A PRELIMINARY STUDY ON PREDICTING THE ^{13}C CHEMICAL SHIFTS FOR A SERIES OF DISUBSTITUTED 2,3-DIPHENYL-1,3-THIAZOLIDIN-4-ONES

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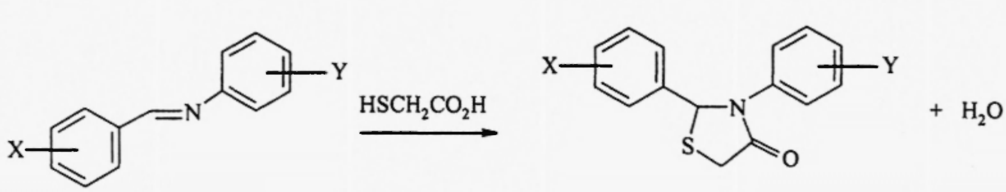
Abstract: A successful attempt has been made to predict ^{13}C chemical shifts for a series of disubstituted 2,3-diphenyl-1,3-thiazolidin-4-ones. Prior work has shown that substituents placed on either phenyl ring of the 2,3-diphenyl-1,3-thiazolidin-4-one system affect the electron density surrounding the C-2, C-4 and C-5 atoms. These changes are reflected in the different nmr chemical shifts for these carbon atoms relative to the unsubstituted compound. The ^{13}C chemical shifts for the C-2, C-4 and C-5 carbons of these compounds have previously been shown to correlate with Hammett σ constants and Swain Lupton dual substituent parameters. Because of these correlations we decided to investigate the potential for predicting ^{13}C chemical shifts for C-2, C4 and C-5 in the thiazolidinone ring based on the known shifts for the two mono-substituted series of compounds. The effect of the substituents on the ^{13}C chemical shifts for the C-2, C-4 and C-5 carbons in the disubstituted 2,3-diphenylthiazolidinones are discussed relative to the two *mono*-substituted 2,3-diphenylthiazolidinone series. The data is then used to predict the ^{13}C chemical shift values at C-2, C-4 and C-5 in the thiazolidinone ring with all possible substituents combinations in the 2-phenyl and 3-phenyl rings.

Introduction

The reasons for our interest in thiazolidinones have been discussed extensively in previous publications.[1-5] It should be pointed out that the most popular method of synthesizing the substituted diphenyl-1,3-thiazolidin-4-ones, shown in Scheme 1, is by the reaction of the appropriately substituted imine with thioglycollic acid.[6,7] However, this method does not always result in the desired product.



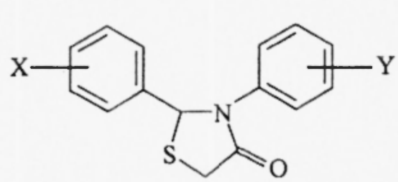
Scheme 1

When the formation of the imine is attempted by the reaction of chloral hydrate with an amine, the reaction can result in two outcomes depending on whether the amine is aliphatic or aromatic. The reaction of an aromatic amine yields an unstable imine[8] that can be trapped with thioglycolic acid to form a thiazolidinone,[4] and the reaction with an aliphatic amine produces formamides.[9] Recently, evidence of oxazolidione formation has been shown as a side reaction in the process.[6] Attempts to use hydroxylated aldehydes for imine formation by treatment with substitiuted anilines result in polymeric products.[10] Having a method for predicting the C-2, C-4 and C-5 resonances, in advance of synthesis, would aid in a quick confirmation of the desired product.

Results and Discussion.

