.960, n=10, P>95\%)$$

$$\delta\text{CO (ppm)} = 188.172(\pm 0.087) - 1.320(\pm 0.440)\sigma_1 - 0.830(\pm 0.276)\sigma_R \quad \dots(26)$$

$$(R = 0.994, n=10, P>95\%)$$

$$\delta\text{CO (ppm)} = 188.238(\pm 0.139) - 1.074(\pm 0.307)F - 0.403(\pm 0.134)R \quad \dots(27)$$

$$(R = 0.978, n=10, P>95\%)$$

3.4. Antimicrobial activity

All the synthesized substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds were dissolved in Dimethyl sulfoxide (DMSO) separately at the concentration of 250 µg/mL for antimicrobial assay.

3.4.1. Antibacterial sensitivity assay

The antibacterial activities of all synthesized substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have been studied against five gram positive pathogenic strains *Bacillus subtilis*, *Clostridium botulini*, *Staphylococcus aureus*, *Nocardia species* and *Enterococcus species* and five gram negative pathogenic strains *Escherichia coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Salmonella typhi* and *Vibrio cholera* have been studied by Kirby-Bauer method. Ciprofloxacin was used as standard.

The antibacterial screening effect of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds is shown in Figure 3 (Plates 1–20). The measured zone of inhibition values are given

in Table 4 and the corresponding clustered column chart is shown in Figure 3. The zone of inhibition (mm) values of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds reveals that most of the compounds have shown moderate, good and excellent (some of the poor) activity against all the ten microorganisms evaluated in the present investigation. The 4-OCH₃ substituted compounds has shown excellent activity against *E. species*, *E. coli* and *P. mirabilis*. The 3-NO₂ substituted compound has shown excellent activity against *B. subtilis*, *E. coli* and *P. mirabilis*. The 3-Br substituted compound has shown excellent activity against *C. bululini* and *S. typhi*. The 4-F substituted compound has shown excellent activity against *Enterococcus species* and *E. coli*. The 3-OC₆H₅ substituted compound has shown excellent activity against *E. coli* and *P. mirabilis*. The H (parent) and 4-Br substituted compounds have shown excellent activity against *S. typhi*. The 3-Cl substituted compound has shown excellent activity against *P. mirabilis*. The 4-CH₃ substituted compound has shown excellent activity against *E. coli*. The remaining substituted compounds have shown good and moderate antibacterial activity.

Table 4. Zone of inhibition (mm) values of antibacterial activity of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

Entry	Substituents	Zone of Inhibition (mm)									
		Gram positive Bacteria					Gram negative Bacteria				
		<i>B. subtilis</i>	<i>C. botulini</i>	<i>Enterococcus sp</i>	<i>Nocardia sp</i>	<i>S. aureus</i>	<i>E. coli</i>	<i>K. pneumonia</i>	<i>P. mirabilis</i>	<i>S. typhi</i>	<i>V. cholera</i>
1	H	9	9	7	0	0	7	0	7	20	0
2	3-Br	7	20	7	0	0	8	7	0	28	9
3	4-Br	7	15	0	0	0	10	0	7	13	0
4	3-Cl	13	10	0	9	12	0	7	13	9	7
5	3-F	10	9	0	9	13	0	0	0	9	9
6	4-F	7	11	14	0	7	30	9	9	8	7
7	4-OCH ₃	7	10	22	9	9	27	10	11	8	0
8	4-CH ₃	9	0	8	0	7	25	10	8	10	0
9	3-NO ₂	20	9	8	10	0	20	8	26	0	7
10	3-OC ₆ H ₅	0	7	9	7	0	18	13	30	0	7
Standard	Ciprofloxacin	14	14	13	17	15	9	15	10	12	10
Control	DMSO	0	0	0	0	0	0	0	0	0	0

