Reactions of Nitropolymethylbiphenyls

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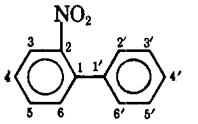
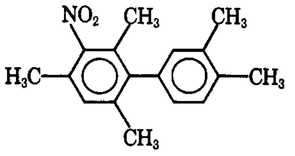
The nitropolymethylbiphenyls most readily obtained by nitrative coupling of methylated benzenes were converted into carbazoles by the Cadogan reaction, to amines by hydrogenation, and to phenols and fluorenes *via* the diazonium salts. These phenols are weak acids on the basis of their solubility; nmr data are given for the carbazoles and fluorenes. A mechanism is proposed for the formation of fluorenes from diazotized *o*-amino-*o*′-methylbiphenyls.

Nitrative coupling of methylated benzenes[1-3] made available several new nitropolymethylbiphenyls. To study their behavior and to confirm some of the structures, we have converted the more readily accessible into amines by hydrogenation, into phenols *via* the diazonium salts, and, when structural features were suitable, into carbazoles by the Cadogan reaction and into fluorenes by the Mascarelli reaction.

The starting compounds are listed below. With one exception, the structures originally proposed[1,2] were confirmed.





VII

No.	Methylated positions
I	3′, 4, 4′, 5
II	2′, 4, 4′, 5
III	2′, 4, 4′, 5, 5′
IV	3, 3′, 4, 4′, 6
V	2′, 3, 3′, 4, 4′, 5
VI	3, 3′, 4, 4′, 5, 6

Polymethylcarbazoles by the Cadogan Reaction.—Reductive cyclization of *o*-nitrobiphenyls by triethyl phosphite gives a high yield of carbazoles if at least one *ortho*′ position of the biphenyl is unsubstituted.[4] This reaction gives valuable information concerning the structure of the starting nitrobiphenyl. It confirms not only the *ortho* position of the nitro group, but also helps in locating the substituents in the unnitrated benzene ring. We obtained carbazoles from I, II, and III at the reflux temperature of the triethyl phosphite solution (160–170°) but at a slower rate than indicated by the experimental conditions of Cadogan, *et al.*[4] This may be due to the presence of methyl groups which create a higher electron density on the nitro group, thus hindering nucleophilic attack by triethyl phosphite.[4,5] Compounds IV, V, and VI underwent reaction with triethyl phosphite only at 195–205°, probably because of steric hindrance by the 3-methyl groups. Even then, the rate of carbazole formation was very slow. Attempts to accelerate the reaction by raising the temperature failed because of decomposition of the triethyl phosphite. Under the forcing conditions, N-ethylation of the carbazole by the phosphorus ester also complicated the reaction. For these reasons, triphenyl phosphine[4] might be a better reagent for the reductive cyclization of IV, V, and VI.

The minor by-products of the reaction were diethylaminobiphenyls, ethylaminobiphenyls, and the N-ethylcarbazoles already mentioned.

Compounds II, III, and V gave only one, but I, IV, and VI gave two carbazole isomers. Originally IV, from the cross-coupling of *o*-xylene and pseudocumene, was pictured as 2-nitro-2′,3,4,4′,5′-pentamethylbiphenyl.[2] However, since it forms two isomeric carbazoles, that assignment must have been wrong; formula IV agrees both with the results of the Cadogan reaction and also with the spectroscopic data.[2] A third possibility based on spectroscopic data, 2-nitro-3,3′,4′,5,6-pentamethylbiphenyl, is ruled out by the identity of one of the isomeric carbazoles from IV with the carbazole prepared from III. Analogously, the formation of two isomeric carbazoles from VI rules out the alternative 2-nitro-2′,3,3′,4,4′,5′-hexamethylbiphenyl assignment which could not be eliminated by spectroscopy.[2]

The melting points and elemental analyses of the new polymethylcarbazoles are given in Table I. Table II gives the nmr absorptions. If located at the 4 or 5 position, the methyl protons are deshielded by approximately 0.4 ppm and the aromatic protons by approximately 0.9 ppm. The deshielding can be attributed to the ring current of those rings to which these substituents are not attached. The effect of ring current on the aromatic protons in other polycyclic aromatic hydrocarbons is well documented,[6] and recently the deshielding of aromatic and methylene protons at the 4 and 5 positions of carbazole was also demonstrated.[7]

The symmetrical structure of VIII is shown by its high melting point and nmr spectrum; its isomer must have structure IX. From IV, the minor isomer was identical with compound XI prepared from III; the structure XII is left for the other isomer. The structure XVII was assigned to the higher melting isomer from VI on the basis of the nmr coupling pattern of the aromatic protons. For the compounds XIV and XVI nmr and ir spectra clearly indicated that N-ethylation had occurred.

