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## Assessment of substituent effects on $\beta$ -naphthyl based isoxazoles by IR and NMR spectra

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### ABSTRACT

A series containing thirteen 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydroisoxazole have been synthesized and examined their purities by their data reported earlier. The characteristic infrared  $\nu_{\text{C=N}}$  ( $\text{cm}^{-1}$ ) stretches, NMR chemical shifts ( $\delta$ , ppm) of  $\text{H}_{4,4'}$ ,  $\text{H}_5$  protons,  $\text{C}_{3,5}$  carbons were assigned and correlated with Hammett substituent constants and Swain-Lupton's parameters using single and multi-regression analysis. From the results of regression analysis the effect of substituents on the spectral data have been studied.

**Keywords:**  $\beta$ -naphthyl dihydroisoxazoles; IR and NMR spectra; Correlation analysis

### 1. INTRODUCTION

Isoxazoles are five membered heterocyclic compounds containing oxygen and nitrogen atom in the ring. They are medicinal and pharmaceutical important natural products. Numerous conventional and environmentally benign synthetic methods are reported for the isoxazoles synthesis. The [3+2]cycloaddition of alkynes and nitrile oxides and its alcohols [1-5], side chain rearrangements [6] and C-H activation/[4+1] annulation [7] and were employed for synthesis of isoxazoles derivatives. Various catalysts such as Silica gel-MW [8], NaCN-DMF [9], *p*-TsOH-KSF [9],  $\text{SnCl}_2\text{-CH}_3\text{OH}$  [9],  $\text{Ti}(\text{dpm})(\text{NMe}_2)_2$  [9],  $\text{Ti}(\text{dpm})(\text{NMe}_2)_2$  [9],  $\text{FeBr}_2$  [9],  $\text{TMSCl-NaI}$  [9],  $\text{Mg}(\text{OAc})_2$  [9],  $\text{CrO}_2\text{-CH}_3\text{CN}$  [9],  $\text{NaNH}_2\text{-Liq}\cdot\text{NH}_3$  [10],  $\text{K}_2\text{CO}_3$  [11], Clay-glycol [12],  $\text{Pd}(\text{TFA})_2$  [7],  $\text{KOH-C}_2\text{H}_5\text{OH}$  [13],  $\text{KO-Bu}$  [14], CSA-DMF [15], Ultrasound waves [16,17], Hypervalent  $\text{I}_2$  [18],  $\text{NaH-DMF}$ [19],  $\text{SOCl}_2\text{-CH}_2\text{Cl}_2$ [19],  $\text{LiAlH}_4\text{-Ether}$  [19], *t*-BuLi:THF [20], triton-B:fly-ash-MW [21], *t*-BuOH:H<sub>2</sub>O-NaOH [22], NBS-SiO<sub>2</sub>

[23], Continuous flow microliter-MW [24], 1,4-Diazabicyclo[2.2.2]octane [25], Chloramine-T [26], PTSA-MW [27], DMF-NaOH [5], Si [1], Pd complexes [28], Sodium saccharin [29], H<sub>2</sub>O [30], CH<sub>3</sub>COONa [31], C<sub>2</sub>H<sub>5</sub>OH-NaOH [32], CH<sub>3</sub>OH/25-70 °C [33] and Cu(I) [34] were utilized for deriving isoxazoles from carbonyl compounds and hydroxylamine hydrochloride. Under solvent-assisted or solvent-free conditions, chalcones also employed for deriving isoxazoles by cyclization with hydroxylamine hydrochloride in presence of catalysts. Cyclization of substituted phenyl and chalcones with hydroxylamine hydrochloride yields some novel aryl and indole based isoxazoles [35,36].

This method is useful for deriving benzothiophene [37] and 3-(2-furyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles [38]. Isoxazole derivatives possess many kinds of biological activities due to hetero atom O, N, double bond and polar groups presents in the ring [37]. The important biological activities of isoxazoles are antibacterial [9,22,26,33,37,39], antifungal [9,22,26,37,39], antioxidant [9,40,41], antitubercular [40,41], anti-inflammatory [41,42], ulcerogenicity [42], antihypertensive [43], immunological activity [11], growth promoting effect of plants [44], molecular docking [22], nicotinic receptor binding [20], photonuclease activity [22], DNA binding [22], anti-analgesic [9], *invitro* calcium channel antagonist activity [9], anti-platelet [9] anthelmintic [31] and anti HIV [9] activities. Isoxazole derivatives were used for synthesizing metal complexes like copper(II) complexes [45].

The photo physical, physiochemical [46] and electrochemical behavior of isoxazole [45] thorough experimental and theoretical investigations were reported. Based on the spectroscopic data the molecular ground state equilibration, geometrical and spatial arrangement of atoms were studied [47,48].

The effect of substituents also studied through spectral data of many organic compounds. Thirunarayanan and his co-workers have studied the spectral correlations on many chalcones and heterocyclic compounds [49,50]. Recently, Senbagm et al., have studied the substituent effects on some triazole imines [51]. Within the above view, the study of effect of substituents on some 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazole derivatives has not been reported. Hence, the author have prepared 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles and recorded their infrared and NMR spectra for investigation of effect of substituents.

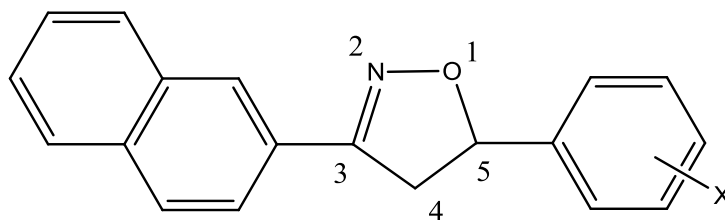
## 2. EXPERIMENTAL

### 2. 1. General

The Sigma-Aldrich and E. Merck chemicals were used for in the present study. Infrared spectra (KBr, 4000–400 cm<sup>-1</sup>) of all isoxazoles were recorded on Thermo scientific Nicolet iS5, US-made Fourier transform spectrophotometer. The NMR spectra of all compounds were recorded on a Bruker AV 400 spectrometer operating at 400 MHz for <sup>1</sup>H NMR spectra and 100 MHz for <sup>13</sup>C NMR spectra in CDCl<sub>3</sub> solvent using TMS as internal standard.

### 2. 2. Synthesis of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles.

In the present investigation compounds 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles were prepared from literature method [52]. The purities of these isoxazoles were examined by data reported earlier in literature. The general structure of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles was illustrated in Fig. 1. The analytical and physical constants of the isoxazoles are presented in Table 1.



X=H, 3-NH<sub>2</sub>, 4-NH<sub>2</sub>, 3-Br, 3-Cl, 4-Cl, 4-N(CH<sub>3</sub>)<sub>2</sub>, 4-OH, 4-OCH<sub>3</sub>, 4-CH<sub>3</sub>, 2-NO<sub>2</sub>, 3-NO<sub>2</sub>, 4-NO<sub>2</sub>

**Fig. 1.** The general structure of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles.

### 3. RESULTS AND DISCUSSION

#### 3. 1. IR spectral correlations

In the present investigations, the effect of substituents on the spectral  $\nu\text{C}=\text{N}$  ( $\text{cm}^{-1}$ ) stretches, NMR chemical shifts ( $\delta$ , ppm) of H<sub>4,4'</sub>, H<sub>5</sub> protons, C<sub>3-5</sub> carbons of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles were assigned and correlated with Hammett substituent constants and Swain-Lupton's [53] parameters using single and multi- regression analysis. In infrared spectral correlations, the Hammett equation was employed as

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

where  $\lambda_0$  is the absorption maximum of the parent member of this series.

The assigned  $\nu\text{C}=\text{N}$  ( $\text{cm}^{-1}$ ) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles are presented in Table 1. These frequencies were correlated with Hammett substituent constants and Swain-Lupton's [53] parameters using single and multi- regression analysis [47-51]. The results of statistical analyses are presented in Table 2.

**Table 1.** The infrared spectral  $\nu\text{C}=\text{N}$  ( $\text{cm}^{-1}$ ) stretches, NMR chemical shifts ( $\delta$ , ppm) of H<sub>4,4'</sub>, H<sub>5</sub> protons, C<sub>3-5</sub> carbons of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles

Sl. No.	X	IR $\nu$ ( $\text{cm}^{-1}$ )	<sup>1</sup> H NMR ( $\delta$ , ppm)			<sup>13</sup> C NMR ( $\delta$ , ppm)		
		C=N	H <sub>4</sub>	H <sub>4'</sub>	H <sub>5</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
1	H	1598	3.571	3.683	6.405	157.34	43.89	85.72
2	3-NH <sub>2</sub>	1574	3.418	3.715	6.132	158.31	44.76	85.93
3	4-NH <sub>2</sub>	1598	3.626	3.708	6.238	158.93	44.81	85.96
4	3-Br	1599	3.602	3.682	5.749	156.82	43.66	85.07
5	3-Cl	1594	3.679	3.795	5.826	156.93	43.49	85.54

6	4-Cl	1597	3.684	3.830	5.709	157.11	43.61	84.96
7	4-N(CH <sub>3</sub> ) <sub>2</sub>	1599	3.640	3.677	6.118	157.71	43.86	85.74
8	4-OH	1605	3.643	3.722	5.964	156.97	43.09	84.97
9	4-OCH <sub>3</sub>	1594	3.632	3.654	6.094	155.74	42.36	82.76
10	4-CH <sub>3</sub>	1598	3.642	3.710	6.264	157.07	43.19	85.17
11	2-NO <sub>2</sub>	1593	3.677	3.734	6.599	156.92	44.34	85.76
12	3-NO <sub>2</sub>	1605	3.659	3.758	6.599	157.14	44.96	88.94
13	4-NO <sub>2</sub>	1602	3.619	3.805	6.601	157.28	45.09	85.73

**Table 2.** Results of statistical analysis of IR and NMR spectral data of of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles with Hammett  $\sigma$ ,  $\sigma^+$ ,  $\sigma_I$ ,  $\sigma_R$  constants, F and R parameters.

Frequency	Constant	r	I	$\rho$	s	n	Correlated derivatives
$\nu_{C=N}$ (cm <sup>-1</sup> )	$\sigma$	0.705	1592.58	2.148	21.90	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.608	1592.76	0.044	21.93		
	$\sigma_I$	0.724	1586.29	20.331	21.26		
	$\sigma_R$	0.835	1598.39	28.576	20.51		
	F	0.731	1583.90	27.561	20.79		
	R	0.732	1598.36	17.653	20.76		
$\delta_{H_4}$ (ppm)	$\sigma$	0.715	3.620	0.020	0.07	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.769	3.623	0.006	0.07		
	$\sigma_I$	0.743	3.587	0.111	0.06		
	$\sigma_R$	0.732	3.579	0.086	0.06		
	F	0.746	3.639	0.132	0.06		
	R	0.731	3.640	0.057	0.06		
$\delta_{H_4}$ (ppm)	$\sigma$	0.905	3.741	0.059	0.04	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.915	3.734	0.036	0.04		
	$\sigma_I$	0.906	3.723	0.127	0.04		

	$\sigma_R$	0.843	3.687	0.092	0.05		
	F	0.905	3.689	0.122	0.04		
	R	0.847	3.749	0.067	0.04		
$\delta H_5$ (ppm)	$\sigma$	0.834	6.158	0.209	0.30	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.827	6.193	0.108	0.31		
	$\sigma_I$	0.901	6.109	0.209	0.32		
	$\sigma_R$	0.905	6.308	0.669	0.27		
	F	0.902	6.021	0.269	0.32		
	R	0.904	6.219	0.362	0.29		
$\nu C_3$ (ppm)	$\sigma$	0.782	157.29	0.427	0.75	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.730	157.20	0.286	0.75		
	$\sigma_I$	0.734	157.30	1.045	0.74		
	$\sigma_R$	0.730	157.07	0.584	0.75		
	F	0.744	157.66	1.274	0.72		
	R	0.736	157.02	0.719	0.74		
$\delta C_4$ (ppm)	$\sigma$	0.939	43.84	0.625	0.79	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.934	43.98	0.344	0.81		
	$\sigma_I$	0.837	43.60	1.018	0.80		
	$\sigma_R$	0.934	44.14	1.082	0.80		
	F	0.826	44.64	0.889	0.82		
	R	0.925	44.10	0.556	0.83		
$\delta C_5$ (ppm)	$\sigma$	0.638	85.47	0.976	1.27	13	H, 3-NH <sub>2</sub> , 3-NH <sub>2</sub> , 3-Br, 3-Cl, 4-Cl, 4-N(CH <sub>3</sub> ) <sub>2</sub> , 4-OH, 4-OCH <sub>3</sub> , 4-CH <sub>3</sub> , 2-NO <sub>2</sub> , 3-NO <sub>2</sub> , 4-NO <sub>2</sub>
	$\sigma^+$	0.703	85.64	0.561	1.28		
	$\sigma_I$	0.721	85.09	1.485	1.31		
	$\sigma_R$	0.904	85.94	2.132	1.24		
	F	0.729	85.08	1.475	1.32		
	R	0.733	85.91	1.138	1.29		

r = correlation coefficient; I = intercept;  $\rho$  = slope; s = standard deviation; n = number of correlated derivatives

From Table 2, all correlations of  $\nu_{\text{C=N}}$  ( $\text{cm}^{-1}$ ) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave poor correlation coefficient along with positive  $\rho$  values. This is due to the inability of effects of substituents on the CN stretches and the hydride ions in the conjugative structure as shown in Figure 2. Some of the single Hammett plots are shown in Figs. 3-6.

