Anal. Calcd. for $C_{13}H_8Cl_2O$: C, 62.18; H, 3.21; Cl, 28.24. Found: C, 62.41; H, 3.62; Cl, 28.35.

The same ketone was prepared by heating at reflux a mixture of bis-(*o*-chlorophenyl)-carbinol and sodium dichromate in sulfuric acid and acetic acid for three hours. The neutral fraction gave upon distillation a nearly quantitative yield of oil, b. p. 127–135° (1 mm.), which upon crystallization from ethanol, melted at 45.4–46.6 (cor.).

2,4-Dinitrophenylhydrazones of the Isomeric Dichlorobenzophenones.—To 1.0 g. (0.0073 mole) of 2,4-dinitrophenylhydrazine dissolved in 2 ml. of concentrated sulfuric acid 15 ml. of 95% ethanol was added; this solution was then mixed with a solution of 1.25 g. (0.005 mole) of the ketone dissolved in 25 ml. of 95% ethanol. In most cases crystallization was complete in one to two hours; the *o,o'*-dichlorobenzophenone was allowed to stand overnight as crystallization was very slow. Yields were not calculated, but were high. The crude 2,4-dinitrophenylhydrazones were dissolved in hot pyridine and recrystallized by the addition of warm 95% ethanol. This is similar to the method of Brady.[29] The properties of the dinitrophenylhydrazones are given in Table IV.

Summary

Studies have been made of the composition of several samples of technical DDT and a sample of "by-product oil" recovered from a process of refinement of crude DDT prepared from "chlorinated alcohol" and chlorobenzene. Technical DDT has been found to contain upwards of 70% of 1-trichloro-2,2-bis-(*p*-chlorophenyl)-ethane (*p,p'*-DDT), the most active insecticidal ingredient. The major impurity is 1-trichloro-2-*o*-chlorophenyl-2-*p*-chlorophenylethane (*o,p'*-DDT).

(29) Brady, *J. Chem. Soc.*, 756 (1931).

TABLE IV

2,4-DINITROPHENYLHYDRAZONES OF ISOMERIC DICHLOROBENZOPHENONES

Isomer	M. p. of derivative, Crude, °C.	M. p. of derivative, Pure, °C.	Analyses,[a] % C	H	Cl
o,o'	200–205	206–208	53.3	2.8	13.2
o,p'	225–228	230–231	52.8	2.8	13.1
o,m'	253–257	255–257	52.8	3.0	12.9
m,m'	234–238	235–238	53.2	2.8	12.9
m,p'	253–256	258–260	52.9	2.8	12.8
p,p'	195–203	238–240	53.3	2.8	13.2

[a] Calcd. for $C_{19}H_{12}O_4N_4Cl_2$: C, 52.9; H, 2.8; N, 13.0.

Lesser amounts of twelve other organic impurities have been found, the presence of which may be explained on the basis of side reactions involving chloral, chlorobenzene, sulfuric acid, and impurities in the starting materials.

Work on the proof of structure, including synthesis, of the by-product materials, is described.

The *o,p'*- and the *m,p'*-isomers of *p,p'*-DDT and various derivatives of these compounds are described.

The synthesis of all the isomeric dichlorobenzophenones with one chlorine atom on each ring and of the 2,4-dinitrophenylhydrazones of these ketones is described.

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[CONTRIBUTION FROM THE GATES AND CRELLIN LABORATORIES OF CHEMISTRY, CALIFORNIA INSTITUTE OF TECHNOLOGY, No. 1006]

The Reactions of Antisera Homologous to Various Azophenylarsonic Acid Groups and the *p*-Azophenylmethylarsinic Acid Group with Some Heterologous Haptens*

