[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF MICHIGAN]

Molecular Rearrangement of Diazotized *o*-Aminophenylcarbinols[1]

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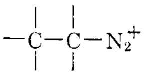
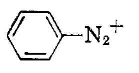
A number of substituted *o*-aminobenzohydrols, containing various substituents on the α-carbon and in the rings, were prepared and diazotized, and the diazonium salts were decomposed in aqueous acid. Substituted fluorenols, formed by ring closure, and phenols, formed by simple hydrolysis, were accompanied in most cases by ketones, formed by the 1,3-shift of an aryl group. In some cases the ketone was the major recognizable product. The factors determining the distribution of products in these reactions are discussed, and it is concluded that the results provide further evidence that aryl cations are quite nonselective in their reactions.

Loss of nitrogen from an aliphatic diazonium ion (I) is a strongly exothermic process which characteristically leads to a variety of products. Substitution, elimination, rearrangement, and solvolysis reactions are all commonly observed. This multiplicity of reaction paths can be explained on the assumption[3] that activation energies for the several alternative processes are much closer together than in other heterolyses, owing to a great compression of the energy scale associated with the production of the stable nitrogen molecule.



$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-N_2^+$$

I

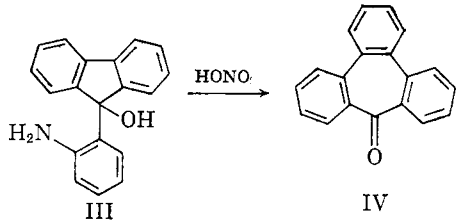


II

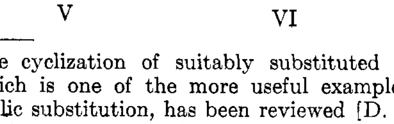
The heterolytic decomposition of an aromatic diazonium ion (II) requires a greater input of energy due to stabilization of the ion by conjugation of the positive charge on the diazonium group with the aromatic system. There is convincing evidence from several sources that the mechanism in this case involves formation of a transient aryl cation.[4-7] There are also indications[5,6] that such cations are highly reactive toward nucleophilic centers, and that a wide spectrum of products should result in this case as well. However, the structure of an aryl cation is such that rearrangement and elimination reactions of the familiar type are not feasible. Decomposition of aromatic diazonium salts in acid solution normally leads, therefore, to simple substitution by solvent or other nucleophiles.[8]

Recent observations have indicated that in certain cases molecular rearrangement[9] and an elimination reaction[10] (to form a benzyne intermediate) can be major reaction paths in the decomposition of diazonium salts. An investigation of the first of these two new reaction paths is the subject of this paper.

The first example of the rearrangement,[9] shown in Equation 1, was the conversion of 9-*o*-aminophenylfluorenol (III) to tribenzotropone (IV). It was assumed at the time[1b] that the rearrangement required the presence of the carbinol function to furnish the necessary lability in the skeletal bonds. The correctness of this assumption has since been verified by the finding[11] that 9-*o*-aminophenylfluorene undergoes the diazonium ring closure satisfactorily without evidence of rearrangement. It also appeared likely that the rearrangement would compete with the more familiar reactions only when the latter were made difficult, as the ring closure might be in III. It has been reported, for example, that *o*-aminobenzyl alcohol (V) could



(1)



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[1] (a) Taken largely from the Ph.D. thesis of A. J. Sisti, University of Michigan, 1959. (b) Some of these results were presented before the Division of Organic Chemistry, American Chemical Society Meeting, Miami, Fla., 1957; *Abstracts*, p. 70-O.

[2] Allied Chemical and Dye Corp. Fellow, 1957–58.

[3] A. Streitwieser, Jr., *J. Org. Chem.*, **22**, 861 (1957).

[4] J. F. Bunnett and R. E. Zahler, *Chem. Revs.*, **49**, 273 (1951).

[5] E. S. Lewis, *J. Am. Chem. Soc.*, **80**, 1371 (1958).

[6] D. F. DeTar and D. I. Relyea, *J. Am. Chem. Soc.*, **76**, 1680 (1954).

[7] K. R. Brower, *J. Am. Chem. Soc.*, **82**, 4535 (1960).

[8] The cyclization of suitably substituted diazonium salts, which is one of the more useful examples of such nucleophilic substitution, has been reviewed [D. F. DeTar, *Org. Reactions*, **9**, 409 (1957)].

[9] (a) M. Stiles and A. J. Libbey, Jr., *J. Org. Chem.*, **22**, 1243 (1957). (b) M. Stiles and A. J. Sisti, *J. Org. Chem.*, **24**, 268 (1959).

[10] M. Stiles and R. G. Miller, *J. Am. Chem. Soc.*, **82**, 3802 (1960).