We previously reported an investigation of the relationship between substituent chemical shift values for two series of monosubstituted 2,3-diphenyl-1,3-thiazolidin-4-ones, with both Hammett and Swain Lupton substituent constants.[2] A similar study utilizing differently substituted diphenyl thiazolidinones has also been reported.[11]

Based on these previous studies[2,11] we became interested in seeing if the same substituent, placed at the same position in both rings would give predictable ^{13}C chemical shift values at C-2, C-4 and C-5. This should be the case in light of the Hammett correlations previously observed for the two monosubstituted Series 1 and 2 (Figure 1). Three additional monosubstituted diphenyl-1,3-thiazolidinones, **1k**, **1m** and **2m** (Figure 1) that were not included in the original work[2] were synthesized. Their addition to the sequence of monosubstituted compounds did not change the correlations determined in the original work; their synthesis did complete the full comparison with the disubstituted diphenyl-1,3-thiazolidinones in Series 3. We report in Table 1, the high resolution ^{13}C nmr results for the two mono-substituted series of 2,3-diphenyl-1,3-thiazolidin-4-ones (Series 1 and 2).



Series 1: X = *p*-NO_2, *m*-NO_2, *p*-F, *m*-F, *p*-Cl, *p*-Br, *m*-Br, H, *p*-CH_3, *m*-CH_3, *p*-OCH_3, *m*-OCH_3; Y = H

Series 2: Y = *p*-NO_2, *m*-NO_2, *p*-F, *m*-F, *p*-Cl, *p*-Br, *m*-Br, H, *p*-CH_3, *m*-CH_3, *p*-OCH_3, *m*-OCH_3; X = H

Series 3: X = Y = *p*-NO_2, *m*-NO_2, *p*-F, *m*-F, *p*-Cl, *p*-Br, *m*-Br, *p*-CH_3, *m*-CH_3, *p*-OCH_3, *m*-OCH_3

Figure 1

Also shown in Figure I are the disubstituted diphenylthiazolidinones of Series 3. The experimental ^{13}C chemical shift values at C-2, C-4 and C-5 are presented Table 2. The values in parentheses below for each of the experimental values are calculated chemical shift values, derived from the values for the two monosubstituted series. Equation 1 was used to calculate the values given in Table 2. The calculated chemical shift value for C-2, C-4 or C-5 in Series 3 compounds is denoted as δ_{XY}. Similarly, δ_H is the chemical shift value for the unsubstituted compound, δ_X is the chemical shift value observed for Series 1 compounds, and δ_Y is the chemical shift value observed for Series 2 compounds.

$\delta_{XY} = \delta_H + (\delta_X\text{-}\delta_H) + (\delta_Y\text{-}\delta_H)$ (1)

The largest deviations between experimental and predicted ^{13}C chemical shifts for the Series 3 compounds occurs at C-2, in particular, for the *para*-nitro **3a**, *meta*-nitro **3b**, *meta*-fluoro **3d** and *meta*-methoxy **3m** substituents. All the other predicted chemical shifts are within 0.1 ppm of the respective experimental values for C-2, C-4 and C-5.

An additional resonance effect between the two nitro groups in **3a** is probably in play accounting for the difference in experimental and predicted chemical shifts. The transmission of effects from substituents on the phenyl rings at C-2 and N-3 are not equal. We previously noted an attenuation of effects from substituents to sites, C-2, C-4 and C-5, in the thiazolidinone ring, from the phenyl ring via the N-3 atom. The *para*-nitro group on the N-3 phenyl is probably exhibiting an increased attenuation with the *para*-nitro group on the C-2 phenyl, hence the 0.35 ppm difference between experimental and predicted values; this discrepancy is not predicted from the linear combination of the individual mono-substituted Series 1 and 2. Also, additional inductive effects must play a role in order to account for the discrepancies between experimental and predicted ^{13}C chemical shifts at C-2 for **3b**, **3d** and **3m**, respectively.

Table-1: ^{13}C Chemical Shift Data for the Two Series of Monosubstituted 2,3-Diphenylthiazolidin-4-ones in ppm relative to TMS.

