to iodine vapor. Acme's silica gel G (100–200 mesh) was used in the column chromatography. Petroleum ether refers to fraction between 60 and 80 °C. All solvent extracts were washed with brine, dried over $Na_2SO_4$, and dried on a Buchi-El rotary evaporator under reduced pressure.

**Reaction of Tricyclo[6.3.0.0$^{2,6}$]undeca-4,9-diene-3,11-dione (2a) with Sodium Methoxide.** To an ice-cold, magnetically stirred solution of bis enone **2a** (175 mg, 1 mmol) in 5 mL of absolute methanol was added sodium methoxide (200 mg, 3.6 mmol) in small portions over a period of 5 min. The cooling bath was removed and the reaction mixture was stirred at room temperature for 10 min. Most of the methanol was removed under reduced pressure, and the reaction mixture was diluted with water (15 mL). Acidification with dilute HCl, extraction with dichloromethane (15 mL × 3), and usual workup furnished 170 mg of crude material. This material was charged on a silica gel (10 g) column and chromatographed. Careful elution with 20% ethyl accetate–benzene furnished 65 mg (40%) of 11-methoxytetracyclo[5.4.0.0$^{3,10}$.0$^{4,8}$]undecane-2,5-dione (**8**), which was crystallized from dichloromethane–petroleum ether: mp 148–149 °C; IR (KBr) 1745 cm$^{-1}$ (carbonyl); $^1$H NMR (100 MHz, $CDCl_3$) δ 3.52 (1 H, s, *H*COCH$_3$), 3.29 (3 H, s, OCH$_3$), 2.84 (3 H,br s, bridgehead CH), 2.65 (3 H, br, s, bridgehead CH), 2.3 (2 H, m, CH$_2$C(O)-), 1.9–2.2 (2 H, m, CH$_2$); $^{13}$C NMR (25.0 MHz, $CDCl_3$) δ 214.5 (s) and 211.4 (s) (>C=O), 83.1 (d, *C*HOCH$_3$), 64.6 (d), 57.7 (d), 55.5 (q, OCH$_3$), 51.7 (d), 47.3 (d), 45.6 (t, *C*H$_2$C(O)-), 41.0 (d), 39.6 (d), 36.1 (t). Anal. Calcd for $C_{12}H_{14}O_3$: C, 69.89; H, 6.84. Found: C, 69.95; H, 6.74.

Further elution of the column with 40% ethyl acetate–benzene furnished 35 mg of the unreacted starting material. Final elution of the column with ethyl acetate furnished 42 mg (30%) of tricyclo[6.3.0.0$^{2,6}$]undeca -1(8), 4-diene-3,11-dione (**7**), which was identified by comparison (TLC, GLC, and IR) with an authentic sample.[1b]

**Reaction of 11-Methoxytetracyclo[5.4.0.0$^{3,10}$.0$^{4,8}$]undecane-2,5-dione (8) with Sodium Borohydride.** To an ice-cold, magnetically stirred solution of dione **8** (50 mg, 0.24 mmol) in 5 mL of methanol was added sodium borohydride (15 mg, 0.4 mmol). The cold bath was removed, and the reaction was stirred at room temperature for 15 min and quenched with 2 drops of acetone. The solvent was removed under reduced pressure, and the contents of the flask were diluted with water and extracted with dichloromethane (10 mL × 2). The organic extract was washed and dried and the solvent removed to furnish 50 mg (100%) of 7-methoxy-12-oxapentacyclo[6.4.0.0$^{2,6}$.0$^{3,11}$.0$^{4,9}$]dodecan-1-ol (**9**). Bulb-to-bulb distillation (130 °C (0.6 mm)) followed by crystallization from petroleum ether furnished the crystalline compound: mp 54–55 °C; IR (KBr) 3270 cm$^{-1}$; $^1$H NMR (100 MHz, $CDCl_3$) δ 4.96 (1 H, s, exchangeable with $D_2O$), 4.56 (1 H, br s), 3.37 (4 H, s), 2.95 (1 H, m), 2.4–2.7 (2 H, m), 1.2–2.3 (7 H, en); $^{13}$C NMR (25.0 MHz, $CDCl_3$) δ 113.4 (s), 91.2 (d), 77.1 (d), 56.0 (q), 55.4 (d), 54.2 (d), 48.6 (d), 47.6 (d), 40.7 (d), 40.4 (t), 40.2 (d), 38.6 (t); high-resolution mass spectrum *m/e* M$^+$ calcd for $C_{12}H_{16}O_3$ 208.1099, found 208.1098.