[11] H. Rapoport and G. Smolinsky, *J. Am. Chem. Soc.*, **80**, 2910 (1958); **82**, 934 (1960).

TABLE I

YIELDS OF KETONES AND FLUORENOLS FROM DIAZONIUM SALTS

	Amine VII					
	R_1	R_2	R_3	R_4	% Ketone (IX)[a]	% Fluorenol (VIII)[b]
(a)	C_6H_5	H	H	H	0	46
(b)	$4\text{-}CH_3OC_6H_4$	H	CH_3O	H	0	48
(c)	$2\text{-}CH_3C_6H_4$	CH_3	H	H	16.5 (15)	19
(d)	$2,4\text{-}(CH_3)_2C_6H_3$	CH_3	CH_3	H	21.0 (16.6)	19
(e)	$2,5\text{-}(CH_3)_2C_6H_3$	CH_3	H	CH_3	11.4 (10)	21
(f)	$2\text{-}CH_3\text{-}4\text{-}CH_3OC_6H_3$	CH_3	CH_3O	H	28.6 (22.6)	21
(g)	CH_3	H	H	H	3.8[c]	26
(h)	C_2H_5	H	H	H	2.8[c]	23
(i)	CH_3	H	CH_3O	H	4.4[c]	0
(j)	CH_3	CH_3	CH_3	H	10,[c] 11	0
(k)[d]	CH_3	CH_3	CH_3O	CH_3	16 (13)	0

[a] Yields in parentheses refer to recrystallized ketone; those without parentheses to chromatographed but not recrystallized material. [b] In all cases yields are based on recrystallized material. [c] Yield of 2,4-dinitrophenylhydrazone isolated. [d] This reaction, which was described previously [ref. (9b)], also gave an 18% yield of 2-acetyl-2′,5′-dimethyl-4′-methoxyazobenzene.

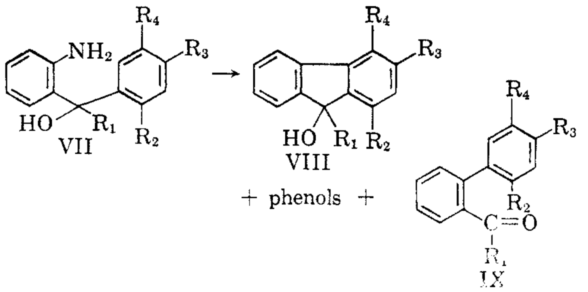
TABLE II

AMINO ALCOHOLS

	M.P.	Yield, %	Calcd.			Found		
			C	H	N	C	H	N
2-Aminophenyldi(4-methoxyphenyl)carbinol (VIIb)	98–99	50	75.19	6.31	4.18	75.37	6.50	4.02
2-Aminophenyldi(2-methylphenyl)carbinol (VIIc)	117–118	28	83.12	6.98	4.62	82.75	6.67	4.60
2-Aminophenyldi(2,4-dimethylphenyl)carbinol (VIId)	181–182	40	83.33	7.60	4.23	83.57	7.42	4.18
2-Aminophenyldi(2,5-dimethylphenyl)carbinol (VIIe)	126–128	34	83.33	7.60	4.23	83.25	7.40	4.20
2-Aminophenyldi(2-methyl-4-methoxyphenyl)carbinol (VIIf)	155–156	42	76.00	6.93	3.85	75.98	7.01	3.75
2-Amino-α-2′,4′-trimethylbenzohydrol (VIIj)	123–124	56	79.61	7.94	5.80	79.53	7.90	5.70
2-Aminophenyldi(2-methoxyphenyl)carbinol (XIa)	177–179	51	75.19	6.31	4.18	75.11	6.45	4.25
2-Aminophenyldi(2-ethoxyphenyl)carbinol (XIb)	117–118	55	76.00	6.93	3.85	76.18	6.71	3.84

be converted quantitatively to saligenin (VI) upon diazotization,[12] and a number of substituted o-aminobenzyl alcohols were diazotized under Sandmeyer conditions without anomalous results.[13a]

In order to investigate the scope of the rearrangement, a group of o-aminophenylcarbinols were synthesized and their reactions with nitrous acid were studied.



RESULTS

The aminocarbinols listed in Table I were prepared by conventional methods. Each compound was diazotized in aqueous sulfuric acid and the resulting diazonium salt was allowed to decompose at room temperature. In general, three different products could be recognized: (1) phenolic material, soluble in alkali, but not otherwise characterized; (2) substituted 9-fluorenols (VIII) in each case crystallized and characterized; and (3) ketones (IX) resulting from molecular rearrangement. Column chromatography on alumina served to separate cleanly the neutral products (VIII and IX). It is readily apparent from the results in the table that the molecular rearrangement is an important reaction path for relatively simple compounds.