BY DAVID PRESSMAN, ARTHUR B. PARDEE AND LINUS PAULING

Recently we have made quantitative studies of the combining powers of substituted phenylarsonic acids and of naphthylarsonic acids with antisera homologous to the *o*-, *m*-, and *p*-azophenylarsonic acid groups[1,2,3] (anti-R_o, -R_m, and -R_p sera, respectively) and to the *p*-(*p*-azophenylazo)-phenylarsonic acid group[2,4] (anti-R'_p serum). The quantitative studies of these antisera have now been extended to include their reactions with substances related to phenylarsonic acid but in which the aromatic nucleus attached to the arsenic atom of the arsonic acid group is replaced by an aliphatic or alkaryl residue, or one of the hydroxy groups of the arsonic acid is replaced by a second organic residue to form an arsinic acid, or the arsonic acid group is altered to form the dimethylarsine dihydroxide or the arsine oxide group, or the arsenic atom is replaced by another atom (phosphorus, antimony, or sulfur). We have studied also the reactions of antiserum homologous to the *p*-azophenylmethylarsinic acid group (anti-R_{CH_3} serum) with several heterologous substances.

Some similar reactions of antisera with heterologous substances have been studied qualitatively by other investigators. Erlenmeyer and Berger[5] found that an antiserum to horse serum coupled with diazotized *p*-aminophenylarsonic acid formed precipitates with ovalbumin coupled with diazotized *p*-aminophenylphosphonic acid as well as with the antigen from diazotized *p*-aminophenylarsonic acid, but not with the antigen from diazotized *p*-aminophenylstibonic acid. Haurowitz

* The Serological Properties of Simple Substances. XI. For No. X of this series see THIS JOURNAL, **67**, 1219 (1945).

(1) D. Pressman, D. H. Brown, and L. Pauling, *ibid.*, **64**, 3015 (1942).

(2) L. Pauling, D. Pressman, and A. L. Grossberg, *ibid.*, **66**, 784 (1944).

(3) L. Pauling and D. Pressman, *ibid.*, **67**, 1003 (1945).

(4) D. Pressman, J. T. Maynard, A. L. Grossberg, and L. Pauling, *ibid.*, **65**, 728 (1943).

(5) H. Erlenmeyer and E. Berger, *Biochem. Z.*, **255**, 429 (1932).

and Breinl[6] tested the inhibition of precipitation of anti-R_p serum and R_p-antigen by methylarsonic acid, dimethylarsinic acid, di-(*p*-aminophenyl)-arsinic acid, *p*-hydroxyphenylarsine oxide, *p*-aminophenylarsine oxide, *p*-acetaminophenylstibonic acid, 2-methyl-4-dimethylaminophenylphosphonic acid, phosphoric acid, and arsenic acid, and found that no inhibition was produced except a slight inhibition by arsenic acid.

In the work reported here we have determined quantitatively the combining powers of the substances studied with antibody by the application of the theory of heterogeneous antisera,[2] which permits the evaluation of the average inhibition constant K_0' and of the index σ of the effective heterogeneity of the antiserum.

Experimental Methods

Protein Antigens.—The R_{CH_3}-sheep serum for inoculation was prepared by diazotizing 0.1, 0.2, and 0.3-g. portions of *p*-aminophenylmethylarsinic acid, coupling each portion with a 50-ml. portion of sheep serum at *p*H about 9, and then mixing the three preparations. The antigen was purified by precipitating twice at *p*H 4 from 150 ml. of solution and finally dissolving at *p*H 8 in saline solution. The R_{CH_3}-ovalbumin test antigen was prepared by diazotizing 0.18 g. of *p*-aminophenylmethylarsinic acid and coupling the product with 2 g. of crystallized ovalbumin at *p*H 9. The azoprotein was precipitated three times with acid from 50 ml. of solution and was then brought to *p*H 8.

The R_o-, R_m-, R_p-, and R_p'-antigens have been described previously.[3,4]

Antisera.—Anti-R_{CH_3} serum was prepared by a method similar to that described previously[7] for the preparation of anti-R_p sera. The preparation of anti-R_o-, -R_m-, -R_p-, and -R_p' sera has been described elsewhere.[1,4,7] Two different pools of anti-R_p serum and of anti-R_p' serum were used.

