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Authors: Pritha Das, Subhodeep Das, Varalaxmi Kasarla, and Ranjan Jana

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Metal-free, Multicomponent Anti-Markovnikov Hydroarylsulfonylation and Alkoxyarylsulfonylation of Vinyl Arenes

Pritha Das,[a] Subhodeep Das,[a,d] Kasarla Varalaxmi,[a,b,d] and Ranjan Jana[a,c]*

[a] Organic and Medicinal Chemistry Division, CSIR-Indian Institute of Chemical Biology, 4 Raja S. C. Mullick Road, Jadavpur, Kolkata-700032, West Bengal, India
Phone: (+91) 33 2499 5819; fax: (+91) 33 2473 5197; e-mail: rjana@iicb.res.in
[b] National Institute of Pharmaceutical Education and Research, Kolkata 700054, West Bengal, India
[c] Academy of Scientific and Innovative Research (AcSIR), Kolkata-700032, India
[d] These authors contributed equally

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Abstract. A unified strategy for the hydro-arylsulfonylation of vinyl arenes has been developed under catalyst, additive-free conditions at room temperature from the corresponding aryldiazonium salts, DABSO (DABCO·2SO_2), and thiophenol as hydrogen atom transfer (HAT) reagent. Mechanistically, an incipient arylsulfonyl radical is generated from the corresponding aryl diazonium salts and DABSO which undergoes anti-Markovnikov addition to styrenes followed by hydrogen atom transfer from thiophenol. Interestingly, this multi-component reaction is highly chemoselective suppressing deleterious thiosulfonylation and thiol-ene reactions. Tuning the reaction conditions, a four-component difunctionalization with alkoxy group has been achieved using 1,4-dicyanobenzene as an oxidant. Furthermore, base-promoted elimination to form vinyl sulfone has been also examined. The practicability of this present reaction has been demonstrated by the *ex situ* generation of sulfur dioxide in an H-type reaction vessel and subsequent hydro- and alkoxyarylsulfonylation in good to moderate yields. The hydroaylsulfonylation reaction is scalable and applied to a metal-free synthesis of the key intermediate for an anti-migraine drug eletriptan.

Keywords: hydroarylsulfonylation; alkoxyarylsulfonylation; sulfone; aryldiazonium salt; DABSO; metal-free.

Sulfone is a unique functional group present in a plethora of drugs,[1] agrochemicals,[2] and functionalized materials (Figure 1).[3],[4] Sulfone also serve as a versatile intermediate in organic synthesis.[5] Hence significant attention has been dedicated to the synthesis of sulfones.[6] Typically, thioethers which are synthesized through nucleophilic substitution of leaving groups,[7] thiol-ene reaction[8] or cross-coupling reactions[9] are oxidized to the corresponding sulfones.[10] However, a mixture of sulfoxide and sulfone is formed in many cases. Alternatively, sulfonyl radicals are also generated from the corresponding sulfonyl halides,[11] sulfonyl hydrazides,[12] sulfinic acids,[13] and sulfites or sulfonates[14] via single-electron reduction for subsequent reaction. We assumed that the synthesis of sulfones from feedstock chemicals such as alkenes and sulfur dioxide will be attractive. However, the direct utilization of gaseous sulfur dioxide is extremely challenging due to its acute toxicity and obnoxious smell. These inherent problems were circumvented by the Willis group through the discovery of a charge transfer DABCO-*bis*(sulfur dioxide) adduct, DABSO, a bench-stable, user-friendly sulfur dioxide equivalent.[15] Subsequently, the Wu group demonstrated that aryldiazonium salts in combination with DABSO generate an arylsulfonyl radical under

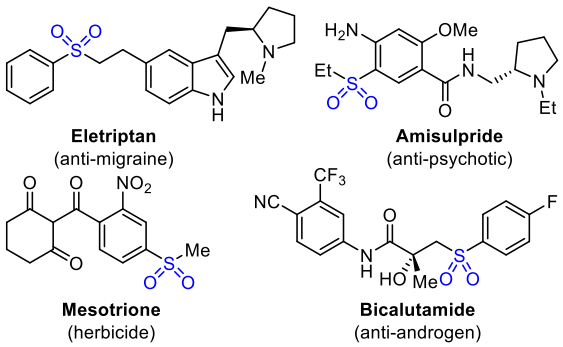

Figure 1. Representative Biologically Active Arylsulfones.

