

Substituted γ -Lactones XXVI. (1a) Note on the Preparation of α -(2-Furfurylidene)- γ -butyrolactone and its *N*- and *S*-Analogues

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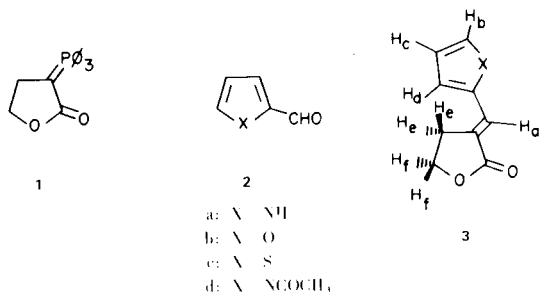
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Some time ago, we described a general method for the preparation of *trans*- α -benzylidene- γ -butyrolactones, employing the Wittig reaction (2).

In connection with our continuing work in the γ -lactone field (3a-c), we found it necessary to prepare several heterocyclic analogs of the benzylidene- γ -lactone series, namely 3a-d, for use as possible chemical and photochemical substrates (4) and therefore wish to record the preparation, utilizing the Wittig reaction, and characterization of such compounds.

Condensation of α -triphenylphosphoranylidene- γ -butyrolactone (1) with the aldehydes 2a-c in refluxing THF solution affords, in good yield, the lactones 3a-c (5). The lactone 3d can be obtained by refluxing 3a in acetic acid anhydride/sodium acetate solution.



The structure of the lactones is established on the basis of the mode of formation, elemental analyses, and spectral properties. All compounds show typical conjugated lactone carbonyl bands at 1720-1740 cm^{-1} in the infrared. In addition, compound 3a shows a single NH band at 3330 cm^{-1} , while compound 3d, obtained from 3a, is lacking such a band. The indicated *trans* geometry was assigned to 3a-d based on (i) the known mode of formation of *trans*-olefins utilizing stabilized phosphonium ylids; (ii) the low field absorption of the pmr of the vinyl hydrogen atom caused by anisotropic deshielding by the close proximity of the carbonyl group; and (iii) the results of irradiation of solutions of 3a-c which showed in their uv spectra the typical spectral behavior for *trans* \rightarrow *cis* photoisomerization. The low field position of the chemical shift of H_A in compound 3d as compared to

3a, b, and c is thought to be due to an anisotropy effect from the two carbonyl groups.

EXPERIMENTAL

The ultraviolet spectra were measured on a Unicam SP-300A ultraviolet spectrophotometer in methanol solution. Infrared spectra were measured in chloroform solution on a Perkin Elmer 700 infrared spectrophotometer and calibrated against polystyrene. Nmr spectra were obtained using a Bruker HFX-10, 90 MHz nmr spectrometer. Chemical shifts are expressed in τ -values measured from tetramethylsilane as an internal standard. The following notation for multiplicities is used: (s) = singlet, (d) = doublet, (t) = triplet, (dd) = doublet of doublets, (td) = triplet of doublets. All integrated areas are consistent with the assignments. A Hitachi-Perkin Elmer RMU-7A mass spectrometer operating at an ionizing potential of 70v was used to obtain the mass spectra. Elemental analysis were performed by Galbraith Micro-analytical Laboratories, Nashville, Tennessee. All melting points are uncorrected.

Preparation of *trans*- α -(2-Pyrrolylmethylidene)- γ -butyrolactone (3a).

A tetrahydrofuran solution (300 ml.) of pyrrole-2-carboxaldehyde (2a) (6.50 g., 68.4 μ moles) and (1) (23.61 g., 68.4 μ moles) was refluxed for 19 hours. After filtering the tetrahydrofuran solution to remove insoluble particles, the solvent was evaporated. The resulting tan solid was recrystallized from methanol (600 ml.) providing 9.66 g. (87%) of 3a, m.p. 205-208 $^{\circ}$, as slightly tan needles. A subsequent recrystallization from methanol gave analytically pure 3a, m.p. 209-211 $^{\circ}$ as colorless needles. Spectral assignments: MS: m/e 163 (M⁺); ir: 3330 cm^{-1} (NH); 1717 cm^{-1} (C=O); 1635 cm^{-1} (C=C); uv: 334 nm (28,000); nmr (DMSO-*d*₆): δ 1.40 (s, NH); 2.60 (t, H_A), J_{Ae} = 3.0; 2.89 (dd, H_B), J_{Bc} = 3.5, J_{Bd} = 1.0; 3.47 (dd, H_D); J_{Dc} = 4.0, J_{Db} = 1.0; 3.67 (dd, H_C), J_{Cd} = 4.0, J_{Cb} = 3.5; 5.57 (t, H_F), J_{Fe} = 7.0; 6.97 (td, H_E), J_{Ea} = 3.0, J_{Ef} = 7.0.

Anal. Calcd. for C₉H₉NO₂: C, 66.24; H, 5.56; N, 8.58. Found: C, 66.25; H, 5.49; N, 8.75.

Trans- α -(2-Furfurylidene)- γ -butyrolactone (3b).

This compound was analogously obtained from 2-furfural (2b) (2.77 g., 28.9 μ moles) and 1 (10.0 g., 28.9 μ moles) giving a yield of 2.6 g. (55%) of 3b, m.p. 91-92 $^{\circ}$ methanol (6a,b) (Lit. 95 $^{\circ}$). Spectral assignments: MS: m/e 164 (M⁺); ir: 1730 cm^{-1} (C=O); 1645 cm^{-1} (C=C); uv: 207 nm (ϵ , 7,200), 309 nm (ϵ , 27,000); nmr (deuteriochloroform): 2.42 (dd, H_B), J_{Bc} = 1.7, J_{Bd} = 0.7; 2.70 (t, H_A), J_{Ae} = 2.8; 3.33 (dd, H_D), J_{Dc} = 3.5, J_{Db} = 0.7; 3.47 (dd, H_C), J_{Cd} = 3.5, J_{Cb} = 1.7; 5.56 (t, H_F), J_{Fe} = 7.2; 6.75

(td, H_e), J_{ea} = 2.8, J_{ef} = 7.2.