Aminopolymethylbiphenyls.—The reduction of I to the corresponding amine with tin and hydrochloric acid was reported in 1911.[8] Compounds I–VII were readily reduced to the corresponding amines without side reaction with ethanolic hydrazine and Raney Ni.[9]

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[1] I. Puskas and E. K. Fields, *J. Org. Chem.*, **31**, 4204 (1966).

[2] I. Puskas and E. K. Fields, *ibid.*, **32**, 589 (1967).

[3] I. Puskas and E. K. Fields, *ibid.*, **32**, 3924 (1967).

[4] J. I. G. Cadogan, M. Cameron-Wood, R. K. Mackie, and R. J. G. Searle, *J. Chem. Soc.*, 4831 (1965).

[5] G. Smolinsky and B. I. Feuer, *J. Org. Chem.*, **31**, 3882 (1966).

[6] (a) J. A. Pople, W. G. Schneider, and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., Inc., Toronto, 1959, pp 247–254. (b) J. W. Emsley, J. Feeney, and L. H. Sutcliffe, "High Resolution Nuclear Magnetic Resonance Spectroscopy," Vol. I, Pergamon Press, New York, 1965, pp 141–145.

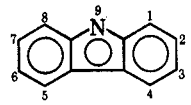
[7] R. E. Moore and H. Rapoport, *J. Org. Chem.*, **32**, 3335 (1967).

[8] A. W. Crossley and C. H. Hampshire, *J. Chem. Soc.*, 721 (1911).

[9] D. Balcom and A. Furst, *J. Amer. Chem. Soc.*, **75**, 4334 (1953).

TABLE I

MELTING POINTS AND ELEMENTAL ANALYSES OF THE NEW POLYMETHYLCARBAZOLES



Starting nitro compd	Compd, indicated by the positions of the methyl groups	Formula no.	Mp, °C^a	Formula^b	Anal, %: Calcd C	Calcd H	Calcd N	Found C	Found H	Found N
I	2,3,6,7	VIII	244–246	$C_{16}H_{17}N$	86.1	7.7	6.3	85.9	7.7	6.5
I	1,2,6,7	IX	202–205	$C_{16}H_{17}N$	86.1	7.7	6.3	86.4	7.6	6.3
II	2,3,5,7	X	185–186	$C_{16}H_{17}N$	86.1	7.7	6.3	85.8	7.6	6.1
III or IV	1,2,4,6,7	XI	147–148	$C_{17}H_{19}N$	86.0	8.1	5.9	85.7	8.1	6.0
IV	1,2,4,7,8	XII	189.5–191	$C_{17}H_{19}N$	86.0	8.1	5.9	85.9	7.9	5.8
V	1,2,3,5,6,7	XIII	192–193	$C_{18}H_{21}N$	86.0	8.4	5.6	85.6	8.3	5.5
V	1,2,3,5,6,7; 9-ethyl	XIV	169–171	$C_{20}H_{25}N$	86.0	9.0	5.0			5.0
VI	1,2,3,4,6,7	XV^c	193–195	$C_{18}H_{21}N$	86.0	8.4	5.6	86.8	8.3	
VI	1,2,3,4,6,7; 9-ethyl	XVI	137.5–138	$C_{20}H_{25}N$	86.0	9.0	5.0			4.8
VI	1,2,3,4,7,8	XVII	203–205	$C_{18}H_{21}N$	86.0	8.4	5.6	85.6	8.1	

[a] Corrected. [b] Confirmed by mass spectrometry. [c] Lack of material prevented the repetition of the elemental analyses. Spectroscopic and gas chromatographic data, however, leave no doubt, that we had the compound at hand in high purity.

