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Article

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Functionalization of alkynes and alkenes using cascade reaction approach: Synthesis of β-keto sulfones under metal-free conditions

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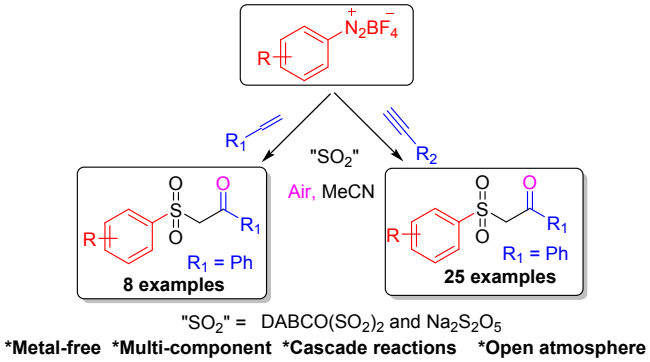

Abstract:

Here, we are reporting a multi-component cascade reaction approach for the synthesis of β-keto sulfones by exploiting differential reactivity pattern of substrates under open-atmosphere and metal-free conditions. The coupling partners are aryldiazonium salts, unsaturated compounds, and DABSO. The optimized conditions worked well with both alkenes and alkynes. Moreover, the reaction also works with metabisulfite for the source of sulfone. The controlled LC-MS and ^{18}O-labelled experiments suggested that air is a source of incoming oxygen atom of keto group of *β*-keto sulfones.

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Introduction:

The *β*-Keto sulfones represents an important core in the area of synthetic and medicinal chemistry because of unique reactivity.[1] *β*-Keto sulfones also possessed biological activity in the number of disease areas such as anti-infective,[2] anti-fungal[3] and inhibitor of 11-HSD1 (Hydroxysteroid dehydrogenase type I) inhibitor,[4] bacterial quorum sensing antagonists.[5] Considering the synthetic and biological potential of *β*-keto sulfones, number of approaches has been developed. Initially, it was generated by the i) oxidation of *β*-keto sulfides,[6] ii) coupling between α-halo ketones[7] or α-tosyloxy ketones[8] and sodium sulfonates, iii) coupling between diazo sulfones and aldehydes,[9] and iv) coupling between (methylsulfonyl)arenes and acyl chlorides. All these methods required pre-functionalized coupling partners. In the last decade, with the advancement in the radical chemistry, the synthesis of *β*-ketosulfones was also achieved by the reaction between phenylsulfonyl radical and alkenes/alkynes, which in turn was generated from diverse sulfonyl containing precursors such as phenyl sulfonyl halides,[10] sodium phenyl sulfinates,[10a, 11] phenylsulfinic acids,[12] phenylsulfonyl hydrazides,[10a, 13] benzenesulfonothioate[13e] under diverse reaction conditions ranging from photo-catalyst to metal to metal-free (Fig 1). The generation of phenylsulfonyl radicals using sulfone surrogate and aryl radicals, providing an effective alternative approach and is being exploited for diverse coupling reactions.[14] In this direction, Jie Wu made an attempt and was successful to coupled phenylsulfonyl radical (generated from aryldiazonium salts and DABSO) with functionalized alkenes (silyl enol ethers) and alkynes (3-arylpropiolic acids) (Fig 1).[15a-c] On the other hand, considering the readily availability of phenylacetylenes and styrenes, their use in this transformation would be more valuable and diverse, however, no such report is available. Considering our interest in radical chemistry,[16] we started an investigation toward the search of suitable conditions for the cascade reactions to functionalized alkynes and alkenes using aryldiazonium tetrafluoroborates and DABSO as coupling partners. Here, we

are reporting an approach for the synthesis of *β*-keto sulfones through the cascade reaction between aryldiazonium tetrafluoroborates, DABSO and alkynes/alkenes under metal-free conditions.

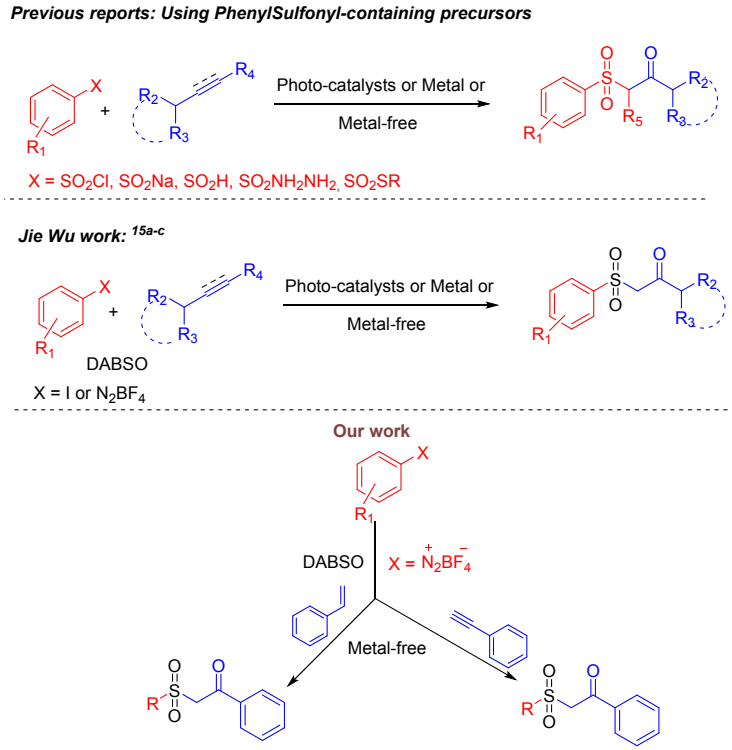
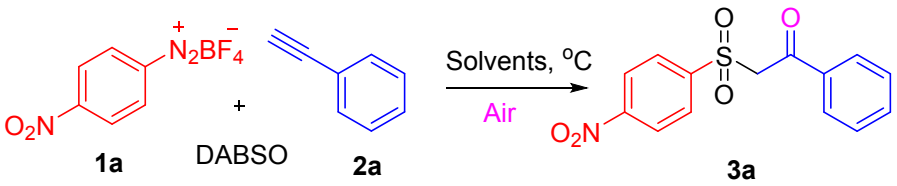


Figure 1: Previous and present approaches

Results and discussion:

Initially, we examine the reaction between 4-nitrobenzenediazonium tetrafluoroborate **1a,** phenylacetylene **2a** and DABSO as model substrates for the optimization of reaction conditions (Table 1).

Table 1: Optimization studies.



entries	Temp (°C)	DABSO	Solvent	**3a** Yield %[b]
1	rt	2	DMSO	NR
2	100	2	DMSO	<10
3	100	2	H_2O	NR
4	100	2	DMF	NR
5	80	2	THF	NR
6	100	2	1,4-Dioxane	NR
7	100	2	DMA	NR
8	100	2	MeCN	62
9	**80**	**2**	**MeCN**	**78**
10	80	1.5	MeCN	64
11	80	1	MeCN	38
12	80	0.5	MeCN	<10

