tempts to effect the reaction of triphenylsilane with allyl alcohol, *t*-butyl alcohol, triphenylcarbinol, tetrahydrofurfuryl alcohol, benzhydrol and tri-1-naphthylsilanol were unsuccessful. Hexaphenyldisiloxane was an important by-product in most of these reactions whether the desired product was obtained or not.

TABLE I

REACTIONS OF TRIPHENYLSILANE WITH COMPOUNDS OF THE TYPE ROH

ROH	Reflux, hr.	Yield, %	$(C_6H_5)_3SiOR$ M.p., °C.[a]	Silicon, %[b] Calcd.	Silicon, %[b] Found
C_2H_5OH	4.5	40	65–66	..	..[c]
HOC_2H_4OH	4	54	111–112.5	8.76	8.74, 8.83[d]
$CH_3OC_2H_4OH$	1	78	67–68	8.39	8.43, 8.47
s-C_4H_9OH	8	38	120–122	8.43	8.47, 8.52
$C_6H_5CH_2OH$	2.5	73	84–85.5[e]	7.66	7.81, 7.82
o-$CH_3C_6H_4OH$	3.5	82	72–74[e]	7.66	7.84, 7.93
$(C_6H_5)_3SiOH$[f]	4	45	220–221	..	..[c]
(*p*-$CH_3C_6H_4)_3$-SiOH[f]	72	35	160–162	..	..[c]

[a] Uncorrected. [b] Silicon analyses by the method of H. Gilman, B. Hofferth, H. W. Melvin and G. E. Dunn, THIS JOURNAL, **72**, 5767 (1950). [c] Identified by mixed melting point with a known sample. [d] Mol. wt. (cryoscopic in benzene) calcd. for $C_{20}H_{20}O_2Si$, 320.4; found, 320, 323. [e] A mixed m.p. between triphenylbenzyloxysilane and triphenyl-*o*-cresyloxysilane was depressed about 20°, showing that the triphenylbenzyloxysilane preparation is not complicated by rearrangements of the benzyl group as is the case in certain Grignard reactions. [f] Dissolved in dry xylene. See introduction to the Experimental part.

Previous methods for the preparation of triarylalkoxysilanes and triarylaryloxysilanes have been reviewed recently,[2] as have methods for the preparation of unsymmetrical disiloxanes.[3] The most convenient and versatile of the previous methods for the synthesis of either of these types of compounds has been the reaction between a triarylchlorosilane and a metal salt of an alcohol, phenol or silanol. Of the compounds listed in Table I only triphenylethoxysilane,[2,4] hexaphenyldisiloxane[3,5] and 1,1,1-triphenyl-3,3,3-tri-*p*-tolyldisiloxane[3] have been prepared previously.

Our data is not extensive enough to permit any broad generalizations as to the relative merits of the older methods and our preparation from triarylsilanes. It appears that the method using triarylchlorosilanes gives better yields and is successful in one case, at least, where the triarylsilane method failed. It should be mentioned, however, that optimum conditions for the triarylsilane method have not been worked out and particular care has not been taken to work under anhydrous conditions, so that the yields from this method may well be capable of improvement. The method using triarylsilanes, where applicable, has two advantages. First, the triphenylsilane is less subject to hydrolysis during manipulation than is triphenylchlorosilane. Second, all reagents and products except triphenylsilane and the oxysilane are frequently volatile liquids or gases. Thus, upon completion of the reaction, the liquids can be distilled and the product obtained as a residue without the necessity of separating it from an inorganic by-product.

Experimental

The triphenylsilane used in this investigation was prepared by the reduction of triphenylchlorosilane with lithium aluminum hydride.[6] All the compounds of Table I were synthesized by one procedure which is illustrated by the preparation of triphenyl-2-methoxyethoxysilane described below. The only important modification of this procedure was for the solid alcohols and silanols. The weight of these solid reagents theoretically necessary to react with 0.020 mole of triphenylsilane was dissolved in 75 ml. of xylene, and this solution was used in place of a liquid alcohol in the procedure below.

