p-Toluenesulfonylacetylene as Thiol Protecting Group

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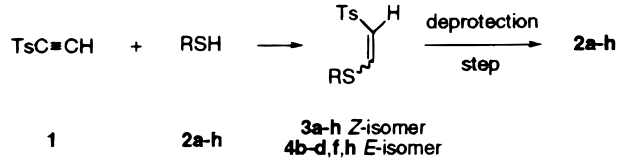
The protection of a thiol group constitutes a common problem in synthetic organic chemistry.[1] Among the methods so far described, those which make use of Michael addition reactions are very common.[2] However, all of them suffer some limitations derived from the use of basic conditions for the protection step or acidic, reductive, or basic conditions for the deprotection step. Phenyl vinyl sulfone and *p*-tolyl isobutenyl sulfone have been previously used for this purpose,[3] but in these cases, a basic medium was necessary for the protection reaction (MeOLi or MeONa in MeOH) and for the deprotection step (*t*-BuOK in *t*-BuOH, MeONa or MeOLi in MeOH, KOH in MeOH).

In this paper, we account for the use of commercially available *p*-toluenesulfonylacetylene (**1**) (Scheme 1) as protecting group for aliphatic and aromatic thiols **2** including hydroxythiols. It should be pointed out that, to the best of our knowledge, there is not a suitable method for the selective protection of a thiol group in the presence of an alcoholic hydroxy substituent.

Results and Discussion

The protection reaction was performed (Table 1) using CH_2Cl_2 as solvent, usually at room temperature and in the presence of an excess of thiol (ratios **2**:**1** between 1.5 and 5.0 depending on the starting thiol). In some cases, equimolecular amounts of both reactants or excess of **1** in the presence of Et_3N (Table 1, entries 3, 7, and 13) were used. In these conditions, no improvement of the yield of **3** or **4** was observed. Thus, the best conditions for this transformation are the use of an excess of thiol **2**. The excess of thiol was always recovered in 90−100% isolated yield.

Scheme 1



a: R = 2-furylmethyl; **b:** R = C_6H_5; **c:** R = *p*-$NO_2C_6H_4$; **d:** R = *p*-$MeOC_6H_4$; **e:** R = CH_3CH_2; **f:** R = $HO(CH_2)_2$; **g:** R = *p*-HOC_6H_4; **h:** R = $HO_2C(CH_2)_2$

Table 1. Reaction of *p*-Toluenesulfonylacetylene 1 and Thiols 2

entry	compd	ratio **2**:**1**	Et_3N (equiv)	reaction (time)	temp (°C)	isolated yields (%)[a] **3**	**4**
1	**2a**	2.0		2 d	reflux	80 (**3a**)	
2	**2a**	2.0		5 d	rt	49 (**3a**)	
3	**2a**	1.0[b]	1.5	27 h	rt	13[c] (**3a**)	
4	**2b**	2.5		21 h	rt	55 (**3b**)	
5	**2b**	5.0		15 h	rt	78 (**3b**)	18 (**4b**)
6	**2c**	1.5		2 h	rt	89 (**3c**)	
7	**2c**	0.5	2.5	2d	*d*	7[e] (**3c**)	
8	**2c**	0.5		5 d	rt	30[f] (**3c**)	5 (**4c**)
9	**2d**	1.5		2 h	rt	42 (**3d**)	
10	**2d**	2.0		3 h	rt	36 (**3d**)	
11	**2d**	3.0		7 d	rt	60 (**3d**)	40 (**4d**)
12	**2d**	2.0		6 d	reflux	8 (**3d**)	61 (**4d**)
13	**2d**	1.0[b]	1.5	27 h	rt	47[g] (**3d**)	12 (**4d**)
14	**2e**	5.0		2 d	rt	100 (**3e**)	
15	**2f**	2.0		2 h	rt	90 (**3f**)	5 (**4f**)
16	**2g**	1.5		20 h	rt	97 (**3g**)	
17	**2h**	3.0		6 d	*h*	96 (**3h**)	
18	**2h**	2.5[i]		4 d	rt	28 (**3h**)	10 (**4h**)

