the American Cancer Society.

Registry No. *N*-Methyl-*N*-nitrosourea, 684-93-5; *N*-ethyl-*N*-nitrosourea, 759-73-9; *N,N'*-dimethyl-*N*-nitrosourea, 13256-32-1; *N*-methyl-*N'*-ethyl-*N*-nitrosourea, 72479-13-1; *N*-methyl-*N'*-propyl-*N*-nitrosourea, 72479-16-4; *N*-methyl-*N'*-isobutyl-*N*-nitrosourea, 72479-18-6; *N*-methyl-*N'*-isopropyl-*N*-nitrosourea, 72479-15-3; *N*-methyl-*N'*-*sec*-butyl-*N*-nitrosourea, 72479-17-5; *N*-methyl-*N'*-cyclohexyl-*N*-nitrosourea, 16813-38-0; *N*-methyl-*N'*-*tert*-butyl-*N*-nitrosourea, 72479-14-2; *N,N',N'*-trimethyl-*N*-nitrosourea, 3475-63-6; *N*-methyl-*N',N'*-diethyl-*N*-nitrosourea, 50285-72-8; *N*-methyl-*N',N'*-dipropyl-*N*-nitrosourea, 72479-19-7; *N*-methyl-*N',N'*-dibutyl-*N*-nitrosourea, 72479-21-1; *N*-methyl-*N',N'*-diisobutyl-*N*-nitrosourea, 72479-22-2; *N*-methyl-*N',N'*-diisopropyl-*N*-nitrosourea, 72479-19-7; *N*-methyl-*N*-nitroso-1-pyrrolidinecarboxamide, 67084-42-8; *N*-methyl-*N*-nitroso-1-piperidinecarboxamide, 72479-20-0; *N*-isopropyl-*N*-nitrosourea, 16830-14-1; isopropylurea, 691-60-1.

Substituent Effect during the Synthesis of Substituted [2.2]Paracyclophane by Photoextrusion of Carbon Dioxide from a Cyclic Diester

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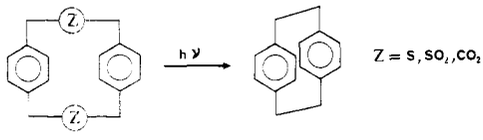
The continued interest in strained molecules such as [2.2]paracyclophanes has stimulated the search for a very effective synthesis. Several recent papers have shown that photoextrusion reactions of sulfur,[1-3] sulfur dioxide,[2,4] or carbon dioxide[5] from the sulfide, sulfone, or ester precursors, readily available by established synthetic methods, are very useful and high yield processes.



During our studies of photochemical reactions in organized media such as liquid crystals, we have been interested in the photodecarboxylation of dilactones (Z = CO_2) reported by Kaplan and Truesdale[5] for the synthesis of unsubstituted [2.2]paracyclophane. We report in this paper a drastic effect of substituents located on benzene rings during such a photodecarboxylation.

The synthesis of cyclic diesters **1** and **2** was accomplished from dibromo compounds and the trimethylammonium salt of 1,4-benzenediacetic acid in refluxing acetonitrile under high dilution conditions (giving higher yields than the heterogeneous condensation of the silver salt of the diacid).[5] The products were isolated by chromatography, and their physical properties, listed in Table I, are entirely consistent with the assigned structures.

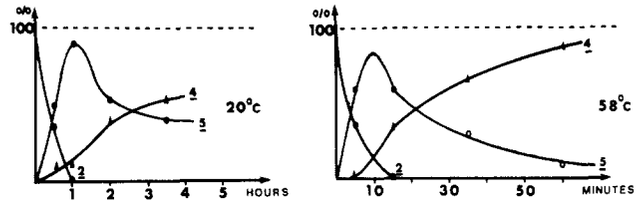
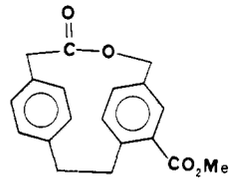


Figure 1.

While the parent diester (R = H) is readily photochemically decarboxylated into the corresponding paracyclophane[5] (70% yield), the dilactones **1** and **2** showed, under the same conditions, decarboxylation yields strongly dependent on the nature of R.

