

Synthesis and X-ray crystallographic analysis of a bis(arylmethylidene)pyranone structure

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The exocyclic olefinic bonds and their *E-E* configuration in a bis(arylmethylidene)pyranone system are confirmed for the first time by X-ray crystallography of the 3,5-dibenzylidene-tetrahydropyran-4-one derivative.

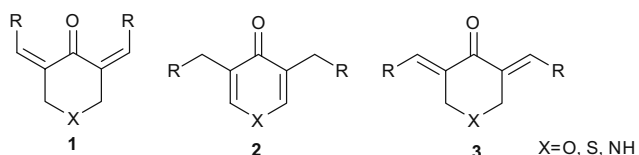
Keywords: bis(arylmethylidene)pyranones, X-ray crystallography, pyranone, Aldol condensation

Bis(arylmethylidene)cycloalkanones, as very important biologically active intermediates,^{1,2} are generally synthesised by aldol condensation of homocyclic ketones with aromatic aldehydes.³⁻⁶ So far, several procedures have appeared in the literature for the synthesis of these compounds using Lewis acid catalysis,⁷⁻¹¹ solid-supported reactions,^{12,13} ionic liquids,¹⁴⁻¹⁶ microwave irradiation¹² and ultrasound mediation.¹³ In contrast for the heterocyclic counterpart much less progress has been achieved. In this regard, we recently reported the Lewis acid-catalysed synthesis of several novel bisarylmethylidene derivatives of pyranone,¹⁷ thiopyranone,¹⁸⁻²⁰ piperidinones,²¹ dioxanones²² and cyclohexenone²³ structures using very straightforward synthetic methods. The structure of these products was assigned logically based on their spectroscopic characterisation. However, to distinguish between the possible isomers (Scheme 1) and to verify the proposed geometry, we decided to determine the crystal structure of a representative compound. In the present article, the X-ray structural analysis of the phenyl derivative of 3 (*X* = O) is reported confirming the existence of the exocyclic double bonds with *E-E* geometry.

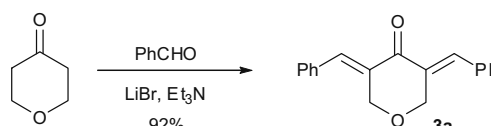
As depicted in Scheme 2, double Aldol condensation of pyran-4-one with two equivalents of benzaldehyde at room temperature resulted in 92% formation of product 3a (*R* = Ph). The reaction was conducted under the influence of catalytic amounts of LiBr²⁴ and Et₃N in the presence of CH₂Cl₂ and at ambient temperature within a 6 hours time period. A yellow coloured single crystal of the product was grown from an ethyl acetate/hexane solution.

The X-ray experimental results, as shown in Fig. 1, clearly support the proposed structure with exocyclic double bonds C7–C8 and C10–C13. The central pyranone ring shows a folding angle of 120.5(1)° at the C11...C12 axis. The maximum deviation of the atoms C8, C9, O1, C10, C11, C12 from the 'best' plane is 0.071(2) Å only. By steric hindrance, the phenyl substituents are tilted out of this plane by 14.63(4)° (ring C1 to C6) and 24.55(4)° (ring C14 to C19), respectively. The deformation shows up as well in the torsion angles (Table 1) deviating remarkably from 0° or 180° around the bonds C4–C7 and C13–C14. Nevertheless, short H...H contacts H5...H12b 2.18(2) Å and H19...H11a 2.10(2) Å are observed.