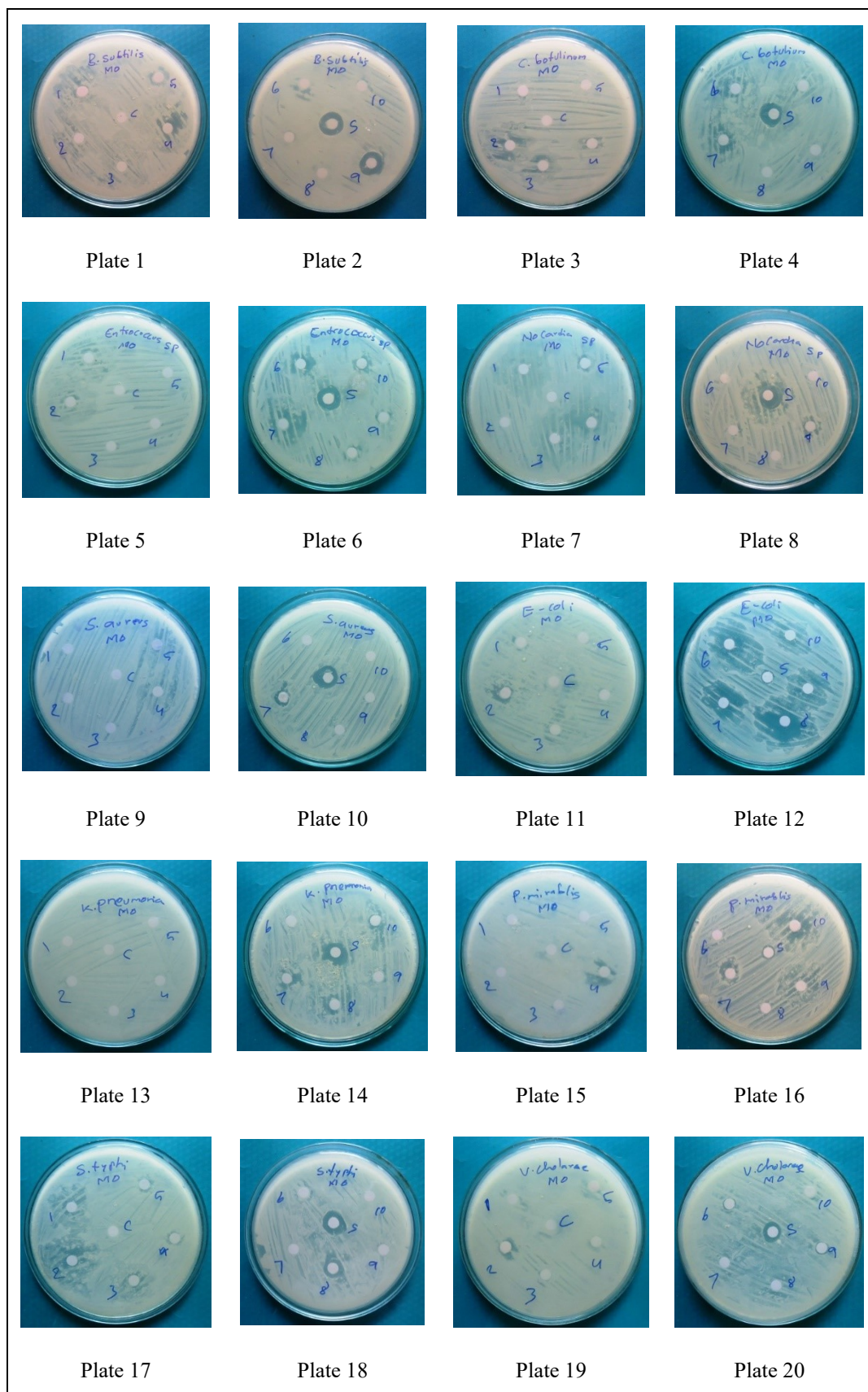


Figure 3. Antibacterial activity of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds (petri plates).

