Anal. Calcd. for $C_{21}H_{38}O_5Si_5$: C, 49.4; H, 7.5; mol. wt., 511. Found: C, 49.2; H, 7.6; mol. wt., 497 ± 5% (benzene, 25°).

3,5-Diphenyl-1,1,1,7,7,7-hexamethyl-3,5-bis(trimethylsiloxy)-tetrasiloxane.—To a solution of 0.390 g. (1.33 mmole.) of the tetrol in 40 ml. of ether was added 4.0 ml. (31.6 mmoles.) of trimethylchlorosilane and 2.0 ml. of pyridine. Work-up as above yielded 0.422 g. (57%) of distillate which mostly solidified to a waxy solid. Vapor phase chromatography showed this to be about 95% pure; a specimen collected by v.p.c. melted at 85–90° and had an infrared spectrum identical with that of a sample prepared by Simmler's[2] procedure. This spectrum (in CS_2) showed a very strong ν_aSiOSi band near 1062 cm.$^{-1}$ [probably a 1065 (s), 1052 (m) doublet] with a medium shoulder near 1105 cm.$^{-1}$, but no bands of SiOH groups.

Anal. Calcd. for $C_{24}H_{46}O_5Si_6$: C, 49.4; H, 8.0; mol. wt., 583. Found: C, 49.6; H, 8.0; mol. wt., 582 ± 5% (benzene, 25°).

Acknowledgment.—The authors are indebted to Mr. H. W. Middleton and Miss C. L. Harrington for the analyses, to Miss D. V. McClung for the spectra, and to Messrs. E. D. Brown and P. J. Launer of the General Electric Silicone Products Department for the preparation and spectrum of the authentic specimen of the tetrakistrimethylsilylation product.

The Reaction of Diethyl Malonate with Styrene Oxide

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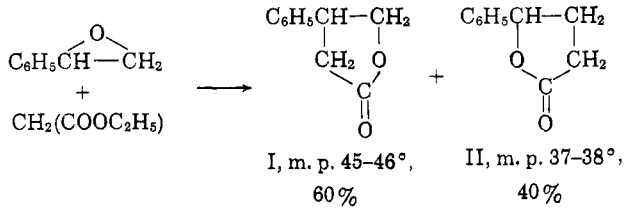
Russell and VanderWerf have reported[1] that the reaction of styrene oxide with diethyl malonate leads, after hydrolysis and decarboxylation, to γ-phenyl-γ-butyrolactone, which they report to have m.p. 45.5–46°. Other workers have made use of the supposed specificity of this reaction.[2]

In fact, two isomeric γ-lactones, I and II, are formed in this reaction. The compound of m.p. 45–46 is the β-phenyl-γ-lactone I and comprises approximately



I, m. p. 45–46°, 60%

II, m. p. 37–38°, 40%

60% of the product. The γ-phenyl isomer (II) melts, in agreement with numerous literature references[3] at 37–38°. The two isomers could not be separated by g.p.c. or fractional distillation, but were separable on thin layer or column chromatography using silica gel.

(1) R. R. Russell and C. A. VanderWerf, *J. Am. Chem. Soc.*, **69**, 11 (1947).

(2) (a) G. Van Zyl and E. E. van Tamelen, *ibid.*, **72**, 1357 (1950); (b) S. J. Cristol and R. F. Helmreich, *ibid.*, **74**, 4083 (1952); (c) E. E. van Tamelen and S. R. Bach, *ibid.*, **77**, 4683 (1955).

(3) (a) R. Fittig and H. W. Jayne, *Ann.*, **216**, 97 (1883); (b) N. H. Cromwell, P. L. Creger, and K. E. Cook, *J. Am. Chem. Soc.*, **78**, 4412 (1956); (c) R. Oda, S. Muneimuja, and M. Okano, *J. Org. Chem.*, **26**, 1341 (1961).

Experimental

Reaction of Styrene Oxide with Diethyl Malonate.—In a 5-l. round-bottom flask equipped with a condenser and a mechanical stirrer sodium metal (50 g., 2.2 g.-atoms) was dissolved in 2 l. of dry ethanol and diethyl malonate (325 g., 2.0 moles) was added. The solution was heated to reflux and styrene oxide (240 g., 2.0 moles) was added over a period of 2 hr. After heating for an additional 2 hr. sodium hydroxide (40 g., 1 mole) in 2 l. of water was added and the ethanol was removed by distillation. Concentrated hydrochloric acid (300 ml.) was carefully added and the organic material was extracted with methylene chloride. The methylene chloride was removed and the residue heated at 140° to induce decarboxylation. When the evolution of carbon dioxide ceased the material was distilled to give 200 g. (62% yield) of a mixture of β- and γ-phenyl-γ-butyrolactone, b.p. 103–105 at 0.2 mm. (lit.[1] b.p. 126–126.5 at 0.8 mm.).

