point of the material was 93–94° (lit.[3] mp 95°) after two crystallizations from ethanol.

The identification of **4** as 1,2-diphenoxyethane and **7** as 2-phenxoyethanol were made by comparison of their spectral and physical properties with those of authentic samples.

The formation of symmetrical bisphenoxylakanes was shown to be general in that cyclic ketals **2** and **3** reacted under the same conditions to yield 1,3-diphenoxypropane (**5**) and 1,4-diphenoxybutane (**6**), respectively, spectral properties of which are given in Table I.

TABLE I

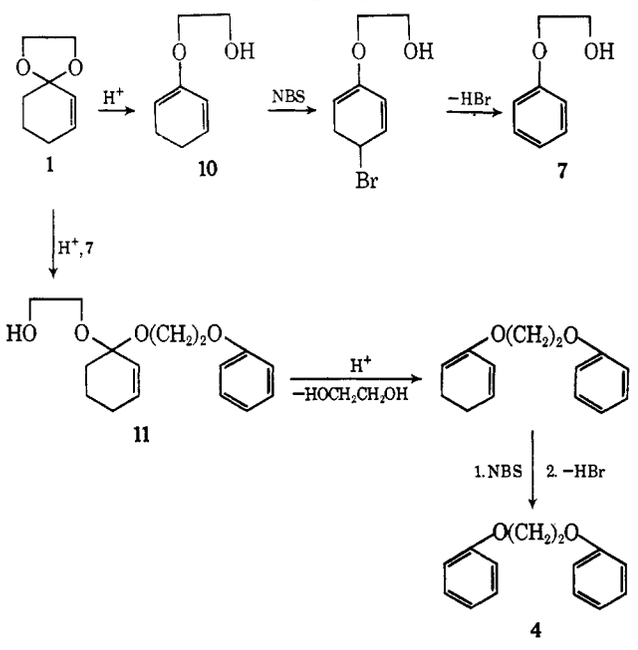
SPECTRAL PROPERTIES OF 1,3-DIPHENOXYPROPANE (**5**) AND 1,4-DIPHENOXYBUTANE (**6**)

Compd	Mass spectra, m/e	Uv, mμ	Ir, μ	Nmr, δ
5	228	221[a]	6.27, 11.45	2.21 (1, H, t)
	135	272	6.71, 12.30	4.10 (2 H, t)
	107	279	8.05, 13.30	6.79 (3 H, m)
			8.47, 14.49	7.24 (2 H, m)
6	242	220[a]	6.28, 11.42	1.93 (2 H, m)
	149	270	6.71, 12.00	3.94 (2 H, m)
	107	227	8.03, 13.39	6.77 (3 H, m)
			8.54, 14.52	7.19 (2 H, m)

[a] Maximum.

A possible coupling mechanism (Scheme I) involves opening of the cyclic acetal[4] to yield diene **10**, followed by bromination, and dehydrobomination to give 2-phenoxyethanol (**7**). This alcohol (**7**) reacts with **1** to form a new acetal (**11**) which upon protonation, elimination of ethylene glycol, bromination, and dehydrobromination yields 1,2-diphenoxyethane (**4**).

SCHEME I



The necessity of rigorously excluding moisture from allylic brominations of ethylene ketals has been previously noted[5] when an anomolous result was obtained with 2-cyclopentenone ethylene ketal and NBS.

Experimental Section

The ketals used in this work were prepared by the method of Salmi[6] from 2-cyclohexenone and the appropriate diol.

The NBS used was purchased from Matheson Coleman and Bell. It was recrystallized from water and dried in the air on a porous plate.

Reaction of 1 with NBS.—2-Cyclohexenone ethylene ketal (**1**, 1.4 g, 0.01 mol) and 1.8 g (0.01 mol) of NBS were placed in 12.5 ml of carbon tetrachloride. The reaction mixture was heated to reflux, and after only 5 min a vigorous exotherm occurred. Heating was continued for an additional 10 min before the solution was cooled and the succinimide was removed by filtration. Removal of the solvent left 1.2 g of a white solid. Elution chromatography of this material with 90% petroleum ether–10% benzene from 20 g of Woelm aluminum oxide (activity grade III) yielded 0.85 g of 1,2-diphenoxyethane (**4**) and 0.30 g of 2-phenoxyethanol (**7**).