**2,3,8,10-Tetrachloro-1(or 11),7-dimethoxy-12-oxapentacyclo[6.4.0.0$^{2,6}$.0$^{3,11}$.0$^{4,9}$]dodecan-11(or 1)-ol (11).** To an ice-cold, magnetically stirred solution of tetrachloro bis enone **2b** (500 mg, 1.6 mmol) in 15 mL of absolute methanol was added sodium methoxide (200 mg, 3.6 mmol) in small portions over a period of 5 min. Most of the methanol was removed under reduced pressure, and the reaction mixture was diluted with water, acidified with dilute HCl, and extracted with dichloromethane (30 mL × 2). The organic extract was washed and dried. Evaporation of the solvent and filtration through a small silica gel (10 g) column using 5% ethyl acetate–benzene furnished 400 mg (65%) of **11**, which was crystallized from dichloromethane–petroleum ether; mp 207 °C; IR (KBr) 3390 cm$^{-1}$ (hydroxyl); $^1$H NMR (270 MHz, $CDCl_3$) δ 5.06 (1 H, s, exchanged with $D_2O$, OH), 4.0 (1 H, d, *J* = 3.3 Hz, *H*CCl), 3.63 (3 H, s, OCH$_3$), 3.55 (3 H, s, OCH$_3$), 3.25 (1 H, s, *H*COCH$_3$), 2.82 (1 H, t, *J* = 3.3 Hz), 2.75 (1 H, dd, $J_1$ = 7 Hz, $J_2$ = 2.5 Hz), 2.5–2.7 (1 H, m), 2.54 (1 H, m), 1.89 (1 H, dd, $J_1$ = 12.5 Hz, $J_2$ = 1.1 Hz); $^{13}$C NMr (25.0 MHz, acetone-$d_6$) δ 109.6 (s, >C(OCH$_3$)o-), 105.2 (s, >C(OH)O-), 91.2 (d, *C*HOCH$_3$), 86.9 (s), 83.8 (s), and 69.9 (s) (CCl), 59.9 (d), 59.1 (d), 55.1 (q?), 52.8 (q, OCH$_3$), 51.1 (d), 50.4 (d), 35.5 (t, CH$_2$). Anal. Calcd for $C_{13}H_{14}Cl_4O_4$: C, 41.49; H, 3.72. Found: C, 41.46; H, 3.69.

**7,10-Dibromo-12-oxapentacyclo[6.4.0.0$^{2,6}$.0$^{3,11}$.0$^{4,9}$]dodecane (12).** To an ice-cold, magnetically stirred solution of **4** (300 mg, 1.87 mmol) in $CCl_4$ (10 mL) was added bromine (300 mg, 1.87 mmol) in 3 mL of $CCl_4$, drop by drop, over a period of 20 min. The reaction mixture was allowed to warm up and stirred at room temperature for another 10 min. Carbon tetrachloride was removed under reduced pressure, and the crude residue (400 mg) was purified by a quick filtration through a silica gel (10 g) column and crystallized from petroleum ether on long standing at 0 °C to furnish the dibromo compound **12** (330 mg, 54%): mp 54–55 °C; IR (KBr) 1210, 1080, 840, 730 cm$^{-1}$; $^1$H NMR (100 MHz, $CDCl_3$) δ 5.18 (1 H, br s, HCO-), 4.68 (1 H, d, HCO-), 4.36 (1 H, s, HCBr), 4.06 (1 H, s, HCBr), 3.2–2.76 (4 H, br m), 2.56–2.32 (2 H, br s), 2.2–2.04 (2 H, br m); $^{13}$C NMR (25.0 MHz, $CDCl_3$) δ 85.6 (d), 85.5 (d), 59.1 (d), 58.8 (d), 53.7 (d), 50.9 (d), 50.2 (d), 47.4 (d), 45.8 (d), 41.2 (t); high-resolution mass spectrum, *m/e* M$^+$ calcd for $C_{11}H_{12}OBr_2$ 317.9256, no M$^+$ detected, 239.0065 (m − Br)$^+$.

