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The Preparation of Fuchsones

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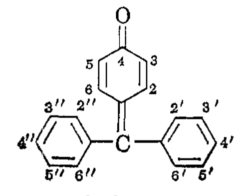
Acid-catalyzed condensation of benzhydrol with substituted phenols leads to substituted 4-hydroxytriphenylmethanes, which are easily converted into substituted fuchsones by oxidation with active manganese dioxide or nickel peroxide. The intermediate phenoxy radical can be trapped with 2,4,6-tri-*t*-butylphenoxy radical, thus giving quinol ethers, whose stability depends on the nature of the substituents. Attempts to prepare the sterically hindered 2,3,5,6-tetramethylfuchsone were unsuccessful.

Within the class of quinone methides, fuchsones (α,α-diphenyl-1,4-benzoquinone methides) are of particular interest because of their early application as triphenylmethane dyes. Different from most other quinone methides, which often play an important role as nonisolable reactive intermediates in phenol oxidation, fuchsones are stable crystalline compounds.[1] The parent compound has been known for many years[2] and numerous substituted fuchsones have been described in the literature. They can be prepared by either elimination[3] of water from 4-hydroxytriphenylcarbinols (which are available from the reaction of phenylmagnesium bromide with substituted methyl-4-hydroxybenzoates) or by oxidation of substituted 4-hydroxytriphenylmethanes, which, in turn, are prepared by acid-catalyzed condensation of phenols with aromatic aldehydes. Benzoyl peroxide,[4] amyl nitrite,[4] or potassium ferricyanide[5] in alkaline solution have been used as oxidizing agents.

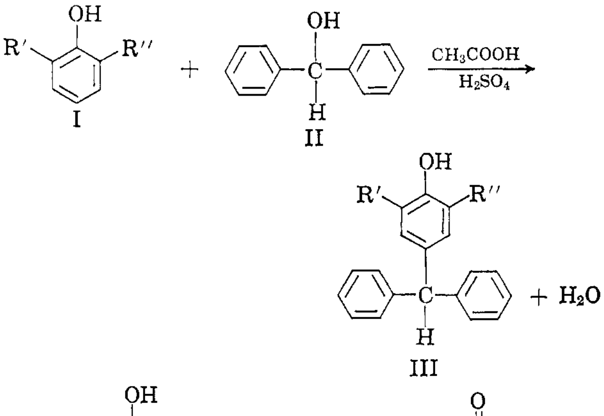


fuchsone

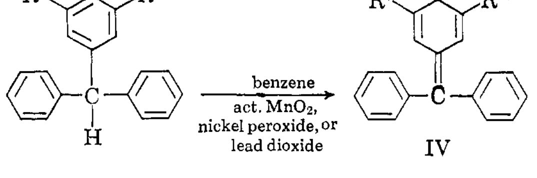
An essentially one-step procedure for the preparation of 3,5-disubstituted fuchsones was recently found in the photochemical reaction of benzophenone with some 2,6-disubstituted phenols.[6] In connection with that investigation, we found that fuchsones can undergo a unique photosensitized addition reaction with phenols to give substituted 4,4′-dihydroxytetraphenylmethanes (bisphenols).[7] This paper describes a simple high yield procedure for the preparation of 3,5-disubstituted fuchsones which were needed as starting materials for the photochemical bisphenol synthesis.

Results and Discussion

A variety of substituted phenols (Ia–f) was found to condense at room temperature with benzhydrol (II) in the presence of sulfuric acid to give substituted 4-hydroxytriphenylmethanes (IIIa–f) in yields between 84 and 97% (eq 1). These 4-hydroxytriphenylmethanes are in high yield converted to the corresponding 3,5-disubstituted fuchsones IVa–f by oxidation with



(1)



(2)

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[1] For a recent review on quinone methides, see A. B. Turner, *Quart. Rev.* (London), **18**, 347 (1964).

[2] A. Bistrzycki and C. Herbst, *Ber.*, **36**, 2335 (1903).

[3] See, *e.g.*, K. I. Beynon and S. T. Bowden, *J. Chem. Soc.*, 4247 (1957).

[4] Kerestya and Wolf, British Patent 485,228 (1938); *Chem. Abstr.*, **32**, 8080 (1938).

[5] C. D. Cook and N. D. Gilmour, *J. Org. Chem.*, **25**, 1429 (1960); see also E. Müller, *et al.*, *Ann.*, **645**, 66 (1961).

[6] H-D. Becker, *J. Org. Chem.*, **32**, 2115 (1967).