Compound	substituent X	substituent Y	C(2)	C(4)	C(5)
1a	*p*-NO_2	H	64.06	170.60	33.21
2a	H	*p*-NO_2	64.53	170.67	33.37
1b	*m*-NO_2	H	64.52	170.73	33.39
2b	H	*m*-NO_2	64.94	171.10	33.35
1c	*p*-F	H	64.92	170.82	33.43
2c	H	*p*-F	65.59	170.98	33.23
1d	*m*-F	H	64.88	170.88	33.29
2d	H	*m*-F	65.33	170.97	33.38
1e	*p*-Cl	H	64.73	170.65	33.32
2e	H	*p*-Cl	65.31	170.90	33.35
1f	*m*-Cl	H	64.88	170.80	33.31
2f	H	*m*-Cl	65.34	170.98	33.35
1g	*p*-Br	H	64.85	170.69	33.35
2g	H	*p*-Br	65.24	170.88	33.35
1h	*m*-Br	H	64.72	170.92	33.41
2h	H	*m*-Br	65.16	170.78	33.24
1i	H	H	65.51	170.99	33.47
1j	*p*-CH_3	H	65.57	170.92	33.43
2j	H	*p*-CH_3	65.68	170.98	33.41
1k	*m*-CH_3	H	65.50	171.04	33.39
2k	H	*m*-CH_3	65.68	170.93	33.41
1l	*p*-OCH_3	H	65.41	170.93	33.54
2l	H	*p*-OCH_3	65.91	171.10	33.36
1m	*m*-OCH_3	H	65.37	170.95	33.35
2m	H	*m*-OCH_3	66.29	171.70	34.14

At this point we have chosen not to make any additional corrections for the discrepancies between the experimental and predicated values already mentioned. This method of predicting the chemical shift values by using experimental data does appear to show a reasonable degree of sensitivity to the substituents used in this study.

Further, using Equation 1, we can predict the ^{13}C chemical shift values at C-2, C-4 and C-5 for the disubstiuted thiazolidinones where the substituents are different on both rings. The predicted values for the ^{13}C chemical shifts for C-2 are shown in Table 3 and the values for C-4 and C-5 are shown in Tables 4 and 5, respectively.

Table-2: Experimental and Calculated (in parenthesis) ^{13}C Chemical Shift Data for a Series of Disubstituted 2,3-Diphenylthiazolidin-4-ones in ppm relative to TMS.

compound	Substituent X = Y	C(2)	C(4)	C(5)
3a	*p*-NO_2	63.43 (63.08)	170.76 (170.28)	33.14 (33.11)
3b	*m*-NO_2	63.79 (63.95)	170.79 (170.84)	33.27 (33.27)
3c	*p*-F	65.07 (65.00)	170.84 (170.81)	33.31 (33.19)
3d	*m*-F	64.51 (64.70)	170.80 (170.86)	33.22 (33.20)
3e	*p*-Cl	64.59 (64.53)	170.74 (170.56)	33.29 (33.20)
3f	*m*-Cl	64.51 (64.71)	170.81 (170.79)	33.23 (33.19)
3g	*p*-Br	64.64 (64.58)	170.78 (170.58)	33.34 (33.23)
3h	*m*-Br	64.44 (64.37)	170.76 (170.71)	33.17 (33.18)
3j	*p*-CH_3	65.54 (65.74)	171.04 (170.92)	33.47 (33.37)
3k	*m*-CH_3	65.59 (65.67)	171.03 (170.98)	33.37 (33.33)
3l	*p*-OCH_3	65.71 (65.81)	171.02 (171.04)	33.42 (33.43)
3m	m-OCH_3	65.39 (66.15)	170.93 (171.66)	33.33 (34.02)

Conclusions

The chemical shifts at C-2, C-4 and C-5 for a series of *bis*-disubstituted thiazolidin-4-ones were measured experimentally. The ^{13}C chemical shifts for the same sites were predicted from two mono-substituted series of thiazolidones using an additive formula (Equation 1). The predicted ^{13}C chemical shift values were in good agreement with the experimental values to within 0.1 ppm. There were four compounds outside this range, the 3a, 3b, 3d and 3m; however, the upfield or downfield shift for these values was in the same direction that would generally be predicted by the substituents.