[a] Based on initial concentration of **1** with exception of entries 7 and 8. [b] Additional 0.5 equiv of **1** were added along the reaction. [c] Compound **2a** (14%) was recovered. Compound **12a** was obtained in 73% isolated yield. See text. [d] 36 h at rt and 12 h at reflux. [e] Compound **2c** (44%) was recovered. [f] Compound **2c** (46%) was recovered. [g] Compound **2d** (40%) was recovered. [h] 5 days at rt and 1 day at reflux. [i] Et_2O was used as solvent.l

An interesting feature of the reaction of *p*-toluenesulfonylacetylene (**1**), in the case with 2-furylmethanothiol (**2a**), is that no traces of any reasonably expected cycloadducts were detected, even though **1** and **2a** could participate as dienophile and diene, respectively, in a Diels−Alder-type reaction.

In sharp contrast, the oxygen analog of **2a**, 2-furylmethanol (**5**), reportedly reacted with a close analog of **1**, phenylsulfonylacetylene, to afford a mixture of the normal Diels−Alder adduct **6** and tandem "pincer" Diels−Alder cycloadducts **7** and **8** (Scheme 2).[4] Meanwhile, **2a** has been shown to be an excellent Diels−Alder diene, as it reportedly reacted with ethylenic bis-sulfone **9** to give the adduct **10** in quantitative isolated yield (Scheme 3).[5]

Thus, arylsulfonylacetylene (such as **1**) and 2-furylmethanothiol (**2a**) apparently act as excellent partners resulting in a facile Michael addition reaction, precluding the presumably competitive Diels−Alder reaction. The

(1) (a) Greene, T. W.; Wuts, P. G. M. In *Protective Groups in Organic Synthesis*, 2nd ed.; J. Wiley: 1991; Chapter 6, pp 277−308. (b) Jarowicki, K.; Kocienski, P. *Contemp. Org. Synth.* **1995**, *2*, 315 (see pp 322−323). (c) Jarowicki, K.; Kocienski, P. *Contemp. Org. Synth.* **1996**, *3*, 397 (see pp 406−407). (d) Jarowicki, K.; Kocienski, P. *Contemp. Org. Synth.* **1997**, *4*, 454 (see p 464). (e) Jarowicki, K.; Kocienski, P. *J. Chem. Soc., Perkin Trans. 1* **1998**, 4005 (see pp 4013−4014). During the evaluation of this manuscript a novel thiol protecting group was described, see: (f) Zhang, J.; Matteucci, M. D. *Tetrahedron Lett.* **1999**, *40*, 1467−1470.

(2) For instance, see: (a) Herz, A. H.; Tarbell, D. S. *J. Am. Chem. Soc.* **1953**, *75*, 4657−4660. (b) Wieland, T.; Sieber, A. *Liebigs Ann. Chem.* **1969**, *727*, 121−124. (c) Wieland, T.; Sieber, A. *Liebigs Ann. Chem.* **1969**, *722*, 222−224. (d) Jung, G.; Fouad, H.; Heusel, G. *Angew. Chem. Int. Ed. Engl.* **1975**, *14*, 817−818. (e) Heusel, G.; Jung, G. *Liebigs Ann. Chem.* **1979**, 1173−1188. (f) Katritzky, A. R.; Khan, G. R.; Schwarz, O. A. *Tetrahedron Lett.* **1984**, *25*, 1223−1226. (g) Katritzky, A. R.; Takahashi, I.; Marson, C. M. *J. Org. Chem.* **1986**, *51*, 4914−4920. (h) Ohtsuka, Y.; Oishi, T. *Tetrahedron Lett.* **1986**, *27*, 203−206.

(3) Kuroki, Y.; Lett, R. *Tetrahedron Lett.* **1984**, *25*, 197−200. It should be pointed out that the conjugated addition of thiols to acetylenic sulfones has been known for many years. See: Stirling, C. J. M. *J. Chem. Soc.* **1964**, 5856−5862.