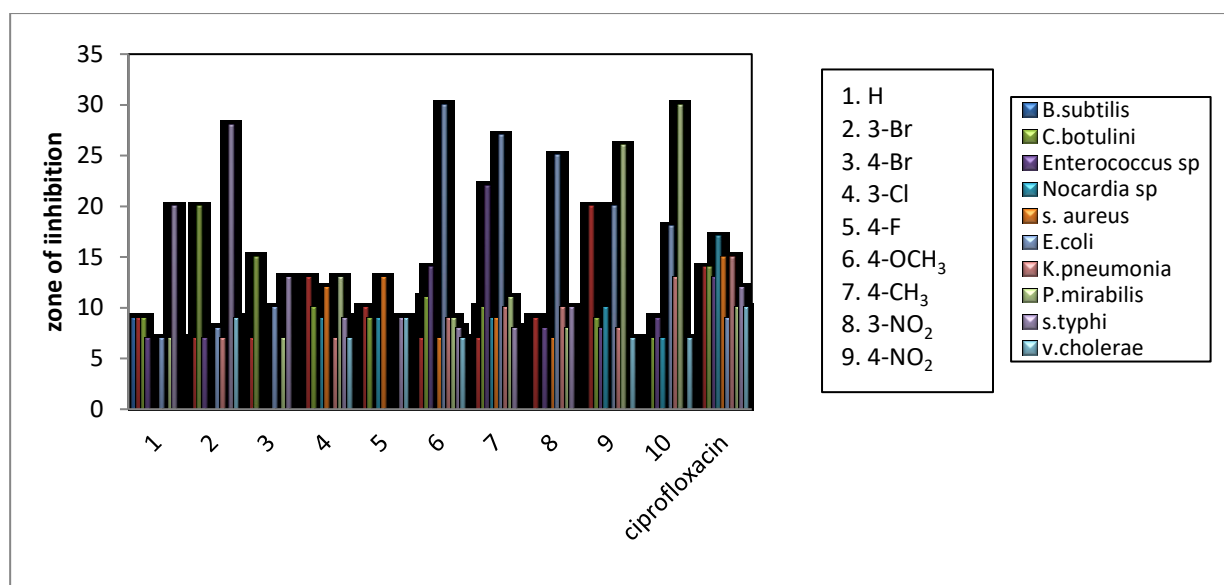


Figure 4. Antibacterial activity of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds (clustered column chart).

3.4.2 Antifungal Sensitivity Assay

The antifungal activities of all synthesized substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds have been studied against five fungal species namely *A. niger*, *A. flavus*, *C. albicans*, *T. viride* and *M. species*. The disc diffusion technique has been followed using the Kirby–Bauer method [25], Micnazole was used as standard. The antifungal screening effect of prepared substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds is shown in Figure 5, (Plates 21–30). The measured zone of inhibition values are given in Table 5 and the corresponding Clustered column chart is shown in Figure 6. All the compounds have shown moderate, good and excellent activity against all the five fungal species evaluated in general.

The 4-OCH₃ and 3-NO₂ substituted compounds have shown good activity against *A. niger*. The 4-CH₃ substituted compound has shown excellent activity against *A. flavus*. 4-F, 4-OCH₃, 3-NO₂ and 3-OC₆H₅ substituted compounds have shown good activity against *A. flavus*. The 4-OCH₃ and 3-NO₂ substituted compounds have shown excellent activity against *C. albicans*. The 4-CH₃ substituted prop-2-en-1-ones has shown good activity against *C. albicans*. The 3-Cl, 4-Br, 3-Cl and 3-F substituted have shown excellent activity against *T. viride*. The 4-CH₃ substituted has shown good activity against *T. viride*. The 4-Br and 4-F substituted prop-2-en-1-ones have shown excellent activity against *M. species*. The 3-F and 4-CH₃ against substituted compound have shown good activity against *M. species*.

Table 5. Zone of inhibition (mm) values of antifungal activities of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds.

Entry	Substituents	Zone of Inhibition (mm)				
		<i>A.niger</i>	<i>A.flavus</i>	<i>C.albicans</i>	<i>M.species</i>	<i>T.virite</i>
1	H	7	0	7	0	0
2	3-Br	9	0	7	13	0
3	4-Br	0	0	0	15	13
4	3-Cl	0	0	0	17	0
5	4-F	0	7	0	15	9
6	4-OCH ₃	0	9	7	0	11
7	4-CH ₃	13	9	13	0	7
8	3-NO ₂	11	11	9	11	9
9	4-NO ₂	13	9	13	0	0
10	3-OC ₆ H ₅	0	9	7	0	9
Standard	micnazole	17	11	9	9	11
Control	DMSO	0	0	0	0	0

