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Palladium-Catalyzed *ortho*-Benzoylation of Sulfonamides through C–H Activation: Expedient Synthesis of Cyclic *N*-Sulfonyl Ketimines

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Abstract. The *ortho*-carbonylation of sulfonylarenes by non-hazardous arylaldehydes as a carbonyl precursor is reported. In this method the sulfonamide group serves as the directing group for C–H activation in the presence of a Pd catalyst under ligand-free conditions. The scope of this strategy has been extended to the one-pot two-step synthesis of cyclic *N*-sulfonyl ketimines under mild reaction conditions. Our approach could be considered as an alternative by circumventing the use of highly reactive organolithium or Grignard reagents to access a wide range of biologically potent cyclic *N*-sulfonyl ketimines.

Keywords: *ortho*-carbonylation; C–H activation; arene sulfonamide; aryl aldehyde; cyclic *N*-sulfonyl ketimines

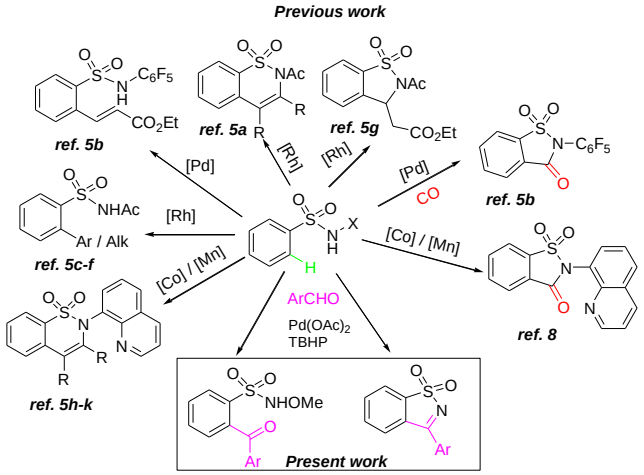
Introduction

Owing to its atom and step economy, transition-metal (TM) catalyzed C–H activation/functionalization reactions have stood out as a powerful and versatile method for the construction of C–C and C–X bonds. Since the pioneering work of Fujiwara[1] and Murai,[2] a vast number of innovative developments have been made in this field. Activation of electronically deficient aromatic C–H bonds are traditionally more difficult than activation of electron-rich aromatic C–H bonds. Nevertheless, introduction of directing groups (DGs)[3] involving nitrogen and oxygen atoms (e.g., pyridyl, amino, azo, amido, thio, hydroxy, carbonyl, ester, aldehyde, and carboxyl groups) facilitates such C–H activation by enhancing the catalytic efficiency of the transition metal through chelation.

Being an ubiquitous motif in numerous pharmaceuticals and biologically potent molecules,[4] a great deal of attention has been paid to C–H functionalization of sulfonylarenes. In particular, C–H olefination and arylation reactions of sulfonylarenes with amide,[5] acid[6] and imine[7] functionalities have been reported extensively. In contrast, direct carbonylation of sulfonylarenes to *ortho*-keto sulfonylarenes is relatively less explored. In 2011, ligand (i.e., Ac-Leu-OH) mediated Pd-catalyzed *ortho*-carbonylation of *N*-aryl sulfonamides using carbon monoxide as the carbonyl source was reported by Yu and co-workers (Scheme 1).[5b] Daugulis and co-workers[8a] developed an interesting Co-catalyzed protocol for aminoquinoline-directed C–H carbonylation reaction to synthesize saccharine derivatives using expensive diisopropyl azodicarboxylate (DIAD) as carbonyl surrogate. Recently, Sundararaju[8b] et al. employed a Co-catalyzed two-chambered tandem reaction pathway for the incorporation of a carbonyl group between N–H and *ortho*-C–H bonds of arenesulfonamides having an 8-aminoquinoline directing group. Although above methods are proficient for *ortho*-C–H carbonylation, the use of gaseous carbon monoxide as a carbonyl precursor is indeed technically challenging. On the other hand, with the growing demand for sustainable chemical synthesis, direct catalytic C–H carbonylation of electronically deficient aromatic ring by employing non-hazardous and less expensive acylating reagent under mild reaction conditions is often intriguing.[9] In this context, it occurred to us that the commercially available carbaldehyde could serve as a reliable handle for C–H carbonylation reaction. Though the *N*-acylation of sulfonamide using aldehyde has already been delineated;[10] to the best of our knowledge,[5,8] sulfonamide directed *ortho*-carbonylation using carbaldehyde precursor has remained elusive in the literature. In continuation of our current research on TM-catalyzed cross-coupling reactions,[11] we became interested to develop an efficient method for *ortho*-carbonylation of sulfonamides through C–H bond activation. Herein, we report the Pd-catalyzed dehydrogenative coupling of *N*-methoxy sulfonamides with aryl aldehydes to produce *o*-keto sulfonamides. Besides, the tandem *ortho*-carbonylation of sulfonamides ($ArSO_2NH_2$) and

subsequent intramolecular annulation to afford cyclic *N*-sulfonyl ketimines was also performed. Evidently, the cyclic *N*-sulfonyl ketimines are privileged structural motifs that show a broad range of biological activities.[12] These have also found applications in organic synthesis, as building blocks,[13] chiral auxiliaries,[14] and directing groups for C–H functionalization.[15] Furthermore, cyclic *N*-sulfonyl ketimines serve as a versatile synthon to access a myriad of *S*- and *N*-containing molecules.[16] As such, the methods to obtain cyclic *N*-sulfonyl ketimines mostly involve the reaction of organolithium compound/Grignard reagent with saccharin or pseudosaccharin chloride;[17] and the cyclization of benzophenone with chlorosulfonyl isocyanate.[18] We were unaware of any report in the literature in which the cyclic *N*-sulfonyl ketimines have been synthesized directly from the readily available arenesulfonamides and aryl aldehydes.

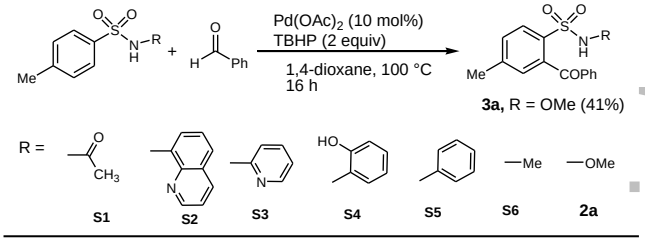
Scheme 1. C–H activation/functionalization of sulfonylarenes



Results and Discussion

At the outset, the *ortho*-carbonylation reaction was performed with the Pd-catalyzed coupling of benzaldehyde (**1a**) and *N*-acylated sulfonamide, **S1** (Scheme 2). Though, the TM-catalyzed C–H functionalization of *N*-acyl arenesulfonamides[5b,5d,19] is well precedent; unfortunately, for the present case the benzoylation reaction under Pd-catalyzed condition [$Pd(OAc)_2$ (10 mol%), TBHP (2 equiv), 1,4-dioxane (2 mL) at 100°C for 16h] failed with complete recovery of the starting material. The required benzoylation reaction with other potential DGs (e.g., **S2**-**S5**) under similar reaction conditions was also unfruitful. Incidentally, when *N*-methyl tosylamide (**S6**) was treated with benzaldehyde, the corresponding *o*-benzoylated product was identified (from TLC and ^{1}H NMR of the crude reaction mixture) only in trace amount. We anticipated that, the presence of an electron-rich substituent at the nitrogen atom may chelate the TM[20] effectively, and thus, the carbonylation would be facilitated. Gratifyingly, when *N*-methoxy-4-methylbenzene-sulfonamide (**2a**) and benzaldehyde (**1a**) were treated under similar reaction conditions in 1,4-dioxane for 16 h, the desired benzoylated product **3a** was isolated in 41% yield.