TABLE II

NMR ABSORPTIONS OF THE POLYMETHYLCARBAZOLES

Compd	Nmr τ values^a: Deuteriochloroform, Aromatic protons	Deuteriochloroform, Methyl protons	Deuteriopyridine or pyridine,^{b} methyl protons
VIII	c	7.61 (12)	7.64 (6)^b
			7.70 (F)^b
IX	c	7.55 (12)	7.60 (3)^b
			7.66 (6)^b
			7.72 (3)^b
X	2.25 (1)	7.25 (3)	7.18 (3)
	3.26 (2)	7.60 (6)	7.62 (6)
	3.40 (1)	7.64 (3)	7.71 (3)
XI	2.27 (1)	7.27 (3)	7.15 (3)
	3.11 (1)	7.68 (6)	7.63 (12)
	3.30 (1)	7.69 (3)	
		7.82 (3)	
XII	2.16 (1)^d	7.21 (3)	7.20 (3)
	2.97 (1)^d	7.57 (12)	7.64 (12)
	3.18 (1)		
XIII	2.18 (1)	7.25 (3)	7.15 (3)
	3.07 (1)	7.58 (3)	7.55 (6)
		7.62 (3)	7.70 (3)
		7.72 (9)	7.79 (6)
XIV	2.14 (1)	7.25 (3)	
	3.02 (1)	7.41 (3)	
		7.58 (6)	
		7.73 (6)	
XVI	2.03 (1)	7.20 (3)	
	2.91 (1)	7.33 (3)	
		7.57 (6)	
		7.73 (6)	
XVII	2.08 (1)^d	7.22 (3)	
	3.00 (1)^d	7.57 (9)	
		7.64 (6)	

[a] Numbers in brackets indicate the number of protons. [b] Indicates pyridine. [c] Owing to poor solubility, signals were hardly distinguishable from the noise level. [d] Center of doublet with coupling constants 8.1 (XII) and 7.5 (XVII) cps.

Characterization of the new aminopolymethylbiphenyls is shown in Table III.

Catalytic hydrogenation of I–VII was only moderately successful. Thus, on Raney Ni in ethanolic solution I was easily reduced, but VII, II, and III were reduced sluggishly, and required relatively large quantities of catalyst. The severe conditions required for completion of the reaction resulted in the formation of several by-products; mass spectrometry indicated that, in addition to alkylation by the solvent,[10] dimerizations, trimerizations, and reductive cleavage to benzene derivatives took place. With *o*-nitrobiphenyls, some carbazole also formed.

Palladium-on-charcoal and Adams catalysts did not give better results. At room temperature in dimethoxyethane palladium on charcoal caused hydrogenolysis of the solvent and alkylation of the amine. Hydrogenation of IV, V, and VI was extremely slow.

Diazotization of Aminopolymethylbiphenyls in Aqueous Sulfuric Acid. Phenol Formation and the Mascarelli Reaction.—Mascarelli has shown that thermal decomposition of diazotized 2-amino-2′-methylbiphenyls gives fluorenes.[11–14] As this reaction has received little attention, we studied it with our diazotized amines.

Thermal decomposition of diazotized XVIII, XIX, and XXI in approximately 2.5% aqueous H_2SO_4 gave the expected fluorenes; hydrolysis to phenols always occurred as well. In accord with the structural assignments, 2-amino-3′,4,4′,5-tetramethylbiphenyl[8] and compounds XX, XXII, and XXIII gave phenols and by-products but no fluorene derivatives. Tables IV and V list the new polymethylfluorenes and the hydroxypolymethylbiphenyls, respectively.

To improve the yield of fluorene, we diazotized XIX and decomposed it in 80% H_2SO_4 as well as in dilute HCl, alone and with cuprous chloride. The yield did not increase. Decomposition of the diazonium fluoroborate gave mainly the fluorinated biphenyl (65%) and only 25% fluorene.

In contrast to *o*-hydroxybiphenyl, the phenols of Table V were not extracted by 10% NaOH; their solubility was extremely low even in Claisen's alkali.[15] This behavior is similar to that exhibited by sterically

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(10) M. Freifelder, *Engelhard Ind. Tech. Bull.*, **2**, No. 3, 93 (1961); D. H. Johnson, *J. Chem. Soc., C*, 1284 (1967).

(11) L. Mascarelli, *Gazz. Chim. Ital.*, **66**, 843 (1936); *Chem. Abstr.*, **31**, 6222 (1937).

(12) L. Mascarelli and D. Gatti, *Atti Congr. Nazl. Chim. Pura Appl., Milan, 1932*, 503 (1933); *Chem. Abstr.*, **29**, 4351 (1935).

(13) L. Mascarelli and B. Longo, *Gazz. Chim. Ital.*, **67**, 812 (1937); *Chem. Abstr.*, **32**, 4564 (1938).

(14) L. Mascarelli and A. Angeletti, *Gazz. Chim. Ital.*, **68**, 29 (1938); *Chem. Abstr.*, **32**, 4565 (1938).

(15) L. Claisen, *Ann.*, **418**, 96 (1919); **442**, 210 (1925).