The ketones (IX) were all new compounds except o-phenylacetophenone (IXg) which was identified by comparison with an authentic specimen.[13b] The structure of o-phenylpropiophenone (IXh) was confirmed by synthesis, using the same method. 2-Methyl-2′-o-tolylbenzophenone (IXc) was prepared from 2-methyl-2′-iodobiphenyl by conversion to the Grignard reagent and treatment with o-toluyl chloride. The product was identical with that obtained from the diazonium salt. Independent syntheses of the other ketones listed in Table I were not accomplished, although the following degradative scheme served to confirm the structure of IXf and, by implication, of the other ketones in the Table.

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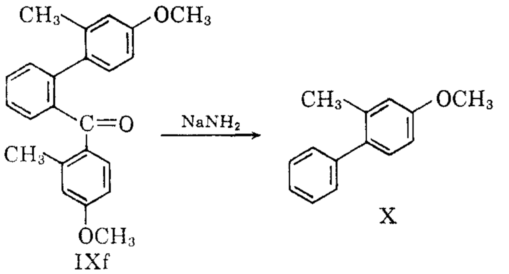
(12) A. Reissert and K. Crämer, *Ber.*, **61**, 2555 (1928).

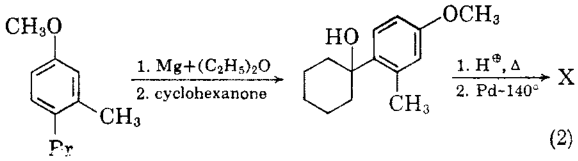
(13)(a) F. Mayer, W. Schäfer, and J. Rosenbach, *Arch. Pharm.*, **267**, 571 (1929).

(13)(b) E. Campaigne and B. Reid, *J. Am. Chem. Soc.*, **68**, 1663 (1946).

Treatment of ketone IXf with sodium amide in refluxing benzene produced a solid neutral product (X). The structure of X was established by synthesis from cyclohexanone and 3-methyl-4-bromoanisole as indicated in Equation 2. This structure for X confirms the structure assigned to IXf and indicates that the 1,3-shift of the aryl group in the rearrangement does not involve any isomerization within the migrating group.

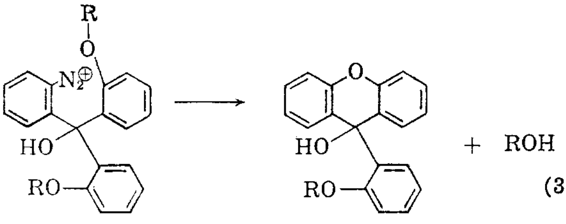


IXf X



(2)

Because of the increased yields of ketone observed when an *ortho*-methyl substituent was present in the migrating phenyl group, attempts were made to include other *ortho*-substituents. In the case of *o*-alkoxy substituents, the diazonium salts (XI) decomposed in an entirely different fashion to give xanthenols (Equation 3). We were unable to prepare amino alcohols containing *o*-chlorophenyl groups.

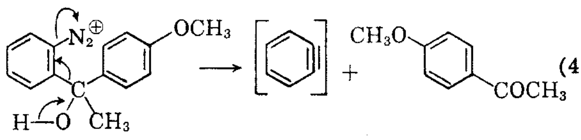


(3)

XIa. R = CH$_3$
b. R = C$_2$H$_5$

No fluorenols could be isolated from aminocarbinols VIIi, VIIj, and VIIk; only highly colored oils were eluted from the column following removal of the ketonic material, and no pertinent structural information was obtained from them. It appears likely that the oils were derived from dehydration products (dibenzofulvenes) of the 9-alkyl-9-fluorenol derivatives.

In the case of aminocarbinol VIIi one additional product was isolated in very low yield (*ca.* 0.3%), but its formation is highly significant. Conversion of the crude ketonic fraction to 2,4-dinitrophenylhydrazones followed by chromatography, furnished the 2,4-dinitrophenylhydrazone of the expected ketone (IXi) and the 2,4-dinitrophenylhydrazone of *p*-methoxyacetophenone. Formation of this product indicates loss of a C_6H_4 fragment during the reaction. A rational representation (Equation 4) gains considerable support from subsequent work which has shown[10] that the diazonium group is an excellent leaving group in benzyne formation.



(4)

All of the diazonium salt decompositions reported here were carried out in strong acid, conditions under which the heterolytic mechanism is known to predominate.[6] As a further indication that free radical chain reactions are not involved, the yields of ketone and fluorenol from compound VIIf were not significantly altered when the reaction was carried out in the presence of copper powder.

