

An Efficient Method for the Sulfonylation of Aromatic Rings with Arene/Alkane Sulfonic Acid by Using P₂O₅/SiO₂ under Heterogeneous Conditions[§]

BiBi Fatemeh Mirjalili,^{*} Mohamad Ali Zolfigol,[†] Abdolhamid Bamoniri,[‡] and Leila Khazdooz

Department of Chemistry, College of Science, Yazd University, Yazd 89195-741, Iran

[†]Department of Chemistry, College of Science, Bu-Ali Sina University, P.O. Box 4135, Hamadan 65174, Iran

[‡]Department of Chemistry, College of Science, Kashan University, Kashan 51167, Iran

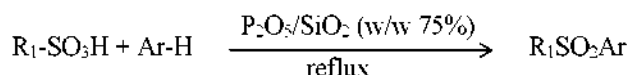
Received March 19, 2003

Key Words : Sulfonylation, Sulfones, Di-phosphorus pentoxide

Aryl sulfones are of great use in organic synthesis and industry.^{1,2} Diaryl sulfones are important drugs active against leishmaniasis, malaria, and infections in patients with AIDS discoid lupus erythematosus.^{3,4}

Diaryl, aryl/alkyl sulfones can be synthesized by conventional Friedel-Crafts type sulfonylation of aromatics by sulfonyl halides in the presence of Lewis acids such as AlCl₃, BF₃, triflic acid/BiCl₃, Zn-exchanged zeolites, Fe(III)-exchanged montmorillonite clay, scandium and lanthanide (III) salts,⁵ Cu(OTf)₂ or Sn(OTf)₂⁶ and etc. Recently, Olah and coworkers have reported the sulfonylation of arenes by sulfonic acids in the presence of Nafion-H.⁷ Very recently, we among many others have demonstrated that heterogeneous reagent systems have many advantages such as simple experimental procedures, mild reaction conditions and minimization of chemical wastes as compared to the homogeneous counterparts.⁸ In this article, we report an efficient preparation of aromatic sulfones directly from arene or alkane sulfonic acid with P₂O₅/SiO₂ system. Literature survey shows that phosphorus pentoxide (phosphoric anhydride) can be used as a dehydrating agent for the formation of anhydride from two molecules of an ordinary acid, ketenimines from amides, vinyl ethers from acetals, nitriles from amides,⁹ amides from oximes,¹⁰ phenolic esters from carboxylic acids¹¹ and so on. On the basis of the above mentioned ability of P₂O₅ we decided to use it embedded on silica-gel for the production of sulfones *via* direct sulfonylation of aromatic rings.

Preparation of symmetric and unsymmetric aromatic sulfones was achieved in moderate to good yields (50-95%) *via* Friedel-Crafts type sulfonylation of arenes with various sulfonic acids (Scheme 1).



R₁ = alkyl or aryl

Scheme 1

The sulfonylation reactions were carried out by refluxing a stirred mixture of the corresponding arene or alkane sulfonic

acid and excess dried arene in the presence of P₂O₅-SiO₂ (w/w 75%). The arene acts as both substrate and solvent. Activated arenes such as anisole and mesitylene afforded the corresponding sulfones in excellent yields (90-95%). The yield of the corresponding sulfones from benzene was low (50-52%) due to its lower boiling point. The present method provides an easy and fast approach to sulfones without any by-product. Sulfonylations of anisole, cumene, toluene and bromobenzene afforded para substituted sulfones as the major product indicating that the reaction belongs to electrophilic aromatic substitutions (Table 1). In contrast to the reported method by Olah *et al.*,⁷ the present method does not require a Dean-Stark trap for removing azeotropic removal of water.

In conclusion, the cheapness and the availability of the reagents, and good yields would make this method attractive for the large-scale operations. We believe that our new process would be an important addition to the existing methods.

Experimental Section

General. chemicals such as various arenes, *p*-toluene sulfonic acid, benzene sulfonic acid, methane sulfonic acid, silica gel and di-phosphorus pentoxide were purchased from Fluka, Merck and Aldrich Chemical Companies. The sulfonylation products were characterized by comparison of their spectral (IR, ¹H-NMR), TLC and physical data with authentic samples.⁶

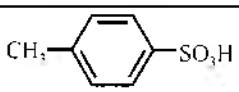
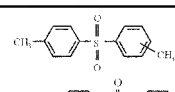
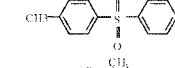
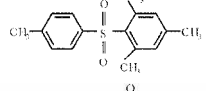
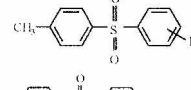

