다양한 치환기가 붙은 Styryl 4-Methoxy-1-Naphthyl Ketone의 합성과 치환기 효과에 관한 연구

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Synthesis and Substituent Effects in Substituted Styryl 4-Methoxy-1-Naphthyl Ketones

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요   약. 초음파를 이용한 응축 반응을 이용하여 다양한 치환기가 붙은 4-methoxy-1-naphthyl ketone화합물들을 90% 이상의 높은 수율로 합성하였으며, 생성된 화합물물들을 미세 분석법, IR, ^1H, ^{13}C NMR 분석법 등을 이용하여 확인하였다. IR 스펙트럼에서 s-cis와 s-trans C=O stretching 모드를 확인하였으며, NMR 데이터로부터 에틸렌의 탄소와 수소에 대한 chemical shift를 확인하였다. 이러한 분광데이터를 이용하여 여러 분자들에 대한 Hammet 치환기 상수값 들을 얻을 수 있었으며, 이들로부터 가용매 분해반응에 미치는 치환기 효과를 해석할 수 있었다.

주제어: 합성, 치환기 효과, 적외선 분광법, 핵자기공명 분광법, 나프틸 칼론

ABSTRACT. A series of substituted styryl 4-methoxy-1-naphthyl ketones [(2E)-1-(4-methoxy-1-naphthyl)-3-phenyl-2-propen-1-ones] were synthesized using facile method of microwave assisted condensation reaction. The yield of chalcones is more than 90%. They are characterized by their physical constants, micro analysis, infrared (KBr, 4000-400 cm^{-1}) and NMR both ^1H and ^{13}C spectral data. From infrared spectra, the s-cis and s-trans stretching vibrations of carbonyl group, from NMR spectra the ethylenic proton and carbon chemical shifts (ppm) are assigned. These spectral data are correlated with various Hammett substituent constants. From the results of statistical analysis the effect of substituents on CO, α and β proton and carbons are explained.

Keywords: Synthesis, Substituent Effects, Infrared Spectroscopy, NMR Spectroscopy, Naphthyl Chalcones

INTRODUCTION

With microwave irradiation of substituted benzaldehydes and aromatic ketones in presence of anhydrous zinc chloride gave exclusively high yield of substituted styryl chalcones.[1] Their basic skeletons of chalcones are widely figured in natural products and are known to have multi pronged activity.[2] Many of the chalcones are used as agrochemical and drugs.[3] Recently much attention has paid on the synthesis of chalcones mainly from acetophenone analogs[4] with various aromatic benzaldehydes. Several catalysts[5] such as basic alumina, Al$_2$O$_3$-AlPO$_4$, P$_2$O$_5$-piperidone ultrasonic rays using C-200 and Lewis acids have been used for knovenogal condensation and bases or quaternary ammonium salts have also been employed. Further studies on the efficient synthesis of chalcones are of current interest because of their wide range of application. Thus the author to report here the first time a simple fac-

ile approach to synthesis high yield of substituted
styryl 4-methoxy-1-naphthyl chalcones and investi-
gate the substituent effects from infrared and nuclear
magnetic resonance spectra were recorded.

EXPERIMENTAL SECTION

A mixture of substituted benzaldehydes (0.01 mol)
and 4-methoxy-1-naphthyl ketones (0.01 mol) and
anhydrous zinc chloride (0.001mol) was taken in
ACE tube and flushed with Argon and tightly
capped. The mixture is subjected to microwave
oven heating for 5-8 minutes in a domestic micro-
wave oven (LG Microwave Oven MG-395WA)
and then it is allowed to reach to room temperature.
The reaction mixture was treated with ethanol and
the separated solid was filtered, washed with n-Hex-
ane and dried. The solid was recrystallised by ben-
zene-hexane mixture[6]. The reaction is shown in
Scheme 1. Compounds a-f and h are unknown and
the remaining compounds are known.

