Synthesis of 1-Phenylsulfonylcyclopropanecarboxylic Acid Derivatives

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(Received May 17, 1984)

Synopsis. Ethyl phenylsulfonylacetate was treated with 1,2-dibromoethane in the presence of benzyltriethylammonium chloride and alkali to give 1-phenylsulfonylcyclopropanecarboxylic acid, from which the carbonyl chloride, ester, carboxamide, 1,2-diacylhydrazine, carbonyl azide, carbamate, isocyanate, and γ-butyrolactone derivatives were prepared.

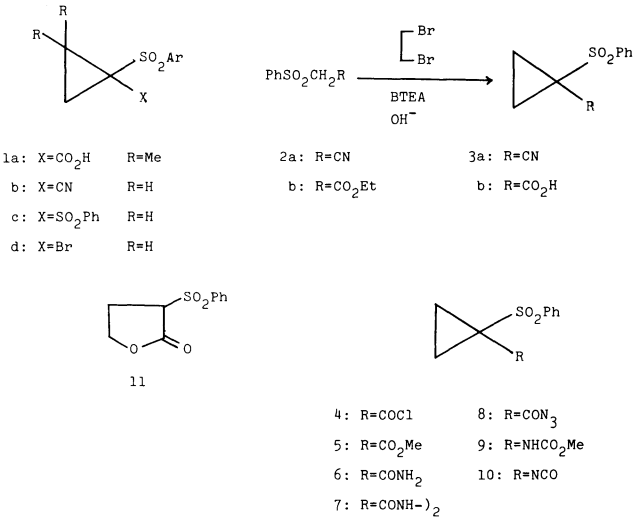
Cyclopropanes which are activated by geminal electron-withdrawing substituents have great potential in organic synthesis.[1] However, the synthesis and reactions of cyclopropanes that have a sulfonyl group[2] as one of the geminal activating groups are limited. Preparative approaches to these cyclopropanes include; (a) carboxylation of lithiated sulfonylcyclopropanes to **1a**;[3] (b) oxidation of arylthiocyclopropanes to the corresponding arylsulfonylcyclopropanes **1b**[4] and **1c**, which has been developed as a synthon for a propyrene 1,3-dipole;[5] (c) direct cyclopropanation of aryl bromomethyl sulfone with 1,2-dibromoethane in the presence of phase-transfer catalyst and alkali to yield **1d**.[6]

In connection with our studies on the synthesis of heterocycles using cyclopropanes[7] we became interested in the reactions of this relatively unknown class of cyclopropanes because of the possibility of their intramolecular cyclization to heterocycles, and therefore we prepared some derivatives of 1-phenylsulfonylcyclopropanecarboxylic acids.

Phenylsulfonylacetonitrile (**2a**) and -acetate (**2b**) undergo Knoevenagel condensation.[2,8] These acidic sulfones **2a** and **2b** were subjected to direct cyclopropanation in a similar manner as for **1d**[6] and other active methylene compounds.[9] Although cyclopropanecarbonitrile (**3a**) was obtained from **2a** in the presence of a catalytic amount of benzyltriethylammonium chloride (BTEA) in a 71% yield, only phenylsulfonylacetic acid was produced from **2b** under the same reaction conditions. Cyclopropanation of **2b**, however, was accomplished by the use of an equimolar quantity of BTEA to yield **3b** in a 67% yield. Treatment of **3b** with thionyl chloride gave the carbonyl chloride **4** (77%), from which the methyl ester **5** (97%), carboxamide **6** (84%), 1,2-diacylhydrazine **7** (71%), and carbonyl azide **8** (79%) were prepared in the usual manner. Heating of **8** in methanol gave the methyl carbamate **9** (92%), indicating the presence of the intermediary isocyanate **10** in the course of the Curtius rearrangement. Isolation of **10** was attempted by heating **8** in toluene but only crude **10** (73%) was obtained. The structure of **10** was ascertained by conversion to **9** on refluxing a methanolic solution of **10**. Attempts to prepare cyclopropylamine from **6** or **9** were unsuccesful.

Cyclopropanecarboxylic acids were reported to rearrange to γ-butyrolactones thermally[10] or in the presence of acids.[11] Heating of **3b** in polyphosphoric acid at 160°C for 10 h gave 3-phenylsulfonyltetrahydro-2-furanone (**11**) in a 45% yields.

The structures of the products are evident on the basis of the analytical and spectral data. In particular, the NMR spectra of **3—10** showed the characteristic absorptions of A_2B_2 system at *ca.* δ 1.1—2.2 due to the adjacent methylene groups of the cyclopropane rings.



