An Improved Synthesis of Arylsulfonyl Chlorides from Aryl Halides

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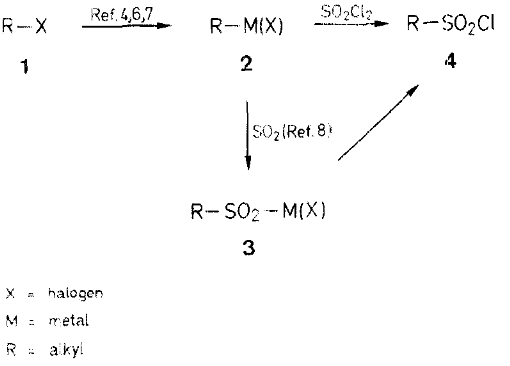
Arylsulfonyl chlorides **8** are prepared from aryl bromides **5** *via* lithium arylsulfinates **7** in excellent yields.

Although sulfonation is the most basic and general method of preparing aromatic sulfonic acid derivatives, alternative methods are sometimes required especially in the case of complex compounds. In the course of a study of electron-transfer photochemistry[1], we recently reported a new protecting group for the amino function, 4-(4,8-dimethoxynaphthylmethyl)benzenesulfonyl (DNMBS), which was readily and efficiently removed by near UV irradiation (> 300 nm)[2]. The reagent for this amine protection is DNMBS chloride (**8j**), which cannot be synthesized *via* direct sulfonation.

Two other methods for the synthesis of aromatic sulfonyl chlorides – from aromatic halides *via* Grignard compounds[3,4] and from aromatic amines *via* diazonium compound[4,5] – have been sometimes used, though the yields, especially with the former method, are only moderate or poor. On the other hand, the synthesis from aliphatic halides *via* organometallic compounds (MgX,[4] Li,[6] Cu,[7] etc.) provides a general method of obtaining aliphatic sulfonyl chlorides as shown in the scheme. Unfortunantely, the yield is not always sufficiently high. In 1979, a highly efficient procedure of preparing aliphatic and aromatic sulfinate salts (**3**) by the reaction of Grignard reagents or alkyllithiums (**2**) with sulfur dioxide[8]. This method is now applied to the synthesis of additional aromatic sulfinate salts, which are oxidatively chlorinated to afford aromatic sulfonyl chlorides.



When arylithiums (**6**, except **6c, e**), prepared from the corresponding aryl halides (**5**) and n-butyllithium, were reacted with a large excess of sulfur dioxide at –60 °C (or –100 °C) lithium arylsulfinates (**7**) were obtained in almost quantitative yields. Suspensions of powdered crude **7** in hexane were treated with an equimolar amount of sulfuryl chloride at 0 °C for 10 min to easily afford arylsulfonyl chlorides (**8**) in excellent yields (Table)[10,11].

$$\underset{\mathbf{5a\text{-}l}}{\mathrm{ArX}} \xrightarrow[-60\,^{\circ}\mathrm{C}\ \text{or}\ -100\,^{\circ}\mathrm{C}]{n\text{-}C_4H_9Li/THF,} \underset{\mathbf{6a\text{-}l}}{\mathrm{ArLi}} \xrightarrow[\text{or THF, }-60\,^{\circ}\mathrm{C}\ \text{or}\ -100\,^{\circ}\mathrm{C}]{SO_2/\text{ether}} \underset{\mathbf{7a\text{-}l}}{\mathrm{ArSO_2Li}}$$

$$\xrightarrow[82-98\,\%]{SO_2Cl_2/n\text{-hexane}} \underset{\mathbf{8a\text{-}l}}{\mathrm{ArSO_2Cl}}$$

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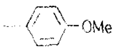
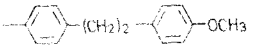
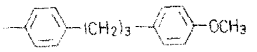
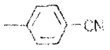
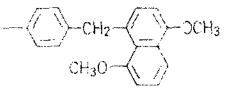
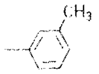
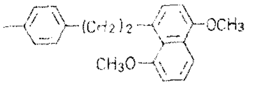
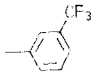
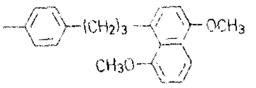
a		**h**	
b		**i**	
c		**j**	
d		**k**	
e		**l**	
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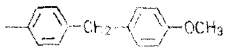
g			

In conclusion, the results presented here provide an efficient and versatile method for the preparation of arylsulfonyl chlorides from aryl halides.