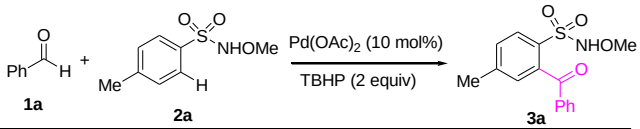
Scheme 2. *ortho*-Carbonylation of sulfonamides



Inspired by these results, we screened different oxidants, solvents, reaction temperatures, and additives in the presence of $Pd(OAc)_2$ (10 mol%) catalyst (Table 1). Notably, when **2a** was treated with **1a** in the presence of TBHP for 16 h at room temperature in 1,4-dioxane, no reaction occurred with the recovery of starting material (Table 1, entry 1). However, with the increase in reaction temperature to 50°C, the desired 2-benzoyl-*N*-methoxy-4-methylbenzenesulfonamide (**3a**) was produced in 52% yield (Table 1, entry 2) with remaining unreacted starting material. Further rise of reaction temperature to 90°C gave **3a** in 64% yield with the recovery of starting material 20% (Table 1, entry 4). However, at 120°C, 25% of **3a** was isolated with the appearance of several unwanted spots in TLC from the decomposition of the product (entry 6). The optimum yield of 68% was also obtained even when the reaction mixture [TBHP (2 equiv), $Pd(OAc)_2$ (10 mol%) in dioxane] was heated at 100 °C for 15 min (entry 16). However, by increasing the reaction time, the yield of **3a** was subsided due to the formation of several uncharacterized byproducts (entries 5, 14 & 15). The yield of the **3a** was also not improved appreciably by increasing the concentration of catalyst (20 mol%, 69% yield) or oxidant (4 equiv.) Moreover, the reaction did not proceed in the absence of oxidant (e.g., TBHP). Use of other solvents such as DMSO, toluene, DCE, CH_3CN, THF, t-BuOH could not improve the yield (entries 7-12) with an exception to DME, which delivered **3a** in comparable yield (entries 13, 16 &18). Replacement of TBHP by other oxidants such as H_2O_2, DTBP, BQ, $K_2S_2O_8$, oxone, AgOAc and $Cu(OAc)_2$ did not afford the required product **3a** with complete recovery of **2a** (for details: see supporting information). Addition of 1 equiv. of acids or bases [e.g., AcOH, PTSA, TFA, PivOH,

NaOAc, ^{t}BuOK, K_2CO_3] as additives inhibited the benzoylation and **2a** was recovered. Among the tested Pd-catalysts [$Pd(OAc)_2$, $PdCl_2$, $Pd(PPh_3)_2Cl_2$, $Pd(CH_3CN)_2Cl_2$, $Pd(OCOCF_3)_2$, $Pd(PPh_3)_4$, $Pd(dba)_2$] $Pd(OAc)_2$ enabled the *ortho*-benzoylation product **3a** (see supporting information) in maximum yield.

Table 1. Optimization of reaction conditions[a]

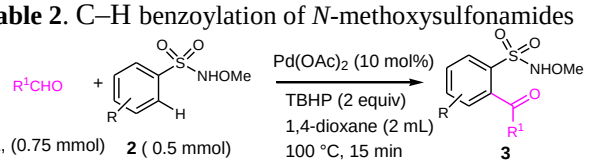


Entry	temperature	time	solvent	yield(%)
1	rt	16 h	1,4-dioxane	NR
2	50 °C	16 h	1,4-dioxane	52
3	65 °C	16 h	1,4-dioxane	59
4	90°C	16 h	1,4-dioxane	64
5	100 °C	16 h	1,4-dioxane	41
6	120 °C	16 h	1,4-dioxane	25
7	90 °C	16 h	Toluene	32
8	90 °C	16 h	DCE	28
9	90 °C	16 h	CH_3CN	NR
10	90 °C	16 h	DMSO	NR
11	90 °C	16 h	t-BuOH	NR
12	90 °C	16 h	THF	22
13	90 °C	16 h	DME	59
14	100 °C	4 h	1,4-dioxane	48
15	100 °C	1h	1,4-dioxane	63
16	100 °C	1 h	DME	61
17	100 °C	15 min	1,4-dioxane	68
18	100 °C	15 min	DME	64

[a] *Reaction conditions:* **1a** (40 mg, 0.37 mmol), **2a** (50 mg, 0.25 mmol), $Pd(OAc)_2$ (10 mol %), TBHP (70% in decane) (2 equiv) in 2 mL of the solvent. rt: room temperature.

Having the optimized reaction conditions in hand, we examined the substrate scope by varying the substituents at the aryl group of sulfonamides (Table 2). Pd-catalyzed C–H functionalization of *N*-methoxy sulfonamides having various substituents, such as -Me, -Cl, -Br, -OMe, enabled the corresponding *ortho*-benzoylated products in moderate yields (Table 2, entries 1-10). Unfortunately, the Pd-catalyzed C–H activation failed with *N*-methoxy-4-nitrobenzene-sulfonamide (**2k**) with complete recovery of starting material, probably due to ring deactivation by the nitro group (Table 2, entry 11). Further, by extending the substrate scope of the carbonylation reaction with differently substituted aryl aldehydes gave the corresponding benzoylated derivatives in moderate yields (entries 12-21). Interestingly, the halogen-substitutions in the aldehydes as well as sulfonamides were compatible to the optimal reaction conditions and exhibit the desired product in appreciable yield. Notably, coupling of **2a** with aryl aldehydes featuring cyano- and ester group (e.g., **1j** and **1k**) resulted in the corresponding carbonylated products in poor yield (entries 20 and 21). Again, aliphatic aldehydes such as hexanal and octanal were also found to be reactive to this Pd-catalysis to afford the *o*-carbonylated product **3s** and **3t** respectively (entries 18 & 19). However, when cinnamaldehyde was employed as a carbonylating agent, the corresponding *ortho*-carbonylated product **3u** was not formed; rather, **3a** was isolated in 35% yield (entry 22). Probably, under our reaction conditions, cinnamaldehyde underwent Pd-catalyzed C-C cleavage[21] to benzaldehyde; which could couples with **2a** to afford **3a**.

Table 2. C–H benzoylation of *N*-methoxysulfonamides



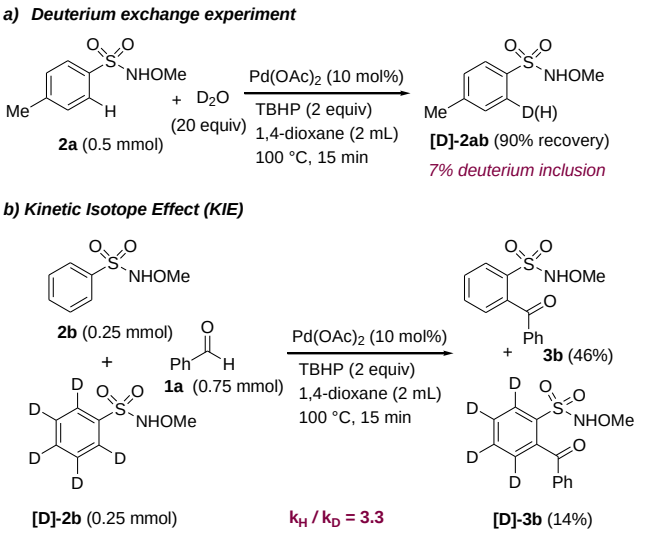
Entry	Aldehyde (1)	Sulfonamide (2)	Product (3)	yield (%)[b]
1	**1a**, R^1 = C_6H_5-	**2a**, R = 4-CH_3	**3a**	68
2	**1a**	**2b**, R = H	**3b**	66
3	**1a**	**2c**, R = 4-Cl	**3c**	64
4	**1a**	**2d**, R = 4-Br	**3d**	48
5	**1a**	**2e**, R = 4-I	**3e**	ND
6	**1a**	**2f**, R = 4-Et	**3f**	66
7	**1a**	**2g**, R = 4-OMe	**3g**	49
8	**1a**	**2h**, R = 3,4-$(OMe)_2$	**3h**	53
9	**1a**	**2i**, R = 3,4-$(Me)_2$	**3i**	57
10	**1a**	**2j**, R = 3,4-$(Cl)_2$	**3j**	49
11	**1a**	**2k**, R = -NO_2	**3k**	NR
12	**1b**, R^1 = 4-MeC_6H_4-	**2a**	**3l**	67
13	**1c**, R^1 = 4-ClC_6H_4-	**2a**	**3m**	63
14	**1d**, R^1 = 4-BrC_6H_4-	**2a**	**3n**	64
15	**1e**, R^1 = 4-$NO_2C_6H_4$-	**2a**	**3o**	NR
16	**1f**, R^1 = 4-FC_6H_4-	**2a**	**3p**	63
17	**1g**, R^1 = 2-BrC_6H_4-	**2a**	**3q**	57
18	**1h**, R^1 = *n*-hexyl-	**2a**	**3r**	31
19	**1i**, R^1 = *n*-octyl-	**2a**	**3s**	29
20	**1j**, R^1 = 4-CNC_6H_4-	**2a**	**3t**	28
21	**1k**, R^1 = 4-$CO_2MeC_6H_4$-	**2a**	**3u**	33
22	**1l**, R^1 = Ph-CH=CH-	**2a**	**3v**	0(35)[c]

[a] *Reaction conditions:* A mixture of **1** (0.75 mmol), **2** (0.5 mmol), $Pd(OAc)_2$ (10 mol%), TBHP (1 mmol) in 1,4-dioxane (2 mL) was heated at 100°C for 1 h. [b]Isolated yield. [c] **3a** was isolated in 35% yield.

To elucidate the reaction pathway, an H/D exchange experiment was performed. Under the standard reaction conditions, when *N*-methoxy-4-methylbenzenesulfonamide (**2a**) was treated with 20 equiv. of D_2O in the absence of benzaldehyde (**1a**), low inclusion of deuterium (7% from ^{1}H NMR) in the aryl ring (i.e., of [D]-**2a**) was observed (Scheme 3a). This result indicates that the initial cleavage of the *ortho* C−H bond generates aryl−Pd intermediate species and this is an irreversible process. Further, kinetic isotope effects (KIE) experiment was

performed by reacting equivalent amounts of **2b** and **[D]-2b** with benzaldehyde under standard reaction conditions (Scheme 3b). The resulting k_H/k_D (= 3.3) suggests that the initial C–H activation step is the rate-determining step in the overall transformation.