Reaction of Antiserum with Antigen and Hapten.—The reactants were mixed and permitted to stand for one hour at room temperature and over two nights at 5°. The precipitates were centrifuged, washed three times with 10-ml. portions of 0.9% sodium chloride solution, and analyzed by our standard method.[8] All dilutions were made with borate buffer solution[1] of *p*H 8.0.

Preparation of Substances

The substances not described below have been described elsewhere[1,4] or were commercial products.

Benzylarsonic acid was prepared by the method of Quick and Adams[9]: m. p., 166–168°; reported, 167–168°.

Phenylmethylarsinic acid was prepared by the method of Bertheim[10]; m. p., 177–179.5°; reported, 179.5°.

***p*-Aminophenylmethylarsinic acid** was prepared by the method of Bertheim[10]: m. p., 201.5–202.0°; reported, 201°.

***p*-Aminophenylarsine oxide** was prepared by the method of Ehrlich and Bertheim[11]: m. p., 90–100°; reported, 80–100°.

Phenyldimethylarsine hydroxybromide was prepared by dissolving 7.2 g. of phenyldimethylarsine (prepared by the method of Winmill[12]) in 150 ml. of ligroin (80–100°), and adding 10 ml. of water and a 25% solution of bromine in petroleum ether until a permanent yellow color was obtained. The aqueous phase was separated and evaporated. The residue was recrystallized twice from 85% acetone solution: m. p., 161–162°; reported, 162°.

Phenyldimethylarsine dihydroxide was prepared by adding silver oxide to a solution of the hydroxybromide (see Steinkopf and Schwen[13]). The resulting solution was used directly in the hapten inhibition experiments.

Phenylphosphonic acid was prepared by the method of Michaelis[14]: m. p., 158°; reported, 158°.

Phenylstibonic acid was prepared by the method of Schmidt.[15]

Discussion

Data concerning the hapten inhibition of precipitation of anti-R_o, -R_m, -R_p, and -R_p' serum with R_o-, R_m-, R_p-, and R_p'-ovalbumin, respectively, are given in Table I, of anti-R_p and -R_p' serum with "Chrom" R_{p_3}'[16] in Table II, and of anti-R_{CH_3} serum with R_{CH_3}-ovalbumin in Table III. The serum pools of Tables I and II are different. Where sufficient inhibition was observed to permit the calculation of the heterogeneity constant σ and the hapten inhibition constant K_0' by the application of the heterogeneity theory,[2] these values have been included in the tables.

The Effect of Replacing the Arsenic Atom by Phosphorus, Antimony, or Sulfur.—Their nearly equal values of K_0' strongly indicate that the structures of phenylarsonic acid and phenylphosphonic acid in aqueous solution at *p*H 8 are closely similar. Our results substantiate the observation by Erlenmeyer and Berger[5] that *p*-azophenylphosphonic acid antigens form precipitates with anti-R_p sera. The failure of Haurowitz and Breinl[6] to observe inhibition of precipitation of an anti-R_p serum with an R_p-antigen by a substituted phenylphosphonic acid can be attributed to the steric effect of the ortho methyl-group in the substance they used, 2-methyl-4-dimethylaminophenylphosphonic acid.

It is interesting that phenylphosphonic acid combines with the antisera somewhat more strongly than does the homologous phenylarsonic acid. A reasonable explanation of this observation can be proposed. The phosphonic acid group is smaller than the arsonic acid group, and accordingly can easily enter a cavity large enough to accommodate an arsonic acid group. Due to the smaller size of the phosphonic acid group, its negative charge in the ionized state might approach more closely to the positive charge which is probably situated on the antibody molecule in the neighboring region, and the increased coulomb attraction might thus lead to a greater combining power with the antibody. However, in order to bring this effect into play, the attached benzene nucleus is shifted from the position in which it can exert the optimum combining force. This shift takes place with a decrease in the total free-energy of combination only with those antibody