TABLE III

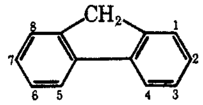
MELTING POINTS AND ELEMENTAL ANALYSES OF THE NEW AMINOPOLYMETHYLBIPHENYLS

Starting nitro compd	Amine	Mp, °C, or $[n]^{19.5}$D	Formula[a]	Anal, % Calcd C_1	H_1	N	Found C_1	H_1	N
II	XVIII	1.5986	$C_{16}H_{19}N$	85.3	8.5	6.2	85.3	8.5	6.3
III	XIX	1.5950	$C_{17}H_{21}N$	85.3	8.8	5.9	85.0	8.8	5.8
IV	XX	80–81	$C_{17}H_{21}N$	85.3	8.8	5.9	85.5	9.0	
V	XXI	122–123	$C_{18}H_{23}N$	85.3	9.2	5.5	85.6	9.0	
VI	XXII	110.5–1115	$C_{18}H_{23}N$	95.3	9.2	5.5	85.8	9.2	
VII	XXIII	63.5–64.5	$C_{17}H_{21}N$	85.3	8.8	5.9	84.9	8.8	6.0

[a] Confirmed by mass spectrometry.

TABLE IV

YIELDS AND PHYSICAL CONSTANTS OF THE NEW POLYMETHYLFLUORENES



Starting nitro compd	Position of methyl groups	Formula no.	Yield,[a] %	Mp, °C[b]	Formula[c]	Anal, % Calcd C	H	Found C	H
II	2,3,7	XXIV	36	110–111	$C_{16}H_{16}$	92.3	7.7	92.0	7.6
III	2,3,6,7	XXV	40	171	$C_{17}H_{18}$	91.8	8.2	91.7	8.2
V	1,2,3,7,8	XXVI	36	177.5–178.0	$C_{18}H_{20}$	91.5	8.5	91.2	8.5

[a] Isolated yields. Total yields were in the 50–57% range according to gas chromatographic analyses. Compound XXV crystallized most readily owing to its symmetrical structure. [b] Corrected. [c] Confirmed by mass spectrometry.

TABLE V

MELTING POINTS AND ELEMENTAL ANALYSES OF THE NEW HYDROXYPOLYMETHYLBIPHENYLS

Starting nitro compd	Phenol[a,b]	Mp, °C, or $[n]^{20}$D	Formula[c]	Anal, % Calcd C	H	Found C	H
I	XXVII	72–73	$C_{16}H_{18}O$	84.9	8.0	85.0	7.8
II	XXVIII	1.5853	$C_{16}H_{18}O$	84.9	8.0	84.3	8.0
III	XXIX	1.5820	$C_{17}H_{20}O$	85.0	8.4	85.2	8.2
IV	XXX	1.5803	$C_{17}H_{20}O$	85.0	8.4	84.1	8.5
V	XXXI	102–102.5	$C_{18}H_{22}O$	85.0	8.7	85.0	8.6
VI	XXXII	78–79	$C_{18}H_{22}O$	85.0	8.7	85.0	8.5
VII	XXXIII	66.5–68.0	$C_{17}H_{20}O$	85.0	8.4	84.7	8.3

[a] Purification of these compounds was difficult. However, purities were higher than 99% with the exception of compounds XXIX (97.6%), XXX (93.0%), and XXXI (94.5%) based on gas chromatographic analyses. [b] Nmr spectra confirmed the hydroxypolymethylbiphenyl structures and eliminated the possibility of isomericbenzyl alcohols. [c] Confirmed by mass spectrometry.

hindered phenols.[16] Recently ionic dissociations of substituted phenols have been extensively studied.[17-19] The change of the Hammett reaction constants for *o,o'*-disubstituted phenols has been interpreted as a consequence of steric inhibition of solvation in the hindered phenoxide anions.[17-19] The phenols of Table V appear to be weak acids on the basis of their solubility; their p*K*'s could not be calculated because the substituent constants for polymethylphenyl groups are unknown. However, electron donation by methyl substituents cannot adequately account for their weak acidity. Severe steric hindrance to hydration cannot be invoked either; many of these phenols have one unsubstituted *ortho* position. Clearly, a quantitative study of the ionic dissociation of these phenols would be desirable.