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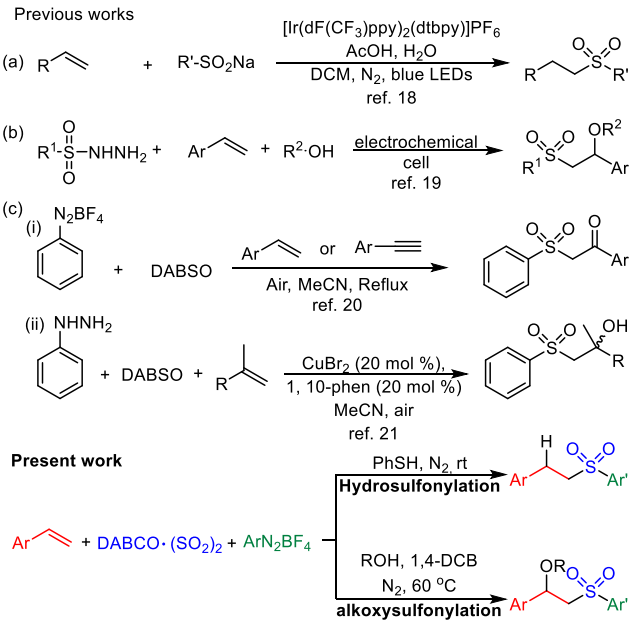
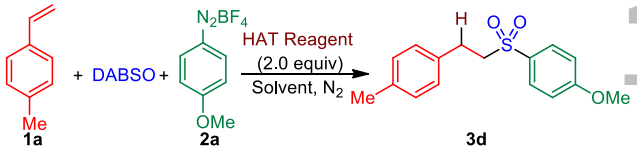
exceptionally mild reaction conditions that underwent subsequent addition/coupling reactions.[16] Similarly, an alkyl-sulfonyl radical species was generated from alkyl iodide or Hantzsch esters under photoredox catalysis for the 1,4-addition to activated alkenes.[17] Recently, different groups have reported photoredox catalyzed hydroarylsulfonylation of alkene using sodium sulfinates as the sulfonyl group source (Scheme 1a).[18] Moreover, the Lei group reported an alkoxyarylsulfonylation using sulfonyl hydrazines, styrene, and alcohol via an electrochemical oxidative pathway (Scheme 1b).[19] The Singh group has reported a metal-free synthesis of *β*-ketosulfones from alkene or alkyne using aryldiazonium salt and DABSO where molecular oxygen is incorporated into styrene to provide the keto group (scheme 1c(i)).[20] A copper catalyzed formation of *β*-hydroxysulfones was also achieved from arylhydrazines, DABSO and alkene where arylhydrazine serves as a precursor of aryl radical under aerobic condition (scheme 1c(ii)).[21] From these literature precedence, we presumed that a combination of diazonium salt and DABSO can be used as an arylsulfonyl source for hydro- or alkoxyarylsulfonylation of vinyl arenes in the presence of a hydrogen atom donor or oxidant/nucleophile respectively which is not known to the best of our knowledge. We report here, a simple and practical four-component anti-Markovnikov hydroarylsulfonylation of vinyl arenes from aryldiazonium salts, DABSO, styrenes, and thiophenol as hydrogen atom transfer (HAT) reagent. Surprisingly, this catalyst-free, multicomponent reaction proceeds with a high degree of chemoselectivity obviating deleterious thiol-ene, diaryl sulfone, or thiosulfonates.[22] Furthermore, we have executed alkoxyarylsulfonylation of the electron-rich styrenes under oxidative conditions.



Scheme 1. Hydroarylsulfonylation and Alkoxyarylsulfonylation of Styrenes.

We commenced our investigation by stirring a mixture of 4-methyl styrene **1a**, (4-methoxy)-phenyldiazonium tetrafluoroborate **2a**, 1.0 equiv. DABSO as the sulfonylating agent, and 2.0 equiv. thiophenol as HAT reagent in DCE solvent at room temperature. Gratifyingly, the desired hydroarylsulfonylation product **3d** was observed in 51% yield within 10 h (Table 1, Entry 1). To improve the yield further, we screened a variety of solvents (entries 2-6) where MeCN found optimal providing 76% yield (Entry 6). The yield was dropped to 64% when the reaction was performed at 60 °C (Entry 7). Next, we turned our attention to optimize the HAT reagent which is crucial for hydrofunctionalization. Thus, 2-phenyl malononitrile, phenyl silane did not give the desired product leaving the starting styrene intact (Entry 11 and 15). Aryl thiols (Entry 12-14) served as a better HAT reagent than the alkyl thiols (Entry 8-10) where simple thiophenol delivered the best yield. Interestingly, this multicomponent reaction is highly chemoselective to the formation of hydroarylsulfonylation product suppressing the deleterious hydrothiolation (thiol-ene), thiosulfonylation of aryldiazonium, DABSO, and thiol. We also found that just 1.0 equiv. of DABSO is optimal whereas yield was decreased both in lower and higher loading (Entry 16 and 17). However, the yield was deceased drastically from 76% to 37% under aerobic condition (Entry 18).

Table 1. Optimization of the Reaction Conditions.[a]



Entry	HAT Reagent	Solvent	Yield (%) **3d**[b]
1	Thiophenol	DCE	51
2	Thiophenol	DMF	trace
3	Thiophenol	Toluene	53
4	Thiophenol	Methanol	63
5	Thiophenol	THF	68
6	Thiophenol	MeCN	76
7[c]	Thiophenol	MeCN	64
8	**4**	MeCN	trace
9	**5**	MeCN	trace
10	**6**	MeCN	trace
11	**7**	MeCN	0
12	**8**	MeCN	50
13	**9**	MeCN	64
14	**10**	MeCN	71
15	$PhSiH_3$	MeCN	0
16[d]	Thiophenol	MeCN	21
17[e]	Thiophenol	MeCN	10
18[f]	Thiophenol	MeCN	37

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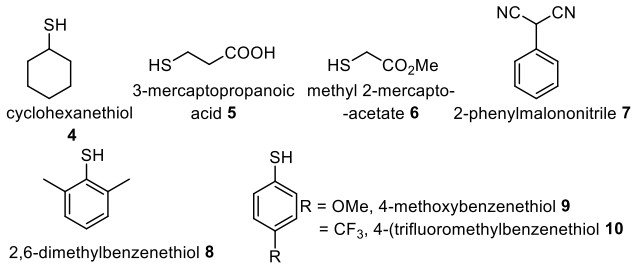

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (1.5 equiv.), DABSO (1.0 equiv.), HAT reagent (2.0 equiv.) in 2 mL solvent stirred for 10hrs in inert atmosphere. [b] Isolated yields. [c]at 60 °C. [d]2.0 equiv. of DABSO, [e]0.6 equiv. of DABSO. [f]Aerobic condition, trace amount of β-ketosulfone is formed.

