(3a*R**, 6a*S**)-5,5-DIPHENYL-2, 3, 3a, 4, 6, 6a-HEXAHYDROSILOLANO-[3,4-*b*]FURAN-2-ONE: A NEW FUSED γ-BUTYROLACTONE

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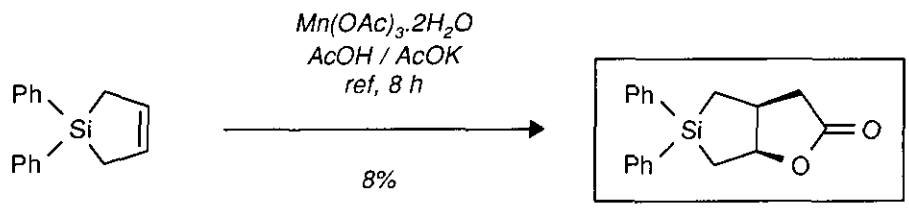
Dedicated to the memory of Dr Z. Janousek, deceased on July 17, 1996

Abstract- The title fused γ-butyrolactone (**1**) was prepared in four steps, starting from 1,1-diphenyl-1-silacyclopent-3-ene.

In connection with our studies on the synthesis of silylated therapeutical agents, [1] we aimed at the preparation of various diphenylsilacyclopentane derivatives. [2] In order to achieve this, we made use of fused γ-butyrolactones such as hexahydrosilolano[3,4-*b*]furan-2-one as starting materials. We describe herein an efficient and simple synthesis of such a heterocycle *via* an intramolecular radical cyclization. [3] (3a*R**, 6a*S**)-5,5-Diphenyl-2, 3, 3a, 4, 6, 6a-hexahydrosilolano[3,4-b]furan-2-one (**1**) was readily prepared in a four steps from 1,1-diphenyl-1-silacyclopent-3-ene (**2**)[4] with an overall yield of 32%. We first attempted to prepare **1** by a direct one-step synthesis from **2** (Scheme 1) through oxidative addition of acetic acid by means of $Mn(OAc)_3.2H_2O$ *via* the formation of a carboxymethyl radical.[5] The desired compound (**1**) was obtained in 8% yield (ref, 8 h) after purification by flash chromatography on silica gel as the only isolated product.