Table VI shows the nmr absorptions of the polymethylfluorenes. According to the most reasonable interpretation of the data, the aromatic proton signals at the lower field must be due to the protons located in the 4 or 5 positions, where deshielding by the ring current would be expected as in the carbazoles. Comparison of the data in Tables VI and II indicate that in the carbazoles the aromatic protons in the 1, 2, 3, 6, 7, and 8 positions resonate at higher field and in the 4 and 5 positions at lower field than in the fluorenes. This could be explained by assuming that in the fully aromatic carbazoles the 14 π electrons circulate in three loops, whereas in fluorenes the 12 π electrons circulate only in two loops around the two six-membered rings under the influence of magnetic field. Consequently, the π-electron density and the intensity of the ring current in the six-membered rings of fluorene will be higher, and therefore the aromatic deshielding mechanism will be more pronounced. In the 4 and 5 positions, however, the substituents are exposed to the ring current of only one additional loop in fluorene and of two additional loops in carbazole. As a result, additional

TABLE VI

NMR ABSORPTIONS OF THE POLYMETHYLFLUORENES

Compd	Nmr τ values in deuteriochloroform[a] Aromatic protons[b]	Methylene protons	Methyl protons
XXIV	2.49 (1)[c]	6.36 (2)	7.66 (3)
	2.54 (1)		7.76 (6)
	2.85 (2)		
	2.94 (1)[c]		
XXV	2.52 (2)	6.31 (2)	7.69 (12)
	2.76 (2)		
XXVI	2.58 (1)[c]	6.52 (2)	7.69 (3)
	2.64 (1)		7.73 (3)
	2.88 (1)[c]		7.80 (6)
			7.85 (3)

[a] Numbers in parentheses indicate the numbers of protons. [b] When coupling was observed the peak positions were calculated based on the interpretation of the coupling pattern. [c] Centers of doublets with coupling constants of 7.8 (XXIV) and 7.5 (XXVI) cps.

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(16) G. H. Stillson, D. W. Sawyer, and C. K. Hunt, *J. Amer. Chem. Soc.*, **67**, 303 (1945); also G. H. Stillson, *ibid.*, **68**, 722 (1946).

(17) L. A. Cohen and W. M. Jones, *ibid.*, **85**, 3397 (1963).

(18) A. Fischer, G. J. Leary, R. D. Topsom, and J. Vaughan, *J. Chem. Soc., B*, **686**, 846 (1967).

(19) C. H. Rochester and B. Rossall, *ibid.*, 743 (1967).

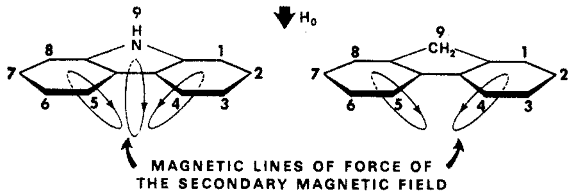
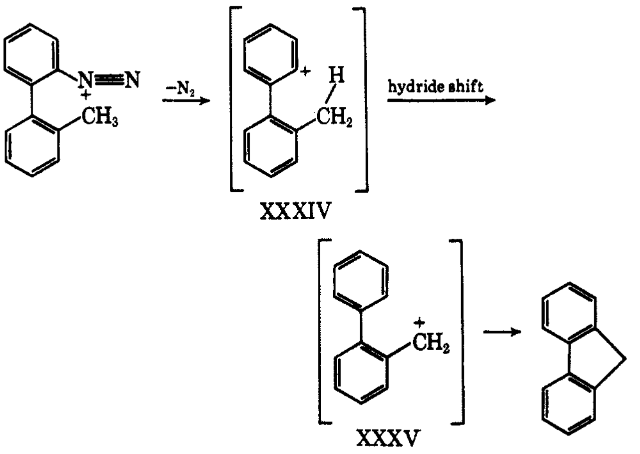


Figure 1.—Schematic representation of the deshielding mechanism at the 4 and 5 positions of carbazoles and fluorenes.

deshielding in these positions should be approximately twice as much in carbazole as in fluorene. This is illustrated in Figure 1. An alternative explanation, that fluorene is nonplanar, is untenable on the basis of the X-ray crystallographic investigations by Burns and Iball.[20]