Next, we sought to examine the scope of this hydroarylsulfonylation reaction with substituted aryldiazonium tetrafluoroborates and 4-methyl styrene **1a** under the optimized condition (Table 2). Various functional groups on diazonium salt were well-tolerated providing the corresponding products in good to excellent yields. Electronically unbiased (**3a-3c**) or electron-donating methoxy substitution at the *para*-position (**3d**) of aryldiazonium salts furnished high yields of the desired product. Electron withdrawing 4-nitro-phenyl diazonium salt delivered good yield as well (**3e**). The representative structure of **3d** was unambiguously characterized by X-ray crystallography (CCDC 2009757).[23] Halogens such as Cl, Br, I (**3f-3h**) remained intact under this mild reaction conditions which is useful for further transformations. However, a synthetically useful yield (50%) was obtained with ester-substituted diazonium salt using a higher amount of diazonium salt, DABSO, and thiophenol (**3i**). *meta*-CF_3 substituted phenyl diazonium salt delivered the hydroarylsulfonylation product in good yield (**3j**). *m*-COMe group also survived providing 60% product (**3k**). Sterically encumbered *ortho*-SMe substitution was also competent under the reaction conditions providing the desired product in 59% yields (**3l**). A diazonium salt derived from the pyrene moiety, which is frequently used as a fluorescent probe provided the hydroarylsulfonylation product albeit in low yield (35%, **3n**). Gratifyingly, heteroaromatic diazonium salts were also compatible under this mild reaction conditions (**3o**, **3p**).

Subsequently, we examined the scope of substituted styrenes with **2a** under the same reaction conditions. For example, ethyl, *tert*-butyl, phenyl moiety at the *para* position of styrene worked well affording the corresponding sulfone products in good to excellent yields (**3q-3s**). A 5.0 mmol scale reaction with 4-*tert*-butyl styrene and **2a** afforded **3r** in 71% yield demonstrating the potential of this green protocol for future industrial application. Halogen (F, Cl, Br) bearing substrates at the *para* position were well-tolerated under the optimized reaction conditions (**3t-3v**). The electron-withdrawing groups such as CN, NO_2, CO_2Me at the *para* position furnished the desired product in good yields (**3w-3y**). Similarly, the electron-donating alkoxy substituted styrenes (**3z**, **3aa**) delivered the sulfone product in high yields. *tert*-Butyldimethyl(4-vinylphenoxy)silane also provided the desired product albeit in 40% yield (**3ac**). 3,4-Disubstituted styrenes also underwent hydroarylsulfonylation reaction providing high yields (**3ad, 3ae**). Sterically hindered 2, 4, 6-trimethylstyrene afforded the desired product in 55% yield (**3ag**). Additionally, 1-vinyl naphthalene, 2-vinylnapthalene, 3-vinylbenzo[*b*]thiophene furnished the corresponding products in 74%, 66% and 36% respectively (**3ah-3aj**). It is noteworthy that α-methylstyrene delivered the corresponding product with 4-methoxyphenyl diazonium salt albeit in lower yield (**3ak**). Unfortunately, the reaction did not proceed with other activated or unactivated olefin.