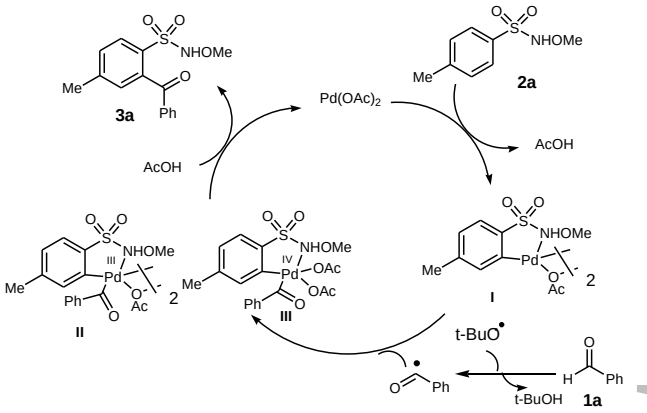
Scheme 3. Deuterium labelling experiment



In line with the above observation and earlier literature precedence,[20] we proposed a mechanism (Scheme 4) in which $Pd(OAc)_2$ initially chelates to the electronically rich –NHOMe group effectively and induces *ortho* C–H activation through the formation of cyclopalladated intermediate **I**[22] by releasing one equivalent of AcOH. As addition of 1 equiv. of radical inhibitor (i.e., TEMPO) to the optimized reaction condition results in lower yield of **3a** (12%), we believed that the reaction follows a radical pathway to afford the benzoylated product. From the decomposition of TBHP, $^tBuO\cdot$ radical thus generates would react with the aldehyde to afford the reactive benzoyl radical by hydrogen abstraction.[22f] It may be hypothesized that the benzoyl radical would add to the palladacycle **I** oxidatively with the formation of putative intermediate **II**[22d] or **III**[22e]. Finally, by reductive depalladation, the desired *ortho*-benzoylated sulfonamide forms with the regeneration of $Pd(OAc)_2$ for subsequent catalytic cycle (Scheme 4).

Next, we became interested in exploiting the C–H carbonylation of aryl sulfonamides ($ArSO_2NH_2$) with an aim to achieve *ortho*-benzolylated sulfonamide, which could undergo intramolecular annulation to afford the biologically potent cyclic *N*-sulfonyl ketimines. Pleasantly, when tosylamide (**4a**) was treated with benzaldehyde (**1a**) under the similar reaction conditions, cyclic *N*-sulfonyl ketimine **5a** was isolated directly in 58% yield over a period of 1 h.

Scheme 4. Plausible reaction pathway

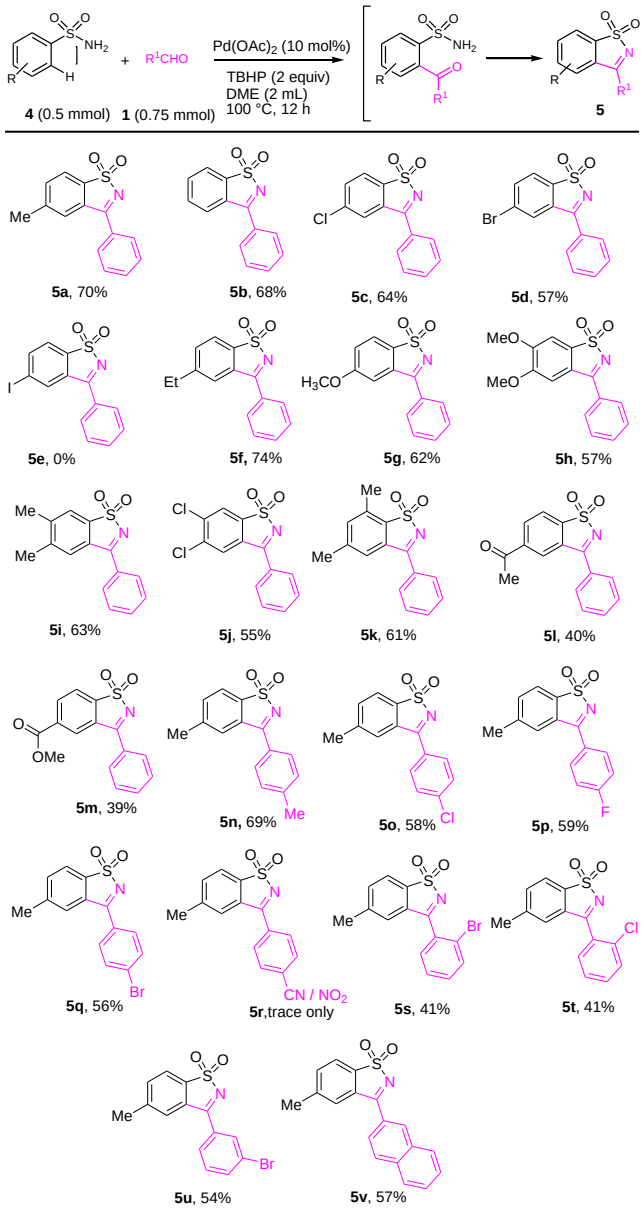


An increase in reaction time to 4 h could not improve the yield (58%). Unlike the former, decomposition did not occur even on heating for 12 h. Interestingly, by changing the solvent to DME, **5a** was obtained in optimum yield (70%) over a period of 12 h. Here, we presumed that $-SO_2NH_2$ serves as a directing group for the *ortho*-benzoylation of sulfonylarene and the resulting intermediate undergoes intramolecular annulation to afford the cyclic *N*-sulfonyl ketimines. Notably, both the steps (i.e., *ortho*-benzoylation and intramolecular annulation) occur sequentially and the attempts to isolate the intermediate were unsuccessful. To a side note, sulfonamide ($-SO_2NH_2$) directed C–H activation/functionalization has not been reported yet.

To extend the scope of the reaction, a series of differently substituted cyclic *N*-sulfonyl ketimines (**5**) were synthesized following the same C–H activation strategy (Scheme 5). Gratifyingly, a series of sulfonamides with a range of substituents were amenable to the reaction conditions and the respective cyclic *N*-sulfonyl ketimines (**5**) were produced in moderate yields. Although the coupling reactions of sulfonamides featuring keto and ester functionalities delivered the cyclic ketimines, similar reaction of sulfonamides having CN and NO_2 substituents failed. Additionally, the 4-nitrobenzaldehyde also did not couple under the optimized reaction conditions to afford **5r** with the recovery of **2a**. Notably, the halo-substitutions to the aryl ring of the sulfonamide as well as the aryl ring of aldehyde were found to be tolerant to the reaction conditions and the desired ketimines were produced in appreciable yield. In particular, the sustained bromo-functionality in the resulting cyclic ketimines, e.g., **5d**, **5q**, **5s** and **5u** allow for further cross-coupling reactions to be performed on the products. On the other hand, preparation of such derivatives by other means (i.e., with use of organolithium or Grignard reagent) is not possible. Notably, the *ortho*-substituted aldehydes afforded poor yield of ketimine (**5s** and **5t**) probably due to steric reason. Interestingly, when benzyl

sulfonamide was treated with aryl aldehyde, the C–H benzoylation followed by annulation occurs at 100°C and the corresponding six-membered cyclic *N*-sulfonyl ketimines (**6a** & **6b**) occurred.[23]

Scheme 5. Synthesis of cyclic *N*-sulfonyl ketimines [a]



[a]*Reaction conditions*: Sulfonamide(0.5 mmol), aldehyde (0.75 mmol), $Pd(OAc)_2$ (10 mol%), TBHP (1 mmol) in DME (2 mL) was heated at 100 °C for 12 h.

Conclusion

In summary, a simple method for the sulfonamide directed *ortho*-carbonylation of arenes has been developed. Non-hazardous arylaldehydes was successfully employed as a carbonylating precursor in the presence of Pd-catalyst. The reaction procedure is very simple and does not require any ligand or additive or inert atmosphere to enable the *ortho*-benzoylated product. Deuterium labeling experiment and KIE study indicates that the initial C–H activation step is irreversible process and is also the rate determining step. Additionally, this strategy has been extended for the one-pot two-step synthesis of a wide range of synthetically important cyclic *N*-sulfonyl ketimines. Mild reaction conditions and the simple experimental procedure for C–H activation make the process interesting and could be a preferred route to access cyclic *N*-sulfonyl ketimines over the reported multistep approaches.

Experimental Section

General Experimental Information. All the solvents for routine isolation of products and chromatography were reagent grade. Column chromatography was performed using silica gel (100−200 mesh) and mixture of ethyl acetate−petroleum ether (60−80 °C) as eluent. Melting points are uncorrected. FTIR spectrophotometer (IR Affinity 1S W/L with quest ATR) was used to record the IR spectra. ^{1}H NMR and ^{13}C NMR spectra were recorded on 400 MHz (^{1}H NMR) and 100 MHz (^{13}C NMR) spectrometers using $CDCl_3$ as the solvent and TMS as the internal standard. The ^{1}H NMR data are reported as the chemical shift in parts per million, multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet), coupling constant in hertz (Hz), and number of protons. High-resolution mass spectra were obtained using a high-resolution ESI-TOF mass spectrometer. The used aldehydes (**1**) are of commercial grade. *N*-methoxy sulfonamides [24] (**2**) and sulfonamides[25] (**4**) are known compounds and were prepared by following the similar literature procedure.