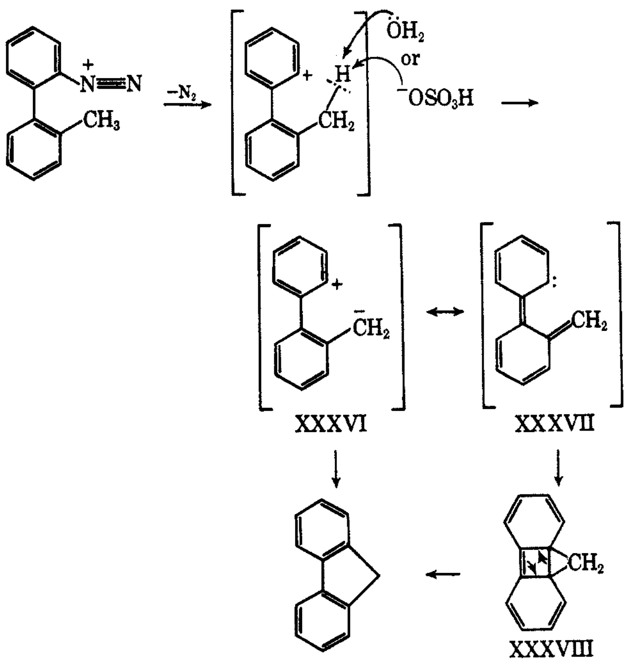
A mechanism involving an intramolecular 1,5-hydride shift has been proposed by Cohen, *et al.*,[21] for the Mascarelli reaction, shown in Scheme I. Their suggestion is based on the observation[22] that intramolecular 1,5-hydride shifts occur during the decomposition of diazotized N,N-disubstituted *o*-aminobenzamides. Whereas their evidence appears to be convincing for benzamides, it does not necessarily apply to biphenyls. Furthermore, it is known from the work of Gies and Pfeil[23] that, during diazotization of aromatic amines, hydrocarbon by-products are formed unless the diazotization is carried out in cold, very dilute acid. Although the exact mechanism of these reactions is not known, it must involve intermolecular reactions. In this light the evidence for the intramolecular 1,5-hydride shifts in the benzamide case would be much stronger had it been shown that the hydride ion transfer is independent of the substrate concentration and also occurs in high dilution. A 1,5-hydride shift does not appear to explain the Mascarelli reaction. Had the benzylic cation XXXV been formed, it would have produced benzyl alcohol by-product, just as phenol is formed from the phenyl cation XXXIV. We observed only fluorene and phenol, although we looked for a benzyl alcohol. The possibility cannot be excluded that the rate of intramolecular cyclization of XXXV is much faster than its rate of hydrolysis, but this did not apply for benzamides where the analogous hydrolysis was much more pronounced than the intramolecular cyclization. That any benzyl alcohol formed was converted into fluorene by the dilute aqueous acid is also unlikely, especially with our polymethyl compounds when the benzyl alcohol would be expected to precipitate from the solution. No fluorene was reported from *o*-phenylbenzyl alcohol in refluxing hydrobromic acid.[24]

Scheme I



The mechanism in Scheme II appears more reasonable for the Mascarelli reaction. The phenyl cation XXXIV generated by the loss of nitrogen could polarize the benzylic C–H bond located nearby; a benzylic proton is then lost to yield the bipolar ion XXXVI, which goes to fluorene simultaneously with the loss of the proton. Theoretically, XXXVI could give a resonance hybrid carbene (XXXVII) which might give XXXVIII by the addition to the double bond. Since a compound like XXXVIII would hardly survive the experimental conditions, an extensive search for such a product was not made. If the proton abstraction from XXXIV is important in fluorene formation it should be helped by electron-withdrawing and hindered by electron-releasing substituents unless the substituents are in *ortho* positions.[11] The yields of fluorene from diazotized 2-amino-2′-methylbiphenyl[12] and 2-amino-2′,4′-dimethylbiphenyl are nearly 100%[13]; the fluorene yield decreases with increasing number of methyl substituents (Table IV). This agrees qualitatively with our mechanism. Indazole formation from diazotized *o*-toluidines probably involves a similar mechanism. Only nitro- and chloro-substituted diazotized *o*-toluidines give good yields of indazoles;[25] in these cases the abstraction of a benzylic proton would be facilitated by the electron-withdrawing substituent without decomposition to nitrogen and a phenyl cation. A similar mechanism

Scheme II



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[20] D. M. Burns and J. Iball, *Proc. Roy. Soc.*, **A227**, 200 (1955).

[21] T. Cohen and J. Lipowitz, *J. Amer. Chem. Soc.*, **86**, 2514 (1964), and references cited therein.

[22] T. Cohen and J. Lipowitz, *ibid.*, **86**, 2515 (1964).

[23] H. Gies and E. Pfeil, *Ann.*, **578**, 11 (1952).

[24] G. H. Cookson and F. G. Mann, *J. Chem. Soc.*, 2888 (1949).

[25] E. H. Rodd, Ed., "Chemistry of Carbon Compounds," Vol. IV, part A, Elsevier Publishing Co., Amsterdam, 1957, pp 279–280.

might also be involved for the synthesis of 4-hydroxycinnoline from diazotized *o*-aminoacetophenones.[26] Proton abstraction in acid may indeed occur if it is concerted with the next reaction step.

