

Synthesis and Structure of 1-{2,2-Dimethyl-4,6-dioxo-5-(1-pyridinio)-1,3-dioxan-5-yl}pyridinium Ylide: A New Route to Meldrum's Acid Derivatives

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Dedicated to Professor Peter Eilbracht on the occasion of his 60th birthday

2-Bromo-5,5-dimethyl-4,6-dioxo-1,3-dioxane (**3**) reacts with pyridine and aqueous potassium carbonate to give 1-{2,2-dimethyl-4,6-dioxo-5-(1-pyridinio)-1,3-dioxan-5-yl}pyridinium ylide (**5**). The crystal structure analysis confirms the betaine nature of **5** consisting of two distorted ring fragments [interplanar angle 58.0(4) $^{\circ}$] connected by a C-N single bond [1.440(1) Å].

Key words: Synthetic Methods, Heterocycles, Betaines, Crystal Structure

Introduction

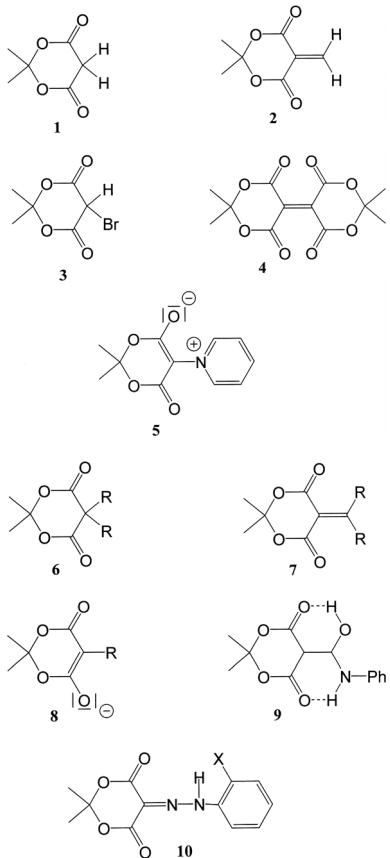
Starting with its discovery [1] and correct structural assignment [2], Meldrum's acid (**1**) has become a widely used reagent in organic synthesis [3]. In general, nucleophilic attack occurs at the carbonyl carbon atoms followed by ring fragmentation. Under basic conditions, the anion acts as a nucleophile itself to generate methylene Meldrum's acid (**2**) derivatives. In contrast to a great number of publications on reactions with organic electrophiles, reports dealing with nitrogen electrophiles including amine oxides [4], diazonium ions [5, 6], and the nitrite ion are rare [7]. Therefore, it seems useful to find a synthetic route to Meldrum's acid derivatives starting from nitrogen nucleophiles.

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As a consequence of our interest in the synthesis of heterocyclic carbenes [8] and their inorganic [9] and organic [10] chemistry, we investigated the deprotonation of 5-bromo-2,2-dimethyl-4,6-dioxo-1,3-dioxane (**3**) [11] to generate “Meldrum's olefin” (**4**) [12]. In fact, **3** reacts with stoichiometric amounts of pyridine followed by aqueous carbonate workup to form the pyridinium adduct **5** as pale yellow crystals in good yield.

A comparison of spectroscopic data reveals the π -electron shift into the six-membered ring going from **3** to its derivative **5**. The formal negative charge of the exocyclic oxygen atoms in the betaine **5** and the lowering of the corresponding CO bond order cause a significant shift of the CO stretching frequencies (ν_{CO} : **3** 1788, 1750; **5** 1624 cm $^{-1}$) to lower wave numbers as mentioned for other betaine Meldrum's acid derivatives. Surprisingly, the chemical shift values in the ^{13}C -NMR spectra for the carboxylate carbon atoms (δ : **3** 160.9, **5** 160.3) are not influenced markedly by the charge redistribution. The stability of the central C-N bond is revealed by the fragmentation pattern of **5** in the mass spectrum which does not contain the mass of the Meldrum's carbene fragment.

We determined the crystal structure of **5** (Tables 1–3, Fig. 1) for comparison with other Meldrum's acid derivatives. The bond lengths and angles in the Meldrum's acid ring are very similar to other betaine type structures. Surprisingly, the pyridine and malonate fragments are not coplanar [C(1)-N(1)-C(6)-C(7) –54.3(2) $^{\circ}$], and only weak and distorted intramolecular C-H-O hydrogen bonds between them are detected [C(1)-H(1) 0.94(2), H(1)-O(1) 2.65(2), C(5)-H(5) 0.96(2), H(5)-O(3) 2.82(2) Å, C(1)-H(1)-O(1) 100.7(1), C(5)-H(5)-O(3) 95.4(1) $^{\circ}$]. The central C-N bond [N(1)-C(6) 1.440(1) Å] is in the range of an elongated single bond of trigonal planar atoms. On comparison with the struc-



Scheme 2.