Table 2. Substrate Scope of Hydroarylysulfonylation Reaction[a],[b

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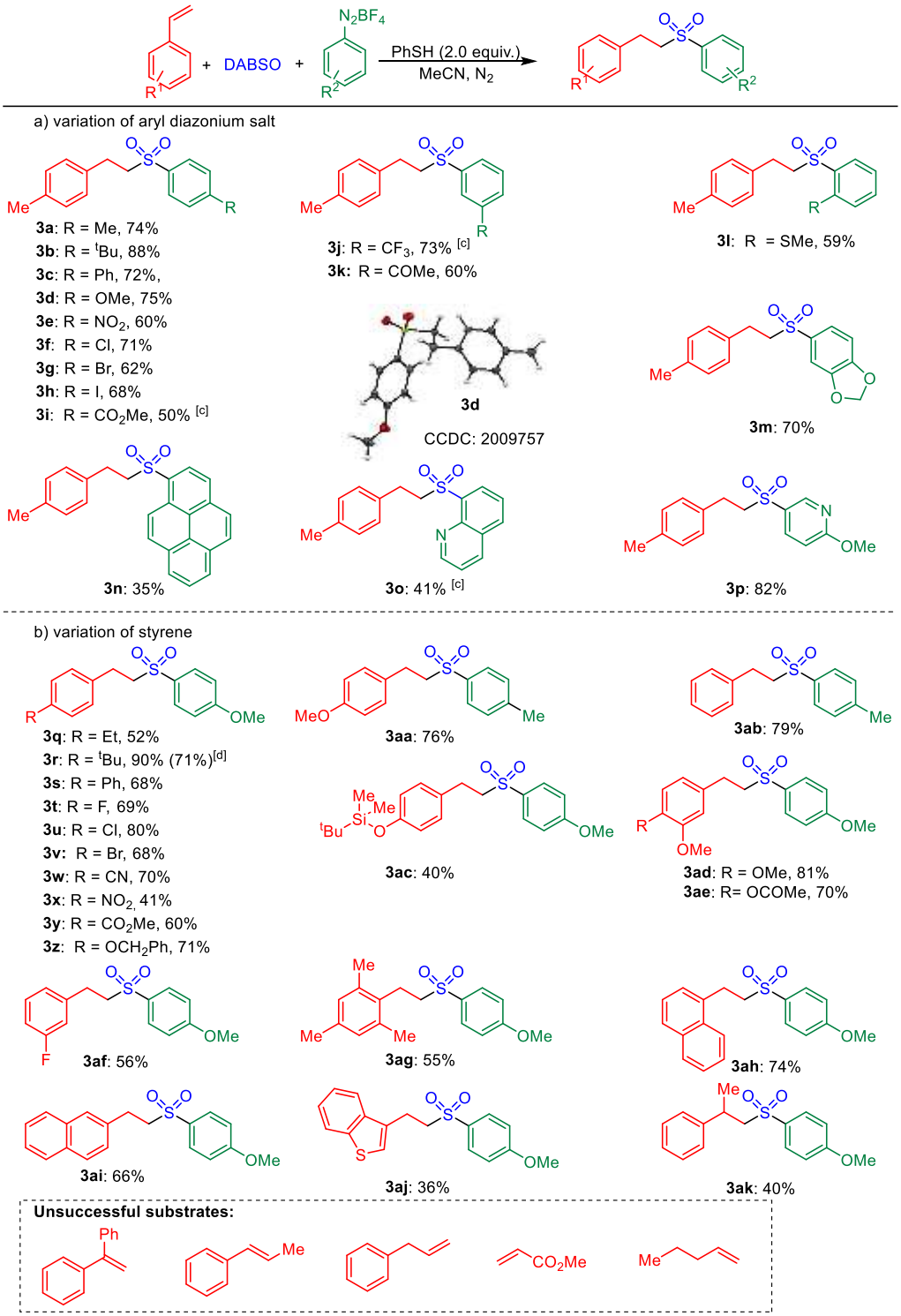

[a] Reaction conditions: Styrene (0.2 mmol), Aryldiazonium salt (0.3 mmol), DABSO (0.2 mmol), thiophenol (0.4 mmol) in 2 mL MeCN under inert atmosphere for 10 hrs. [b] Isolated yield. [c] diazonium salt (0.5 mmol), DABSO (0.3 mmol), thiophenol (0.6 mmol), [d] Reaction was performed in 5.0 mmol scale.

Subsequently, we extended our methodology for the difunctionalization of styrenes. Gratifyingly, corresponding methoxysulfonylated product was obtained in 20% yield simply replacing thiophenol by 10 equivalents of MeOH in a mixture of 4-methoxystyrene **1e**, 4-methoxyphenyldiazonium tetrafluoroborate **2a** and DABSO and stirring in MeCN solvent at room temperature for 12 h. Taking inspiration from the König's group, 1 equivalent of nitrobenzene was used as an oxidant which improved the yield upto (41%).[24] This result indicates that DABCO radical cation is not capable of doing the

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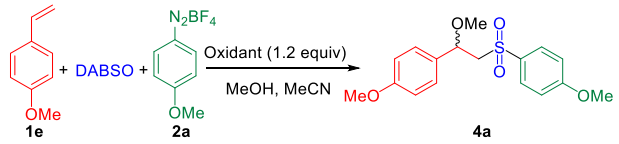
oxidation effectively and an external oxidant is required for the multicomponent reaction. After screening a series of oxidants *e.g.* $K_2S_2O_8$, TBHP, DTBP, $BrCCl_3$, selectfluor, 1,4-dinitrobenzene, etc. 1,4-dicyanobenzene (DCB) found to be the best for this four-component reaction furnishing 60% of the methoxysulfonylated product (Table 3, entries 1-10). The yield was increased further to 73% performing the reaction at 60 °C for 15 h (Entry 11).

Table 3. Optimization of Alkoxyarylsulfonylation Reaction Conditions.[a]



Entry	Oxidant	Temperature (°C)	Yield(%) **4a**[b]
1	$(NH_4)_2S_2O_8$	25	19
2	$Na_2S_2O_8$	25	30
3	$K_2S_2O_8$	25	47
4	DTBP	25	15
5	TBHP	25	Trace
6	$BrCCl_3$	25	13
7	Ph-NO_2	25	41
8	1,4-Dinitrobenzene	25	40
9	Selectfluor	25	16
10	1,4-Dicyanobenzene	25	60
11	1,4-Dicyanobenzene	60	73
12	1,4-Dicyanobenzene	50	57
13	1,4-Dicyanobenzene	70	54

[a]Reaction conditions: **1e** (0.2mmol), **2a** (0.3 mmol), DABSO (0.2 mmol), oxidant (0.24 mmol), MeOH (0.4 mL) in 2 mL MeCN under inert atmosphere for 15 hrs. [b] Isolated yield.