[7] H-D. Becker, *ibid.*, **32**, 2131 (1967).

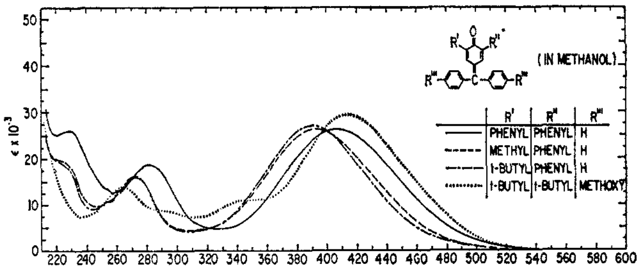


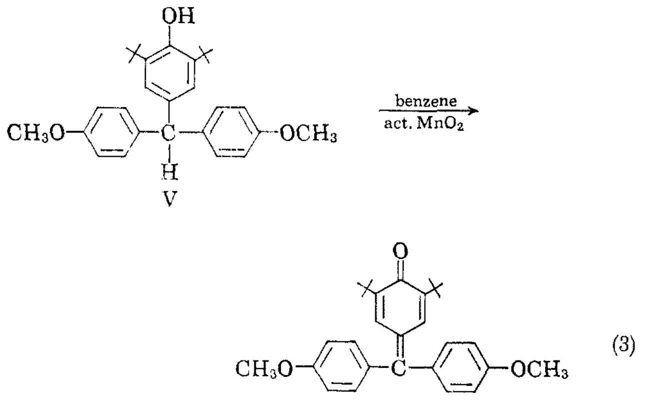
Figure 1.

active manganese dioxide, nickel peroxide, or lead dioxide in benzene solution (eq 2). The results of the condensation and oxidation reaction are summarized in Table I.

TABLE I

I	R'	R''	Yield of III, %	Yield of IV, %
a	Methyl	Methyl	90	84
b	Isopropyl	Isopropyl	92	94
c	Cyclohexyl	Cyclohexyl	92	99
d	Phenyl	Phenyl	96	92
e	Methyl	Phenyl	84	92
f	Phenyl	*t*-Butyl	97	94

Fuchsones substituted in the phenyl rings also are available by this method. Thus, 4,4'-dimethoxybenzhydrol, easily prepared by reduction of 4,4'-dimethoxybenzophenone with $NaBH_4$ in boiling ethanol, was found to react with 2,6-di-*t*-butylphenol in the same manner as previously described for benzhydrol,[5] yielding 4',4''-dimethoxy-3,5-di-*t*-butyl-4-hydroxymethane (V) in 94% yield, which gave 4',4''-dimethoxy-3,5-di-*t*-butylfuchsone (VI) in 76% yield upon oxidation with active manganese dioxide (eq 3).



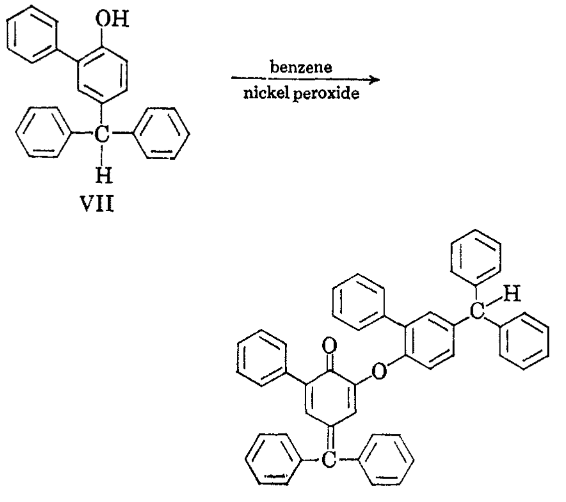
V

(3)

VI

All new fuchsones are crystalline compounds of yellow to orange color. Their structures are fully supported by infrared, proton magnetic resonance, and ultraviolet spectra (see Figure 1).

The 3,5-disubstitution of 4-hydroxytriphenylmethanes appears to be a prerequisite for the smooth oxidation to the corresponding fuchsones. 4-Hydroxy-3-phenyltriphenylmethane (VII), which was prepared by acid-catalyzed condensation of *o*-phenylphenol with benzhydrol, was oxidized by nickel peroxide in benzene solution (eq 4). However, the only identifiable product, isolated in 20% yield from a mixture of apparently polymeric reaction products, was a dimer for which analytical data are in agreement with structure VIII. The low solubility of VIII made any spectroscopic investigation impossible.

