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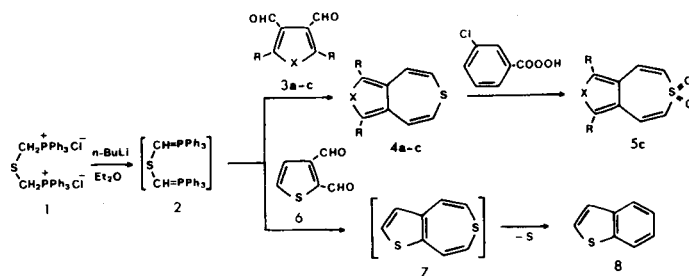
Bis-Wittig reactions of dicarbaldehydes **3a-c**, **6** with ylid **2** gave thiepins **4a-c** and **7**, respectively. In contrast to the considerable stability of compounds **4a-c**, thiepin **7** was desulfurized to benzo[*b*]thiophene before its isolation.

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In recent years a great deal of interest has been focused on the chemistry and theoretical study of thiepins. Although thiepin is unstable and has not been described, a number of highly substituted monocyclic (1) and annulated thiepins have been prepared, usually by derivatization of suitable ketones (3) or ring opening of annulated thiophene (1) and thiopyran (2) derivatives. Some of the annulated thiepins show a considerable stability in agreement with theoretical calculations (4), but these heterocycles generally undergo thermal rearrangement with loss of sulfur to the corresponding benzene derivatives. Schlessinger and Ponticello prepared the remarkably stable thieno[3,4-*d*]thiepin **4a** (5) and furano[3,4-*d*]thiepin **4b** (6) by treatment of 4,5-dihydrothieno[3,4-*d*]thiepin 6-oxide and 4,5-dihydrofuran[3,4-*d*]thiepin 6-oxide, respectively with acetic anhydride at 150°, under special conditions. The total sequence for each of these preparations includes several steps. The one-pot synthesis of some telluropheno[3,4-*d*]thiepin (7) and thiepin[4,5-*c*]pyrrole (8) derivatives has been reported recently, by thermal condensation of the corresponding telluropheno- and pyrrole-3,4-dicarbaldehydes with activated sulfides. In connection with our previous work on bis-Wittig reactions (9,10) we now report the one-pot synthesis of thiepins **4a-c** (at room temperature) as well as the synthesis (at -50°) and desulfurization of the unstable thieno[2,3-*d*]thiepin **7** via bis-Wittig reactions of bis-ylid **2** with dicarbaldehydes **3a-c**, and **6** respectively. Concerning the thermal instability of many thiepins (4) we consider that this method is more suitable for the synthesis of the less stable and unsubstituted thiepins, since the other methods mentioned above generally require heating.

Wittig reactions of bis-ylid **2** (presynthesized from the dichloride **1** with *n*-butyllithium in ether) with 3,4-dicarbaldehydes **3a-c** at room temperature gave the known thiepins **4a**, **4b** and the new 1,3-dimethylthieno[3,4-*d*]thiepin **4c** in 13%, 9% and 8% yield, respectively. Oxidation of **4c** with *m*-chloroperbenzoic acid in chloroform gave sulfone **5c**. Wittig reaction of **2** with thiophene-2,3-dicarbaldehyde **6** at -50° resulted apparently in the formation and further desulfurization of thiepin **7**, in agreement with the predicted instability for this system

(4), as it was indicated by the isolation from the reaction mixture and identification of the finally produced benzo[*b*]thiophene **8** in 5% yield.



