

Short Note

Trimethyl 4,6-Dicyano-5-hydroxybenzene-1,2,3-tricarboxylate

Afsaneh Zonouzi ^{1,*}, Roghieh Mirzazadeh ¹ and Seik Weng Ng ²

¹ School of Chemistry, University College of Science, University of Tehran, Tehran, 14174, Iran

² Department of Chemistry, University of Malaya, Kuala Lumpur, 50603, Malaysia

* Author to whom correspondence should be addressed; E-Mail: zonouzi@khayam.ut.ac.ir.

Received: 28 April 2012 / Accepted: 1 August 2012 / Published: 28 August 2012

Abstract: A novel synthesis of a fully substituted fluorescent phenol by a one-pot reaction of dimethyl acetylenedicarboxylate and malononitrile in the presence of catalysts has been developed. The structure of the synthesized compound was assigned on the basis of its elemental analysis, ¹H-NMR, ¹³C-NMR, IR, mass spectral and X-ray data. The photophysical data of the new compound are reported.

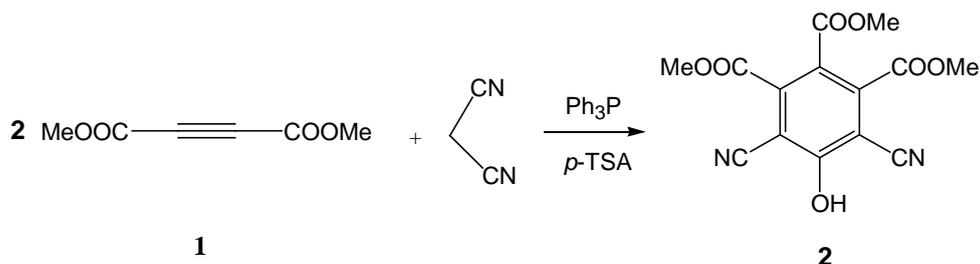
Keywords: fully substituted phenol; fluorescence; one-pot reaction; malononitrile; dimethyl acetylenedicarboxylate; keto-enol tautomerization

Optoelectronic devices such as optical fibers, switches, tunable lasers and amplifiers, modulators with various applications need compounds emitting in the blue spectral region [1]. Multi-component reactions (MCRs) are of increasing significance in organic and medicinal chemistry. MCRs allow organic compounds to be synthesized in a few steps or in a one-pot operation [2].

Substituted phenols are of great importance in biosynthesis and also as building blocks in organic synthesis [3,4]. There are a few reports on the synthesis of highly substituted phenols [5]. So the development of a multi-component one-pot procedure for the synthesis of fluorescent poly-functionalized phenol can be seen as urgently interesting for technology upgrading. In continuation of our quest for developing one-pot procedures, here we wish to report a novel one-pot condensation reaction of dimethyl acetylenedicarboxylate **1** and malononitrile in the presence of Ph₃P (triphenylphosphine) and *p*-toluenesulfonic acid (*p*-TSA) for the synthesis of fully substituted phenol **2** with bright fluorescence property (Scheme 1).

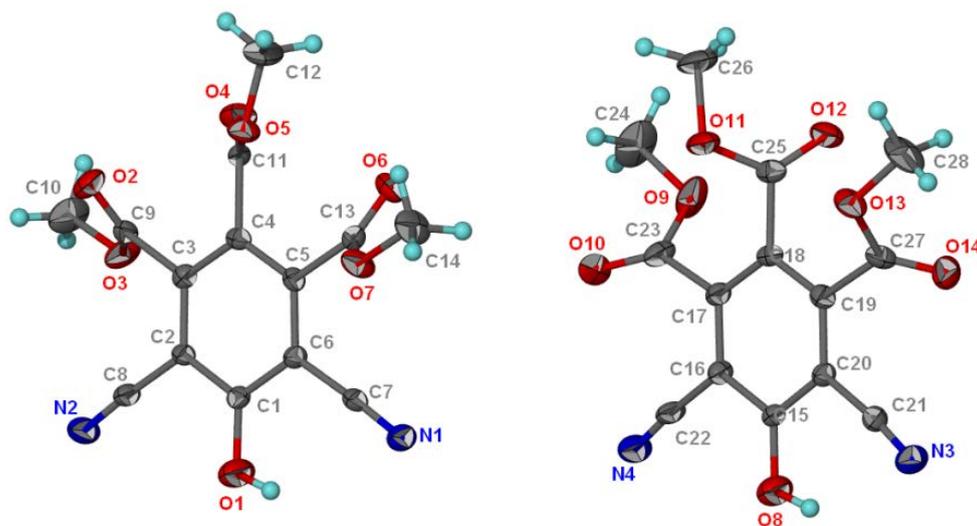
Easy, rapid and mild reaction conditions and also high atom economy of this one-pot procedure make the present method useful for the synthesis of highly functionalized phenols.

Scheme 1. Synthesis of trimethyl 4,6-dicyano-5-hydroxybenzene-1,2,3-tricarboxylate.



Structure **2** was assigned on the basis of its elemental analysis, ¹H-NMR, ¹³C-NMR, IR and mass spectral data. The light green crystals of **2** were obtained by slow crystallization from ethyl acetate and its X-ray structure was determined to confirm unambiguously its structure [6] (Figure 1).

