Stereospecific Reductive Desulfinylation of 1-Aryl-2-(methylsulfinyl)-2-(methylthio)ethenes with Grignard Reagents[1)]

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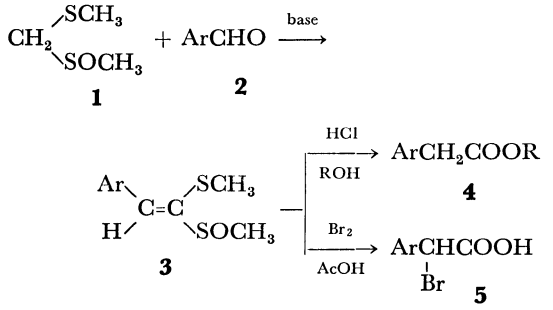
(Received May 6, 1982)

Synopsis. (*E*)-1-Aryl-2-(methylsulfinyl)-2-(methylthio)ethene, obtained by the Knoevenagel-type condensation of methyl (methylthio)methyl sulfoxide with the corresponding aromatic aldehyde, was found to react with ethylmagnesium chloride to give (*Z*)-1-aryl-2-(methylthio)ethene predominantly. Since the reaction of (*Z*)-1-(methylsulfinyl)-1-(methylthio)-2-phenylethene afforded (*E*)-1-(methylthio)-2-phenylethene, the present reaction appeared to be stereospecific.

In the previous papers,[3,4)] methyl (methylthio)methyl sulfoxide (**1**) was reported to react with an aromatic aldehyde (**2**) in the presence of a base to give the (*E*)-1-aryl-2-(methylsulfinyl)-2-(methylthio)ethene (**3**), which appeared to be one of the most important precursors for synthesizing arylacetic acid derivatives. For example, the reaction of **3** with hydrogen chloride in an alcohol (ROH) yields the arylacetic ester (**4**) and treatment of **3** with bromine in acetic acid produces the α-bromoarylacetic acid (**5**).

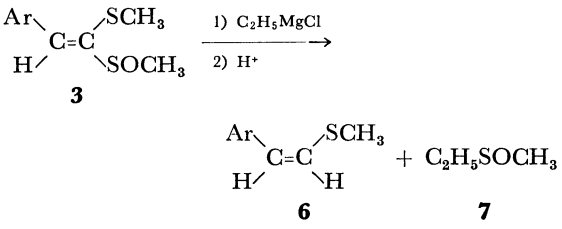


We further examined the reaction of **3** with Grignard reagents, where many types of the reactions could be expected to take place: (i) Attack on the sulfur atom of the sulfinyl group, bringing about the replacement reaction, analogous to the reaction of aryl chloromethyl sulfoxide (Eq. 1);[5)] (ii) reduction of the sulfinyl group with concomitant alkylation of the sulfinyl methyl group as observed in the reaction of dimethyl sulfoxide (Eq. 2);[6)] (iii) Michael-type addition to the α,β-unsaturated sulfoxide moiety;[7)] and (iv) proton transfer to form a carbanion on the methyl adjacent to the sulfinyl group. In this note, we report that a Grignard

$$ArSOCH_2Cl + RMgBr \longrightarrow ArSOR \quad (1)$$

$$CH_3SOCH_3 + RMgX \longrightarrow CH_3SCH_2R \quad (2)$$

reagent causes reductive desulfinylation of **3** to give a (*Z*)-1-aryl-2-(methylthio)ethene (**6**) stereospecifically.