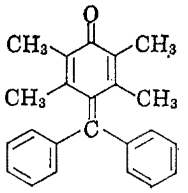


VII

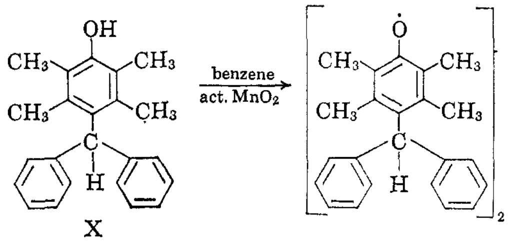
(4)

VIII

Unsuccessful attempts were made to prepare 2,3,5,6-tetramethylfuchsone (IX) for which a molecular Stuart–Briegleb model indicated hindered rotation of the phenyl rings. The parent 4-hydroxy-2,3,5,6-tetramethyltriphenylmethane (X) was readily prepared by acid-catalyzed condensation of durophenol with benzhydrol. The oxidation with active manganese dioxide or nickel peroxide in benzene solution, however, did not yield any fuchsone, but a dimer of the corresponding phenoxy radical (eq 5). The structure of the colorless compound is enigmatic. The infrared spectrum of the dimer does not reveal the presence of any hydroxyl or carbonyl groups, but shows strong absorption in the ether region. Its proton magnetic resonance spectrum indicates that all methyl groups (three types) as well as the tertiary hydrogen (two types) are still present. These data for the dimer are compatible with structure XI, which could have been formed in a coupling-rearrangement sequence. We are greatly indebted to a referee who suggested the structure and possible way of formation for XI (eq 6).

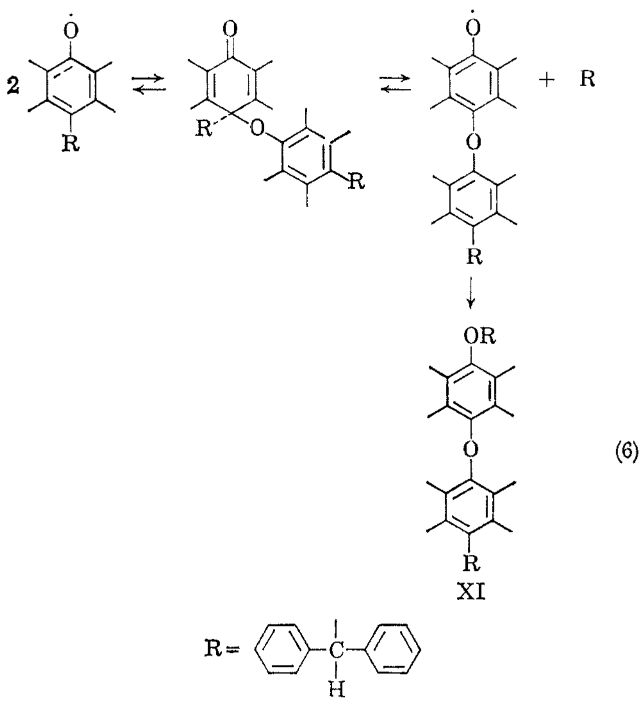


IX



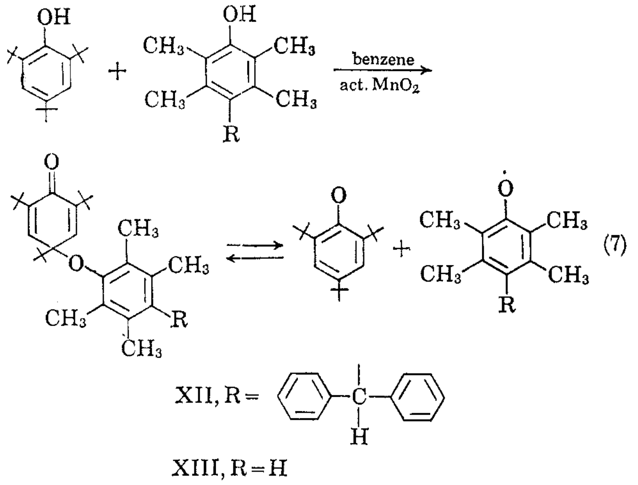
X

(5)