Anal. Calcd. for $C_{10}H_{10}O_2$: C, 74.05; H, 6.22. Found: C, 73.84; H, 6.15.

β-Phenyl-γ-butyrolactone (I).—In some cases part of the product crystallized giving the lactone reported by Russell and VanderWerf, m.p. 45–46°. The n.m.r. spectrum of this isomer in CCl_4 solution consists of an eight-peak multiplet (AB part of an ABX) centered at δ 2.50, assigned to the methylene group adjacent to the carbonyl group, a doublet of triplets at δ 3.64 (benzylic hydrogen), and a six-peak multiplet (AB part of ABX with coincidental overlaps of two peaks) centered at δ 4.39. This assignment was supported by an experiment in which the reaction product was worked up in D_2O–DCl before decarboxylation. The product from that reaction had no absorption near δ 2.50 and the sextuplet at δ 3.64 had collapsed to a broadened triplet.

γ-Phenyl-γ-butyrolactone.—N.m.r. analysis of the crude, distilled reaction product showed that it contained only about 60% of the β-phenyl lactone and 40% of an isomer. No effective separation of the isomers could be obtained by gas chromatography. They were separated by column chromatography using a 3 ft. × 0.65 in. column and 80–20-mesh silica gel. The lactone mixture (1.5 g.) was added to the column in pentane and eluted with benzene–ethyl acetate (3:1). The β-phenyl lactone was eluted first and then the γ-phenyl-γ-butyrolactone (480 mg. of pure material), m.p. 37–38°. The middle fractions (~300 mg.) contained a mixture of the two lactones. This lactone had a complex four-proton pattern centered near δ 2.37 and a single, complex peak at δ 5.33 assigned to the benzylic proton also attached to a carbon bearing oxygen.

Acknowledgment.—We are indebted to Maria Wiedemann for the chromatography, and to the National Science Foundation for financial support.

Derivatives of 1,4-Xylene-2,5-diboronic Acid and 1,4-Xylene-2-boronic Acid[1]

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The remarkable stability toward hydrolytic deboronation of the simple boronolactone, boronophthalide[2] (I), suggests that compounds containing this system be made available for biological testing, for example as possible boron carriers in a proposed method of irradiation therapy.[3] This Note describes experiments on the preparation of the tricyclic diboronolactone (II), which may be named 1,5-dibora-2,6-dioxa-*sym*-hydrindacene-1,5-diol.

(1) Part of this work was supported by a grant from the U. S. Atomic Energy Commission; Report No. COO-314-9.

(2) H. R. Snyder, *et al.*, *J. Am. Chem. Soc.*, **80**, 835 (1958).

(3) A. H. Soloway, *ibid.*, **82**, 2442 (1960).

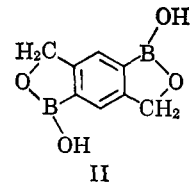
1,4-Xylene-2,5-diboronic acid (III) was prepared in 44% yield by the reaction of the Grignard reagent from 2,5-dibromo-1,4-xylene with *n*-butyl borate; some 5-bromo-1,4-xylene-2-boronic acid was obtained as a by-product. The diboronic acid closely resembled benzene-1,4-diboronic acid[4] in that it was resistant to dehydration and was readily esterified with N-methyldiethanolamine.[5] However, unlike the benzene diboronic acid, it could not be made to condense with *o*-phenylenediamine.[4,5] In the preparation of boronophthalide from *o*-tolueneboronic acid, the latter (or its anhydride) is brominated in chloroform or carbon tetrachloride solution. Attempts to brominate III in these solvents failed, presumably because of its extremely low solubility. However, when III was esterified with ethanol it became soluble in carbon tetrachloride, and bromination of the crude ester with 1 equiv. of N-bromosuccinimide in carbon tetrachloride under ultraviolet irradiation, followed by treatment with dilute alkali and dilute acid, did produce the desired dilactone II, although in poor (16%) yield. Increasing the ratio of N-bromosuccinimide to the theoretically required 2 equiv. per mole of the ester reduced the yield.