Scheme 1

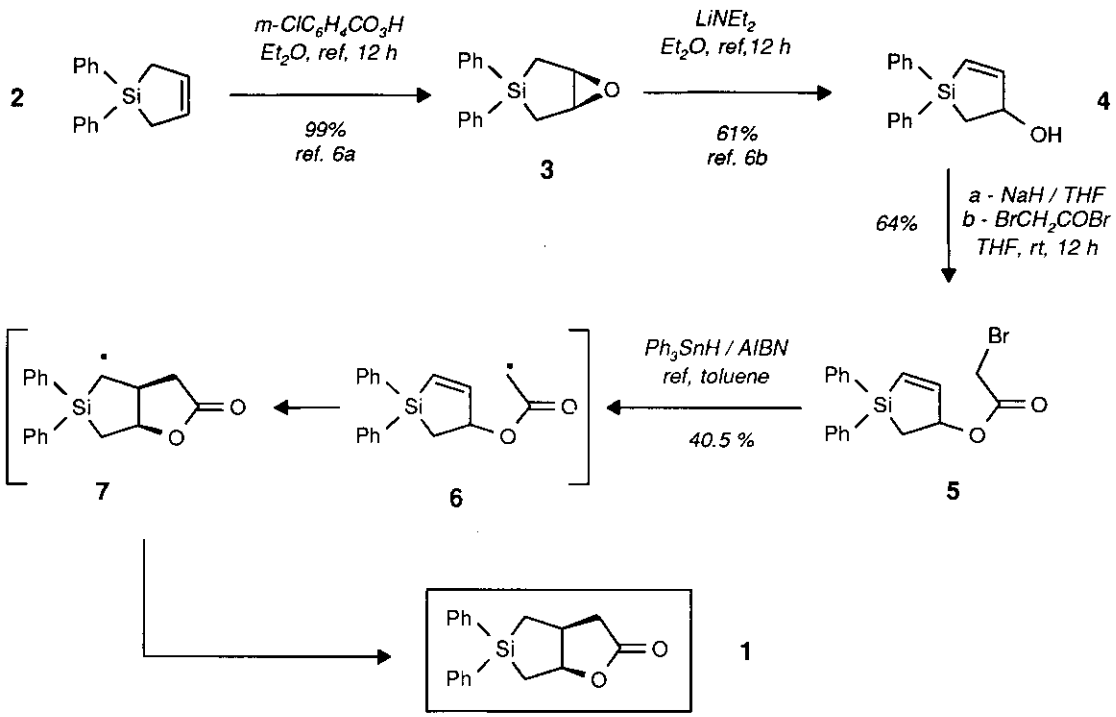


2 **1**

Next, we envisaged the preparation of **1** *via* an intramolecular radical-induced cyclization from compound (**5**), using tin hydride (Ph_3SnH) in the presence of a catalytic amount of 2,2'-azobisisobutyronitrile (AIBN) in refluxing toluene (5 h). Pure γ-butyrolactone (**1**) was obtained in 40.5% yield from **5** according to Scheme 2 after purification using flash chromatography on silica gel. Compound (**5**) was obtained by the reaction between **4**[6ab] and bromoacetyl bromide (NaH, THF, 12 h, rt) in 64% yield after purification by flash chromatography on silica gel. The reduction of the brominated compound (**5**) promoted the formation of an sp^3 carbon-centered radical (**6**) which led to radical adduct (**7**) (5-*exo*-*trig*), giving finally the γ-butyrolactone (**1**) by hydrogen abstraction. As far as we know, few free-radical additions to vinylsilane moieties have been described, [7] and few synthetic

applications of free radical chemistry to the direct preparation[8] of fused γ-butyrolactones are known : the synthesis of the cyclic lactone from iodo ester using $(Bu_3Sn)_2$ under photochemical conditions, [9] from α-haloacetates, [10] and more recently the synthesis of butenolides through a xanthate based-radical process. [11]

Scheme 2



In conclusion, the fused γ-butyrolactone (**1**) was easily prepared under mild reaction conditions.

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We are indebted to M. Vuilhorgne and coworkers for the analytical determinations.

EXPERIMENTAL

Solvents (tetrahydrofuran, ether, toluene) were dried over 4Å molecular sieves. Commercially available reagents were used as received from suppliers. The progress of the reactions was monitored by TLC on silica gel (Merck Kieselgel $60F_{254}$). Melting points were determined using a Reicher-Kofler apparatus and are uncorrected. ^{1}H-NMR spectra were recorded on a AC 200 Brucker spectrometer. IR spectra were recorded on a 510 Nicolet spectrophotometer. MS were obtained on a Finigan 3000 apparatus. The combustion analyses were performed at the Centre de Recherche de Vitry-Alfortville (Rhône-Poulenc Rorer). Flash colum chromatography was performed on silica gel (Merck Kieselgel, 230-400 mesh).

(3a*R, 6a*S**)-5,5-Diphenyl-2, 3, 3a, 4, 6, 6a-hexahydrosilolano[3,4-*b*]furan-2-one (1).**

A. Scheme 1: A mixture of **2** (2 g, 8.5 mmol), $Mn(OAc)_3.2H_2O$ (4.5 g, 16.8 mmol) and potassium acetate (15 g, 153 mmol) in acetic acid (80 mL), was vigourously stirred and refluxed under a nitrogen atmosphere during 6 h until the brown colour of manganic acetate disappeared. The yellow solution was then diluted with water (300 mL) and extracted with ether (2 x 200 ml). The organic layer was dried over anhydrous magnesium sulphate and concentrated on a rotary evaporator. The residue was purified by flash chromatography on silica gel using a cyclohexane/ethyl acetate mixture (7/3) as eluent to give 0.2 g (8%) of **1** as a colourless oil which slowly crystallized, mp 80-85°C (R_f= 0.5 in cyclohexane-ethyl acetate mixture 7/3). ^{1}H-NMR ($CDCl_3$) δ 1.0 (dd, J = 8.5 and 16 Hz, 1H, Si-CH-), 1.6 (m, 3H, Si-