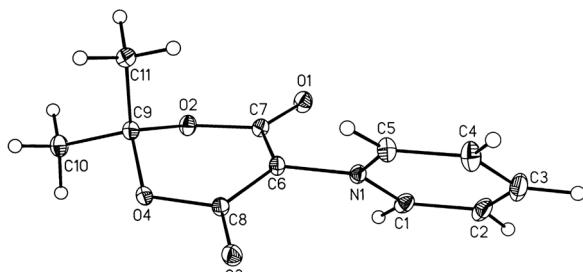
ture of Meldrum's acid **1** itself [13], the enolate structure of the dioxane ring is reflected by elongated exocyclic C-O bonds [$C(7)$ -O(1) 1.225(1), $C(8)$ -O(3) 1.227(1) Å] and by short endocyclic C-C and C-O bonds [$C(6)$ -C(7) 1.411(1), $C(6)$ -C(8) 1.411(1), $C(7)$ -O(2) 1.380(1), $C(8)$ -O(4) 1.375(1) Å]. The folding angle along the endocyclic oxygen atoms axis is 41.2(5)°.

Discussion

Several structures have been reported for Meldrum's acid derivatives which belong to the types **6**, **7** and **8**, most of them containing organic substituents in 2-position [13–17]. Apparently, the title compound clearly represents the type **8**, no resonance formula avoiding charge separation being possible. The strong betaine character, on comparison with the known structures of **8** [15], is indicated by its elongated exocyclic C-O and short endocyclic C-C bonds in the Meldrum's fragment as well as by the central C-N single bond and the nonplanar arrangement of the heterocyclic rings. It appears that the steric demand of the pyridine fragment

Table 1. Crystal data and structure refinement for **5**.

Empirical formula	$C_{11}H_{11}NO_4$
Formula weight	221.21
Temperature	173(2) K
Wavelength	0.71073 Å
Crystal system	monoclinic
Space group	$P2_1/n$
Unit cell dimensions	$a = 10.963(2)$ Å $b = 8.404(3)$ Å $\beta = 100.60(2)$ ° $c = 11.238(4)$ Å
Volume	1017.8(5) Å ³
Z	4
Density (calculated)	1.444 Mg/m ³
Absorption coefficient	0.111 mm ⁻¹
F(000)	464
Crystal size	0.50 × 0.15 × 0.15 mm ³
Theta range for data collection	2.39 to 30.51°
Index ranges	$-15 \leq h \leq 14$, $-12 \leq k \leq 12$, $-15 \leq l \leq 16$
Reflections collected	10907
Independent reflections	3104 [$R(\text{int}) = 0.0339$]
Completeness to theta = 30.51°	100.0%
Absorption correction	None
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3104 / 0 / 190
Goodness-of-fit on F^2	0.971
Final R indices [$I > 2\sigma(I)$]	$R_1 = 0.0380$, $wR_2 = 0.1079$
R Indices (all data)	$R_1 = 0.0470$, $wR_2 = 0.1153$
Extinction coefficient	0.036(4)
Largest diff. peak and hole	0.340 and -0.184 e Å ⁻³

Fig. 1. View of the molecule of **5** in the crystal. Ellipsoids of thermal vibration represent 20% probability.

requires a deviation from planarity which is well documented for five membered ring systems like **9** [17].

To the best of our knowledge [5], only two structures of a Meldrum's acid derivative have been reported in which the substituents in 2-position are connected through a heteroatom. In the phenylhydrazone derivatives **10**, the length of the central C-N bond (*ca.* 1.31 Å) clearly reflects the character of a double bond, and therefore these compounds clearly belong to the type **7** series.

The formation of **5** through nucleophilic attack of pyridine at the malonate methylene carbon atom marks

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$) for **5**. U(eq) is defined as one third of the trace of the orthogonalized U_{ij} tensor.

Atom	<i>x</i>	<i>y</i>	<i>z</i>	U(eq)
N(1)	7726(1)	-47(1)	1257(1)	24(1)
O(1)	9188(1)	1750(1)	-103(1)	34(1)
O(2)	7902(1)	1199(1)	-1835(1)	29(1)
O(3)	5778(1)	-1693(1)	-252(1)	31(1)
O(4)	6138(1)	-451(1)	-1901(1)	27(1)
C(1)	8853(1)	-630(1)	1763(1)	30(1)
C(2)	9169(1)	-795(2)	3005(1)	39(1)
C(3)	8321(1)	-392(2)	3718(1)	46(1)
C(4)	7158(1)	171(2)	3183(1)	44(1)
C(5)	6881(1)	345(1)	1942(1)	32(1)
C(6)	7417(1)	170(1)	-35(1)	24(1)
C(7)	8228(1)	1093(1)	-592(1)	26(1)
C(8)	6408(1)	-708(1)	-672(1)	24(1)
C(9)	6612(1)	985(1)	-2355(1)	26(1)
C(10)	6557(1)	731(2)	-3696(1)	36(1)
C(11)	5854(1)	2407(1)	-2093(1)	32(1)

Table 3. Selected bond lengths [\AA] and angles [$^\circ$] for **5**.