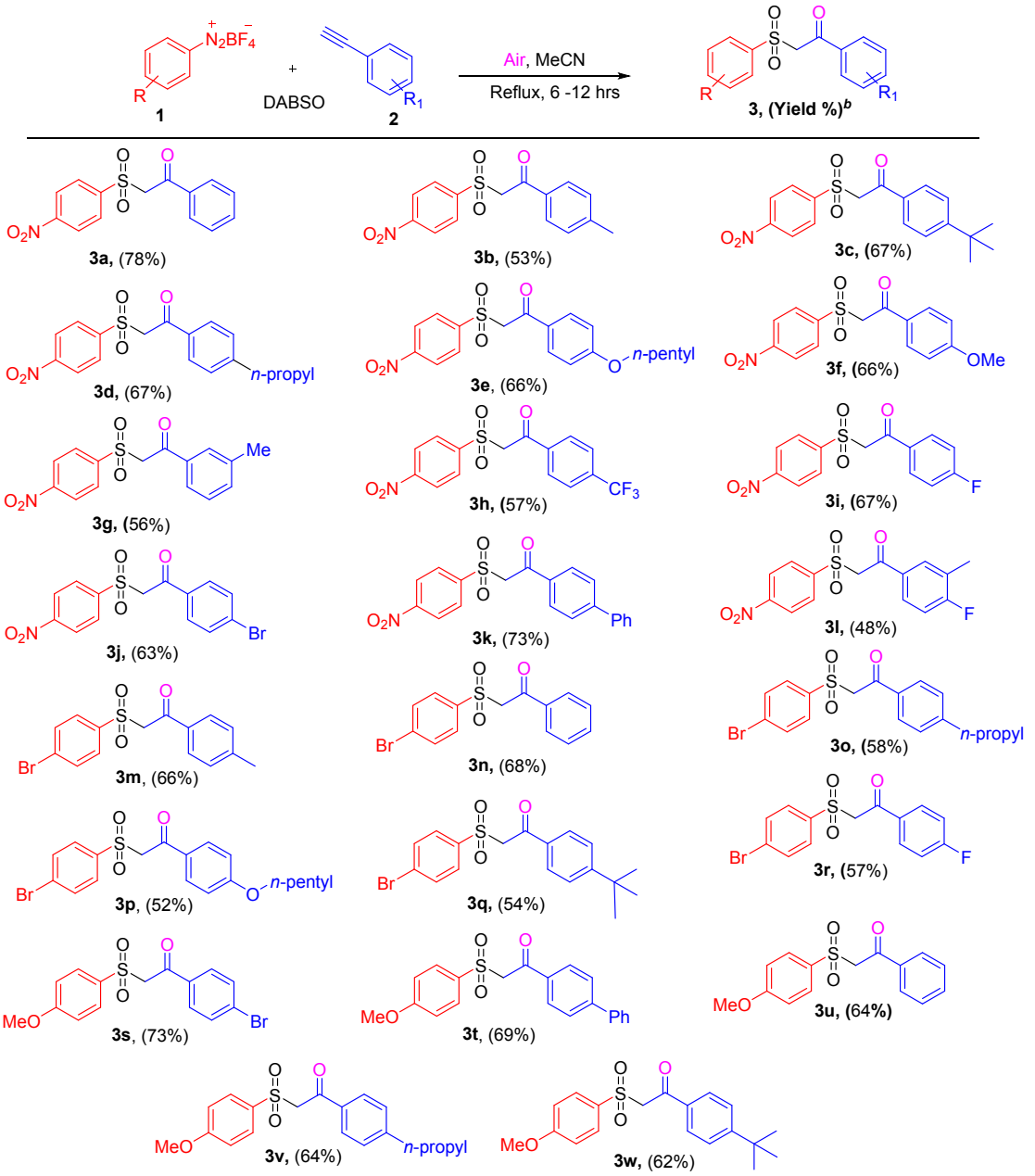
Reaction conditions: [a]Reactions were carried out using **1** (1equiv.), **2** (1.2 equiv) and DABSO (2 equiv) 8mL of solvent; [b]isolated yields; 6-12 hrs.

In the first experiment, 4-nitrobenzenediazonium tetrafluoroborate **1a** (1 mmol), DABSO (2 mmol) phenylacetylene **2a** (1.5 mmol) were dissolved in DMSO and stirred at the room temperature under open atmosphere, no desired product formation was observed (entry 1). In the next experiment, the reaction was heated at 80 °C, the formation of desired *β*-keto sulfones **3a** was observed with very low yields (entry 2) giving a positive indication towards the working of the concept. In further experiments, a range of solvents such as H_2O, DMF, THF, 1,4-Dioxane, DMA and MeCN were screened (entries 3-8) and surprisingly MeCN gave the desired product with 62% yields and none of the others gave the desired product. The decrease in the temperature from 100 °C to 80 °C further enhanced

the yields to 78% (entry 9) and further fall in temperature also decreased the yields. In further attempts, a varied amount of DABSO was also studied which found to affect the yields (entries 10-12). After trying the number of optimization experiments, reaction conditions of **entry 9** is found to be best.

After the optimization, the scope of the reaction with respect to different diazonium salts and acetylenes were investigated (Scheme 1). The reaction of 4-nitrobenzenediazonium tetrafluoroborate **1a** with phenyl acetylenes having electron-donating (4-Me, 4-*t*-butyl, 4-O-*n*-propyl, 4-O-*n*-pentyl, 4-OMe, 3-Me) and electron-withdrawing groups (4-CF_3, 4-F, 4-Br, 4-Ph) on attempt underwent smoothly and gave the corresponding products **(3a−3k)** in good yields (78-56%). When bisubstituted phenylacetylenes were tried, the corresponding *β*-keto sulfone **(3l)** was observed in a yield of 48%. After this, (4-bromo and 4-methoxy) substituted benzenediazonium tetrafluoroborate salts were also tried to examine its diversification. All the tried reactions underwent smoothly and gave their corresponding products **(3m-3w)** with good to moderate yields (73-52%).

Scheme 1. Substatre scopes[a]

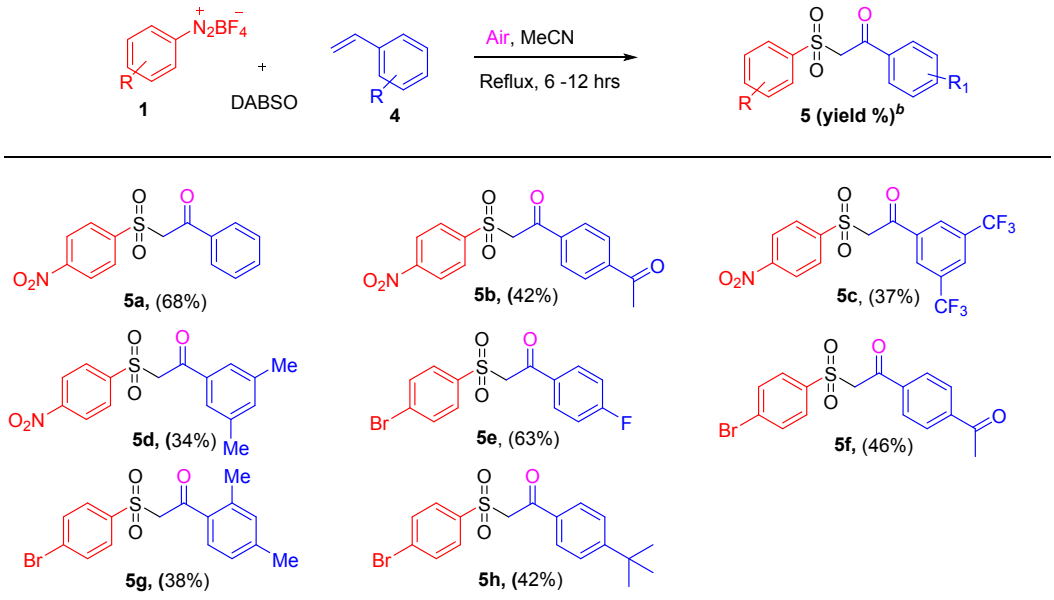


Reaction conditions: [a]Reactions were carried out using **1** (1equiv.), **2** (1.2 equiv) and DABSO **2** equiv 8-10 mL of solvent, 6-12 hrs; [b]isolated yields.

In the next attempts, we also explored the optimized conditions for alkenes as unsaturated coupling partner, which worked nicely and afforded the *β*-keto sulfones **5** in a good to excellent yields. 4-Nitrobenzenediazonium tetrafluoroborate **1a**, when treated with phenyl styrene gave the

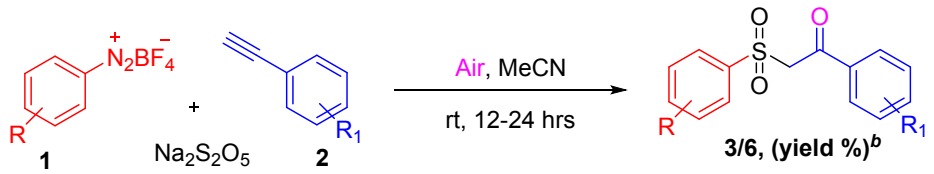
corresponding *β*-keto sulfones **5a** in a yield of 68%. In the next attempts, mono- and bi-substituted styrenes were tried which gave the corresponding *β*-keto sulfones **(5a-5h)** in a yield of 68-34% (Scheme 2). When sodium metabisulphite ($Na_2S_2O_5$) was tried in place of DABSO for the source of sulfone, we feel happy to report that the reaction between benzenediazonium tetrafluoroborate salts **1** and phenyl acetylenes **2** underwent smoothly at room temperature and gave the corresponding *β*-keto sulfone **(6a-6f)** in a yield of 63-43% (Scheme 3). We also carried out the reaction of benzenediazonium tetrafluoroborate with phenyl styrene which gave the corresponding β-keto sulfones (**7a-7c**) in a yield of 39-48% (Scheme 4). Sodium metabisulphite being an inexpensive source of sulfone providing an additional advanatge to the present methdology. When we carried out this reaction on a large scale (1 gm, 4.23 mmol) it gave the corresponding *β*-keto sulfones product **3a** with a (68% yield) (Scheme 5).

