



Synthesis and Crystal Structure of (2,5-Dimethyl-2-phenyl-1,3-dioxane-5-yl) methanoic Acid

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Received: 30 May 2014;

Accepted: 12 August 2014;

Published online: 27 April 2015;

AJC-17143

A new cyclic compound (2,5-dimethyl-2-phenyl-1,3-dioxane-5-yl) methanoic acid was prepared from the reaction of acetophenone with 2,2-bis(hydroxymethyl) propionic acid and characterized by ¹H NMR and FT-IR. The molecular structure was presented by single crystal X-ray diffraction analyses, which shows that the title compound belongs to orthorhombic system with space group Cmca with a = 10.011(3) Å, b = 6.421(3) Å, c = 37.688(11) Å. Mr = 236.26, V = 2422.6(13) Å³, Dc = 1.296 g/cm³, Z = 8, μ = 0.096 mm⁻¹, F(000) = 1008, R = 0.0553, wR = 0.1699. In the title compound, the 1,3-dioxane ring adopts a chair conformation and the phenyl substituent occupies an axial site. In the crystal, adjacent two molecules are connected by O-H...O hydrogen bonding to form a dimer.

Keywords: 1,3-Dioxane, 2,2-bis(Hydroxymethyl) propionic acid.

INTRODUCTION

Ketal compounds continue to be focus because they are usually used as a protection of carbonyl or synthetic intermediate in organic syntheses¹. 2,2-Bis(hydroxymethyl) propionic acid is a kind of common chemical products²⁻⁵, in which the neoamyl group displays a good heat resistance, hydrolysis resistance and colour stability and some special purpose such as the application in the synthesis of waterborne polyurethane and biodegradable surfactant using the carboxyl and glycol groups as hydrophilic group^{6,7}. Herein, a new compound (2,5-dimethyl-2-phenyl-1,3-dioxane-5-yl) methanoic acid was synthesized by the reaction of acetophenone and 2,2-bis(hydroxymethyl) propionic acid with *p*-toluene sulfonic acid as catalyst, DMF as solvent and cyclohexanone as water-carrying agent.

EXPERIMENTAL

General procedures: All of the chemicals are commercially available and used without further purification. Crystal structure was determined on a Bruker Smart Apex II diffractometer. Melting point data were recorded in a Buchi B545 spectrometer. The FT-IR spectra were recorded in the 4000-400 cm⁻¹ region using KBr pellets and a Nicolet AVATAR-360 spectrometer. Elemental analyses were performed by direct combustion with a PE2400 instrument. ¹H NMR spectra were recorded in a CDCl₃ solution with a Bruker AV-400 spectrometer.

Synthesis of (2,5-dimethyl-2-phenyl-1,3-dioxane-5-yl) methanoic acid: Acetophenone (0.5027 g, 4.18 mmol), 2,2-bis(hydroxymethyl) propionic acid (0.5102 g, 3.80 mmol), cyclohexane (15 mL), N,N-dimethyl formamide (2 mL) and *p*-toluene sulfonic acid (0.03 g) were heated and stirred at 378 K for 6 h. Before the solvent was evaporated under reduced pressure, sodium bicarbonate (0.0163 g, 0.19 mmol) was added to deal with the catalyst. The organic solution was washed with water (30 mL) and dried with anhydrous sodium sulphate. The resulting solution was filtered and evaporated and the product was recrystallized from ethyl acetate to afford colourless crystals (0.37 g; yield 41.6 %; m.p. 481.6 K) (**Scheme-I**). Anal. Calcd for C₁₃H₁₆O₄: C, 66.02; H, 6.77 %. Found C, 65.94; H 6.82 %. IR (KBr, ν_{max}, cm⁻¹): 2998, 2921, 2648, 1700, 1458, 1418, 1364, 1330, 1285, 1265, 1190, 1120, 1069, 1029, 1009, 947, 871, 802, 764, 702, 669, 599, 537, 478, 448. ¹H NMR (CDCl₃, 400 MHz) δ(ppm): 7.46-7.46 (4H, d, ArH), 7.37-7.38 (1H, d, ArH), 4.22-4.25 (2H, d, J = 11.2 Hz, O-CH₂-C), 3.54-3.57 (2H, d, J = 11.2 Hz, O-CH₂-C), 1.57 (3H, s, CH₃-C-O), 0.92 ((3H, s, CH₃-C).