(4) Arjona, O.; Iradier, F.; Medel, R.; Plumet, J. *Heterocycles* **1999**, *50*, 653−656.

(5) Arjona, O.; Iradier, F.; Mañas, R. M.; Plumet, J.; Grabuleda, X.; Jaime, C. *Tetrahedron* **1998**, *54*, 9095−9110.

10.1021/jo990308c CCC: $18.00
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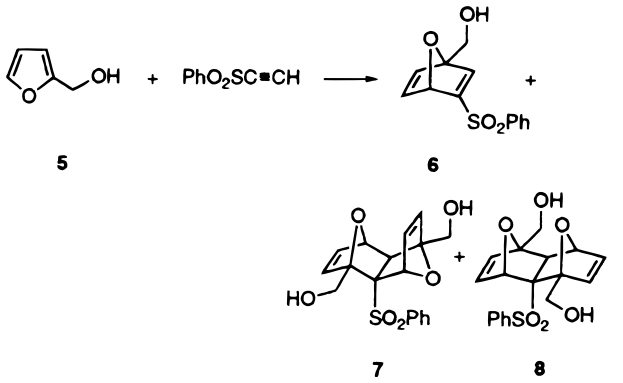
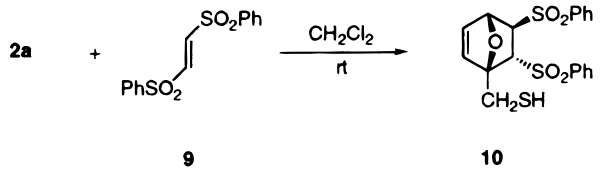
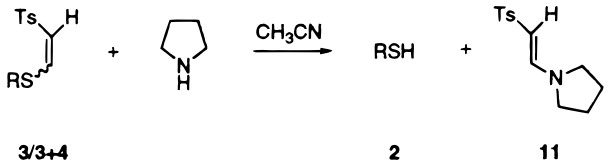
Scheme 2



Scheme 3



Scheme 4



reactivity of the thiol group (in contrast to the hydroxyl group in analog **5** above) is apparently crucial to the course of the reaction and provides the basis of selective protection of the thiol group in presence of hydroxy groups as in compound **2f**−**h**.

Regarding the stereochemistry of the process, the major stereoisomer was, in all cases, the (*Z*)-vinyl sulfone **3** (with the exception of Table 1, entry 12). When prolonged reaction times (Table 1, entries 8, 11, and 18) were employed or under reflux (Table 1, entry 12), the *E* isomer **4** was obtained in variable amounts. Configurational assignment was made on the basis of coupling constants for the ethylenic protons (J_E = 14.2−14.6 Hz, J_Z = 10.0−10.3 Hz) and NOE measurements.

The deprotection step was accomplished by reaction of compounds **3** or mixtures of **3** and **4** with pyrrolidine via Michael addition followed by elimination reaction.[6] In all cases, (*E*)-2-(1-pyrrolidyl)-1-*p*-toluenesulfonylethylene (**11**) was isolated together with compounds **2** (Scheme 4).

The results are gathered in Table 2.

All reactions were conducted in CH_3CN at room temperature. In the case of the furyl derivative **3a**, increasing the reaction temperature did not improve the yield of the recovered thiol. In several cases (**3a**,**b**, **4b**, and **3g**) variable amounts of compound **12** (Scheme 5) arising from the Michael addition of liberated thiol **2** to **3** or **4** were isolated.

On the other hand, in the case of **3f** (Table 2, entry 9), intramolecular Michael addition to give **13** (9%) was observed (Scheme 5). The yield of the deprotection of *p*-hydroxythiophenol (Table 2, entries 10 and 11) was lowered by the difficulty of the chromatographic separation of **11** and **2g**. Finally, the chromatographic isolation of the 3-mercaptopropionic acid obtained in the deprotection step was not possible.