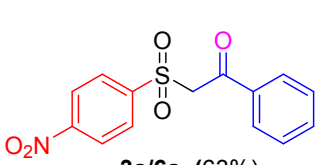
Scheme 2. Substatre scopes[a]

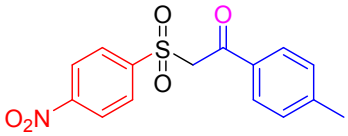


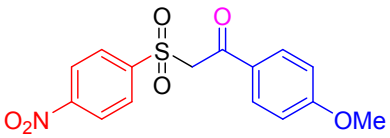
Reaction conditions: [a]Reactions were carried out using **1** (1equiv.), **4** (1.2 equiv) and DABSO **2** equiv 8mL of solvent; [b]isolated yields; 6-12 hrs.

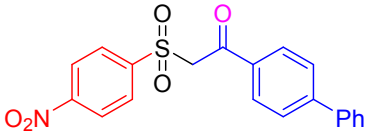
Scheme 3. Reaction of phenyl acetylenes with another sulfone source[a]

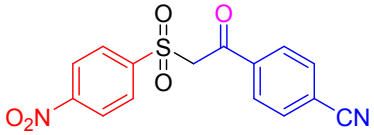


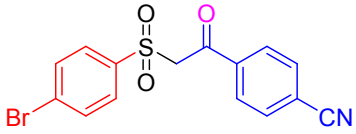

3a/6a, (63%)


3b/6b, (47%)


3f/6c, (47%)

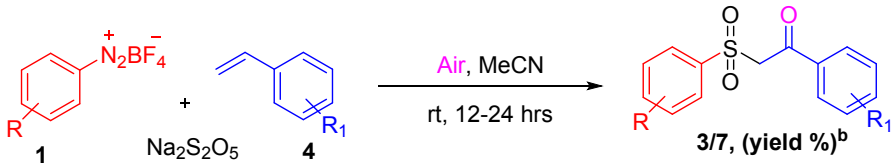

3k/6d, (49%)

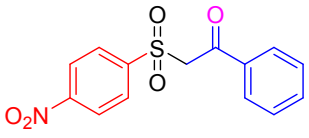

6e, (46%)

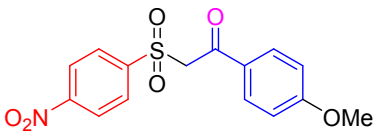

6f, (43%)

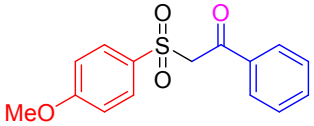
Reaction conditions: [a]Reactions were carried out using **1** (1equiv.), **2** (1.2 equiv) and $Na_2S_2O_5$ (2 equiv.), 8-10 mL of solvent, 12-24 hrs; [b]isolated yields.

Scheme 4. Recation of p**henyl styrene with another sulfone source**[a]



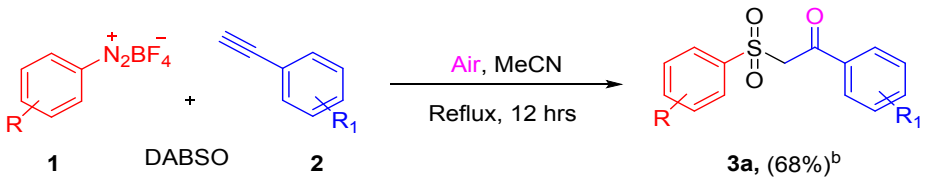

3a/7a, (48%)


3f/7b, (41%)


3u/7c, (39%)

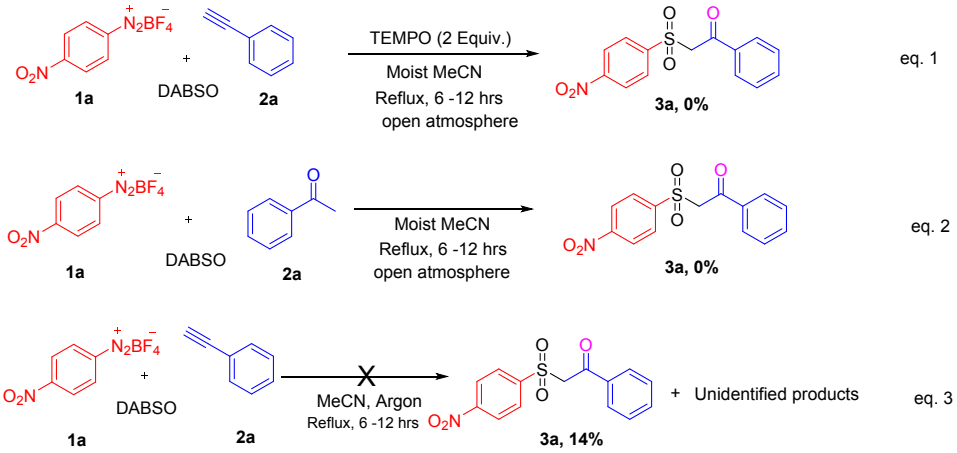
Reaction conditions: [a]Reactions were carried out using **1** (1equiv.), **4** (1.2 equiv) and $Na_2S_2O_5$ (2 equiv.), 8-10 mL of solvent, 12-24 hrs; [b]isolated yields.

Scheme 5. Reaction in gram scale[a]



Reaction conditions: [a]Reactions were carried out using **1** (1 equiv., 4,23 mmol), **2** (1.2 equiv, 6.83 mmol) and DABSO (2 equiv, 8.47 mmol), [b]isolated yields.

Scheme 6. Controlled experiments.



In order to confirm the proposed mechanistic pathway, a number of confirmatory controlled experiments have been performed. In the first instance, the reaction was performed in the presence of free-radical scavenger TEMPO, no desired product was formed (eq. 1, Scheme 6) confirmed the radical pathway. In the literature reports, it is known that phenyl acetylenes hydrated to acetophenone,[17] and also suggested its involvement under present conditions. In order to rule out this assumption, the reaction was performed with acetophenone under optimized conditions, no desired product formation was formed, ruled out its involvement (eq. 2, Scheme 6). To know the source of incoming oxygen in the *β*-keto sufones, when the reaction was performed under an argon atmosphere, the formation of desired product **3a** was significantly suppressed (eq. 3, Scheme 6) suggested that oxygen may be source of incoming oxygen atom in *β*-keto sulfones. In the next attempts, the reaction of *4*-

nitrobenzenediazonium tetrafluoroborate **1a** with phenyl acetylene **2a** and styrene **4a**, respectively, were conducted and studied in a LC-MS at different interval of times (Figure 2, and details provided in page no.s S2-S7 of Supporting Information (SI)). The LC-MS study revealed the formation of phenyl sulfone radical **III** and peroxy radical intermediate (**X**). The existence of peroxy radical intermediate (**X**) suggested that oxygen is the source of incoming oxygen. Next, we conducted the reaction in the presence of ^{18}O-labelled oxygen gas (Fig 3), wherein LC−MS analysis showed 81% presence of ^{18}O in the product, confirmed the source of incoming oxygen is air.