The dilactone II proved to be a surprisingly high-melting substance, giving no evidence of melting or decomposition at temperatures up to 350°. As expected from this behavior its solubility in common inert solvents is extremely low. If the lactone rings were opened by hydrolysis the resulting dihydroxydiboronic acid would, presumably, be quite soluble in water. The stability of the lactone rings, however, is such that the substance is scarcely affected by boiling with water for 1 hr. It is readily soluble in aqueous potassium hydroxide, but precipitates unchanged on acidification of the solution.

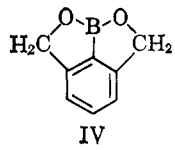
The infrared spectrum of II (Nujol mull) shows a strong absorption band at 980 cm.$^{-1}$, which is characteristic of boronophthalide and its derivatives.[6] The proton magnetic resonance spectrum of II in dimethyl sulfoxide shows peaks at τ = 0.75 (s), 2.24 (s), and 4.92 (s) p.p.m., with relative areas 1:1:2. These were assigned to hydroxyl, aromatic, and methylene protons, respectively, by analogy with the spectrum of boronophthalide.[7]

In a trial experiment, the action of 2 equiv. of N-bromosuccinimide on the anhydride of 5-bromo-1,4-xylene-2-boronic acid, followed by treatment with alkali and then acid, gave the expected product 4-bromo-5-hydroxymethylboronophthalide. The infrared spectrum of this compound (Nujol mull) showed the characteristic boronophthalide absorption band at 1000 cm.$^{-1}$ and no absorption between 1600 and 2000 cm.$^{-1}$. However, the same set of reactions, applied to 1,4-xylene-2-boronic acid anhydride, failed to yield 5-hydroxymethyl boronophthalide; instead, a mixture containing a carbonyl compound was obtained.

Reaction of 1,4-xylene-2-boronic acid anhydride with 1 equiv. of N-bromosuccinimide, etc., produced 5-methyl boronophthalide, as expected, in 46% yield. Further reaction of this with 1 equiv. of N-bromosuccinimide, followed by alkali and acid, gave a mixture from which a small amount of 2-formyl-5-methylbenzeneboronic acid was isolated. This compound was identified by elemental analysis and infrared and p.m.r. spectra. Like *o*-formylbenzeneboronic acid,[2] it was resistant to dehydration.



II



IV

These results recall the failure of Snyder, Lennarz, and Hawkins[7] to obtain the tricyclic compound IV by bromination of 1,3-xylene-2-boronic acid or 6-methylboronophthalide. It appears that in 1,4-xylene-2-boronic acid anhydride, preferential bromination of the methyl group *ortho* to boron occurs.

Experimental[8]

Preparation of 1,4-Xylene-2,5-diboronic Acid.—2,5-Dibromo-1,4-xylene (66 g., 0.25 mole) in dried tetrahydrofuran (250 ml.) was stirred rapidly and heated under reflux with magnesium turnings (12.2 g., 0.5 mole) for 20 hr. under an atmosphere of helium. The solution of Grignard reagent was then cooled and added under a stream of helium to *n*-butyl borate (115 g., 0.5 mole) cooled in Dry Ice–acetone. The mixture was allowed to come to room temperature and was then heated under reflux for 10 min. After cooling, the Grignard complex was decomposed by addition of an excess of cold, dilute hydrochloric acid.

The reaction products were extracted with ether and the solvents were distilled off. The residue was then heated with 1-butanol until no more butanol–water azeotrope distilled when butanol was distilled off under reduced pressure and the residue fractionated. The viscous, colorless liquid (52.5 g.) boiling between 164 and 176° (0.07 mm.) was stirred into cold water and allowed to stand; the suspension of diboronic acid thus obtained was heated in an open beaker for 5 min., then cooled. 1,4-Xylene-2,5-diboronic acid was filtered off, washed, and dried under vacuum, yield 21.3 g. (44%).

A sample for analysis recrystallized from a large volume of hot water as white powder; it was dried at 100° (0.1 mm.) over phosphorus pentoxide. It did not melt or decompose below 350°.

Anal. Calcd. for $C_8H_{12}B_2O_4$: C, 49.58; H, 6.20. Found: C, 49.54; H, 6.14.

Preparation of N-Methyl diethanolamine Diester of 1,4-Xylene 2,5-diboronic Acid.—The acid (0.98 g.) was heated and stirred with N-methyldiethanolamine (1.20 g.) in dry benzene (100-ml.); 85 ml. of solvent was distilled and the residue was dissolved in absolute ethanol. The solution was treated with Darco, filtered, and cooled; the ester which separated was recrystallized from ethanol and dried at 80° over phosphorus pentoxide, yield 0.99 g. (55%), m.p. 231–232° dec.

