



A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

The procedures in *Organic Syntheses* are intended for use only by persons with proper training in experimental organic chemistry. All hazardous materials should be handled using the standard procedures for work with chemicals described in references such as "Prudent Practices in the Laboratory" (The National Academies Press, Washington, D.C., 2011; the full text can be accessed free of charge at http://www.nap.edu/catalog.php?record_id=12654). All chemical waste should be disposed of in accordance with local regulations. For general guidelines for the management of chemical waste, see Chapter 8 of Prudent Practices.

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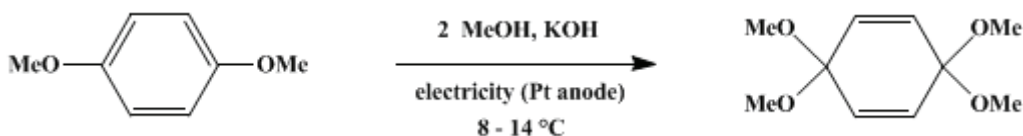
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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3,3,6,6-TETRAMETHOXY-1,4-CYCLOHEXADIENE

[1,4-Cyclohexadiene, 3,3,6,6-tetramethoxy-]



Submitted by Paul Margaretha¹ and Paul Tissot².
Checked by Ronald F. Sieloff and Carl R. Johnson.

1. Procedure

A 600-ml., tall-form beaker is equipped with a thermometer, a magnetic stirring bar, and two electrodes, a 45-mesh, cylindrical platinum anode (Note 1) surrounded by a cylindrical nickel cathode (Note 2). The electrodes are held in place (distance between anode and cathode: 0.75 cm.) and suspended in the beaker with a clamp formed from Delrin rods (Note 3). The electrodes are connected to an adjustable DC power supply (Note 4), (Note 5).

A solution of 27.6 g. (0.200 mole) of 1,4-dimethoxybenzene (Note 6), 4.0 g. of potassium hydroxide, and 400 ml. of methanol is placed in the apparatus. The beaker and contents are cooled with a 0° bath. The magnetically stirred solution is electrolyzed for 6 hours at a current intensity maintained at 2.0 amp. (Note 5), (Note 7). The temperature of the solution varies between 8° and 14°. During this time small amounts of methanol are added from time to time to compensate for evaporation.

After electrolysis the solution is reduced to a volume of 100 ml. with a rotary evaporator and extracted 10 times with 100-ml. portions of hexane. The hexane fractions are dried over anhydrous magnesium sulfate and the hexane evaporated with a rotary evaporator, yielding white crystals. Recrystallization from 75 ml. of pentane (Note 8) affords 27.8–28.2 g. (70–71%) of pure 3,3,6,6-tetramethoxy-1,4-cyclohexadiene, m.p. 40–43° (Note 9).

2. Notes

1. The platinum anode used was Model 611 obtained from Engelhard Industries. This electrode has a height of 5.6 cm. and a diameter of 5.1 cm. The total surface area claimed by the supplier is 200 cm.²
2. The nickel cathode, fashioned from 22 gauge nickel sheet obtained from Huntington Alloys, Inc., Huntington, W. Va. 25720, had a height of 5.6 cm. and a diameter of 6.6 cm. When the sheet was rolled into a cylinder a small gap was left at the seam.
3. The clamp consisted of a 30 cm. vertical Delrin rod (0.5 cm. in diameter) threaded through the center of two 7-cm. horizontal Delrin rods (1.25 cm. in diameter). The horizontal rods were notched to hold the electrodes between them.
4. The power source used by the checkers was a 30-volt, 3-amp. adjustable DC supply.
5. The submitters used a cathode of nickel foil (140 × 71 × 0.5 mm.) rolled into a cylinder 3.5 cm. in diameter surrounded by three curved platinum anodes each having the dimensions 70 × 30 × 1 mm. (total surface area 130 cm.²) with a distance of 0.5–1 cm. between the cathode and the anodes. The submitters electrolyzed for 6 hours at a current maintained at 3.25 amp. This corresponds to a total of 19.5 amp.-hours and an anodic current density of 0.025 amp./cm.² Under these conditions the submitters report yields of 81–84%.
6. 1,4-Dimethoxybenzene was obtained from Aldrich Chemical Company Inc.
7. This corresponds to 12 amp.-hours (theoretical value is 10.6 amp.-hours). Longer electrolysis times did not significantly increase the yield of product.
8. Cooling is necessary to complete crystallization.
9. ¹H NMR (CDCl₃) δ (multiplicity, number of protons, assignment): 3.30 (s, 12H 4OCH₃), 6.10 (s, 4H, 4CH).

3. Discussion

The procedure described is essentially that of Belleau and Weinberg³ and represents the only known way of obtaining the title compound. One other [quinone ketal, 1,4,9,12-tetraoxadispiro\[4.2.4.2\]tetradeca-6,13-diene](#), has been synthesized by a conventional method (reaction of [1,4-cyclohexanedione](#) with [ethylene glycol](#) followed by bromination and dehydrobromination⁴) as well as by an electrochemical method [anodic oxidation of [2,2-\(1,4-phenylenedioxy\)diethanol](#)⁵]. Quinone ketals have been used as intermediates in the synthesis of [4,4-dimethoxy-2,5-cyclohexadienone](#), *syn*-bishomoquinone,^{4,6} and compounds related to natural products.⁷

Aromatic diethyl ethers and furans undergo alkoxylation by addition upon electrolysis in alcohol containing a suitable electrolyte.^{8,9,10,11,12} Other compounds such as aromatic hydrocarbons, alkenes, *N*-alkyl amides, and ethers lead to alkoxyated products by substitution. Two mechanisms for these electrochemical alkoxyations are currently discussed. The first one consists of direct oxidation of the substrate, giving the radical cation which reacts with the alcohol, followed by reoxidation of the intermediate radical, and either alcoholysis or elimination of a proton to the final product. In the second mechanism the primary step is the oxidation of the alcoholate, giving an alkoxy radical which reacts with the substrate, the consequent steps then being the same as above. The formation of quinone ketals in particular seems to proceed *via* the second mechanism.⁵

References and Notes

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Appendix

Chemical Abstracts Nomenclature (Collective Index Number); (Registry Number)

[syn-bishomoquinone](#)

[methanol \(67-56-1\)](#)

[nickel \(7440-02-0\)](#)

[potassium hydroxide \(1310-58-3\)](#)

ethylene glycol (107-21-1)

Pentane (109-66-0)

magnesium sulfate (7487-88-9)

hexane (110-54-3)

1,4-dimethoxybenzene (150-78-7)

1,4-Cyclohexanedione (637-88-7)

3,3,6,6-Tetramethoxy-1,4-cyclohexadiene,
1,4-Cyclohexadiene, 3,3,6,6-tetramethoxy- (15791-03-4)

quinone ketal

1,4,9,12-tetraoxadispiro[4.2.4.2]tetradeca-6,13-diene

2,2-(1,4-phenylenedioxy)diethanol (104-38-1)

4,4-dimethoxy-2,5-cyclohexadienone