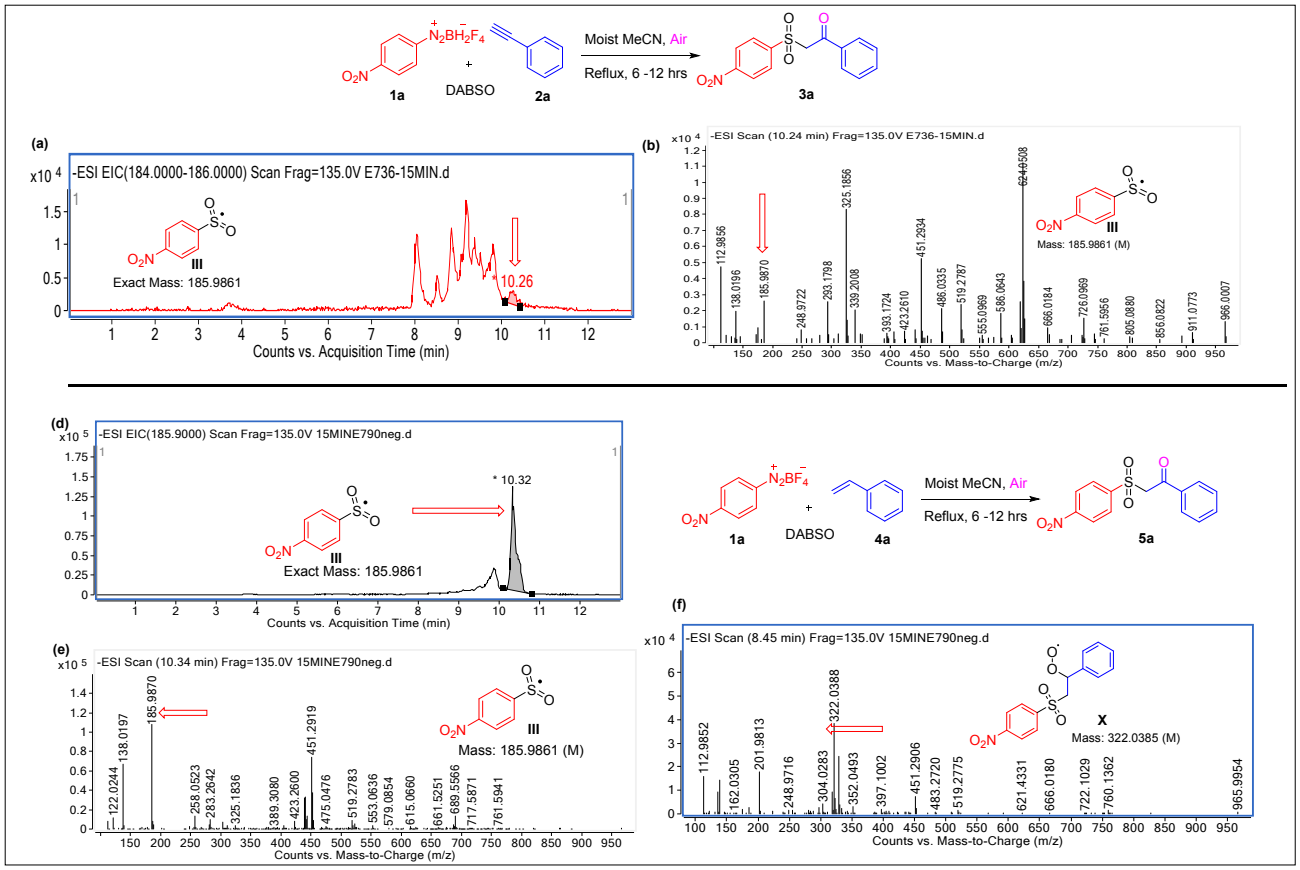


Figure 2. LC-MS analysis regarding intermediates capturing; a-b) analysis of reaction with phenylacetylene, d-f) analysis of reaction with styrene.

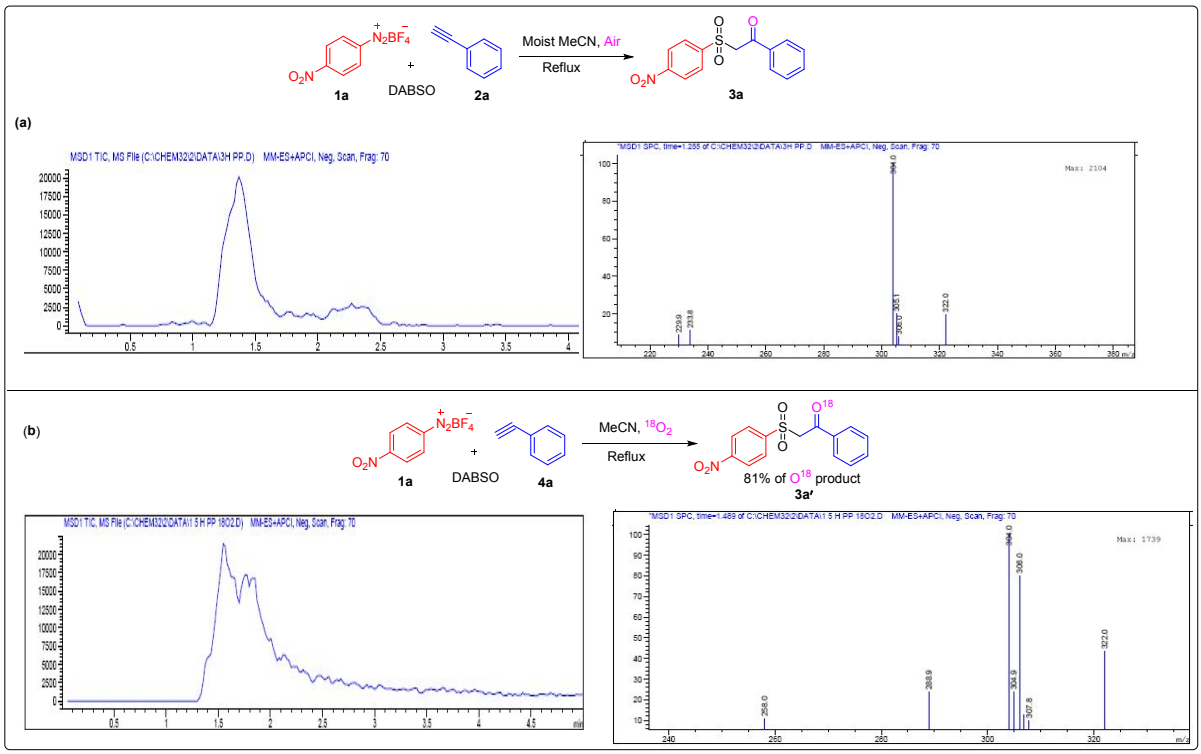
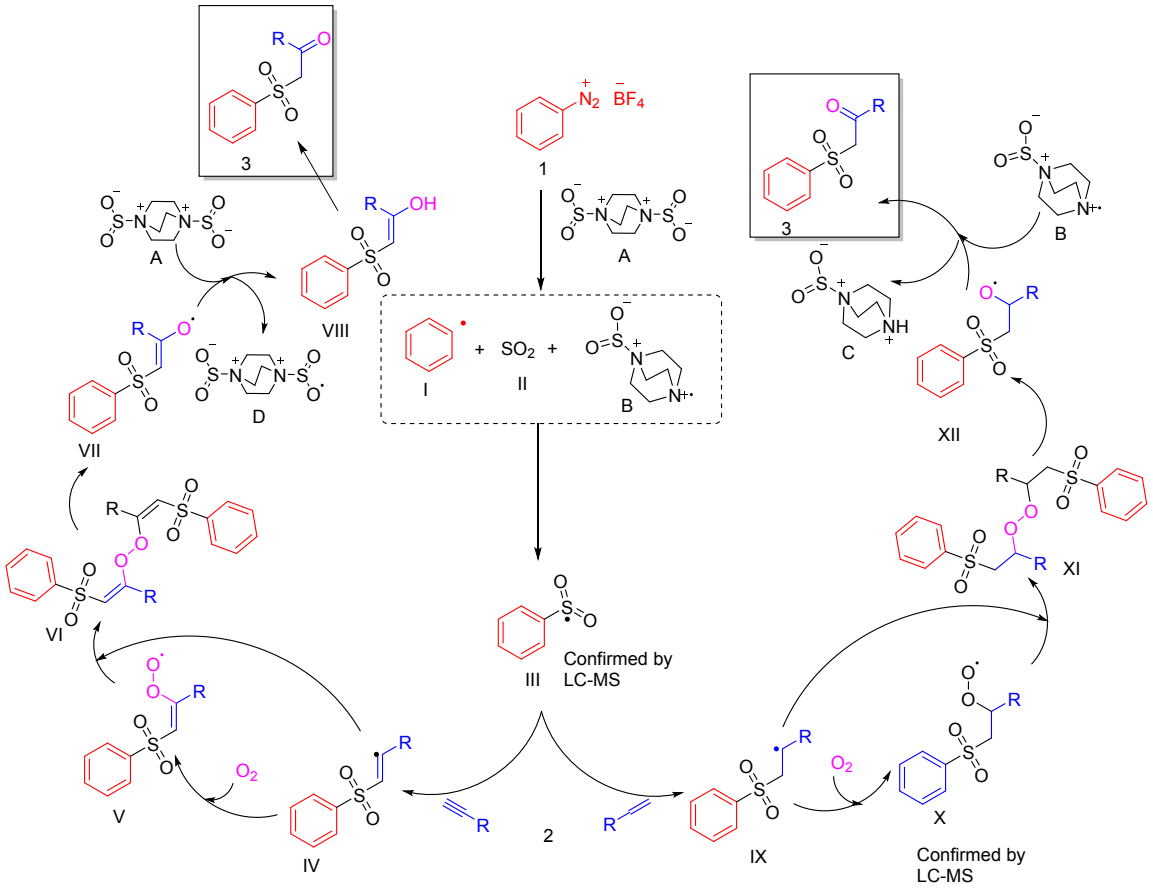


Figure 3. a) LC-MS Chromatogram of reaction mixture under air; b) LC-MS Chromatogram of reaction mixture conducted under ^{18}O-labeled oxygen**.**

Based on the controlled experiments and literature precedents,[15a, 18] the following plausible mechanistic pathway is proposed (Fig 4). The diazonium salt 1 on reaction with DABSO (A) generates phenyl radical (**I**), sulfur dioxide (**II**) and DABCO-based cation radical (**B**). The formed phenyl radical (**I**) immediately react with sulfur dioxide (**II**) to from phenylsulfonyl radical (**III**).[14a] The intermediate (**III**) attack on the unsaturated partner and give radical based intermediates (**IV** and **IX**) which attack by the oxygen[10d, 12b] and then formed dimer (**VI** and **XI**) [12b] followed by homolytic cleavage into oxy-radical based intermediates (**VII** and **XII**). The intermediate **VII** undergoes single-electron transfer reaction[12b, 15a] with DABSO to hydroxylated intermediates **VIII**, which immediately isomerizes to *β*-keto sulfones **3**. Moreover, in case of alkenes, the oxy-radical based intermediate **XII** undergoes proton abstraction reaction[10d, 12b] with **B** to give *β*-keto sulfones **3**.