Registry No.—**4**, 104-66-5; **5**, 726-44-3; **6**, 3459-88-9; **7**, 122-99-6.

(3) G. Gilta, *Bull. Soc. Chim. Belges*, **31**, 245 (1922).

(4) A. Marquet, H. B. Kagan, M. Dvolaitzky, C. Mamlok, C. Weidmann, and J. Jacques, *C. R. Acad. Sci., Paris*, **248**, 984 (1959).

(5) C. H. DePuy, B. W. Ponder, and J. D. Fitzpatrick, *J. Org. Chem.*, **29**, 3508 (1964).

(6) E. J. Salmi, *Ber.*, **71**, 1803 (1938).

Reaction of Phosphoranes with Mannich Bases. Synthesis of α-Substituted β-Arylacrylic Acids *via* the Wittig Reaction

M. VON STRANDTMANN, M. P. COHEN, C. PUCHALSKI, AND J. SHAVEL, JR.

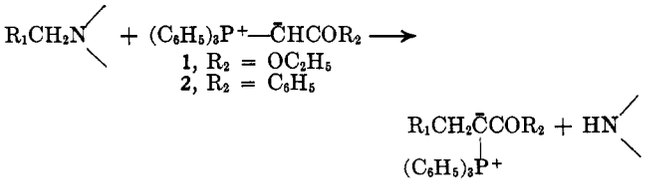
Department of Organic Chemistry,

Warner–Lambert Research Institute, Morris Plains, New Jersey

The alkylation of phosphonium ylides[1-3] is an important route to more complex ylides which are often unavailable by other methods.[4] Our continuing interest in carbon–carbon bond formation by amine replacement[5,6] led us to investigate the alkylation of phosphoranes with Mannich bases, and the synthetic utility of the products of this reaction.

Carbethoxymethylenetriphenylphosphorane (**1**) and benzoylmethylenetriphenylphosphorane (**2**) were found to react readily with Mannich bases according to Scheme I.

SCHEME I



(1) G. Wittig and M. Rieber, *Ann.*, **562**, 177 (1949).

(2) H. J. Bestmann and H. Schultz, *Tetrahedron Lett.*, No. 4, 5 (1960).

(3) H. J. Bestmann and H. Schultz, *Ber.*, **95**, 2921 (1962).

(4) For a recent review of reactions of phosphonium ylides, see A. W. Johnson, "Ylid Chemistry," Academic Press, New York, N. Y., 1966.

(5) M. von Strandtmann, M. P. Cohen, and J. Shavel, Jr., *J. Org. Chem.*, **30**, 3240 (1965).

(6) M. von Strandtmann, M. P. Cohen, and J. Shavel, Jr., *Tetrahedron Lett.*, 3103 (1965).

TABLE I

COMPOUNDS PREPARED BY REACTION OF PHOSPHONIUM YLIDES WITH MANNICH BASES

Compound	Type	R_1	R_2	R_3	Mp, °C	Yield, %	Calcd, % C	Calcd, % H	Calcd, % N	Calcd, % P	Found, % C	Found, % H	Found, % N	Found, % P
3	A	OC_2H_5	H	H	187–189	92	77.97	5.91	2.92	6.49	78.27	5.90	2.86	6.44
4	A	C_6H_5	H	H	268–272	80	82.50	5.54	2.75	6.08	82.58	5.56	2.94	5.96
5	A	OC_2H_5	CH_3	OCH_3	190–193	87	75.99	6.18	2.69	5.94	76.05	6.09	2.50	5.99
6	A	OC_2H_5	CH_3	H	181.5–183	80	78.19	6.15	2.85	6.30	78.23	6.09	2.74	6.00
7	B	OC_2H_5			203–206	89	76.64	5.99		6.81	76.54	5.92		6.60
8[a]	B	C_6H_5			259–260.5	72				6.37				6.30
9					189–192	42	76.29	5.82	2.70	5.96	76.03	5.81	2.85	5.73
10					208–211	55	75.63	4.44		6.50	75.78	4.55		6.21
11					190–192.5	5	80.43	5.25	2.61	5.76	80.37	5.42	2.81	5.74
12[b]					177–183	20	88.34	5.46			88.68	5.24		
13					167–169.5	20	83.37	5.05	5.40		83.26	5.15	5.15	

