

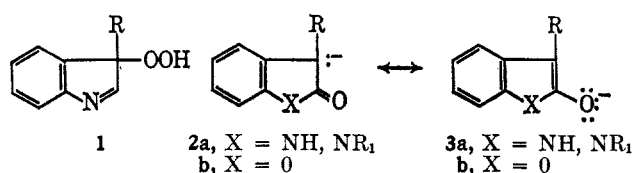
Products Obtained from the Reaction of
Molecular Oxygen with the Sodium Salts of
3-Phenyloxindoles and 3-Phenyl-2-cumaranone

PAUL AEBERLI AND WILLIAM J. HOULIHAN

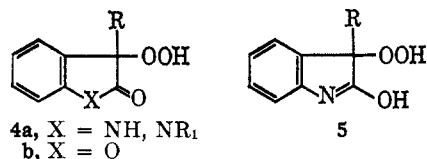
Research Laboratories, Sandoz Pharmaceuticals,
Hanover, New Jersey 07936

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The reaction of molecular oxygen with indoles and compounds containing an indole nucleus to form 3-hydroxyperoxyindolenines such as **1** has been described in the literature.¹ Under the proper conditions the 3-phenyl derivatives of **1** (R = aryl) can be converted into the pharmaceutically useful 2-aminobenzophenones as with **2a**.²



The 3-carbanion of an oxindole (**2a**), which can also be represented as the oxy anion of a 2-hydroxyindole (**3a**), might also be expected to react with oxygen to form a hydroperoxide **4a** or **5**. When R is an aryl



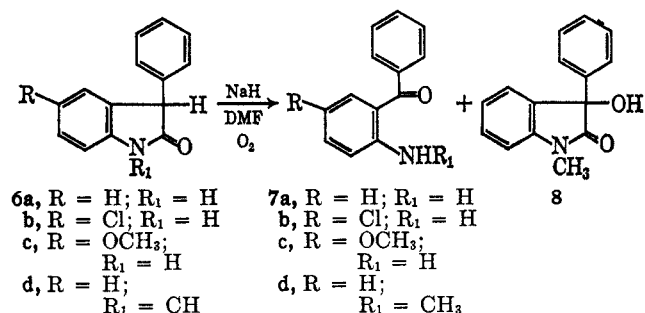
group it should also be possible to convert **4a** or **5** into 2-aminobenzophenones. In a similar way the carbanion of a 2-cumaranone (**2b** or **3b**) can form a hydroperoxide (**4b**) that can be converted into a 2-hydroxybenzophenone when R in **4b** is phenyl.

Several examples of the reaction of oxygen with alkaline solutions of oxindoles have been reported. From 1,3-dimethyloxindole,^{3a} 1,3-dimethyl-5-methoxyoxindole,^{3b} 3-(2-aminoethyl)-oxindole,^{3c} and 3-oxindole propionic acid^{3d} there was obtained the corresponding dioxindole analogs. Nothing has been reported on the reaction of 2-cumaranones with oxygen.

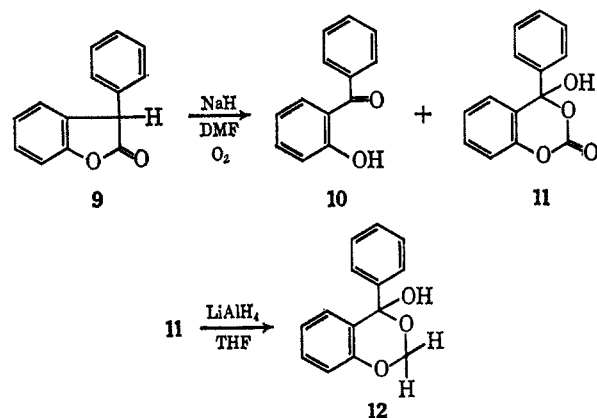
In the present paper we wish to report our findings on the air oxidation of the anions obtained from some 3-phenyloxindoles and 3-phenyl-2-cumaranone.