General procedure for the synthesis of N-methoxysulfonamides [24] (2)

To a stirred solution of arenesulfonyl chloride (1.05 mmol) in DCM (5.0 ml), pyridine (2.0 equiv) was added slowly at 0°C. After 15 minutes, *N*-methoxyamine hydrochloride (1.2 equiv) was added, and then the reaction mixture was allowed to attain room temperature slowly. After 4h, the reaction mixture was acidified with 2N HCl solution and triturated with EtOAc (20 mL). The organic layer was separated and washed with H_2O, brine and dried over anhydrous Na_2SO_4. The filtrate was evaporated under reduced pressure and the corresponding pure *N*-methoxy sulfonamide was obtained by recrystallization from ethanol.

General procedure for the synthesis of sulfonamides [25] (4)

To a stirred solution of arylsulfonyl chloride (1.05 mmol) in DCM (5.0 ml), pyridine (2.0 equiv) was added slowly at 0°C. After 15 minutes, 25% aqueous ammonia solution (4 equiv) was added, and then the reaction mixture was allowed to attain room temperature slowly. After 4h, the reaction mixture was acidified with 2N HCl solution and triturated with EtOAc (20 mL). The organic layer was separated and washed with H_2O, brine and dried over

anhydrous Na_2SO_4. The filtrate was evaporated under reduced pressure and the corresponding pure sulfonamide was obtained by recrystallization from ethanol.

General procedure for the synthesis of 2-benzoyl-*N*-methoxy-arylsulfonamide (3). To a mixture of aldehyde (**1**, 0.75 mmol), *N*-methoxy sulfonamide (**2**, 0.5 mmol) and $Pd(OAc)_2$ (11 mg, 10 mol%) in 1,4-dioxane (2 mL), TBHP (70% in decane) (1 mmol) was added dropwise keeping the oil bath temperature 100°C. After 15 min, the reaction mixture was cooled to room temperature and filtered over a short pad of celite. The filtrate was eluted with 3x 10 mL of ethyl acetate. The combined organic layer was washed with dilute (10%) $NaHCO_3$ solution (3 x 10 mL). Then the organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude reaction mixture was purified by column chromatography to afford the *o*-benzoylated sulfonyl arenes (**3**).

General procedure for the synthesis of cyclic N-sulfonyl ketimines (5 & 6). To a mixture of aldehyde (**1**, 0.75 mmol), sulfonamide (**4**, 0.5 mmol) and $Pd(OAc)_2$ (11 mg, 10 mol%) in DME (2 mL), TBHP (70% in decane) (1 mmol) was added dropwise keeping the oil bath temperature 100 °C. After 12 h, the reaction mixture was cooled to room temperature and filtered over a short pad of celite. The filtrate was eluted with 3x 10 mL of ethyl acetate. The combined organic layer was washed with dilute (10%) $NaHCO_3$ solution (3 x 10 mL). Then the organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude reaction mixture was purified by column chromatography to afford the desired cyclic *N*-sulfonyl ketimines **(5)**. Six-membered cyclic N-sulfonyl ketimines were also prepared following the similar procedure with only change in reaction time from 1h to 2h.

Synthesis and Characterization 4-Iodo-*N*-methoxybenzenesulfonamide (2e). Following the general procedure, the reaction of 4-iodo benzenesulfonylchloride with *N*-methoxylamine hydrochloride gave 902 mg (87% yield) of **2e** as a white solid. M.P. 95 °C; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.92 (d, 2H, *J* = 8.4 Hz), 7.63 (d, 2H, *J* = 8.4 Hz), 7.34 (s, 1H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ138.4, 136.1, 129.8, 101.8, 65.2.

4-Ethyl-*N*-methoxybenzenesulfonamide (2f). Following the general procedure, the reaction of 4-ethyl benzenesulfonylchloride with *N*-methoxylamine hydrochloride gave 970 mg (92% yield) of **2f** as a white solid. M. P. 75°C; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.85 (d, 2H, *J* = 8.4 Hz), 7.38 (d, 2H, *J* = 8.4 Hz), 7.23 (s, 1H), 3.80 (s, 3H), 2.75 (q, 2H, *J* = 7.6 Hz), 1.28 (t, 3H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 151.0, 133.6, 128.6, 128.6, 65.0, 28.9, 15.0.

***N*-Methoxy-3,4-dimethylbenzenesulfonamide (2i)**. Following the general procedure, the reaction of 3,4-dimethylbenzenesulfonylchloride with *N*-methoxylamine hydrochloride gave 938 mg (89% yield) of **2i** as a white solid. M. P.: 72 °C; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.69 (s, 1H), 7.67 (d, 1H, *J* = 8.0 Hz), 7.34-7.23 (m, 2H), 3.79 (s, 3H), 2.35 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.6, 137.9, 133.6, 130.2, 129.2, 126.0, 65.0, 20.0, 19.7.

4-(Methoxycarbonyl)benzenesulfonamide. A mixture of tosylamide (**2a**) (1gm, 0.58 mmol) and $KMnO_4$ (2.0 equiv, 1.17 mmol) in 10 ml H_2O was heated at reflux for 12h. Then, the reaction mixture was cooled to 0^0C and few drops of conc. H_2SO_4 were added during which precipitate was formed. The precipitate was filtered out, washed with cold water (2 x 10 mL), dried on air and then recrystallized from methanol to get 775 mg of methyl 4-sulfamoylbenzoic acid in 66% yield as a white solid, which was used as it is for the preparation of methyl 4-sulfamoylbenzoate without further purification. A solution of 4-sulfamoylbenzoic acid (700 mg, 3.48 mmol.) in dry methanol (10mL) was refluxed in the presence of 10 drops of conc. H_2SO_4 for 12 h. After completion of the reaction, the mixture was poured into ice cold water during which precipitate was formed. The precipitate was filtered and dried to give 666 mg of 4-(methoxycarbonyl)-benzenesulfonamide in 89% yield as a white crystalline solid. M. P. 115°C; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.13 (d, 2H, *J* = 8.4 Hz), 7.97 (d, 2H, *J* = 8.0 Hz), 7.56 (s, 2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.5, 153.2, 137.5, 135.0, 131.2, 57.7.

2-Benzoyl-*N*-methoxy-4-methylbenzenesulfonamide (3a). Following the general procedure, reaction of **1a** and **2a** [24] gave 103 mg (68% yield) of **3a** as a white solid. M.P.: 73-74 °C. IR: 3547, 3219, 3072, 2988, 2939, 1927, 1662, 1591, 1382, 1320, 1151, 719, 544 cm^{-1}.^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.23 (s, 1H), 8.09 (d, 1H, *J* = 8.4 Hz), 7.85 (d, 2H, *J* = 7.6 Hz), 7.65 (d, 1H, 7.6 Hz), 7.50 (t, 3H, *J* = 7.6 Hz), 7.24 (s, 1H), 3.86 (s, 3H), 2.47 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.6, 143.9, 138.2, 135.8, 134.2, 133.6, 132.8, 132.3, 130.8, 130.7, 130.1, 128.5, 128.4, 64.9, 21.5. HRMS (ESI) m/z $[M+Na]^+$ calcd for $C_{15}H_{15}NNaO_4S^+$ 328.0619; found 328.0614.

2-Benzoyl-*N*-methoxybenzenesulfonamide (3b). Following the general procedure, reaction of **1a** and **2b** [24] gave 95 mg (66% yield) of **3b** as a colorless gummy liquid. IR: 2982, 2817, 2360, 2325, 1654, 1599, 1549, 1501, 1445, 1145, 998, 705, 614 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.30 (s, 1H), 8.25-8.19 (m, 1H), 7.88-7.82 (m, 2H), 7.74-7.66 (m, 2H), 7.68-7.62 (m, 1H), 7.54-7.43(m, 3H), 3.87 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.5, 138.3, 135.9, 135.8, 134.4, 132.7, 132.4, 130.8, 130.4, 129.6, 128.6, 65.0. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{14}NO_4S^+$ 292.0644; found 292.0639.

2-Benzoyl-4-chloro-*N*-methoxybenzenesulfonamide (3c). Following the general procedure, from the reaction of **1a** and **2c**, [24] **3c** was isolated in 64% yield (104 mg) as a white solid. M.P.: 88-89 °C. IR: 3743, 3645, 3219, 2974, 2925, 2855, 2360, 2318, 1662, 1605, 1543, 1445, 1382, 1348, 1278, 1159, 816,705,558 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.16 (d, 1H, *J* = 3.2 Hz), 8.13 (s, 1H), 7.85 (d, 2H, *J* = 8.4 Hz), 7.73-7.64 (m, 2H), 7.57-7.49 (m, 2H), 7.42 (d, 1H, *J* = 2 Hz), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 195.9, 139.7, 139.6, 135.0, 134.6, 134.1, 133.6, 130.6, 130.2, 129.3, 128.7, 65.0. HRMS (ESI) m/z

$[M+Na]^+$ calcd for $C_{14}H_{12}ClNNaO_4S^+$ 348.0073; found 348.0068.