Melting points were determined in open glass
capillaries on Mettler FP51 melting point apparatus
and are uncorrected. Infrared spectra (KBr, 4000-
400 cm[1]) were recorded on JASCO IR-700 Japan
model spectrophotometer. The nuclear magnetic
resonance spectra both ^{1}H and ^{13}C of chalcones
were recorded using UNITYPLUS-300 "KIBSIPS"
300 MHz spectrometer, operating at 200MHz fre-
quency for recording ^{1}H NMR spectra and 75.45 MHz

frequency for recording ^{13}C NMR Spectra. The micro
analysis of the chalcones were performed in Perkin
Elmer 240C Analyzer.

Based on Hays and Timmons[7] infrared carbonyl
stretching frequencies of s-cis and s-trans conform-
ers are assigned. The NMR chemical shifts (ppm)
of ethylene α, β protons and carbons are assigned
based on reported in earlier literature[8]. The Physi-
cal constants, micro analysis and spectral data of all
chalcones are summarized in Table 1.

Substituent effects

Correlation study involves the prediction of ground
state molecular equilibrations[11] of organic substrates
such as s-cis and s-trans isomers of alkenes, alkynes,
benzoylchlorides, styrenes and α, β-unsaturated ketones
from spectral data. Their use in structure parameter
correlations has now becomes popular for studying
transition state study of reaction mechanisms,[12] bio-
logical activities and normal coordinate analysis.[13]
Dhami and Stothers[14] have extensively studied the
^{1}H NMR spectra of a large number of acetophenones
and styrenes with a view to establish the validity of
the additivity of substituent effects in aromatic
shieldings, first observed by Lauterber.[15] Savin and
coworkers[16] obtained the NMR spectra of unsatur-
ated ketones of the type RC_nH_4-CH=CH-COCMe,
and sought Hammett correlations for the ethylenic
protons. Solcaniova and coworkers[17] have measured
^{1}H and ^{13}C NMR spectra of substituted phenyl sty-
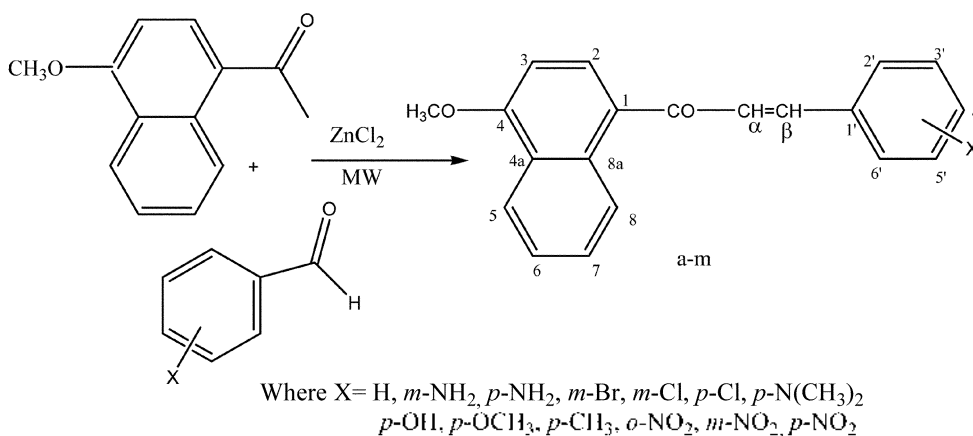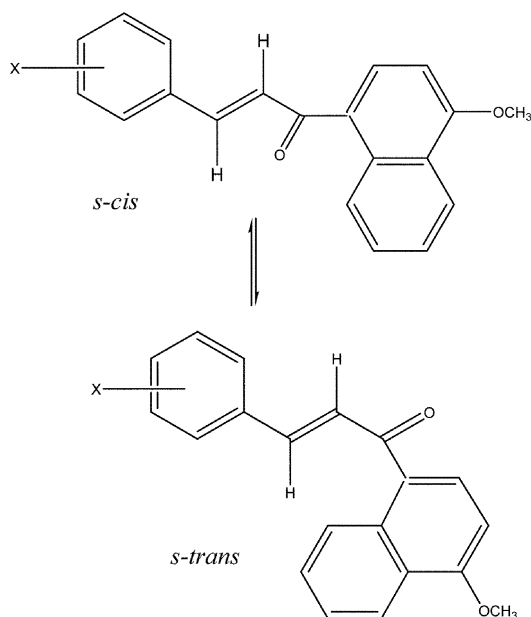
Where X= H, m-NH$_2$, p-NH$_2$, m-Br, m-Cl, p-Cl, p-N(CH$_3$)$_2$
p-OH, p-OCH$_3$, p-CH$_3$, o-NO$_2$, m-NO$_2$, p-NO$_2$

