

SYNLETT Spotlight 93

Meldrum's Acid

Compiled by Vasco D. B. Bonifácio



This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

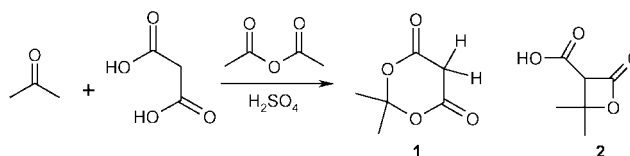
Vasco Bonifácio was born in Luanda, Angola in 1973. He studied Chemical Engineering (1992–1995) in ISEL/IPL and Applied Chemistry – Organic Chemistry (1995–1997) in FCT/UNL in Lisbon, Portugal. He received a research grant (1997–2000) and joined the research group of Prof. A. Maçanita in the ITQB/UNL Research Institute in Oeiras, Portugal under the project 'Development of Light Activated Pesticides.' In 2001, he joined the research group of Prof. S. Prabhakar and Prof. A. Lobo in FCT/UNL and is currently working towards his PhD. His research interests are focused on the asymmetric synthesis of aziridines and the development of new synthetic methods.

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Introduction

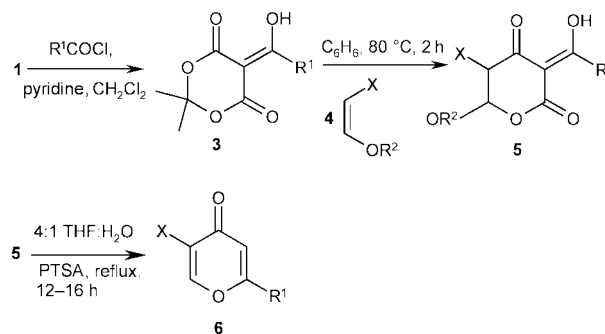
Meldrum's acid (**1**, isopropylidene malonate or 2,2-dimethyl-4,6-dioxo-1,3-dioxane), was first synthesized by Meldrum in 1908¹ and the structure was incorrectly assigned as the β -lactone of β -hydroxyisopropylmalonic acid (β,β -dimethyl- β -propiolactone- α -carboxylic acid).² It was only 40 years later that Davidson and Bernhard assigned the correct structure.² Meldrum's acid has attracted considerable attention due to its high acidity ($pK_a = 4.97$)³ and rigid cyclic structure. Acylated derivatives (synthetic

equivalents of mixed ketenes) readily undergo alcoholysis to give β -keto esters.⁴ Alkylidene derivatives are strong electrophiles and can undergo Diels-Alder reactions with high diastereoselectivity.⁵ This versatile tool is a key intermediate for a large number of important building blocks and there remains much to discover.

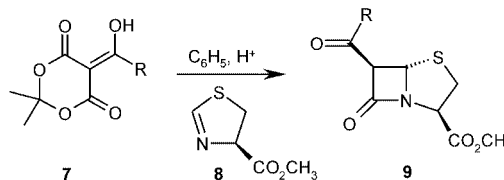


Abstracts

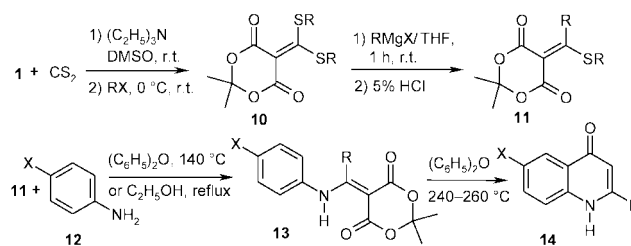
(A) Substituted γ -pyrones **6** can be used in the synthesis of polyacetate- and spiroketal-containing natural products and as cycloaddition substrates for the construction of polycyclic systems. Acylated Meldrum's acid **3** reacts with a vinyl ether **4** with loss of acetone and ring closure to the pyrone ring followed by decarboxylation. The γ -pyrone can then be obtained refluxing with a PTSA–H₂O mixture (40–85% yield). A variety of acid chlorides and vinyl ethers can be used to prepare mono-, di- and trisubstituted pyrones.⁶



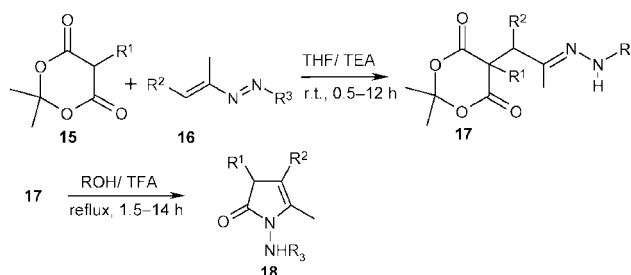
(B) Optically active β -lactams **9** are obtained in excellent yields (up to 93%) and with complete stereoselectivity from Meldrum's acid derivatives **7** and Δ^2 -thiazolines **8**.⁷