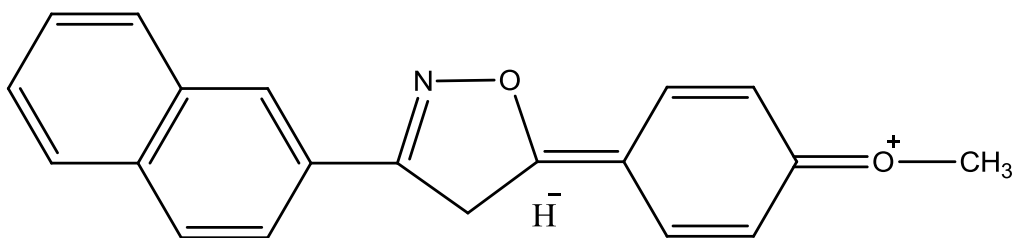


Fig. 2. The resonance-conjugative structure.

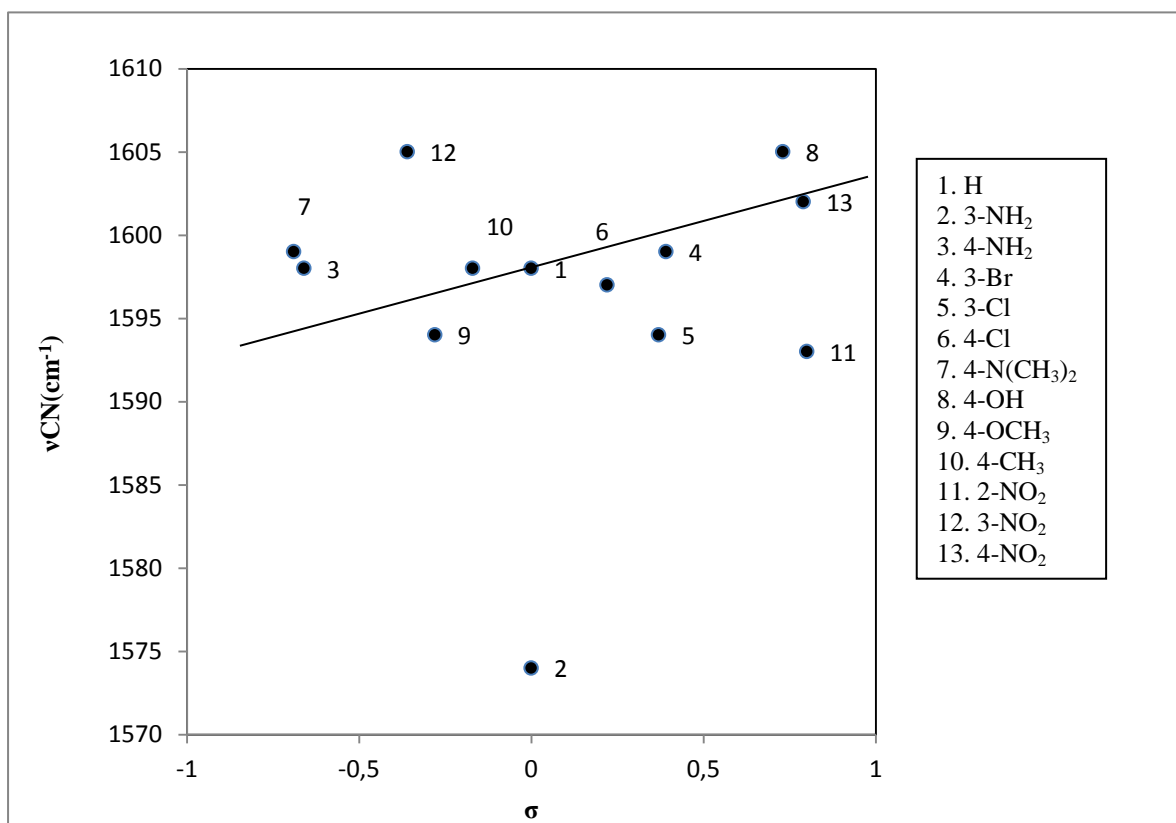
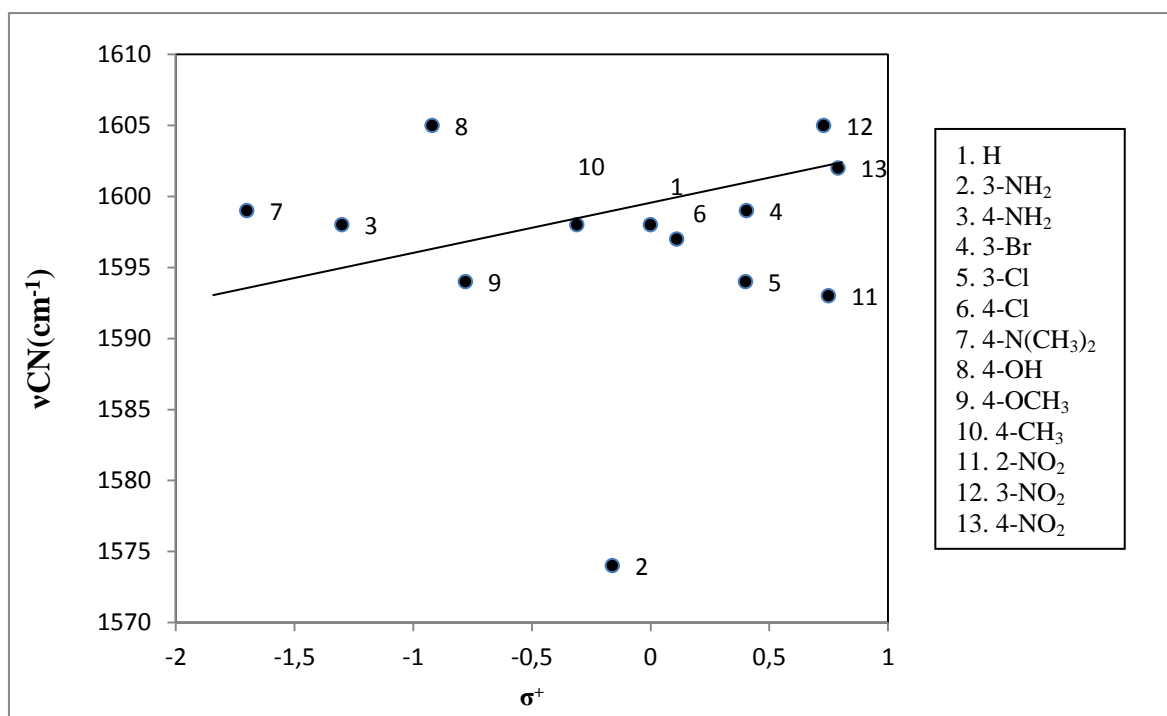
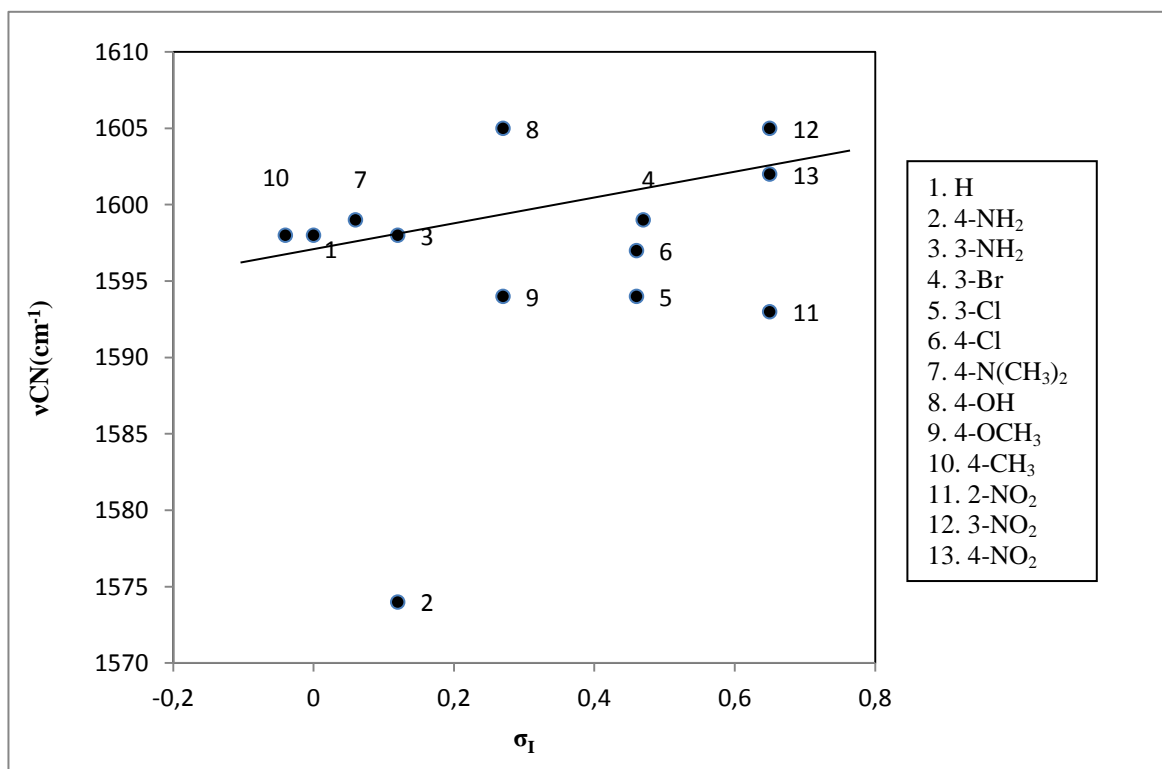