DISCUSSION

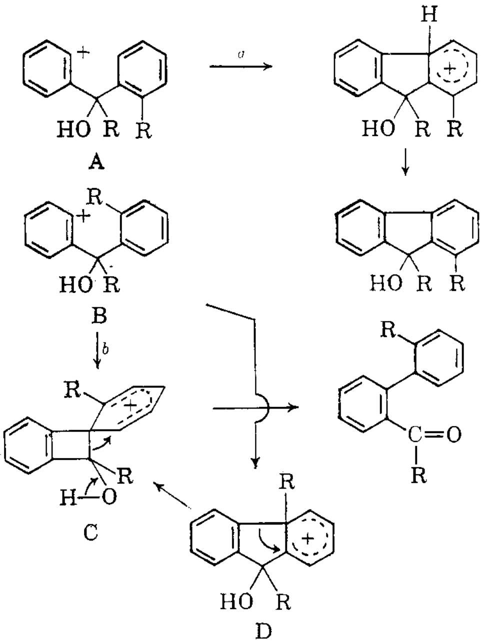
The most striking feature of Table I is the effect of *ortho*- substituents. Comparing the first six compounds (VIIa–VIIf), which are triphenylcarbinol derivatives, one notes that no rearrangement occurred except when an *ortho*- substituent was present. *Ortho*- substitution is also an important factor in the rearrangement of the diarylalkylcarbinol derivatives (VIIg–VIIk), although some ketone is formed in these cases even when an *ortho*-substituent is lacking. The effect of the *ortho*-methyl groups is not principally electrical in nature as can be seen from the fact that VIIb, with a much more powerful electron-donor group in the *para*-position, does not rearrange.

Electron-donor groups in the *para*- position of the migrating group apparently facilitate rearrangement, provided the required *ortho*- substituent is present. Thus a *para*-methyl (VIId and VIIj) and a *para* - methoxyl (VIIf and VIIk) increase the yield of ketone significantly. These electrical effects are to be expected in a rearrangement which involves migration of the aryl group to a positive center. For some reason a *meta*-methyl substituent (compare VIIc and VIIe) appears to decrease slightly the yield of ketone.

A feature of the data in Table I which may hold considerable significance for the reaction mechanism is the direct proportionality between the yield of fluorenol and the number of free *ortho*-positions for ring closure. The yield of substituted fluorenol from the eight compounds (VIIa–VIIh) was near 50% for compounds containing four free *ortho*- positions, and 19–26% for those with two. It apparently made no difference that the two free positions were sometimes in the same ring (VIIg and VIIh) and sometimes in different rings (VIIc–f). In fact, if one divides the yield of fluorenol for each of the eight compounds by the number of free *ortho*- positions, the result is 11.0 ± 1.0% for the whole group. In particular it should be noted that increases in the yield of ketone through introduction of electron-donor *para*- substituents (Vc, Vd, and Vf) has no effect on the yield of fluorenol.

These data suggest that the lifetime of the aryl cation formed by loss of nitrogen is very short compared with the time required for rotational equilibrium within the molecule. Thus the probability that an unsubstituted *ortho*- position will be within incipient bonding distance of the positive center at the time of its formation will be, to a first approximation, proportional to the total number of free *ortho*- positions. If no such free *ortho*- carbon is within this distance, an alternative reaction path, such as rearrangement or solvolysis, could intervene before the conformation favorable to ring closure had been achieved. Similar reasoning was used to explain the relatively small effect of substituents upon the diazonium ring closure of *o*-aminobenzophenones.[6]

The following reaction scheme is in accord with the information currently available. If A and B represent conformations[14] in which the unsubstituted *ortho*- position is, respectively, within and without the incipient bonding distance to the positive center, then the ratio of reaction paths *a* and *b* will reflect the relative populations of A and B, provided that the activation energy for these steps is sufficiently small. It also seems possible that D may precede C, and that the yields of ketones may also vary because of alternative modes of breakdown of intermediate D. It should be pointed out that B→D→C→ketone does not involve any step that could be described mechanistically as a 1,3-shift, being a combination of 1,2-shifts, but the former designation is conveniently expressive of the overall transformation.



EXPERIMENTAL[15]

Synthesis of amino alcohols. All of the amino alcohols in Table II were prepared by reaction of the appropriate arylmagnesium bromide with methyl anthranilate,[16] except VIIj, which was prepared from 2-amino-2′,4′-dimethylbenzophenone[17] and methylmagnesium iodide. In each case the ethereal solution of the Grignard reagent was cooled in an ice bath during addition of the carbonyl compound. The reactions were then completed by stirring for several hours at room temperature, followed by hydrolysis in ammonium chloride solution. Compounds VIIj, VIIc, XIa, and Xb were crystallized from benzene–petroleum ether (b.p. 30–60°); VIId and VIIf were crystallized from benzene-ethanol; VIIb was crystallized from ethanol, and VIIe from petroleum ether (b.p. 30–60°).