Scheme 1.

s-cis

s-trans

(I)

Where X= H, m-NH₂, p-NH₂, m-Br, m-Cl, p-Cl, p-N(CH₃)₂,
p-OH, p-OCH₃, p-CH₃, o-NO₂, m-NO₂, p-NO₂

(II)
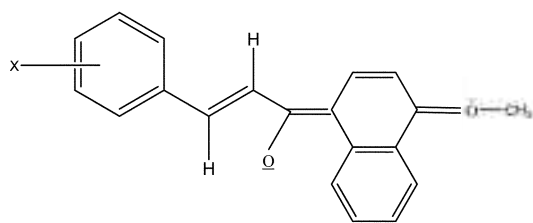
Where X= H, m-NH₂, p-NH₂, m-Br, m-Cl, p-Cl, p-N(CH₃)₂,
p-OH, p-OCH₃, p-CH₃, o-NO₂, m-NO₂, p-NO₂

renes and substituted styryl phenyls and obtained good Hammett correlations for the olefinic protons and carbons. Now a day's scientists[18] have paid more interest to correlate the group frequencies of spectral data with Hammett substituent constants to explain the substituent effect of organic compounds. Recently Dae Dong Sung and Ananthakrishna Nadar[19] investigate elaborately the single and multi substituent effects by spectral data of biphenyl and 9H-Fluorenyl chalcones. With in the above view there is no information available in the literature in the past with substituted styryl 4-methoxy-1-naphthyl ketones.

Hence the authors have synthesized thirteen chalcones of the above type using microwave irradiation technique. And the substituent effects of above compounds are investigated from infrared and NMR spectra were made.

Substituent Effects from infrared spectra

The carbonyl stretching frequencies (cm⁻¹) of s-cis and s-trans isomers of present study are shown in Table 1 and the corresponding conformers are shown in (I).

The infrared spectra were all recorded on the KBr disc in order to avoid the shoulder formation[20] on carbonyl doublets. The s-cis conformers exhibit higher frequencies than the s-trans conformers due to the bulkier naphthalene group causes greater strain and they enhance the higher absorption of carbonyl group of s-cis isomer than the s-trans isomer. These frequencies are separately analyzed through various Hammett sigma constants.

From the statistical analysis, there is no significant correlation obtained with Hammett sigma constants in s-cis conformers. This is the conjugation between the C–O and the -CH–CH- parts is less important due to non-co planarity arising out of non bonded repulsion between naphthalene and styryl parts in the systems. In s-cis conformers there is significant correlation is obtained (r=0.995) with σ_R constants. Further no significant correlations are obtained for both conformers with σ^+, σ_I and σ_R parameters except s-trans with σ_R constants. This is due to the cross conjugation of methoxy substituent in fourth position of naphthyl ring as shown in (II)

In view of the inability of some σ constants to produce individually satisfactory correlations, it was thought worthwhile to seek multiple correlations involving either σ_I and σ_R constants or Swain-Lupton's F and R parameters. The correlation equations (1,2) generated are

vC=O (s-cis) (cm⁻¹)=1669 + 17.660F + 11.697R
(±2.311) (±4.580) (±2.900)
(R=0.939, n=13, P > 90%)   (1)

vC–O (s-trans) (cm⁻¹)=1638.8-2.769σ_I · 29.893σ_R

Table 1. Physical constants. micro analysis and spectral data of substituted styryl 4-methoxy-1-naphthyl ketones.