Then we examined the scope of this four-component alkoxyarylsulfonylation reaction (Table 4) under the optimized condition. Different types of primary and secondary alcohols such as ethanol, 2-propanol, 1-butanol delivered the desired products in good yields (**4a**-**4d**). The hydroxyl group bearing ethylene glycol was well tolerated in the reaction conditions providing 61% of the desired product (**4e**) whereas, 2-methoxy ethanol provided the product in 42% yield (**4f**). Surprisingly, when we started exploring the scope using substituted styrenes, we observed that electron donating alkoxy substituent at the *para*-position is essential for the reaction to occur (**4g**-**4i**). It may be attributed to the stabilization of the incipient benzylic carbocation for the subsequent nucleophilic attack.[25] Therefore, as expected, different alkoxy-substituted styrenes such as *O*-butyl, *O*-allyl were also effective for this transformation. Of note, in case of *O*-allyl substituted styrene, the reaction took place

Table 4. Substrate Scope of Alkoxyarylsulfonylation Reaction[a],[b]

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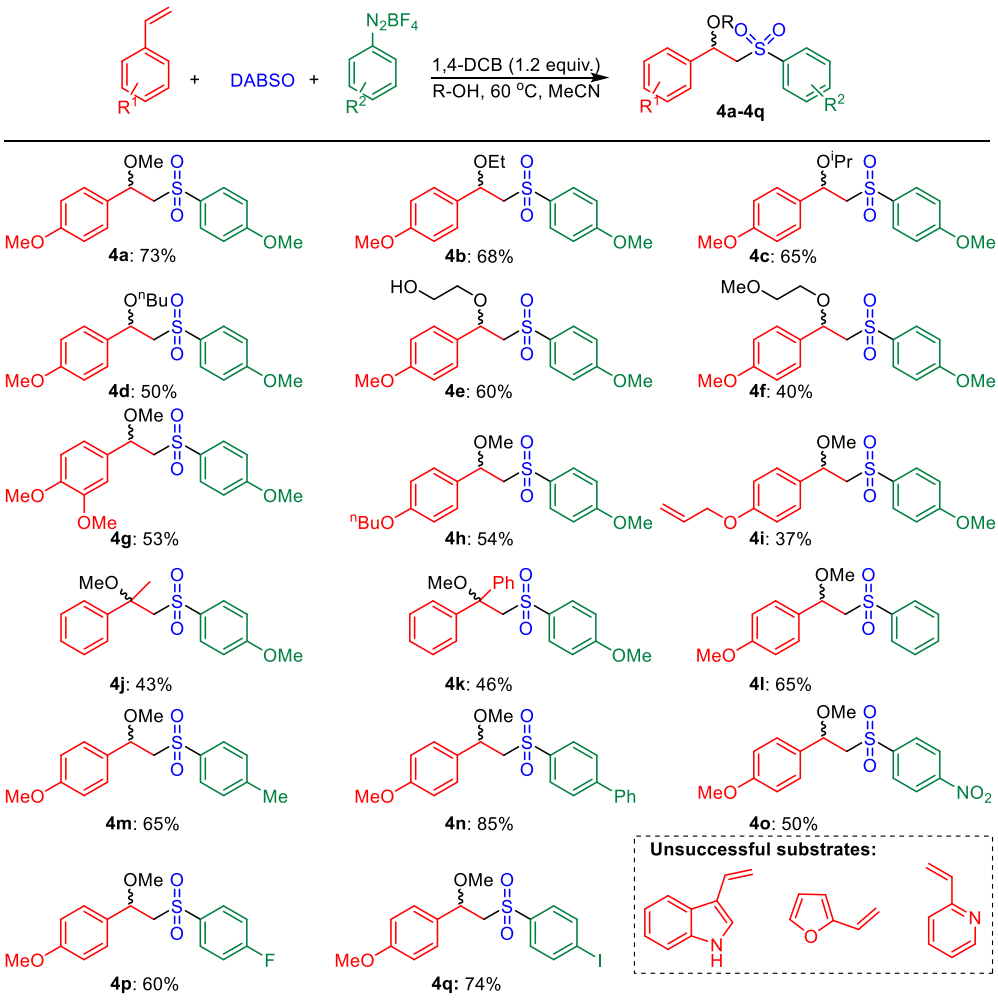
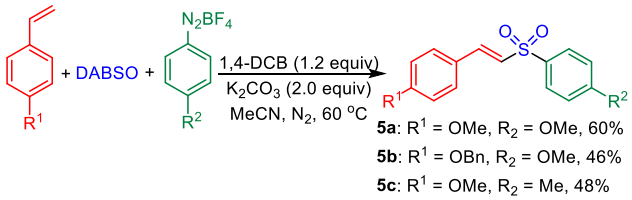


[a] Reaction conditions: Styrene (0.2 mmol), diazonium salt (0.3 mmol), DABSO (0.2 mmol), 1,4-dicyanobenzene (0.24 mmol), R-OH (0.4 mL) in 2 mL MeCN under inert atmosphere at 60 °C for 15 hrs. [b] Isolated yield.

selectively at the styrenyl double bond leaving the allylic double bond intact (**4i**). The α-substituted styrenes provided the desired product in moderate yield (**4j**, **4k**). Diversely substituted phenyl diazonium salt (methyl, phenyl, halogen substitution) performed well in this four-component reaction furnishing moderate to good yields of desired products (**4l-4q**).