The following amino alcohols were prepared as described previously: 2-amino-α-methylbenzohydrol (VIIg), m.p. 84–85 (reported[18] 84–85°); 2-amino-α-ethylbenzohydrol (VIIh), m.p. 99–100° (reported[19] 102–103°); 2-aminotriphenylcarbinol (VIIa), m.p. 119–120° (reported,[20] 121.5°); 2-amino-4′-methoxy-α-methylbenzohydrol (VIIi), m.p. 93–94° (reported,[21] 99°). The intermediates, 2-aminobenzophenone and 2-amino-4′-methoxybenzophenone, were prepared by the procedure of Simpson.[22]

Diazotizations. Unless otherwise indicated below, the amino alcohols were diazotized in aqueous 10% sulfuric acid at 0–5° with slightly more than an equivalent quantity of sodium nitrite. The amino alcohol (8–20 mmoles) was dissolved in 200–250 ml. of the aqueous acid, and the sodium nitrite, in 10 ml. of water, was added. The solution was then allowed to stand at 0–10° for at least 0.5 hr. before warming to room temperature. After at least 3 hr. the reaction mixture, in which an oily layer had separated, was warmed to 50° for a few minutes. [It was found that the ratio of products from these reactions was not changed significantly by altering the temperature (10–50°) at which the solution was held during decomposition of the diazonium salt.] The mixture was extracted twice with ether and the ether extracts were washed with 5% sodium hydroxide to remove phenolic material, which was not characterized further. The dried ether solution was then evaporated and the residue in each case was examined as described below.

Products from VIIa. The neutral product was dissolved in equal volumes of benzene and petroleum ether and adsorbed on alumina.[23] Elution with benzene yielded 9-phenyl-9-fluorenol (VIIIa) which was recrystallized from carbon tetrachloride to furnish 1.5 g. (46%), m.p. 85–88° (reported[24] m.p. 85–88°).

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(14) Structures A and B are not intended to imply that the two rings are coplanar.

(15) Microanalyses by Spang Microanalytical Laboratory, Ann Arbor, Mich. Melting points and boiling points were not corrected for stem exposure.

(16) M. Heidelberger, *Advanced Laboratory Manual of Organic Chemistry*, Chemical Catalog Co., Inc., New York, 1923, p. 32.

(17) L. Chardonnens and A. Wurmuli, *Helv. Chim. Acta*, **33**, 1338 (1950).

(18) R. Stoermer and H. Fincke, *Ber.*, **42**, 3119 (1909).

(19) J. C. E. Simpson, *J. Chem. Soc.*, 673 (1946).

(20) A. Baeyer, V. Villiger, and H. Bassett, *Ber.*, **37**, 3192 (1904).

(21) R. Stoermer and O. Gaus, *Ber.*, **45**, 3104 (1912).

(22) J. C. E. Simpson, C. M. Atkinson, K. Schofield, and O. Stephenson, *J. Chem. Soc.*, 646 (1945).

(23) All chromatograms described in this paper were carried out using ordinary Merck alumina, 30 g. per gram of compound, unless otherwise stated.

(24) A. Kliegl, *Ber.*, **38**, 284 (1905).

Product from VIIb. The crude product was dissolved in 40% benzene–60% petroleum ether and adsorbed on alumina. Elution with 1:1 benzene:chloroform yielded material which was recrystallized from benzene-petroleum ether to furnish 1.4 g. (48%) of *3-methoxy-9-(p-methoxyphenyl)-9-fluorenol* (VIIIb), m.p. 118–120°; ν 3600 cm.$^{-1}$ (chloroform).

Anal. Calcd. for $C_{21}H_{18}O_3$: C, 79.21; H, 5.71. Found: C, 79.41; H, 5.71.

Product from VIIc. The crude product was dissolved in 1:3 benzene–petroleum ether and adsorbed on alumina. Elution with more of the same solvent mixture furnished 0.53 g. (17%) of a light yellow oil, ν 1665 cm.$^{-1}$ (carbon tetrachloride). Crystallization from petroleum ether gave 0.475 g. (15%) of colorless *2-methyl-2′-(o-tolyl)benzophenone* (IXc), m.p. 72–73°.

Anal. Calcd. for $C_{21}H_{18}O$: C, 88.07; H, 6.33. Found: C, 88.04; H, 6.38.