[a] Correct carbon analysis could not be obtained. The purity of the sample was confirmed by tlc; the identity was established by hydrolysis to the known[15] 3-(*p*-hydroxyphenyl)propiophenone. [b] Reference 13.

Application of this reaction to the most common types of Mannich bases derived from ketones, phenols, and indoles gave compounds listed in Table I. The products generally crystallized from the reaction mixture in high yields and in a high degree of purity. The identities of phosphoranes **3** and **8** were confirmed by hydrolysis to indole-3-propionic acid and 3-(*p*-hydroxyphenyl)propiophenone, respectively.

Some *o*-phenolic Mannich bases yield products different from the "normal" ylide such as **11**. Owing to the participation of the phenolic hydroxyl, the alkylation may be accompanied by lactonization (**10**), or by a "hemiketalization–dephosphoranylation" sequence, which can be viewed as an "internal Wittig" (Scheme II and **12** and **13**, Table I).

SCHEME II

12

It was of interest to explore the synthetic usefulness of the alkylated phosphoranes. In particular, the Wittig reaction should lead to β-arylacrylic acids having an α substituent with a reactive nucleus, such as indole or oxygenated benzene. Compounds of this type are not easily available by other methods. The obvious alternate syntheses, the Perkin reaction and the Oglialoro modification,[7] are known to give poor yields with β-arylpropionic acids.

When the alkylated ylides of Table I were allowed to react with aromatic aldehydes, the Wittig reaction occurred readily to give the compounds listed in Table II. Since isolation of the products was simplified by alkaline hydrolysis of the Wittig reaction mixture, most of the compounds were obtained as acids rather than esters. Exceptions were the esters **14**, **17**, and **18**, and the lactone **25** derived from the lactone ylide **10**.

The Wittig reaction with an *o*-hydroxyaldehyde, 2-hydroxy-1-naphthaldehyde, was accompanied by spontaneous lactonization resulting in compounds **23** and **24** (Table II).

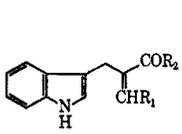
Most the the reactions of stabilized ylides with aldehydes reported to date have led to the formation of the *trans* olefin as the major product.[8] Consideration of Dreiding models of the α-substituted β-arylacrylic acids and esters of Table II suggests that in all cases the preferred form is that in which the carboxyl and aryl groups are *trans*. These observations suggest that the

(7) J. R. Johnson, *Org. Reactions*, **I**, 225 (1942).

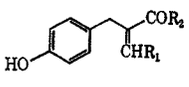
(8) (a) See ref 4, p 181; (b) M. O. House and G. R. Rasmusson, *J. Org. Chem.*, **26**, 4278 (1961); (c) D. H. Wadsworth, O. E. Schupp, E. J. Seuss, and J. A. Ford, *ibid.*, **30**, 680 (1965); (d) D. E. Bissing, *ibid.*, **30**, 1296 (1965).