The sodium salt of 3-phenyloxindole (**6a**), generated by treating a dimethylformamide solution of **6a** with sodium hydride dispersion, was gassed with a stream

of air for 52 hr. After processing the reaction there was obtained a 77% yield of 2-aminobenzophenone (**7a**). In a similar manner 3-phenyl-5-chloro- (**6b**) and 3-phenyl-5-methoxyoxindole (**6c**) gave 79% and 68% yields of 2-amino-5-chloro (**7b**) and 2-amino-5-methoxybenzophenone (**7c**). When the salt of 1-methyl-3-phenyloxindole (**6d**) was oxygenated there was obtained 7% of 2-methylaminobenzophenone (**7d**) and in addition a 71% yield of 1-methyl-3-phenyldioxindole (**8**).



Treatment of a dimethylformide solution of the sodium salt of 3-phenyl-2-cumaranone (**9**) with air for 56 hr gave 5% of 2-hydroxybenzophenone (**10**) and 52% of an acidic C₁₄H₁₀O₄ compound. The infrared spectrum gave strong absorption in the 3.20–4.10- μ region typical of a carboxyl group, but a strong band at 5.80 μ suggested that a lactone or ester carbonyl was present.⁴ The ultraviolet spectrum was typical of an isolated benzene system and the nmr spectrum disclosed one exchangeable and nine aromatic protons. Mass spectrum confirmed the empirical formula (M = 242) and also gave strong peaks at M - 45 and m/e 105 suggesting that a -CO₂H and C₆H₅CO- might be present.



Lithium aluminum hydride reduction of this compound in refluxing tetrahydrofuran gave a new weak acid with empirical formula C₁₄H₁₂O₃. The infrared spectrum of this substance disclosed -OH absorption at 2.92 μ but lacked any bands in the carbonyl region. The nmr spectrum disclosed one exchangeable proton, a broad two-proton singlet at 3.92 ppm, and nine aromatic protons. From the mass spectrum strong peaks at M - 31 (M = 228) and m/e 105 suggested the presence of a -CH₂OH and C₆H₅CO- grouping.

The infrared, ultraviolet, and nmr data indicate that the C₁₄H₁₀O₄ compound is 4-phenyl-1,3-benzodioxan-4-ol-2-one (**11**) and the reduction product is 4-phenyl-

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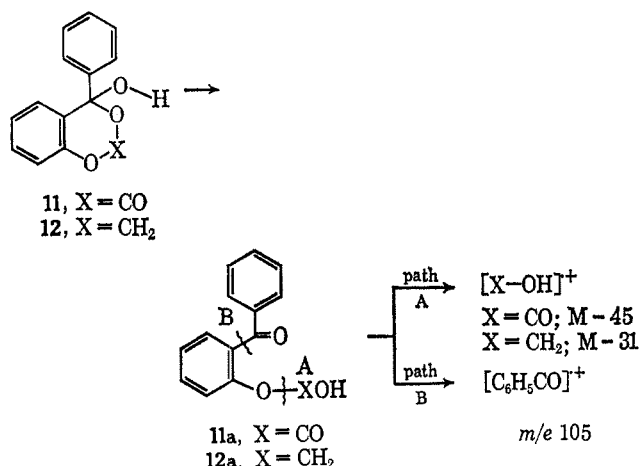
(2) S. J. Childress and M. I. Gluckman, *J. Pharm. Sci.*, **53**, 577 (1964); L. H. Sternbach, L. O. Randall, and S. R. Gustafson in "Psychopharmacological Agents," M. Gordon, Ed., Academic Press Inc., New York, N. Y., 1964, Chapter 5.

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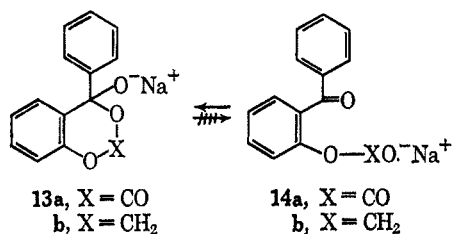
(4) L. J. Bellamy, "Infrared Spectra of Complex Molecules," John Wiley and Sons, Inc., New York, N. Y., 1958.

1,3-benzodioxan-4-ol (12). Additional support for these structures was obtained by hydrolyzing 11 and 12 with aqueous acetic acid. In both cases 2-hydroxybenzophenone (10) was obtained.

The apparent presence of a $-\text{COOH}$, $-\text{CH}_2\text{OH}$, and $\text{C}_6\text{H}_5\text{CO}-$ groups in the mass spectrum of 11 and 12 can be explained by a thermal or electronic rearrangement of these to 11a and 12a in the mass spectrometer. Fragmentation by path A can account for the $-\text{COOH}$ and $-\text{CH}_2\text{OH}$ groups while path B produces the $\text{C}_6\text{H}_5\text{CO}-$ group.