**12-Oxapentacyclo[6.4.0.0$^{2,6}$.0$^{3,11}$.0$^{4,9}$]dodecane (6).** The dibromo compound **12** (200 mg, 0.62 mmol) in 10 mL of dry DME was placed in a three-necked, round-bottomed flask flushed with dry nitrogen. To the stirred solution was added tri-*n*-butytin chloride (135 mg, 0.41 mmol) followed by sodium borohydride (200 mg, 5.2 mmol). The reaction mixture was refluxed for 24 h, cooled to room temperature, and diluted with ether (25 mL). The ethereal layer was washed with brine and dried. Evaporation of the solvent gave 200 mg of crude product, which was directly sublimed (70 °C (≃30 mm)) to furnish 12-oxapentacyclo-[6.4.0.0$^{2,6}$.0$^{3,11}$.0$^{4,9}$]dodecane (**6**, 50 mg, 50%): mp 198–199 °C; IR (KBr) 2950, 1080 cm$^{-1}$; $^1$H NMR (100 MHz, $CDCl_3$) δ 4.59 (1 H, unresolved triplet, *J* = 5 Hz), 4.24–4.14 (1 H, br m), 3.0–2.52 2.52 (2 H, br m), 2.52–2.28 (1 H, m), 2.28–1.2 (9 H, m); $^{13}$C NMR (25.0 MHz, $CDCl_3$) δ 86.5 (d), 79.8 (d), 55.1 (d), 51.8 (d), 49.6 (d), 41.27 (t), 40.07 (2c), 39.6 (d), 37.3 (t), 35.5 (d); high-resolution mass spectrum, *m/e* M$^+$ calcd for $C_{11}H_{14}O$ 162.1045, found 162.1038.

**Registry No. 2a**, 82217-29-6; **2b**, 73843-53-5; **4**, 82253-76-7; **6**, 87453-44-9; **7**, 82253-89-2; **8**, 87453-45-0; **9**, 87453-46-1; **11**, 87453-47-2; **12**, 87453-48-3.

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## Bromine-Initiated Rearrangement of 4-Homoadamantanone Ethylene Dithioketal

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In the course of our studies in homoadamantane chemistry[1] we investigated bromination of 4-homoadamantanone ethylene dithioketal (**1**). The product was an olefin, 4,5-[(thioethano)thio]-4-homoadamantene (**2**)! According to our knowledge such a reaction of an ethylene dithioketal with bromine is unprecedented.

Dithioketal **1** was prepared in 79% yield from 4-homoadamantanone[2] by the usual procedure.[3] Treatment of