Triphenyl-2-methoxyethoxysilane.—A 125-ml. round-bottomed flask was equipped with a reflux condenser to the outlet of which a gas-washing bottle containing Nujol was attached through a calcium chloride tube. In the flask were placed 5.2 g. (0.020 mole) of triphenylsilane, 75 ml. (0.95 mole) of methyl cellosolve and 10 ml. (0.10 mole) of piperidine. Gas evolution began as soon as the piperidine was added, and it continued for half an hour while the solution was refluxed. When gas ceased to escape through the Nujol, the refluxing was continued for another half-hour, then the solvent was distilled under the vacuum from a water aspirator. On standing overnight the residual oil crystallized to a solid melting at 60–65°. This was taken up in a slight excess of hot petroleum ether (b.p. 60–70°). On cooling, the solution deposited 0.5 g. (9.4%) of hexaphenyldisiloxane, m.p. 210–211°. The petroleum ether solution was filtered, concentrated to about half-volume, and allowed to cool in a refrigerator. The crystalline material, 4.2 g., which separated was removed and the mother liquor again concentrated to half-volume. A second crop of 1.0 g. brought the total yield of triphenyl-2-methoxyethoxysilane to 5.2 g. (78%). Its melting point was 67–68°.

Attempted Preparations.—When triphenylsilane was treated with allyl alcohol in the manner described above, the only product isolated was hexaphenyldisiloxane in 62% yield. Similarly, only hexaphenyldisiloxane was obtained in attempted reactions with tetrahydrofurfuryl alcohol[7] and *t*-butyl alcohol. Attempted reaction of triphenylsilane with triphenylcarbinol, tri-1-naphthylsilanol and benzhydrol led to the formation of some hexaphenyldisiloxane and the recovery of 75–95% of the alcohol or silanol. Triphenylbenzhydryloxysilane has been prepared in 27% yield from triphenylchlorosilane and the sodium salt of benzhydrol.[8]

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(2) H. Gilman and G. N. R. Smart, *J. Org. Chem.*, **19**, 441 (1954).

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(4) A. Polis, *Ber.*, **19**, 1012 (1886); H. Gilman and L. S. Miller, THIS JOURNAL, **73**, 968 (1951).

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(6) H. Gilman and G. E. Dunn, THIS JOURNAL, **73**, 3404 (1951).

(7) Unpublished studies by J. J. Goodman.

(8) Unpublished studies by T. C. Wu.

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Studies on Bis-(benzylisoquinolines). I. Synthesis of *dl*-N-(4-Hydroxyphenylacetyl)-5-iodo-4-acetoxy-3-methoxyphenylalanine Methyl Ester

BY XORGE ALEJANDRO DOMINGUEZ, BEATRIZ GOMEZ
ERIKA HOMBERG AND JORGE SLIM

RECEIVED AUGUST 27, 1954

The alkaloid isochondrodendrine (I) is a bis-(benzylisoquinoline) of the curare group, and methods of synthesizing it are of medical as well as chemical interest.[1,2] An Ullmann diphenyl ether condensa-

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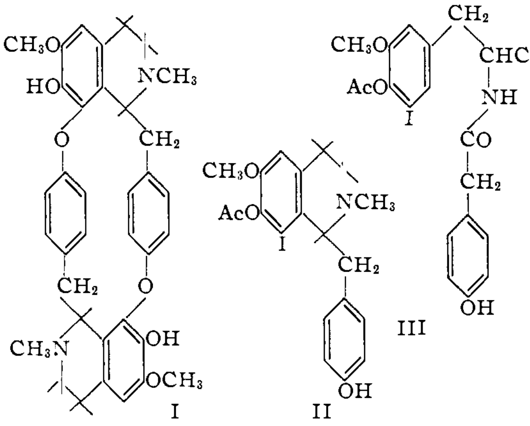
(1) A. Burger, "Medicinal Chemistry," Vol. I, Interscience Publishers, Inc., New York, N. Y., 1951, p. 390.