Since the structures 11-11a and 12-12a are related to each other as ring-chain tautomers it was of interest to determine if the anions of the parent acids 11 and 12 exist in the ring (13a,b) or the chain (14a,b) forms. The gross features of the ultraviolet spectra of 11 and 12 in ethanol and sodium hydroxide-ethanol solution were identical. The position and intensity of the band maxima were typical of an isolated benzenoid chromophore rather than that of the benzophenone systems 14a and b. This establishes that in solution both the



anion and free acid exist in the ring forms 13a and b. The stability of these anions in the ring form may account for the unusual lithium aluminum hydride reduction of 11 to 12 where both C-O bonds of the starting lactone group are left intact.⁵

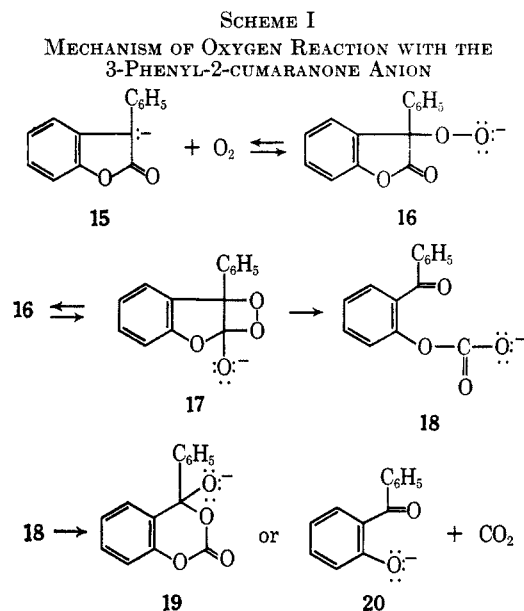
Although no detailed study on the mechanism of formation of the novel ring system 11 has been carried out, it seems possible to comment on this based on the analogy with the known mechanism¹ of indole anion oxidation.

Reaction of the 3-phenyl-2-cumaranone anion 15 with molecular oxygen in a manner similar to that reported⁶ for other anions can give the hydroperoxide anion 16.

(5) A survey of the literature failed to uncover any example where a carbonate, cyclic or open chain, has been reduced with lithium aluminum hydride or other reducing hydride. By analogy with the hydride reduction of esters and lactone the carbonates would be expected to reduce to alcohols.

(6) H. R. Gersmann, H. J. W. Nieuwenhuis, and A. F. Biekel, *Tetrahedron Lett.*, 1383 (1963).

Intramolecular attack of the negatively charged oxygen on the adjacent carbonyl carbon results in the cyclic peroxy anion 17. Bond reorganization of 17 gives the oxo carboxylate anion 18 which can react with the benzophenone carbonyl to form the cyclic anion 19 or lose carbon dioxide to give the 2-hydroxybenzophenone anion 20 (see Scheme I).



Experimental Section⁷

Synthesis of N-Aryl-DL-mandelamides.—A mixture of 15.2 g (0.10 mol) of DL-mandelic acid, 9.3 g (0.10 mol) of aniline, and 250 ml of technical *o*-dichlorobenzene were stirred and refluxed in a flask equipped with an extractor for removing water. After all the water had been removed the reaction mixture was cooled in an icebath. The resultant solid was filtered off and crystallized from methanol-water to give 15.1 g (66%) of N-phenyl-DL-mandelamide: mp 146-147° (lit.^{8a} mp 148°); ir (KBr), 3.04 and 3.08 (NH, OH), and 6.01 μ (C=O).

In a similar manner 152 g (1.0 mol) of DL-mandelic acid, 127.6 g (1.0 mol) of *p*-chloroaniline, and 2000 ml of technical *o*-dichlorobenzene gave 176 g (67%) of N-*p*-chlorophenyl-DL-mandelamide: mp 160-163° (CH₃OH-H₂O); ir (KBr), 3.01 and 3.09 (NH, OH) and 6.00 μ (C=O).

Anal. Calcd for C₁₄H₁₂ClNO₂: C, 64.3; H, 4.6; Cl, 13.4; N, 5.4; O, 12.3. Found: C, 64.0; H, 4.5; N, 5.5.