Anal. Calcd. for C₉H₈O₃: C, 65.85; H, 4.91. Found: C, 65.77; H, 4.83.

Trans- α -(2-Thienylidene)- γ -butyrolactone (**3c**).

This compound was formed analogously from 2-thiophene carboxaldehyde (**2c**) (2.5 g., 22.3 mmoles) and **1** (7.7 g., 22.3 mmoles) giving 9.1 g. (89%) as light tan platlets, m.p. 141-142° (methanol). Spectral assignments: MS: m/e 180 (M⁺); ir: 1740 cm⁻¹ (C=O), 1645 cm⁻¹ (C=C); uv: 209 nm (ϵ , 8,640), 311 nm (ϵ , 27,900); nmr (deuteriochloroform): 2.26 (t, H_a), J_{ac} = 2.8, 2.44 (dd, H_b), J_{bc} = 4.6, J_{bd} = 1.2; 2.67 (dd, H_d), J_{dc} = 3.5, J_{db} = 1.2; 2.85 (dd, H_c), J_{cd} = 3.5, J_{cb} = 4.6; 5.53 (t, H_f), J_{fe} = 7.2; 6.87 (td, H_e), J_{ef} = 7.2, J_{ea} = 2.8.

Anal. Calcd. for C₉H₈SO₂: C, 59.98; H, 4.47. Found: C, 60.17; H, 4.33.

Acylation of **3a**.

A solution of **3a** (2.0 g., 12.3 mmoles) and sodium acetate (0.5 g.) in 50 ml. of acetic acid anhydride was refluxed for 15 hours. The resulting dark solution was poured over cracked ice and the precipitate which formed was filtered to give a tan solid. Recrystallization from methanol provided 1.5 g. (59%) of *trans*-N-acetyl- α -(2-pyrrolylmethylidene)- γ -butyrolactone (**3d**) as colorless crystals, m.p. 152.5-154°. Spectral assignments: MS: m/e 205 (M⁺); ir: 1740 cm⁻¹ (broad, C=O), 1641 cm⁻¹ (C=C); uv: 253 nm (ϵ , 7,400), 327 nm (ϵ , 19,200); nmr (deuteriochloroform): 1.72 (t, H_a), J_{ac} = 3.0; 2.29 (dd, H_b), J_{bc} = 3.5, J_{bd} = 1.5; 3.21 (dd, H_d), J_{dc} = 3.5, J_{db} = 1.5; 3.51 (dd or t, H_c), J_{cb} = 3.5, J_{cd} = 3.5; 5.42 (t, H_f), J_{fe} = 7.3; 6.89 (td, H_e), J_{ef} = 7.3, J_{ea} = 3.0; 7.31 (s, COCH₃).

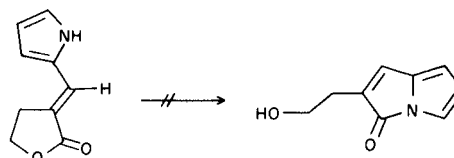
Anal. Calcd. for C₁₁H₁₁NO₃: C, 64.38; H, 5.40; N, 6.83. Found: C, 64.29; H, 5.21; N, 6.83.

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REFERENCES

- (1a) Part XXV of this series: R. G. Gailey and Hans Zimmer, *Tetrahedron Letters*, 2839 (1970). (b) Environmental Health Trainee, 1968-1970. (c) NDEA Fellow, 1968-1970. (d) Author to whom correspondence regarding this paper should be addressed.
- (2) Hans Zimmer and T. Pampalone, *J. Heterocyclic Chem.*, **2**, 95 (1965).
- (3a) R. G. Gailey and H. Zimmer, *Tetrahedron Letters*, 2839 (1970); (b) Hans Zimmer, D. C. Armbruster, S. P. Kharidia and D. C. Lankin, *ibid.*, 4053 (1969); (c) Hans Zimmer, F. Haupter, S. P. Kharidia, H. Pauling, R. G. Gailey, T. C. Pampalone, T. C. Purcell and R. Walter, *ibid.*, 5436 (1968); (d) R. Walter, T. C. Purcell and Hans Zimmer, *J. Heterocyclic Chem.*, **3**, 235 (1966); (e) Hans Zimmer, F. Haupter, J. Rothe, W. E. J. Schrof and R. Walter, *Z. Naturforsch.*, **18b**, 165 (1963).
- (4) In this respect compound **3a** was of particular interest to us because if in analogy to our earlier papers (3d,3e) a photochemical or proton catalysed rearrangement according to Fig. 2



should occur, a facile entry into the unusual 3-oxo-3H-pyrrolizine ring system would result. However, all our attempts toward this goal met with failure. Irradiation of **3a** only led to *trans-cis* isomerization. Acid treatment resulted in extensive decomposition. Also when the anion of **3a** (generated by treatment of **3a** with e.g. sodium hydride or potassium *t*-butoxide) was irradiated (under nitrogen or argon), the desired rearrangement did not occur. Only intractable tars were observed.

(5) Compound **3b** has also been prepared by direct base catalyzed condensation of γ -butyrolactone with furan-2-carboxaldehyde (6a,b).

(6a) T. C. Bruice, P. G. Kury, D. M. McMahon, *J. Am. Chem. Soc.*, **92**, 6674 (1970); (b) W. Reppe, *Ann. Chem.*, **596**, 158 (1955).