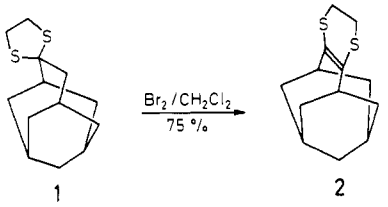
(1) (a) Majerski, Z.; Hameršak, Z. *Tetrahedron Lett.* **1978**, 3291. (b) Majerski, Z.; Hameršak, Z.; Škare, D. *Ibid.* **1977**, 3943. (c) Mlinarič-Majerski, K.; Majerski, Z.; Pretsch, E. *J. Org. Chem.* **1976**, *41*, 686. (d) *Ibid.* **1975**, *40*, 3772. (e) Hameršak, Z.; Škare, D.; Majerski, Z. *J. Chem. Soc., Chem. Commun.* **1977**, 478. (f) Osawa, E.; Aigami, K.; Takaishi, N.; Inamoto, Y.; Fujikura, Y.; Majerski, Z.; Schleyer, P. v. R.; Engler, E. M.; Farcasiu, M. *J. Am. Chem. Soc.* **1977**, *99*, 5361. (g) Janjatovič, J.; Škare, D.; Majerski, Z. *J. Org. Chem.* **1974**, *39*, 651.

(2) Schleyer, P. v. R.; Funke, E.; Liggero, S. H. *J. Am. Chem. Soc.* **1969**, *91*, 3965.

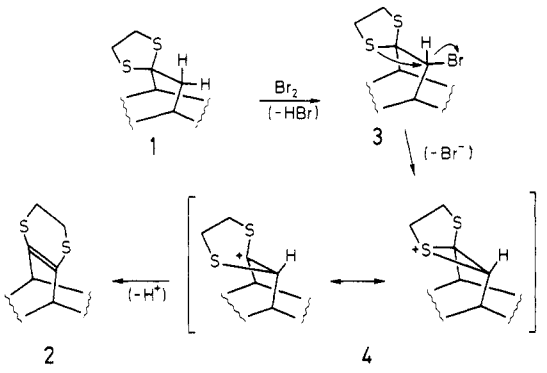
(3) Fieser, L. F.; Fieser, M. "Reagents for Organic Synthesis"; Wiley: New York, 1967; Vol. 1, p 356.

0022-3263/83/1948-5109$01.50/0 

Scheme I




Scheme II




1 with an excess of bromine in methylene chloride at room temperature afforded 75% of a white crystalline product, **2** (Scheme I). Its structure was established by spectral means. The mass spectrum showed a molecular ion peak at $m/z$ 238 (100%), indicating that the starting dithioketal **1** had lost two hydrogens and incorporated no bromine. The $^1H$ NMR and IR spectra showed the absence of olefinic protons, while the $^{13}C$ NMR spectrum indicated the presence of one (or more equivalent) olefinic carbon atom(s). These data as well as the relative $^{13}C$ NMR signal intensities in the quantitative spectrum and their splitting patterns in the proton off-resonance spectrum [six signals: s (2 C), d (2 C), t (1 C), t (4 C), m (2 C), d (2 C)] revealed that this product was 4,5-[(thioethano)thio]-4-homoadamantene (**2**). The crude product was 90% pure (by $^{13}C$ NMR) and was purified by column chromatography. It was entirely inert to bromine as well as to catalytic and diimide hydrogenation. The unreactivity is probably caused by steric hindrance.

The analogous treatment of 2-norbornanone ethylene dithioketal with bromine yielded, however, 75% of 3-bromo-2-norbornanone ethylene dithioketal and approximately 10% of a saturated byproduct.[4]

The mechanism of the bromine-initiated rearrangement of dithioketal **1** to olefin **2** probably involves $\alpha$-bromination of **1** followed by the sulfur participation (Scheme II). $\beta$ participation by divalent sulfur is well-known.[5] Owing to the flexibility of the ethano bridge, the 3p orbital of one of the two sulfur atoms in the bromo dithioketal **3** can achieve a favorable alignment with the developing electron-deficient center. Such a favorable alignment is not possible in the rigid 3-bromo-2-norbornanone ethylene dithioketal. The sulfur participation in **3** leads to the resonance stabilized sulfonium ion **4**, which loses a proton to yield olefin **2**.[6]