From 152 g (1.0 mol) of DL-mandelic acid, 123 g (1.0 mol) of *p*-methoxyaniline, and 2000 ml of technical *o*-dichlorobenzene there was obtained 206 g (80%) of N-*p*-methoxyphenyl-DL-mandelamide: mp 148-150° (CH₃OH-H₂O); ir (KBr), 3.03 and 3.07 (NH, OH) and 6.02 μ (C=O).

Anal. Calcd for C₁₅H₁₅NO₃: C, 70.0; H, 5.8; N, 5.4; O, 18.8. Found: C, 69.9; H, 5.7; N, 5.5.

Cyclization of N-Aryl-DL-mandelamides to 3-Aryloxindoles. 3-Phenyloxindole (6a).—Following the procedure of Bruce and Sutcliffe^{8a} there was obtained 2.5 g of crude 3-phenyloxindole (6a) from 5.7 g of DL-N-phenylmandelamide. Vacuum sublimation (0.5 mm) at 120-130° gave 1.78 g of pure 6a, mp 186-189° (lit. mp 191°^{8a} and 185-187°^{8b}).

(7) Melting points were determined on a Thomas-Hoover capillary melting point apparatus and have not been corrected. Proton nmr spectra were obtained on a Varian Associates A-60 spectrometer and are recorded in parts per million (ppm) from an internal tetramethylsilane standard. Infrared spectra were determined on a Perkin-Elmer Infracord. Ultraviolet spectra were carried out on a Cary Model 15 spectrometer. Potentiometric titrations were run on a Metrohm recording potentiometric titrator Model E 336. Mass spectra were determined on a Consolidated Electronics Co. mass spectrometer Model 21 103C, equipped with an all-glass heated inlet. Samples were injected by the direct inlet technique at a source temperature of approximately 250°.

(8) (a) J. M. Bruce and F. K. Sutcliffe, *J. Chem. Soc.*, 4793 (1957); (b) C. Marschalk, *Bull. Soc. Chim. Fr.*, 949 (1952).

3-Phenyl-5-chloroxindole (6b).—To a cold, rapidly stirred mixture of 225 ml of concentrated sulfuric acid (96%) and 25 ml of fuming sulfuric acid (65% oleum) there was added portionwise 50 g of DL-N-p-chlorophenylmandelamide. The internal temperature was not allowed to exceed 40° during this addition. The mixture was stirred an additional 1.5 hr at room temperature and then poured onto 1000 g of crushed ice. The solid was filtered off and crystallized from CH₃OH-H₂O (1:1) to give 43.5 g of crude **6b**, mp 185–187°. Vacuum sublimation (0.5 mm) of this material at 150–160° gave 35.4 g of 3-phenyl-5-chloroxindole (**6b**): mp 191–193°; ir (KBr), 3.00 (NH) and 5.89 μ (C=O).

Anal. Calcd for C₁₄H₁₀ClNO: C, 69.0; H, 4.1; Cl, 14.5; N, 5.7; O, 6.6. Found: C, 68.8; H, 3.9; Cl, 14.6; N, 5.8; O, 6.6.

3-Phenyl-5-methoxyxindole (6c).—A mixture of polyphosphoric acid (60 g) and DL-N-p-methoxyphenylmandelamide (5.0 g) were stirred and heated at 50° for 1.5 hr. The viscous product was then poured into ice water and extracted three times with chloroform. The chloroform was washed with saturated sodium chloride and dried with magnesium sulfate. Removal of the chloroform gave 5.0 g of crude product, mp 80–170°. Chromatography of this material on a silica gel column (CHCl₃-C₆H₆, 1:1, eluent) gave 1.7 g of 3-phenyl-5-methoxyxindole (**6c**): mp 195–197° (CH₃OH-H₂O); ir (KBr), 3.01 (NH) and 5.91 μ (C=O).

Anal. Calcd for C₁₅H₁₃NO₂: C, 75.3; H, 5.4; N, 5.9. Found: C, 75.0; H, 5.2; N, 5.9.

An attempt to prepare **6c** by the sulfuric acid technique given above failed to give any water-insoluble material.