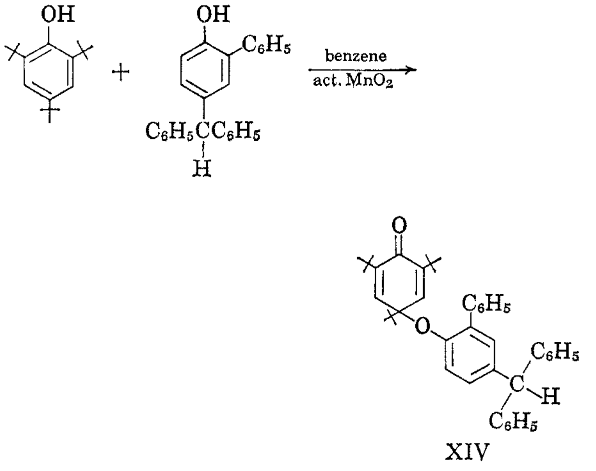

(6)

XI

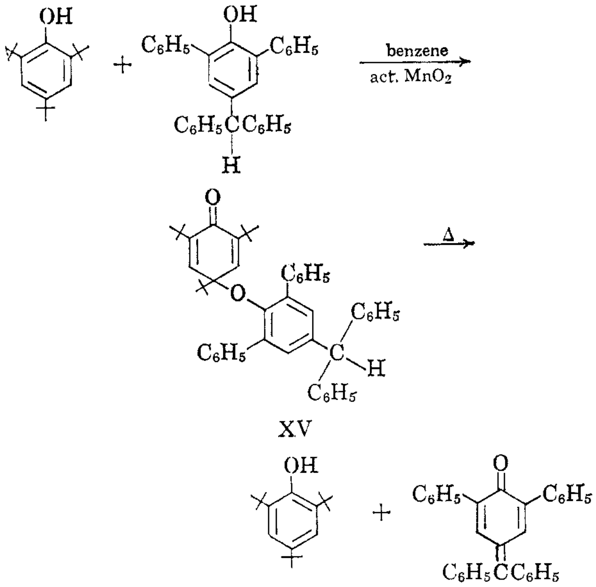
It is worth noting that the phenoxy radical leading to dimer XI can easily be trapped if the oxidation of 4-hydroxy-2,3,5,6-tetramethyltriphenylmethane (X) is carried out in the presence of 2,4,6-tri-*t*-butylphenoxy radical. Cooxidation of X and 2,4,6-tri-*t*-butylphenol with active manganese dioxide in benzene according to a previously described procedure[8] yields a light blue crystalline compound (yield 85%) for which analytical and spectroscopic data are in agreement with the quinol ether structure XII (eq 7). Because of its steric hindrance, XII easily undergoes homolytic dissociation, indicated by the formation of deep blue solutions. The quinol ether XIII, prepared by cooxidation of durophenol and 2,4,6-tri-*t*-butylphenol with active manganese dioxide, was found to behave similarly.


(7)

Other substituted 4-hydroxytriphenylmethanes upon oxidation in the presence of 2,4,6-tri-*t*-butylphenol also yield quinol ethers. As one would expect, the stability of these quinol ethers depends greatly on the nature of the substituents in the 3,5 position of the 4-hydroxytriphenylmethanes employed. Cooxidation of 2,4,6-tri-*t*-butylphenol and 4-hydroxy-3-phenyltriphenylmethane yields the stable quinol ether XIV in 75% yield (eq 8). The quinol ether XV, however, prepared by cooxidation of 2,4,6-tri-*t*-butylphenol and 3,5-diphenyl-4-hydroxytriphenylmethane with active manganese dioxide, rapidly dissociated when dissolved, yielding 3,5-diphenylfuchsone and 2,4,6-tri-*t*-butylphenol (eq 9).


(8)

XIV


XV

(9)

The mechanism of the oxidation of all 3,5-disubstituted 4-hydroxytriphenylmethanes to yield fuchsones obviously involves the intermediate formation of phenoxy radicals, which disproportionate to their quinone methides and parent 4-hydroxytriphenylmethanes. This mechanism has been proven earlier[5,9] in the case of 2,6-di-*t*-butyl-substituted phenols and it is further substantiated by the cooxidation experiments with 2,4,6-tri-*t*-butylphenol presented in this paper.

Experimental Section

Materials.—All phenols[10] employed in this work were distilled[11] before use. Active manganese dioxide[12] and nickel peroxide[13]

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(8) H-D. Becker, *J. Org. Chem.*, **29**, 3068 (1964).

(9) C. D. Cook and B. E. Norcross, *J. Am. Chem. Soc.*, **78**, 3797 (1956).

(10) Thanks are due to Drs. A. S. Hay and J. R. Ladd for providing the author with some 2,6-disubstituted phenols.

(11) Distillations were kindly carried out by Mr. W. Ruminski.