We actually observed that a methoxy group strongly enhanced the decarboxylation process as compared to a carbomethoxy group: complete disappearance of the starting dilactone required 12 min in the case of **1** and 1 h in the case of **2** when irradiation was conducted in quartz (MeOH, 20 °C). In addition, the dilactone **2** is first monodecarboxylated, leading only to the monolactone **5**[6]



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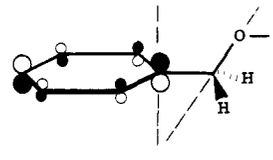
which is indeed difficult to decarboxylate further, as shown in Figure 1 and Table II, although this decarboxylation process was strongly temperature dependent: 6 times faster at 58 °C than at 20 °C (Table II). No such monodecarboxylation was detected from compound **1**.

Irradiation conducted in Pyrex ($\lambda > 300$ nm) led to an 86% yield of paracyclophane **3** from compound **1** (ϵ_{300nm} 978) in 50 min (20 °C) and only to a 36% yield of monolactone **5** from **2** (ϵ_{300nm} 283) in 20 h (20 °C).

The results obtained by Givens[8] during a photodecarboxylation study of esters showed that efficient CO_2 loss requires a phenyl substitution β to the oxygen atom as shown in **6**. This can be translated in terms of orbital interactions: the π_{arom}–σ^*_{C-O} hyperconjugation stabilizes conformer **6** and weakens the C–O bond.



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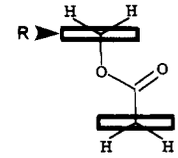

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Likewise, in our case, the conformation **7** of the dilactone is both electronically (π–σ^* interaction) and sterically favored, which is consistent with the easy decarboxylation. The observed substituent effect is in agreement with this model: a methoxy group raises the aromatic π level,

(1) V. Boekelheide, I. D. Reingold, and M. Tuttle, *J. Chem. Soc., Chem. Commun.*, 406 (1973).
(2) W. Rebafka and H. Staab, *Angew. Chem., Int. Ed. Engl.*, **12**, 776 (1973).
(3) R. Gray and V. Boekelheide, *Angew. Chem., Int. Ed. Engl.*, **14**, 107 (1975).
(4) R. S. Givens, R. J. Olsen, and P. L. Wylie, *J. Org. Chem.*, **44**, 1608 (1979).
(5) M. L. Kaplan and E. A. Truesdale, *Tetrahedron Lett.*, 3665 (1976).

(6) TLC as well as ^1H and ^{13}C NMR spectroscopy indicate that only one isomer was formed and that the decarboxylation was regioselective. Structure **5** was demonstrated by 250-MHz ^1H NMR by comparison of the chemical shifts of benzylic protons linked to oxygen in molecules **2** and **5** [in **2**, δ_{AB} 5.50 (benzylic protons ortho to CO_2Me), 5.08 (benzylic protons meta to CO_2Me); in **5** δ_{AB} 5.02] and by the magnitude of the nonequivalence observed for the methylene ortho to CO_2Me in **4** and **5** [in **4**, δ_A 4.11, δ_B 2.88; in **5**, δ_A 4.04, δ_B 2.87]. A conformational study of these molecules will be published shortly (submitted for publication in *Can. J. Chem.*).
(7) H. J. Reich and D. J. Cram, *J. Am. Chem. Soc.*, **91**, 3534 (1969).
(8) R. S. Givens and W. F. Oettle, *J. Am. Chem. Soc.*, **93**, 3301 (1971).