N-Methyl-3-phenyloxindole (6d).—N-Methyl-3-phenyloxindole was prepared by the aluminum chloride cyclization of N-methyl- α -bromophenylacetanilide. It had mp 120° (lit.^{9a} mp 119.5°); ir (KBr), 5.86 (C=O), 6.18, 6.67, 6.81, 7.26, and 7.43 μ ; uv, $\lambda_{\max}^{\text{EtOH}}$ 249 m μ (ϵ 8030).

Air Oxidation of the Sodium Salts of 3-Phenyloxindoles.

A. 3-Phenyloxindole (6a).—To a flask equipped with a magnetic stirring bar, gas inlet tube, and a calcium chloride drying tube there was added 2.5 g (0.012 mol) of 3-phenyloxindole, 1.5 g (0.033 mol NaH) of a 53% sodium hydride mineral oil dispersion,⁹ and 125 ml of absolute dimethylformamide. The solution was stirred and gassed with a stream of dry air for 52 hr at room temperature. The solution first turned red and then yellow. After removal of the solvent *in vacuo* the residue was treated with water and then extracted with chloroform. The chloroform layer was dried and concentrated to give 2.4 g of oil. Chromatography on silica gel (CHCl₃ eluent) gave 1.82 g (77%) of 2-aminobenzophenone (**7a**): mp 100–101° (lit.¹⁰ mp 102°); ir (KBr), 2.92 and 3.02 (OH), 6.11 (C=O), 6.72, 6.85, and 7.98 μ ; uv, $\lambda_{\max}^{\text{EtOH}}$ 236 m μ (ϵ 21,460) and 379 m μ (ϵ 5880).

B. 3-Phenyl-5-chloroxindole (6b).—The procedure used to oxidize **6a** was followed.

From 5.0 g (0.02 mol) of 3-phenyl-5-chloroxindole, 1.8 g (0.04 mol NaH) of 53% sodium hydride mineral oil dispersion, and 250 ml of absolute dimethylformamide there was obtained 6.0 g of oil (contains mineral oil). Chromatography on silica gel (CHCl₃ eluent) gave 3.6 g (79%) of 2-amino-5-chlorobenzophenone (**7b**): mp 96–98° (C₆H₆-pentane) (lit.¹¹ mp 98–100°) uv, $\lambda_{\max}^{\text{EtOH}}$ 238 m μ (ϵ 25,670) and 391 m μ (ϵ 12,835).

C. 3-Phenyl-5-methoxyxindole (6c).—The procedure used to oxidize **6a** was followed.

From 1.5 g (0.006 mol) of 3-phenyl-5-methoxyxindole, 0.9 g (0.02 mol NaH) of 53% sodium hydride mineral oil dispersion, and 100 ml of absolute dimethylformamide there was obtained 1.6 g of an oil (contains mineral oil). Chromatography on silica gel (CHCl₃-C₆H₆, 1:1 eluent) gave 1.4 g of oil that crystallized from ether to give 0.93 g (68%) of 2-amino-5-methoxybenzophenone (**7c**): mp 51° (lit.¹² 51–52°); ir (KBr), 2.92 and 3.01 (NH₂) and 6.12 μ (C=O).

Air Oxidation of the Sodium Salt of 1-Methyl-3-Phenyloxindole (6d).—To a flask equipped with a magnetic stirring bar, gas inlet tube, and a calcium chloride drying tube there was added 5.0 g (0.023 mol) of 1-methyl-3-phenyloxindole, 1.2 g (0.026 mol NaH) of a 53% sodium hydride dispersion, and 300 ml of absolute dimethylformamide. The solution was stirred and

gassed at ambient temperature with a stream of dry air for 8 hr. The clear yellow solution was then concentrated *in vacuo*. The residue was neutralized with 2 N HCl and then extracted with ethyl acetate. The acetate solution was washed with saturated sodium chloride, water, and then dried with magnesium sulfate. Removal of the solvent gave 5.3 g of oil. Crystallization from a pentanemethylene chloride-carbon tetrachloride mixture gave 1.9 g of 1-methyl-3-phenyldioxindole (**8**), mp 137–138°. The mother liquor was concentrated to give 4.2 g of oil that contained two components with *R*_f 0.28 and 0.80 (CHCl₃-CH₃OH, 95:5). Chromatography of this mixture through a silica gel column (C₆H₆ eluent) gave 0.3 g of an oil A (*R*_f 0.28) and 2.3 g of **8**, (*R*_f 0.80), mp 138–141°.