2-Benzoyl-4-bromo-*N*-methoxybenzenesulfonamide (**3d**). Following the general procedure, from the reaction of **1a** and **2d**,[24] **3d** was isolated in 48% yield (88 mg) as a white crystalline solid. M.P.: 120-121 °C. IR: 2928, 2855, 1732, 1668, 1577, 1459, 1396, 1340, 1284, 1165, 1047, 1012, 725, 572 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.16 (s, 1H), 8.06 (d, 1H, *J* = 8.4 Hz), 7.88-7.81 (m, 3H), 7.69 (t, 1H, *J* = 7.6 Hz), 7.58 (s, 1H), 7.53 (t, 2H, *J* = 8.0 Hz), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 195.9, 139.8, 135.2, 134.8, 133.7, 133.4, 132.2, 130.8, 128.6, 128.1, 65.1. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{13}BrNO_4S^+$ 369.9749; found 369.9745.

2-Benzoyl-4-ethyl-*N*-methoxybenzenesulfonamide (**3f**). Following the general procedure, from the reaction of **2f** and **1a**, **3f** was isolated in 66% yield (104 mg) as a white solid. M.P.: 76-78 °C. IR: 3743, 3651, 2974, 2925, 2855, 2367, 2318, 1710, 1585, 1515, 1438, 1292, 1151, 852, 725, 650, 544, 502 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.24 (S, 1H), 8.12 (d, 1H, *J* = 8.0 Hz), 7.86 (d, 2H, *J* = 8.4 Hz), 7.66 (t, 1H, *J* = 7.6 Hz), 7.51 (t, 3H, *J* = 8.0 Hz), 7.26 (s, 1H), 3.87 (s, 3H), 2.76 (q, 2H, 7.6 Hz) 1.27 (t, 3H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): 197.7, 149.9, 138.4, 135.9, 134.3, 133.1, 132.5, 130.8, 129.6, 129.2, 128.6, 65.0, 28.7, 14.9. HRMS (ESI) m/z $[M+Na]^+$ calcd for $C_{16}H_{17}NNaO_4S^+$ 342.0776; found 342.0770.

2-Benzoyl-4,*N*-dimethoxybenzenesulfomide (3g). Following the general procedure, the reaction of **1a** and **2g**,[24] gave 79 mg of **3g** as a white solid in 49% yield. M.P.: 85-87 °C. IR: 37365, 3645, 3219, 2967, 2939, 2897, 2360, 2325, 1647, 1577, 1459, 1389, 1334, 1242, 1165, 1061, 1026, 928, 852, 705, 551 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.14 (d, 1H, *J* = 8.8 Hz), 8.11 (s, 1H), 7.87 (d, 2H, *J* = 7.6 Hz), 7.66 (t, 1H, *J* = 7.6 Hz), 7.50 (t, 2H, *J* = 7.6 Hz), 7.13(d, 1H, *J* = 8.8 Hz), 6.92 (s, 1H), 3.89 (s, 3H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.0, 162.7, 140.2, 135.6, 134.6, 134.3, 130.8, 128.6, 127.1, 116.1, 114.1, 64.9, 55.9. (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{16}NO_5S^+$ 322.0749; found 322.0749.

2-Benzoyl-4,5,*N*-trimethoxybenzenesulfonamide (**3h**). Following the general procedure, reaction of **1a** and **2h** [24] gave 94 mg of **3h** as a gummy liquid in 53% yield. IR: 2982, 2905, 2360, 2325, 1654, 1599, 1501, 1452, 1340, 1256, 1207, 1165, 1068, 1019, 866, 711 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.38 (s, 1H), 7.85 (d, 2H, *J* = 8 Hz), 7.64 (d, 2H, *J* = 8.8 Hz), 7.50 (t, 2H, *J* = 7.6 Hz), 6.88 (s, 1H), 4.05 (s, 3H), 3.86 (s, 3H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 196.8, 151.5, 149.6, 136.0, 134.1, 131.5, 130.6, 128.5, 114.6, 112.4, 64.9, 56.4, 56.3. HRMS (ESI) m/z $[M+Na]^+$ calcd for $C_{16}H_{17}NNaO_6S^+$ 374.0674; found 374.0669.

2-Benzoyl-4,5-dimethyl-*N*-methoxybenzenesulfonamide (**3i**). Following the general procedure, reaction of **1a** and **2i** gave 88 mg of **3i** (57% yield) as a white solid. M.P.:108-109 °C. IR: 3212, 3065, 2982, 2925, 2318, 1654, 1591, 1452, 1389, 1340, 1278, 1173, 1019, 886, 719, 586 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.37 (s, 1H), 7.97 (s, 1H), 7.85 (d, 2H, *J* = 7.6 Hz), 7.65 (t, 1H, *J* = 7.6 Hz), 7.50 (t, 2H, *J* = 7.6 Hz), 7.21 (s, 1H), 3.87 (s, 3H), 2.44 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.7, 142.4, 139.8, 136.2, 135.7, 134.1, 133.3, 133.1, 131.2, 130.8, 128.5, 65.0, 19.9, 19.8. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{16}H_{18}NO_4S^+$ 320.0957; found 320.0954.

2-Benzoyl-4,5-dichloro-*N*-methoxybenzenesulfonamide (**3j**). Following the general procedure, reaction of **1a** and **2j**[24] gave the desired compound in 49% yield (88 mg) as a white solid. M.P.: 104 °C. IR: 3205, 3100, 2982, 2932, 2855, 2346, 1654, 1599, 1543, 1452, 1389, 1348, 1278, 1165, 956, 894, 725, 565, 516 cm^{-1}. .^1H NMR (400 MH_Z, $CDCl_3$): δ 8.28 (s, 1H), 8.25 (s, 1H), 7.84 (d, 2H, *J* = 8.4 Hz), 7.71 (t, 1H, *J* = 7.6 Hz), 7.58-7.50 (m, 3H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 195.2, 137.9, 137.4, 135.6, 135.3, 135.1, 134.9, 134.1, 131.2, 130.7, 128.9, 65.2. HRMS (ESI) m/z $[M-NHOMe]^+$ calcd for $C_{13}H_7Cl_2O_3S^+$ 312.9493; found 312.9507.

***N*-Methoxy-4-methyl-2-(4-methylbenzoyl)benzenesulfonamide (3l)**. Following the general procedure, reaction of **1b** and **2a** gave 107 mg of **3l** as a white solid (67% yield). M.P.: 126-127 °C. IR: 3012, 2909, 2312, 1678, 1612, 1503, 1498, 1352, 1298, 1232, 1056, 922 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$): δ 8.25 (s, 1H), 8.08 (d, 1H, *J* = 8 Hz), 7.75 (d, 2H, *J* = 8.4 Hz), 7.48 (d, 1H, *J* = 8.0 Hz), 7.30 (d, 2H, *J* = 8.0 Hz), 7.24 (s, 1H), 3.85 (s, 3H), 2.46 (s, 3H), 2.45 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.2, 145.5, 143.8, 138.4, 133.3, 132.3, 130.9, 130.6, 130.1, 129.3, 64.9, 21.8, 21.5. HRMS (ESI) m/z $[M+Na]^+$ calcd for $C_{16}H_{17}NNaO_4S^+$ 342.0776; found 342.0770.

2-(4-Chlorobenzoyl)-*N*-methoxy-4-methylbenzenesulfonamide (3m). Following the general procedure, reaction of **1c** and **2a** gave 107 mg of **3m** as a white solid (63% yield). M.P.: 107 °C. IR: 3212, 2982, 2932, 2367, 2324, 1647, 1525, 1389, 1340, 1292, 1173, 1089, 949, 725, 530 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.13(s, 1H), 8.09 (d, 1H, *J* = 8.0 Hz), 7.79 (d, 2H, *J* = 8.4 Hz), 7.53-7.45 (m, 3H), 7.21 (s, 1H), 3.86 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 196.4, 144.0, 140.9, 137.8, 134.1, 132.8, 132.4, 132.0, 131.0, 129.7, 129.0, 65.0, 21.5. HRMS (ESI) m/z $[M+Na]^+$ calcd for $C_{15}H_{14}ClNNaO_4S^+$ 362.0230; found 362.0224.

2-(4-Bromobenzoyl)-*N*-methoxy-4-methylbenzenesulfonamide (3n). Following the general procedure, reaction of **1d** and **2a** gave 122 mg of **3n** as a white crystalline solid (64% yield). M.P.: 83 °C. IR: 2982, 2905, 2367, 2318, 1654, 1585, 1508, 1466, 1340, 1256, 122, 1165, 1068, 1012, 705, 537, cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.12 (s, 1H), 8.09 (d, 1H, *J* = 8.4 Hz), 7.71 (d, 2H, *J* = 8.8 Hz), 7.65 (d, 2H, *J* = 8.4 Hz), 7.50 (d, 1H, *J* = 8.0 Hz), 7.21(s, 1H), 3.86 (s, 3H), 2.47 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 196.5, 144.0, 137.7, 134.5, 132.8, 132.3, 132.0, 131.9, 130.9, 129.7, 129.7, 64.9, 21.4. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{15}BrNO_4S^+$ 383.9905; found 383.9901.