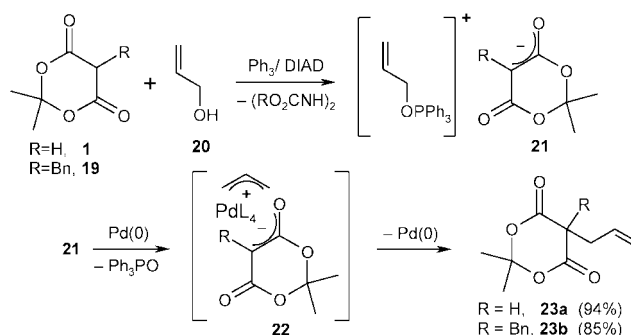
(C) 2-Alkyl and 2-aryl 4-quinolones **14** can be prepared starting from Meldrum's acid **1** via their derivatives bisalkylthiolydine **10** (32–77% yield) and alkyl- and arylthioalkylidene **11** (52–90% yield). Further reaction with arylamines **12** gives the arylaminoalkylidene derivatives **13** (54–87% yield) which provide the quinolone products upon heating (60–96% yield).⁸



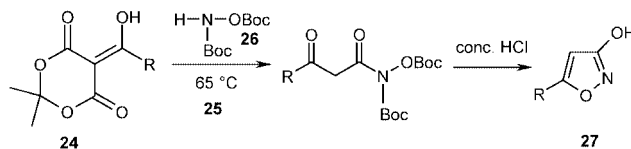
(D) The reaction of Meldrum's acid and its 5-substituted derivatives **15** with conjugated azoalkenes **16**, in the presence of triethylamine, produces the corresponding hydrazones **17** (71–98% yield) via 1,4-conjugate addition. The hydrazone products then undergo decarboxylative alcoholysis and simultaneous cyclization to give 3-unsubstituted and 3-monosubstituted 1-amino-1*H*-pyrrol-2-(3*H*)-ones **18** (55–96% yield).⁹



(E) C-Dialkylation of Meldrum's acid and 5-benzyl Meldrum's acid can be achieved through Mitsunobu dehydration using allylic and arylmethyl alcohols as alkylating agents. With primary alcohols, the alkylations always take place at the carbon bearing the hydroxyl group. For secondary alcohols, a catalytic amount of Pd(0) must be added to enhance the regioselectivity of C-alkylation over O-alkylation. Using (Ph₃P₄)Pd(0) as a catalyst, the reaction occurs specifically at the less hindered carbon, and the configuration of the resulting double bond is always *trans*.¹⁰



(F) 5-Substituted 3-isoxazolols **27** can be synthesized in a three-step procedure starting from Meldrum's acid. After conversion into the acylated derivative **24** (74–100% yield), aminolysis with *N,O*-bis(*tert*-butoxycarbonyl)hydroxylamine (**25**) leads to the *N,O*-diBoc β-keto hydroxamic acid **26** (53–91% yield). Treatment with hydrochloric acid promotes cyclization to the desired product (76–99% yield).¹¹



(G) The pyrolysis of Meldrum's acid derivatives in solution and in gas phase takes place by loss of acetone and carbon dioxide to provide ketene intermediates. In particular, methylene derivatives often provide methyleneketenes, which act as substrates for internal hydrogen transfer, leading to cyclization reactions. These cyclization reactions are used for the efficient preparation of a diverse range of cyclic compounds such as quinolinones, 3-hydroxythiophenes, naphthols, azepin-3(2*H*)-ones or pyrrolizin-3-ones, initiated respectively by 1,3-, 1,4-, 1,5-, 1,6 or 1,7-prototropic shifts.¹²

References

- Meldrum, A. N. *J. Chem. Soc.* **1908**, 93, 598.
- Davidson, D.; Bernhard, S. A. *J. Am. Chem. Soc.* **1948**, *70*, 3426.
- Pihlaja, K.; Seilo, M. *Acta Chem. Scand.* **1969**, *23*, 3003.
- Oikawa, Y.; Sugano, K.; Yonemitsu, O. *J. Org. Chem.* **1978**, *43*, 2087.
- Endo, T.; Kihara, N.; Mizukami, S. *Tetrahedron Lett.* **1993**, *34*, 7437.
- Zawacki, F. J.; Crimmins, M. T. *Tetrahedron Lett.* **1996**, *37*, 6499.
- Hemtenäs, H.; Soto, G.; Hultgren, S. J.; Marshall, G. R.; Almqvist, F. *Org. Lett.* **2000**, *14*, 2065.
- (a) Huang, X.; Chen, B.-C. *Synthesis* **1986**, 967. (b) Chen, B.-C.; Huang, X.; Wang, J. *Synthesis* **1989**, 317.
- Arcadi, A.; Attanasi, O. A.; Liao, Z.; Serra-Zanetti, F. *Synthesis* **1994**, 605.
- Shing, T. K.; Li, L.-H.; Narkunan, K. *J. Org. Chem.* **1997**, *62*, 1617.
- Sørensen, U. S.; Falch, E.; Krogsgaard-Laesen, P. *J. Org. Chem.* **2000**, *65*, 1003.
- Gaber, A. E.-A.; McNab, H. *Synthesis* **2001**, 2059.