3, **4**, **5a**, **R** = H, **X** = S
b, **R** = H, **X** = O
c, **R** = CH₃, **X** = S

The prepared thiepins **4a,b** are identical to those reported in the literature, while the structure of the new compounds **4c**, **5c** was confirmed by their microanalyses and spectral data (ir, nmr, ms), which are very similar to those of compounds **4a,b** and **5a,b** (5,6,11). Thiepin **4c** gave in the nmr spectrum proton resonance at field values higher than its sulfone **5c**, due to the presence of a paramagnetic ring and in agreement with the similar spectroscopic behaviour of the known compounds **4a,b** **5a,b**. The mass spectra of compounds **4a-c** and **5c** gave the expected parent ions as well as the ions rising by a loss of S and SO₂ respectively, from the seven-membered ring to the corresponding benzene ring. Compounds **4a-c** also gave, besides the other fragments, the interesting abundant ions (M-45)⁺ and *m/e* = 45, a fact suggesting that the thiepin ring also follows another fragmentation pattern, attributed to the loss of a CHS group (*m/e* 45), with possible formation of a five-membered ring.

EXPERIMENTAL

Melting points were determined on a Kofler hot stage apparatus and are uncorrected. The ir spectra were recorded on a Perkin-Elmer 297 spectrophotometer. The proton nmr spectra were recorded on a Varian

A-60A spectrometer using tetramethylsilane as an internal reference. The mass spectra were obtained with a Hitachi-Perkin-Elmer Model RMU-6L spectrometer; the ionization energy was maintained at 70 eV. Earlier reported procedures were used for the preparation of compounds **1** (12), **3c** (13) and **6** (14). Analyses were performed with a Perkin-Elmer Model 240 CHN Analyser. No attempt was made to optimize yields.

Thieno[3,4-*d*]thiepin (**4a**).

Dimethylthioether- α,α' -triphenylphosphonium dichloride (**1**, 2.34 g, 3.57 mmoles, dried at 105°/0.1 torr over phosphorus pentoxide) was suspended in dry ether (150 ml) under dry nitrogen and *n*-butyllithium (7.14 mmoles) in hexane was added to the stirred mixture. The deep red solution of the prepared bis-ylid **2** was stirred for 15 minutes at room temperature and a solution of thiophene-3,4-dicarbaldehyde (**3a**, 0.5 g, 3.57 mmoles) in dry ether was added in one portion to the stirred solution. The red color was discharged and the solution was then stirred for 2 hours. The ethereal solution was washed with water (4 × 100 ml), dried (sodium sulfate) and the solvent was removed under reduced pressure. The residue was dissolved in chloroform (15 ml), the resultant solution was preadsorbed on silica gel (10 g) and the mixture was added to a column of silica gel (250 g). The column was eluted with petroleum ether containing increasing amounts of ether to give a mixture of **4a** and triphenylphosphine. This mixture was then separated by preparative tlc on silica gel using petroleum ether as eluent. Compound **4a** was collected from the faster moving band as a yellow solid (78 mg, 13%), mp 150-152° (recrystallized from carbon tetrachloride), lit (15) mp 152-153°; ir (potassium bromide): 3090, 1635, 1625, 1618, 1353, 1330, 1280, 1233, 1170, 872, 808, 790, 728, 708 cm⁻¹; nmr (carbon tetrachloride): δ 6.52 (s, 2H), 5.98 (d, 2H, J = 12 Hz), 5.12 (d, 2H, J = 12 Hz); ms: 166 (M⁺, 100), 165 (23), 134 (81), 122 (16), 121 (51), 90 (21), 89 (17), 77 (13), 45 (31).

Furano[3,4-*d*]thiepin (**4b**).

The preparation of **2** from **1** (1.84 g, 2.8 mmoles) in dry ether (100 ml) with *n*-butyllithium (5.6 mmoles), the reaction of **2** with a solution of furano-3,4-dicarbaldehyde (**3b**, 0.35 g, 2.8 mmoles) in dry ether (30 ml) was carried out and the reaction mixture was worked up and separated by column chromatography and preparative tlc as it is described above to give 38 mg (9%) of compound **4b**, mp 115-116° (recrystallized from petroleum ether), lit (6) mp 116°; ir (potassium bromide): 3130, 1649, 1539, 1412, 1350, 1219, 1118, 1048, 876, 804, 788, 729, 720 cm⁻¹; nmr (carbon tetrachloride): δ 6.80 (s, 2H), 5.90 (d, 2H, J = 12 Hz), 5.20 (d, 2H, J = 12 Hz); ms: 150 (M⁺, 82), 149 (8), 122 (12), 121 (100), 118 (14), 105 (26), 90 (19), 89 (21), 77 (52), 51 (52), 45 (55), 29 (30).