(6) See: Faja, M.; Ariza, X.; Gálrez, C.; Vilarrasa, J. *Tetrahedron Lett.* **1995**, *36*, 3261−3264.

Table 2. Deprotection Reaction of Vinylsulfones 3 and 4

entry	compd	ratio pyrrolidine: (**3**+**4**)	reaction time (h)	isolated yield (%) **2**
1	**3a**	1.2	2.5	28 (**2a**)
2	**3a**	3.0	20	44 (**2a**)
3	**3a**	2.5	24	75 (**2a**)
4	**3a**	2.0	2	50[a] (**2a**)
5	**3b** + **4b**	2.0	2.5	88 (**2b**)
6	**3c**	2.0	3	86 (**2c**)
7	**3d**	9.0	31	100 (**2d**)
8	**3e**	4.0	17.	89[b] (**2e**)
9	**3f**	2.0	26	90 (**2f**)
10	**3g**	2.0	8	29 (**2g**)
11	**3g**	4.0	19	70 (**2g**)

[a] The reaction was performed at reflux. [b] Isolated by distillation. See Experimental Section.

Scheme 5

In summary, a new method for the protection of the thiol functionality via Michael addition of *p*-toluenesulfonylacetylene has been described offering an alternative to those so far described.

Experimental Section

General. Reagents and solvents were handled by using standard syringe techniques. Dichloromethane, acetonitrile, and Et_3N were distilled over CaH_2 before using. The remaining solvents and chemicals were commercial and used as received. ^1H and ^{13}C NMR were recorded at 200 or 300 MHz. Chemical shifts (δ) are reported in ppm from internal $(CH_3)_4Si$. Flash chromatography was performed using 230−400 mesh silica gel. Analytical TLC was carried out on silica gel plates. Melting points are uncorrected. Elemental analyses were performed at the Universidad Complutense de Madrid.

General Procedures for Thiols Protection. Method A: Absence of Et_3N. To a solution of *p*-toluenesulfonylacetylene (**1**) in dry CH_2Cl_2 was added the corresponding thiol (**2a**−**h**) in the molar ratio indicated in Table 1. The mixture was stirred at the temperature and for the time indicated in the same table. The solvent was removed in vacuo, and the residue was purified by column chromatography on silica gel using a mixture of hexane−EtOAc (10:1) as eluant.

Method B: Presence of Et_3N. To a solution of the corresponding thiol in dry CH_2Cl_2 were added Et_3N and *p*-toluenesulfonylacetylene (**1**) in the molar ratio indicated in Table 1. The mixture was stirred at room temperature for the time indicated in the same table. The reaction was quenched with HCl (0.5 N), and the aqueous layer was extracted with CH_2Cl_2. The organic phases were dried over $MgSO_4$ and filtered, and then the solvent was eliminated under reduced pressure. The resulting crude product was purified by column chromatography on silica gel using a mixture of hexane−EtOAc (10:1) as eluant.

(*Z*)-2-[(2′-Furyl)methylthio]-1-*p*-toluenesulfonylethylene (3a): mp 81−82 °C; ^1H NMR ($CDCl_3$, 300 MHz) δ 2.41 (s, 3 H), 3.92 (s, 2 H), 6.20 (d, 1 H, J = 10.3 Hz), 6.23 (dd, 1 H, J = 0.7, 3.3 Hz), 6.29 (dd, 1 H, J = 1.8, 2.9 Hz), 7.10 (d, 1 H, J = 10.3 Hz), 7.30 (d, 2 H, J = 8.1 Hz), 7.34 (dd, 1 H, J = 0.7, 1.8 Hz), 7.81 (d, 2 H, J = 8.5 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.5, 31.4, 108.8, 110.5, 123.2, 127.1, 129.6, 138.3, 142.9, 144.3, 144.4, 149.6; IR (KBr) ν 3053, 1545, 1302 cm^{-1}. Anal. Calcd for $C_{14}H_{14}O_3S_2$: C, 57.14; H, 4.76. Found: C, 57.10; H, 4.93.