X-ray crystal structure determination: A colourless block crystal with dimensions of 0.45 mm × 0.42 mm × 0.35 mm was selected for measurement. Diffraction data of compound were collected at 296(2) K on a Bruker Smart CCD area detector, with MoK_α radiation (λ = 0.71073 Å). A total of 12607 reflections were collected in the range of 2.16 to 27.57° by using an φ-ω multiscan mode, of which 1467 were unique

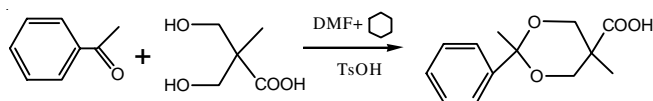
with $R_{\text{int}} = 0.0251$ and 1316 were observed with $I > 2\sigma(I)$. The structure was solved by direct methods and refined on F^2 by full-matrix least-squares procedures using the SHELX-97 program package⁸. All non-hydrogen atoms were refined anisotropically. The hydrogen atoms attached to carbon atoms were fixed at their ideal positions. The final $R = 0.0553$, $wR = 0.1699$ ($w = 1/[s^2(\text{Fo}^2) + (0.1161\text{P})^2 + 1.0768\text{P}]$, where $\text{P} = (\text{Fo}^2 + 2\text{Fc}^2)/3$), $S = 1.080$, $(\Delta/\sigma)_{\text{max}} = 0.001$, $(\Delta\rho)_{\text{max}} = 0.379$ and $(\Delta\rho)_{\text{min}} = -0.219 \text{ e}\cdot\text{\AA}^{-3}$. The crystallographic data for the title compound is summarized in Table-1. Selected bond lengths and angles are listed in Table-2. Hydrogen bond parameters are given in Table-3.

TABLE-1
CRYSTAL DATA AND STRUCTURE
REFINEMENT FOR THE TITLE COMPOUND

Parameter	Compound
Empirical formula	$\text{C}_{13}\text{H}_{16}\text{O}_4$
Formula weight	236.26
Crystal size (nm)	$0.45 \times 0.42 \times 0.35$
Crystal system, Space group	Orthorhombic, Cmca
a, b, c (Å)	10.011(3), 6.421(3), 37.688(11)
α, β, γ (°)	90, 90, 90
$V/\text{\AA}^3$	2422.6(13)
$D_c/\text{Mg cm}^{-3} Z$	1.296, 8
μ/mm^{-1}	0.096
$F_{(000)}$	1008
Index ranges (h, k, l)	$-12 \leq h \leq 12, -8 \leq k \leq 8, -48 \leq l \leq 48$
θ Range for data collection	2.16-27.57
Reflections collected/unique	12607/1467(0.0251)
Completeness to θ	98.7 %
Goodness-of-fit on F^2	1.080
Final R indices [$I > 2\sigma(I)$]	0.0553, 0.1699
R indices (all data)	0.0649, 0.1845
Max. peak/hole ($\text{e}\cdot\text{\AA}^{-3}$)	0.379/-0.219

RESULTS AND DISCUSSION

The title compound were obtained when acetophenone reacted with 2,2-bis(hydroxymethyl) propionic acid in a 1:1:1 molar ratio in DMF and cyclohexane with *p*-toluene sulfonic acid as catalyst (Scheme-I).



Scheme-I

TABLE-3
HYDROGEN BOND PARAMETERS
(Å, °) FOR THE TITLE COMPOUND

D-H...A	d(D-H)	d(H...A)	d(D...A)	$\angle(\text{DHA})$
$\text{O}(2)\text{-H}(1\text{B})\dots\text{O}(2)^{\#A}$	0.79(5)	1.87(5)	2.657(2)	173(6)

Symmetry codes: #A x, -y, -z + 1

The complex gave satisfactory elemental analyses and the FT-IR spectra exhibit the strong absorption in the range $1190\text{-}1029 \text{ cm}^{-1}$, which are consistent with O-C-O acetal bond character. It is clear from analysis of the room temperature ^1H NMR spectra for the product isolated. The ^1H NMR spectra show two sets of split signals corresponding to the $-\text{CH}_2-$ protons of 1,3-dioxane ring. These results indicate that the equatorial bond protons He_q and straight bond protons Hax of $-\text{CH}_2-$ in 1,3-dioxane ring produce coupling.