TABLE II

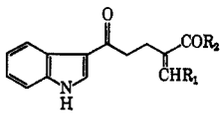
COMPOUNDS PREPARED FROM PHOSPHORANES OF TABLE I AND ALDEHYDES



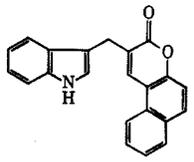
A



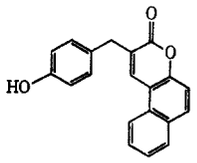
B



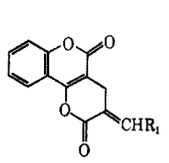
22



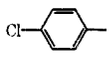
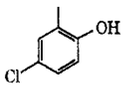
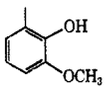
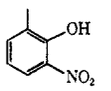
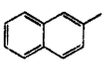
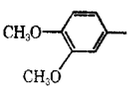
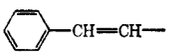
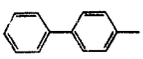
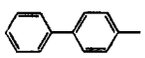
23



24



25

Compound	Type	R1	R2	Mp, °C	Yield, %	Calcd, % C	Calcd, % H	Calcd, % N	Found, % C	Found, % H	Found, % N	$\nu_{max}^{C_2H_5}$, mμ (ε)
14	A		OC_2H_5	127–128	54	74.49	5.92	9.15	74.60	5.90	9.23	220 (40,000), 258 (19,000)
15	A		OH	189–196	52	69.35	4.53	4.49	69.37	4.71	4.35	222 (45,800), 271 (26,000)
16	A		OH	202–205	58	65.96	4.31	4.27	65.84	4.32	4.12	222 (50,100), 266 (14,500), 318 (5900)
17	A		OC_2H_5	120–131	43	71.78	6.02	3.99	72.06	5.78	4.06	221 (52,000), 276 (18,700)
18	A		OC_2H_5	123–126	24	65.56	4.95	7.65	65.63	4.90	7.42	220 (46,500), 255 (19,200), 272 (18,600)
19	B		OH	209–212.5	50	78.93	5.30		78.93	5.23		223 (23,200), 259 (36,300), 301 (16,250)
20	B		OH	180–185	36	68.78	5.77		68.92	5.85		222 (21,600), 287 (17,000), 309 (16,100)
21	B		OH	236–239.5	53	77.12	5.75		77.40	5.89		226 (14,000), 241 (7900), 316 (39,800)
22			OH	226.5–228	6.5	78.96	5.35	3.54	79.19	5.43	3.35	241 (18,800), 298 (40,500)
23				211–213.5	40	81.21	4.65	4.30	81.18	4.65	4.20	221 (69,800), 232 (55,000), 249 (15,200)
24				242–244	60	79.45	4.67		79.60	4.69		229 (50,600), 233 (54,500), 246–250 (12,000) plat, 317 (11,100), 347 (12,900)
25				229.5–231	52	78.93	4.24		78.86	4.23		254 (51,200), 347 (39,400)

acids and esters of Table II are the *trans* isomers (*trans,trans* for compound **21**[9]). This tentative assignment is supported by the intensities of the ultraviolet absorption maxima of compounds such as **14** and **15** which are of the same order of magnitude as those of *trans* cinnamic acid (ϵ_{max} 21,000).[10]

The alkylated ylids of Table I were found to be inert toward ketones, such as cyclohexanone and N-methylpiperidone, with or without benzoic acid catalysis.[11] The ylides, **4** and **8**, derived from benzoylmethylenetriphenylphosphorane are highly insoluble in most organic solvents. Under our standard conditions, **8** and 2-naphthaldehyde in dimethyl sulfoxide or N,N-dimethylformamide failed to react.

(9) The ease with which allo-5-phenyl-2,4-pentadienoic acid rearranges to the *trans,trans* form [J. C. Ghosh and S. Gupto, *Quart. J. Indian Chem. Soc.*, **2**, 241 (1925); J. C. Ghosh and M. N. Mitra, *ibid.*, **3**, 273 (1926)] suggests that the basic hydrolysis used to prepare the acids would afford only the *trans,trans* isomer.

(10) A. E. Gillam and E. S. Stern, "Electronic Absorption Spectroscopy," 2nd ed, Arnold Ltd., London, 1960, p 269.

(11) C. Ruechardt, S. Eichler, and P. Pause, *Angew. Chem. Intern. Ed. Engl.* **2**, 619 (1963).