Lithium Arylsulfinates (7); General Procedure:

To a vigorously stirred solution of sulfur dioxide (10 ml) in ether or tetrahydrofuran (20 ml) cooled to –60 °C (or –100 °C, see below), gradually added through a Teflon cannula a solution of an aryllithium (**6**), prepared from an aryl bromide or chloride (**5**; 3 mmol) in tetrahydrofuran (20 ml) and 1.6 M *n*-butyllithium in hexane (1.9 ml) at –60 °C (or –100 °C, see below) under argon. A white powdery precipitate (**7** except **7c, e**) started to separate almost immediately. The addition is complete after 5 min, and the reaction mixture is allowed to warm to room temperature during ca. 1 hr (or overnight, see below). In the case of **7c** and **7e**, precipitates form during the rise in temperature after the addition of **6c, e**. After removal of the solvent *in vacuo*, the residual crude lithium arylsulfinate (**7**) is washed with ether and used in the next reaction without further purification.

For the preparation of aryllithiums bearing an electron-withdrawing substituent such as **6c** and **6e**, a lower temperature is required[9]. The reaction occurs at –100 °C to give **6c** and **6e**, which are added to a tetrahydrofuran solution of sulfur dioxide at the same temperature. The resulting clear solutions are allowed to warm to room temperature overnight to give lithium arylsulfinates (**7c, e**), which are then converted to the final arylsulfonyl chlorides (**8c, e**) in