As shown in Fig. 2, the molecules are all aligned with their long axes parallel to the [201] direction. They are grouped in pairs of enantiomorphs with closest contacts C10...C3' 3.59, C13...C2' 3.74 Å, suggesting π...π interactions. These pairs are packed with rotations of about 90°. The closest contacts to a rotated molecule are possibly weak C–H...π interactions: The shortest C...C contact is between the CH₂ groups C11, C12 and C8' and C10' of the exocyclic double bond (3.41 and 3.36 Å), and between the C–H groups C18 and C6 and C2' (C18...C2' 3.70, H18...C2' 2.81 Å) or C16' (C6...C16' 3.92, H6...C16'



Scheme 1



Scheme 2

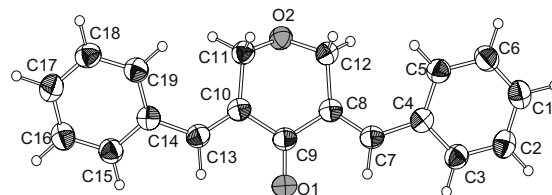


Fig. 1 Structure of 3a at 193 K in the crystal. Displacement ellipsoids at 50% probability level.

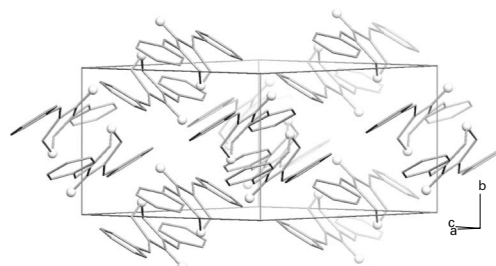


Fig. 2 Packing of molecules. H-atoms omitted, O-atoms drawn as spheres.

2.98 Å), respectively. But also weak C–H...O interactions may play a role (H7...O1' 2.54 Å, H19...O1' 2.58 Å). In summary, the structure and geometry of a bis(arylmethylidene)pyranone system was confirmed by single crystal X-ray diffraction analysis of the phenyl derivative.

Experimental

Melting points are uncorrected. UV spectra were recorded on a Perkin-Elmer Lambda 9 instrument. FT-IR spectra used KBr disk on a Bruker Vector-22 IR spectrometer and absorptions are reported as wavenumbers (cm⁻¹). ¹H NMR and ¹³C NMR spectra were obtained on a Bruker Ultra Shield (500 MHz) instrument as CDCl₃ solutions and the chemical shifts are expressed as δ units with Me₄Si as the internal standard. Mass spectrum was obtained on a Finnigan Mat 8430 apparatus at ionisation potential of 70 eV.

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Table 1 Bond lengths/Å and angles/° for **3a**

O1–C9	1.2319(19)	O2–C11–C10	110.21(12)
O2–C12	1.424(2)	O2–C12–C8	112.07(13)
O2–C11	1.430(2)	C10–C13–C14	130.31(16)
C4–C7	1.464(2)	C15–C14–C13	118.09(15)
C7–C8	1.346(2)	C19–C14–C13	124.52(16)
C8–C9	1.486(2)	C5–C4–C7–C8	19.9(3)
C8–C12	1.510(2)	C3–C4–C7–C8	–159.86(17)
C9–C10	1.498(2)	C4–C7–C8–C9	–180.00(3)
C10–C13	1.341(2)	C7–C8–C9–O1	–7.0(2)
C10–C11	1.508(2)	C12–C8–C9–O1	172.57(15)
C13–C14	1.461(2)	O1–C9–C10–C13	0.3(2)
C12–O2–C11	111.60(13)	O1–C9–C10–C11	–177.99(15)
C5–C4–C7	125.32(15)	C12–O2–C11–C10	–66.33(16)
C3–C4–C7	117.55(15)	C13–C10–C11–O2	–145.62(16)
C4–C7–C8	130.44(15)	C9–C10–C11–O2	32.55(19)
C7–C8–C9	117.54(15)	C11–O2–C12–C8	61.03(16)
C7–C8–C12	125.36(15)	C4–C7–C8–C12	0.5(3)
C9–C8–C12	117.10(14)	C7–C8–C12–O2	157.36(15)
O1–C9–C8	120.98(16)	C9–C8–C12–O2	–22.18(19)
O1–C9–C10	120.57(16)	C9–C10–C13–C14	179.95(15)
C8–C9–C10	118.44(14)	C11–C10–C13–C14	–1.9(3)
C13–C10–C9	117.95(15)	C10–C13–C14–C15	156.88(17)
C13–C10–C11	125.74(15)	C10–C13–C14–C19	–22.4(3)
C9–C10–C11	116.28(14)		

Elemental analysis was performed using a CHN–O–Rapid Herazeus instrument.