CH_2- and Si-CH-), 2.4 (dd, J = 3 and 17 Hz, 1H, -CO-CH-), 2.8 (d, J = 17 Hz, 1H, -CO-CH-), 2.9 (m, 1H, Si-CH_2-CH-CH_2-), 5.1 (td, J = 4 and 6 Hz, 1H, Si-CH_2-CH-O-), 7.5 (m, 10H, phenyl rings); IR (KBr) 3070 and 3050 and 3020 (C-H arom.), 2960 and 2920 and 2905 and 2895 (C-H aliph.), 1760 (C=O), 1585 and 1565 (C=C), 1485 and 1425 (aromatic ring), 1160 (C-O), 1115 (Si-C), 945 (C-O), 810 (Si-CH_2), 745 (C-H aromatic ring), 725 (aromatic ring); MS (EI) m/z: 294 (M^+), 253, 240, 225, 199, 183, 180, 172, 163, 105 (100%), 77; (DCI-NH_3) 311($M+NH_4^+$, 100%), 295; *Anal.* Calcd for $C_{18}H_{18}O_2Si$: C, 73.43; H, 6.16; Si, 9.54. Found: C, 73.5; H, 6.4; Si, 9.6.

B. Scheme 2: Epoxide (**3**) (99%) and alcohol (**4**) (61%) were easily prepared as described in references 6a and 6b respectively.

1,1-Diphenyl-2,3-dihydro-1H-silol-3-yl 2-bromoacetate (5):

To a stirred mixture of NaH (0.25 g, 6.3 mmol, 60%) in THF (20 mL) under a nitrogen atmosphere, was added dropwise a solution of alcohol (**4**) (1.26 g, 5 mmol) in THF (20 mL) at rt during 1 h. The reaction mixture was then cooled to -40°C, and a solution of bromoacetyl bromide (0.5 mL, 5.7 mmol) in THF (20 mL) was added dropwise. The solution was then allowed to reach rt during 12 h. The yellow solution was diluted with water (100 mL) and extracted with ethyl acetate (2 x 100 mL). The combined organic layers were dried over anhydrous magnesium sulphate and concentrated on a rotary evaporator. The residue was purified by flash chromatography on silica gel using a dichloromethane/cyclohexane mixture (6/4) as eluent to give 1.2 g (64%) of **5** as a yellow oil (R_f=0.5 in dichloromethane-cyclohexane mixture 6/4). ^{1}H-NMR ($CDCl_3$) δ 1.3 (dd, J = 6 and 16 Hz, 1H, Si-CH_2-), 2.1 (dd, J = 7 and 16 Hz, 1H, Si-CH_2-), 3.9 (s, 2H, -CH_2Br), 6.1 (m, 1H, -CH-O-CO-), 6.6 (d, J = 10 Hz, 1H, Si-CH=CH-), 7.0 (d, J = 10 Hz, 1H, Si-CH=CH-), 7.3-7.6 (m, 10H, phenyl ring); IR (CCl_4) 3150-3000 (C-H arom.), 2970 and 2925 and 2850 (C-H aliph.), 1740 (O-C=O), 1595 (C=C), 1490 and 1435 (aromatic ring), 1275 (C-O), 1120 (Si-C), 700 (aromatic ring), MS (EI) m/z: 295, 234, 217, 207, 181, 173, 157, 129, 105 (100%), 77.

(3a*R, 6a*S**)-5,5-Diphenyl-2, 3, 3a, 4, 6, 6a-hexahydrosilolano[3,4-*b*]furan-2-one (1).**

To a refluxing solution of **5** (1.4 g, 38 mmol) in toluene (190 mL) under a nitrogen atmosphere, was added dropwise using a syringe pump, a solution of Ph_3SnH (1.8 g, 5.2 mmol) and AIBN (0.25 g, 1.5 mmol) in toluene (30 mL) during 5 h. The reaction mixture was then concentrated, and the residue (3.5 g) was triturated with ether (100 mL). The resulting white solid was filtered. The ethereal solution was washed with a saturated solution of KF (2 x 100 mL), and the combined organic layers were dried over anhydrous magnesium sulphate and concentrated to give 1.4 g of a yellow oil which was purified by flash chromatography on silica gel using a cyclohexane/ethyl acetate mixture (7/3) as eluent. Compound (**1**) was obtained in 40.5% yield (0.45 g) as a colourless oil which slowly crystallized, mp 80-85°C.

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