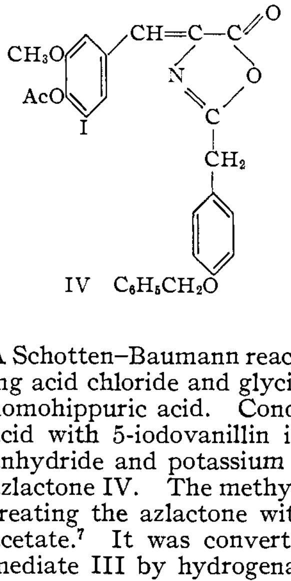
(2) R. H. F. Manske and H. L. Holmes, "The Alkaloids," Vol. IV, Academic Press, Inc., New York, N. Y., 1954, p. 199.

tion between two molecules of the tetrahydroisoquinoline II should yield racemic isochondrodendrine if steric hindrance about the iodine atoms is not prohibitive.[3] A method is described for preparing *dl*-N-(4-hydroxyphenylacetyl)-5-iodo-4-acetoxy-3-methoxyphenylalanine methyl ester (III), an important intermediate for preparing compound II by Galat's method for synthesizing papaverine.[4,5]

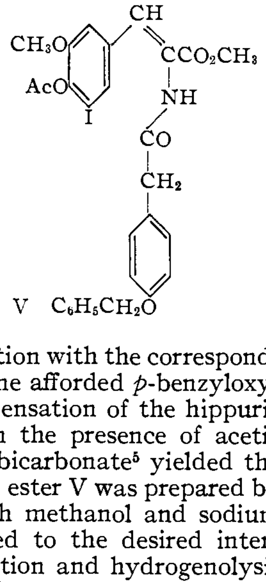
p-Benzyloxyacetophenone, prepared in 93% yield from *p*-hydroxyacetophenone, was converted to *p*-benzyloxyphenylacetic acid in 33% yield by the Kindler modification of the Willgerodt reaction.[6]



I II III



IV



V

A Schotten–Baumann reaction with the corresponding acid chloride and glycine afforded *p*-benzyloxyhomohippuric acid. Condensation of the hippuric acid with 5-iodovanillin in the presence of acetic anhydride and potassium bicarbonate[5] yielded the azlactone IV. The methyl ester V was prepared by treating the azlactone with methanol and sodium acetate.[7] It was converted to the desired intermediate III by hydrogenation and hydrogenolysis in the presence of Raney nickel W-6.[8,9] The structure of III is supported by its molecular weight, its hydrolysis to an amino acid (positive ninhydrin test), and by the isolation and identification of *p*-hydroxyphenylacetic acid. The stability of the iodine atom to hydrogenolysis may be attributable to steric hindrance.

Experimental

***p*-Benzyloxyacetophenone.**—A mixture of 26 g. (0.2 mole) of *p*-hydroxyacetophenone, 25.3 g. (0.2 mole) of benzyl chloride, 14 g. of potassium hydroxide and 50 ml. of ethanol was refluxed for 3 hours, then poured into 250 ml. of water. The precipitate was washed with water and dried; it weighed 40 g. (93% yield) and melted at 94–95°. A sample recrystallized from ethanol melted at 95–96° (reported[10] m.p. 96–97°). The semicarbazone (from methanol) melted at 197–199°.

Anal. Calcd. for $C_{16}H_{17}O_2N_3$: N, 15.49. Found: N, 15.62.

***p*-Benzyloxyhomohippuric Acid.**—*p*-Benzyloxyphenylacetic acid was prepared in 33% yield according to Weiss[6] and melted at 120–121° (recorded[11] m.p. 121°). A mixture of 2.5 g. (0.01 mole) of it, 2.5 ml. (0.05 mole) of thionyl chloride and 25 ml. of petroleum ether (b.p. 30–60°) was refluxed on the steam-bath for one hour. The petroleum ether and excess thionyl chloride were removed *in vacuo*. The solid acid chloride was mixed at once with a cold, stirred solution of 0.8 g. (0.011 mole) of glycine in 12 ml. of 10% sodium hydroxide solution. The product was precipitated by adjusting the *p*H to 5–5.5 by adding diluted hydrochloric acid (1:1). After drying, it weighed 2.2 g. (72% yield). It melted at 190–192° (from 2:1 benzene–ethanol).

Anal. Calcd. for $C_{17}H_{17}O_4N$: C, 68.21; H, 5.73; N, 4.68. Found: C, 68.11; H, 5.43; N, 4.76.