Experimental Section[12]

Phosphoranes of Table I.—A solution of 0.1 mol of a Mannich base and 0.1 mol of a phosphorane in 500 ml of toluene was refluxed for 6–7 hr with a gentle sweep of dry nitrogen through the solution. The mixture was chilled; the crystalline precipitate was filtered off and consecutively washed with cold toluene and petroleum ether (bp 37–47°). The analytical samples were prepared by recrystallization from ethyl acetate (**3**, **7**), acetonitrile (**4**, **5**, **6**, **11**) and N,N-dimethylformamide (**8**).

In the case of **9** and **10**, the solutions were decanted from some tar and concentrated under reduced pressure. The residual gums were crystallized from acetonitrile (**9**) and toluene (**10**).

3-Phenyl-1H-naphtho[2,1-*b*]pyran (12).[13]—A solution of 2.01 g (0.01 mol) of 1-dimethylaminomethyl-2-naphthol and 3.8 g (0.01 mol) of benzoylmethylenetriphenylphosphorane in 50 ml

(12) Melting points were determined with the Thomas–Hoover capillary melting point apparatus which was calibrated against known standards. The thin layer chromatography was performed using silica gel G according to Stahl (Merck, Darmstadt) as the absorbent and ethanol as the eluent. Chromatograms were developed by spraying with aqueous $KMnO_4$. The authors are indebted to the Analytical and Physical Chemistry Department under the supervision of Mr. A. D. Lewis. In particular we wish to thank Dr. C. Greenough for the spectral data and Mrs. U. Zeek for analytical determinations.

(13) Compound has been previously described by H. Hellmann and J. Pohlmann, *Ann.*, **642**, 40 (1961): mp 180–184°.

of toluene was refluxed for 6 hr with a gentle sweep of nitrogen through the solution. The toluene was removed under reduced pressure leaving a semicrystalline solid which was recrystallized three times from acetonitrile.

3-Phenyl-1H-pyrano[3,2-*f*]quinoline (13).—This compound was obtained from 5-[(dimethylamino)methyl]-6-quinolinol in analogy to **12** after 2 hr of refluxing and crystallization from ethanol or ethyl acetate.

Hydrolysis of 3.—A solution of 10 ml of 10% NaOH and 2 g of **3** in 40 ml of 95% ethanol was refluxed for 2 hr and concentrated under reduced pressure. The aqueous residue was diluted with 50 ml of water and washed several times with chloroform in order to remove triphenylphosphine oxide. The aqueous portion was chilled and acidified with 5 *N* HCl. The precipitated solid was recrystallized from benzene. The physical and analytical properties of the product were identical with those of indole-3-propionic acid: mp 132–133° (lit.[14] mp 132–133°); ν_{max}^{Nujol} 1697 cm^{-1} (-COOH).

Anal. Calcd for $C_{11}H_{11}NO_2$: C, 69.82; H, 5.86; N, 7.40. Found: C, 69.83; H, 5.89; N, 7.34.

Hydrolysis of 8.—A mixture of 1 g of **8** and 1 g of KOH was refluxed in 100 ml of 75% ethanol for 6 hr. The clear solution was concentrated under reduced pressure, and the aqueous residue was diluted with 75 ml of water. The resulting oily precipitate which solidified on standing was identified as triphenylphosphine oxide.[15] The aqueous filtrate was acidified with concentrated HCl, and the crystalline precipitate was filtered off and recrystallized from ethanol. The physical and analytical properties of the product were identical with those of 3-(*p*-hydroxyphenyl)-propiophenone: mp 118.5–120.5° (lit.[16] mp 116–117°); ν_{max}^{Nujol} 3400 (-OH), 1675 cm^{-1} (>CO).

Anal. Calcd for $C_{15}H_{14}O_2$: C, 79.69; H, 6.24. Found: C, 79.66; H, 6.27.

The Wittig Reaction (Compounds of Table II).—The following procedures are illustrative of the methods employed for the preparation of the acids, esters, and lactones of Table II.