(*Z*)-2-(Phenylthio)-1-*p*-toluenesulfonylethylene (3b): mp 107−108 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.45 (s, 3 H), 6.26 (d, 1 H, J = 10.3 Hz), 7.22 (d, 1 H, J = 10.3 Hz), 7.40−7.34 (m, 5 H), 7.42−7.47 (m, 2 H), 7.92 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 122.9, 127.2, 128.7, 129.5, 129.8, 131.2, 134.6, 138.3, 144.5, 146.1; IR (KBr) ν 3045, 1319, 1290 cm^{-1}. Anal. Calcd for $C_{15}H_{14}O_2S_2$: C, 62.07; H, 4.83. Found: C, 62.12; H, 4.66.

(*E*)-2-(Phenylthio)-1-*p*-toluenesulfonylethylene (4b): mp 91−92 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.43 (s, 3 H), 5.99 (d, 1 H, J = 14.4 Hz), 7.31 (d, 2 H, J = 8.5 Hz), 7.41−7.46 (m, 5 H), 7.71 (d, 2 H, J = 8.3 Hz), 7.80 (d, 1 H, J = 14.4 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.6, 123.5, 127.4, 127.5, 129.8, 129.9, 133.3, 133.4, 135.4, 144.1, 145.6; IR (KBr) ν 3069, 1493, 1277 cm^{-1}. Anal. Calcd for $C_{15}H_{14}O_2S_2$: C, 62.07; H, 4.83. Found: C, 62.15; H, 4.70.

(*Z*)-2-(*p*-Nitrophenylthio)-1-*p*-toluenesulfonylethylene (3c): mp 152−153 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.46 (s, 3 H), 6.43 (d, 1 H, J = 10.0 Hz), 7.26 (d, 1 H, J = 10.0 Hz), 7.37 (d, 2 H, J = 8.1 Hz), 7.58 (d, 2 H, J = 8.8 Hz), 7.88 (d, 2 H, J = 8.6 Hz), 8.22 (d, 2 H, J = 9.0 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 124.4, 125.7, 127.3, 130.0, 130.2, 137.7, 141.2, 143.2, 145.0; IR (KBr) ν 3651, 1545, 1342 cm^{-1}. Anal. Calcd for $C_{15}H_{13}NO_4S_2$: C, 53.73; H, 3.88. Found: C, 53.81; H, 3.65.

(*E*)-2-(*p*-Nitrophenylthio)-1-*p*-toluenesulfonylethylene (4c): ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.48 (s, 3 H), 7.24 (d, 1 H, J = 14.2 Hz), 7.39 (d, 2 H, J = 8.1 Hz), 7.57 (d, 1 H, J = 14.2 Hz), 7.76 (d, 2 H, J = 9.0 Hz), 7.81 (d, 2 H, J = 9.0 Hz), 8.43 (d, 2 H, J = 9.0 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.7, 124.6, 125.1, 125.4, 128.2, 130.4, 135.4, 135.4, 145.9, 146.8, 147.7; IR ($CHCl_3$) ν 2926, 1599, 1306 cm^{-1}. Anal. Calcd for $C_{15}H_{13}NO_4S_2$: C, 53.73; H, 3.88. Found: C, 53.68; H, 3.70.

(*Z*)-2-(*p*-Methoxyphenylthio)-1-*p*-toluenesulfonylethylene (3d): mp 138−139 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.45 (s, 3 H), 3.80 (s, 3 H), 6.18 (d, 1 H, J = 10.2 Hz), 6.88 (d, 2 H, J = 9.0 Hz), 7.11 (d, 1 H, J = 10.2 Hz), 7.35 (d, 2 H, J = 8.1 Hz), 7.37 (d, 2 H, J = 9.0 Hz), 7.91 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 55.4, 115.0, 122.0, 125.1, 127.1, 129.7, 133.7, 138.4, 144.4, 148.0, 160.3; IR (KBr) ν 3385, 1493, 1249 cm^{-1}. Anal. Calcd for $C_{16}H_{16}O_3S_2$: C, 60.00; H, 5.00. Found: C, 60.14; H, 4.92.