(6) F. Haurowitz and F. Breinl, *Z. physiol. Chem.*, **214**, 111 (1933).
(7) L. Pauling, D. Pressman, D. H. Campbell, C. Ikeda, and M. Ikawa, THIS JOURNAL, **64**, 2994 (1942).
(8) D. Pressman, *Ind. Eng. Chem., Anal. Ed.*, **15**, 357 (1943).
(9) A. J. Quick and R. Adams, THIS JOURNAL, **44**, 811 (1922).
(10) A. Bertheim, *Ber.*, **48**, 350 (1915).
(11) P. Ehrlich and A. Bertheim, *ibid.*, **43**, 919 (1910).
(12) T. F. Winmill, *J. Chem. Soc.*, **101**, 723 (1912).
(13) W. Steinkopf and G. Schwen, *Ber.*, **54**, 2795 (1921).
(14) A. Michaelis, *ibid.*, **6**, 816 (1873).
(15) H. Schmidt, *Ann.*, **421**, 174 (1920).
(16) "Chrom" R_{p_3}' is

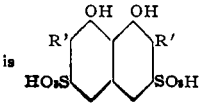


TABLE I

EFFECT OF HAPTENS ON THE PRECIPITATION OF ANTI-R_o, -R_m, -R_p, AND -R'_p SERA WITH R_o-, R_m-, R_p-, AND R'_p-OVALBUMINS, RESPECTIVELY

With anti-R_o serum: antigen solution, 1 ml. (65 μg.); anti-R_o serum, 1 ml.; hapten solution, 1 ml. With anti-R_m, anti-R_p, and anti-R'_p sera: antigen solution, 0.5 ml. (190 μg. R_m-ovalbumin, 210 μg. R_p-ovalbumin, and 150 μg. R_p-ovalbumin, respectively); antiserum, 0.5 ml.; hapten solution, 0.5 ml.; *p*H of supernates, 8.1.

Hapten	K'_0	σ	Molar concn. of hapten solution added × 10^5: 0.97	3.9	7.8	15.6	31.3	62.5	125	250	500	1000
			Amount of precipitate[a]									
Anti-R_o serum and R_o-ovalbumin												
Arsenic acid								760		850		790
Methylarsonic acid					740		(710)		730			
Dimethylarsinic acid					650		530		730			
Benzylarsonic acid	0.001	3.5						950		770		650
Phenylarsonic acid	1.00	4	600	480		270						
Phenylmethylarsinic acid	0.04	7						510		420		310
Phenylphosphonic acid	2.05	3	600	200		140						
Benzenesulfonic acid	0.001	7						740		630		610
Anti-R_m serum and R_m-ovalbumin												
Arsenic acid												956
Methylarsonic acid												945
Dimethylarsinic acid												956
Benzylarsonic acid										925		800
Phenylarsonic acid	1.00	2.5					861		682		428	
Phenylmethylarsinic acid												855
Phenylphosphonic acid	1.02	2.5					855		695		419	
Benzenesulfonic acid												951
Anti-R_p serum and R_p-ovalbumin												
Arsenic acid												833
Methylarsonic acid												895
Dimethylarsinic acid												1070
Benzylarsonic acid										968		(832)
Phenylarsonic acid	1.00	2					838	460	460		(242)	
Phenylmethylarsinic acid												987
Phenylphosphonic acid	0.98	3					705		544		264	
Benzenesulfonic acid												1000
Anti-R'_p serum and R'_p-ovalbumin												
Arsenic acid												885
Methylarsonic acid										970		875
Dimethylarsinic acid												1190
Benzylarsonic acid	0.047	2.5						(1040)		750		511
Phenylarsonic acid	1.00	2.5			830		556		317			
Phenylmethylarsinic acid								1040		977		880
Phenylphosphonic acid	1.84	3			700		478		254			
Benzenesulfonic acid												906

[a] The amounts of precipitate are in parts per mille of the amounts in absence of hapten: 102, 692, 322, and 268 μg. for anti-R_o, anti-R_m, anti-R_p, and anti-R'_p sera, respectively. Blanks of antiserum and buffer: 11, 4, 6, and 8 μg., respectively. All values are averages of triplicate analyses, with mean deviation ± 5, 2, 3, and 3%, respectively.

molecules which do not fit the benzene ring too closely. Thus a considerably increased value of K'_0 is observed with anti-R'_p serum, which is known to require only a loose fit,[3,4] and with anti-R_o serum, in which the region specific to the arsonic acid group is probably near the opening of the cavity, whereas no significant effect is observed with anti-R_m serum and anti-R_p serum.