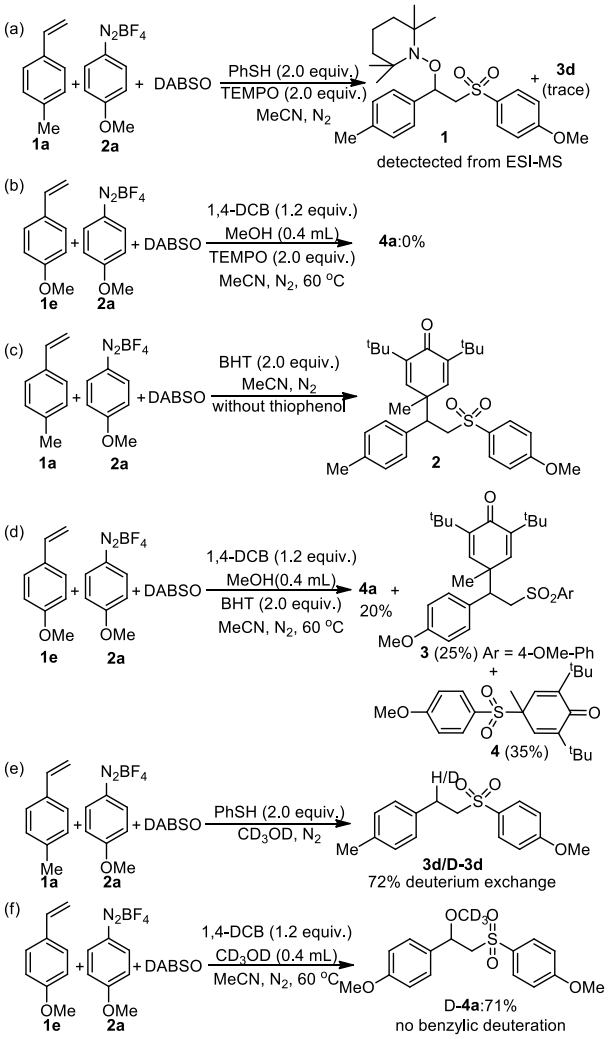
We also triggered the elimination reaction in the presence of K_2CO_3 to provide the corresponding vinyl sulfones.[26] Hence, a reaction among 4-methoxy styrene (**1e**), 4-methoxyphenyl diazonium salt (**2a**), and DABSO furnished vinyl sulfone **5a** in 60% isolated yield. Substituted aryl diazonium salts and electron-rich styrenes are compatible with this reaction (**5b, 5c,** Scheme 2).



Scheme 2. Base-Promoted Synthesis of Vinyl Sulfones.

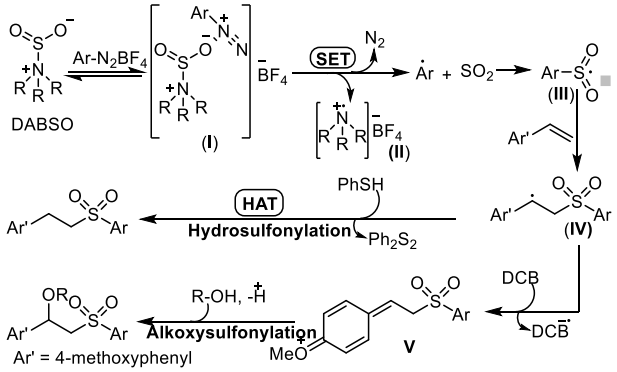
To gain insight into this four-component sulfonylation reaction, we performed several control experiments as shown in Scheme 3. When the standard reaction for hydroarylsulfonylation was performed in the presence of 2.0 equivalents of radical scavenger 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO), the formation of desired product **3d** was drastically reduced and the TEMPO-adduct **1** was detected by ESI-MS (Scheme 3a) from the reaction mixture. Similarly, no expected product was formed when 2.0 equivalents of TEMPO was added in the standard alkoxyarylsulfonylation reaction (Scheme 3b). Furthermore, when the hydrosulfonylation reaction was performed in the presence of butylated hydroxyl toluene (BHT), in the absence of thiol, a BHT-incorporated sulfone **2** was isolated rather than the desired product (Scheme 3c). It indicates that the reaction proceeds via a radical pathway. Similar BHT-incorporated sulfone **3** was obtained upon using 2.0 equivalents BHT in the standard alkoxysulfonylation reaction along with the BHT-adduct **4** (Scheme 3d). These results indicate that the alkoxyarylsulfonylation also proceeds via a radical pathway. Performing the hydroarylsulfonylation reaction in CD_3OD instead of acetonitrile solvent, 72% deuterium incorporation was observed (Scheme 3e) which indicates that

deuterium exchange with thiophenol take place prior to transfer to the benzylic position. We also examined the alkoxyarylsulfonylation reaction with CD_3OD in MeCN solvent which resulted in the formation of D-4a in 71% yield with no incorporation of deuterium at the benzylic position (Scheme 3f).