Anal. Calcd. for $C_{18}H_{30}B_2N_2O_4$: C, 60.04; H, 8.40; N, 7.78. Found: C, 60.15; H, 8.64; N, 7.62.

Preparation of the Dilactone II.—The tetraethyl ester of 1,4-xylene-2,5-diboronic acid was prepared by heating the acid (5.82 g.) in absolute ethanol (50 ml.); ethanol was distilled off and replaced by dried carbon tetrachloride. To the stirred, refluxing solution was added N-bromosuccinimide (5.5 g., 1 equiv.) and the mixture was irradiated with an ultraviolet lamp for 80 min. After cooling, the solution was shaken with cold, dilute potassium hydroxide solution; the alkaline extracts were filtered, acidified, and allowed to stand for 15 hr. The creamy powder that precipitated was filtered off, washed, crystallized from aqueous ethanol after treatment with Darco, and dried under vacuum, yield 0.94 g. (16.5%). A sample was recrystallized for analysis. It was dried at 100° (0.05 mm.) over phosphorus pentoxide for 2 hr. Heating to 350° under a microscope produced no visible change.

(4) D. R. Nielsen and W. E. McEwen, *J. Am. Chem. Soc.*, **79**, 3082 (1957).

(5) W. R. Bamford and S. Fordham, *Soc. Chem. Ind.* (London) *Monograph*, **13**, 320 (1961); *Chem. Abstr.*, **56**, 5991*b* (1962).

(6) W. J. Lennarz and H. R. Snyder, *J. Am. Chem. Soc.*, **82**, 2172 (1960).

(7) H. R. Snyder, W. J. Lennarz, and R. T. Hawkins, *ibid.*, **82**, 3053 (1960).

(8) Microanalyses were carried out by Mr. Josef Nemeth and his associates, University of Illinois.

Anal. Calcd. for $C_8H_8B_2O_4$: C, 50.61; H, 4.25; B, 11.40. Found: C, 50.29; H, 4.39; B, 11.21.

Increasing the amount of N-bromosuccinimide used to 2 equiv. reduced the yield of II.

Isolation of 5-Bromo-1,4-xylene-2-boronic Acid.—In the fractionation of the butyl ester of 1,4-xylene-2,5-diboronic acid a considerable amount of material, lower boiling than the required ester, was obtained. From this was isolated, by hydrolysis and several crystallizations, 5-bromo-1,4-xylene-2-boronic acid anhydride, m.p. 228°.

Anal. Calcd. for C_8H_8BBrO: C, 45.57; H, 3.82; Br, 37.90. Found: C, 45.58; H, 3.88; Br, 37.72.

Preparation of 4-Bromo-5-hydroxymethylboronophthalide.—5-Bromo-1,4-xylene-2-boronic acid anhydride (4.34 g.) in boiling carbon tetrachloride (600 ml.) was treated with N-bromosuccinimide (7.5 g., 2 equiv.) in small portions, under ultraviolet irradiation. The solution was cooled, filtered, and shaken with dilute potassium hydroxide solution; the alkaline extract was acidified and the product was extracted with ether. Ether was distilled off and the residue was crystallized from aqueous ethanol after treatment with Darco, yield 0.64 g. (13%). Recrystallization and drying at 100° (0.1 mm.) gave white needles, m.p. 279–280°.

Anal. Calcd. for $C_8H_8BBrO_3$: C, 39.56; H, 3.32. Found: C, 39.71; H, 3.37.

Preparation of 5-Methylboronophthalide.—1,4-Xylene-2-boronic acid anhydride (6.6 g.), m.p. 196°, in boiling carbon tetrachloride (700 ml.) was treated with N-bromosuccinimide (8.9 g., 1 equiv.) under ultraviolet irradiation. After filtration the solution was cooled and shaken with dilute potassium hydroxide solution which, on acidification, gave 5-methylboronophthalide, 3.42 g. (46%), m.p. 111–113°. Recrytallization from water raised the melting point to 115° although softening still began at 111°.

Anal. Calcd. for $C_8H_9BO_2$: C, 64.93; H, 6.13. Found: C, 65.17; H, 6.27.