X-ray diffraction analyses indicate that the title compound contains 1,3-dioxane rings and the phenyl substituent occupies an axial site (Fig. 1). The 1,3-dioxane ring adopts a chair conformation with torsion angles for $\text{C}5\text{-O}1\text{-C}7\text{-C}8$ and $\text{C}5\text{-O}1\text{B-C}7\text{B-C}8$ ($\text{B } 1-x, y, z$) being 56.84° and -56.84° , respectively. In the crystal, adjacent two molecules are connected by O-H...O ($\text{O}2\text{-H}1\text{B}\dots\text{O}2^{\#A}$ 2.657(2) Å, A x, -y, 1-z) hydrogen bonding interactions between the oxygen atoms to form a dimer (Fig. 2 and Table-3). There are some similar crystal structures have been described in previous reports⁹⁻¹⁴.

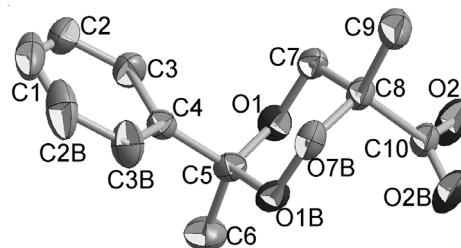


Fig. 1. Molecular structure of the title compound with the atom numbering scheme. Displacement ellipsoids are drawn at the 50 % probability level for non-H atoms, the symmetry codes for the generated atoms: B (1-x, y, z)

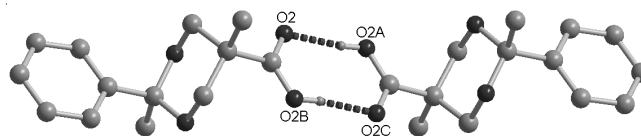


Fig. 2. Two monomers are connected by hydrogen bonding interactions into a dimer, symmetry codes: A x, -y, 1-z; B 1-x, y, z; C 1-x, -y, 1-z

TABLE-2
SELECTED BOND LENGTHS (Å) AND BOND ANGLES (°)

Bonds	d	Bonds	d	Bonds	d
O(1)-C(5)	1.4153(14)	O(1)-C(7)	1.4310(19)	C(7)-C(8)	1.5181(19)
C(1)-C(2)	1.360(3)	C(5)-O(1)	1.4153(14)	O(2)-C(10)	1.2595(15)
C(8)-C(9)	1.538(3)	C(3)-C(2)	1.391(3)	C(8)-C(10)	1.522(3)
C(5)-C(4)	1.529(3)	C(3)-C(4)	1.3772(18)	C(5)-C(6)	1.519(3)
Angles	ω	Angles	ω	Angles	ω
O(1)-C(7)-C(8)	110.78(11)	C(6)-C(5)-C(4)	109.82(17)	C(7)-C(8)-C(7) ^{#1}	107.15(15)
O(2)-C(10)-O(2) ^{#1}	123.15(18)	O(1)-C(5)-C(6)	105.96(11)	C(10)-C(8)-C(9)	107.05(17)
C(3)-C(4)-C(5)	120.63(10)	C(4)-C(3)-C(2)	120.38(18)	O(1)-C(5)-C(4)	111.93(10)
C(7)-C(8)-C(10)	110.96(11)	O(2)-C(10)-C(8)	118.38(9)	C(3) ^{#1} -C(4)-C(3)	118.5(2)
O(1)-C(5)-O(1) ^{#1}	110.88(15)	C(1)-C(2)-C(3)	120.6(2)	C(2)-C(1)-C(2) ^{#1}	119.5(2)

Symmetry codes: #1 x, -y, -z + 1

Conclusion

In conclusion, the title compound (2,5-dimethyl-2-phenyl-1,3-dioxane-5-yl) methanoic acid was synthesized by the reaction of acetophenone with 2,2-bis(hydroxymethyl) propionic acid, DMF as solvent and cyclohexanone as carrier of water, *p*-toluene sulfonic acid as catalyst. The title compound contains 1,3-dioxane rings with a chair conformation and the phenyl substituent occupies an axial site and a dimer is formed by the linking of adjacent two molecules *via* O-H...O hydrogen bonding.

Appendix A. Supplementary data

Crystallographic data for the structural analysis have been deposited with the Cambridge Crystallographic Data Centre: CCDC 979129. Copies of the data can be obtained free of charge *via* <http://www.ccdc.cam.ac.uk>.

ACKNOWLEDGEMENTS

This work was financially Supported by the Construct Program of Key Discipline in Hunan Province (2011-76), Science and Technology Planning Project of Hunan Province (2013FJ-3004), Scientific Research Fund of Hunan Provincial Education Department (13A030, 13B029, 13C350), Key Laboratory of Functional Organometallic Materials of Hunan Province College (13K09, 13K10).

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