Table. Arylsulfonyl Chlorides 8 Prepared

Product	Yield[a] [%]	m.p. [°C]	Molecular Formula[b] or Lit. Data	^{1}H-NMR ($CDCl_3$/TMS) δ [ppm]	MS (70 eV) *m/e* (rel. int. %)
8a	95	40–42	41–42°C[12]	3.90 (s, 3H), 7.01 (d, 2H, *J* = 9 Hz), 7.94 (d, 2H, *J* = 9 Hz)	208 (12), 206 (M^+, 28), 171 (100), 107 (57), 77 (55)
8b	90	74–75	75.4°C[13]	7.72 (d, 2H, *J* = 9 Hz), 7.90 (d, 2H, *J* = 9 Hz)	258 (8), 256 (M^+, 32), 254 (24) 221 (88), 219 (87), 157 (98), 155 (100)
8c	98	111–112	111–112°C[14]	7.93 (d, 2H, *J* = 9 Hz), 8.19 (d, 2H, *J* = 9 Hz)	203 (5), 201 (M^+, 10) 166 (52), 102 (100)
8d	96	bp 80–81°C/ 0.4 torr	93.5–94°C/ 1.3 torr[15]	2.48 (s, 3H, 7.40–7.60 (m, 2H), 7.65–7.90 (m, 2H)	192 (5), 190 (M^+, 13), 155 (28), 91 (100)
8e	85	bp 96°C/ 1 torr	54–55°C/ 0.1 torr[16]	7.76 (t, 1H, *J* = 8 Hz), 8.00 (d, 1H, *J* = 8 Hz) 8.20 (d, 1H, *J* = 8 Hz), 8.26 (s, 1H)	246 (2.3), 244 (M^+, 6.7), 209 (52), 145 (100)
8f	92	77–78	75–76.5°C[17]	7.5–8.1 (m, 6H), 8.76 (s, 1H)	228 (10), 226 (M^+, 27), 191 (26), 127 (100)
8g	99	108	$C_{14}H_{13}O_3SCl$ (296.8)	3.80 (s, 3H), 4.03 (s, 2H), 6.84 (d, 2H, *J* = 8 Hz), 7.08 (d, 2H, *J* = 8 Hz), 7.38 (d, 2H, *J* = 8 Hz), 7.92 (d, 2H, *J* = 8 Hz)	298 (37), 296 (M^+, 100), 197 (75), 121 (70)
8h	97	86–87	$C_{15}H_{15}O_3SCl$ (310.8)	2.70–3.20 (m, 4H), 3.79 (s, 3H), 6.80 (d, 2H, *J* = 8 Hz), 7.04 (d, 2H, *J* = 8 Hz), 7.34 (d, 2H, *J* = 8 Hz), 7.91 (d, 2H, *J* = 8 Hz)	312 (0.5), 310 (M^+, 1.1), 121 (100)
8i	92	oil[c]	$C_{16}H_{17}O_3SCl$ (324.8)	1.70–2.20 (m, 2H), 2.20 (t, 2H, *J* = 8 Hz), 2.74 (t, 2H, *J* = 8 Hz), 3.86 (s, 3H), 6.80 (d, 2H, *J* = 8 Hz), 7.06 (d, 2H, *J* = 8 Hz), 7.36 (d, 2H, *J* = 8 Hz), 7.90 (d, 2H, *J* = 8 Hz)	326 (1.3), 324 (M^+, 3.3), 121 (100)
8j	91	115	$C_{19}H_{17}O_4SCl$ (376.9)	3.56 (s, 3H), 4.00 (s, 3H), 4.64 (s, 2H), 6.73 (dd, 1H, *J* = 1 Hz, 8 Hz), 6.77 (d, 1H, *J* = 8 Hz), 7.15 (d, 2H, *J* = 8 Hz), 7.20 (d, 1H, *J* = 8 Hz), 7.37 (t, 1H, *J* = 8 Hz), 7.83 (d, 2H, *J* = 8 Hz), 7.94 (dd, 1H, *J* = 1 Hz, 8 Hz)	378 (40), 376 (M^+, 100), 310 (30)
8k	86	123–125	$C_{20}H_{19}O_4SCl$ (390.9)	2.90–3.14 (m, 2H), 3.23–3.60 (m, 2H), 3.96 (s, 6H), 6.65 (d, 1H, *J* = 8 Hz), 6.90 (dd, 1H, *J* = 2 Hz, 8 Hz), 6.96 (d, 1H, *J* = 8 Hz), 7.35 (d, 2H, *J* = 8 Hz), 7.36 (t, 1H, *J* = 8 Hz), 7.80 (d, 2H, *J* = 8 Hz), 7.82 (d, 1H, *J* = 8 Hz)	392 (1.5), 390 (M^+, 3.8), 324 (3.3), 201 (100)
8l	82	103–104	$C_{21}H_{21}O_4SCl$ (404.9)	1.80–2.30 (m, 2H), 2.76 (t, 2H, *J* = 8 Hz), 3.20 (t, 2H, *J* = 8 Hz), 3.79 (s, 3H), 3.92 (s, 3H), 6.64 (d, 1H, *J* = 8 Hz), 6.78 (dd, 1H, *J* = 2 Hz, 8 Hz), 7.02 (d, 1H, *J* = 8 Hz), 7.28 (d, 1H, *J* = 8 Hz), 7.33 (d, 2H, *J* = 8 Hz), 7.86 (d, 3H, *J* = 8 Hz)	406 (3.2), 404 (M^+, 6.8), 338 (5.7), 201 (100)

[a] Overall yield of isolated product from **5**.

[b] Satisfactory microanalyses obtained: C ±0.27, H ±0.10, S ±0.29, Cl ±0.31.

[c] Molecular distillation at 90°C/0.001 torr.

excellent overall yields. However, attempts to prepare **6c, e** and **7c, e** at −60°C gave only very poor results[9], and the yields of the final **8c** and **8e** were 0 and 45%, respectively.

Arylsulfonyl Chlorides (8); General Procedure:

To a stirred suspension of a finely powdered lithium arylsulfinate (**7**; 3 mmol) in anhydrous *n*-hexane (15 ml) is added sulfuryl chloride (405 mg, 3 mmol) in anhydrous *n*-hexane (7 ml) in portions at 0°C over 1 min. During the addition **7** dissolves, and then a white precipitate forms. After 10 min, the precipitate is collected by filtration, washed with a small amount of ice-cold *n*-hexane, and then taken up in benzene. Insoluble material is removed by filtration and filtrate is concentrated *in vacuo* to leave crude arylsulfonyl chloride (**8**). Solid products (**8a, b, c, f, g h, j, k**) are recrystallized from *n*-hexane to give colorless crystals. Products which are oils are purified by vacuum distillation (for **8d, e**) or molecular distillation (for **8i**).

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