Figure 1. X-Ray crystal structure of **2**.



A possible mechanism for the synthesis of **2** is shown in Scheme 2. It is suggested that the zwitterion **3** is produced at first by addition of Ph₃P to the acetylenic ester. Then the zwitterion **3** condenses with another ester molecule to produce zwitterion **4**. Attack of the malononitrile anion at **4**, followed by loss of Ph₃P and intramolecular cyclization affords **5**. Elimination of CN⁻ from C₂ and addition of CN⁻ to C₆ in the presence of OTS⁻ can produce the intermediate **6**. Finally, **6** can be aromatized to **2** by keto-enol tautomerization. Intermediate **6** was detected in the early stage of the reaction by ¹H-NMR and IR spectra. The proton adjacent to the CN group appears at δ = 4.53 for **6** in the ¹H-NMR spectrum and the carbonyl group of **6** has been detected at ν_{max} = 1,801 cm⁻¹ in the IR spectrum of the reaction mixture. At the end of this transformation (after 24 h), there was no carbonyl absorption detectable in the IR spectrum. Probably, the stability gained from aromatic ring generation drives this keto-enol tautomerization.

Experimental

Elemental analysis for C, H and N was performed using a Thermo Finnigan Flash EA1112 instrument. ¹H-NMR and ¹³C-NMR spectra were determined on a Bruker 500 spectrometer. IR spectra were measured on a Bruker EQUINOX 55 spectrophotometer with the ATR method. Mass spectra were recorded on a Finnigan-MAT 8430 spectrometer. Photophysical data measurements were made with a Cary Eclipse Fluorescence spectrophotometer.

Trimethyl 4,6-dicyano-5-hydroxybenzene-1,2,3-tricarboxylate (2). To a magnetically stirred solution of dimethyl acetylenedicarboxylate (0.28 g, 2 mmol) in 3 mL of CH₂Cl₂, Ph₃P (0.26 g, 1 mmol) and malononitrile (0.1 g, 1.5 mmol) in 3 mL of CH₂Cl₂ were added dropwise by two dropping funnels at -10 °C over 40 min and stirring was continued at this temperature for 2 h. Then, 0.069 g (40 mol%) *p*-TSA were added. The reaction mixture was warmed up to room temperature and stirred for 24 h. The solvent was removed under reduced pressure and the residue was purified by column chromatography on silica gel, using *n*-hexane/ethyl acetate (3/1) as the mobile phase. The product was obtained as light green crystals, 0.26 g, 83%. Melting point: 129–130 °C.

Structural Characterization

IR, ν_{\max} : 3419, 3348, 3252, 2961, 2232, 1728, 1651, 1573, 1430, 1370, 1303, 1240, 1173, 1015 cm⁻¹; δ_{H} (500 MHz, CDCl₃): 3.78 (3H, s, CH₃), 3.91 (6H, s, 2CH₃), 8.03 (1H, br s, OH) ppm; δ_{C} (125 MHz, CDCl₃): 54.2, 54.6 (CH₃), 96.5 (CN), 113.9, 114.2, 114.4, 155.0 (Ar), 163.7, 165.8 (CO) ppm; MS: m/z = 318 (M⁺), 317, 214, 156, 141, 59, 45; Anal. Calcd for C₁₄H₁₀N₂O₇: C, 52.84; H, 3.17; N, 8.80; Found: C, 52.79; H, 3.15; N, 8.62.

Acknowledgements

Support of this study by the Research Council at the University of Tehran is gratefully acknowledged.

References and Notes

1. Lakowicz, J.R. *Principle of Fluorescence Spectroscopy*, 3rd ed.; Springer: New York, NY, USA, 2006.
2. Hussain, H.H.; Babic, G.; Durst, T.; Wright, J.S.; Flueraru, M.; Chichirau, A.; Chepelev, L.L. Development of novel antioxidants: Design, synthesis, and reactivity. *J. Org. Chem.* **2003**, *68*, 7023–7032.
3. Vosooghi, M.; Rajabalian, S.; Sorkhi, M.; Badinloo, M.; Nakhjiri, M.; Negahbani, A.S.; Asadipour, A.; Mahdavi, M.; Shafiee, A.; Foroumadi, A. Synthesis and cytotoxic activity of some 2-amino-4-aryl-3-cyano-7-(dimethylamino)-4*H*-chromenes. *Res. Pharm. Sci.* **2010**, *5*, 9–14.
4. Wright, J.S.; Johnson, E.R.; DiLiabio, G.A. Predicting the activity of phenolic antioxidants: Theoretical method, analysis of substituent effects, and application to major families of antioxidants. *J. Am. Chem. Soc.* **2001**, *123*, 1173–1183.
5. Samshuddin, S.; Narayana, B.; Sarojini, B.K. Ethyl 4,4''-difluoro-5'-hydroxy-1,1':3',1''-terphenyl-4'-carboxylate. *Molbank* **2011**, *2011*, M745.

6. Crystallographic data for compound **2** reported in this paper have been deposited with the Cambridge Crystallographic Data Center as supplementary publication CCDC No. 842814. These data can be obtained free of charge via www.ccdc.com.ac.uk/data_request/cif.

© 2012 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).