Recrystallization of the 4.2 g of crude **8** from methanol gave 3.9 g (71%) of **8**: mp 139–141°; ir (KBr), 2.98 (OH) and 5.81 μ (C=O); ir (CH₂Cl₂), 2.83 and 2.96 (LH) and 5.81 μ (C=O); nmr (CDCl₃), 3.09 (3 H, singlet, CH₃) and 4.28 ppm (1 H, singlet, OH); uv, $\lambda_{\max}^{\text{EtOH}}$ 210 m μ (ϵ 30,150), 258 (6300), and 290 (1230).

Anal. Calcd for C₁₅H₁₃NO₂: C, 75.3; H, 5.5; N, 5.9; O, 13.4. Found: C, 74.8; H, 5.5; N, 5.8; O, 13.4.

Crystallization of the oil A from pentane gave 0.27 g (7%) of 2-methylaminobenzophenone¹³ (**7d**): mp 65° (lit.¹³ 66° and 69°); ir (CCl₄), 3.02 (NH), and 6.16 μ (C=O); uv, $\lambda_{\max}^{\text{EtOH}}$ 236 m μ (ϵ 20,750) and 396 m μ (ϵ 6730); nmr (CDCl₃), 2.12 (1 H, singlet, NH), 2.88 (3 H, singlet, CH₃), 6.58 (2 H, quartet, aromatic H) and 7.20–7.82 ppm (7 H, multiplet, aromatic H).

Air Oxidation of the Sodium Salt of 3-Phenyl-2-Cumarone (9).—The 3-phenyl-2-cumarone (**9**) was prepared by the procedure of Elderfield and King¹⁴ from phenol and DL-mandelic acid. It had mp 112–113° (lit.¹⁴ mp 110–111°); ir (KBr), 5.57 μ (lactone C=O); nmr (CDCl₃), 4.82 (1 H, singlet, -CH) and 7.06–7.50 ppm (9 H, multiplet, C₆H₅ and C₆H₄).

To a flask equipped with a magnetic stirring bar, gas inlet tube, and a calcium chloride drying tube there was added 4.0 g (0.019 mol) of **9**, 200 ml of dry dimethylformamide, and 2.6 g (0.014 mol NaH) of sodium hydride as a 53% dispersion in mineral oil. The pale yellow solution was stirred and dry air was bubbled through the solution at room temperature for about 56 hr. The solution first turned green and then changed back to yellow after several hours. The dimethylformamide was removed *in vacuo*. The residue was treated with 25 ml of HCl and then extracted with chloroform. The chloroform was washed with saturated sodium chloride solution and water. After drying with magnesium sulfate the chloroform was removed to give 6.7 g of oil (contains mineral oil). The oil was taken up in methanol and treated with water until crystals formed. The substance was separated to give 3.60 g of solid, mp 158–167°. Tlc on silica gel (CHCl₃-CH₃OH 95:5) revealed two components, (*R*_f 0.20 and *R*_f 0.85). Vacuum sublimation (1.5 mm) at 100° (bath temperature) gave 0.150 g of oil (*R*_f 0.85, trace 0.20), and at 170° there was obtained an additional 2.70 g of solid, mp 166–169° (*R*_f 0.20). Chromatography of the oil on silica gel (developed with CHCl₃ and eluted with CHCl₃-CH₃OH, 95:5) gave 0.110 g (5%) of 2-hydroxybenzophenone (**10**): mp 41° (lit.¹⁶ 39–40°); *R*_f 0.85; ir (CCl₄), 3.10 (OH) and 6.16 μ (C=O); uv, $\lambda_{\max}^{\text{EtOH}}$ 259 m μ (ϵ 11,720) and 338 m μ (ϵ 4220). Comparison of the infrared and ultraviolet spectrum of **10** with those of an authentic sample¹⁶ of 2-hydroxybenzophenone showed them to be identical.