(12) J. Attenburrow, A. F. B. Cameron, J. H. Chapman, R. N. Evans, B. A. Hems, A. B. A. Jansen, and T. Walker, *J. Chem. Soc.*, 1094 (1952).

(13) K. Nakagawa, R. Konaka, and T. Nakata, *J. Org. Chem.*, **27**, 1597 (1962).

TABLE II

PREPARATION OF 3,5-DISUBSTITUTED 4-HYDROXYTRIPHENYLMETHANES

	I						III			Calcd			Found		
III	R′	R″	mmoles	II, mmoles	CH_3COOH, ml	H_2SO_4, ml	Yield, %	Mp, °C	Formula	C, %	H, %	Mol wt	C, %	H, %	Mol[a] wt
a	Methyl	Methyl	50	50	50	5	90	129–130	$C_{21}H_{20}O$	87.46	6.99	288.40	87.68	6.99	293
b	Isopropyl	Isopropyl	20	20	20	1	92	107	$C_{25}H_{28}O$	87.16	8.19	344.50	87.32	8.09	338
c	Cyclohexyl	Cyclohexyl	30	30	30	3	92	151–152	$C_{31}H_{36}O$	87.69	8.55	424.64	87.75	8.65	423
d	Phenyl	Phenyl	100	100	150	10	96	141–142	$C_{31}H_{24}O$	90.26	5.86	412.54	90.03	5.77	415
e	Methyl	Phenyl	20	20	20	2	84	98–99	$C_{26}H_{22}O$	89.11	6.33	350.47	88.96	6.29	339
f	Phenyl	*t*-Butyl	100	100	200	10	97	153	$C_{29}H_{28}O$	88.73	7.19	392.55	89.05	7.26	387

[a] Molecular weights were determined by thermoelectric measurement in benzene.

TABLE III

PREPARATION OF 3,5-DISUBSTITUTED FUCHSONES

	III						IV			Calcd			Found		
IV	R′	R″	mmoles	Benzene, ml	Oxidant, g	Reaction time, hr	Yield, %	Mp, °C	Formula	C, %	H, %	Mol wt	C, %	H, %	mol wt
a	Methyl	Methyl	10	200	Act. MnO_2, 29	1.5	84	200–202[a]							
b	Isopropyl	Isopropyl	10	200	Act. MnO_2, 34	1	94	170–171[a]							
c	Cyclohexyl	Cyclohexyl	12	400	Act. MnO_2, 50	3	99	238–240[a]							
d	Phenyl	Phenyl	20	400	Act. MnO_2, 82	6	92	297–298[b]	$C_{31}H_{22}O$	90.70	5.40	410.52	90.78	5.53	413[e]
e	Methyl	Phenyl	10	200	Act. MnO_2, 35	1	92	219[c]	$C_{26}H_{20}O$	89.62	5.79	348.45	89.61	5.59	313[f]
f	Phenyl	*t*-Butyl	30	400	NiPO, 120	3	94	209–210[d]	$C_{29}H_{26}O$	89.19	6.71	390.53	89.33	6.80	379[f]
g	*t*-Butyl	*t*-Butyl	81	400	PbO_2, 300	2	97	182[a]							

[a] Mixture melting point with authentic[6] material was not depressed. [b] Recrystallized from a boiling chloroform–benzene mixture. [c] Recrystallized by dissolving in a little hot benzene and adding ether. [d] Sublimed at 185° (1 mm). [e] Thermoelectric measurement in chloroform. [f] Thermoelectric measurement in benzene.

were prepared according to the literature. Lead dioxide was commercial grade. All melting points were taken on a Fisher-Johns melting point apparatus and are not corrected. Molecular weights were determined by thermoelectric measurement. The solvents used are placed in parentheses.

3,5-Disubstituted 4-hydroxytriphenylmethanes IIIa–f have been prepared in the same manner as described below for V. All essential data are listed in Table II.

Fuchsones IVa–g have been prepared in the same manner as described for VI. All essential data are listed in Table III.

4′,4″-Dimethoxy-3,5-di-*t*-butyl-4-hydroxytriphenylmethane (V).—Concentrated sulfuric acid (1.2 ml) was added dropwise to a stirred solution of 2,6-di-*t*-butylphenol (4.12 g, 20 mmoles) and 4,4′-dimethoxybenzhydrol (4.88 g, 20 mmoles) in acetic acid (50 ml). The precipitate thus obtained was filtered and washed with dilute methanol: yield, 8.1 g (94%) of colorless crystals; mp 125–126°. Recrystallization from aqueous methanol did not raise the melting point.