Ethyl α-(4-Pyridylmethylene)indole-3-propionate (14).—A solution of 30.5 g of **3** and 6.9 g of 4-pyridinecarboxaldehyde in 250 ml of dioxane was refluxed for 21 hr and evaporated under reduced pressure. The residual gum was dissolved in 200 ml of ether, and the solution was extracted with three 50-ml portions of 4 *N* HCl. The acid solution was made basic with 5% NaOH solution and extracted with chloroform to afford 22 g of crude product upon evaporation. Crystallization from 100 ml of ether followed by recrystallization from 50% aqueous ethanol gave analytical material: ν_{max}^{Nujol} 740 (ms), 1070 (m), 1202 (ms), 1257 (ms), 1600 (w), 1710 (s), 3150 (m) cm^{-1}.

Ethyl α-(2-Hydroxy-3-methoxybenzylidene)indole-3-propionate (17).—A solution of 1.52 g of 2-hydroxy-3-methoxybenzaldehyde and 4.77 g of **3** in 75 ml of dioxane was refluxed for 18 hr. The dioxane was removed under reduced pressure, and the residual gum was extracted with five 25-ml portions of Skellysolve B. The remaining gum was dissolved in ethyl acetate and chromatographed on a column of 300 g of Florisil. Concentration of the first few fractions gave crystalline material. The crystals were combined, and recrystallized from ethanol: ν_{max}^{Nujol} 730 (m), 750 (m), 960 (m), 1020 (m), 1185 (ms), 1225 (ms), 1250 (s), 1575 (mw), 1610 (mw), 1690 (ms), 3375 (m), 3395 (ms) cm^{-1}.

2-(*p*-Hydroxybenzyl)-5-phenyl-2,4-pentadienoic Acid (21).—A solution of 5.28 g of cinnamaldehyde and 18 g of **7** in 300 ml of dioxane was refluxed for 24 hr. The dioxane was removed under reduced pressure, and the residue was taken up in 100 ml of 50% ethanol. The solution was treated with 8 g of KOH and refluxed for 4 hr. The ethanol was removed under reduced pressure, and the concentrate was diluted to *ca.* 100 ml with H_2O. The aqueous mixture was extracted with four 50-ml portions of ether. The aqueous phase was made strongly acidic with concentrated HCl, and the precipitated product was filtered, washed with cold H_2O, and recrystallized from absolute ethanol: ν_{max}^{Nujol} 730 (m), 785 (mw), 985 (m), 1100 (mw), 1165 (m), 1215 (ms), 1275 (ms), 1280 (ms), 1515 (ms), 1590 (s), 1610 (ms), 1665 (ms), 3400 (m) cm^{-1}.

α-(4-Biphenylmethylene)-α-oxoindole-3-valeric Acid (22).—A solution of 10.38 g of **9** and 3.64 g of 4-biphenylcarboxaldehyde in 150 ml of dioxane was refluxed for 24 hr. The dioxane was removed under reduced pressure, and the residue was taken up in 50 ml of 50% ethanol. After addition of 4 g of KOH and refluxing for 4 hr, the ethanol was removed under reduced pressure, and the aqueous concentrate was diluted to *ca.* 50 ml with H_2O. The mixture was washed with four 50-ml portions of ether, followed by four extractions, each with 25 ml of ethyl acetate. The combined ethyl acetate extracts were dried over Na_2SO_4 and concentrated to a gum under reduced pressure. The gum was crystallized from ethanol: ν_{max}^{Nujol} 690 (m), 750 (m), 970 (mw), 1150 (mw), 1230 (m), 1520 (m), 1580 (m), 1610 (ms), 1675 (ms), 3150 (ms) cm^{-1}.