The crystalline fraction recrystallized from CCl₄-CHCl₃ to give 2.40 g (52%) of 4-phenyl-1,3-benzodioxan-4-ol-2-one (**11**): mp 170–172°; *R*_f 0.20 (CHCl₃-CH₃OH 95:5); ir (KBr), 3.20–4.05 (broad, ionic OH), 5.80 (O-CO-O), 6.72, 7.01, 7.36, 7.82, 8.12, and 8.93 μ ; uv, λ_{\max} 218 m μ (ϵ 6090) and 282 m μ (ϵ 4040) in ethanol and λ_{\max} 283 m μ (ϵ 4840) in 5% KOH-ethanol; nmr (CDCl₃), 6.88 (4 H, singlet), 7.21–7.84 (5 H, multiplet), and 9.02 ppm (1 H, exchangeable, OH). The mass spectrum exhibits a molecular ion peak at *m/e* 242 (C₁₄H₁₀O₄) with abundant fragment peaks at *m/e* 197 (M⁺ - HCO₂), 105 (C₆H₅CO⁺), and 77 (C₆H₅⁺). The p*K*_{mes}^{*} value¹⁷ was 5.5.

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(15) E. Moriconi, W. F. O'Connor, and W. F. Forbes, *ibid.*, **82**, 5454 (1960).

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(17) The value of p*K*_{mes}^{*}, the apparent p*K*_a value in a mixture of 80% methyl Cellosolve and 20% water was determined by the procedure of Simon: W. Simon, *Helv. Chim. Acta*, **41**, 1835 (1958).

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(10) K. Suzuki, E. K. Weisburger, and J. B. Weisburger, *J. Org. Chem.*, **26**, 2239 (1961).

(11) G. N. Walker, *ibid.*, **27**, 1929 (1962).

(12) L. H. Sternbach, R. I. Fryer, W. Metlesics, G. Sach, and A. Stempel, *ibid.*, **27**, 3781 (1962).

Anal. Calcd for $C_{14}H_{10}O_4$: C, 69.5; H, 4.2; O, 26.3. Found: C, 69.7; H, 4.3; O, 26.0.

Lithium Aluminum Hydride Reduction of 4-Phenyl-1,3-Benzodioxan-4-ol-2-one (11).—A solution of 1.3 g (0.0054 mol) of 11 in 25 ml of dry tetrahydrofuran was added dropwise in about 0.5 hr to a stirred slurry of 2.0 g (0.05 mol) of lithium aluminum hydride in 50 ml of tetrahydrofuran. The mixture was blanketed with nitrogen and refluxed for 120 hr. After cooling in an ice bath the reactants were treated with 4.0 ml of 2 *N* sodium hydroxide, 6.0 ml of water, and 25 g of anhydrous sodium sulfate. The salts were filtered off and washed with tetrahydrofuran. The combined filtrates were concentrated to give 0.9 g (73%) of 4-phenyl-1,3-benzodioxan-4-ol (12): mp 73–75° (diethyl ether-pentane); ir (KBr), 2.29 (OH), 3.43, 6.72, 7.92, 8.05, 9.36, and 10.30 μ ; uv, λ_{max} 230 m μ (ϵ 2955), 279 (shoulder, 3200), 283 (4220), and 289 (shoulder, 3210) in ethanol and λ_{max} 279 m μ (shoulder, ϵ 7050), 283 (7240), and 289 (shoulder, 5440) in 5% KOH-ethanol; nmr ($CDCl_3$), 2.43 (1 H, exchangeable, OH), 3.92 (2 H, broad singlet, O-CH₂O), 6.78 (4 H, singlet), and 7.20–7.78 ppm (5 H, multiplet). The mass spectrum exhibits a molecular ion peak at *m/e* 228 ($C_{14}H_{12}O_3$) with abundant fragment peaks at *m/e* 197 ($M^+ - CH_3O$), 105 ($C_6H_5CO^+$) and 77 ($C_6H_5^+$). The pK_{mes}^* value¹⁷ was 9.5.

Anal. Calcd for $C_{14}H_{14}O_3$: C, 73.7; H, 5.3; O, 21.0. Found: C, 73.6; H, 5.4; O, 21.2.

Registry No.—*N-p*-Chlorophenyl-DL-mandelamide, 10295-53-1; *N-p*-methoxyphenyl-DL-mandelamide, 15815-96-0; 6b, 15815-97-1; 6c, 15757-31-0; 8, 15757-32-1; 11, 15757-33-2; 12, 15757-34-3.