With the 23 monosubstituted diphenylthiazolidinones and the corresponding 12 disubstituted diphenylthiazolidinones it is possible to predict the ^{13}C chemical shift values for the other 134 compounds in the 13 x 13 matrix of potential derivatives.

Table-3: Calculated ^{13}C Chemical Shifts for C-2

2-phenyl- ↓ / 3-phenyl- →	p-nitro	m-nitro	p-F	m-F	p-Cl	m-Cl	p-Br	m-Br	H	p-Me	m-Me	p-MeO	m-MeO
p-nitro	63.02	63.43	64.08	63.82	63.80	63.83	63.73	63.65	64.06	64.17	64.17	64.40	64.78
m-nitro	63.48	63.89	64.54	64.28	64.26	64.29	64.19	64.11	64.52	64.63	64.63	64.86	65.24
p-F	63.88	64.29	64.94	64.68	64.66	64.69	64.59	64.51	64.92	65.03	65.03	65.26	65.64
m-F	63.84	64.25	64.90	64.64	64.62	64.65	64.55	64.47	64.88	64.99	64.99	65.22	65.60
p-Cl	63.69	64.10	64.75	64.49	64.47	64.50	64.40	64.32	64.73	64.84	64.84	65.07	65.45
m-Cl	63.84	64.25	64.90	64.64	64.62	64.65	64.55	64.47	64.88	64.99	64.99	65.22	65.60
p-Br	63.81	64.22	64.87	64.61	64.59	64.62	64.52	64.44	64.85	64.96	64.96	65.19	65.57
m-Br	63.68	64.09	64.74	64.48	64.46	64.49	64.39	64.31	64.72	64.83	64.83	65.06	65.44
H	64.53	64.94	65.59	65.33	65.31	65.34	65.24	65.16	65.57	65.68	65.68	65.91	66.29
p-Me	64.53	64.94	65.59	65.33	65.31	65.34	65.24	65.16	65.57	65.68	65.68	65.91	66.29
m-Me	64.46	64.87	65.52	65.26	65.24	65.27	65.17	65.09	65.50	65.61	65.61	65.84	66.22
p-MeO	64.37	64.78	65.43	65.17	65.15	65.18	65.08	65.00	65.41	65.52	65.52	65.75	66.13
m-MeO	64.33	64.74	65.39	65.13	65.11	65.14	65.04	64.96	65.37	65.48	65.48	65.71	66.09

Table-4: Calculated ^{13}C Chemical Shifts for C-4

2-phenyl- ↓ / 3-phenyl- →	p-nitro	m-nitro	p-F	m-F	p-Cl	m-Cl	p-Br	m-Br	H	p-Me	m-Me	p-MeO	m-MeO
p-nitro	170.35	170.78	170.66	170.65	170.58	170.66	170.56	170.46	170.60	170.66	170.61	170.78	171.38
m-nitro	170.48	170.91	170.79	170.78	170.71	170.79	170.69	170.59	170.73	170.79	170.74	170.91	171.51
p-F	170.57	171.00	170.88	170.87	170.80	170.88	170.78	170.68	170.82	170.88	170.83	171.00	171.60
m-F	170.63	171.06	170.94	170.93	170.86	170.94	170.84	170.74	170.88	170.94	170.89	171.06	171.66
p-Cl	170.40	170.83	170.71	170.70	170.63	170.71	170.61	170.51	170.65	170.71	170.66	170.83	171.43
m-Cl	170.55	170.98	170.86	170.85	170.78	170.86	170.76	170.66	170.80	170.86	170.81	170.98	171.58
p-Br	170.44	170.87	170.75	170.74	170.67	170.75	170.65	170.55	170.69	170.75	170.70	170.87	171.47
m-Br	170.67	171.10	170.98	170.97	170.90	170.98	170.88	170.78	170.92	170.98	170.93	171.10	171.70
H	170.67	171.10	170.98	170.97	170.90	170.98	170.88	170.78	170.92	170.98	170.93	171.10	171.70
p-Me	170.67	171.10	170.98	170.97	170.90	170.98	170.88	170.78	170.92	170.98	170.93	171.10	171.70
m-Me	170.79	171.22	171.10	171.09	171.02	171.10	171.00	170.90	171.04	171.10	171.05	171.22	171.82
p-MeO	170.68	171.11	170.99	170.98	170.91	170.99	170.89	170.79	170.93	170.99	170.94	171.11	171.71
m-MeO	170.70	171.13	171.01	171.00	170.93	171.01	170.91	170.81	170.95	171.01	170.96	171.13	171.73