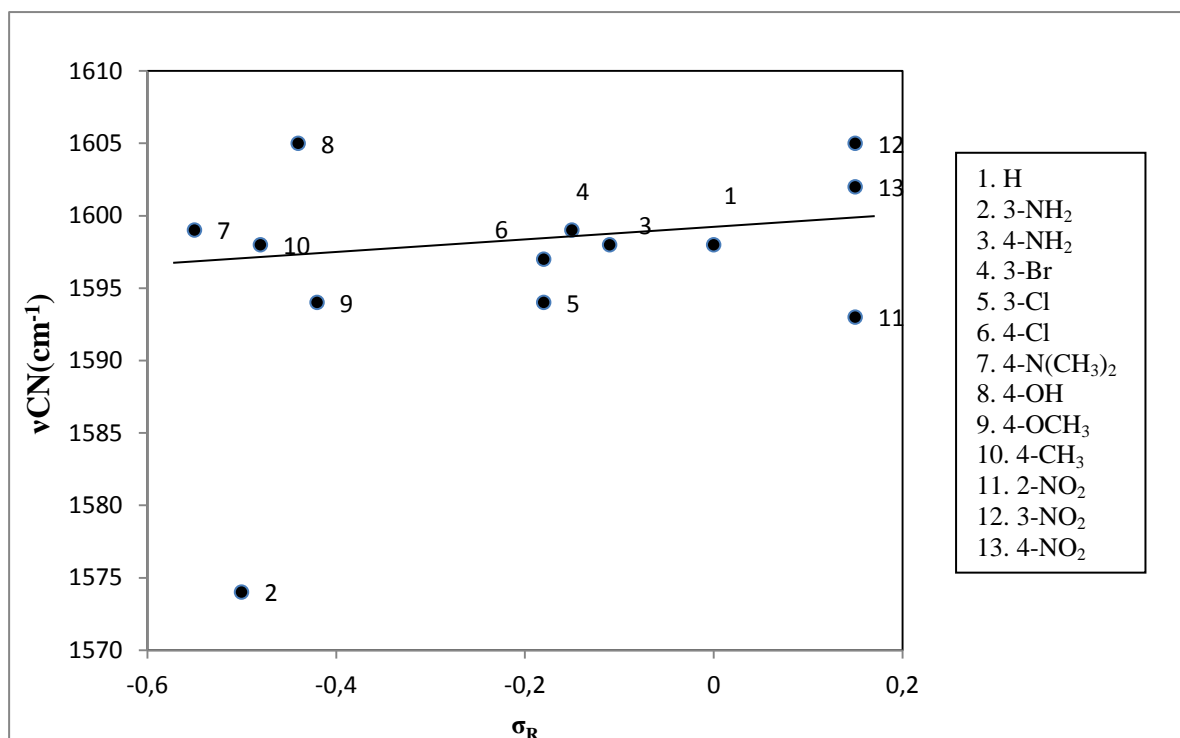
Fig. 3. Plot of  $\nu_{\text{C=N}}$  ( $\text{cm}^{-1}$ ) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$ .



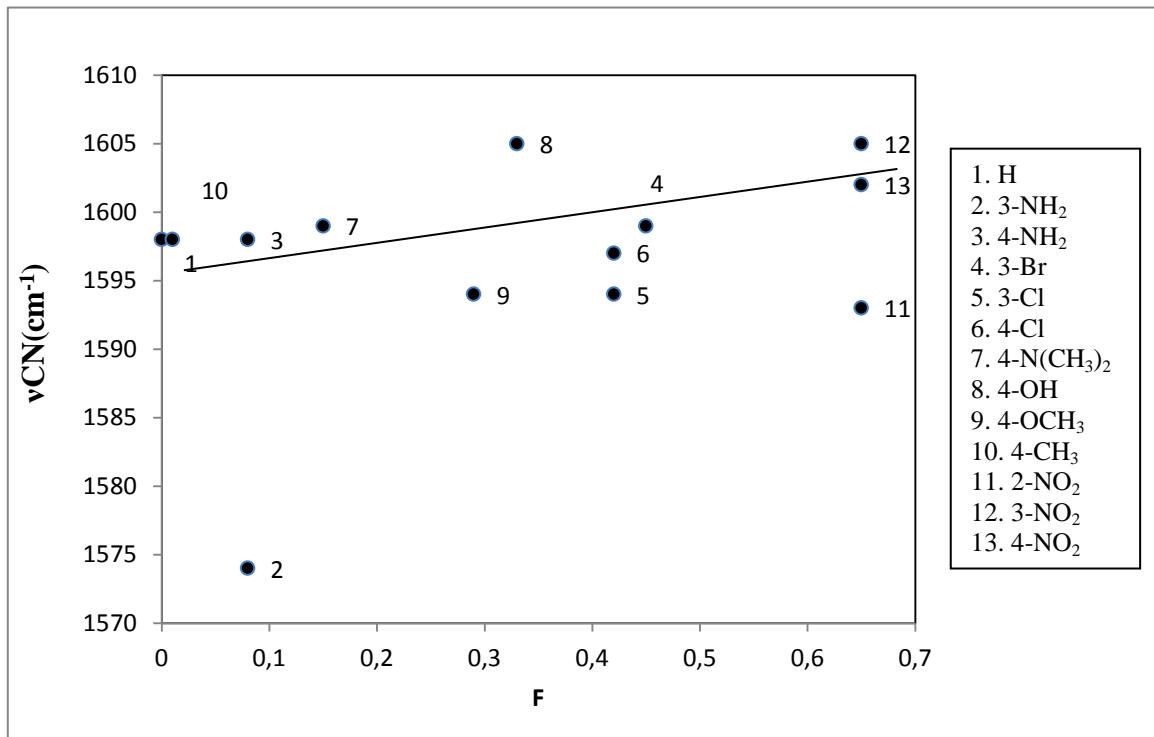
**Fig. 4.** Plot of  $\nu_{C=N}$  (cm<sup>-1</sup>) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma^+$ .



**Fig. 5.** Plot of  $\nu_{C=N}$  (cm<sup>-1</sup>) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_1$ .

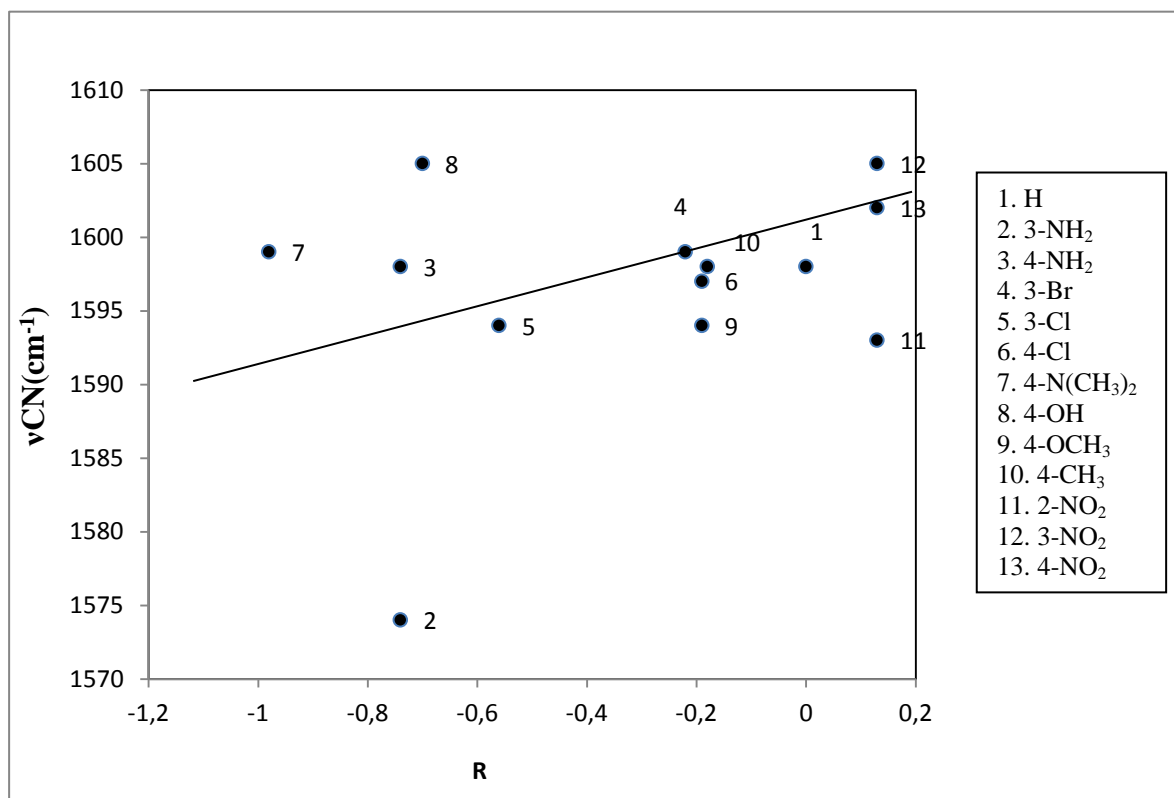


**Fig. 6.** Plot of  $\nu_{C=N}$  (cm<sup>-1</sup>) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_R$ .



**Fig. 7.** Plot of  $\nu_{C=N}$  (cm<sup>-1</sup>) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus F.





**Fig. 8.** Plot of  $\nu_{\text{C=N}}$  ( $\text{cm}^{-1}$ ) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus R.

The  $\nu_{\text{C=N}}$  ( $\text{cm}^{-1}$ ) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles are fail in correlations with Hammett  $\sigma$ ,  $\sigma^+$ ,  $\sigma_I$ ,  $\sigma_R$  constants, F and R parameters in single parameter correlations. While they are worth full when seeking these are in multi-regressions with  $\sigma_I$ ,  $\sigma_R$  constants, F and R Swain-Lupton's [53] parameters. In this analysis satisfactory correlations obtained. The multi-regression analysis equations are (2 and 3) as;

$$\nu_{\text{C=N}} (\text{cm}^{-1}) = 1596.90 (\pm 15.619) - 3.412 (\pm 1.347) \sigma_I + 26.513 (\pm 2.301) \sigma_R \quad \dots (2)$$

$(R = 0.935, n = 13, P > 90\%)$

$$\nu_{\text{C=N}} (\text{cm}^{-1}) = 1590.84 (\pm 15.919) + 19.089 (\pm 3.173) F + 11.297 (\pm 9.171) R \quad \dots (3)$$

$(R = 0.35, n = 13, P > 90\%)$

### 3. 2. $^1\text{H}$ NMR correlations

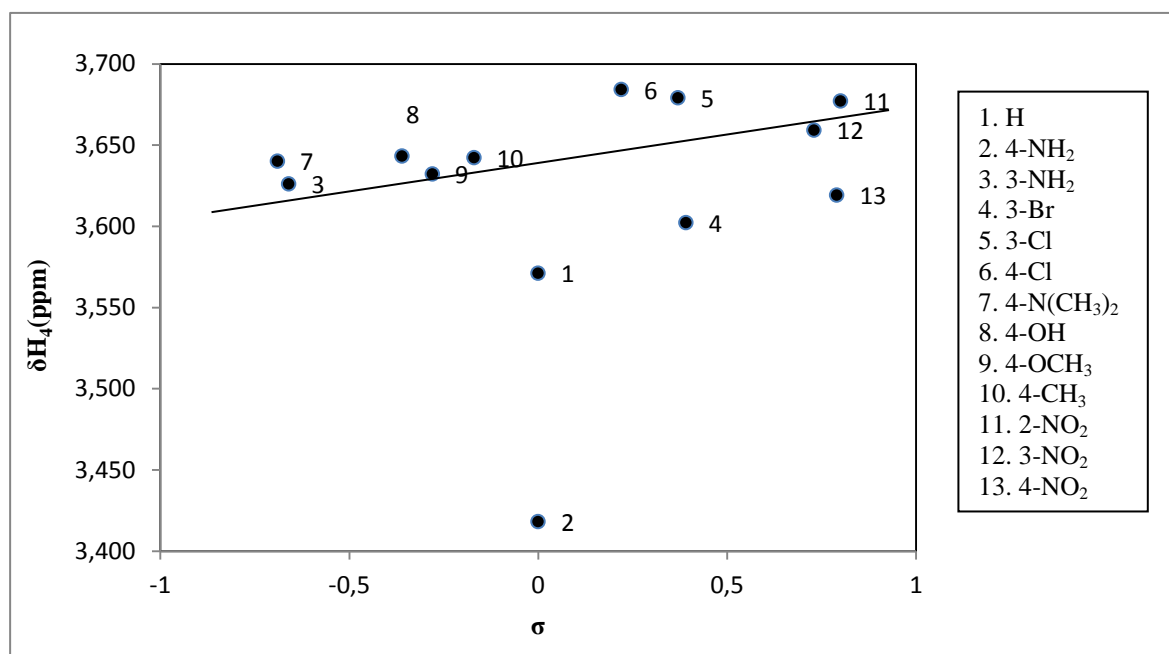
The assigned NMR chemical shifts ( $\delta$ , ppm) of  $\text{H}_{4,4'}$ ,  $\text{H}_5$  of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles are presented in Table 1. These chemical shifts ( $\delta$ , ppm) were correlated with Hammett substituent constants and Swain-Lupton's [53] parameters using single and multi-regression analysis [47-51]. In NMR spectral correlations, the Hammett equations was taken in the form of