(*E*)-2-(*p*-Methoxyphenylthio)-1-*p*-toluenesulfonylethylene (4d): mp 87−88 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.42 (s, 3 H), 3.82 (s, 3 H), 5.83 (d, 1 H, J = 14.4 Hz), 6.92 (d, 2 H, J = 8.8 Hz), 7.30 (d, 2 H, J = 8.5 Hz), 7.36 (d, 2 H, J = 9.0 Hz), 7.69 (d, 2 H, J = 9.3 Hz), 7.75 (d, 1 H, J = 14.4 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.5, 55.4, 115.5, 118.9, 122.8, 127.3, 129.8, 135.7, 138.1, 143.9, 146.8, 161.0; IR (KBr) ν 3853, 1496, 1302 cm^{-1}. Anal. Calcd for $C_{16}H_{16}O_3S_2$: C, 60.00; H, 5.00. Found: C, 59.87; H, 4.79.

(*Z*)-2-(Ethylthio)-1-*p*-toluenesulfonylethylene (3e): mp 96−97 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 1.31 (t, 3 H, J = 7.6 Hz), 2.42 (s, 3 H), 2.77 (q, 2 H, J = 7.6 Hz), 6.21 (dd, 1 H, J = 0.7, 10.2 Hz), 7.05 (d, 1 H, J = 10.5 Hz), 7.32 (d, 2 H, J = 8.5 Hz), 7.84 (d, 2 H, J = 8.5 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 15.1, 21.5, 29.9, 122.7, 127.1, 129.6, 138.5, 144.2, 146.2; IR (KBr) ν 3651, 2926, 1541 cm^{-1}. Anal. Calcd for $C_{11}H_{14}O_2S_2$: C, 54.54; H, 5.78. Found: C, 54.62; H, 5.85.

(*Z*)-2-((2-Hydroxyethyl)thio)-1-*p*-toluenesulfonylethylene (3f): mp 90−91 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.26 (t, 1 H, J = 5.9 Hz), 2.44 (s, 3 H), 2.94 (t, 2 H, J = 5.9 Hz), 3.85 (q, 2 H, J = 5.9 Hz), 6.24 (d, 1 H, J = 10.3 Hz), 7.13 (d, 1 H, J = 10.3 Hz), 7.34 (d, 2 H, J = 8.5 Hz), 7.86 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.5, 38.4, 61.8, 122.8, 127.0, 129.7, 138.1, 144.4, 146.8; IR (KBr) ν 3853, 3036, 1537 cm^{-1}. Anal. Calcd for $C_{11}H_{14}O_3S_2$: C, 51.16; H, 5.43. Found: C, 50.94; H, 5.55.

(*E*)-2-((2-Hydroxyethyl)thio)-1-*p*-toluenesulfonylethylene (4f): ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.44 (s, 3 H), 3.00 (t, 2 H, J = 5.9 Hz), 3.87 (t, 2 H, J = 5.9 Hz), 6.25 (d, 1 H, J = 14.6 Hz), 7.33 (d, 2 H, J = 8.1 Hz), 7.70 (d, 1 H, J = 14.6 Hz), 7.75 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 35.4, 60.7, 123.1, 127.4, 129.9, 138.1, 144.5; IR ($CHCl_3$) ν 3489, 2926, 1269 cm^{-1}. Anal. Calcd for $C_{11}H_{14}O_3S_2$: C, 51.16; H, 5.43. Found: C, 51.23; H, 5.39.