Table-5: Calculated ^{13}C Chemical Shifts for C-5

2-phenyl- ↓ / 3-phenyl- →	p-nitro	m-nitro	p-F	m-F	p-Cl	m-Cl	p-Br	m-Br	H	p-Me	m-Me	p-MeO	m-MeO
p-nitro	33.17	33.15	33.03	33.18	33.15	33.15	33.15	33.04	33.21	33.21	33.21	33.16	33.94
m-nitro	33.35	33.33	33.21	33.36	33.33	33.33	33.33	33.22	33.39	33.39	33.39	33.34	34.12
p-F	33.39	33.37	33.25	33.40	33.37	33.37	33.37	33.26	33.43	33.43	33.43	33.38	34.16
m-F	33.25	33.23	33.11	33.26	33.23	33.23	33.23	33.12	33.29	33.29	33.29	33.24	34.02
p-Cl	33.28	33.26	33.14	33.29	33.26	33.26	33.26	33.15	33.32	33.32	33.32	33.27	34.05
m-Cl	33.27	33.25	33.13	33.28	33.25	33.25	33.25	33.14	33.31	33.31	33.31	33.26	34.04
p-Br	33.31	33.29	33.17	33.32	33.29	33.29	33.29	33.18	33.35	33.35	33.35	33.30	34.08
m-Br	33.37	33.35	33.23	33.38	33.35	33.35	33.35	33.24	33.41	33.41	33.41	33.36	34.14
H	33.37	33.35	33.23	33.38	33.35	33.35	33.35	33.24	33.41	33.41	33.41	33.36	34.14
p-Me	33.39	33.37	33.25	33.40	33.37	33.37	33.37	33.26	33.43	33.43	33.43	33.38	34.16
m-Me	33.35	33.33	33.21	33.36	33.33	33.33	33.33	33.22	33.39	33.39	33.39	33.34	34.12
p-MeO	33.50	33.48	33.36	33.51	33.48	33.48	33.48	33.37	33.54	33.54	33.54	33.49	34.27
m-MeO	33.31	33.29	33.17	33.32	33.29	33.29	33.29	33.18	33.35	33.35	33.35	33.30	34.08

Experimental

The thiazolidine-4-ones were prepared, with one exception, using the procedure previously described[2] by adapting a method originally utilized by Surrey.[12] Compound **3a** was prepared by forming the imine *in situ* in refluxing ethanol for 3 hours. After cooling, the thioglycolic acid was added to the ethanol solution and the solution was further heated under reflux for 48 hours. On cooling the product crystallized out. The compounds **1a-j**, **1l**, and **2a-l** have all been previously reported.[2] Melting points are uncorrected; a Mel-Temp apparatus was used. All spectra were recorded on a Bruker 300 at 298K observing ^{1}H and ^{13}C at 300.15 and 75.48 MHz, respectively. All samples were dissolved in $CDCl_3$ at a concentration of 100 mg/mL using precision bore 5 mm nmr tubes supplied by Norell, Inc.