Phenylstibonic acid was found not to combine appreciably with anti-R_p serum or anti-R'_p serum. The solution of the salt became cloudy shortly after mixing, presumably because of polymerization, as has been discussed by Schmidt.[15] Erlenmeyer and Berger's observation that a *p*-azophenylstibonic acid-antigen did not form a precipitate with an anti-R_p serum is probably more significant than our observation. Their result shows that either depolymerization did not take place even on coupling with protein or the structure of the monomer is quite different from that of phenylarsonic acid. The latter possibility is not unreasonable; antimony has a pronounced tendency to form complexes in which its coördination number is greater than four.[17]

The replacement of the arsonic acid group of phenylarsonic acid by a sulfonic acid group greatly decreases the combining power with anti-

(17) L. Pauling, THIS JOURNAL, **55**, 1895 (1933).

TABLE II

EFFECT OF HAPTENS ON THE PRECIPITATION OF ANTI-R_p AND ANTI-R'_p SERA WITH "CHROM" R'_p

With anti-R_p serum: antigen solution, 1.0 ml. (38 μg.); antiserum (pool B), 1.0 ml.; hapten solution, 1.0 ml.; *p*H of supernates, 8.1. With anti-R'_p serum: antigen solution, 1.5 ml. (25 μg.); antiserum (pool B), 0.5 ml.; hapten solution, 1.0 ml.; *p*H of supernates, 7.9.

Hapten	Anti-R_p serum K'_0	σ[a]	Anti-R'_p serum K'_0	σ[a]	Moles of hapten added × 10^8: 1.4	4.1	12.3	37	111	333	1000	1.4	4.1	12.3	37	111	333	1000
					Amount of precipitate with anti-R_p serum[b]							Amount of precipitate with anti-R'_p serum[b]						
Methylarsonic acid	0.01	(2)	0.01	(2.5)			1000	1030	1000	910	720			1030	1080	950	930	770
Benzylarsonic acid	0.02	3.5	.3	(2.5)			950	890	770	650	470		1090	880	880	270	160	
Phenylarsonic acid	1.00	1.5	1.00	2	1000	900	670	390					900	720	510			
p-Aminophenylarsonic acid	1.66	1.5	1.66	3.5	970	810	580	340					740	580	430			
Phenylmethylarsinic acid	0.01	(2)	0.01	(2.5)			1000	1010	1020	920	660			1000	960	970	930	780
p-Aminophenylmethylarsinic acid	.015	(2)	.01	(2.5)			1020	980	950	800	610			1030	950	1070	900	780
p-Aminophenylarsine oxide	.00		.00							990							1030	
Phenyldimethylarsine hydroxybromide	.00		.00				970	960	980	980	970				1030	1030	1060	1050
Phenyldimethylarsine dihydroxide	.00		.00							970	960						990	990
Phenylphosphonic acid	.60	2	1.13	2.5	990	900	770	500	170			900	860	610	420			
Phenylstibonic acid	.02		0.00				990	950	930				1120	1050	1110	990		

[a] Values of σ in parentheses are assumed. [b] The amounts of precipitate are in parts per mille of the amounts in the absence of hapten: 230 μg. for anti-R_p serum and 162 μg. for the anti-R'_p serum. All values are averages of triplicate analyses, with mean deviation ±5%.