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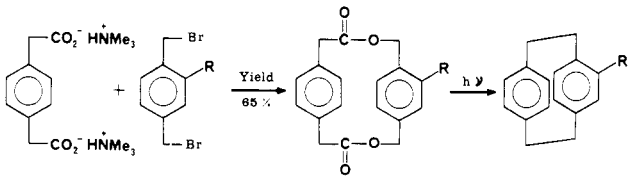
Table I. Product Characteristics



compd	mp, °C	spectral properties
1	146	250-MHz NMR ($CDCl_3$) δ 3.39 (br s, 4 benzylic H), 3.82 (s, 3 H, Me), 2 AB systems (4 H, OCH_2Ar; $\|J_{AB}\|$ = 11 Hz, δ_A 4.84, δ_B 5.23; $\|J_{A'B'}\|$ = 11 Hz, $\delta_{A'}$ 5.0, $\delta_{B'}$ 5.27), 6.6-7 (m, 7 H, aromatic); mass spectrum,[a] *m/e* 326 (m^+, 15), 282 ($M^+ - 2\ CO_2$, 3), 238 ($M^+ - 2\ CO_2$, 9), 134 ($H_2CC_6H_3(OCH_3)CH_2$, 100), 104 ($CH_2C_6H_4CH_2$, 40); UV (MeOH) λ_{max} 269 nm (ε 5880)
2	128	250-MHz NMR ($CDCl_3$) δ 3.8 (br s, 2 benzylic H), one AB system (2 benzylic H; $\|J_{AB}\|$ = 1 Hz, δ_A 3.44, δ_B 3.36), 4.0 (s, 3 H, Me), 2 AB systems (4 H, OCH_2Ar; $\|J_{AB}\|$ = 11 Hz, δ_A 5.05, δ_B 5.12; $\|J_{A'B'}\|$ = 11 Hz, $\delta_{A'}$ 5.36, $\delta_{B'}$ 5.64), 6.76-7.04 (m, 6 H aromatic), 7.72 (s, 1 H aromatic ortho); mass spectrum,[a] *m/e* 354 (M^+, 7), 310 ($M^+ - CO_2$, 3), 266 ($M^+ - 2\ CO_2$, 20), 162 ($H_2CC_6H_4(CO_2Me)CH_2$, 44), 104 ($CH_2C_6H_4CH_2$, 100); UV (MeOH) λ_{max} 271 nm (ε 13 560)
3	114	250-MHz NMR ($CDCl_3$) δ 2.6 (m, 1 benzylic H), 3.04 (m, 6 benzylic H), 3.40 (m, 1 benzylic H), 3.70 (s, 3 H, OMe), 5.66 (br s, 1 H, aromatic), 6.25-6.75 (m, 6 aromatic H); mass spectrum,[a] *m/e* 238 (M^+, 30), 148 ($(CH_2)_2C_6H_3(OMe)CH_2$, 10), 134 ($CH_2C_6H_3(OMe)CH_2$, 100), 104 ($CH_2C_6H_4CH_2$, 56)
4	132	250-MHz NMR ($CDCl_3$) δ 2.88 (m, 1 benzylic H), 3.11 (m, 6 benzylic H), 3.95 (s, 3 H, Me), 4.11 (m, 1 benzylic H), 6.50-6.68 (m, 6 aromatic H), 7.16 (br s, 1 H aromatic); mass spectrum,[a] *m/e* 266 (M^+, 64), 251 ($M^+ - CH_3$, 4), 235 ($M^+ - OCH_3$, 4), 162 ($CH_2C_6H_3(CO_2Me)CH_2$, 70), 104 ($CH_2C_6H_4CH_2$, 100)
5	104	250-MHz NMR ($CDCl_3$) δ 2.87 (m, 1 benzylic H), 4.04 (m, 1 benzylic H), 3.18 (m, 2 benzylic H), 3.33 (s, 2 H, $ArCH_2CO$), 3.97 (s, 3 H, Me), one AB system (2 H, $ArCH_2O$; $\|J_{AB}\|$ = 11 Hz, δ_A 4.68, δ_B 5.37), 6.43-6.83 (m, 6 aromatic H), 7.51 (s, 1 aromatic H); mass spectrum,[a] *m/e* 310 (M^+, 51), 285 ($M^+ - CH_3$, 10), 279 ($M^+ - OCH_3$, 80), 266 ($M^+ - CO_2$, 46), 162 ($CH_2C_6H_3(CO_2Me)CH_2$, 74), 147 ($CH_2C_6H_3(CO_2)CH_2$, 18), 104 ($CH_2C_6H_4CH_2$, 100)

[a] Fragmentations and relative intensities are given in parentheses.