^{1}H spectra were collected into 32K data sets over a spectral width of 3012.0 Hz using a 30° pulse; pulse width, 3.0 μs; acquisition time, 2.72 s; relaxation delay, 1.0 s; number of scans, 16. ^{13}C spectra were collected into 16K data sets over a spectral width of $\pm$10.000 Hz with a 60° observed pulse using Waltz-16 decoupling; pulse width, 6.0 μs; acquisition time 409.6 ms; relaxation delay, 2.00 s; number of scans, 512. Elemental analyses on all samples were performed by Galbraith Laboratories, Inc., 2323 Sycamore Drive, Knoxville, TN 37921-1750 USA

2,3-Diphenylthiazolidin-4-one (**1i**): yield 60%; m.p. 131-132 °C, (lit. m.p.130-131 °C)[2,13]; ^{1}H NMR: δ 7.30-7.14 (9H, m), 6.09 (1H, s,), 4.01-3.82 (2H, dd, J = 15.9 Hz); ^{13}C NMR: δ 170.99, 139.51, 137.51, 129.05, 128.85, 126.91, 125.54, 65.57, 33.41.

2-(3-Methylphenyl)-3-phenyl-1,3-thiazolidin-4-one (**1k**): yield 74%; m.p. 111-112 °C; Anal. Found: C, 71.55; H, 5.87. Calc. for $C_{16}H_{15}NOS$: C, 71.35; H, 5.61; ^{1}H NMR: δ 7.31-7.05 (9H, m), 6.07 (1H, s,), 4.03, 3.98, 3.87, 3.82 (2H, dd, J = 15.6 Hz), 2.29 (3H, s); ^{13}C NMR: δ 171.04, 139.62, 138.61, 137.62, 129.62, 129.00, 128.73, 127.30, 126.90, 125.41, 123.81, 65.50, 33.39, 21.37.

2-(4-Methoxyphenyl)-3-phenyl-1,3-thiazolidin-4-one (**1m**): yield 68%; m.p. 117-118 °C; Anal. Found: C, 67.71; H, 5.48. Calc. for $C_{16}H_{15}NO_2S$: C, 67.34; H, 5.30; ^{1}H NMR: δ 7.29-6.76 (9H, m), 6.07 (1H, s), 4.01, 3.95, 3.86, 3.81 (2H, dd, J = 15.9 Hz), 3.73 (3H, s); ^{13}C NMR: δ 170.95, 159.91, 141.22, 137.58, 129.89, 129.00, 126.91, 125.36, 118.98, 114.18, 112.37, 65.37, 55.19, 33.35.

2-Phenyl-3-(3-methoxyphenyl)-1,3-thiazolidin-4-one (**2m**): yield 57%; m.p. 98-99 °C; Anal. Found: C, 67.41; H, 5.68. Calc. for $C_{16}H_{15}NO_2S$: C, 67.34; H, 5.30; ^{1}H NMR: δ 7.35-6.73 (9H, m), 6.13 (1H, s), 4.05, 3.99, 3.98, 3.86 (2H, dd, , J = 15.9 Hz), 3.71 (3H, s); ^{13}C NMR: δ 170.93, 159.89, 139.57, 138.58, 129.64, 128.82, 126.84, 117.66, 112.66, 111.55, 65.57, 55.20, 33.21.

2-(4-Nitrophenyl)-3-(4-nitrophenyl)-1,3-thiazolidin-4-one (**3a**): yield 26%; m.p. 168-169 °C; Anal. Found: C, 51.94; H, 3.32, Calc. for $C_{15}H_{11}N_3O_5S$: C, 52.17; H, 3.21; ^{1}H NMR: δ 8.19-7.46 (8H, m), 6.34 (1H, s, CH), 4.01, 3.97, 3.93, 3.90 (2H, dd, J = 16.2 Hz); ^{13}C NMR: δ 170.76, 148.21, 145.69, 145.29, 142.69, 127.27, 124.57, 123.87, 63.43, 33.14.