Scheme 3. Control Experiments

On the basis of these preliminary experimental results and previous related reports, a plausible mechanism for both reactions is depicted in Scheme 4.[27] The combination of aryldiazonium cations and DABSO is anticipated to give the complex **I**, which generates SO_2, aryl radical, nitrogen and tertiary amine radical cation **II** by the homolytic cleavage of the N-S bond via a SET process. Then the aryl radical is captured by SO_2 rapidly to afford the more stable sulfur-centered arylsulfonyl radical **III** which undergoes addition to the styrene regioselectively in anti-Markovnikov fashion to generate a more stabilized benzylic radical intermediate **IV**. This incipient benzylic radical then abstracts a hydrogen atom from thiophenol to generate the hydroarylsulfonylated product. In the absence of DABSO, we did not observed any hydroarylation product. Two equivalents of thiyl radical generated from two consecutive runs coupled together to provide disulphide byproduct which was isolated and characterized. In case of alkoxyarylsulfonylation reaction, the corresponding benzylic radical intermediate **IV** undergoes single electron oxidation by 1, 4-dicyanobenzene resulting in a putative quinone methide intermediate **V.** It undergoes nucleophilic attack by the alcohol coupling partner to afford the desired benzylic etherification.



Scheme 4. Plausible Reaction Mechanism.

Next we have demonstrated this sulfonylationlation reaction in a H-type COware closed vessel which was originally designed by the Skrydstrup group (Figure 2).[28] The SO_2 gas is produced by the reaction of sodium sulphite and concentrated H_2SO_4 in the left chamber. It is diffused to the other arm through the connector for hydro- and alkoxyarylsulfonylation reaction affording moderate to good yields of the desired products.[29] This experiment demonstrates that SO_2 gas is capable to react with diazonium salt even in the absence of DABCO.

We have applied this mild and highly practical protocol to the synthesis of a key intermediate of Eletriptan (an anti-migraine drug, trade name Relpax, marketed and manufactured by Pfizer) (Scheme 5). Hence, 5-styrenylindole **5** was synthesized by Wittig reaction from commercially available indole-5-carboxaldehyde. It underwent hydroarylsulfonylation reaction with phenyldiazonium salt and DABSO under the standard condition providing the key intermediate **6** in 64% yield. It can be converted to eletriptan by established procedure.[30] This metal-free and mild reaction could be commercially and environmentally competitive to the existing palladium-catalyzed protocols.[31]

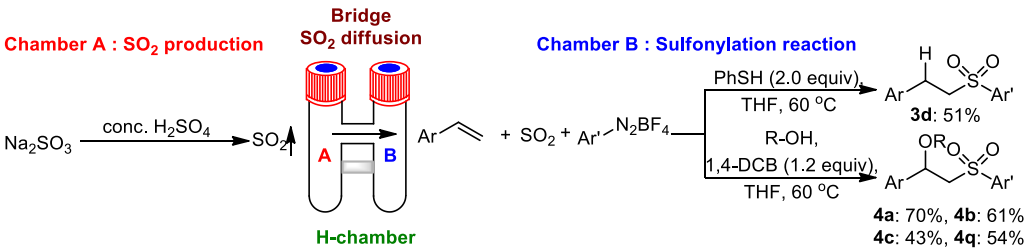
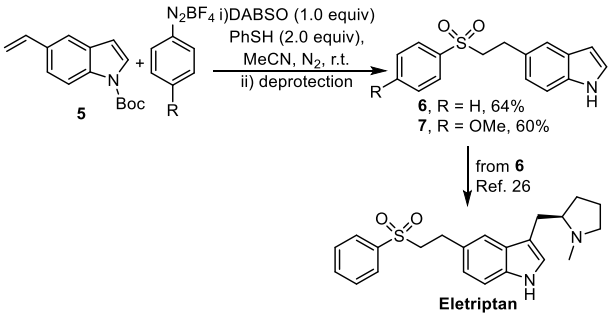


Figure 2. Closed Vessel Hydro- and Alkoxyarylsulfonylation Reaction via *ex situ* Generated SO_2.



Scheme 5. Synthesis of the Key Intermediate of Eletriptan

In conclusion, we have developed a mild, green, and four-component reaction for the hydroarylsulfonylation of vinylarenes with aryldiazonium salts, DABSO, vinyl arenes, and thiophenol as hydrogen atom transfer (HAT) reagent. The reaction proceeds in a highly chemoselective manner at room temperature without any catalyst or additive. Mechanistic investigation suggests that the reaction proceeds via a single electron transfer (SET) process. The reaction is scalable and applicable for the synthesis of the anti-migraine drug, Eletriptan. We have also extended this protocol for the four component alkoxyarylsulfonylation of 4-alkoxystyrenes and the synthesis of vinyl sulfones under oxidative and basic reaction conditions respectively. The four-component alkoxyarylsulfonylation reaction may proceed via a quinone-methide intermediate. We anticipate that the present cost-effective protocol will be useful for pharmaceutical and material science applications.

Experimental Section

General Information

Melting points were determined in open end-capillary tubes and are uncorrected. TLC was performed on silica gel plates (Merck silica gel 60, f254), and the spots were visualized with UV light (254 and 365 nm) and $KMnO_4$ stain. The crystal data was collected in X-ray spectroscopy (Bruker Kappa Apex-2, CCD Area Detector), and the data was analyzed using OLEX2 software. ^{1}H NMR was recorded at 300 MHz (Bruker-DPX), 400 MHz (JEOL-JNM-ECZ400S/L1) frequency, and ^{13}C NMR spectra were recorded at 400 MHz (JEOL-JNM-ECZ400S/L1) frequency in $CDCl_3$ solvent using TMS as the internal standard. ^{19}F NMR was recorded at 376 MHz (JEOL-JNM-ECZ400S/L1) frequency using hexafluorobenzene as an internal standard. Chemical shifts were measured in parts per million (ppm) referenced to 0.0 ppm for tetramethylsilane. The following abbreviations were used to explain multiplicities: s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet. Coupling constants, *J* was reported in Hertz unit (Hz). HRMS (m/z) were measured using ESI (Q-TOF, positive ion) techniques. Unless otherwise stated, all commercial reagents were used without additional purification.