2-(4-Fluorobenzoyl)-*N*-methoxy-4-methylbenzenesulfonamide (3p). Following the general procedure, reaction of **1f** and **2a** gave 102 mg of **3p** as a white crystalline solid (63% yield). M.P.: 132-133°C. IR: 3212, 3107, 3079, 2982, 2919, 2855, 1654, 1585, 1501, 1466, 1389, 1278, 1229, 1159, 1047, 942, 705, 544 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.15(s, 1H), 8.09 (d, 1H, *J* = 8Hz), 8.01-7.85 (m, 2H), 7.50 (d, 1H, *J* = 8.0 Hz), 7.19 (q, 2H, *J* = 9.4 Hz), 3.86 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 196.1, 167.7, 165.2, 144.1, 138.0, 133.6, 133.5, 132.8, 132.4, 132.3, 130.9, 129.8, 116.0, 115.8, 65.0, 21.5. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{15}FNO_4S^+$ 324.0706; found 324.0694.

2-(2-Bromobenzoyl)-*N*-methoxy-4-methylbenzenesulfonamide (3q). Following the general procedure, reaction of **1g** and **2a** gave 109 mg of **3q** as a white crystalline solid (57% yield). M.P.: 103-104°C. IR: 3219, 2982, 2919, 2849, 2360, 2325, 1662, 1563, 1459, 1424, 1396, 1334, 1306, 1264, 1207, 1165, 1033, 922, 725, 530 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$): δ 8.12-8.06 (m, 2H), 8.02-7.97 (m, 1H), 7.81-7.71 (m, 2H), 7.52 (d, 1H, *J* = 8.0 Hz), 7.39 (t, 1H, *J* = 8.0 Hz), 7.21 (s, 1H), 3.86 (s, 3H), 2.49 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 196.3, 144.2, 137.6, 137.1, 133.3, 132.9, 132.5, 131.2, 130.2, 129.8, 129.4, 123.0, 65.0, 21.6. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{15}BrNO_4S^+$ 383.9905; found 383.9901.

2-Hexanoyl-*N*-methoxy-4-methylbenzenesulfonamide (3r). Following the general procedure, reaction of **1h** and **2a** gave 57 mg of **3r** as a gummy liquid (31% yield). IR: 2960, 2932, 2863, 2367, 2318, 1696, 1557, 1459, 1340, 1165, 1089, 1012, 824, 677, 565 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.31 (s, 1H), 8.01 (d, 1H, *J* = 8 Hz), 7.46-7.39 (m, 1H), 7.36 (s, 1H), 3.82 (s, 3H), 2.94 (t, 2H, *J* = 7.6 Hz), 2.50 (d, 3H, *J* = 4.4 Hz), 1.74 (t, 2H, *J* = 7.6 Hz), 1.41-1.33 (m, 4H), 0.92 (t, 3H, *J* = 7.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 206.9, 144.6, 140.1, 132.4, 131.5, 130.9, 128.4, 64.9, 42.5, 31.1, 23.3, 22.4, 21.5, 13.9. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{22}NO_4S^+$ 300.1269; found 300.1264.

***N*-Methoxy-4-methyl-2-octanoyl-benzenesulfonamide (3s).** Following the general procedure, reaction of **1i** and **2a** gave 47 mg of **3s** as a colourless gummy liquid (47 mg, 29% yield). ^1H NMR (400 MHZ, $CDCl_3$) δ: 8.01 (d, 1H, *J* = 8 Hz), 7.43 (d, 1H, *J* = 8 Hz), 7.36 (s, 1H), 3.82 (s, 3H), 2.94 (t, 2H, *J* = 7.2 Hz), 1.77-1.68 (m, 3H), 1.40-1.25 (m, 9H), 0.90 (t, 3H, *J* = 6.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): 206.9, 144.5, 140.2, 132.4, 131.6, 130.9, 128.4, 64.9, 42.5, 31.6, 29.0, 28.9, 23.6, 22.6, 21.5, 14.0. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{16}H_{27}NO_4S^+$ 329.1661; found 329.1658.

2-(4-Cyano-benzoyl)-*N*-methoxy-4-methylbenzenesulfonamide (3t). Following the general procedure, reaction of **1j** and **2a** gave 47 mg of **3t** as a white crystalline solid (28% yield). M.P.: 121-123 °C. IR: 3219, 2974, 2367, 2318, 2241, 1662, 1535, 1396, 1278, 1173, 1054, 949, 963, 852, 725, 530 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.10 (d, 1H, *J* = 8.0 Hz), 8.00 (s, 1H), 7.94 (d, 2H, *J* = 8.4 Hz), 7.81 (d, 2H, *J* = 8.4 Hz), 7.54 (d, 1H, *J* = 8.4Hz), 7.18 (s, 1H), 3.86 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 196.2, 144.4, 139.0, 137.3, 133.0, 132.6, 132.4, 131.4, 130.9, 129.5, 117.7, 117.3, 65.1, 21.5. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{16}H_{15}N_2O_4S^+$ 331.0757; found 331.0753.

4-(2-Methoxysulfamoyl-5-methylbenzoyl)benzoic acid methyl ester (3u). Following the general procedure, reaction of **1k** and **2a** gave 60 mg of **3u** as a white solid (33% yield). M.P.: 77-79°C. IR: 3219, 2932, 2849, 1724, 1662, 1563, 1501, 1438, 1410, 1348, 1278, 1165, 1109, 956, 830, 747, 565 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.18-8.07 (m, 4H), 7.90 (d, 2H, *J* = 8.4 Hz), 7.52 (d, 1H, *J* = 8 Hz), 7.21 (s, 1H), 3.98 (s, 3H), 3.86 (s, 3H), 2.47 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 197.0, 166.0, 144.1, 139.1, 137.8, 134.8, 133.0, 132.5, 131.2, 130.6, 129.9, 129.7, 65.0, 52.6, 21.5. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{17}H_{18}NO_6S^+$ 364.0855; found 364.0859.

5-Methyl-3-phenyl-benzo[*d*]isothiazole 1,1-dioxide[26] (5a). Following the general procedure, the reaction of tosylamide [25a] with benzaldehyde gave 90 mg (70 % yield) of **5a** as a white solid. M.P.: 84-86 °C. IR: 3365, 3253, 2982, 2919, 2367, 2318, 1718, 1599, 1529, 1445, 1389, 1298, 1151, 900, 816, 656, 530 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.97 (d, 2H, *J* = 7.2 Hz), 7.90 (d, 1H, *J* = 8.0 Hz), 7.75-7.56 (m, 5H), 2.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.2, 144.9, 138.2, 133.9, 133.3, 131.0, 130.5, 129.4, 129.2, 127.1, 122.8, 21.9.

3-Phenyl-benzo[*d*]isothiazole 1,1-dioxide[26] (5b). Following the general procedure, the reaction of benzene sulfonamide with benzaldehyde gave 82 mg (68 % yield) of **5b** as a white solid. M.P.: 124-126 °C. IR: 3065, 2974, 2360,1746, 1599, 1529, 1445, 1326, 1165, 958, 783, 733, 696, 663, 530 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$): δ 8.04 (d, 1H, *J* = 6.8 Hz), 7.99 (d, 2H, *J* = 8.4 Hz), 7.93 (d, 1H, *J* = 7.6 Hz), 7.85-7.68 (m, 3H), 7.63 (t, 2H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.1, 141.1, 133.6, 133.4, 133.4, 130.5, 130.4, 129.5, 129.2, 126.6, 123.1.

5-Chloro-3-phenyl-benzo[*d*]isothiazole 1,1-dioxide[18b] (5c). Following the general procedure, the reaction of 4-chloro phenyl sulfonamide[25a] with benzaldehyde gave 89 mg (64% yield) of **5c** as a white solid. M.P.: 129 °C. IR: 3635, 3645, 3072, 2982, 2911, 2360, 1704, 1591, 1522, 1438, 1326, 1165, 1075, 970, 816, 802, 683, 544 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.97 (d, 3H, *J* = 8 Hz), 7.87 (s, 1H), 7.81-7.71 (m, 2H), 7.66 (t, 2H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.8, 140.2, 139.3, 133.7, 133.2, 132.4, 129.9, 129.4, 126.7, 124.0.

5-Bromo-3-phenyl benzo[*d*]isothiazole 1,1-dioxide (5d) Following the general procedure, the reaction 4-bromo benzenesulfonamide[25a] with benzaldehyde gave 91 mg (57 % yield) of **5d** as a white solid. M. P.: 133 °C. IR: 3735, 3645, 3072, 2982, 2360, 2325, 1591, 1522, 1320, 1165, 1068, 963, 789, 537 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$): δ 8.03 (s, 1H), 8.00-7.87 (m, 4H), 7.75 (t, 1H, *J* = 7.6 Hz), 7.66 (t, 2H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.8, 139.8, 136.2, 133.7, 132.4, 129.9, 129.6, 129.4, 128.3, 124.1. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{13}H_9BrNO_2S^+$ 321.9537; found 321.9542.