Figure 4. Plausible mechanism



In conclusion, a metal-free multi-component cascade reaction approach has been developed for the synthesis of *β*-keto sulfones using commercially available arenediazonium salt and alkyns/alkenes as a starting materials, while DABSO as a source of sulfur dioxide. The examples collected in Scheme 1−2 demonstrate the broad scope and high functional group tolerance of the optimized conditions. Regarding the source of sulfone, the optimized conditions work with inexpensive reagent sodium metabisulfite at room temperature and provided additional advantages in contrast to previous methods (Scheme 3-4).

EXPERIMENTAL SECTION

General Information

All reactions were conducted under condenser fitted round bottom flask in open atmosphere and reaction mixture was monitored by thin-layer chromatography (TLC). TLC pre-coated silica gel 60 F254 (20 × 20 cm). TLC plates were visualized by exposing UV light or by iodine vapors or immersion in staining solution of cerric ammonium sulfate and anisaldehyde. Organic solvents were evaporated on rotary evaporator and all the compounds were purified on flash Column chromatography (230−400 mesh size). Mass spectra were obtained using an Agilent 6540 accurate mass Q-TOF LC/MS (135 eV) spectrometer, using electrospray ionization (ESI). ^{1}H NMR spectra were recorded on 400 and 500 MHz NMR instruments. Chemical data for protons are reported in parts per million (ppm, scale) downfield from tetramethylsilane as referenced to the residual proton in the NMR solvent ($CDCl_3$: δ 7.26, 1.56 $CDCl_3$ moister and 1.25 grease peak or other solvents as mentioned). All the NMR spectras were processed with MestReNova software. The coupling constant (*J*) are in Hz. ESI-MS and HRMS spectra were recorded on LC-Q-TOF machines.

General Procedure

In a 50 ml Round bottom flask, to a solution of substituted diazonium tetrafluoroborate salt **1** (237 mg, 1equiv., 1 mmol) dissolved in MeCN (8-10 ml) and then sulfur source{DABSO (480 mg, 2 mmol) or $Na_2S_2O_5$ (950 mg, 5 mmol) and phenylacetylene or alkene **2** or **4** (130 µl, 1.2 mmol) were stirred at 80 °C (temperature of oil bath) for 6 -12 h under an open atmosphere. After completion of the reaction, reaction was monitored by TLC, the reaction mixture was cooled to room temperature and MeCN was evaporated. The dried reaction mixture was admixed with ethyl acetate. The organic layer was washed with water (3 × 30 mL). The organic layer was dried over anhydrous $Na_2SO_4$and evaporated under

vacuum. The crude product was obtained then purified by flash column chromatography using EtOAc and hexane to give required products **3a-w**, **5a-5h**, **6a-6f and 7a-7c.**

General Procedure for gram scale reaction

In a 250 ml Round bottom flask, to a solution of substituted diazonium tetrafluoroborate salt **1** (1 gm, 4.23 mmol) dissolved in MeCN (20 ml) and then DABSO (2.02 gm, 8.47 mmol) and phenylacetylene **2** (566 µl, 6.83 mmol) were stirred at 80 °C (temperature of oil bath) for 6 -12 h under an open atmosphere. After completion of the reaction, reaction was monitored by TLC, the reaction mixture was cooled to room temperature and MeCN was evaporated. The dried reaction mixture was admixed with ethyl acetate. The organic layer was washed with water (3 × 200 mL). The organic layer was dried over anhydrous $Na_2SO_4$and evaporated under vacuum. The crude product was obtained then purified by flash column chromatography using EtOAc and hexane to give required product **3a** with a (68% yield, 874 mg).

Experimental Data:

2-((4-Nitrophenyl)sulfonyl)-1-phenylethan-1-one (3a/7a, Scheme 1):[10a] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 78% (238 mg); Yellow solid; m.p.: 166 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.12 (d, *J* = 8.8 Hz, 2H), 7.95 – 7.90 (m, 2H), 7.66 (s, 1H), 7.51 (t, *J* = 7.8 Hz, 2H), 4.82 (s, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.6, 151.1, 144.1, 135.4, 134.8, 130.3, 129.2, 129.1, 124.3, 63.1; HRMS (ESI-TOF) calcd. for: $C_{14}H_{10}NO_5S$ 304.0280 [M-H]-, found 304.0303.

2-((4-Nitrophenyl)sulfonyl)-1-*(p*-tolyl)ethan-1-one (3b, Scheme 1):[10d] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 53% (168 mg); Yellow gummy; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.8 Hz, 2H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.32 (s, 2H), 4.78 (s, 2H), 2.44 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, CDCl3) δ 187.8, 150.9, 144.1, 139.1, 135.6, 135.42, 130.3, 129.5, 128.9, 126.5, 124.2, 63.0, 21.3; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}NO_5S$ 318.0436 [M-H]-, found 318.0462.

1-(4-(*tert*-Butyl)phenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3c, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.3; Yield 67% (241 mg); Gummy dark reddish; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.9 Hz, 2H), 7.86 (d, *J* = 8.6 Hz, 2H), 7.51 (d, *J* = 8.5 Hz, 2H), 4.79 (s, 2H), 1.34 (s, 9H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.1, 159.1, 151.0, 144.1, 132.8, 130.3, 129.2, 126.1, 124.2, 115.6, 63.0, 35.4, 30.9; HRMS (ESI-TOF) calcd. for: $C_{18}H_{18}NO_5S$ 360.0906 [M-H]-, found 360.0926.

2-((4-Nitrophenyl)sulfonyl)-1-(4-propylphenyl)ethan-1-one (3d, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.3; Yield 67% (203 mg); Yellow crystalline solid; m.p.: 125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.8 Hz, 2H), 7.84 (d, *J* = 8.2 Hz, 2H), 7.30 (d, *J* = 8.2 Hz, 2H), 4.79 (s, 2H), 2.68 – 2.64 (m, 2H), 1.66 (dq, *J* = 14.8, 7.4 Hz, 3H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.1, 167.2, 150.9, 144.1, 133.2, 130.4, 129.4, 129.2, 124.3, 63.0, 38.1, 29.7, 24.1, 13.7; HRMS (ESI-TOF) calcd. for: $C_{17}H_{16}NO_5S$ 346.0749 [M-H]-, found 346.0759.

2-((4-Nitrophenyl)sulfonyl)-1-(4-(pentyloxy)phenyl)ethan-1-one (3e, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 66% (211 mg); Dark reddish; m.p.: 116 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 8.36 (t, *J* = 14.4 Hz, 2H), 8.10 (d, *J* = 8.9 Hz, 2H), 7.89 (d, *J* = 8.9 Hz, 2H), 7.08 – 6.80 (m, 2H), 4.75 (s, 2H), 4.04 (t, *J* = 6.5 Hz, 2H), 1.91 – 1.72 (m, 2H), 1.52 – 1.34 (m, 4H), 0.96 – 0.92(m, 3H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 185.7, 164.6, 151.0, 144.1, 131.8, 130.3, 128.1, 124.2, 114.7, 68.6, 62.9, 28.7, 28.0, 22.4, 13.9; HRMS (ESI-TOF) calcd. for: $C_{19}H_{20}NO_6S$ 390.1011 [M-H]-, found 390.1028.