Anal. Calcd for $C_{29}H_{36}O_3$: C, 80.52; H, 8.39; mol wt, 432.61. Found: C, 80.78; H, 8.39; mol wt (benzene), 414.

4,4″-Dimethoxy-3,5-di-*t*-butylfuchsone (VI).—A suspension of active manganese dioxide (43 g) in a solution of 4′,4″-dimethoxy-3,5-di-*t*-butyl-4-hydroxytriphenylmethane (4.32 g, 10 mmoles) in benzene (100 ml) was stirred for 3 hr. Filtration, evaporation *in vacuo*, and recrystallization from a mixture of acetone and methanol gave 3.3 g (76%) of 4′,4″-dimethoxy-3,5-di-*t*-butylfuchsone, mp 180°.

Anal. Calcd for $C_{29}H_{34}O_3$: C, 80.90; H, 7.96; mol wt, 430.60. Found: C, 80.66; H, 7.91; mol wt (benzene), 424.

4-Hydroxy-3-phenyltriphenylmethane (VII).—Concentrated sulfuric acid (10 ml) was added dropwise to a stirred solution of *o*-phenylphenol (8.5 g, 50 mmoles) and benzhydrol (9.2 g, 50 mmoles) in acetic acid (100 ml). After 24 hr the colorless crystalline precipitate was removed by filtration and repeatedly recrystallized, first from methanol and then from petroleum ether (bp 65–110°): yield, 6.8 g (40.5%); mp 142–143°.

Anal. Calcd for $C_{25}H_{20}O$: C, 89.25; H, 5.99; mol wt, 336.44. Found: C, 89.30; H, 5.92; mol wt (chloroform), 342.

Oxidation of 4-Hydroxy-3-phenyltriphenylmethane (VII).—A suspension of nickel peroxide (11 g) in a solution of 4-hydroxy-3-phenyltriphenylmethane (1.12 g, 3 mmoles) in benzene (80 ml) was shaken for 3.5 hr in a stoppered flask. Filtration and washing of the residual metal oxide with benzene gave a brown-red filtrate which yielded a semisolid residue upon evaporation *in vacuo*. It was triturated with little benzene, filtered, and recrystallized by dissolving in hot chloroform and adding benzene: yield, 0.195 g (19%) of orange-red crystals; mp 325–328°.

Anal. Calcd for $C_{50}H_{36}O_2$: C, 89.79; H, 5.42; mol wt, 668.85. Found: C, 89.51; H, 5.43; mol wt (chloroform), 649.

4-Hydroxy-2,3,5,6-tetramethyltriphenylmethane (X).—Concentrated sulfuric acid (6 ml) was added dropwise to a stirred solution of durophenol (6.0 g, 40 mmoles) and benzhydrol (7.37 g, 40 mmoles) in acetic acid (60 ml). The reaction mixture containing the crystalline colorless reaction product was stirred for 1 hr and then diluted with a little aqueous methanol and filtered. Recrystallization from aqueous methanol gave 10.8 g (85%) of colorless crystals, mp 147–148°.

Anal. Calcd for $C_{23}H_{24}O$: C, 87.30; H, 7.64; mol wt, 316.45. Found: C, 87.43; H, 7.63; mol wt (benzene), 313.

Oxidation of 4-Hydroxy-2,3,5,6-tetramethyltriphenylmethane (X).—4-Hydroxy-2,3,5,6-tetramethyltriphenylmethane (1.0 g) was dissolved in 100 ml of benzene and shaken for 30 min in the presence of nickel peroxide (10 g). The light yellow solution was filtered, the filtrate was evaporated *in vacuo*, and the oily residue was treated with a mixture of a little ether and methanol. The light yellow to colorless precipitate formed was removed by filtration and dried *in vacuo*: yield, 400 mg (40%); mp ∼95–100°.

Anal. Calcd for $C_{46}H_{46}O_2$: C, 87.58; H, 7.35; mol wt, 630.88. Found: C, 87.64; H, 7.23; mol wt (benzene), 628.