Table II. Decarboxylation[a] of Dilactone 2 in Quartz

at 20 °C				at 58 °C			
t, h	2, %[b]	5, %[b]	4, %[b]	*t*, min	2, %[b]	5, %[b]	4, %[b]
0.5	39	50	11	5	38	62	0
1	0	89	11	15	0	61	39
2	0	53	47	35	0	33	67
3.5	0	43	57	60	0	10	90
				105	0	0	100[c]

[a] Irradiation experiments were performed with a Hanovia lamp (100 W, medium pressure). [b] The product ratios were determined by NMR mainly from the signals corresponding to the benzylic protons α to oxygen in compounds 2 and 5 and from the signal at 7.16 ppm, corresponding to an aromatic proton, in 4. [c] Including some degradation products, an 85% yield in isolated product was obtained.

causing a better $\pi-\sigma^*$ interaction and favoring the decarboxylation, whereas the carbomethoxy group plays the opposite role, lowering the aromatic π level.

However, monodecarboxylation cannot be rationalized with such a qualitative reasoning.

Our results confirm the expected sequential extrusion of the carbon dioxide molecules followed by recombination of the resultant radicals.[9]

In conclusion, our results showed the general synthetic utility of the photodecarboxylation process which is a high-yield route to paracyclophanes. However, according to the nature of the substituents located on the aromatic rings the experimental conditions must be modified: irradiation in Pyrex at room temperature in the case of electron-donating substituents and in quartz at higher temperature in the case of electron-withdrawing substituents.

Experimental Section

General Procedure for the Preparation of Ortho-Substituted Dibromo-*p*-xylenes. A mixture of 0.01 mol of ortho-substituted *p*-xylene (R = OMe or CO_2Me), 0.021 mol of *N*-bromosuccinimide, and a few milligrams of dibenzoyl peroxide in 250 mL of anhydrous CCl_4 was refluxed for 1 h under visible light irradiation. After the mixture cooled, succinimide was filtered and solvent evaporated. The crude product was recrystallized from cyclohexane. For R = OMe: mp 124 °C; yield 63%; NMR ($CDCl_3$) δ 7.7–6.95 (m, 3 H, arom), 4.59 (s, 2 H, benzylic), 4.50 (s, 2 H, benzylic), 2.73 (s, 3 H, CH_3). For R = CO_2Me: mp 83 °C; yield 73%; NMR ($CDCl_3$) 7.98 (s, 1 H, arom), 7.40 (s, 2 H, arom), 4.88 (s, 2 H, benzylic), 4.40 (s, 2 H, benzylic), 3.85 (s, 3 H, CH_3).

General Procedure for the Preparation of Dilactones 1 and 2. A 4-L reactor containing 2-L of anhydrous acetonitrile was equipped with a reflux condenser, an efficient mechanical stirrer and two dropping funnels respectively containing 0.01 mol of ortho-substituted dibromo-*p*-xylene dissolved in 200 mL of acetonitrile and 0.01 mol of the trimethylammonium salt of *p*-phenylenediacetic acid in 200 mL of acetonitrile. The acetonitrile in the reactor was refluxed under vigorous stirring, and the reactants were added dropwise and simultaneously for 8 h.

At the end of the addition, solvent was evaporated, and the crude product was extracted with dichloromethane. Purification was achieved by flash chromatography[10] on silica gel (eluent was 80/20 hexane–ether), affording pure products with a 65% yield.

General Procedure for the Photochemical Decarboxylation. A 10^{-3}-mol sample of dilactone was dissolved in 800 mL of methanol and degassed with N_2 for 20 min in a 1-L photochemical reactor. Irradiation was performed in Pyrex with a Philips HPK 125 high-pressure mercury lamp or in quartz with a Hanovia 100-W medium-pressure mercury lamp at the desired temperature. The reaction was followed by TLC.

After evaporation of the solvent, products were purified by flash chromatography[10] on silica gel with a hexane–ether (90/10) mixture as eluent.