$$\delta = \rho \sigma + \delta_0 \quad \dots (4)$$

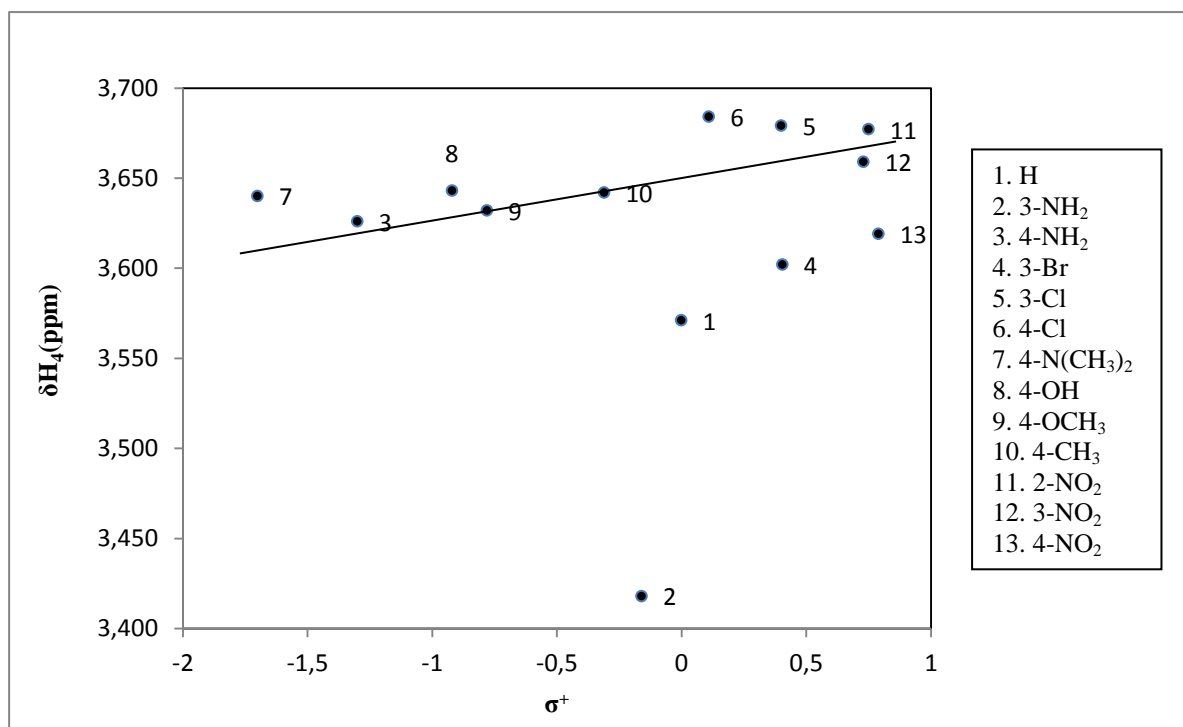
where  $\delta_0$  is the absorption maximum of the parent member of this series.

The results of statistical analyses are presented in Table 2. From Table 2, The correlation of  $H_4$  chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave poor correlation coefficients. All correlations gave positive  $\rho$  values. This implies that the normal substituent effects operates in all systems. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2.

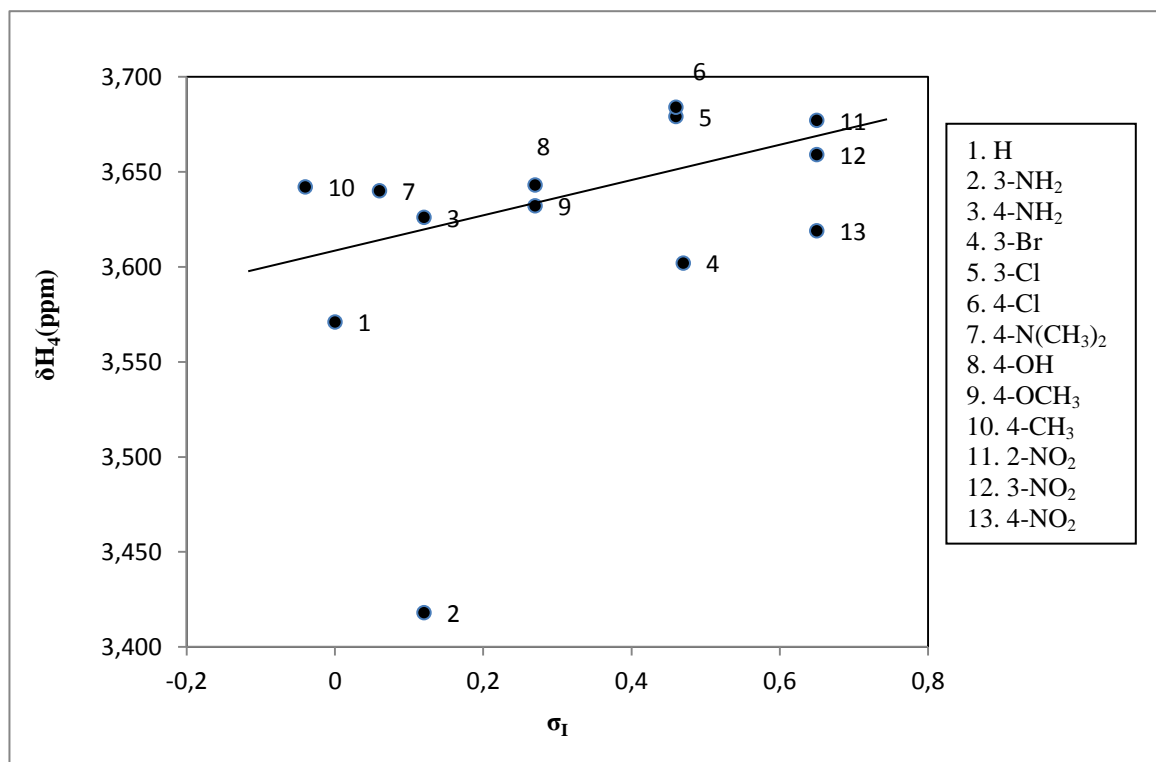
The correlation of  $H_4$  chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave satisfactory correlation coefficients with Hammett  $\sigma$ ,  $\sigma^+$ ,  $\sigma_I$  constants and F parameters in single parameter correlations excluding 3-Br, 3-Cl, 4-Cl and nitro substituents. When they will include the correlations, the correlation coefficients decreased considerably. All correlations gave positive  $\rho$  values. This implies that the normal substituent effect operates in all systems. The Hammett  $\sigma_R$  constant and R parameters fail in correlations. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2. The correlation of  $H_5$  chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave satisfactory correlation coefficients with Hammett  $\sigma_I$ ,  $\sigma_R$  constants, F and R parameters in single parameter correlations excluding 4-Cl substituents. When they will include the correlations, the correlation coefficients decreased considerably. All correlations gave positive  $\rho$  values. This implies that the normal substituent effects operates in all systems. The Hammett  $\sigma$  and  $\sigma^+$  constants fail in correlations. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2. Some of the single plots are given in Figs. 9-20. Some of the NMR chemical shifts ( $\delta$ , ppm) of  $H_{4,4'}$ ,  $H_5$  of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles are fail in single parameter correlations. These are produced satisfactory correlations with multi-regression analysis using  $\sigma_I$ ,  $\sigma_R$  constants, F and R Swain-Lupton's [53] parameters. The obtained multi-regression analysis equations are given in (5-10).



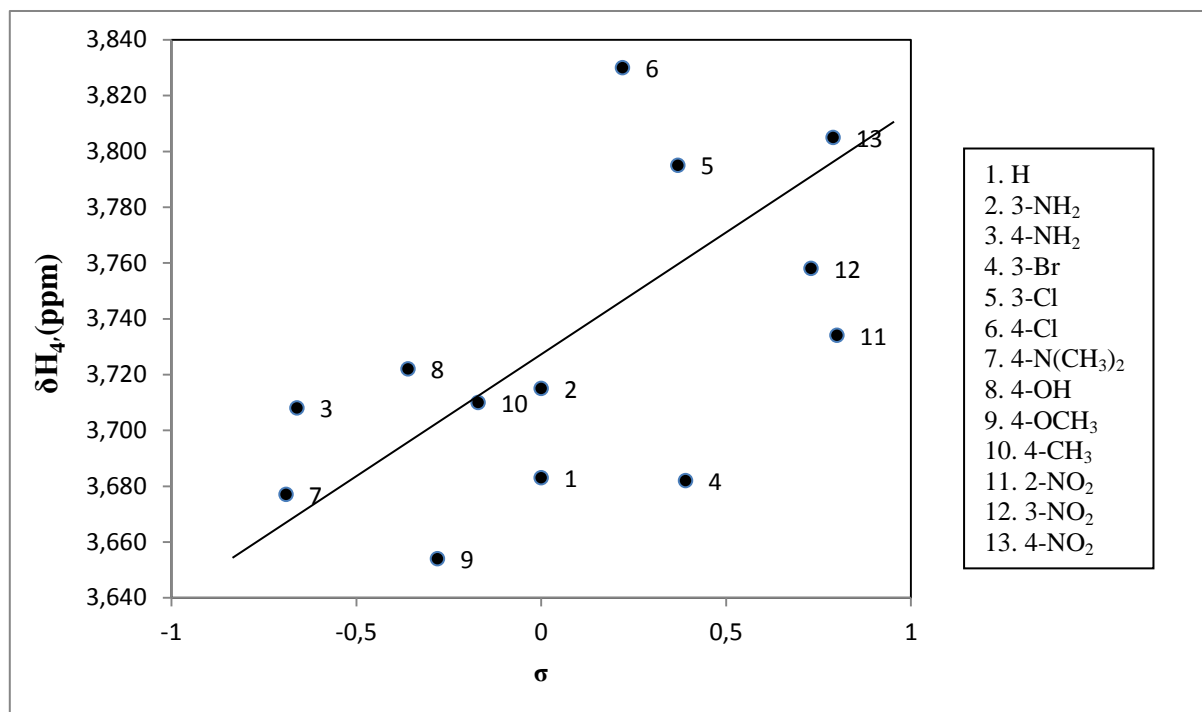
**Fig. 9.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$



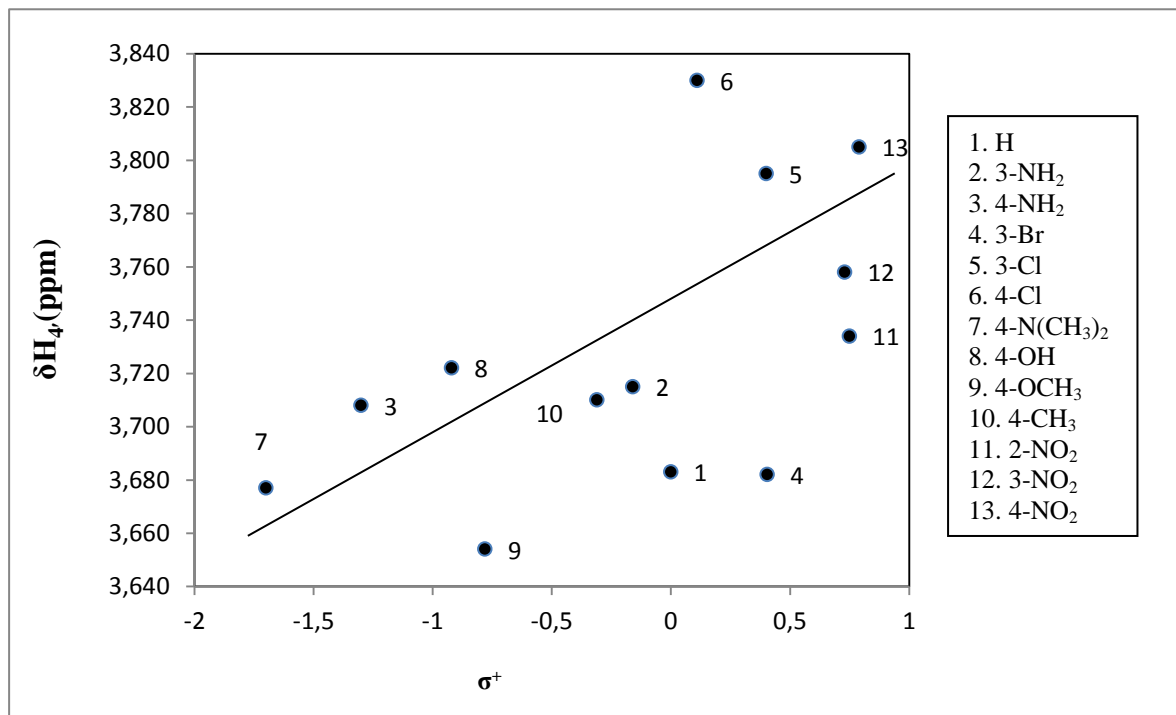
**Fig. 10.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma^+$ .