TABLE III

EFFECT OF HAPTENS ON THE PRECIPITATION OF ANTI-R_{CH_3} SERUM WITH R_{CH_3}-OVALBUMIN

Antigen solution, 0.4 ml. (60 μg.); hapten solution, 2 ml.; antiserum, 1.6 ml.; *p*H of supernates, 8.1.

Hapten	Moles of hapten added × 10^8: 2.7	6.6	20	200	2000
	Amount of precipitate[a]				
Methylarsonic acid			920	870	620
Benzylarsonic acid			1030	1100	680
Phenylarsonic acid			1020	990	670
p-(*p*-Hydroxyphenylazo)-phenylarsonic acid			1060	850	
Phenylmethylarsinic acid	950	950	880	0	
Phenylphosphonic acid			1090	1160	840

[a] The amounts of precipitate are in part per mille of the amount in the absence of hapten, 126 μg., and are corrected for blank of serum and buffer, 10 μg. Values are averages of triplicate analyses, with mean deviation ±5%.

arsonic acid sera. Practically no combination was observed except with anti-R_o serum. With this serum some inhibition was found, with a large value for the heterogeneity index; this means that an appreciable quantity of the antibody combines with the hapten much more strongly than does the rest. The sulfonate ion has the same charge as the monobasic arsonate ion, but lacks the ability to donate a proton in the formation of a hydrogen bond. It has nearly the same steric structure, but only half of the electrical charge of the dibasic arsonate ion. These two differences would be expected to cause a great decrease in combining power, as is observed.

The Effect of Replacing the Benzene Ring by a Methyl or Benzyl Group.—Methylarsonic acid combines very weakly with antiarsonic acid sera in general. This small combining power is the expected result of the fact that the van der Waals attractive force of a methyl group is very much less than that of a benzene ring.

There seems to be present in our anti-R_o serum a small amount (25%) of antibody which combines strongly with arsenic acid, methylarsonic acid, and dimethylarsinic acid. The reason for this behavior is not clear.

Benzylarsonic acid is a stronger hapten than methylarsonic acid, but is weaker than phenylarsonic acid. In benzylarsonic acid the benzene ring is shifted from the position of optimum attraction by the methylene group.

The Effect of Replacing a Hydroxyl Group by a Methyl Group.—Phenylmethylarsinic acid was found to combine appreciably with anti-R_o serum, one pool of anti-R_p serum, and one pool of anti-R'_p serum. The combination is much weaker than that of phenylarsonic acid. The replacement of a hydroxyl group of phenylarsonic acid by a methyl group decreases the combining power in the same ways (inability to contribute a proton for the hydrogen bond which can be formed by the singly charged arsonate ion, and inability to form a doubly charged ion) as the replacement of the arsenic atom by a sulfur atom, and in addition the methyl group might cause some steric interference with combination with antibody. Hence we expect phenylmethylarsinic acid to be as weak

a hapten as benzenesulfonic acid (possibly slightly weaker), in agreement with observation.

Dimethylarsinic acid was observed to have only very small combining power with the antisera.

The Action of Other Arsenic Compounds.—No inhibition was observed with *p*-aminophenylarsine oxide, phenyldimethylarsine dihydroxide, or phenyldimethylarsine hydroxybromide. (The last two substances probably produce the same ion in solution.)

Hapten Inhibition of Precipitation of Anti-R_{CH_3} Serum.—Phenylmethylarsinic acid, the homologous substance to anti-R_{CH_3} serum, combines more strongly with it than any other hapten tested. The arsonic acids and phenylphosphonic acid were found to combine only very weakly with this antiserum. Replacing the methyl group by a hydroxyl group greatly decreases the combining power of the hapten. It is interesting that methylarsonic acid combines with the antiserum as strongly as does phenylarsonic acid, which can exert a much greater van der Waals attraction.

This investigation was carried out with the aid of a grant from The Rockefeller Foundation. We wish to thank Mr. Dan Rice for assistance in analyses.