1-(3-Methoxyphenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3f/7b, Scheme 1): TLC (Hexane/EtOAc, 6:4) R_f = 0.5; Yield 66% (221 mg); Yellow solid; m.p.: 106 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.7 Hz, 2H), 8.13 (d, *J* = 8.7 Hz, 2H), 7.50 (d, *J* = 7.6 Hz, 1H), 7.41 (dd, *J* = 10.5, 5.0 Hz, 2H), 7.19 (dd, *J* = 8.0, 2.0 Hz, 1H), 4.80 (s, 2H), 3.84 (s, 3H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 187.5, 160.1, 151.1, 144.1, 136.6, 130.4, 130.1, 124.3, 121.9, 121.8, 121.5, 113.0, 63.1, 55.6; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}NO_6S$ 334.0391 [M-H]-, found 334.0398.

2-((4-Nitrophenyl)sulfonyl)-1-(m-tolyl)ethan-1-one (3g, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 56% (169 mg); Yellow Solid; m.p.: 130 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.5 Hz, 2H), 8.12 (d, *J* = 8.1 Hz, 2H), 7.72 (d, *J* = 6.5 Hz, 2H), 7.52 – 7.33 (m, 2H), 4.80 (s, 2H), 2.41 (s, 3H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 187.8, 150.9, 144.1, 139.1, 135.6, 135.42, 130.3, 129.5, 128.9, 126.5, 124.2, 63.0, 21.3; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}NO_5S$ 318.0442 [M-H]-, found 318.0450.

2-((4-Nitrophenyl)sulfonyl)-1-(4-(trifluoromethyl)phenyl)ethan-1-one (3h, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 57% (156 mg); Yellow gummy; ^1H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, *J* = 8.7 Hz, 2H), 8.10 (dd, *J* = 13.9, 8.5 Hz, 4H), 7.80 (d, *J* = 8.2 Hz, 2H), 4.83 (s, 2H); $^{13}C\{^1H\}$

NMR (101 MHz, $CDCl_3$) δ 186.9, 151.2, 143.7, 138.0, 136.0 (d, *J* = 41.58 Hz), 129.5 (d,= *J* = 127.226 Hz), 129.6, 129.0, 126,2 (q = *J* = 5.04 Hz), 124.46 (d = *J* = 4.28 Hz), 124.29, 121.91, 63.28; HRMS (ESI-TOF) calcd. for: $C_{15}H_9F_3NO_5S$ 372.0154 [M-H]-, found 372.0156.

1-(4-Fluorophenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3i, Scheme 1):[10d] TLC (Hexane/EtOAc, 6:4) R_f = 0.4; Yield 67% (216 mg); yellow solid; m.p.: 120 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.42 (d, *J* = 8.4 Hz, 2H), 8.11 (d, *J* = 8.4 Hz, 2H), 8.00 (dd, *J* = 8.3, 5.3 Hz, 2H), 7.20 (t, *J* = 8.3 Hz, 2H), 4.78 (s, 2H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 186.2, 165.3, 143.7, 137.0, 136.8, 132.2 (d, *J* = 9.09 Hz), 130.3, 124.4, 116.4 (d, *J* = 25.25 Hz) 63.1; HRMS (ESI-TOF) calcd. for: $C_{14}H_9FNO_5S$ 322.0191 [M-H]-, found 322.0227.

1-(4-Bromophenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3j, Scheme 1):[10d] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 63% (241 mg); Yellow crystalline solid; m.p.: 170 °C;^1H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 8.3 Hz, 2H), 8.11 (d, *J* = 8.3 Hz, 2H), 7.81 (d, *J* = 8.1 Hz, 2H), 7.67 (d, *J* = 8.1 Hz, 2H), 4.77 (s, 2H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 186.7, 151.0, 143.8, 134.1, 132.1, 131.6, 130.6, 130.3, 124.3, 63.1; HRMS (ESI-TOF) calcd. for: $C_{14}H_9BrNO_5S$ 383.9364 [M-H]-, found 383.9381.

1-([1,1'-Biphenyl]-4-yl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3k, Scheme 1): TLC (Hexane/EtOAc, 6:4) R_f = 0.6; Yield 73% (381mg); Crystaline solid.; m.p.: 158°C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, *J* = 8.8 Hz, 2H), 8.14 (d, *J* = 8.7 Hz, 2H), 8.01 (d, *J* = 8.3 Hz, 1H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.63 (d, *J* = 7.2 Hz, 2H), 7.46 (dt, *J* = 22.6, 7.1 Hz, 3H), 4.85 (s, 2H); $^{13}C\{^1H\}$ NMR NMR (101 MHz, $CDCl_3$) δ 187.2, 151.1, 147.6, 139.1, 133.9, 130.4, 129.9, 129.1, 128.8, 127.7, 127.7, 124.4, 63.1; HRMS (ESI-TOF) calcd. for: $C_{20}H_{14}NO_5S$ 380.0593 [M-H]-, found 380.0591.

1-(4-Fluoro-3-methylphenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (3l, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 48% (161 mg); Yellow crystalline; m.p.: 125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.8 Hz, 2H), 7.93 – 7.67 (m, 2H), 7.85 – 7.71 (m, 2H), 7.13 (t, *J* = 8.7 Hz, 1H), 4.77 (s, 2H), 2.34 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 186.3, 165.5 (d,*J* = 258.56 Hz) 151.1, 143.9, 133.2 (d, *J* = 1.01 Hz), 133.1 (d, *J* = 2.02Hz), 131.6 (d, *J* = 3.03 Hz), 130.3, 129.6 (d, *J* = 10.1 Hz), 126.5, 126.3, 126.1, 116.1 (d, *J* = 5.05 Hz) 115.8 (d, *J* = 4.04 Hz), 63.0, 14.6; HRMS (ESI-TOF) calcd. for: $C_{15}H_{11}FNO_5S$ 336.0342 [M-H]-, found 336.0359.

2-((4-Bromophenyl)sulfonyl)-1-(p-tolyl)ethan-1-one (3m, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 66% (222 mg); Yellow solid; m.p.: 142 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.2 Hz, 2H), 7.74 (d, *J* = 8.6 Hz, 2H), 7.68 (d, *J* = 8.6 Hz, 2H), 7.28 (d, *J* = 8.1 Hz, 2H), 4.71 (s, 2H), 2.43 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.4, 145.8, 137.7, 133.2, 132.5, 130.2, 129.7, 129.6, 129.4, 63.3, 21.8; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}BrO_3S$ 350.9691 [M-H]-, found 350.9696.

2-((4-Bromophenyl)sulfonyl)-1-phenylethan-1-one (3n, Scheme 1):[11b] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 68% (230 mg); Yellow gummy; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 7.7 Hz, 2H), 7.76 (d, *J* = 8.5 Hz, 2H), 7.69 (d, *J* = 8.5 Hz, 2H), 7.51 (d, *J* = 7.7 Hz, 2H), 4.74 (s, 2H); HRMS (ESI-TOF) calcd. for: $C_{14}H_{10}BrO_3S$ 338.9519 [M-H]-, found 338.9526.

2-((4-Bromophenyl)sulfonyl)-1-(4-propylphenyl)ethan-1-one (3o, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 58% (196 mg); Yellow solid; m.p.: 114 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.3 Hz, 2H), 7.75 (d, *J* = 8.6 Hz, 2H), 7.75 (d, *J* = 8.6 Hz, 2H), 7.68 (d, *J* = 8.7 Hz, 2H), 7.28 (d, *J* = 8.2 Hz, 2H), 4.71 (s, 2H), 2.83 – 2.53 (m, 2H), 1.67 (dq, *J* = 14.8, 7.4 Hz, 2H), 0.93 (dd, *J* = 21.6, 14.2 Hz, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.4, 150.4, 137.7, 133.4, 130.2, 129.2, 129.4, 129.0, 63.3, 38.1, 24.0, 13.7; HRMS (ESI-TOF) calcd. for: $C_{17}H_{16}BrO_3S$ 380.9989 [M-H], found 380.9992.

2-((4-Bromophenyl)sulfonyl)-1-(4-(pentyloxy)phenyl)ethan-1-one (3p, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 52% (184 mg); Yellow solid; m.p.: 121 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.9 Hz, 2H), 7.74 (d, *J* = 8.6 Hz, 2H), 7.67 (d, *J* = 8.6 Hz, 2H), 6.93 (d, *J* = 8.9 Hz, 2H), 4.67 (s, 2H), 4.03 (t, *J* = 6.5 Hz, 2H), 1.87 – 1.78 (m, 2H), 1.48 – 1.36 (m, 4H), 0.94 (t, *J* = 7.0 Hz, 3H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 186.0, 164.4, 137.7, 132.5, 131.9, 130.2, 129.7, 128.7, 114.6, 68.5, 63.3, 28.7, 28.1, 22.4, 13.9; HRMS (ESI-TOF) calcd. for: $C_{19}H_{21}BrO_4S$ 425.0245 [M-H]-, found 425.0253.