(9) E. A. Truesdale, *Tetrahedron Lett.*, 3777 (1978).

(10) W. C. Still, M. Kahn, and A. Mitra, *J. Org. Chem.*, **43**, 2923 (1978).

Acknowledgment. Dr. A. Solladié-Cavallo is gratefully acknowledged for helpful discussions.

Registry No. 1, 74725-03-4; 2, 74725-04-5; 3, 5628-12-6; 4, 10029-01-3; 5, 74725-05-6; methyl 2,5-dimethylbenzoate, 13730-55-7; 2,5-dimethylanisole, 1706-11-2; 2,5-bis(bromomethyl)anisole, 46045-95-8; methyl 2,5-bis(bromomethyl)benzoate, 74725-06-7; *p*-phenylenediacetic acid trimethylammonium salt (1:2), 74725-07-8.

Two Stereoisomeric Macrocyclic Resorcinol–Acetaldehyde Condensation Products[1,2]

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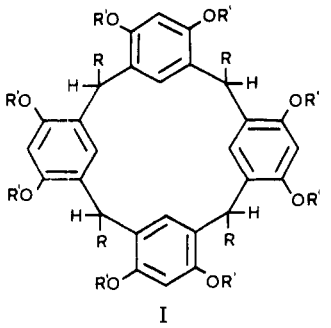
The formation of crystalline, high-melting products by the acid-catalyzed condensation of resorcinol with acetaldehyde[3-7] or higher aliphatic aldehydes[5,6] or by the reaction of resorcinol with acetylene in the presence of mercuric salts[4,8] is well-known. At first, these products were thought to be of low molecular weight and were assigned various acetal,[3c] diphenylalkane,[5,8] or vinylresorcinol[4] structures. Niederl and Vogel obtained a *single* product from the reaction of resorcinol with acetaldehyde in aqueous sulfuric acid and assigned it the macrocyclic structure I (R = CH_3; R′ = H).[6] The mass spectrum of an octamethyl ether, prepared by Erdtman et al., was in agreement with this structure (I, R = R′ = CH_3).[7]



I

We have found that under similar conditions resorcinol reacts with several aromatic aldehydes such as benzaldehyde and *p*-bromobenzaldehyde to give *two* stereoisomeric macrocycles of the same general structure (I, R = aryl, R′ = H).[9] We have therefore reinvestigated the resorcinol–acetaldehyde reaction.

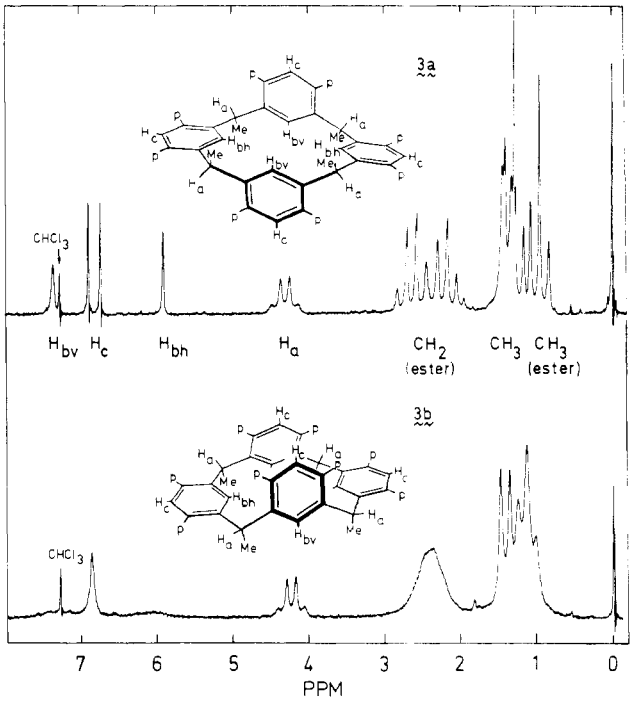
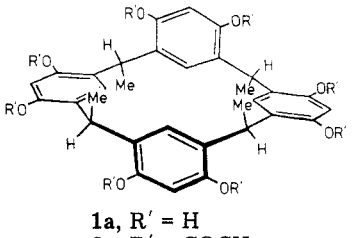


Figure 1. 60-MHz NMR spectra of the octapropionates **3a** and **3b** in $CDCl_3$ solutions at 28 °C (Me_4Si as internal standard). The $OCOCH_2CH_3$ groups are indicated by p.