Summary

Quantitative studies have been made of the inhibiting power of various haptens (including arsenic acid, methylarsonic acid, dimethylarsinic acid, benzylarsonic acid, phenylarsonic acid, phenylmethylarsinic acid, phenylphosphonic acid, benzenesulfonic acid, and phenylstibonic acid) on the precipitation of anti-*o*-, anti-*m*-, and anti-*p*-azophenylarsonic acid sera, anti-*p*-(*p*-azophenylazo)-phenylarsonic acid serum, and anti-*p*-azophenylmethylarsinic acid serum with hapten-homologous azoproteins and (for two antisera) with a dihaptenic azo-dye. The results are discussed in relation to the structure of the molecules.

PASADENA 4, CALIFORNIA RECEIVED MAY 1, 1945

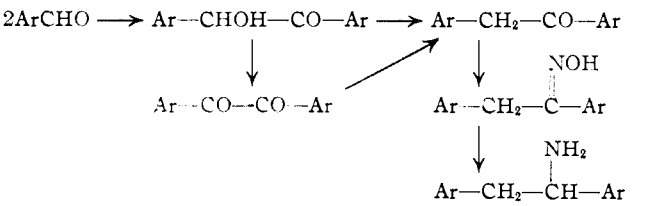
[CONTRIBUTION FROM THE NATIONAL CANCER INSTITUTE, NATIONAL INSTITUTE OF HEALTH, U. S. PUBLIC HEALTH SERVICE]

Some α,β-Diphenylethylamines[1,2]

BY JONATHAN L. HARTWELL AND SYLVIA R. L. KORNBERG

The report of Lettré and co-workers[3] that α,β-diphenyl-ethylamines substituted in one of the phenyl groups by at least one methoxyl group possess the ability to inhibit the mitosis of certain cells in tissue culture prompted the inclusion of this type of compound in a systematic study of the action of chemical agents on mammalian cancer. The present paper describes the preparation and properties of several of these compounds and their intermediates. The biological results, obtained in collaboration with other workers on this joint project,[2] will be reported elsewhere.

The method of synthesis chosen for most readily obtaining a variety of alkoxyl-substituted α,β-diphenylethylamines was the benzoin condensation of alkoxybenzaldehydes followed usually by reduction to the desoxybenzoin, oximation, and finally reduction, as outlined by the formulas



In this work many compounds not new to the literature were prepared, but the present paper reports only the new compounds and new observations deemed of interest. New benzoins were prepared in the usual manner from 2,3-dimethoxy-, 2,5-dimethoxy- and 3,4,5-trimethoxybenzaldehyde. The failure of benzoin formation in the cases of 2,4- and 3,5-dimethoxybenzaldehyde is to be noted. Desoxybenzoins were produced directly by reduction of all the benzoins with the exception of 2,5,2′,5′-tetramethoxybenzoin, veratroin and 3,4,5,3′,4′,5′-hexamethoxybenzoin. Of these the last was obtained crystalline but in too small yield for further preparative work. The first two failed to crystallize, but the crude products were oxidized to the benzils. Desoxyveratroin was then obtained from veratril by reduction; not enough of the other benzil was available for further work. The oximation of our desoxybenzoins appeared to give one

(1) Paper XI in the series entitled "Chemical Treatment of Tumors." Paper X in this series: Brues and Shear, *J. Nat. Cancer Inst.*, **5**, 195 (1944).

(2) Material contained in this paper was presented, in part, at the A. A. A. S., Gibson Island Conference on Cancer at Gibson Island, Maryland, on August 3, 1945, as one of the contributions in the symposium entitled "Some Aspects of a Joint Institutional Research Program on Chemotherapy. Current Laboratory and Clinical Experiments with Bacterial Polysaccharide and with Synthetic Compounds," by Shear, Hartwell, Peters, Dalton, Diller, Royle, Holloman, Oakey, Rees, Hauschke, Dunn and Reimann.

(3) Lettré, Albrecht and Fernholz, *Naturwissenschaften*, **29**, 390 1941); Lettré and Fernholz, *Z. physiol. Chem.*, **278**, 175 (1943).