No.	Molecular formula	m.p. °C	%C (Required)	%H (Required)	%N (Required)
a	$C_{20}H_{16}O_2$	113-114(113)[1]	---	---	---
b	$C_{20}H_{15}NO_3$	99-100	79.13(79.19)	5.46(5.65)	4.60(4.62)
c	$C_{20}H_{15}NO_3$	82-83	79.16(79.19)	5.59(5.65)	4.58(4.62)
d	$C_{20}H_{15}BrO_2$	78-79	65.36(65.41)	4.09(4.12)	---
e	$C_{20}H_{15}ClO_2$	120-121	74.38(74.42)	4.61(4.68)	---
f	$C_{20}H_{15}ClO_2$	137-138	74.40(74.42)	4.64(4.68)	---
g	$C_{22}H_{21}NO_2$	126-127(127)[ii]	---	---	---
h	$C_{20}H_{16}O_3$	113-114	78.19(78.93)	5.23(5.30)	---
i	$C_{20}H_{18}O_3$	88-89(88)[v]	---	---	---
j	$C_{20}H_{18}O_2$	114-115(115)[v]	---	---	---
k	$C_{20}H_{15}NO_2$	106-107(106)[v]	---	---	---
l	$C_{20}H_{15}NO_2$	113-114(114)[16]	---	---	---
m	$C_{20}H_{15}NO_2$	141-142(142)[iii]	---	---	---

No	IR v(cm⁻¹)		¹H NMR δ(ppm)		¹³C NMR δ(ppm)	
	CO (s-cis)	CO (s-trans)	d, 1H, α	d, 1H, β	C_α	C_β
a	1666	1635	8.312	8.560	119.400	139.363
b	1668	1622	8.262	8.524	119.266	140.604
c	1663	1624	8.021	8.364	118.700	138.495
d	1665	1630	8.368	8.660	119.889	141.257
e	1673	1637	8.442	8.614	119.583	142.376
f	1671	1631	8.361	8.531	119.330	140.626
g	1658	1627	7.921	8.331	118.922	137.175
h	1663	1625	8.019	8.454	119.406	138.690
i	1667	1354	8.324	8.454	119.977	140.873
j	1662	1639	8.240	8.510	118.491	141.270
k	1684	1641	8.542	8.641	119.936	143.914
l	1685	1637	8.654	8.742	120.325	140.312
m	1681	1640	8.623	8.714	120.157	142.472

$$(\pm 2.181)\ (\pm 4.907)\ (\pm 4.185)$$
$$(R=0.927,\ n=13,\ P > 90\%) \qquad (2)$$

Some cases where both the group parameters were fail to predict collectively the substituent effects. This may treated exceptional and by large it is to be realized that the collective participation of either σ_I and σ_R parameters or F and R parameters is more dependent than that of any single parameters role to predict the substituent effects. A good single parameter correlation is shown in *Fig.* 1.

Substituent effects from NMR Spectra
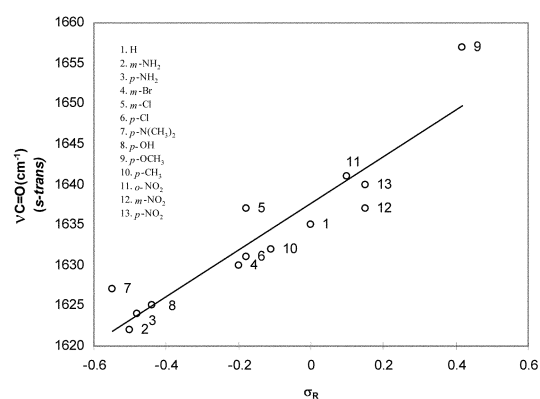### ¹H NMR Spectra
The ¹H NMR spectral signals of ethylenic pro-

Fig. 1. Plot of νC–O (s-trans) of substituted styryl 4-methoxy-1-naphthyl ketones versus σ_R.

tons in all chalcones investigated are assigned. The chemical shifts of H_α protons are at higher field

Table 2. Results of statistical analysis of chemical shifts of H_α and H_β protons of substituted styryl 4-methoxy-1-naphthyl ketones

Type of protons	Constants for correlation	r	I	ρ	s	n	Substituents in styryl part
H_α	σ	0.974	8.278	0.148	0.070	13	H, m-NH₂,
	σ I	0.970	8.355	0.263	0.077	13	p-NH₂, m-Br,
	σ-	0.878	8.096	0.687	0.150	13	m-Cl, p-Cl,
	σ_R	0.861	8.391	0.564	0.158	13	p-NMe₂, p-OH,
H_β	σ	0.980	8.527	0.233	0.031	13	p-OCH₃,
	σ+	0.983	8.570	0.149	0.030	13	p-CH₃, o-NO₂,
	σ-	0.900	8.430	0.369	0.083	13	m-NO₂
	σ_R	0.766	8.547	0.247	1.105	13	p-NO₂