## Experimental Section

The purity of all compounds was controlled by GC and $^{13}C$ NMR. $^{13}C$ NMR and $^1H$ NMR spectra were taken on a JEOL FX-90Q spectrometer, IR spectra were recorded with a Perkin-Elmer 297 spectrophotometer, and mass spectra were obtained on a Varian CH-7 mass spectrometer. The quantitative analyses with $^{13}C$ NMR were performed by using a combination of long pulse intervals (120 s) to assure complete relaxation of all $^{13}C$ nuclei and a gated decoupling, which eliminated the nuclear Overhauser enhancement.[9] GC analyses were carried out on a Varian Aerograph 940 or 1800 gas chromatograph. Melting points were determined in sealed capillary tubes completely immersed in oil by using a Thiele apparatus and are uncorrected.

**4-Homoadamantanone Ethylene Dithioketal (1).** Freshly distilled boron trifluoride etherate (0.75 mL) was added to a mixture of 4-homoadamantanone[2] (1.6 g, 10 mmol) and 1,2-ethanedithiol (1.5 mL, 17.5 mmol) stirred at 0 °C.[3] The reaction mixture was stirred for additional 10 min at room temperature and then diluted with ether (20 mL). The resulting mixture was washed with 10% aqueous sodium hydroxide solution (2 × 20 mL) followed by water (20 mL) and dried ($MgSO_4$). Evaporation of the solvent yielded the crude product, which was recrystallized from ethanol to give dithioketal **1**: 1.9 g (79%; ≥97% pure by GC, OV-210, 140 °C); mp 57–59 °C; $^{13}C$ NMR ($CDCl_3$) $\delta$ 77.6 (s, 1 C), 56.0 (t, 1 C), 47.0 (d, 1 C), 39.6 (m, 2 C), 37.6 (t, 2 C), 36.6 (t, 1 C), 36.1 (t, 2 C), 31.8 (d, 1 C), 27.6 (d, 2 C); $^1H$ NMR ($CDCl_3$) $\delta$ 3.5–3.0 (m, 4 H), 2.8–2.6 (d, 2 H), 2.4–1.4 (m, 14 H); IR (KBr) 2900 (s), 2840 (m), 1440 (m) $cm^{-1}$; MS, $m/z$ (relative intensity) 242 ($M^+$, 12), 241 ($M^+ + H$, 17), 240 ($M^+$, 83), 212 (33), 180 (100), 147 (41), 118 (52), 105 (38), 91 (41), 79 (39). Anal. Calcd for $C_{13}H_{20}S_2$: C, 65.00; H, 8.33; S, 26.67. Found: C, 65.07; H, 8.41; S, 26.38.

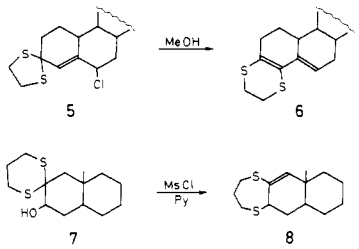
**4,5-[(Thioethano)thio]-4-homoadamantene (2).** A solution of bromine (500 mg, 3.1 mmol) in methylene chloride (5 mL) was added dropwise to a solution of **1** (240 mg, 1 mmol) in methylene chloride (20 mL). The reaction mixture was stirred at room temperature for 15 min. The solvent and the excess of bromine were removed in vacuo, yielding the crude, brown, crystalline product, which was purified by column chromatography on silica gel with a 2:1 pentane–methylene chloride mixture as the eluent. Olefin **2** (white crystals, ≥98% pure by GC, OV-210, 140 °C) was obtained: 75% yield (180 mg); mp 117–118 °C; $^{13}C$ NMR ($CDCl_3$) $\delta$ 127.5 (s, 2 C), 42.7 (d, 2 C), 35.8 (t, 1 C), 33.9 (t, 4 C), 28.9 (m, 2 C), 28.4 (d, 2 C); $^1H$ NMR ($CDCl_3$) $\delta$ 3.1 (s, 4 H), 2.2–1.6 (m, 14 H); IR (KBr) 2920 (s), 2840 (m), 1615 (w), 1440 (m), 1415 (m), 1285 (m), 1120 (w), 970 (w), 640 (w) $cm^{-1}$; MS, $m/z$ (relative intensity) 240 ($M^+$, 11), 239 ($M^+ + H$, 17), 238 ($M^+$, 100), 177 (7), 153 (7), 145 (8), 135 (7), 117 (7), 105 (7), 97 (7), 91 (12), 79 (10), 77 (9), 71 (8). Anal. Calcd for $C_{13}H_{18}S_2$: C, 65.55; H, 7.56; S, 26.89. Found: C, 65.39; H, 7.81; S, 26.99.