Experimental Section

Nmr spectra were measured on a Varian Associates HR-60 spectrometer at 52 Mc with tetramethylsilane as an internal standard. Mass spectra were taken on a modified CEC Model 21-103 mass spectrometer. Gas chromatographic analyses were carried out on a Varian Aerograph, Model 202, with 4.5 ft × 0.25 in. SE-30 silicone-gum rubber column.

Carbazole Formation.—A 5-g sample of I, II, or III, was refluxed in 15 ml of triethyl phosphite for 20–24 hr. After the phosphorus esters were distilled at 0.2 Torr, the residues crystallized. From I the isomeric carbazole mixture was separated by fractional crystallization from benzene–dioxane. Compound VIII was isolated in 27% and IX was isolated in 42% yield. From II and III, X and XI were obtained after recrystallization from benzene–methanol in 71 and 58% yields, respectively.

A 3-g sample of IV, V, or VI, and 25 ml of triethyl phosphite were shaken in a pressure vessel, evacuated to 2 Torr at 205° for 63 hr. This treatment was too short for V and VI, and 44 and 33% starting material, respectively, did not react. Under these conditions N-ethylation was not significant. However, in some cases, decomposition of the phosphorus ester was shown by development of pressure. When compound V was treated with triethyl phosphite at 205° for 156 hr, the N-ethylcarbazole XIV was the major and the only isolated product. Treatment of VI with triethyl phosphite at 192° for 12 days resulted to a great extent in N-ethylation of the carbazoles; compounds XVI and XVII could be isolated from this mixture by fractional crystallization from benzene–methanol.

Compound XI was isolated both from III, as the only product, and from IV, as one of the isomeric products; mixture melting point and infrared spectra confirmed the identity.

Balcom Reduction of the Nitropolymethylbiphenyls.—A mixture of 5 g of nitroarene, 75 ml of ethanol, 15 ml of 65% hydrazine, and 0.2–0.8 g of wet Raney nickel was refluxed for 3–5 hr. Removal of the solvent from filtered solutions gave the amines in quantitative yield. For analyses the solid products were recrystallized from hexane; the liquid amines were analyzed without further purification.

Hydrogenations of Nitropolymethylbiphenyls over Raney Nickel. A 5–10-g sample I, II, III, or VII, ethanol (50–100 ml), and wet Raney nickel (0.5–1.0 g) were charged into a 300-ml pressure vessel. The cylinder was evacuated, filled with hydrogen at 500 psig, and heated on a rocker with automatic temperature control at 100–105° for 1, 14, 40, and 8 hr, respectively. Removal of the solvent from filtered solutions gave crystalline amine only from I; after recrystallization from methanol it melted at 73–76° (lit.[6] mp 80°). The amine XXIII from VII crystallized after a few weeks, mp 53–59° (less pure than that obtained by the Balcom method). The syrupy amine XIX from III was 93% pure according to gas chromatography.

Hydrogenation of 2-Nitro-2′,4,4′,5,5′-pentamethylbiphenyl (III) over Pd/C in Dimethoxyethane.—Compound III (19 g) was hydrogenated in 100 ml of dimethoxyethane with 4 g of 5% Pd/C for 10 hr at 25° (500 psig of hydrogen pressure). Removal of the catalyst by filtration and of the solvent by evaporation *in vacuo* left a syrup (17 g) which gave the following mass spectrometric analysis at low ionizing voltage: mass (relative intensity), 225 (1.6), 239 (100), 253 (5.2), 267 (0.8), 281 (10.3), 297 (4.9), 311 (0.1), 312 (0.1). Products with masses 253, 281, and 297 very likely correspond to methylated, methylethylated, and methoxyethylated amine, resulting from hydrogenolysis of the solvent.

Rate Studies of Hydrogenations over Palladized Charcoal in Acetone.—Because of difficulties involving solubilities and solvent interactions, we used acetone instead of alcohols or ethers. This would be expected to give isopropylamines[27] with consumption of one extra mole of hydrogen per mole of nitro compound.