General Experimental Procedure for Hydroarylsulfonylation Reaction

A 2 mL MeCN solution of 4-methoxyphenyldiazonium tetrafluoroborate **2a** (0.3 mmol, 1.5 equiv., 66 mg) and DABSO (0.2 mmol, 1.0 equiv., 24 mg) was taken in a teflon screw capped glass vial (7 mL). 4-Methylstyrene **1a** (0.2 mmol, 23.6 µL) and thiophenol (0.4 mmol, 2.0 equiv., 44 µL) was then added sequentially to the solution. The resulting solution was degassed with N_2 for 5 min and then allowed to stir at room temperature for 10 h. After that, the acetonitrile solvent was evaporated under reduced pressure and the reaction mixture was extracted with ethyl acetate (30.0 mL), water (10 mL×2), washed with brine (10 mL), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography (SiO_2, eluting with hexane/ethylacetate) to afford the desired product.

General Experimental Procedure for Alkoxyarylsulfonylation Reaction

A 2 mL MeCN solution of 4-methoxyphenyldiazonium tetrafluoroborate **2a** (0.3 mmol, 1.5 equiv., 66 mg), DABSO (0.2 mmol, 1.0 equiv., 24 mg) and 1, 4-dicyanobenzene (0.24 mmol, 1.2 equiv., 30 mg) was taken in a teflon screw-capped glass vial (7 mL). 4-methoxystyrene (0.2 mmol, 26.6 μL) and methanol (0.4 mL) were then added sequentially to the solution. The resulting solution was degassed with N_2 for 5 min and then allowed to stir at 60 ºC for 15 hrs. After that, the solvent was evaporated under reduced pressure and the reaction mixture was extracted with ethyl acetate (30.0 mL), water (10 mL×2), washed with brine (10 mL), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography (SiO_2, eluting with hexane/ethylacetate) to afford the desired product.

General Experimental Procedure for Sulfonylation Reaction with *Ex-situ* Generated SO_2 gas in Closed H-Vessel

i) Hydroarylsulfonylation Reaction

In a COware apparatus, Na_2SO_3 (0.5 mmol, 2.5 equiv., 63 mg) was taken in chamber A. In chamber B, a mixture of 4-methoxyphenyldiazonium tetrafluoroborate **2a** (0.3 mmol, 1.5 equiv., 66 mg) and DABSO (0.2 mmol, 1.0 equiv., 24 mg) was taken. The system was sealed with teflon screw cap, evacuated, and backfilled with N_2 three times via needle. In chamber A, 1 mL water and in chamber B, 2 mL THF followed by 4-methyl styrene **1a** (0.2 mmol, 23.6 μL) was added via syringe. Then it was dipped into an oil bath preheated at 60 ºC. Next, conc. H_2SO_4 (5.0 equiv., 55 μL) was added dropwise in chamber B via a needle for 30 min. Simultaneously, in chamber B, thiophenol (0.4 mmol, 2.0 equiv., 44 μL) was added for 30 min. Then it is allowed to stir for 15 h. Once the reaction is completed as indicated by TLC, the reaction mixture was transferred via pipette from chamber B to a round bottom flask. After that the reaction mixture was extracted with ethyl acetate (30.0 mL), water (10 mL×2), washed with brine (10 mL), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. Finally, the desired product was purified by column chromatography (SiO_2, eluting with hexane/ethylacetate).

ii) Alkoxyarylsulfonylation Reaction

In a COware apparatus, Na_2SO_3 (0.5 mmol, 2.5 equiv., 63 mg) was taken in chamber A. In chamber B, 4-methoxyphenyldiazonium tetrafluoroborate 2a (0.3 mmol, 1.5 equiv., 66 mg), DABSO (0.2 mmol, 1.0, equiv. 24 mg) and 1, 4-dicyanobenzene (0.24 mmol, 1.2 equiv., 30 mg) was taken. The system was sealed with a Teflon screw cap, evacuated, and backfilled with N_2 three times via needle. In chamber A, 1 mL water and in chamber B, 2 mL THF followed by 4-methoxystyrene (0.2 mmol, 26.6 μL) and methanol (0.4 mL) was added sequentially. Then it was dipped into an oil bath preheated at 60 ºC. Next, conc. H_2SO_4 (5.0, equiv. 55 μL) was added dropwise in chamber B via a needle for 15 min. Then it was allowed to stir for 15 h. Once the reaction is completed as indicated by TLC, the reaction mixture was transferred via pipette from chamber B to a round bottom flask. After that the reaction mixture was extracted with ethyl acetate (30.0 mL), water (10 mL×2), washed with brine (10 mL), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. Finally, the desired product was purified by column chromatography (SiO_2, eluting with hexane/ethylacetate).

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