N(1)-C(5)	1.350(1)	N(1)-C(1)	1.354(1)
N(1)-C(6)	1.440(1)	O(1)-C(7)	1.225(1)
O(2)-C(7)	1.379(1)	O(2)-C(9)	1.439(1)
O(3)-C(8)	1.227(1)	O(4)-C(8)	1.375(1)
O(4)-C(9)	1.444(1)	C(1)-C(2)	1.382(2)
C(2)-C(3)	1.377(2)	C(3)-C(4)	1.388(2)
C(4)-C(5)	1.379(2)	C(6)-C(8)	1.411(1)
C(6)-C(7)	1.411(1)		
C(5)-N(1)-C(1)	121.19(9)	C(5)-N(1)-C(6)	119.01(8)
C(1)-N(1)-C(6)	119.80(9)	C(7)-O(2)-C(9)	117.06(7)
C(8)-O(4)-C(9)	117.43(7)	C(8)-C(6)-C(7)	124.14(8)
C(8)-C(6)-N(1)	117.58(8)	C(7)-C(6)-N(1)	117.82(8)
O(1)-C(7)-O(2)	117.78(9)	O(1)-C(7)-C(6)	127.44(9)
O(2)-C(7)-C(6)	114.73(8)	O(3)-C(8)-O(4)	117.40(8)
O(3)-C(8)-C(6)	126.97(9)	O(4)-C(8)-C(6)	115.60(8)
O(2)-C(9)-O(4)	110.63(8)		

a novel possible entrance to the synthesis of Meldrum's acid derivatives. The mechanism of the reaction has not been proved, as yet. The initial formation of a pyridinium salt could be detected by n.m.r., but this compound does not form **5** on addition of aqueous base. Apparently, nucleophilic attack of the pyridine base at the 2-position of the 2-bromodioxane anion occurs in a second step to eliminate bromide followed by deprotonation of the bicyclic salt formed thereby.

As indicated by the mass spectrum of **5**, the pyridine adduct contains a stable central C-N bond and is not suitable for pyridine substitution. As the interme-

iate pyridinium salt mentioned above reacts with basic nucleophiles on deprotonation, the pyridine reaction of **3** followed by addition of nucleophiles is not a general method to obtain Meldrum's acid derivatives. We therefore are presently investigating the reaction of **3** with further nucleophiles to get more labile adducts, and will report on our results in the near future.

Experimental Section

All experiments were performed in purified solvents under argon. **3** has been obtained according to a published procedure [11].

C₁₁H₁₁NO₄ (**5**)

A solution of 1.115 g (5 mmol) of **3** and 0.41 ml (5 mmol) of pyridine in 30 ml of tetrahydrofuran was stirred for 12 h at room temp. The solvent was removed *in vacuo* and the residue dissolved in 30 ml of water. After addition of 10 ml of a saturated aqueous solution of K₂CO₃, the yellow solution was extracted three times with 10 ml of dichloromethane. The organic layer was dried over Na₂SO₄ and evaporated to dryness. The residue was recrystallised from dichloromethane to give 0.57 g (52%) of **5**, pale yellow crystals. M.p. 204 to 206 °C. – IR (KBr): $\nu = 1624$ (C=O) cm⁻¹. – ¹H NMR (250 MHZ, CD₂Cl₂): $\delta = 1.65$ (s, 6 H, C_{2M}-Me), 7.73, 8.05, 8.81 (3 m, 5 H, Pyr). – ¹³C-NMR (CD₂Cl₂): $\delta = 25.2$ (Me), 101.7 (C_{2M}), 125.3, 140.1, 145.5 (Pyr), 160.3 (C_{4,6M}), C_{5M} not observed. – MS (EI, 70 eV): *m/e* (%) = 221 (70) [M⁺], 163 (70) [M⁺ – C₃H₆O], 119 (80) [M⁺ – C₃H₆O, CO₂], 91 (100) [M⁺ – C₃H₆O, CO₂, CO], 79 (20) [C₅H₅N⁺] and further fragments. – Analysis for C₁₁H₁₁NO₄ (221.07): calcd. C 59.73, H 5.01, N 6.33; found C 58.92, H 4.27, N 6.14.

Supplementary material

Crystallographic data for the structural analysis have been deposited with the Cambridge Crystallographic Data Centre, CCDC 201715, of compound **5**. Copies of this information may be obtained free of charge from the Director, CCDC, 12 Union Road, Cambridge, CB2 1EZ, UK, Fax: +44-1223-336033; E-mail: deposit@ccdc.cam.ac.uk or www: <http://www.ccdc.cam.ac.uk>.

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