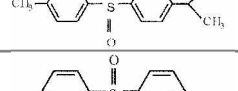
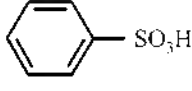
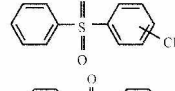
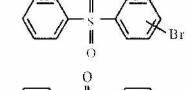
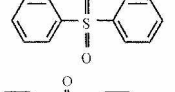
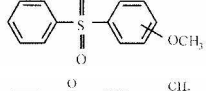
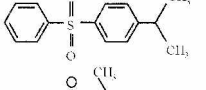
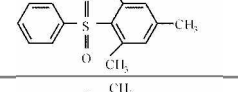
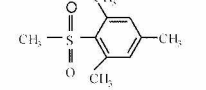
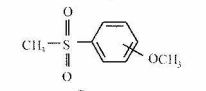
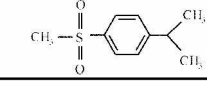
Typical procedure for the preparation of sulfones: preparation of anisyl tolyl sulfone. To a mixture of toluene-4-sulfonic acid monohydrate (0.6 g, 3.1 mmole) and dry anisole (5 mL) was added P₂O₅/SiO₂ (w/w 75%, 1.2 g). The solution was refluxed continuously with stirring for 30 minutes. The reaction mixture was filtered and washed with 10% NaHCO₃ solution to remove unreacted sulfonic acid. After washing with water and drying with anhydrous Na₂SO₄, excess anisole was distilled off by vacuum and the residue was recrystallized with *n*-hexane to afford anisyl tolyl sulfone as a white crystalline solid (0.75g, 90%), mp=79-80 °C, R_f = 0.5 (50 : 50 ether/petroleum ether).

Acknowledgment. Financial support made by the research affairs, Yazd University, Yazd, Iran and also Bu-Ali Sina University, Hamadan, Iran, is gratefully acknowledged.

[§]Dedicated to our teacher, professor Abdolhossein Rustaiyan on the occasion of his seventyfifth birthday

^{*}Corresponding author. E-mail: fmirjalili@yazduni.ac.ir

Table 1. Sulfonation of aromatic rings by aryl or alkyl sulfonic acids in presence of P₂O₅/SiO₂ (w/w 75%)

Entry	Sulfonic acid	arene	Time (min)	Yield (%) (o:m:p)	sulfone
1		Toluene	90	80 (13:0:87)	
2		benzene	105	50	
3		Mesitylene	30	85	
4		bromobenzene	90	60 (20:10:70)	
5		anisole	30	90 (34:0:66)	
6		Cumene	60	80	
7		Toluene	90	85 (25:0:75)	
8		bromobenzene	75	65 (20:10:70)	
9		benzene	90	52	
10		anisole	30	95 (45:0:55)	
11		Cumene	30	85	
12		mesitylene	30	90	
13	CH ₃ — SO ₃ H	mesitylene	60	55	
14		anisole	30	60 (30:10:60)	
15		Cumene	60	50	

References

- (a) Jensen, F. R.; Goldman, G. In *Friedel-Crafts and Related Reaction*; Olah, G., Ed.; Wiley Interscience: New York, 1964; VIII, pp 1319-1367. (b) Simpkins, N. S. *Sulfones in Organic Synthesis*; Pergamon Press: Oxford, 1993.
- Roy, K. M. In *Ullmann's Encyclopedia of Industrial Chemistry*; Gerhartz, W., Ed.; VCH: Weinheim, 1985; V.A 25, pp 487-501.
- Hastings, R. C.; Franzblau, S. G. *Ann. Rev. Pharmacol. Toxicol.* **1966**, *28*, 231.
- Wozel, G. *Int. J. Dermatol.* **1989**, *28*, 17.
- Frost, C. G.; Hartley, J. P.; Griffin, D. *Tetrahedron Lett.* **2002**, *43*, 4789.
- Singh, R. P.; Kamble, R. M.; Chandra, K. L.; Saravanane, P.; Singh, V. K. *Tetrahedron* **2001**, *57*, 241.
- Olah, G. A.; Mathew, T.; Parakash, G. K. S. *Chem. Commun.* **2001**, 1969.
- (a) Zolfigol, M. A. *Tetrahedron* **2001**, *57*, 9509 and other our references cited therein. (b) Zolfigol, M. A.; Torabi, M.; Mallakpour, S. E. *Tetrahedron* **2001**, *57*, 8381. (c) Zolfigol, M. A.; Zebarjadian, M. H.; Chehardoli, G.; Mallakpour, S. E.; Shamsipur, M. *Tetrahedron* **2001**, *57*, 1627. (d) Zolfigol, M. A.; Bamoniri, A. *Synlett* **2002**, 1621. (e) Zolfigol, M. A.; Ghorbani-Choghamarani, A.; Hazarkhani, H. *Synlett* **2002**, 1002. (f) Zolfigol, M. A.; Madrakian, E.; Ghaemi, E.; Mallakpour, S. E. *Synlett* **2002**, 1633.
- March, J. *Advanced Organic Chemistry*, 3rd Ed.; John Wiley: New York, 1985; p 904.
- Eaton, C. L. *J. Org. Chem.* **1973**, *38*, 4071.
- Eshghi, H.; Ratei, M.; Karimi, M. H. *Synth. Commun.* **2001**, *31*, 771.