Elution of the column with pure benzene furnished 0.63 g. of solid which, upon recrystallization from benzene-petroleum ether yielded 0.57 g. (18%) of *1-methyl-9-(o-tolyl)-9-fluorenol* (VIIIc), m.p. 114–115°.

Anal. Calcd. for $C_{21}H_{18}O$: C, 88.07; H, 6.33. Found: C, 88.16; H, 6.31.

Product from VIId. The diazotization of this compound was accomplished by adding a slight excess of sodium nitrite in 10 ml. of water to 4.0 g. (0.012 mole) of the amino alcohol dissolved in a mixture of 200 ml. of water, 100 ml. of ethanol, and 6 ml. of sulfuric acid. The neutral product from decomposition of the diazonium was adsorbed on alumina, and eluted with mixtures of benzene and petroleum ether. In the 10–30% benzene eluates there was obtained 0.80 g. (21%) of a light oil, ν 1655 cm.$^{-1}$ (film). Recrystallization from ethanol furnished 0.63 g. (17%) of *2,4-dimethyl-2′-(2,4-dimethylphenyl)benzophenone*, (IXd), m.p. 70.5–71.0°, ν 1658 cm.$^{-1}$ (chloroform).

Anal. Calcd. for $C_{23}H_{22}O$: C, 87.85; H, 7.05. Found: C, 87.89; H, 7.12.

Elution of the column with 70–100% benzene yielded, after recrystallization from petroleum ether, 0.70 g. (19%) of *1,3-dimethyl-9-(2,4-dimethylphenyl)fluorenol* (VIIId), m.p. 140–141°, ν 3600 cm.$^{-1}$ (chloroform).

Anal. Calcd. for $C_{23}H_{22}O$: C, 87.85; H, 7.05. Found: C, 87.81; H, 7.11.

Product from VIIe. The neutral product was dissolved in 30% benzene–70% petroleum ether (30–60°), placed on a column of alumina, and eluted with more of the same solvent mixture. There was obtained 0.39 g. (11%) of a yellow oil, ν 1662 cm.$^{-1}$ (film), which crystallized from ethanol to furnish 0.32 g. (10%) of colorless *2,5-dimethyl-2′-(2,5-dimethylphenyl)benzophenone* (IXe), m.p. 59–60°, ν 1662 cm.$^{-1}$ (carbon tetrachloride).

Anal. Calcd. for $C_{23}H_{22}O$: C, 87.85; H, 7.05. Found: C, 87.94; H, 7.22.

Elution with 1:1 chloroform-benzene yielded, after recrystallization from benzene–petroleum ether, 0.70 g. (21%) of *1,4-dimethyl-9-(2,5-dimethylphenyl)-9-fluorenol* (VIIIe), m.p. 158–159°.

Anal. Calcd. for $C_{23}H_{22}O$: C, 87.85; H, 7.05. Found: C, 87.60; H, 7.02.

Product from VIIf. The diazotization of this amino alcohol (3.0 g., 8.3 mmoles) was carried out in a medium consisting of 50 ml. of water, 100 ml. of dioxane, and 2 ml. of sulfuric acid, by the addition of a small excess of sodium nitrite in 10 ml. of water at room temperature. After 1 hr. at room temperature 100 ml. of water was added and the mixture allowed to stand a further 2 hr. before dilution with another 100-ml. portion of water and warming to 40–50°. The neutral product was dissolved in benzene, adsorbed on alumina, and eluted with more benzene. A light oil [0.82 g., 29%, ν 1645 (film)] was obtained and crystallized from ethanol to yield 0.65 g. (23%) of *2-methyl-4-methoxy-2′-(2-methyl-4-methoxyphenyl)-benzophenone* (IXf), m.p. 95.5–96.0°, ν 1650 cm.$^{-1}$ (chloroform).

Anal. Calcd. for $C_{23}H_{22}O_3$: C, 79.74; H, 6.40. Found: C, 79.68; H, 6.38.

Elution with 1:1 chloroform-benzene yielded, after recrystallization from benzene–petroleum ether, 0.60 g. (21%) of 1-methyl-3-methoxy-9-(2-methyl-4-methoxyphenyl)-9-fluorenol (VIIIf), m.p. 170–171°, ν 3450 cm.$^{-1}$ (Nujol).

Anal. Calcd. for $C_{23}H_{22}O_3$: C, 79.74; H, 6.40. Found: C, 79.66; H, 6.37.

When two reactions on amino alcohol VIIf were carried out exactly as described above, except that 1.5 g. of copper powder was added to each solution during the decomposition of the diazonium salt, the yields of ketone were 24% and 21% and of the fluorenol, 20% and 19%.