5-Ethyl-3-phenyl-benzo[*d*]isothiazole-1, 1-dioxide (5f). Following the general procedure, the reaction of 4-ethyl benzenesulfonamide[25b] with benzaldehyde gave 99 mg (74 % yield) of **5f** as a white solid. M.P.: 106-107 °C. IR: 3645, 3065, 2967, 2919, 2877, 2360, 2325, 1599, 1535, 1445, 1312, 1145, 970, 852, 796, 733, 649, 537, 446 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.00-7.90 (m, 3H), 7.76-7.59 (m, 5H), 2.83 (q, 2H, *J* = 7.6 Hz), 1.31(t, 3H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.2, 151.2, 138.4, 133.3, 132.9, 131.1, 130.5, 129.5, 129.2, 126.0, 123.0, 29.1, 15.5. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{14}NO_2S^+$ 272.0739; found 272.0739.

5-Methoxy-3-phenyl-benzo[*d*]isothiazole-1,1-dioxide [26] **(5g)**. Following the general procedure, the reaction of 4-methoxybenzenesulfonamide [25a] with benzaldehyde gave 84 mg (62% yield) of **5g** as a white solid. M.P.: 104-106 °C. IR: 3086, 2974, 2925, 2841, 2360, 2325, 1585, 1306, 1165, 1123, 697, 558, 509 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.99-7.90 (m, 3H), 7.70 (d, 1H, *J* = 7.2 Hz), 7.63 (t, 2H, *J* = 7.6 Hz), 7.32 (s, 1H), 7.25-7.20 (m, 1H), 3.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.2, 164.0, 133.0, 133.0, 132.8, 130.6, 129.3, 129.1, 124.2, 117.4, 112.7, 56.2.

5,6-Dimethoxy-3-phenyl-benzo[*d*]isothiazole-1,1-dioxide[27] (5h). Following the general procedure, the reaction of 3,4-dimethoxy benzenesulfonamide [25c] with benzaldehyde gave 86 mg (57 % yield) of **5h** as a white solid. M.P.: 222-223 °C. IR: 2925, 2849, 2360, 2318, 1732, 1577, 1494, 1312, 1145, 1040, 922, 775, 691, 488 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.95 (d, 2H, *J* = 7.6 Hz), 7.71 (t, 1H, *J* = 7.6 Hz), 7.63 (t, 2H, *J* = 7.6 Hz), 7.50 (s, 1H), 7.22 (s, 1 H), 4.07 (s, 3H), 3.98 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.2, 153.7, 152.9, 134.8, 133.1, 130.7, 129.2, 123.5, 107.7, 105.4, 56.8, 56.6.

5,6-Dimethyl-3-phenyl-benzo[*d*]isothiazole 1,1-dioxide (5i). Following the general procedure, the reaction of 3,4-dimethy benzenesulfonamide[25a] with benzaldehyde gave 86 mg (63% yield) of **5i** as a white solid. M.P.: 179-180 °C. IR: 3735, 3561, 2982, 2367, 2318, 1724, 1522, 1320, 1151, 928, 586 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$): δ 7.97 (d, 2H, *J* = 7.6 Hz), 7.78 (s, 1H), 7.70 (t, 1H, *J* = 7.6 Hz), 7.66-7.58 (m, 3H), 2.46 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.2, 143.6, 143.2, 138.9, 133.1, 130.7, 129.4, 129.1, 128.7, 127.2, 124.0, 20.6, 20.4. HRMS (ESI) m/z $[M+H]^+$calcd for $C_{15}H_{14}NO_2S^+$ 272.0740; found 272.0739.

5,6-Dichloro-3-phenyl-benzo[*d*]isothiazole 1,1-doxide (5j). Following the general procedure, the reaction of 3,4-dichloro benzenesulfonamide[25a] with benzaldehyde gave 85 mg (55% yield) of **5j** as a white solid. M.P.: 233 °C. IR: 3107, 1585, 1515, 1326, 1151, 1068, 977, 866, 796, 691, 579 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.11 (s, 1H), 8.00-7.93 (m, 3H), 7.76 (t, 1H, *J* = 7.4 Hz), 7.67 (t, 2H, *J* = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.2, 140.3, 139.1, 138.6, 133.9, 130.0, 129.6, 129.5, 129.4, 127.9, 124.9. HRMS (ESI) m/z $[M+H]^+$calcd for $C_{13}H_8Cl_2NO_2S^+$ 311.9647; found 311.9655.

5,7-Dimethyl-3-phenyl-benzo[*d*]isothiazole 1,1-dioxide[28] (5k). Following the general procedure, the reaction of 2,4-dimethy benzenesulfonamide[25d] with benzaldehyde gave 82 mg (61 % yield) of **5k** as a white solid. M.P.:123 °C. IR: 3735, 3651, 2974, 2919, 2855, 2360, 2325, 1591, 1515, 1438, 1292, 1145, 844, 725, 656 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.95 (d, 2H, *J* = 7.6 Hz), 7.70 (t, 1H, *J* = 7.6 Hz), 7.62 (t, 2H, *J* = 7.6 Hz), 7.46 (s, 1H), 7.35 (s, 1H), 2.74 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.3, 144.6, 136.7, 136.0, 135.5, 133.0, 131.2, 130.8, 129.4, 129.1, 124.6, 21.6, 17.2.

1-(1,1-Dioxo-3-phenyl-1*H*-1λ⁶-benzo[*d*]isothiazol-5-yl)ethanone (5l). Following the general procedure, the reaction of 4-acetyl benzenesulfonamide[25e] with benzaldehyde gave 56 mg (40% yield) of **5l** as a white solid. M.P.: 143-144 °C. IR: 3735, 3651, 3072, 2982, 2367, 2325, 1690, 1522, 1312, 1242, 1151, 838, 739, 697, 642, 593 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.47 (s, 1H), 8.35 (d, 1H, *J* = 8.0 Hz), 8.13 (d, 1H, *J* = 7.6 Hz), 8.02 (d, 2H, *J* = 7.6 Hz), 7.76 (t, 1H, *J* = 7.2 Hz), 7.67 (t, 2H, *J* = 7.6 Hz), 2.72 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 195.4, 170.3, 144.3, 141.5, 133.8, 133.4, 131.4, 130.0, 129.5, 129.4, 125.9, 123.4, 27.0. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{12}NO_3S^+$ 286.0533; found 286.0533.

1,1-Dioxo-3-phenyl-1*H*-1λ⁶-benzo[*d*]isothiazole-5-carboxylic acid methyl ester (5m). Following the general procedure, the reaction of 4-(methoxycarbonyl)-benzenesulfonic acid **5m** was prepared in 39 % yield (59 mg) of as a white solid. M.P.: 108 °C. IR: 3743, 3648, 3093, 2988, 2960, 2360, 2318, 1718, 1599, 1535, 1438, 1340, 1284, 1179, 963, 767, 691 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 8.55 (s, 1H), 8.48 (d, 1H, *J* = 8.0 Hz), 8.11 (d, 1H, *J* = 8.0 Hz), 8.03 (d, 2H, *J* = 7.2 Hz), 7.76 (t, 1H, *J* = 7.6 Hz), 7.67 (t, 2H, *J* = 7.6 Hz), 4.02 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.3, 164.6, 144.5, 135.4, 134.6, 133.7, 131.1, 130.0, 129.6, 129.4, 127.5, 123.1, 53.1. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{15}H_{12}NO_4S^+$ 302.0487; found 302.0489.

5-Methyl-3-*p*-tolyl-benzo[*d*]isothiazole-1,1-dioxide[29] (**5n**). Following the general procedure, the reaction of tosylamide with 4-methylbenzaldehyde gave 94 mg (69 % yield) of **5n** as a white solid. M.P.: 191 °C. IR: 2982, 2919, 2353, 1920, 1746, 1605, 1508, 1542, 1298, 1151, 1061, 963, 866, 810, 747, 677, 544 cm^{-1}.^1H NMR (400 MH_Z, $CDCl_3$), δ: 7.89 (d, 3H, *J* = 8 Hz), 7.69 (s, 1H), 7.58 (d, 1H, *J* = 7.6 Hz), 7.43 (d, 2H, *J* = 7.6 Hz), 2.54 (s, 3H), 2.51 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.9, 144.7, 144.4, 138.4, 133.8, 131.2, 129.9, 129.6, 127.8, 127.0, 122.8, 21.8, 21.8.

3-(4-Chlorophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide[29] (5o). Following the general procedure, the reaction of tosylamide with 4-chlorobenzaldehyde gave 85 mg (58 % yield) of **5o** as a white solid. M.P.: 223 °C. IR: 3086, 2982, 2367, 2318, 1718, 1590, 1515, 1403, 1326, 1151, 970, 844, 663, 579 cm^{-1}. ^1H NMR (400 MH_Z, $CDCl_3$): δ 7.92 (t, 3H, *J* = 8.8 Hz), 7.65 - 7.58 (m, 4H), 2.55 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.0, 145.0, 139.9, 138.3, 134.1, 130.8, 130.7, 129.6, 128.9, 126.7, 123.0, 21.9.