Attempts of bromination of **2** ($CH_2Cl_2$, reflux 5 h; $CCl_3CH_3$, reflux 4 h) as well as diimide[10] and catalytic hydrogenation (a large

(4) The $^{13}C$ NMR, $^1H$ NMR, IR, and mass spectra indicated that this was 2,3-norbornanedione monoethylene dithioketal (see Experimental Section). It was probably formed by oxidation of the initially produced 3-hydroxy-2-norbornanone ethylene dithioketal with bromine.

(5) Block, E. "Reactions of Organosulfur Compounds"; Academic Press: New York, 1978; pp 141–145.

(6) The suggested mechanism is in agreement with formation of olefins **6** and **8** in solvolysis of allylic chloro ethylene dithioketal **5**[7] and attempted conversion of hydroxy trimethylene dithioketal **7** into the mesylate,[8] respectively.




(7) Karmas, G. *J. Org. Chem.* **1967**, *32*, 3147.

(8) Marshall, J. A.; Roebke, H. *J. Org. Chem.* **1969**, *34*, 4188.

(9) Shoolery, J. N. *Prog. Nucl. Magn. Reson. Spectrosc.* **1977**, *11*, 79.

(10) (a) Nishida, S.; Fushimi, K.; Tsuji, T. *J. Chem. Soc., Chem. Commun.* **1973**, 525. (b) Ohno, M.; Okamoto, M. *Tetrahedron Lett.* **1964**, 2423. (c) Corey, J. E.; Mock, L. W.; Pasto, D. J. *Ibid.* **1961**, 347.

excess of 10% Pd/C in EtOAc;[11] $(PPh_3)_3RhCl$ in benzene[12]) were unsuccessful.

**2-Norbornanone ethylene dithioketal** was obtained in 90% yield from 2-norbornanone following the procedure used for preparation of 1: $^{13}C$ NMR ($CDCl_3$) $\delta$ 72.2 (s, 1 C), 51.8 (d, 1 C), 49.4 (t, 1 C), 39.8 (t, 1 C), 39.7 (m, 2 C), 36.8 (d, 1 C), 28.3 (t, 1 C), 26.6 (t, 1 C); $^1H$ NMR ($CDCl_3$) $\delta$ 3.4–3.0 (m, 4 H), 2.4–2.1 (m, 3 H), 2.0–1.1 (m, 7 H); IR (film) 2960 (s), 2872 (m), 1452 (m), 1307 (w), 1275 (w), 970 (w) $cm^{-1}$; MS, *m/z* (relative intensity) 186 ($M^+$, 43), 158 (100), 125 (19), 93 (18), 67 (31), 66 (26). Anal. Calcd for $C_9H_{14}S_2$: C, 58.06; H, 7.53; S, 34.41. Found: C, 58.22; H, 7.74; S, 34.69.