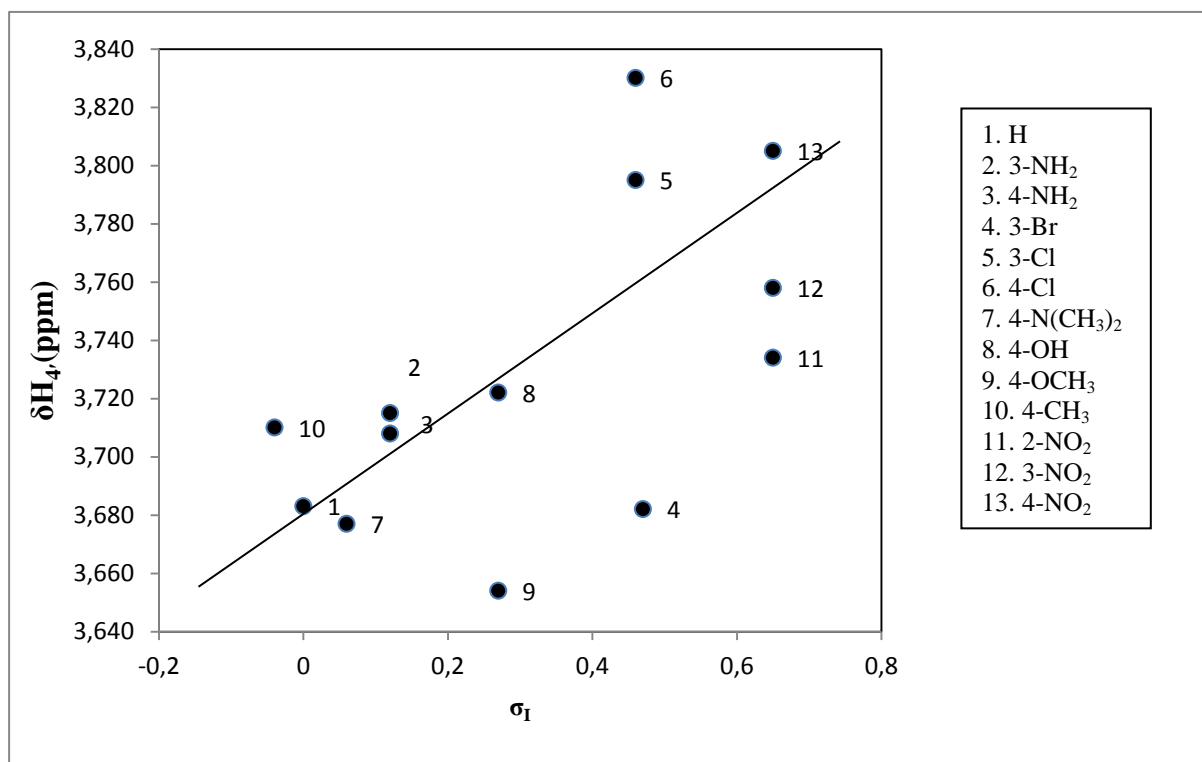
**Fig. 11.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_I$ .



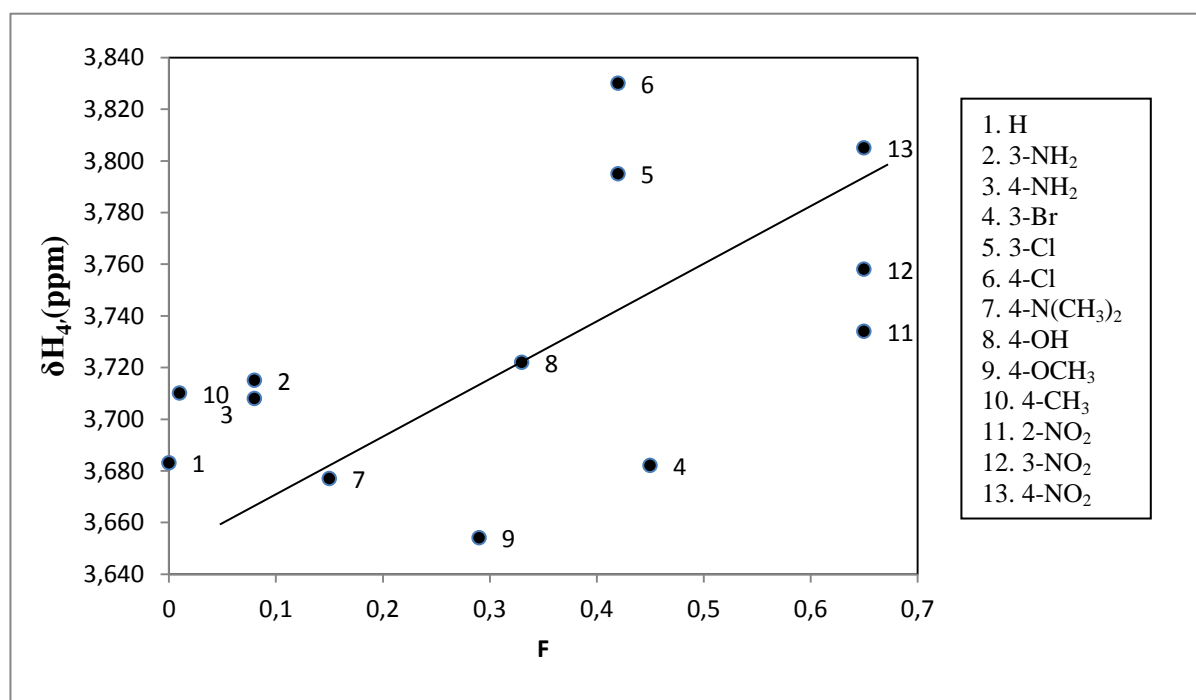
**Fig. 12.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$ .



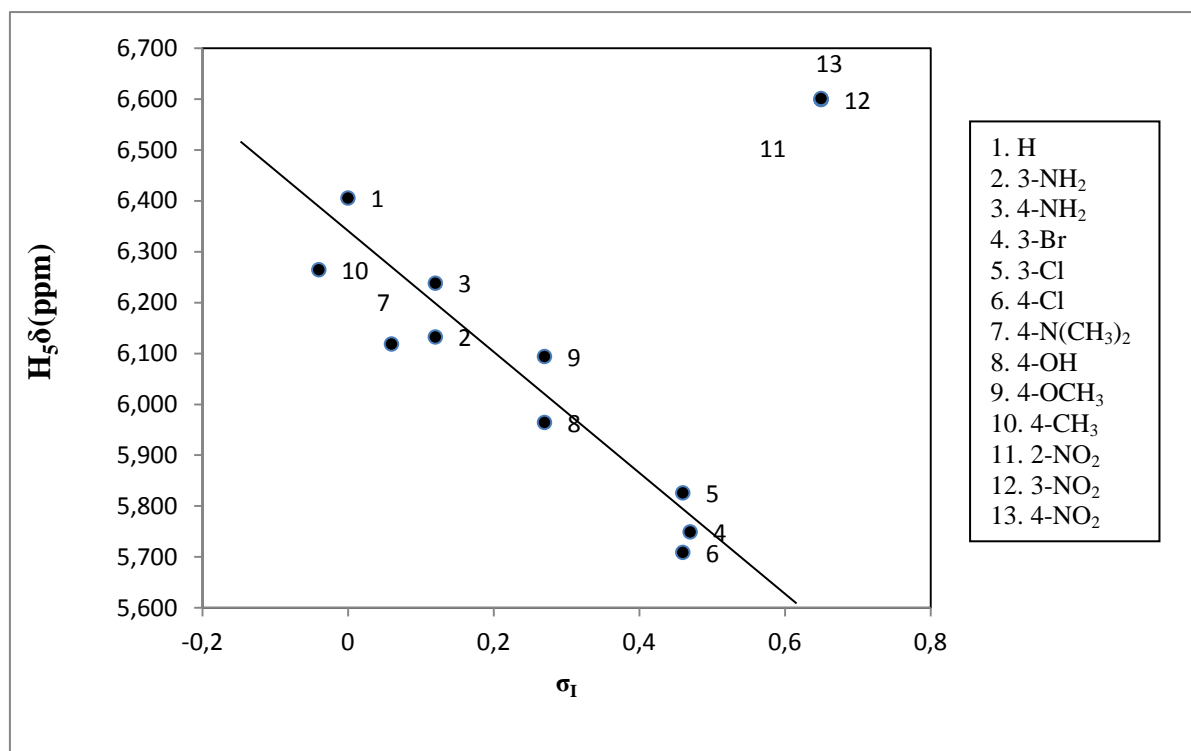
**Fig. 13.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma^+$ .



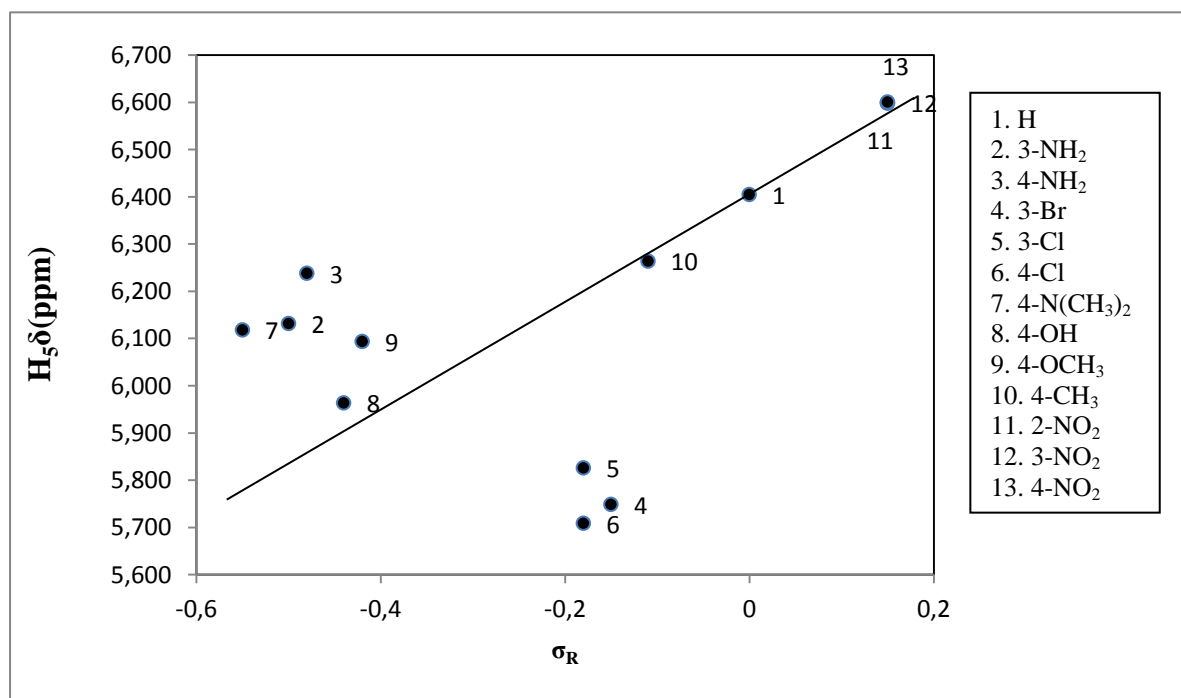
**Fig. 14.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_I$ .