3-(4-Fluorophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide (**5p**). Following the general procedure, the reaction of tosylamide with 4-fluorobenzaldehyde gave 82 mg (59 % yield) of **5p** as a white solid. M.P.: 187 °C. IR: 3079, 1927, 1591, 1494, 1410, 1306, 1229, 1151, 977, 844, 767, 663, 544, 488 cm^{-1}.^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.02 (t, 2H, *J* = 6.4 Hz), 7.91 (d, 1H, *J* = 7.6 Hz), 7.65 (s, 1H), 7.60 (d, 1H, *J* = 7.6 Hz), 7.33 (t, 2H, *J* = 8.4 Hz), 2.56 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.9, 167.1, 164.5, 144.9, 138.4, 134.0, 132.0, 131.9, 130.8, 126.8, 126.7, 126.7, 122.9, 116.7, 116.5, 21.9. HRMS (ESI) m/z $[M+H]^+$calcd for $C_{14}H_{11}FNO_2S^+$ 276.0495; found 276.0497.

3-(4-Bromophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide (**5q**). Following the general procedure, the reaction of tosylamide with 4-bromobenzaldehyde gave 94 mg (56 % yield) of **5q** as a white solid. M.P.: 227 °C. IR: 3086, 2974, 2925, 2841, 2367, 2318, 1577, 1522, 1396, 1320, 1159, 977, 830, 656, 537 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.91 (d, 1H, *J* = 7.6 Hz), 7.86 (d, 2H, *J* = 8.4 Hz), 7.78 (d, 2H, *J* = 8.4 Hz), 7.61 (d, 2H, *J* = 9.6 Hz), 2.55 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.1, 114.9, 138.4, 134.1, 132.6, 130.8, 130.7, 129.4, 128.4, 126.7, 123.0, 21.8. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}BrNO_2S^+$ 335.9694; found 335.9696.

3-(2-Bromophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide (**5s**). Following the general procedure, the reaction of tosylamide with 2-bromobenzaldehyde gave 69 mg (41% yield) of **5s** as a white solid. M.P.:116-118 °C. IR: 3079, 2967, 2919, 2855, 2367, 2388, 1710, 1522, 1417, 1320, 1173, 810, 753, 691, 544 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.10 (s, 1H), 7.90 (t, 2H, *J* = 7.2 Hz), 7.84 (d, 1H, *J* = 8.0 Hz), 7.61 (d, 2H, *J* = 5.6 Hz), 7.52 (t, 1H, *J* = 8.0 Hz), 2.56 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.8, 145.1, 138.2, 136.1, 134.2, 132.3, 132.1, 130.7, 130.6, 127.9, 126.7, 123.3, 123.0, 21.9. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}BrNO_2S^+$ 335.9688; found 335.9696.

3-(2-Chlorophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide (**5t**). Following the general procedure, the reaction of tosylamide with 4-chlorobenzaldehyde gave 60 mg (41% yield) of **5t** as a white solid. M.P.: 82-84 °C. IR: 3219, 2982, 2919, 2855, 1742, 1662, 1599, 1543, 1374, 1180, 1054, 977, 747, 551cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.88 (d, 1H, *J* = 8.0 Hz), 7.63-7.54 (m, 4H), 7.56-7.46 (m, 1H), 7.24 (s, 1H), 2.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.1, 145.1, 137.0, 134.2, 132.7, 132.5, 131.3, 130.7, 130.3, 129.9, 127.4, 127.0, 122.6, 21.7. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}ClNO_2S^+$ 292.0199; found 292.0193.

3-(3-Bromophenyl)-5-methyl-benzo[*d*]isothiazole-1,1-dioxide (**5u**). Following the general procedure, the reaction of tosylamide with 3-bromobenzaldehyde gave 90 mg (54% yield) of **5u** as a white solid. M.P.:119 °C. IR: 3065, 2974, 2919, 2849, 1535, 1417, 1320, 1165, 880, 810, 656, 544, 502 cm^{-1}.^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.11 (s, 1H), 7.91 (t, 2H, *J* = 8.4 Hz), 7.84 (d, 1H, *J* = 7.6 Hz), 7.61 (d, 2H, *J* = 5.6 Hz), 7.52 (t, 1 H, *J* = 8.0 Hz), 2.56 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.5, 144.9, 138.6, 135.9, 134.0, 132.5, 132.1, 130.6, 130.5, 127.8, 126.5, 123.3, 122.9, 21.7. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}BrNO_2S^+$ 335.9688; found 335.9695.

5-Methyl-3-naphthalen-2-yl-benzo[*d*]isothiazole-1,1-dioxide (**5v**). Following the general procedure, the reaction of tosylamide with 2-naphthaldehyde gave 83 mg (54% yield) of **5v** as a white solid. M.P.:133-134 °C. IR: 3058, 2974, 2924, 2360, 2311, 1738, 1535, 1452, 1320, 1151, 942, 803, 551 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 8.23 (d, 1H, *J* = 7.6 Hz), 8.14 (d, 1H, *J* = 8.0 Hz), 8.0 (d, 1H, *J* = 8.0 Hz), 7.95 (d, 1H, *J* = 8.0 Hz), 7.83 (d, 1H, *J* = 7.2 Hz), 7.68 (d, 1H, *J* = 8 Hz), 7.67-7.56 (m, 3H), 7.30 (d, 1H, *J* = 10.8 Hz), 2.45 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 171.7, 145.0, 137.7, 134.1, 133.9, 132.6, 132.4, 130.6, 128.7, 128.1, 127.8, 127.3, 127.1, 125.2, 124.6, 122.6, 21.7. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{18}H_{14}NO_2S^+$ 308.0745; found 308.0748.

4-(4-Chlorophenyl)-1*H*-isothiochromene-2,2-dioxide (**6a**). Following the general procedure, the reaction of benzylsulfonamide with 4-chlorobenzaldehyde gave 51 mg (36% yield) of **6a** as a white solid. M.P.: 200-201 °C. IR: 3072, 2974, 2905, 2855, 2360, 1585, 1529, 1396, 1320, 1137, 1089, 1012, 949, 830, 719, 544, 468 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.75 (d, 2H, *J* = 8.8 Hz), 7.67 (t, 1H, *J* = 7.6 Hz), 7.61-7.48 (m, 4H), 7.47 (d, 1H, *J* = 7.6 Hz), 4.52 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): 176.1, 139.2, 134.0, 133.8, 132.7, 132.4, 131.8, 130.7, 129.3, 129.0, 125.5, 48.7. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}ClNO_2S^+$ 292.0199; found 292.0196.

4-(4-Fluorophenyl)-1*H*-isothiochromene-2,2-dioxide (**6b**). Following the general procedure, the reaction of benylsulfonamide with 4-fluorobenzaldehyde have 53 mg (40 % yield) of **6b** as a white solid. M.P.: 185 °C. IR: 3749, 3596, 3079, 2967, 2919, 2855, 2360, 2318, 1704, 1591, 1515, 1389, 1312, 1229, 1117, 949, 789, 537 cm^{-1}. ^{1}H NMR (400 MH_Z, $CDCl_3$): δ 7.86-7.79 (m, 2H), 7.67 (t, 1H, *J* = 7.6 Hz), 7.58(d, 1H, *J* = 7.6Hz), 7.53 (d, 1H, *J* = 7.6 Hz), 7.47 (d, 1H, *J* = 7.6 Hz), 7.24 (t, 2H, *J* = 8.0 Hz), 4.51 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): 176.1, 166.7, 164.2, 134.0, 132.9, 132.9, 132.8, 132.5, 131.6, 131.5, 130.7, 129.2, 125.6, 116.0, 115.8, 48.7. HRMS (ESI) m/z $[M+H]^+$ calcd for $C_{14}H_{11}FNO_2S^+$ 276.0495; found 276.0500.

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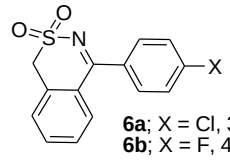
[23] Reaction of benzylsulfonamide and 4-halobenzaldehyde under the optimum reaction conditions gave **6a** & **6b** over period of 2h in 36 and 40% yield respectively.



6a; X = Cl, 36%
6b; X = F, 40%

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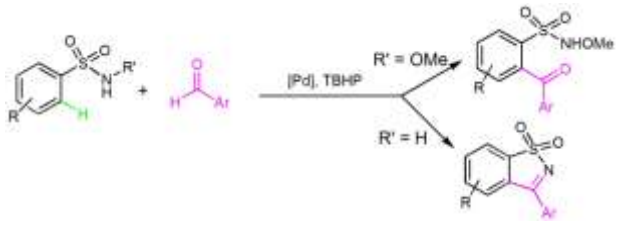
FULL PAPER

Palladium-catalyzed *ortho*-benzoylation of sulfonamides through C–H activation: Expedient synthesis of cyclic *N*-sulfonyl ketimines



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