Product from VII g. When the neutral product was treated with benzene-petroleum ether there was obtained 0.80 g. (26%) of 9-methyl-9-fluorenol (IXg), m.p. 172–174° (reported[25] 174°). The filtrate was placed on a column of alumina and eluted with 15% benzene–85% petroleum ether. The yellow oil eluted, ν 1685 cm.$^{-1}$ (film), was converted to its 2,4-dinitrophenylhydrazone (0.225 g., 3.8%), m.p. 169–170°, alone and when mixed with the dinitrophenylhydrazone of *o*-phenylacetophenone, prepared by the method of Campaigne and Reed.[18]

Product from VIIh. The neutral product was dissolved in 40% benzene–60% petroleum ether, adsorbed on alumina, and eluted with more of the same solvent. The oil, ν 1686 cm.$^{-1}$ (film), which was eluted was converted to its 2,4-dinitrophenylhydrazone (0.176 g., 2.8%) m.p. 154–155° alone and when mixed with the dinitrophenylhydrazone of *o*-phenylpropiophenone. Elution of the column with benzene yielded 9-ethyl-9-fluorenol, recrystallized from petroleum ether to furnish 0.80 g. (23%), m.p. 108–110° (recorded,[25] m.p. 102°).

Product from VIIi. The diazotization was carried out by adding a slight excess of sodium nitrite in 20 ml. of water to the amino alcohol (6.5 g., 0.027 mole) dissolved in 200 ml. of water, 75 ml. dioxane, and 3 g. of sulfuric acid at 0–5°. The neutral product was dissolved in 40% benzene–60% petroleum ether, adsorbed on alumina, and eluted with 1:1 benzene–petroleum ether. The light oil, ν 1670 cm.$^{-1}$ (film) eluted was converted to its 2,4-dinitrophenylhydrazone (0.46 g., 4.4%), m.p. 190–191.5° after purification by chromatography on alumina. The ketone is assigned the structure of *2-(4-methoxyphenyl)acetophenone* (IXi).

Anal. Calcd. for $C_{21}H_{18}N_4O_5$: C, 62.06; H, 4.43; N, 13.79. Found: C, 61.99; H, 4.35; N, 13.80.

During chromatographic purification of the preceding dinitrophenylhydrazone, there was isolated 0.035 g. (0.3%) of the bright red dinitrophenylhydrazone of *p*-methoxyacetophenone, m.p. 223–225° alone and mixed with an authentic specimen, which also exhibited the same infrared spectrum. No fluorenol was obtained from this reaction mixture. Further elution of the original column yielded only highly colored oils which could not be crystallized.

Product from VIIj. The diazotization was carried out by adding sodium nitrite in 10 ml. of water to the amino alcohol (3.7g., 0.015 mole) dissolved in 50 ml. of dioxane, 100 ml. of water, and 2 g. of sulfuric acid at 0–5°. The neutral fraction of the product was dissolved in 1:1 benzene–petroleum ether, adsorbed on alumina, and eluted with more of the same mixture. There was obtained 0.395 g. (11%) of an oil, ν 1680 cm.$^{-1}$ (film), which was converted to its 2,4-dinitrophenylhydrazone. The dinitrophenylhydrazone was purified by chromatography on alumina to yield 0.605 g. (10%), m.p. 149–150°.

Anal. Calcd. for $C_{22}H_{20}N_4O_4$: C, 65.33; H, 4.99; N, 13.85. Found: C, 65.43; H, 5.04; N, 13.94.

The ketone is assigned the structure of *2-(2,4-dimethylphenyl)-acetophenone* (IXj). No fluorenol could be found among the products.

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Product from XIa. The neutral product was dissolved in 1:1 benzene–petroleum ether and adsorbed on alumina. Elution with 1:1 chloroform-benzene yielded 1.1 g. of solid, m.p. 162–166°; recrystallization from benzene–petroleum ether furnished 0.90 g. (48%) of *9-(2-methoxyphenyl)-9-xanthenol*, m.p. 164–166°.

Anal. Calcd. for $C_{20}H_{16}O_3$: C, 78.91; H, 5.30. Found: C, 78.97; H, 5.28.

The product was identical (mixed melting point and infrared spectrum) with the compound prepared in 44% yield from xanthone and *o*-methoxyphenylmagnesium bromide.

Product from XIb. The neutral product from the decomposition of this diazonium salt was crystallized from benzene-petroleum ether to furnish 0.80 g. (44%) of *9-(2-ethoxyphenyl)-9-xanthenol*, m.p. 185.0–186.5°.

Anal. Calcd. for $C_{21}H_{18}O_3$: C, 79.21; H, 5.71. Found: C, 79.20; H, 5.86.