1,3-Dimethylthieno[3,4-*d*]thiepin (**4c**).

The preparation of **2** from **1** (3.28 g, 5 mmoles) in dry ether (250 ml) with *n*-butyllithium (10 mmoles) and the reaction of **2** with a solution of 2,5-dimethylthiophene-3,4-dicarbaldehyde (**3c**, 0.84 g, 5 mmoles) in dry ether (60 ml) were carried out and the reaction mixture was worked up and separated by column chromatography and preparative tlc, as it is described above, to give 79 mg (8%) of compound **4c** as a yellow solid, mp 86-88° (recrystallized from petroleum ether); ir (potassium bromide): 3025, 2950, 2920, 2856, 1617, 1440, 1382, 1358, 1279, 1244, 815, 779, 752, 720 cm⁻¹; nmr (carbon tetrachloride): δ 6.08 (d, 2H, J = 11.5 Hz), 5.24 (d, 2H, J = 11.5 Hz), 2.12 (s, 6H); ms: 194 (M⁺, 32), 179 (16), 162 (37), 161 (52), 149 (11), 147 (24), 135 (20), 134 (37), 129 (25), 128 (72), 120 (20), 115 (70), 103 (24), 102 (32), 93 (32), 91 (36), 89 (39), 77 (45), 59 (96), 58 (63), 41 (65), 45 (100).

Anal. Calcd. for C₁₀H₁₀S₂: C, 61.84; H, 5.19. Found: C, 61.53; H, 5.30.

1,3-Dimethylthieno[3,4-*d*]thiepin 6,6-Dioxide (**5c**).

Compound **4c** (19.4 mg, 0.1 mmole) was dissolved in chloroform (3 ml), *m*-chloroperbenzoic acid (51.8 mg, 0.3 mmole) was added and the mixture was stirred for 30 minutes. The solvent was removed under reduced pressure and the residue separated by preparative tlc on silica gel using chloroform as eluent. The prepared sulfone **5c** was collected from the slower moving band as a colorless solid (17 mg, 76%) mp 213-215° (recrystallized from chloroform/petroleum ether); ir (potassium bromide):

3060, 2930, 2860, 1596, 1586, 1410, 1392, 1350, 1292, 1190, 1149, 1115, 951, 862, 788, 721 cm⁻¹; nmr (deuteriochloroform): δ 7.22 (d, 2H, J = 11.5 Hz), 6.65 (d, 2H, J = 11.5 Hz), 2.55 (s, 6H); ms: 226 (M⁺, 13), 164 (15), 163 (40), 162 (100), 161 (96), 147 (42), 134 (10), 129 (53), 128 (69), 115 (26), 102 (15), 77 (21), 59 (33), 51 (24).

Anal. Calcd. for C₁₀H₁₀O₂S₂: C, 53.09; H, 4.46. Found: C, 53.13; H, 4.45.

Wittig Reaction of **2** and **6**.

To a stirred solution of **2** prepared from **1** (9.9 g, 15 mmoles) in 600 ml of dry ether with *n*-butyllithium (30 mmoles) as it is described above, a solution of thiophene-2,3-dicarbaldehyde (**6**, 2.1 g, 15 mmoles) in dry ether (100 ml) was added in one portion at -50°. The red color of the mixture was discharged and stirring was continued for 2 hours at room temperature. The reaction mixture was then worked up and separated by column chromatography on alumina as it is described in preparation of **4a** to give instead of the expected thiepin **7** a mixture of benzo[*b*]thiophene (**8**) and triphenylphosphine (as it was indicated by the nmr spectra of the eluted fractions). This mixture was further separated by preparative tlc on silica gel, using petroleum ether as eluent, to give 98 mg (5%) of compound **8**, mp 30-31° (recrystallized from ethanol), lit (16) mp 31°.

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