2-(3-Nitrophenyl)-3-(3-nitrophenyl)-1,3-thiazolidin-4-one (**3b**): yield 56 %; m.p. 133-134 °C; Anal. Found: C, 52.06; H, 3.22, Calc. for $C_{15}H_{11}N_3O_5S$: C, 52.17; H, 3.21; ^{1}H NMR: δ 8.84-7.32 (8H, m), 6.29 (1H, s), 4.02, 3.97, 3.93, 3.87 (2H, dd, J = 16.2 Hz); ^{13}C NMR: δ 170.79, 151.95, 148.99, 148.53, 140.36, 137.05, 127.62, 126.32, 124.30, 121.96, 121.52, 119.69, 115.37, 63.79, 33.27.

2,-(4-Fluorophenyl)-3-(4-fluorophenyl)-1,3-thiazolidin-4-one (**3c**): yield 70 %; m.p. 119-120 °C; Anal. Found: C, 61.95; H, 3.84, Calc. for $C_{15}H_{11}NOSF_2$: C, 61.84; H, 3.81; ^{1}H NMR: δ 7.47-6.82 (8H, m), 5.97 (1H, s), 3.94, 3.89, 3.85, 3.80 (2H, dd, , J = 15.9 Hz); ^{13}C NMR: δ 170.84, 164.50, 162.85, 161.19, 159.51, 134.79, 133.18, 129.13, 127.81, 116.08, 65.07, 33.31.

2-(3-Fluorophenyl)-3-(3-fluorophenyl)-1,3-thiazolidin-4-one (**3d**): yield 61%; m.p. 88-89 °C; Anal. Found: C, 66.67; H, 3.77, Calc. for $C_{15}H_{11}NOSF_2$: C, 61.84; H, 3.81; ^{1}H NMR: δ 7.39-6.77 (8H , m), 6.03 (1H, s), 3.95, 3.90, 3.82, 3.77 (2H, dd, J = 15.0 Hz); ^{13}C NMR: δ 170.80, 164.44, 161.16, 141.87, 138.79, 130.67, 130.20, 122.34, 120.43, 116.09, 113.81, 112.53, 64.51, 33.22.

2-(4-Chlorophenyl)-3-(4-chlorophenyl)-1,3-thiazolidin-4-one (**3e**): yield 56%; m.p. 143-144 °C; Anal. Found: C, 55.69; H, 3.59, Calc. for $C_{15}H_{11}NOSCl_2$: C, 55.57; H, 3.42; ^{1}H NMR: δ 7.43-7.03 (8H, m), 5.99 (1H, s, CH), 3.92, 3.87, 3.83, 3.77 (2H, dd, J = 15.9 Hz); ^{13}C NMR: δ 170.74, 137.52, 135.74, 134.87, 132.70, 129.25, 128.32, 126.65, 64.59, 33.27 .

2-(3-Chlorophenyl)-3-(3-chlorophenyl)-1,3-thiazolidin-4-one (**3f**): yield 36%; m.p.129-131 °C; Anal. Found: C, 55.66; H, 3.53, Calc. for $C_{15}H_{11}NOSCl_2$: C, 55.57; H, 3.42; ^{1}H NMR: δ 7.38-6.94 (8H, m), 5.98 (1H, s,), 3.95, 3.90, 3.82, 3.77 (2H, dd, J = 15.0 Hz); ^{13}C NMR: δ 170.81, 141.29, 138.43, 134.84, 130.21, 129.28, 127.10, 125.15, 123.28, 64.51, 33.23.

2-(4-Bromophenyl)-3-(4-bromophenyl)-1,3-thiazolidin-4-one (**3g**): yield 54%; m.p. 180-182 °C; Anal. Found: C, 43.35; H, 2.64. Calc. for $C_{15}H_{11}NOSBr_2$: C, 43.61; H, 2.68; ^{1}H NMR: δ 7.40-6.92 (8H, m), 5.98 (1H, s), 3.93, 3.88, 3.83, 3.78 (2H, dd, , J = 15.9 Hz); ^{13}C NMR: δ 170.78, 138.07, 136.28, 132.34, 128.58, 126.90, 123.13, 120.75, 64.64, 33.34.