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The Synthesis and Desulfurization of 2,3,3-Trichloro- and 2,2,3-Trichlorothioxanes¹

MILTON L. EVANS² AND CLARENCE T. MASON

The Carver Research Foundation and the Department of Chemistry, Tuskegee Institute, Alabama

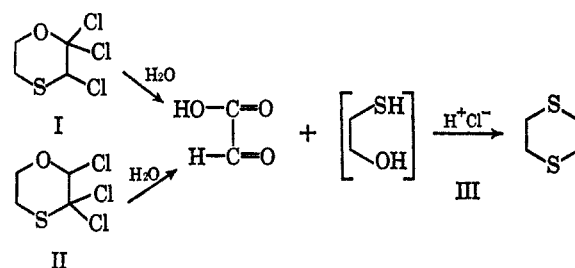
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In the course of a research project on fluorinated derivatives of ethers and thioethers, it became of interest to synthesize some chlorinated derivatives of 1,4-thioxane as intermediates. We chose 1,4-thioxane because it contains both ether and thioether linkages in the ring.

Only a few references to the chlorinated derivatives of 1,4-thioxane are noted in the literature. Haubein^{3,4} reported the preparation of several chlorothioxanes, among them a trichlorothioxane, but did not determine the positions of the chlorine atoms on the ring in the case of the trichlorothioxane. By a modification of the Haubein procedure⁴ we have recently synthesized and identified two trichlorinated derivatives of 1,4-thioxane, $C_4H_5OSCl_3$. When 1,4-thioxane is chlorinated in a CCl_4 solution at 80° and 75 g/hr, a white crystalline compound, $C_4H_5OSiCl_3$, melting at 58° is isolated in 90% yield. If the rate is increased to 150 g/hr, a white crystalline compound melting at 53°

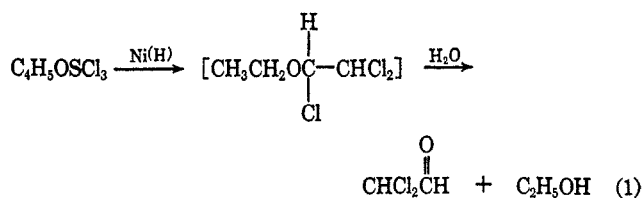
is isolated in 93% yield. These compounds are stable when kept free of moisture but fume in moist air with the elimination of HCl and have a characteristic obnoxious odor. They impart slight irritation when in contact with the skin.

Aqueous hydrolysis of both compounds yields glyoxylic acid and β -mercaptoethanol which was isolated as dithiane under these conditions.⁵ The hydrolysis products show that all three chlorine atoms were substituted on the same side of the thioxane ring.



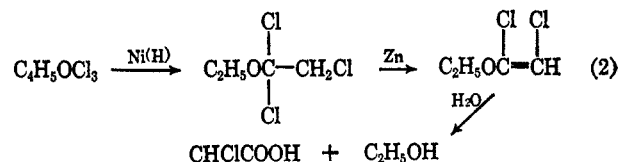
Since the instability of these compounds made structure determination difficult, desulfurization was decided upon as an unambiguous method.

It was found that an active preparation of Raney nickel, Raney nickel "C,"⁶ could be used to desulfurize the trichlorinated compounds without causing hydrogenolysis of the chlorine atoms. The compound melting at 53° was desulfurized according to the reaction in eq 1.

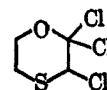


The α,α,β -trichloroethyl ether was not isolated but was hydrolyzed in solution. Identification of the hydrolysis products dichloroacetaldehyde and ethanol was taken as proof that the compound melting at 53° was 2,3,3-trichlorothioxane.

Desulfurization of the compound melting at 58° took place according to eq 2. In this case the heretofore



unknown α,α,β -trichloroethyl ether was hydrolyzed to monochloroacetic acid in solution. The desulfurization products confirmed that the compound melting at 58° is 2,2,3-trichlorothioxane.



The chlorination of 1,4-thioxane at 145° to give 2,3,3-trichlorothioxane is consistent with the chlorination

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(2) All inquiries should be addressed to this author at General Electric Silicone Products Department, Waterford, N. Y.

(3) A. H. Haubein, U. S. Patent 2,766,169 (1956).

(4) A. H. Haubein, *J. Amer. Chem. Soc.*, **81**, 144 (1959).

(5) E. Swistak, *Comp. Rend.*, **240**, 1544 (1955).

(6) C. D. Hurd and B. Rudner, *J. Amer. Chem. Soc.*, **73**, 5157 (1951).