2,4,6-Tri-*t*-butyl-4-(4-diphenylmethyl-2,3,5,6-tetramethylphenoxy)-2,5-cyclohexadien-1-one (XII).—2,4,6-Tri-*t*-butylphenol (1.31 g, 5 mmoles) dissolved in benzene (175 ml) was shaken under nitrogen with active MnO_2 (13 g) for 2 min. Over a period of about 3 min, 4-hydroxy-2,3,5,6-tetramethyltriphenylmethane (1.58 g, 5 mmoles) was added with shaking to the blue solution containing the manganese dioxide. Filtration gave a blue-green filtrate, which was evaporated *in vacuo*. The blue-green oily residue thus obtained crystallized upon treatment with a little methanol. Filtration gave 2.45 g (85%) of light blue crystals, mp 130°. Recrystallization by dissolving in a little chloroform (yielding a deep blue solution) and adding methanol raised the melting point to 131–133° (green melt). The infrared spectrum of XII exhibited quinolid bands at 1638 and 1660 cm^{-1} (in KBr).

Anal. Calcd for $C_{41}H_{52}O_2$: C, 85.37; H, 9.09; mol wt, 576.84. Found: C, 85.38; H, 8.97; mol wt (benzene), 530 (solution turned blue).

2,4,6-Tri-*t*-butyl-4-(2,3,5,6-tetramethylphenoxy)-2,5-cyclohexadien-1-one (XIII).—Durophenol (450 mg, 3 mmoles) was added in three portions under nitrogen to a stirred suspension of active manganese dioxide (7.8 g) in a solution of 2,4,6-tri-*t*-butylphenol (786 mg, 3 mmoles) in benzene (100 ml). The blue solution was filtered, the manganese dioxide washed with benzene (50 ml), and the filtrate was evaporated *in vacuo*. The green oily residue was treated with a little methanol, yielding colorless to light green crystals. The substance forms deep blue solutions in ether from which it can be reprecipitated with methanol:

yield, 700 mg (57%); mp 140–145°. The infrared spectrum (in KBr) of XIII exhibited quinolid bands at 1645 and 1665 cm^{-1}.

Anal. Calcd for $C_{28}H_{42}O_2$ (mol wt, 410.62): C, 81.90; H, 10.31. Found: C, 82.04; H, 10.15.

2,4,6-Tri-*t*-butyl-4-(4-diphenylmethyl-2-phenylphenoxy)-2,5-cyclohexadien-1-one (XIV).—4-Hydroxy-3-phenyltriphenylmethane (673 mg, 2 mmoles) was added in four portions under nitrogen to a suspension of active manganese dioxide (5.3 g) in a solution of 2,4,6-tri-*t*-butylphenol (524 mg, 2 mmoles) in benzene (80 ml) which was shaken between each addition. Filtration and evaporation *in vacuo* gave a yellow oily residue which crystallized upon treatment with methanol. It was recrystallized by dissolving in a little ether (under N_2) and adding methanol: yield, 900 mg (75%) of light green to colorless crystals, mp 116–117°.

Anal. Calcd for $C_{43}H_{48}O_2$: C, 86.52; H, 8.11; mol wt, 596.86. Found: C, 86.69; H, 8.23; mol wt (chloroform), 554.

2,4,6-Tri-*t*-butyl-4-(2,6-diphenyl-4-diphenylmethylphenoxy)-2,5-cyclohexadien-1-one (XV).—3,5-Diphenyl-4-hydroxytriphenylmethane (412 mg, 1 mmole) was added over a period of 1 min to a suspension of active manganese dioxide (2.6 g) in a solution of 2,4,6-tri-*t*-butylphenol (262 mg, 1 mmole) which was agitated by a stream of nitrogen. Filtration and evaporation of the light yellow filtrate gave a yellow oily residue which crystallized upon treatment with methanol. It was filtered through a sintered-glass frit, dissolved on the frit in few milliliters of ether (which left a few milligrams of yellow substance undissolved), and filtered into about 50 ml of methanol. The methanol filtrate was agitated by a stream of nitrogen and the very light yellow crystalline precipitate thus formed was removed by filtration: yield, 415 mg (62%). The substance turned yellow above 100° and melted around 275°. During the process of heating, 3,5-diphenylfuchsone is probably formed.

Anal. Calcd for $C_{49}H_{52}O_2$: C, 87.72; H, 7.51; mol wt, 670.45. Found: C, 87.27; H, 7.95; mol wt (chloroform, very yellow solution), 562.

Decomposition of XV.—The deep green solution of the quinol ether derived from 2,4,6-tri-*t*-butylphenol and 3,5-diphenyl-4-hydroxytriphenylmethane (671 mg, 1 mmole) in benzene (25 ml) was refluxed under nitrogen for 3 hr. The solution was then deep brown. Upon cooling to room temperature, 330 mg (80%) of 3,5-diphenylfuchsone crystallized and was removed by filtration: mp 297–298°. The mixture melting point with authentic sample was not depressed.