Experimental

Melting points were determined on a Yanagimoto micro-melting point apparatus and are uncorrected. ^{1}H-NMR, IR, and mass spectra were measured with a JEOL JMX-60, a JASCO A-102, and a JEOL JMS-DX300 spectrometer, respectively. Microanalysis was performed with a Shimadzu UM-3B microanalyser.

1-Phenylsulfonylcyclopropanecarbonitrile (3a). A mixture of phenylsulfonylacetonitrile[8] (4.35 g, 24 mmol), 1,2-dibromoethane (9.02 g, 48 mmol), and BTEA (270 mg, 1.2 mmol) in 50% aqueous NaOH (120 cm^3) was stirred with cooling in a water bath for 1 h. The mixture was diluted with water until all the precipitates were dissolved, and extracted with ether. The ethereal solution was dried over $MgSO_4$, and evaporated. The residue was recrystallized from AcOEt to give **3a** (3.51 g, 71%), mp 80—81 °C (lit,[4] mp 88 °C). IR (KBr): 2230 (CN), 1570, 1440, 1415 cm^{-1}. NMR ($CDCl_3$): δ=1.73 (m, 2H), 1.93 (m, 2H), 7.48—8.07 (m, 5H). Found: C, 57.97; H, 4.38%. Calcd for $C_{10}H_9O_2SN$: C, 58.25; H, 4.33%.

1-Phenylsulfonylcyclopropanecarboxylic Acid (3b). A mixture of ethyl phenylsulfonylacetate (**2b**)[8] (2.28 g, 10 mmol), 1,2-dibromoethane (3.76 g, 20 mmol), and BTEA (3.28 g, 10 mmol) in 50% aqueous NaOH (20 cm^3) was stirred in a water bath for 1 h. The mixture was diluted with water until all the precipitates were dissolved, and washed with ether. The aqueous layer was acidified with conc. HCl, and extracted with ether. The ethereal solution was dried over $MgSO_4$ and evaporated. The residue was recrystallized from AcOEt to give **3b** (1.53 g, 67%), mp 144—145 °C. IR (KBr): 3230 (OH), 1720 (CO), 1575, 1475, 1420, 1410 cm^{-1}. NMR ($CDCl_3$): δ=1.77 (m, 2H), 2.00 (m, 2H), 7.60—8.02 (m, 5H), 10.10 (s, 1H). Found: C, 53.06; H, 4.55%. Calcd for $C_{10}H_{10}O_4S$: C, 53.09; H, 4.45%.

1-Phenylsulfonylcyclopropanecarbonyl Chloride (4). Mp

62—63 °C (AcOEt). IR (KBr): 3075, 1755 (CO), 1575, 1475, 1445, 1410 cm^{-1}. NMR ($CDCl_3$): δ=2.10 (m, 2H), 2.22 (m, 2H), 7.51—8.07 (m, 5H). Found: C, 49.34; H, 3.67%. Calcd for $C_{10}H_9ClSO_3$: C, 49.09; H, 3.71%.

Methyl 1-Phenylsulfonylcyclopropanecarboxylate (5). Mp 76—77 °C (AcOEt). IR (KBr); 1710 (CO), 1575, 1440, 1310 cm^{-1}. NMR ($CDCl_3$): δ=1.58—1.80 (m, 2H), 1.95—2.14 (m, 2H), 3.63 (s, 3H), 7.50—8.06 (m, 5H). Found: C, 54.87; H, 5.06%. Calcd for $C_{11}H_{12}SO_4$: C, 54.99; H, 5.03%.

1-Phenylsulfonylcyclopropanecarboxamide (6). Mp 138 −140 °C (MeOH). IR (KBr): 3400, 3170 (NH), 1665 (CO), 1605, 1440 cm^{-1}. NMR ($CDCl_3$): δ=1.75 (s, 2H), 1.80 (s, 2H), 6.15 (br s, 2H), 7.50—7.95 (m, 5H). Found: C, 53.68; H, 4.92%. Calcd for $C_{10}H_{11}O_3NS$: C, 53.33; H, 4.92%.

1,2-Bis[1-(phenylsulfonyl)cyclopropylcarbonyl]hydrazine (7). Mp 147—148 °C (AcOEt). IR (KBr): 3250 (NH), 1730 (CO), 1580, 1480, 1445 cm^{-1}. NMR ($CDCl_3$): δ=1.58—1.80 (m, 2H), 1.97—2.18 (m, 2H), 7.50—8.03 (m, 10H), 10.20 (s, 2H). Found: C, 53.29; H, 4.64%. Calcd for $C_{20}H_{20}N_2O_6S_2$: C, 53.56; H, 4.49%.