Table 3. Results of statistical analysis of chemical shifts of H_α and H_β protons of substituted styryl 4-methoxy-1-naphthyl ketones with σ_I and σ_R or F and R parameters

Correlation equations for H_α protons	
$\delta_{H_\alpha}^{(ppm)} = 8.213 + 0.481\sigma_I + 0.368\sigma_R$	$\delta_{H_\alpha}^{(ppm)} = 8.350 + 0.296F + 0.415R$
(+ 0.067) (+ 0.151) (+ 0.129)	(+ 0.070) (+0.140) (−0.089)
(R − 0.938, n − 13, P > 90%)	(R − 0.960, n − 13, P > 90%)
Correlation Equations for H_β protons	
$\delta_{H_\beta}^{(ppm)} = 8.470 − 0.299\sigma_I + 0.125\sigma_R$	$\delta_{H_\beta}^{(ppm)} = 8.566 + 0.166F + 0.224R$
(= 0.047) (± 0.107) (± 0.091)	(± 0.041) (± 0.082) (= 0.052)
(R = 0.902, n = 13, P > 95%)	(R = 0.955, n = 13, P > 90%)

than those of H_β protons in all chalcones. The ethylenic proton signals give an AB pattern and the β protons doublet in most cases is well separated from the signals of the aromatic protons. The chemical shifts of α, β protons are given in *Table* 1. The observation that H_α protons appear at higher field than that of H_β protons makes the subject very interesting. This may possibly due to the polarization of C=C double bond in the system being predominantly caused by the carbonyl group so as to make electron density greater at the α position than that of β position.

The results of statistical analysis are presented in *Table* 2. All the attempted correlations involving substituent parameters gave only positive ρ values. This shows normal substituent effects is operates in all the chalcones. The Chemical shifts observed for H_α and the H_β protons in the present investigation are correlated satisfactorily with Hammett sigma constants. In some cases correlation of H_β with σ values is slightly better. By and large the necessity of enhanced σ values for correlation is not demanded by substituents. That the correlation with σ_I and σ_R parameters is not satisfactory in H_α implies that
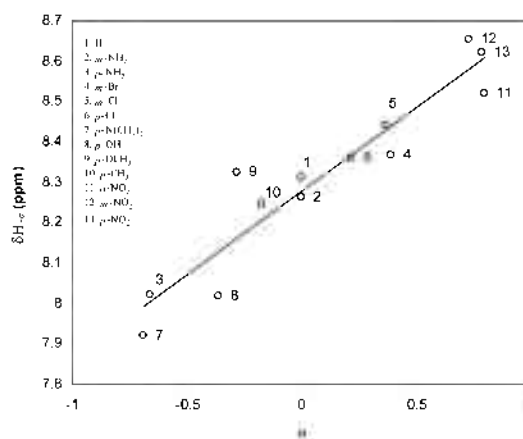
Fig. 2. Plot of δH-α (ppm) of substituted styryl 4-methoxy-1-naphthyl ketones versus σ.

such σ values are incapable of predicting chemical shifts individually due to the domination of cross conjugation between carbonyl group and methoxy group in naphthyl ring. In *Table* 3 the multiple correlations involving either σ_I and σ_R or F and R values for these ketones are presented. It is indeed satisfactorily that in most cases the multiple correlations are successful. Some of the single parameter
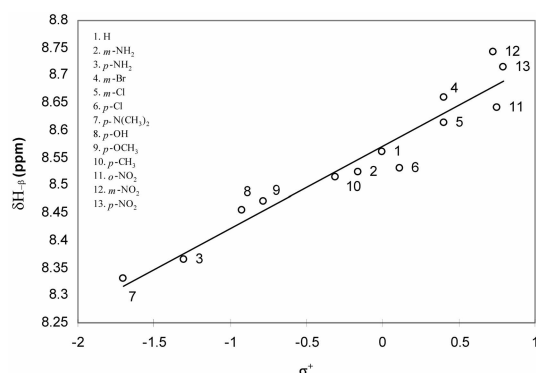
Fig. 3. Plot of δH-β (ppm) of substituted styryl 4-methoxy-1-naphthyl ketones versus σ⁺.