(*Z*)-2-((*p*-Hydroxyphenyl)thio)-1-*p*-toluenesulfonylethylene (3g): ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.34 (s, 3 H), 6.08 (d, 1 H, J = 10.2 Hz), 6.76 (d, 2 H, J = 8.8 Hz), 7.03 (d, 1 H, J = 10.2 Hz), 7.16 (d, 2 H, J = 8.8 Hz), 7.25 (d, 2 H, J = 8.1 Hz), 7.79 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 116.7, 121.3, 124.1, 127.0, 129.8, 133.8, 137.9, 144.7, 149.0, 157.3; IR ($CHCl_3$) ν 3400, 1599, 1288 cm^{-1}. Anal. Calcd for $C_{15}H_{14}O_3S_2$: C, 58.82; H, 4.57. Found: C, 58.90; H, 4.48.

(*Z*)-2-((2-Carboxyethyl)thio)-1-*p*-toluenesulfonylethylene (3h): ^{1}H NMR ($CDCl_3$, 300 MHz) δ 2.43 (s, 3 H), 2.72 (t, 2 H, J = 6.8 Hz), 3.03 (t, 2 H, J = 6.8 Hz), 6.22 (d, 1 H, J = 10.3 Hz), 6.45 (bs, 1 H), 7.13 (d, 1 H, J = 10.3 Hz), 7.32 (d, 2 H, J = 8.1 Hz), 7.83 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.6, 31.0, 35.4, 122.9, 127.1, 129.7, 138.2, 144.5, 146.1, 176.8; IR (CH_2Cl_2) ν 3055, 1715, 1421 cm^{-1}. Anal. Calcd for $C_{12}H_{14}O_4S_2$: C, 50.35; H, 4.89. Found: C, 50.20; H, 4.95.

(*E*)-2-((2-Carboxyethyl)thio)-1-*p*-toluenesulfonylethylene (4h). Compound **4h** has not been isolated. Spectroscopic data of this compound are deduced from an inseparable mixture (1:1.2) of **3h** and **4h:** ^{1}H NMR ($CDCl_3$, 300 MHz) δ 2.44 (s, 6 H), 2.74 (t, 4 H, J = 6.8 Hz), 3.03 (t, 2 H, J = 6.8 Hz), 3.05 (t, 2 H, J = 6.8 Hz), 6.20 (d, 1 H, J = 14.6 Hz), 6.24 (d, 1 H, J = 10.2 Hz), 7.06 (d, 1 H, J = 10.2 Hz), 7.33 (d, 4 H, J = 8.3 Hz), 7.69 (d, 1 H, J = 14.6 Hz), 7.75 (d, 2 H, J = 8.3 Hz), 7.84 (d, 2 H, J = 8.3 Hz).

General Procedure for Deprotection of Thiols. A solution of the protected thiol (*Z* isomer or mixture of *E*−*Z* isomers) in CH_3CN was added dropwise to a stirred solution of pyrrolidine in CH_3CN. The mixture was stirred at rt for the time indicated in Table 2. Solvent was removed under reduced pressure, and the residue was purified by chromatography on silica gel, using mixtures of hexane−EtOAc (5:1 or 10:1) as eluant. Compounds **12** were isolated in the deprotection of compounds **3a**,**b**, **4b**, and **3g**. Compound **13** was isolated in the deprotection of **3f**. Compound **2e** was isolated by distillation of the reaction crude without previous elimination of the solvent.

(*E*)-2-(1-Pyrrolidyl)-1-*p*-toluenesulfonylethylene (11): mp 126−127 °C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 1.93 (bs, 4 H), 2.40 (s, 3 H), 3.03 (bs, 2 H), 3.46 (bs, 2 H), 4.83 (d, 1 H, J = 12.4 Hz), 7.26 (d, 2 H, J = 7.8 Hz), 7.52 (d, 1 H, J = 12.4 Hz), 7.75 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.4, 25.2, 92.8, 126.2, 129.4, 142.0, 142.5, 146.5; IR (KBr) ν 2870, 1281 cm^{-1}. Anal. Calcd for $C_{13}H_{17}NO_2S$: C, 62.15; H, 6.77. Found: C, 61.99; H, 6.60.