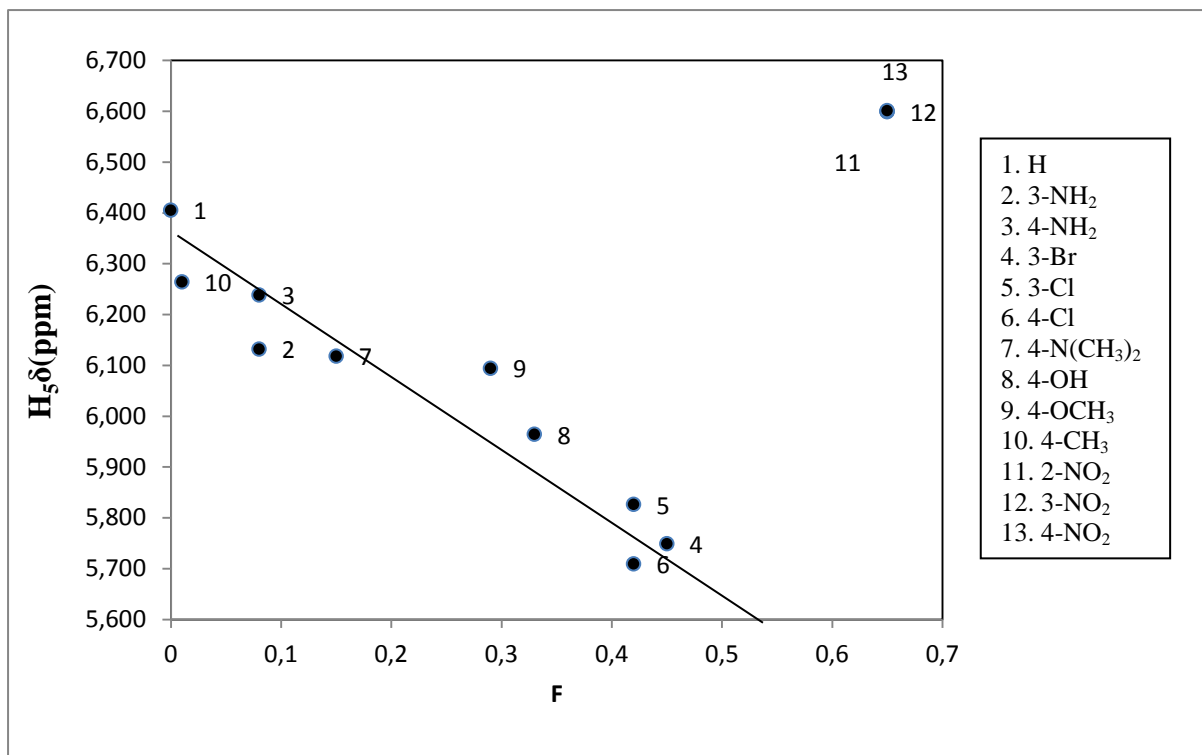
**Fig. 15.** Plot of  $\delta H_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus F.



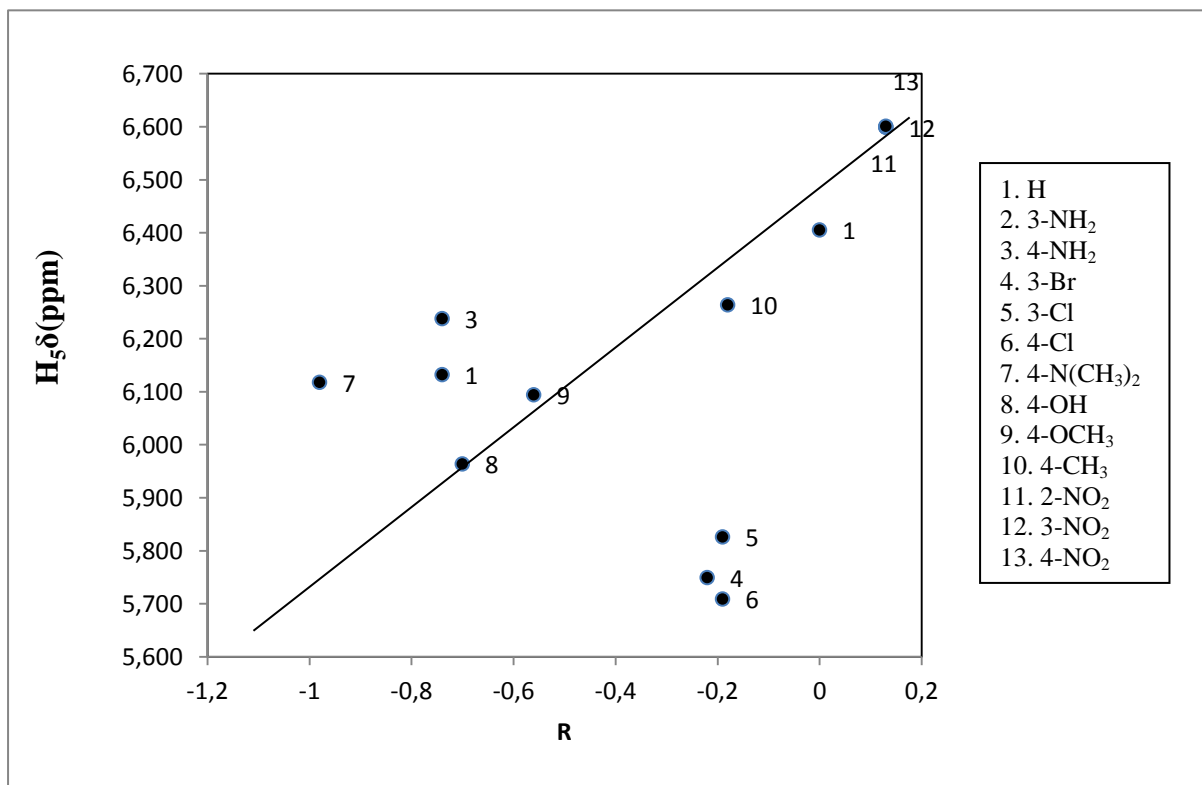
**Fig. 16.** Plot of  $\delta H_5$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_I$ .



**Fig. 17.** Plot of  $\delta H_5$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_R$ .



**Fig. 18.** Plot of  $\delta_{H_5}$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus F.



**Fig. 19.** Plot of  $\delta_{H_5}$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus R.

$$\delta H_4 (\text{ppm}) = 3.595(\pm 0.041) - 0.091 (\pm 0.003) \sigma_I + 0.031(\pm 0.002) \sigma_R \quad \dots (5)$$

$$(R = 0.941, n = 13, P > 90\%)$$

$$\delta H_4 (\text{ppm}) = 3.587(\pm 0.049) + 0.130(\pm 0.032) F + 0.012(\pm 0.001) R \quad \dots (6)$$

$$(R = 0.946, n = 13, P > 90\%)$$

$$\delta H_4 (\text{ppm}) = 3.697(\pm 0.034) + 0.112(\pm 0.068) \sigma_I + 0.023(\pm 0.001) \sigma_R \quad \dots (7)$$

$$(R = 0.960, n = 13, P > 90\%)$$

$$\delta H_4 (\text{ppm}) = 3.789(\pm 0.035) + 0.092(\pm 0.002) F + 0.330(\pm 0.004) R \quad \dots (8)$$

$$(R = 0.944, n = 13, P > 90\%)$$

$$\delta H_5 (\text{ppm}) = 6.463(\pm 0.119) + 0.531(\pm 0.339) \sigma_I + 0.883(\pm 0.388) \sigma_R \quad \dots (9)$$

$$(R = 0.915, n = 13, P > 90\%)$$

$$\delta H_5 (\text{ppm}) = 6.339(\pm 0.227) + 0.108(\pm 0.004) F + 0.403(\pm 0.027) R \quad \dots (10)$$

$$(R = 0.944, n = 13, P > 90\%)$$

### 3. 3. <sup>13</sup>C NMR correlations

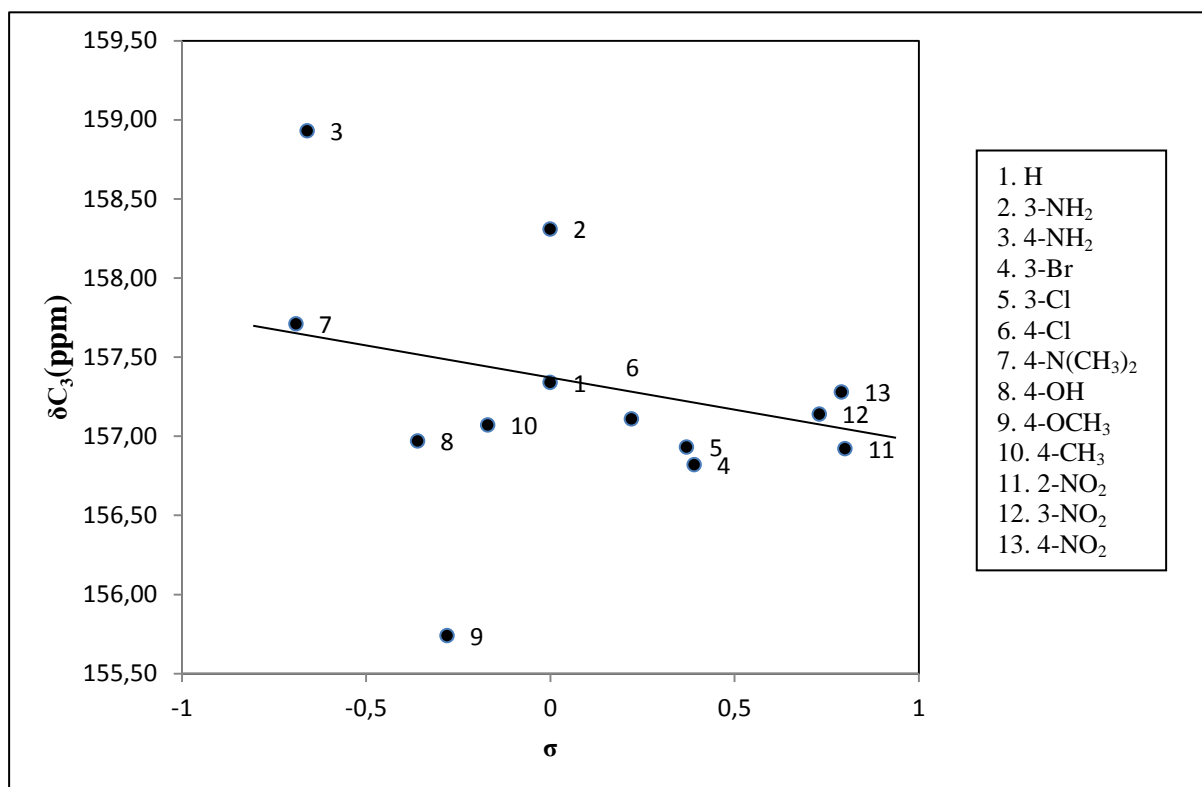
The assigned <sup>13</sup>C NMR chemical shifts ( $\delta$ , ppm) of C<sub>3,5</sub> of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles are presented in Table 1. These chemical shifts ( $\delta$ , ppm) were correlated with Hammett substituent constants and Swain-Lupton's [53] parameters using single and multi- regression analysis [47-51].

The results of statistical analyses are presented in Table 2. From Table 2, The correlation of C<sub>3</sub> chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave poor correlation coefficients. All correlations gave positive  $\rho$  values. This implies that the normal substituent effect operates in all systems. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2.