2-((4-Bromophenyl)sulfonyl)-1-(4-(*tert*-butyl)phenyl)ethan-1-one (3q, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 54% (213 mg); Yellow crystalline solid; m.p.: 162^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.6 Hz, 2H), 7.74 (d, *J* = 8.7 Hz, 2H), 7.68 (d, *J* = 8.7 Hz, 2H), 7.49 (d, *J* = 8.6 Hz, 2H), 4.71 (s, 2H), 1.34 (s, 9H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 187.3, 158.7, 137.7, 133.1, 132.4, 130.23, 129.6, 129.2, 125.9, 63.3, 35.3, 30.9; HRMS (ESI-TOF) calcd. for: $C_{18}H_{18}BrO_3S$ 395.0146 [M-H]-, found 395.0152.

2-((4-Bromophenyl)sulfonyl)-1-(4-fluorophenyl)ethan-1-one (3r, Scheme 1): (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 57% (203 mg); Crystalline solid; m.p.: 95 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (dd, *J* = 7.7, 5.5 Hz, 2H), 7.72 (dd, *J* = 17.2, 8.1 Hz, 4H), 7.18 (t, *J* = 8.1 Hz, 2H), 4.70 (s, 2H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 186.2, 171.2, 167.6 (d, *J* = 258.56 Hz), 137.5, 132.8, 132.6, 132.2 (d, *J* = 7.07 Hz), 130.2, 129.9, 129.6, 116.3 (d, *J* = 22.22 Hz) 63.5; HRMS (ESI-TOF) calcd. for: $C_{14}H_9BrFO_3S$ 354.9440 [M-H]-, found 354.9468.

1-(4-Bromophenyl)-2-((4-methoxyphenyl)sulfonyl)ethan-1-one (3s, Scheme 1):[19] TLC (Hexane/EtOAc, 6:4) R_f = 0.5; Yield 73% (267 mg); Yellow solid; m.p.: 115 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (dt, *J* = 24.9, 12.3 Hz, 5H), 7.63 (d, *J* = 8.5 Hz, 2H), 6.99 (d, *J* = 8.8 Hz, 2H), 4.66 (s,

2H), 3.88 (s, 3H); $^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$) δ 187.4, 164.2, 134.5, 132.2, 130.9, 129.96, 129.8, 114.4, 63.9, 55.7; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}BrO_4S$ 368.9619 [M-H]-, found 368.9628.

1-([1,1'-Biphenyl]-4-yl)-2-((4-methoxyphenyl)sulfonyl)ethan-1-one (3t, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 69% (253 mg); Reddish brown solid; m.p.: 96 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.2 Hz, 2H), 7.82 (d, *J* = 8.8 Hz, 2H), 7.70 (d, *J* = 8.2 Hz, 2H), 7.63 (d, *J* = 7.3 Hz, 2H), 7.52 – 7.41 (m, 3H), 7.00 (d, *J* = 8.8 Hz, 2H), 4.74 (s, 2H), 3.87 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.8, 164.2, 147.0, 139.4, 134.5, 130.9, 130.2, 130.0, 129.0, 128.6, 127.4, 127.3, 114.4, 63.9, 55.7; HRMS (ESI-TOF) calcd. for: $C_{21}H_{17}O_4S$ 365.0848 [M-H]-, found 365.0862.

2-((4-Methoxyphenyl)sulfonyl)-1-phenylethan-1-one (3u/7c, Scheme 1):[11d] TLC (Hexane/EtOAc, 7:3) R_f = 0.5; Yield 64% (185 mg); Yellow solid; m.p.: 98°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.92 (m, 2H), 7.80 (d, *J* = 9.0 Hz, 2H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.48 (t, *J* = 7.8 Hz, 2H), 6.99 (d, *J* = 9.0 Hz, 2H), 4.71 (s, 2H), 3.88 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 188.3, 164.2, 135.9, 134.3, 130.9, 130.3, 129.4, 128.7, 114.4, 63.8, 55.7; HRMS (ESI-TOF) calcd. for: $C_{15}H_{13}O_4S$289.0535 [M-H]-, found 289.0540.

2-((4-Methoxyphenyl)sulfonyl)-1-(4-propylphenyl)ethan-1-one (3v, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 64% (185 mg); Gummy dark reddish; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.3 Hz, 2H), 7.83 – 7.77 (m, 2H), 7.32 – 7.23 (m, 2H), 6.98 – 6.93 (m, 2H), 4.68 (s, 2H), 3.86 (s, 3H), 2.82 – 2.50 (m, 2H), 1.78 – 1.54 (m, 2H), 1.01 – 0.84 (m, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.8, 164.1, 150.1, 133.6, 130.8, 130.3, 129.5, 128.9, 128.7, 114.3, 63.7, 55.7, 38.0, 24.0, 13.7; HRMS (ESI-TOF) calcd. for: $C_{18}H_{21}O_4S$ 333.1161 [M+H]+, found 333.1139.

1-(4-(*tert*-Butyl)phenyl)-2-((4-methoxyphenyl)sulfonyl)ethan-1-one (3w, Scheme 1): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 62% (214 mg); Gummy dark reddish; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.3 Hz, 2H), 7.80 (d, *J* = 8.6 Hz, 2H), 7.48 (d, *J* = 8.3 Hz, 2H), 6.98 (d, *J* = 8.7

Hz, 2H), 4.69 (s, 2H), 3.87 (s, 3H), 1.34 (s, 9H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.8, 164.1, 158.3, 133.3, 130.9, 130.3, 129.3, 125.8, 114.3, 63.7, 55.6, 35.3, 31.0; HRMS (ESI-TOF) calcd. for: $C_{19}H_{21}O_4S$ 345.1161 [M+H]+, found 345.1136.

2-((4-Nitrophenyl)sulfonyl)-1-phenylethan-1-one (5a/3a, Scheme 2):[10a] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 68% (207 mg); Yellow solid; m.p.: 166 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.12 (d, *J* = 8.8 Hz, 2H), 7.95 – 7.90 (m, 2H), 7.66 (s, 1H), 7.51 (t, *J* = 7.8 Hz, 2H), 4.82 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.6, 151.1, 144.1, 135.4, 134.8, 130.3, 129.2, 129.1, 124.3, 63.1; HRMS (ESI-TOF) calcd. for: $C_{14}H_{10}NO_5S$ 304.0280 [M-H]-, found 304.0303.

1-(4-Acetylphenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (5b, Scheme 2): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 42% (145mg); Yellow solid; m.p.: 125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.36 – 8.29 (m, 2H), 8.05 (t, *J* = 7.7 Hz, 2H), 7.90 (d, *J* = 8.6 Hz, 2H), 7.18 (d, *J* = 8.7 Hz, 2H), 4.72 (s, 2H), 2.27 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 186.4, 168.5, 155.7, 143.9, 132.8, 130.9, 130.3, 124.4, 122.3, 122.3, 63.1, 21.1; HRMS (ESI-TOF) calcd. for: $C_{16}H_{12}NO_6S$ 346.0385 [M-H]-, found 346.0394, 304.0280 [M-$COCH_3$]; 185.9872 [M-$CH_2COPhCOCH_3$].

1-(3,5-Bis(trifluoromethyl)phenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (5c, Scheme 2): TLC (Hexane/EtOAc, 6:4) R_f = 0.3; Yield 37% (113 mg); Yellow crystalline solid; m.p.: 155°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.57 – 8.29 (m, 4H), 8.27 – 8.04 (m, 3H), 4.87 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 185.5, 151.4, 151.3, 143.5, 136.8, 133.5, 133.2, 132.9, 130.3, 129.2 (d,*J* = 3.03 Hz) 127.9 (q, *J* = 3.03 Hz), 124.6, 123.9 (q, *J* = 18.18 Hz), 121.2, 63.1; HRMS (ESI-TOF) calcd. for: $C_{16}H_8F_6NO_5S$440.0027 [M-H]-, found 440.0057.

1-(3,5-Dimethylphenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (5d, Scheme 2): TLC (Hexane/EtOAc, 6:4) R_f = 0.6; Yield 34% (113 mg); Dark Brownish gummy; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.7 Hz, 2H), 7.47 (s, 1H), 7.16 (d, *J* = 7.7 Hz, 2H), 4.77

(s, 2H), 2.39 (s, 3H), 2.36 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 189.9, 144.5, 137.2, 135.8, 135.2, 134.1, 132.5, 130.7, 130.3, 124.2, 65.1, 21.1, 20.9; HRMS (ESI-TOF) calcd. for: $C_{16}H_{14}NO_5S$ 332.0598 [M-H]-, found 332.0631.