2-(3-Bromophenyl)-3-(3-bromophenyl)-1,3-thiazolidin-4-one (**3h**): yield 49%; m.p. 140-142 °C; Anal. Found: C, 43.43; H, 2.72. Calc. for $C_{15}H_{11}NOSBr_2$: C, 43.61; H, 2.68; ^{1}H NMR: δ 7.42-7.03 (8H, m), 5.96 (1H, s), 3.95, 3.90, 3.83, 3.78 (2H, dd, J = 15.0 Hz); ^{13}C NMR: δ 170.76, 141.40, 138.44, 132.19, 130.32, 129.79, 128.29, 125.31, 123.81, 122.96, 122.51, 64.44, 33.17.

2-(4Methylphenyl)-3-(4-methylphenyl)-1,3-thiazolidin-4-one (**3j**): yield 52%; m.p. 119-120 °C; Anal. Found: C, 71.92; H, 5.87. Calc. for $C_{17}H_{17}NOS$: C, 72.05; H, 5.97; ^{1}H NMR: δ 7.33-6.96 (8H, m), 5.97 (1H, s), 3.96, 3.91, 3.83, 3.78 (2H, dd, J = 15.9 Hz), 2.24 (3H, d), 2.22 (3H, d); ^{13}C NMR: δ 171.04, 138.74, 136.79, 134.95, 129.62, 126.92, 125.65, 65.53, 33.47, 21.10.

2-(3-Methylphenyl)-3-(3-methylphenyl)-1,3-thiazolidin-4-one (**3k**): yield 55%; m.p. 97-98 °C; Anal. Found: C, 71.85; H, 6.14. Calc. for $C_{17}H_{17}NOS$: C, 72.05; H, 6.05; ^{1}H NMR: δ 7.21-6.95 (8H, m), 6.05 (1H, s), 4.02, 3.97, 3.86, 3.81 (2H, dd, J = 15.6 Hz), 2.28 (3H, s), 2.23 (3H, s_3); ^{13}C NMR: δ 171.03, 139.77, 138.74, 138.52, 137.55, 129.56, 128.72, 127.83, 127.34, 126.28, 123.85, 122.50, 65.89, 33.37, 21.32.

2-(4-Methoxyphenyl)-3-(4-methoxyphenyl)-1,3-thiazolidin-4-one (**3l**): yield 54%; m.p. 119-120 °C, (lit. m.p.119-120 °C) (13); ^{1}H NMR: δ 7.85-6.76 (8H, m, aromatics), 5.95 (1H, s), 3.99, 3.94, 3.80, 3.76 (2H, dd, , J = 15.0 Hz), 3.72 (3H, d), 3.66 (3H, d); ^{13}C NMR: δ 171.02, 159.89, 145.27, 130.23, 128.69, 127.62, 122.05, 114.24, 65.71, 55.46, 33.43.

2-(3-Methoxyphenyl)-3-(3-methoxyphenyl)-1,3-thiazolidin-4-one (**3m**): yield 44%; m.p. 87-88 °C; Anal. Found: C, 64.50; H, 5.54. Calc. for $C_{17}H_{17}NO_2S$: C, 68.20; H, 5.72; ^{1}H NMR: δ 7.21-6.61 (8H, m), 6.04 (1H, s, CH), 3.99, 3.94, 3.84, 3.80 (2H, dd, J = 15.6 Hz), 3.72 (3H, s,), 3.67 (3H, s); ^{13}C NMR: δ 170.93, 159.91, 144.27, 138.66, 129.85, 129.61, 118.93, 117.49, 114.17, 112.58, 112.33, 111.43, 65.39, 55.19, 33.33.

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