2-(Hydroxy)-α-(*p*-hydroxybenzyl)-1-naphthalene Acrylic Acid δ-Lactone-(24).—A solution of 1.72 g of 2-hydroxy-1-naphthaldehyde and 4.54 g of **7** in 75 ml of dioxane was refluxed for 18 hr and evaporated under reduced pressure. The partially crystalline residue was extracted with three 25-ml portions of boiling Skellysolve B and recrystallized from ethanol: ν_{max}^{Nujol} 740 (m), 820 (ms), 1070 (m), 1170 (mw), 1230 (m), 1515 (m), 1580 (m), 1680 (s), 3300 (ms), cm^{-1}.

3-(4-Biphenylylmethylene)-3,4-dihydro-2H,5H-pyrano[3,2-*c*][1]-benzopyran-2,5-dione (25).—A solution of 4.7 g of **10** and 1.82 g of 4-biphenylcarboxaldehyde in 25 ml of dioxane was refluxed for 24 hr. The dioxane was removed under reduced pressure, leaving a semicrystalline residue. This was triturated with five 50-ml portions of boiling ether. The residue was recrystallized from CH_3CN: ν_{max}^{Nujol} 760 (m), 960 (mw), 1040 (mw), 1110 (mw), 1575 (mw), 1645 (m), 1725 (s), 1745 (m), cm^{-1}.

Mannich bases used as starting materials are either commercially available[17] or were prepared by standard methods.[18] The previously undescribed **5-[(dimethylamino)methyl]-6-quinolinol** was obtained from a solution of 6-hydroxyquinoline (7.25 g), dimethylamine (2.7 g), and 37% formaldehyde (4.25 ml) in ethanol (150 ml). The solution was brought to reflux, allowed to stand for 2 days at room temperature, and concentrated under reduced pressure. The oily residue crystallized on standing. The analytical sample was prepared by recrystallizations from ethyl acetate and ethanol with the aid of charcoal: mp 106–107.5°; yield 55%; λ_{max} 239 mμ (ε 33,800), 285 (2900), 336 (3800).

Anal. Calcd for $C_{12}H_{14}N_2O$: C, 71.26; H, 6.98; N, 13.85. Found: C, 71.23; H, 7.07; N, 13.55.

Registry No.—**3**, 17791-03-6; **4**, 17791-04-7; **5**, 17791-05-8; **6**, 17791-06-9; **7**, 17791-07-0; **8**, 17818-06-3; **9**, 17791-08-1; **10**, 17791-09-2; **11**, 17791-10-5; **12**, 14271-36-4; **13**, 17791-12-7; **14**, 17791-13-8; **15**, 17791-14-9; **16**, 17791-15-0; **17**, 17791-16-1; **18**, 17791-17-2; **19**, 17791-18-3; **20**, 17791-19-4; **21**, 17791-20-7; **22**, 17791-21-8; **23**, 17791-22-9; **24**, 17791-23-0; **25**, 5807-40-9; 3-(*p*-hydroxyphenyl)propiophenone, 17791-25-2; 5-[(dimethylamino)methyl]-6-quinolinol, 17791-26-3.

(14) M. R. Snyder, C. W. Smith, and J. M. Stewart, *J. Amer. Chem. Soc.*, **66**, 200 (1944).

(15) A. Michaelis, *Ann.*, **229**, 306 (1885).

(16) V. A. Zasosov, E. I. Metel'kova, and S. N. Milovanova, *Zh. Obshch. Khim.*, **26**, 2499 (1956); *Chem. Abstr.*, **51**, 4994*d* (1956).

(17) Aldrich Chemical Co., Inc.

(18) H. Hellmann and G. Opitz, "α-Aminoalkylierung," Verlag Chemie, Weinheim, 1960.

The Geometrical Isomers of 1,5-Diphenylpentadien-3-ol

J. GRAY DINWIDDIE, JR., AND HAROLD M. WHITE

Department of Chemistry and Geology, Clemson University, Clemson, South Carolina 29631

Received March 25, 1968

In a previous report[1] we described the preparation of the geometrical isomers of dibenzalacetone (1,5-diphenyl-1,4-pentadien-3-one). This paper describes

(1) J. G. Dinwiddie, Jr., H. M. White, and W. J. Day, *J. Org. Chem.*, **27**, 327 (1962).