2-((4-Bromophenyl)sulfonyl)-1-(4-fluorophenyl)ethan-1-one (5e/3r Scheme 2):[10d] (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 63% (184 mg); Yellow solid; m.p.:121 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (dd, *J* = 7.7, 5.5 Hz, 2H), 7.72 (dd, *J* = 17.2, 8.1 Hz, 4H), 7.18 (t, *J* = 8.1 Hz, 2H), 4.70 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 186.2, 171.2, 167.6 (d, *J* = 258.56 Hz), 137.5, 132.8, 132.6, 132.2 (d, *J* = 7.07 Hz), 130.2, 129.9, 129.6, 116.3 (d, *J* = 22.22 Hz) 63.5; HRMS (ESI-TOF) calcd. for: $C_{14}H_9BrFO_3S$ 354.9440 [M-H]-, found 354.9468.

1-(4-Acetylphenyl)-2-((4-bromophenyl)sulfonyl)ethan-1-one (5f, Scheme 2): TLC (Hexane/EtOAc, 6:4) R_f = 0.6; Yield 46% (175 mg); Yellow solid; m.p.: 124 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.6 Hz, 2H), 7.82 – 7.60 (m, 4H), 7.35 – 7.16 (m, 2H), 4.71 (s, 2H), 2.33 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 186.6, 168.5, 155.5, 137.5, 133.1, 132.6, 131.0, 130.2, 122.2, 63.4, 21.1;HRMS (ESI-TOF) calcd. for: $C_{16}H_{10}BrO_4S$ 376.9478 [M-H]-, found 376.9444.

2-((4-Bromophenyl)sulfonyl)-1-(2,4-dimethylphenyl)ethan-1-one (5g, Scheme 2): TLC (Hexane/EtOAc, 6:4) R_f = 0.6; Yield 38%(139 mg); Gummy pinkish; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (dt, *J* = 17.8, 8.2 Hz, 5H), 7.08 (d, *J* = 9.0 Hz, 2H), 4.68 (s, 2H), 2.42 (s, 3H), 2.37 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 189.4, 144.1, 140.6, 138.0, 133.3, 132.7, 132.4, 130.9, 130.1, 129.5, 126.6, 65.3, 21.7, 21.5; HRMS (ESI-TOF) calcd. for: $C_{16}H_{14}BrO_3S$ 366.9833 [M-H]-, found 366.9866.

2-((4-Bromophenyl)sulfonyl)-1-(4-(tert-butyl)phenyl)ethan-1-one (5h/3q, Scheme 2): TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 42% (213 mg); Yellow crystalline solid; m.p.:162 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.6 Hz, 2H), 7.74 (d, *J* = 8.7 Hz, 2H), 7.68 (d, *J* = 8.7 Hz, 2H), 7.49

(d, J = 8.6 Hz, 2H), 4.71 (s, 2H), 1.34 (s, 9H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.3, 158.7, 137.7, 133.1, 132.4, 130.23, 129.6, 129.2, 125.9, 63.3, 35.3, 30.9; HRMS (ESI-TOF) calcd. for: $C_{18}H_{18}BrO_3S$ 395.0146 [M-H]-, found 395.0152.

2-((4-Nitrophenyl)sulfonyl)-1-phenylethan-1-one (6a/3a, Scheme 3):[10a] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 63% (191 mg); Yellow solid; m.p.: 166 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, J = 8.8 Hz, 2H), 8.12 (d, J = 8.8 Hz, 2H), 7.95 – 7.90 (m, 2H), 7.66 (s, 1H), 7.51 (t, J = 7.8 Hz, 2H), 4.82 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.6, 151.1, 144.1, 135.4, 134.8, 130.3, 129.2, 129.1, 124.3, 63.1; HRMS (ESI-TOF) calcd. for: $C_{14}H_{10}NO_5S$ 304.0280 [M-H]-, found 304.0303.

2-((4-Nitrophenyl)sulfonyl)-1-*(p*-tolyl)ethan-1-one (6b/3b, Scheme 3):[10d] TLC (Hexane/EtOAc, 7:3) R_f = 0.4; Yield 47% (149 mg); Yellow gummy; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, J = 8.8 Hz, 2H), 8.11 (d, J = 8.8 Hz, 2H), 7.82 (d, J = 8.2 Hz, 2H), 7.32 (s, 2H), 4.78 (s, 2H), 2.44 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, CDCl3) δ 187.8, 150.9, 144.1, 139.1, 135.6, 135.4, 130.3, 129.5, 128.9, 126.5, 124.2, 63.0, 21.3; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}NO_5S$ 318.0436 [M-H]-, found 318.0462.

1-(3-Methoxyphenyl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (6c/3f, Scheme 3): TLC (Hexane/EtOAc, 6:4) R_f = 0.5; Yield 47% (156 mg); Yellow solid; m.p.: 106 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, J = 8.7 Hz, 2H), 8.13 (d, J = 8.7 Hz, 2H), 7.50 (d, J = 7.6 Hz, 1H), 7.41 (dd, J = 10.5, 5.0 Hz, 2H), 7.19 (dd, J = 8.0, 2.0 Hz, 1H), 4.80 (s, 2H), 3.84 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 187.5, 160.1, 151.1, 144.1, 136.6, 130.4, 130.1, 124.3, 121.9, 121.8, 121.5, 113.0, 63.1, 55.6; HRMS (ESI-TOF) calcd. for: $C_{15}H_{12}NO_6S$ 334.0391 [M-H]-, found 334.0398.

1-([1,1'-Biphenyl]-4-yl)-2-((4-nitrophenyl)sulfonyl)ethan-1-one (6d/3j, Scheme 3): TLC (Hexane/EtOAc, 6:4) R_f = 0.6; Yield 49% (186 mg); Crystaline solid.; m.p.: 158^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, J = 8.8 Hz, 2H), 8.14 (d, J = 8.7 Hz, 2H), 8.01 (d, J = 8.3 Hz, 1H), 7.73 (d, J = 8.4 Hz, 2H), 7.63 (d, J = 7.2 Hz, 2H), 7.46 (dt, J = 22.6, 7.1 Hz, 3H), 4.85 (s, 2H); $^{13}C\{^{1}H\}$ NMR

NMR (101 MHz, $CDCl_3$) δ 187.2, 151.1, 147.6, 139.1, 133.9, 130.4, 129.9, 129.1, 128.8, 127.7, 127.7, 124.4, 63.1; HRMS (ESI-TOF) calcd. for: $C_{20}H_{14}NO_5S$ 380.0593 [M-H]-, found 380.0591.

4-(2-((4-Nitrophenyl)sulfonyl)acetyl)benzonitrile (6e, Scheme 3):[10d] TLC (Hexane/EtOAc, 5:5) R_f = 0.4; Yield 46% (151 mg); Yellow Solid; m.p.: 142°C; ^{1}H NMR (400 MHz, DMSO-d^6) δ 8.46 (d, *J* = 8.8 Hz, 2H), 8.22 (d, *J* = 8.8 Hz, 2H), 8.12 (d, *J* = 8.5 Hz, 2H), 8.04 (d, 2H), 5.67 (s, 2H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d^6) δ 189.0, 151.0, 145.2, 138.8, 133.0, 129.9, 129.4, 124.8, 118.2, 116.7, 62.6; HRMS (ESI-TOF) calcd. for: $C_{15}H_9N_2O_5S$ 329.0238 [M-H]-, found 329.0265.

4-(2-((4-Bromophenyl)sulfonyl)acetyl)benzonitrile (6f, Scheme 3):[14a] TLC (Hexane/EtOAc, 6:4) R_f = 0.3; Yield 43% (149 mg); Yellow Solid; m.p.: 148°C; ^{1}H NMR (400 MHz, $CDCl_3$) ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.2 Hz, 2H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.69 (d, *J* = 29.7 Hz, 4H), 4.73 (s, 2H); ^{13}C{^{1}H} NMR NMR (101 MHz, $CDCl_3$) δ 186.7, 138.2, 137.0, 132.7, 132.7, 130.0, 129.6, 117.7, 117.4, 63.3; MS (ESI-TOF) calcd. for: $C_{15}H_9BrNO_3NO_5S$ 364.2130 [M-H]-, found 364.05

ASSOCIATED CONTENT:

Supporting Information Copies of NMRs, HRMS spectras are given.This material is available free of charge *via* theInternet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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