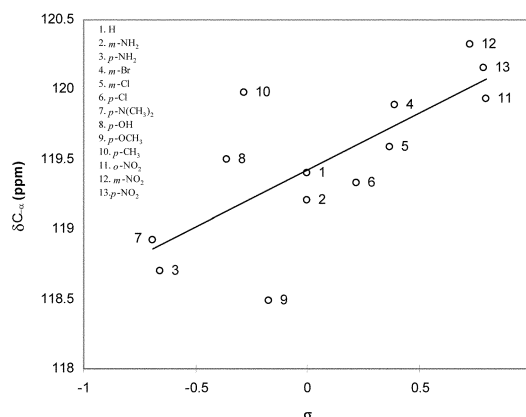correlations are shown in *Fig.* 2, 3.

¹³C NMR Spectra

From ¹³C NMR spectra the observed ¹³C Chemical shifts of C_α and the C_β carbons are presented in *Table* 1. These chemical shifts are correlated with various Hammett substituent constants. The results of statistical analysis of substituent effects on C_α and C_β carbons are shown in *Table* 4. There is a fair degree of correlation obtained for C_α and the C_β carbon chemical shifts with Hammett sigma constants.

Fig. 4. Plot of δC-α (ppm) of substituted styryl 4-methoxy-1-naphthyl ketones versus σ.

The degree of transmission of electronic effects is found to be higher with C_α carbon than C_β carbon. Uniformly σ_I and σ_R parameters or F and R values are adequately explain the substituent effects in all chalcones are evidenced from the correlation equations which are given in *Table* 5.

In single parameter correlations, there are satisfactory correlations obtained with σ⁺ values for C_α

Table 4. Results of statistical analysis of chemical shifts of C_α and C_β protons of substituted styryl 4-methoxy-1-naphthyl ketones

Type of carbons	Constants for correlation	r	I	ρ	s	n	Substituents in styryl part
C_α	σ	0.937	119.421	0.813	0.393	13	H, m-NH₂,
	σ+	0.880	119.563	0.457	0.435	13	p-NH₂, m-Br,
	σ_I	0.907	118.915	1.819	0.333	13	m-Cl, p-Cl, p-NMe₂,
	σ_R	0.768	119.670	1.265	0.439	13	p-OH,
C_β	σ	0.909	140.397	2.906	1.118	13	p-OCH₃,
	σ⁺	0.907	140.834	1.875	1.096	13	p-CH₃, o-NO₂,
	σ_I	0.902	139.137	4.756	1.459	13	m-NO₂,
	σ_R	0.724	141.144	3.574	2.501	13	p-NO₂

Table 5. Results of statistical analysis of chemical shifts of C_α and C_β carbons of substituted styryl 4-methoxy-1-naphthyl ketones with σ_I and σ_R or F and R parameters

Correlation equations for C_α carbons	
$\delta_{C_\alpha}^{(ppm)} = 119.130 - 1.439\sigma_I + 0.679\sigma_R$	$\delta_{C_\alpha}^{(ppm)} = 118.967 + 1.788F - 0.154R$
(± 0.166) (± 0.374) (= 0.319)	(= 0.250) (= 0.495) (± 0.313)
(R = 0.939, n = 13, P > 90%)	(R = 0.914, n = 13, P > 90%)
Correlation equations for C_β carbons	
$\delta_{C_\beta}^{(ppm)} = 139.8 + 3.589\sigma_I + 2.067\sigma_R$	$\delta_{C_\beta}^{(ppm)} = 140.849 + 2.464 F \cdot 2.716 R$
(± 0.807) (± 1.815) (± 1.548)	(± 0.988) (± 1.953) (± 1.240)
(R = 0.911, n = 13, P > 90%)	(R = 0.940, n = 13, P > 90%)

and C_β carbons. This implies that one need not attach any significance to the correlations involving σ values. A good single parameter correlation is shown in *Fig. 4.*

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