Azlactone IV.—5-Iodovanillin was prepared by the method of Erdtmann[12] as modified by Pepper and MacDonald.[13] It was obtained in 91% yield, m.p. 176° (reported[12] m.p. 177°). A mixture of 2 g. (0.007 mole) of 5-iodovanillin, 2 g. (0.0067 mole) of *p*-benzyloxyhomohippuric acid, 1 g. of potassium bicarbonate and 8 ml. of acetic anhydride was refluxed for 45 minutes. It was then precipitated by pouring into ice-cold water. The product was recrystallized from ethanol and melted at 188°. The residual oil was boiled in acetic acid with Norite, yielding a second crop of the azlactone; the over-all yield was 2.5 g. (72%).

Anal. Calcd. for $C_{27}H_{22}O_6NI$: C, 50.1; H, 3.8; N, 2.5. Found: C, 50.3; H, 3.9; N, 2.7.

Methyl α-Amino-N-(4-benzyloxyphenylacetyl)-5-iodo-4-acetoxy-3-methoxycinnamate (V).—A solution of 2 g. (0.0035 mole) of the azlactone IV and 0.5 g. of anhydrous sodium acetate in 20 ml. of methanol was refluxed for 2.5 hours. The cooled mixture was poured into ice-water, and the crystals were collected after one hour. After recrystallization from benzene they weighed 1.6 g. (78% yield) and melted at 189–190° (mixed m.p. with the azlactone, 168–173°).

Anal. Calcd. for $C_{28}H_{26}O_7NI$: C, 54.6; H, 4.22; N, 2.28. Found: C, 54.7; H, 4.4; N, 2.6.

***dl*-N-(4-Hydroxyphenylacetyl)-5-iodo-4-acetoxy-3-methoxyphenylalanine Methyl Ester (III).**—A mixture of 1.5 g. (0.0026 mole) of the ester V, 0.1 g. of Raney nickel W-6 and 30 ml. of methanol was shaken with hydrogen at low pressure (100 mm.) for ten hours. After filtration, washing and evaporation there was obtained 570 mg. (40% yield) of the product III, m.p. 182°.

Anal. Calcd. for $C_{21}H_{22}O_7NI$: C, 47.9; H, 4.2; N, 2.66; mol. wt., 513. Found: C, 48.2; H, 4.3; N, 2.84; mol. wt. (Rast), 531.

A sample of III was hydrolyzed with 20% hydrochloric acid by refluxing for 4 hours. After evaporation to near dryness and cooling, the precipitated *p*-hydroxyphenylacetic acid was collected, washed and dried. It melted at 141–143°; mixed with a known specimen it melted at 142–143°. After neutralization, the filtrate gave a positive ninhydrin test.

Acknowledgments.—The authors wish to express their appreciation to Ing. Carlos Duhne and Ing. Carlos Lopez G. for their interest in this investiga-

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[5] A. Galat, *ibid.*, **72**, 4436 (1950).

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[8] H. Adkins and H. R. Billica, This Journal, **70**, 695 (1948).

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tion, and to Amelia Saldaña and Delia Ortegon for their technical assistance.

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Fatty Acid Esters of 3-Butene-1,2-diol. III. The Polymerization of Erythryl Divalerate[1]

BY ELIZABETH DYER AND STEWART C. BROWN

RECEIVED SEPTEMBER 9, 1954

Since the diacetate of 3-butene-1,2-diol (erythryl diacetate) was shown previously[2] to yield a homopolymer similar in degree of polymerization to polyallyl acetate,[3] it was of interest to check the allylic behavior of the erythryl esters by a more detailed study of another monomer. Erythryl divalerate therefore was heated with benzoyl peroxide for a study of (a) the rate of disappearance of monomer and of peroxide and (b) the nature and molecular weight of the product. Brief studies also were made of the copolymerization of erythryl divalerate with styrene.

TABLE I

POLYMERIZATION OF ERYTHRYL DIVALERATE AT 80° WITH BENZOYL PEROXIDE AS INITIATOR

Bz_2O_2 concn., %	k,[a] hr.$^{-1}$	dM/dP
2.31	0.197	19.0
4.47	.217	13.2
7.45	.228	8.8

[a] First-order velocity constants for the decomposition of benzoyl peroxide, obtained by the method of least squares from the data of Fig. 1.