Treatment of 2-norbornanone ethylene dithioketal with bromine under the same conditions as those used for 1 yielded ~100% of a 8:1 mixture of two products. The products were separated by column chromatography on silica gel with methylene chloride–pentane (1:4) as the eluent. The major product was isolated in 75% yield (2.0 g) as a bright yellow oil and was shown to be 3-bromo-2-norbornanone ethylene dithioketal (≥98% pure by GC, DEGS 170 °C): $^{13}C$ NMR ($CDCl_3$) $\delta$ 78.8 (s), 69.2 (d), 53.1 (d), 49.2 (d), 40.1 (m), 39.5 (m), 38.0 (t), 28.3 (t), 26.9 (t); $^1H$ NMR ($CDCl_3$) $\delta$ 4.33 (d, $J$ = 2.4 Hz, 1 H), 3.4–3.0 (m, 4 H), 2.6–2.4 (m, 2 H), 2.2–1.2 (m, 6 H); IR (film) 2965 (s), 2920 (s), 2875 (m), 1475 (w), 1450 (m), 1420 (w), 1308 (w), 1210 (w), 780 (w), 660 (w) $cm^{-1}$; MS, *m/z* (relative intensity) 266 ($M^+$, 6), 264 ($M^+$, 6), 238 (7), 236 (6), 187 (9), 186 (11), 185 (100), 157 (20), 156 (13), 131 (12), 105 (9), 81 (16). Anal. Calcd for $C_9H_{13}S_2Br$: C 40.75; H, 4.91; S, 24.15; Br, 30.19. Found: C, 41.03; H, 4.87; S, 24.07; Br, 29.91. The minor product (isolated as white crystals in ~10% yield after recrystallization from pentane) exhibited the following characteristics: mp 37–39 °C; $^{13}C$ NMR ($CDCl_3$) $\delta$ 213.7 (s), 71.9 (s), 48.6 (d), 48.4 (d), 39.4 (m), 39.0 (m), 37.4 (t), 27.0 (t), 25.5 (t); $^1H$ NMR ($CDCl_3$) $\delta$ 3.7–3.2 (m, 4 H), 2.8 (br s, 2 H), 2.3–1.5 (m, 6 H); IR (KBr) 2960 (s), 2870 (m), 1742 (s), 1450 (m), 1282 (m), 1180 (m), 1078 (m), 755 (m) $cm^{-1}$; MS, *m/z* (relative intensity) 200 ($M^+$, 6), 172 (11), 144 (22), 131 (100), 71 (39). Anal. Calcd for $C_9H_{12}S_2O$: C, 54.05; H, 6.05; S, 32.01. Found: C, 54.25; H, 6.27; S, 31.80.

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**Registry No.** 1, 50511-34-7; 2, 87450-45-1; $Br_2$, 7726-95-6; 4-homoadamantanone, 24669-56-5; 1,2-ethanedithiol, 540-63-6; 2-norbornanone ethylene dithioketal, 172-69-0; 3-bromo-2-norbornanone ethylene dithioketal, 87450-46-2; 2,3-norbornanedione monoethylene dithioketal, 87450-47-3; 2-norbornanone, 497-38-1.

(11) (a) Eglinton, G.; Lardy, I. A.; Raphael, R. A.; Sim, A. G. *J. Chem. Soc.* **1964**, 1154. (b) Parham, E. W.; Roder, M. T.; Hasek, R. W. *J. Am. Chem. Soc.* **1953**, *75*, 1647.
(12) Birch, J. A.; Walker K. A. M. *Tetrahedron Lett.* **1967**, 1935.

## Simple and Efficient Synthesis of 3-Oxo-2,6,6-trimethylcyclohex-1-ene-1-carboxylic Acid, a Key Synthon for (±)-Strigol

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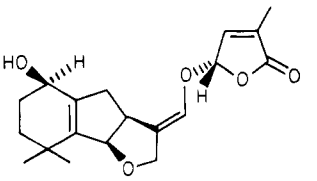
Methyl 3-oxo-2,6,6-trimethylcyclohex-1-ene-1-carboxylate (**1b**) is an important A-ring intermediate for the synthesis of (±)-strigol (**3**), a well-known potent witchweed seed germination stimulant. due to the possible role of **3** as a control agent in witchweed-infested fields, much effort has recently been devoted to improve the preparation of **1a** and/or **1b**.