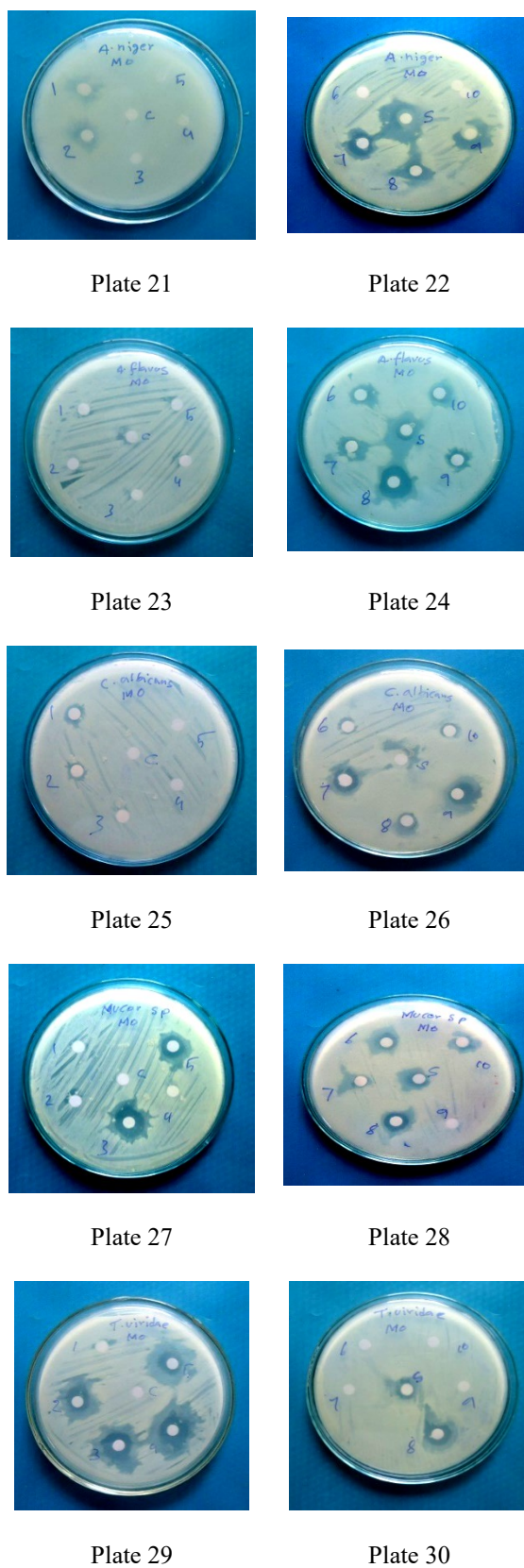


Figure 5. Antifungal activity of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one (petri plates).

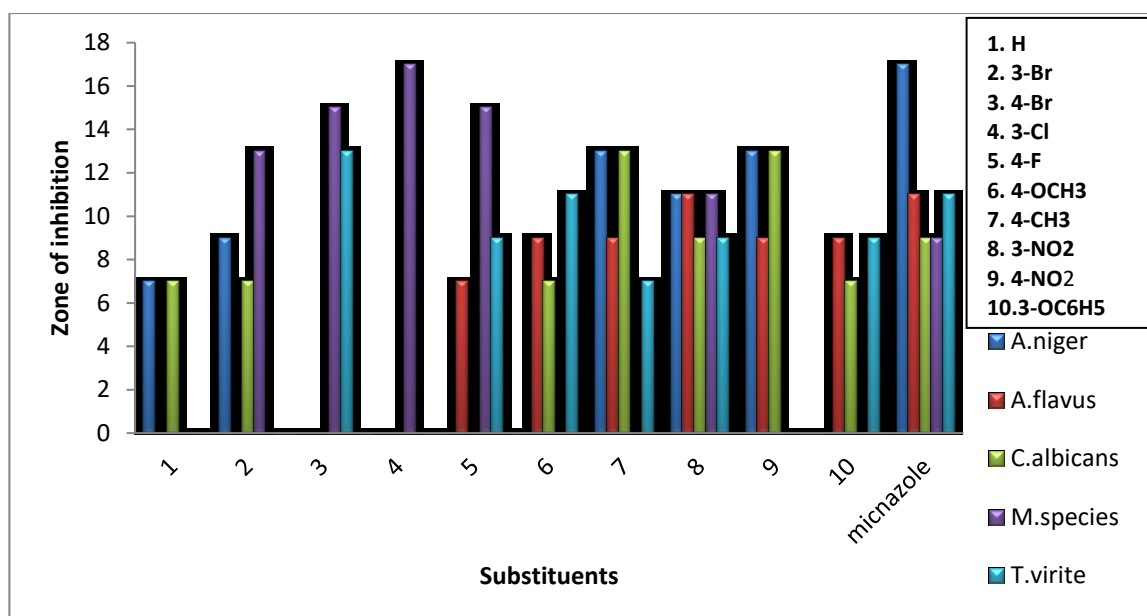


Figure 6. Antifungal activity of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one (clustered column chart).

4. CONCLUSION

A series of substituted (*E*)-1-(3-bromo-4-morpholinophenyl)-3-phenylprop-2-en-1-one compounds has been synthesized by crossed-aldol condensation method. These compounds were confirmed by their physical constants UV, IR and NMR spectral data. The spectral data values 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 multi-linear regression analysis have been satisfactory correlations.

The 4-OCH₃ and 3-NO₂ substituted compounds have shown excellent activity against *Enterococcus species*, *E. coli* and *P. mirabilis*. The 3-NO₂ substituted compound has shown excellent activity against *B. subtilis*, *E. coli* and *P. mirabilis*. The 3-OC₆H₅ substituted compound has shown excellent activity against *E. coli* and *P. mirabilis*. The 4-Br and 4-F substituted prop-2-en-1-ones have shown excellent activity against *M. species*.

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