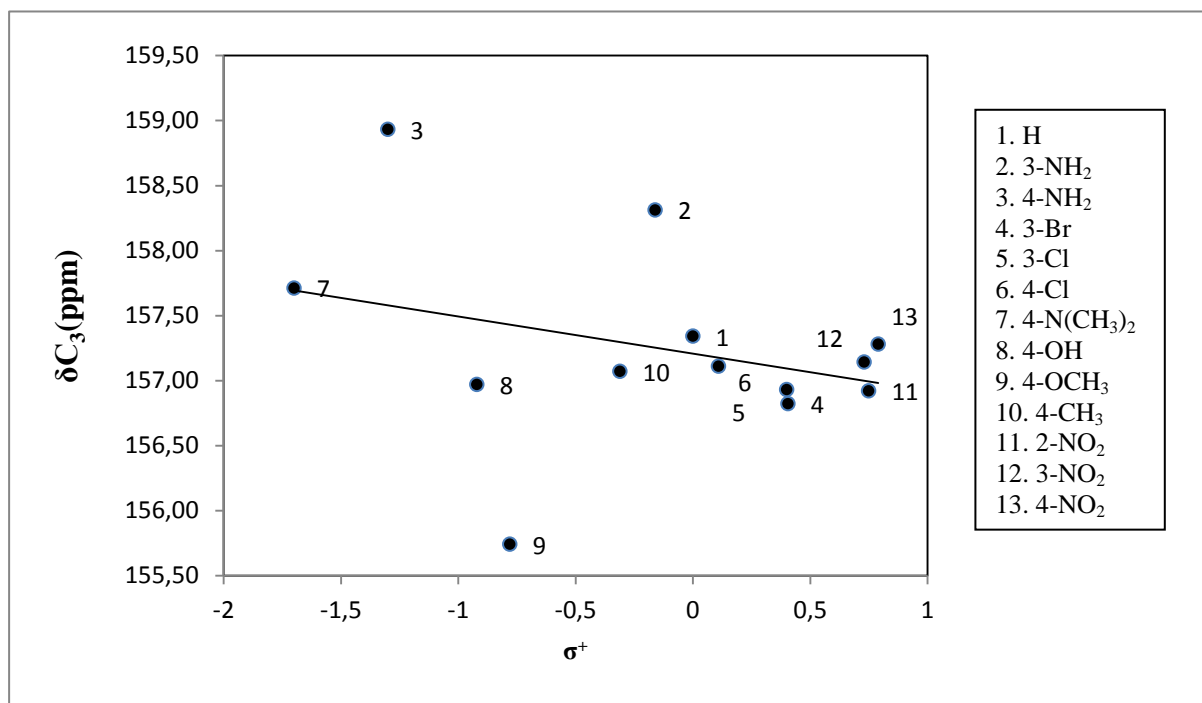
The correlation of C<sub>4</sub> chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave satisfactory correlation coefficients with Hammett  $\sigma$ ,  $\sigma^+$ ,  $\sigma_R$  constants and R parameters excluding amino, 4-dimethylamino substituents. When these substituents are includes in regressions, the reduced the correlations considerably. The Hammett  $\sigma_I$  constant and F parameters fail in correlations. All correlations gave positive  $\rho$  values. This implies that the normal substituent effect operates in all systems. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2.

The correlation of C<sub>5</sub> chemical shifts ( $\delta$ , ppm) of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles gave satisfactory correlation coefficients with Hammett  $\sigma_R$  constant excluding amino, 4-dimethylamino substituents. When these substituents are includes in regressions, the reduced the correlations considerably. The Hammett  $\sigma$ ,  $\sigma^+$ ,  $\sigma_I$  constants, F and R parameters were failing in correlations. All correlations gave positive  $\rho$  values. This implies that the normal substituent effects operate in all systems. The reason for the failure correlations are already stated and associated with resonance-conjugated structure as shown in Fig. 2. Some of the single parameter correlations are shown in Figs. 20-27.

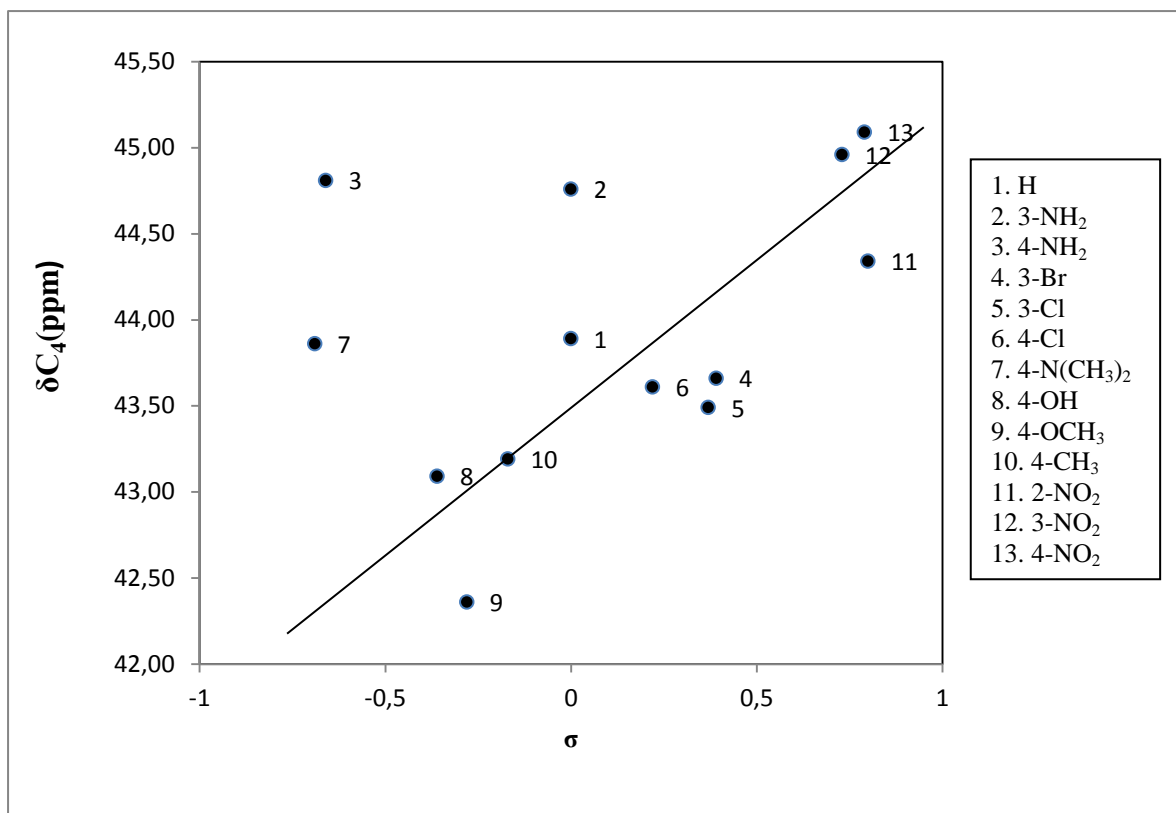




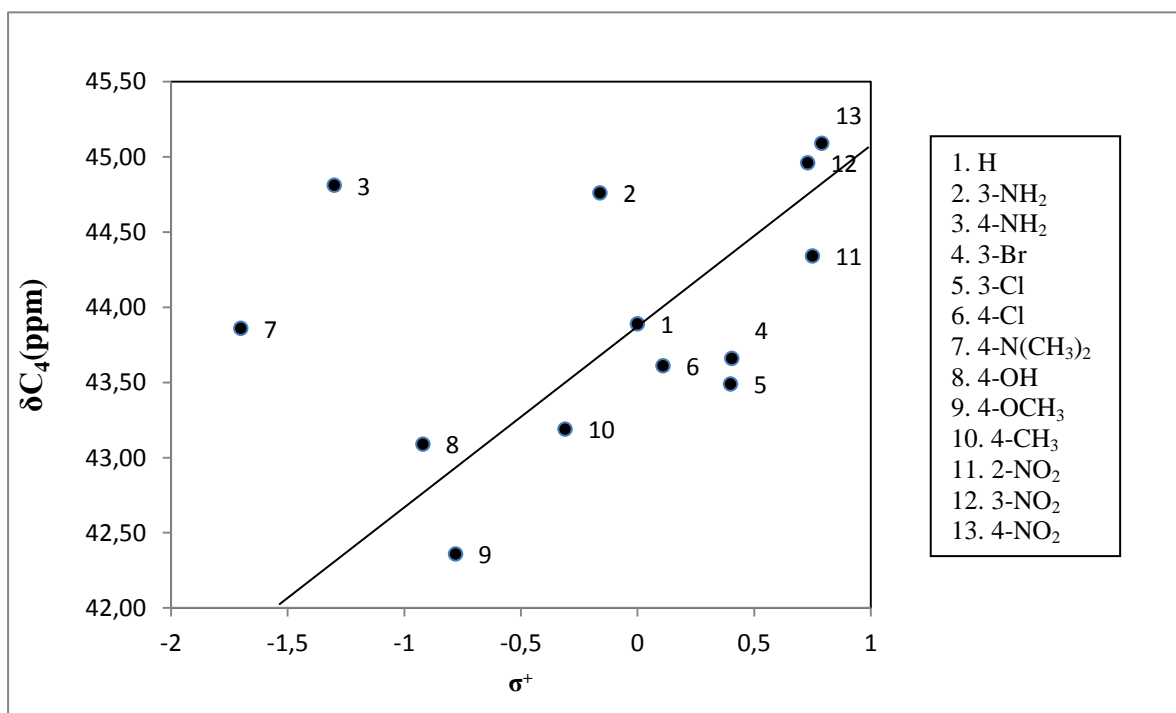
**Fig. 20.** Plot of  $\delta C_3$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$ .



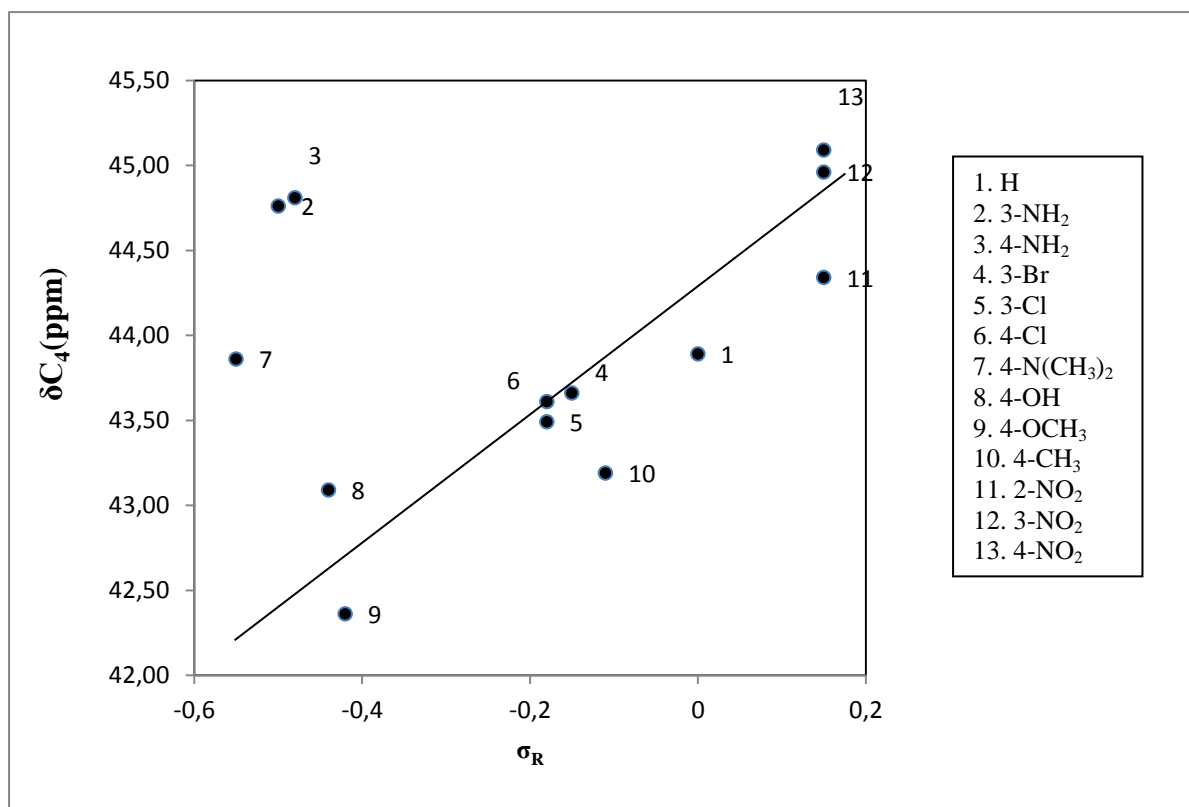
**Fig. 21.** Plot of  $\delta C_3$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma^+$ .