**1a**, R = H
**b**, R = Me

**2a**, R = H
**b**, R = Me




**3**

Sih et al.[1] in their total synthesis of **3**, described two sequences for their preparations. One of them startes from $\alpha$-cyclocitral, requires three steps, and produces **1a** in 36% overall yield. The second one, from $\beta$-cyclocitral, gives **1b** after five steps in 40% overall yield but requires chromatographic purification. Later, Pepperman[2] carried out a careful analysis of the first sequence showing lower yields than those reported, but by introduction of a two-step oxidation procedure the final yield was significantly increased. Recently, Brooks et al.[3] reported a five-step synthesis of **1b** from $\alpha$-ionone with a 48% overall yield. We describe herein a simple, efficient one-step preparation of **1a** from a mixture of $\alpha$- and $\beta$-cyclocitrals.

Treatment of the mixture of $\alpha$- and $\beta$-cyclocitrals[4] by a modification of the procedure for the oxidation of allylic methylenes previously described[5] produced a ca. 9:1 mixture of two carboxylic acids. In a first run they were chromatographically separated as methyl esters and spectroscopically characterized as **1b**, the major product, and **2b**. Subsequent experiments showed that from the crude reaction product pure crystalline **1a** could be obtained and Jones oxidation of the mother liquors furnished and additional amount of **1a**, increasing the total yield to better than 70%.

### Experimental Section

Melting points were determined on an Ernst Leitz hot-stage microscope and are uncorrected. IR spectra were measured with a Beckman Acculab 8 spectrophotometer. $^1H$ and $^{13}C$ NMR spectra were recorded at 80.13 and 20.15 MHz, respectively, on a Bruker WP 80 SY spectrometer in $CDCl_3$ solutions. GC analyses were conducted by using a Perkin-Elmer 820 gas chromatograph equipped with a 0.3 × 300 cm 15% Carbowax 20M column. Silica gel $GF_{254}$ (type 60) was utilized for TLC, and spots were visualized by staining with anisaldehyde–sulfuric acid.[6]

**Methyl 3-Oxo-2,6,6-trimethylcyclohex-1-ene-1-carboxylate (1b) and Methyl 3-Hydroxy-2,6,6-trimethylcyclohex-1-ene-1-carboxylate (2b).** The crude product obtained from the NBS oxidation as described below (500 mg) was dissolved in $Et_2O$ (20 mL) and treated with an excess of diazomethane. Chromatography of the resulting product over silica gel (50 g) with hexane and increasing amounts of EtOAc resulted in the isolation of **1b** (405 mg) and **2b** (46 mg) as colorless oils. **1b**: IR (film) 1727, 1678, 1620, 1240, 1053, 1020 $cm^{-1}$; $^1H$ NMR $\delta$ 1.24 (s, 6 H, C-6, 2 × Me), 1.72 (s, 3 H, C-2, Me), 1.90 (m, 2 H, H-5), 2.55 (m, 2 H, H-4), 3.83 (s, 3 H, OMe); $^{13}C$ NMR $\delta$ 12.8 (q, C-2, Me), 26.6 (q,

(1) Heather, J. B.; Mittal, R. S. D.; Sih, C. J. *J. Am. Chem. Soc.* **1976**, *98*, 3661.
(2) Pepperman, A. B. *J. Org. Chem.* **1981**, *46*, 5039.
(3) Brooks, D. W.; Kennedy, E. *J. Org. Chem.* **1983**, *48*, 277.
(4) Gedye, R. N.; Arora, P. C.; Deck, K. *Can. J. Chem.* **1971**, *49*, 1764.
(5) Finucane, B. W.; Thomson, J. B. *J. Chem. Soc. D* **1969**, 1220.
(6) Stahl, E. "Thin-Layer Chromatography, A Laboratory Handbook", 2nd. ed.; Springer-Verlag: West Berlin, Heidelberg, New York, 1969; p 857.

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