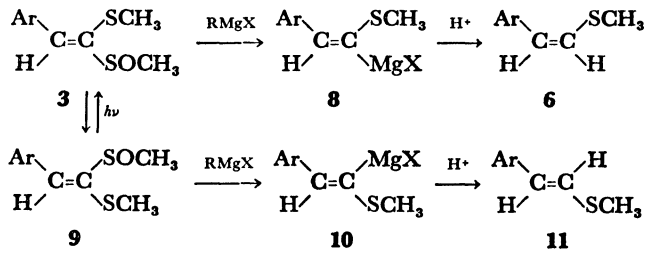
Results and Discussion

To a solution of (*E*)-1-(*p*-chlorophenyl)-2-(methylsulfinyl)-2-(methylthio)ethene (**3**; Ar=*p*-ClC_6H_4), which was obtained by the reaction of **1** with *p*-chlorobenzaldehyde in the presence of a base in tetrahydrofuran (THF),[3)] was added a THF solution of ethylmagnesium chloride (1.5 mol equiv.) under argon atmosphere and cooling with ice–water, and the resulting mixture was stirred at room temperature for 1 h. The color of the mixture changed from pale yellow to orange and then to yellow. Addition of water, followed by the usual work-up, gave 1-(*p*-chlorophenyl)-2-(methylthio)ethene and ethyl methyl sulfoxide (**7**) in yields of 79% and 37%, respectively. The structure of the former was given by an elemental analysis and an NMR spectrum, which showed that this product consisted mainly of the (*Z*)-isomer (**6**; Ar=*p*-ClC_6H_4) together with a small amount (*ca.* 5%) of its (*E*)-isomer. The (*Z*)- and (*E*)-isomers were assigned from the coupling constants (J=11 and 15 Hz, respectively) between the olefinic protons.

In a similar manner, (*Z*)-1-aryl-2-(methylthio)ethenes [**6**; Ar=C_6H_5, *p*-$CH_3C_6H_4$, and *p*-$(CH_3)_2NC_6H_4$] were obtained on treatment of the corresponding (*E*)-1-aryl-2-(methylsulfinyl)-2-(methylthio)ethenes with ethylmagnesium chloride in yields of 82%, 60%, and 41%, respectively. In every case, formation of a small amount of (*E*)-isomer was observed, but the ratio of the (*Z*)- and (*E*)-isomers remained always more than nine. The use of methylmagnesium iodide gave the similar result; The reaction with **3** (Ar=C_6H_5) afforded **6** (Ar=C_6H_5) in 57% yield.

The observation that the thermodynamically less stable (*Z*)-isomer (**6**) was always obtained as the major product in the reaction of **3** with a Grignard reagent suggests stereospecific nature of the reaction. Thus, we studied the reaction of ethylmagnesium chloride with a mixture consisting of **3** (Ar=C_6H_5) and its (*Z*)-isomer (**9**; Ar=C_6H_5). When a 35:65 mixture of **3** (Ar=C_6H_5) and **9** (Ar=C_6H_5), which was obtained by irradiation of **3** (Ar=C_6H_5) with a low-pressure mercury arc lamp,[3)] was subjected to the reaction with ethylmagnesium chloride, the ratio of the (*E*)- and (*Z*)-isomers (**6** and **11**; Ar=C_6H_5) of 1-(methylthio)-2-phenylethene was 29:71. In a similar manner, a 25:75 mixture of **3** (Ar=C_6H_5) and **9** (Ar=C_6H_5) gave a mixture of the corresponding **6** and **11** in the ratio of 21:79. Hence, the present reaction proved to be stereospecific.

The reaction of **3** or **9** with a Grignard reagent may be accounted for by the mechanism involving the attack of a Grignard reagent (RMgX) on the sulfur atom of the sulfinyl group of **3** or **9**, followed by elimination of alkyl methyl sulfoxide ($RSOCH_3$)[8)]



to form a 2-aryl-1-(methylthio)ethenylmagnesium halide (**8** or **10**, respectively) which was finally converted into **6** or **11** by the abstraction of a proton in a retention manner.[9,10]