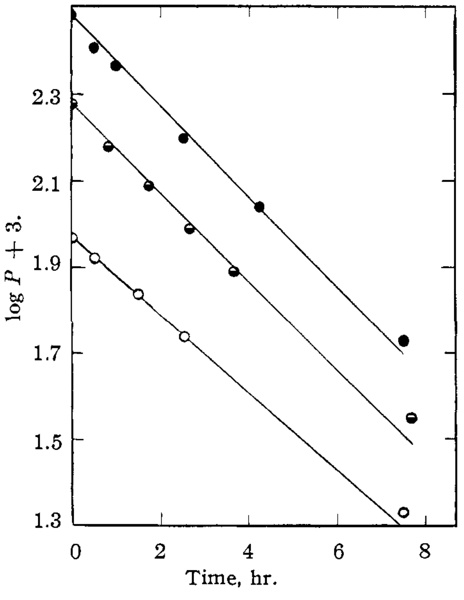


Fig. 1.—Rate of decomposition of benzoyl peroxide in polymerizing erythryl divalerate at 80°. Initial concn. of Bz_2O_2: O, 2.31%; ⊖, 4.47%; ●, 7.45%.

For the kinetic studies, solutions of benzoyl peroxide in erythryl divalerate, at three different concentrations, were heated at 80° and analyses were made for monomer and peroxide after varying intervals of time. The results are shown in Table I and in Fig. 1.

Figure 1 shows that the decomposition of benzoyl peroxide in erythryl divalerate is an unimolecular reaction up to at least 77% completion. The values of the first order rate constants are close to those reported[3,4] for allyl acetate under similar conditions.

A graph of the monomer concentration against peroxide concentration (Fig. 2) shows that in any given polymerization the ratio of dM/dP is constant for benzoyl peroxide and erythryl divalerate, as was observed[3,4] for other allyl esters.

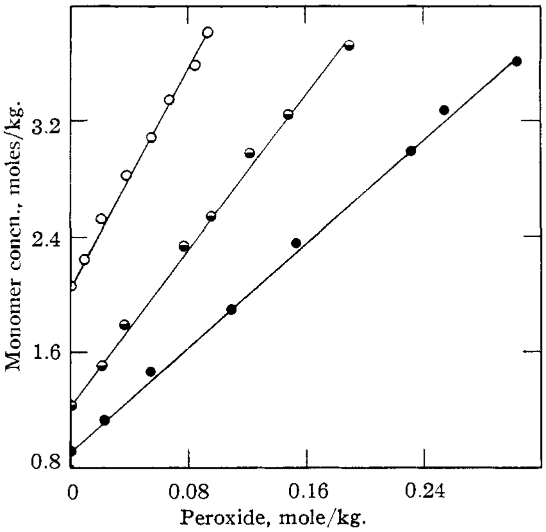
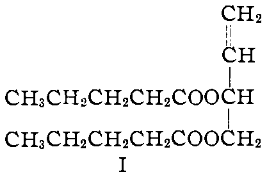


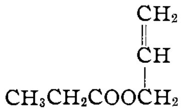
Fig. 2.—Monomer concn. plotted against polymer concn. in the polymerization of erythryl divalerate: initial concn. of Bz_2O_2, O = 2.31%; ⊖, 4.47%; ●, 7.45%.

The values of dM/dP observed for erythryl divalerate are lower than those reported[3,4] for most other allyl esters at comparable concentrations of benzoyl peroxide. For example, the dM/dP values for erythryl divalerate are 25–35% lower than those for allyl acetate, and about 15% lower than those for allyl propionate This lowering of the dM/dP value may be due to an increased ease of degradative chain transfer at the α-position of the erythryl divalerate (I), where there is a tertiary hydrogen atom, while the allyl ester II has only secondary hydrogen at this position.



$$\begin{array}{r} CH_2 \\ \| \\ CH \\ | \\ CH_3CH_2CH_2CH_2COOCH \\ | \\ CH_3CH_2CH_2CH_2COOCH_2 \end{array}$$

I



$$\begin{array}{r} CH_2 \\ \| \\ CH \\ | \\ CH_3CH_2COOCH_2 \end{array}$$

II

Moreover, there is increased opportunity for radical attack on the erythryl ester, since there are two carbonyl groups in the erythryl ester next to which attack can occur with the formation of a new reso-

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[1] From the Master's Thesis of Stewart C. Brown, University of Delaware, 1954.

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