Spectra.[14]—The infrared spectra were taken on a Perkin-Elmer grating infrared spectrophotometer, Model 521. Ultraviolet spectra were obtained with a Cary recording spectrophotometer, Model 14. Proton magnetic resonance spectra were taken on a Varian A-60 in deuteriochloroform with tetramethylsilane as internal standard.

Registry No.—IIIa, 13391-79-2; IIIb, 13391-80-5; IIIc, 13391-81-6; IIId, 13391-82-7; IIIe, 13391-83-8; IIIf, 13391-84-9; IVa, 13135-13-2; IVb, 11135-10-9; IVc, 13127-43-0; IVd, 13391-88-3; IVe, 13391-89-4; IVf, 13391-90-7; IVg, 13131-76-5; V, 13391-91-8; VI, 13391-92-9; VII, 13391-93-0; VIII, 13391-94-1; X, 13391-95-2; XI, 13428-17-6; XII, 13391-96-3; XIII, 13391-97-4; XIV, 13391-98-5; XV, 13428-16-5.

[14] Thanks are due to Miss Dorothy McClung and Miss Mary Ann Olivier for their prompt collaboration in recording the spectra.

Kinetics of Reactions of Amines with Ethers of 2,4-Dinitrophenol in 10% Dioxane–90% Water. Dependence of Base Catalysis on the Entering Amine and on the Leaving Group

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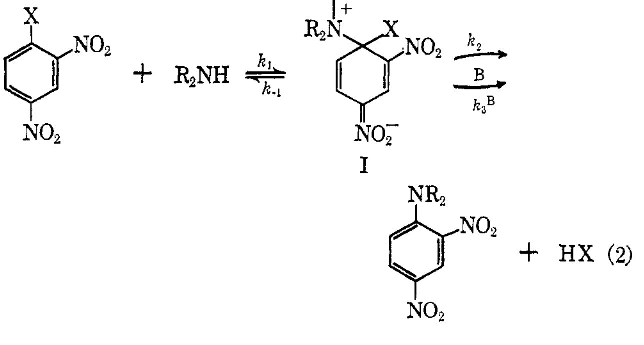
Rates of reactions of 2,4-dinitrophenyl phenyl ether with benzylamine and N-methylbenzylamine have been measured as a function of sodium hydroxide and of amine concentration. The reaction of N-methylbenzylamine is strongly catalyzed by sodium hydroxide and moderately by the amine itself. The second-order rate coefficient k_A is curvilinearly related to hydroxide ion concentration but is an approximately linear function of N-methylbenzylamine concentration. The reaction of benzylamine with 2,4-dinitrophenyl phenyl ether is independent of the hydroxide ion concentration; k_A is slightly decreased with increasing amine concentration. The dependence on piperidine concentration has been determined for the reactions of 2,4-dinitroanisole and of 2,4-dinitrophenyl phenyl sulfide. The second-order rate coefficient of the former reaction is a linear function of piperidine concentration, whereas the latter reaction is not catalyzed by piperidine. In the search for a relation between sensitivity to base catalysis of nucleophilic aromatic substitutions by primary and secondary amines and the acid–base properties of entering amine and leaving group, the partial rate coefficient k_1 and ratios k_2/k_{-1}, k_3^B/k_{-1}, and k_3^B/k_2 were calculated and compared with those previously obtained for similar reactions. The ratio k_3^{OH}/k_2, *i.e.*, the relative catalytic effectiveness of hydroxide ion to water, increases considerably with increasing basicity of the leaving group, but decreases only slightly with increasing basicity of the reacting amine.

Recently Bunnett and Bernasconi[2] investigated the reactions of piperidine with ethers of 2,4-dinitrophenol, in 10% dioxane–90% water, leading to 2,4-dinitrophenylpiperidine. They were able to show that the occurrence of base catalysis depends on the group displaced. Reactions with "good" leaving groups were little or not at all sensitive to catalysis by bases, whereas base catalysis was found to be strong for "poor" leaving groups. This characteristic dependence on the group displaced could easily be rationalized in terms of eq 1,

$$k_A = \frac{k_1k_2 + k_1\Sigma k_3^B[B]}{k_{-1} + k_2 + \Sigma k_3^B[B]} \qquad (1)$$

which is the appropriate kinetic expression for the two-step intermediate complex mechanism for nucleophilic aromatic substitution (eq 2), initially proposed by



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[2] J. F. Bunnett and C. F. Bernasconi, *J. Am. Chem. Soc.*, **87**, 5209 (1965).