Synthesis of 3a: A mixture of the starting ketone (5.0 mmol), benzaldehyde (10.0 mmol), LiBr (0.5 mmol), and Et₃N (10.0 mmol) in CH₂Cl₂ (15 ml) was stirred in a flask. The course of the reaction was monitored by TLC and complete disappearance of the starting materials was observed within few hours. The mixture was diluted with dichloromethane (20 ml) and washed twice with water (20 ml portions). The organic phase was dried over Na₂SO₄, the solvent was removed at reduced pressure and the product was precipitated after removal of the volatile portion. Compound **3a** was obtained and characterised by spectroscopic methods Yellow crystals were obtained in 92% yield, m.p. 179–181°C; UV (CH₂Cl₂, nm) λ_{max} 321; IR (KBr, cm⁻¹) 1668, 1610, 1581; ¹H NMR (CDCl₃) δ 4.87 (s, 4H), 7.20–7.45 (m, 10H), 7.78 (s, 2H); ¹³C NMR (CDCl₃): δ 68.6, 128.6, 129.3, 130.4, 133.2, 134.8, 136.4, 185.5; MS (70 eV) *m/z* (%) 276

(M⁺, 19), 144 (22), 131 (20), 115 (100). Calcd. for C₁₉H₁₆O₂: C, 82.58; H, 5.84. Found: C, 82.2; H, 5.8.

X-ray analysis: A crystal of **3a** was investigated on an IPDS area detector system (Stoe) at –80°C using MoKα-radiation. Crystal and experimental data are given in the Table 2. The structure was solved by direct methods (SHELXS-97) and non-H atoms were refined by full-matrix least-squares method with anisotropic temperature factors (SHELXL-97) (Programs by G.H. Sheldrick, University of Gottingen, Germany, 1997). All hydrogen atoms were located from a difference Fourier map and refined with isotropic displacement parameters. No absorption but an extinction correction was applied. CCDC 654597 contains the supplementary crystallographic data for this paper. The data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request.cif.

Received 7 April 2008; accepted 9 June 2008

Paper 08/5206 doi: 10.3184/030823408X333463

Table 2 Crystal and experimental data for the structure determination of **3**

Empirical formula	C ₁₉ H ₁₆ O ₂
Formula weight	276.32
Temperature	173(2) K
Wavelength	0.71073 Å
Habitus, colour	irregular plate, yellow
Crystal size	0.36 × 0.21 × 0.03 mm ³
Crystal system	monoclinic
Space group	P2 ₁ /c
Unit cell dimensions	<i>a</i> = 14.464(3) Å <i>b</i> = 7.557(1) Å β = 93.83(2)° <i>c</i> = 12.562(2) Å
Volume	1370.0(4) Å ³
Density (calculated)	1.340 Mg/m ⁻³
Absorption coefficient	0.086 mm ⁻¹
F(000)	584
Diffraction type	IPDS-2 (Stoe)
Theta range for data collection	1.41 to 26.30°
Index ranges	–17 < <i>h</i> < 17, –9 < <i>k</i> < 9, –15 < <i>l</i> < 15
Reflections collected	9730
Independent reflections	2756 [R(int) = 0.1149]
Completeness to theta = 26.30°	99.0%
Observed reflections	1916 [I > 2 sigma(I)]
Refinement method	Full-matrix least-squares on F ²
Data/restraints/parameters	2756/0/255
Extinction coefficient	X = 0.026(4)
Goodness-of-fit on F ²	0.917
R indices (all data)	wR ² = 0.1145, R ¹ = 0.0679
R indices [I > 2 sigma(I)]	wR ² = 0.1048, R ¹ = 0.0458
Largest diff. peak and hole	0.193 and –0.194 eÅ ⁻³

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