This product was prepared in 47% yield by the reaction of *o*-ethoxyphenylmagnesium bromide and xanthone.

o-Phenylpropiophenone (IXh). The synthesis was an adaptation of one by Campaigne and Reed.[13] A Grignard reagent, prepared from 2-iodobiphenyl (28 g., 0.10 mole) and 2.5 g. (0.10 g.-atom) of magnesium in 75 ml. of ether, was added dropwise to an ether solution of 26 g. (0.20 mole) of propionic anhydride at −60°. The mixture was worked up in the usual way[13] to yield 6.0 g. (28%) of *o*-phenylpropiophenone, b.p. 120–121° at 6 mm. The ketone was converted to its 2,4-dinitrophenylhydrazone, m.p. 154–155°, which proved identical with that obtained by the decomposition of the diazonium salt from VIIh.

Anal. Calcd. for $C_{21}H_{18}N_4O_4$: C, 64.60; H, 4.65; N, 14.35. Found: C, 64.75; H, 4.66; N, 14.38.

2-Methyl-2'-(2-methylphenyl)benzophenone (IXc) was prepared in low yield by a method described by Fuson.[26] The Grignard reagent, prepared from 2.0 g. (0.0068 mole) of 2-iodo-2'-methylbiphenyl[27] and 1.0 g. (0.041 mole) of magnesium in 25 ml. of ether, was added dropwise to an ether solution of 3.0 g. (0.019 mole) of *o*-toluyl chloride. The reaction was worked up in the usual manner[26] and the product was crystallized from petroleum ether. There was obtained 0.114 g. (6%) of white crystalline solid, m.p. 71–73°, identical with that obtained by decomposition of the diazonium salt from VIIc.

Sodium amide cleavage of ketone IXf. Sodium amide, prepared from 0.3 g. of sodium in 30 ml. of liquid ammonia, was freed of ammonia and suspended in 40 ml. of benzene. The ketone IXf (0.605 g., 0.00175 mole) was added and the mixture was refluxed for 22 hr. before quenching in ice. An ether extract was washed with water, dried, and evaporated to leave an oil. The oil was dissolved in petroleum ether (some dark insoluble material was discarded) and adsorbed on a column of 30 g. of ordinary alumina. In the 5–10% benzene–95–90% petroleum ether eluate there was obtained 0.166 g. (48%) of *2-methyl-4-methoxybiphenyl*, as colorless crystals, m.p. 52.5–54.5°. Recrystallization from petroleum ether raised the melting point only to 53.0–55.0°; a mixed melting point with the material described below was 53.0–55.0°, and the two samples exhibited the same infrared spectrum.

1-(2-Methyl-4-methoxyphenyl)-cyclohexanol. 2-Methyl-4-methoxybromobenzene[28] (b.p. 94–96° at 6 mm.) was prepared by methylating the potassium salt of 3-methyl-4-bromophenol[29] with methyl iodide in ethanol solution. The halide (30 g., 0.15 mole) was treated with 4.5 g. (0.17 g.-atom) of magnesium in 100 ml. of ether. Stirring at reflux for 8 hr. was necessary before the magnesium appeared largely reacted. Cyclohexanone was then added to the cooled solution and the mixture allowed to stir for an additional hour. Hydrolysis with aqueous ammonium chloride, followed by ether extraction, led to the isolation of an oil which contained considerable starting material. Chromatography on alumina, using benzene–petroleum ether (30–60°) as eluant led to the crystalline carbinol, 8.6 g. (39%) m.p. 47–49°. Recrystallization from petroleum ether raised the m.p. to 48.5–50.0°.

Anal. Calcd. for $C_{14}H_{20}O_2$: C, 76.31; H, 9.15. Found: C, 76.41; H, 9.33.

2-Methyl-4-methoxybiphenyl. Two grams (0.0091 mole) of 1-(2-methyl-4-methoxyphenyl)cyclohexanol was refluxed for 2 hr. with 0.05 g. of *p*-toluenesulfonic acid in 40 ml. of benzene. The acid was removed by extraction with aqueous sodium bicarbonate, and the dried organic layer was evaporated to a light oil. The oil, which contained no carbinol as determined by the infrared spectrum, was dissolved in 50 ml. of *p*-xylene and the solution was refluxed with 0.50 g. of 10% palladium on carbon for 21 hr. The catalyst was removed and the solution was concentrated to an oil, which was dissolved in petroleum ether, adsorbed on 50 g. of ordinary alumina, and eluted with petroleum ether–benzene to furnish 0.462 g. (26%) of colorless crystals, m.p. 53–55°. Recrystallization from petroleum ether raised the m.p. to 53.5–55.5°.

Anal. Calcd. for $C_{14}H_{14}O$: C, 84.80; H, 7.11. Found: C, 85.14, 85.03; H, 7.22, 7.39.

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