Reaction of 5-Methylboronophthalide with N-Bromosuccinimide.—5-Methylboronophthalide (1.48 g.) in boiling carbon tetrachloride was stirred and heated with N-bromosuccinimide (1.8 g., 1 equiv.) under ultraviolet irradiation for 2 hr. The solution was filtered, cooled, and treated with dilute alkali; the extract was acidified and the product was taken up in ether. After evaporation of the ether, the residue was crystallized from water after treatment with Darco, then from chloroform–carbon tetrachloride, and twice more from water, yielding needles, m.p. 191–193.5°, after drying over phosphorus pentoxide.

Anal. Calcd. for $C_8H_9BO_3$: C, 58.60; H, 5.53. Found: C, 58.74; H, 5.58.

The infrared spectrum of this compound is very similar to that of *o*-formylbenzeneboronic acid,[9] having a strong absorption band at 1660 cm.$^{-1}$ (Nujol mull). The p.m.r. spectrum, in dioxane, shows peaks at τ = 0.06 (s), 2.32 (m), and 7.60 (s) p.p.m., with approximate relative areas 1:5:3. These were attributed to formyl, aromatic plus hydroxyl, and methyl protons, respectively.

(9) A. J. Reedy, Ph.D. Thesis, University of Illinois (1957).

Monoglucose Derivatives of Gentisic Acid

A. ZANE AND S. H. WENDER

The text below was inadvertently omitted from the Note that was published on p. 2078 of the July, 1964, issue.

Gentisic Acid 5-β-D-Glucopyranoside (I).—Methyl 2-hydroxy-5-*O*-β-D-glucopyranosyloxybenzoate[2] (4.3 g., 0.013 mole) was dissolved in barium hydroxide solution (210 ml., 0.43 *N*) and let stand for 5 hr. at room temperature. The reaction mixture then was neutralized with an equivalent amount of oxalic acid solution. After 1 hr., the precipitate was filtered off, and the clear, pale yellow filtrate was concentrated *in vacuo* at 38° until crystallization occurred. The product was filtered off, washed with a small amount of cold water, and then air-dried to give white, needle-like crystals (3.8 g., 92%), m.p. 97–100°. Crystallization from hot water (30 ml.) produced white needles, m.p. 98–100°.

Anal. Calcd. for $C_{13}H_{16}O_9 \cdot 2H_2O$ (352.29): C, 44.32; H, 5.72. Found: C, 44.51; H, 5.69.

Drying a sample for 6 hr. over phosphorus pentoxide at 110° *in vacuo* produced a semiopaque material, m.p. 126–128°.

Anal. Calcd. for $C_{13}H_{16}O_9 \cdot 1.5H_2O$ (343.28): C, 45.48; H, 5.58. Found: C, 45.21; H, 5.60.

R_f values in the BAW, 2% acetic acid, and IBFW systems were 0.36, 0.81, and 0.24, respectively. The water content of the dried product was 7.3% as obtained by a coulometric Karl Fischer method.[4]

Gentisic Acid 2-β-D-Glucopyranoside (II).—Methyl 5-hydroxy-2-*O*-β-D-glucopyranosyloxybenzoate[2] (10 g., 0.03 mole) was similarly treated with barium hydroxide solution (500 ml.) and oxalic acid. The precipitate was filtered off and, after concentration *in vacuo*, crystallization occurred. The solid material was filtered off and discarded, and the filtrate was taken to dryness *in vacuo*. The resulting solid was dissolved in warm ethyl alcohol (120 ml.) and filtered; the filtrate was concentrated to half volume and then added to an excess of ethyl acetate (1500 ml.). The resulting solution was concentrated to half volume, and the white product was filtered off, washed with ethyl acetate, and then air-dried to yield a white powder (3.3 g., 35%), m.p. 155–156°. Crystallization from hot water produced very fine needles, m.p. 129–131°. Subsequent recrystallizations from water did not raise this last melting point.

Anal. Calcd. for $C_{13}H_{16}O_9 \cdot H_2O$ (334.27): C, 46.71; H, 5.43. Found: C, 46.72; H, 5.42.

R_f values in BAW, 2% acetic acid, and IBFW were 0.40, 0.83, and 0.15, respectively. The water content of the product was 6.4% obtained by a coulometric Karl Fischer method.[4]

Acknowledgment.—The microanalyses were performed by Galbraith Laboratories, Knoxville, Tennessee, and the water analyses were done by Mr. Ronald Grigsby, University of Oklahoma. This work was supported in part by a National Institutes of Health Grant (GM-08276).

(4) A. S. Meyer Jr. and C. M. Boyd, *Anal. Chem.*, **31**, 215 (1959).