2,2-Bis[(2′-furyl)methylthio]-1-*p*-toluenesulfonylethane (12a): ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.45 (s, 3 H), 3.49 (d, 2 H, J = 6.6 Hz), 3.77 (d, 2 H, J = 14.9 Hz), 3.88 (d, 2 H, J = 14.9 Hz), 4.17 (t, 1 H, J = 6.6 Hz), 6.14 (d, 2 H, J = 3.2 Hz), 6.32 (dd, 2 H, J = 1.9, 3.2 Hz), 7.29 (d, 2 H, J = 8.5 Hz), 7.37 (dd, 2 H, J = 0.7, 1.9 Hz), 7.65 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.7, 27.6, 43.9, 61.9, 108.3, 110.6, 127.4, 128.4, 129.7, 142.3, 144.8, 150.2; IR ($CHCl_3$) ν 3050, 1323, 1288 cm^{-1}. Anal. Calcd for $C_{19}H_{19}O_4S_3$: C, 56.02; H, 4.67. Found: C, 56.22; H, 4.79.

2,2-Bis(phenylthio)-1-*p*-toluenesulfonylethane (12b): ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.38 (s, 3 H), 3.45 (d, 2 H, J = 6.6 Hz), 4.68 (t, 1 H, J = 6.6 Hz), 7.19−7.28 (m, 8 H), 7.31−7.36 (m, 4 H), 7.65 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.7, 50.6, 60.3, 128.4, 128.6, 129.2, 129.8, 132.3, 133.3, 133.4, 145.0; IR ($CHC1_3$) ν 3042, 2399, 1323 cm^{-1}. Anal. Calcd for $C_{21}H_{20}O_2S_3$: C, 63.00; H, 5.00. Found: C, 62.89; H, 5.13.

2,2-Bis(*p*-hydroxyphenyl)thio)-1-*p*-toluenesulfonylethane (12g): mp 147−148 °C; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 2.45 (s, 3 H), 3.45 (d, 2 H, J = 6.3 Hz), 4.41 (t, 1 H, J = 6.3 Hz), 5.87 (bs, 1 H), 6.78 (d, 4 H, J = 8.5 Hz), 7.28−7.34 (m, 6 H), 7.70 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 21.0, 30.9, 59.9, 77.2, 116.2, 128.3, 129.8, 136.7, 136.8, 156.9; IR (KBr) ν 3421, 2924, 2852, 1138 cm^{-1}. Anal. Calcd for $C_{21}H_{20}O_4S_3$: C, 58.33; H, 4.63. Found: C, 58.27; H, 4.54.

2-(*p*-Toluenesulfonylmethyl)-1,3-oxathiolane (13): ^{1}H NMR ($CDCl_3$, 300 MHz) δ 2.47 (s, 3 H), 3.01 (dd, 2 H, J = 4.9, 7.1 Hz), 3.46 (dd, 1 H, J = 4.1, 14.4 Hz), 3.67 (dd, 1 H, J = 7.6, 14.4 Hz), 3.81 (dt, 1 H, J = 7.3, 9.0 Hz), 4.22 (quint, 1 H, J = 4.9 Hz), 5.47 (dd, 1 H, J = 4.1, 7.8 Hz), 7.37 (d, 2 H, J = 8.3 Hz),

7.83 (d, 2 H, J = 8.3 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.8, 33.1, 62.5, 72.1, 79.8, 129.1, 130.7, 137.3, 145.9; IR ($CHCl_3$) ν 2928, 1319, 1261 cm^{-1}. Anal. Calcd for $C_{11}H_{14}O_3S_2$: C, 51.16; H, 5.43. Found: C, 50.96; H, 5.32.

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Supporting Information Available: ^{1}H NMR and ^{13}C NMR spectra copies for compounds **3a**−**h, 4b**−**d** and **f**, **12a**−**b** and **g**, **13** and ^{1}H NMR spectra copy for the mixture of **3h** and **4h**. This material is available free of charge via the Internet at http://pubs.acs.org.

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