Experimental

The Reaction of **3** *(Ar=*p*-ClC_6H_4) with Ethylmagnesium Chloride. A Typical Procedure*: To a solution containing 1.18 g (4.8 mmol) of **3** (Ar=*p*-ClC_6H_4) in 6.0 ml of THF, was added 3.5 ml of 2 M solution (1.5 mol equiv.) of ethylmagnesium chloride in THF under argon atmosphere and cooling with an ice–water bath. After removal of the bath, the reaction mixture was stirred for 1 h at room temperature and then water (0.5 ml) was added at 0—5 °C. After addition of diethyl ether (30 ml) and anhydrous sodium sulfate, the resulting mixture was stirred mechanically. The organic layer was separated by decantation and the residue was washed twice with 20 ml of diethyl ether. These ethereal solutions were combined and dried over anhydrous magnesium sulfate, and the solvent was evaporated *in vacuo*. The residual oil was column-chromatographed on silica gel using dichloromethane as an eluent to give 698 mg (79% yield) of **6** (Ar=*p*-ClC_6H_4) as a slightly yellow oil, which was further purified by a short-path distillation [bath temperature: 103—105 °C/0.05 Torr (1 Torr=133.322 Pa)]: IR (neat) 1597, 1590, 1490, 1402, 1089, 1010, 847, 828, and 525 cm^{-1}; NMR ($CDCl_3$) δ 2.35 (3H, s), 6.16 (1H, d, J=11 Hz), 6.30 (1H, d, J=11 Hz), 7.26 (2H, d, J=7 Hz), and 7.33 (2H, d, J=7 Hz).

Found: C, 58.32; H, 4.82%. Calcd for C_9H_9ClS: C, 58.53; H, 4.92%.

Ethyl methyl sulfoxide (**7**) was obtained by washing the residue of the decantation with methanol. Evaporation of the washings gave 162 mg (37% yield) of **7** as a colorless oil, which was identified by a comparison of its IR and NMR spectra with those of the authentic sample prepared by oxidation of ethyl methyl sufide.

The reaction of **3** [Ar=C_6H_5, *p*-$CH_3C_6H_4$, or *p*-$(CH_3)_2NC_6H_4$] with ethylmagnesium chloride under the same conditions afforded **6** [Ar=C_6H_5, *p*-$CH_3C_6H_4$, or *p*-$(CH_3)_2NC_6H_4$] in 82%, 60%, or 41% yield, respectively, as an isomeric mixture consisting mainly of (*Z*)-isomer.

6 (Ar=C_6H_5) purified by a short-path distillation [bath temperature: 130—140 °C/17 Torr (lit,[11] 100—113 °C/3—4 Torr)]: IR (neat) 1600, 1499, 1449, 846, 778, 735, 689, and 530 cm^{-1}; NMR ($CDCl_3$) δ 2.36 (3H, s), 6.19 (1H, d, J=11 Hz), 6.43 (1H, d, J=11 Hz), and 7.1—7.6 (5H, m).

6 (Ar=*p*-$CH_3C_6H_4$) purified by a short-path distillation (bath temperature: 105—115 °C/0.12 Torr): IR (neat) 1598, 1515, 824, 687, and 530 cm^{-1}; NMR ($CDCl_3$) δ 2.29 (3H, s), 2.34 (3H, s), 6.07 (1H, d, J=11 Hz), 6.33 (1H, d, J=11 Hz), 7.11 (2H, d, J=8 Hz), and 7.31 (2H, d, J=8 Hz). Found: C, 72.79; H, 7.15%. Calcd for $C_{10}H_{12}S$: 73.13; 7.36%.

6 (Ar=*p*-$(CH_3)_2NC_6H_4$): mp 63.5—64.5 °C (from methanol); IR (nujol) 1615, 1368, 815, 670, and 530 cm^{-1}; NMR ($CDCl_3$) δ 2.33 (3H, s), 2.91 (6H, s), 5.88 (1H, d, J=10.5 Hz), 6.31 (1H, d, J=10.5 Hz), 6.67 (2H, d, J=8.5 Hz), and 7.34 (2H, d, J=8.5 Hz). Found: C, 68.31; H, 7.78; N, 7.09%. Calcd for $C_{11}H_{15}NS$: C, 68.35; H, 7.82; N, 7.25%.

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9) For examples of the reaction of a vinyl carbanion in a retention manner, see G. Linstrumelle, *Tetrahedron Lett.*, **1974**, 3809; J. Millon, R. Lorne, and G. Linstrumelle, *Synthesis*, **1975**, 434; and the references cited therein.

10) This proton abstraction may occur either during the reaction (from **3** or **7**) or during the work-up. At the present time, we cannot distinguish these possibilities because the pK_a value for the olefinic proton of **6** or **11** is not available in literature.

11) G. A. Russell, E. Sabourin, and G. J. Mikol, *J. Org. Chem.*, **31**, 2854 (1966).