The reaction of resorcinol (2.0 M) with acetaldehyde (2.0 M) in aqueous hydrochloric acid at 75 °C for 1 h gave a phenolic precipitate which was acetylated. Fractional crystallization of the acetylation product gave the two isomeric octaacetates **2a** (13%) and **2b** (47%). Similarly, propionylation gave the two octapropionates **3a** and **3b**. However, when the reaction was carried out in a mixture of ethanol and concentrated hydrochloric acid (4:1 v/v), no precipitate was obtained. On the addition of water to the solution a small amount of a phenolic product precipitated, which on acylation gave only the acetate **2b** (12%). When a mixture of ethanol, water and concentrated hydrochloric acid (2:2:1 v/v) was used, only phenol **1b** precipitated, yielding 57% of the octaacetate **2b** upon acylation. In this case no phenol **1a** was detected in the solution. Finally, direct acylation, without prior purification,[10] of the crude phenolic product, prepared according to the description of Niederl and Vogel[6] (reaction in dilute sulfuric acid for several days) gave both the octapropionate **3a** (18%) and the octapropionate **3b** (45%).



1a, R′ = H
2a, R′ = $COCH_3$
3a, R′ = COC_2H_5

(1) (a) Cyclooligomeric phenol–aldehyde condensation products. Part 3. For part II see ref 9b. (b) Taken from: Högberg, A. G. S. Ph.D. Dissertation, Royal Institute of Technology, Stockholm, Sweden, 1977.

(2) Systematic names: **1a**: *r*-2,*c*-8,*t*-14,*t*-20-tetramethylpentacyclo[19.3.1.1^{3,7}.1^{9,13}.1^{15,19}]octacosa-1(25),3,5,7(28),9,11,13(27), 15, 17, 19(26), 21,23-dodecaen-4,6,10,12,16,18,22,24-octol. **1b**: *r*-2,*c*-8,*c*-14,*c*-20-tetramethylpentacyclo[19.3.1.1^{3,7}.1^{9,13}.1^{15,19}]octacosa-1(25),3,5,7(28),9,11,13-(27),15,17,19(26),21,23-dodecaen-4,6,10,12,16,18,22,24-octol.

(3) (a) Michael, A.; Comey, A. M. *Am. Chem. J.* **1883**, *5*, 349. (b) Möhlau, R.; Koch, P. *Ber. Dtsch. Chem. Ges.* **1894**, *27*, 2887. (c) Causse, H. *Ann. Chim. (Paris)* **1894**, [7] *1*, 90.

(4) Flood, S. A.; Nieuwland, J. A. *J. Am. Chem. Soc.* **1928**, *50*, 2566.

(5) Harden, W. C.; Reid, E. E. *J. Am. Chem. Soc.* **1932**, *54*, 4325.

(6) Niederl, J. B.; Vogel, H. J. *J. Am. Chem. Soc.* **1940**, *62*, 2512. For similar results see ref 16.

(7) Erdtman, H.; Haglid, F.; Ryhage, R. *Acta Chem. Scand.* **1964**, *18*, 1249.

(8) Wenzke, H. H.; Nieuwland, J. A. *J. Am. Chem. Soc.* **1924**, *46*, 177.

(9) (a) Erdtman, H.; Högberg, S.; Abrahamsson, S.; Nilsson, B. *Tetrahedron Lett.* **1968**, 1679. (b) Högberg, A. G. S. *J. Am. Chem. Soc.* **1980**, *102*, 6046.

(10) Niederl and Vogel recrystallized the crude phenolic product from ethanol before acylation.[6] Thus, unless the material present in the mother liquors was recovered, most or all of the phenol **1a** might easily have been lost due to the much higher relative solubility of this isomer.

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