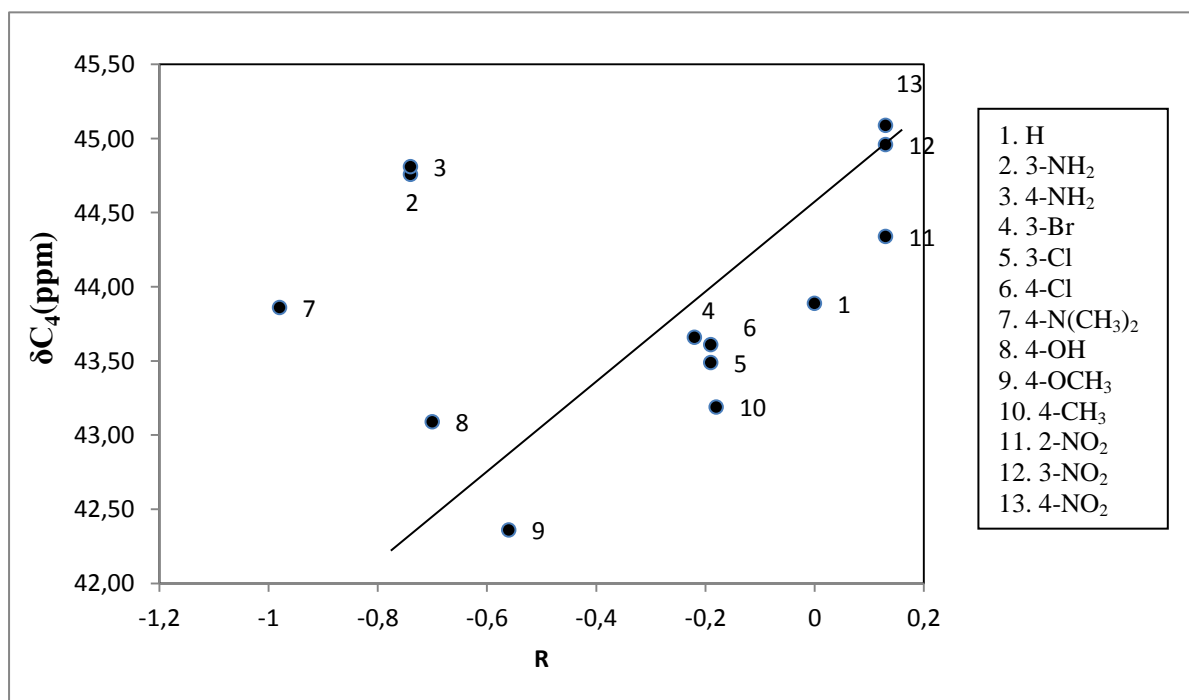
**Fig. 22.** Plot of  $\delta C_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$ .



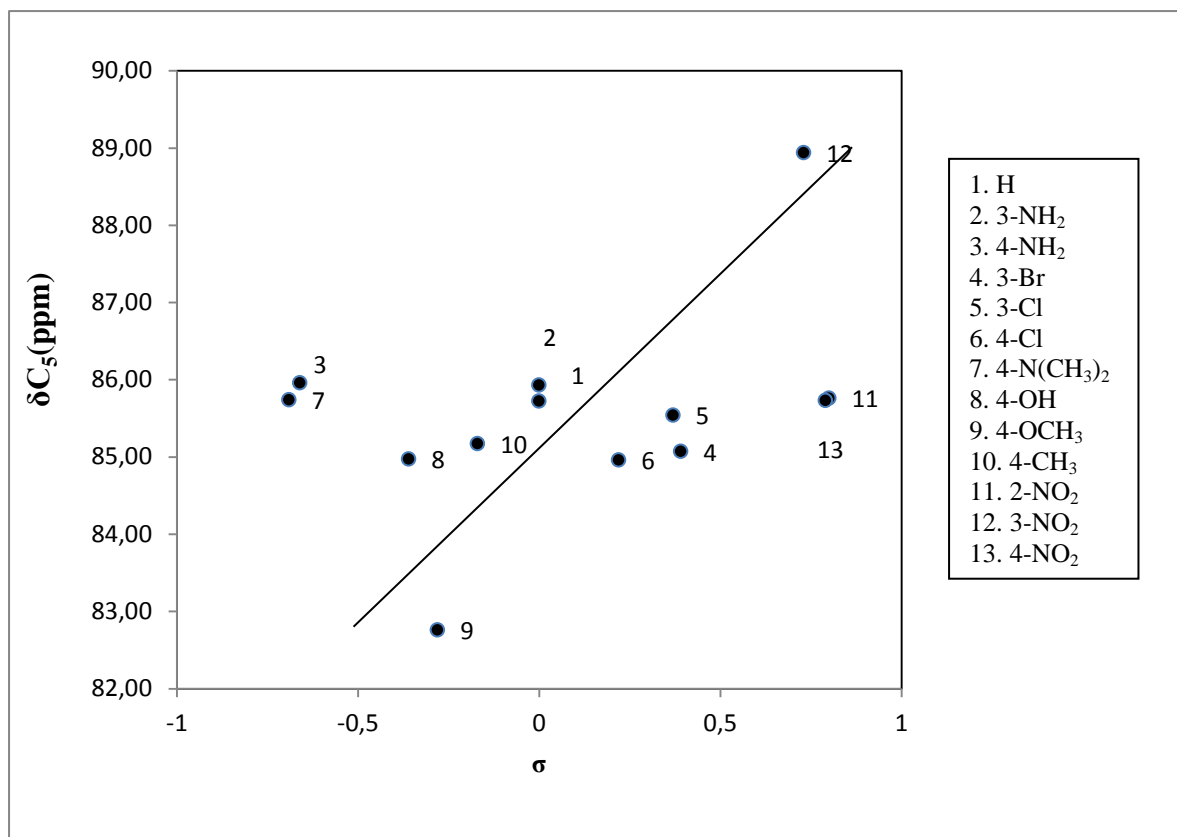
**Fig. 23.** Plot of  $\delta C_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma^+$ .



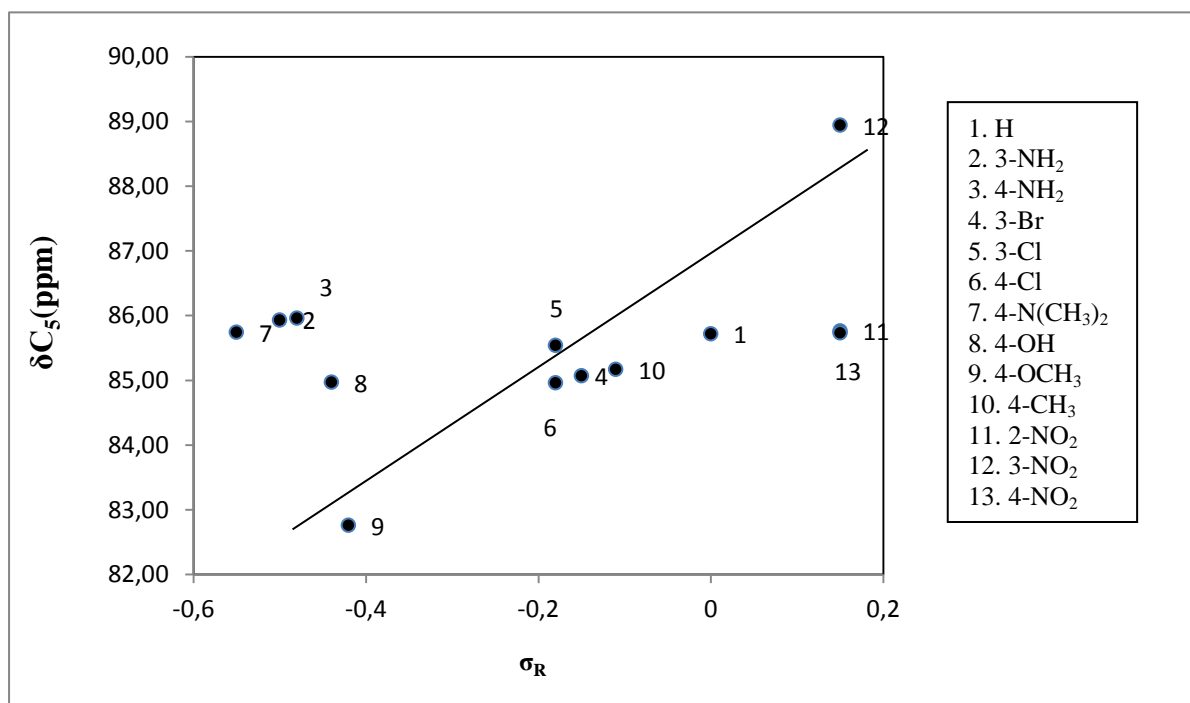
**Fig. 24.** Plot of  $\delta C_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_R$ .



**Fig. 25.** Plot of  $\delta C_4$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus R.



**Fig. 26.** Plot of  $\delta C_5$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma$ .



**Fig. 27.** Plot of  $\delta C_5$  (ppm) stretches of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles versus  $\sigma_R$ .

Some of the  $^{13}\text{C}$  NMR chemical shifts ( $\delta$ , ppm) of  $\text{C}_{3-5}$  of 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydro isoxazoles were fail in correlations. While seeking in multi correlations of these chemical shifts with and  $\sigma_{\text{I}}$  and  $\sigma_{\text{R}}$  or F and R Swain-Lupton's [53] parameters, they produced satisfactory correlation coefficients. The multi-regression analysis equations are (11-16) as;

$$\delta\text{C}_3 \text{ (ppm)} = 157.41(\pm 0.561) + 0.778(\pm 0.112) \sigma_{\text{I}} + 0.415(\pm 0.109) \sigma_{\text{R}} \quad \dots (11)$$

$(R = 0.936, n = 13, P > 90\%)$

$$\delta\text{C}_3 \text{ (ppm)} = 157.43(\pm 0.538) + 0.931(\pm 0.110) F + 0.373(\pm 0.070) R \quad \dots (12)$$

$(R = 0.943, n = 13, P > 90\%)$

$$\delta\text{C}_4 \text{ (ppm)} = 43.91(\pm 0.609) + 0.533(\pm 0.121) \sigma_{\text{I}} + 0.759(\pm 0.118) \sigma_{\text{R}} \quad \dots (13)$$

$(R = 0.936, n = 13, P > 90\%)$

$$\delta\text{C}_4 \text{ (ppm)} = 43.84(\pm 0.640) + 0.594(\pm 0.129) F + 0.318(\pm 0.080) R \quad \dots (14)$$

$(R = 0.928, n = 13, P > 90\%)$

$$\delta\text{C}_5 \text{ (ppm)} = 85.90(\pm 0.948) + 1.169(\pm 0.189) \sigma_{\text{I}} + 2.038(\pm 1.408) \sigma_{\text{R}} \quad \dots (15)$$

$(R = 0.942, n = 13, P > 90\%)$

$$\delta\text{C}_5 \text{ (ppm)} = 85.63(\pm 1.005) + 0.641(\pm 0.198) F + 0.900(\pm 0.012) R \quad \dots (16)$$

$(R = 0.934, n = 13, P > 90\%)$

#### 4. CONCLUSIONS

About thirteen 3-(2-naphthyl)-5-(substituted phenyl)-4,5-dihydroisoxazole were synthesized and examined their purities by their data reported earlier. The characteristic infrared  $\nu\text{C}=\text{N}$  ( $\text{cm}^{-1}$ ) stretches, NMR chemical shifts ( $\delta$ , ppm) of  $\text{H}_{4,4'}$ ,  $\text{H}_5$  protons,  $\text{C}_{3-5}$  carbons were assigned and correlated with Hammett substituent constants and Swain-Lupton's parameters using single and multi-regression analysis. From the results of regression analysis the effect of substituents on the spectral data were studied. The infrared spectral frequencies were failing in correlations. Some of the isoxazole ring protons and carbons produced satisfactory correlations excluding amino and halogen substituents in single parameter correlations. In multi-regression analysis all spectral data gave satisfactory correlations.

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