1-Phenylsulfonylcyclopropanecarbonyl Azide (8). Mp 70—72 °C. IR (KBr): 2150 (N_3), 1685 (CO), 1580, 1475, 1445, 1415 cm^{-1}. NMR ($CDCl_3$): δ=1.58—1.80 (m, 2H), 1.98—2.22 (m, 2H), 7.47—8.05 (m, 5H). Found: C, 48.11; H, 3.55%. Calcd for $C_{10}H_9O_3N_3S$: C, 47.81; H, 3.61%.

Methyl 1-(Phenylsulfonyl)cyclopropylcarbamate (9). Mp 108—111 °C (AcOEt). IR (KBr): 3180 (NH), 1750 (CO), 1610, 1580, 1510, 1445, 1425 cm^{-1}. NMR ($CDCl_3$): δ=1.27—1.58 (m, 2H), 1.73—2.05 (m, 2H), 3.38 (s, 3H), 5.83 (br s, 1H), 7.53—7.98 (m, 5H). MS: *m/z* 255 (M^+). Found: C, 51.88; H, 5.12%. Calcd for $C_{11}H_{13}O_4NS$: C, 51.76; H, 5.13%.

1-Phenylsulfonylcyclopropyl Isocyanate (10). Mp 50—60 °C (further purification was difficult). IR (KBr): 2250 (NCO), 1440, 1315, 1305, 1140 cm^{-1}. NMR ($CDCl_3$): δ=1.12—1.45 (m, 2H), 1.60—1.93 (m, 2H), 7.40—7.92 (m, 5H).

3-Phenylsulfonyltetrahydro-2-furanone (11). A mixture of **3b** (226 mg, 1.0 mmol) and polyphosphoric acid (2 cm^3) was heated at 160 °C for 10 h. The mixture was poured into water and the precipitates were collected by filtration. Recrystallization from AcOEt–petroleum ether gave **11** (101 mg, 45%), mp 116—118 °C. IR (KBr): 2920, 1750 (CO), 1575, 1475, 1440 cm^{-1}. NMR ($CDCl_3$): δ=2.45—3.20 (m, 2H), 3.98—4.55 (m, 3H), 7.53—8.02 (m, 5H). MS: *m/z* 226 (M^+). Found: C, 52.87; H, 4.47%. Calcd for $C_{10}H_{10}O_4S$: C, 53.10; H, 4.46%.

References

1) S. Danishefsky, *Accounts. Chem. Research,* **12**, 66 (1979); M. Murakami and S. Nishida, *J. Synthetic Org. Chem. Jpn.*, **41**, 22 (1983); D. Tunemoto and K. Kondo, *J. Synthetic Org. Chem. Jpn.*, **35**, 1070 (1977).

2) A review of sulfone chemistry; P. D. Magnus, *Tetrahedron,* **33**, 2019 (1977).

3) D. J. Cram and A. Ratajczak, *Ger., Offen.* 1 912 193 (1969); *Chem. Abstr.*, **72**, 12370v (1970).

4) M. Makosza, E. Bialecka, and M. Ludwikow, *Tetrahedron Lett.*, 2391 (1972).

5) B. M. Trost, J. Cossy, and J. Burks, *J. Amer. Chem. Soc.*, **105**, 1052 (1983).

6) A. Jonczyk, K. Banko, and M. Makosza, *J. Org. Chem.*, **40**, 266 (1975).

7) M. Takahashi, T. Nogami, and K. Nidaira, *Heterocycles,* **22**, 581 (1984); M. Takahashi, N. Takeshi, K. Myojoh, H. Sano, and T. Morisawa, *J. Heterocycl. Chem.*, **20**, 209 (1983).

8) H. Dressler and J. E. Graham, *J. Org. Chem.*, **32**, 985 (1967).

9) R. K. Singh and S. Danishefsky, *J. Org. Chem.*, **40**, 2969 (1975).

10) M. Matsui, T. Ohno, S. Kitamura, and M. Toyao, *Bull. Chem. Soc. Jpn.*, **25**, 210 (1952).

11) P. F. Hudrlik, L. R. Rundnick, and S. H. Korzeniowski, *J. Amer. Chem. Soc.*, **95**, 6848 (1973) and references cited therein.