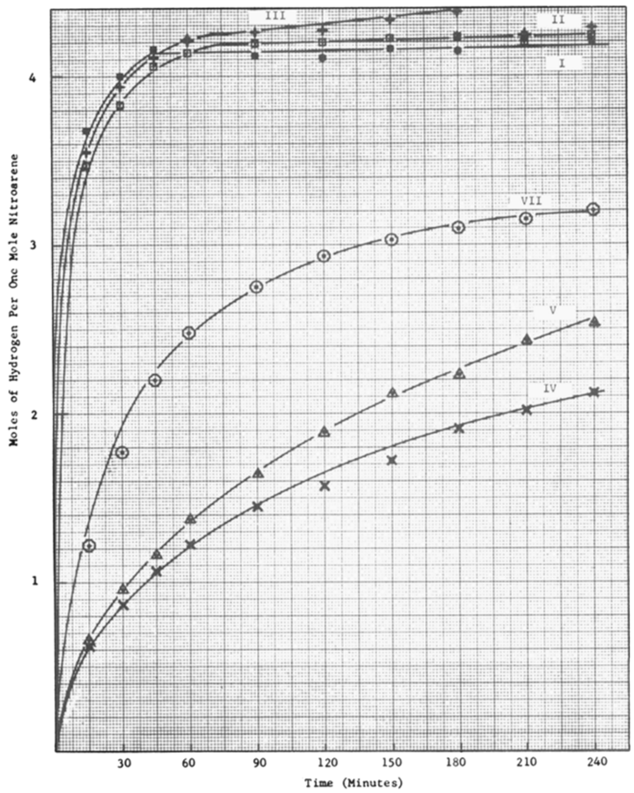

Figure 2.—Hydrogenation of nitropolymethylbiphenyls over palladium–charcoal in acetone solution.

A suspension of 1 g of 5% palladium on charcoal in 105 ml of acetone was saturated with hydrogen in a magnetically stirred microhydrogenator. Samples of I, II, III, IV, V, or VII (0.200 g in 5 ml of acetone) were injected with a syringe through a serum cap. The hydrogen uptake at atmospheric pressure and room temperature (corrected for solvent absorption) is recorded in Figure 2.

Diazotization of Aminopolymethylbiphenyls and Decomposition in Aqueous Sulfuric Acid.—A mixture of 0.02 mol of amine and 250 ml of 3% sulfuric acid was stirred and warmed to form a fine suspension of the amine salt. The suspension was rapidly cooled, and, if the crystals were large, they were finely ground. Then the mixture was diazotized at −2 to 0° with a solution of 1.7–2.0 g of sodium nitrite in 12 ml of water and stirred for one additional hour at 0°. Solutions of the diazonium salts from 2-amino-3′,4,4′,5-tetramethylbiphenyl, XVIII, XIX, XX, and XXIII were filtered, and decomposed at 70–75° after addition of a spatula tip of urea. The diazonium salts from XXI and XXII precipitated; these were decomposed in a stirred suspension after addition of urea.

The product that precipitated from the cooled solution was extracted with ether, and the ether solution was washed, dried, and evaporated *in vacuo*. From XVIII, XIX, and XXI the corresponding fluorenes XXIV, XXV, and XXVI were readily obtained by recrystallization from methanol or benzene–methanol. Purification of the phenols XXVII–XXXIII from 2-amino-3′,4,4′,5-tetramethylbiphenyl and the amines XVIII–XXIII was more difficult, primarily because of their high solubility in organic solvents. These phenols could not be extracted into 10% aqueous sodium hydroxide; even Claisen's solution prepared from 300 g of potassium hydroxide, 200 ml of water, and 800 ml of methanol had unfavorable distribution constants (*e.g.*, the ether solution of the fluorene–phenol mixture from VIII was extracted 16 times with Claisen's solution). This treatment removed only 94% of the phenol from the ether layer.

In the absence of fluorene formation, the phenols were obtained by fractionation at 0.1 Torr, followed by recrystallization from hexane when applicable. In case of fluorene formation, the mother liquors of the fluorenes were taken down to dryness. Residues were crystallized from aqueous methanol to remove fluorenes as completely as possible. From their mother liquors the phenols were recovered in 93–97% purity. Removal of the residual fluorene by chromatography was successful only for

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[26] For review of previous mechanistic suggestions, see R. C. Elderfield, Ed., "Heterocyclic Compounds," Vol. 6, Chapman & Hall, Ltd., New York, N. Y., 1957, pp 136–155.

[27] W. S. Emerson and H. W. Mohrman, *J. Amer. Chem. Soc.*, **62**, 69 (1940).

XXVIII. From basic alumina (Brockmann grade I) hexane eluted the fluorene only; the phenol was eluted with hexane-chloroform.

Attempts to Improve the Yield of Fluorene Formation from XIX. A.—Compound XIX (2.4 g) was diazotized in 200 ml of 1.5% hydrochloric acid and the diazonium salt decomposed at 70°. Yields of the corresponding fluorene, phenol, and chlorobiphenyl were 52, 39, and 2%, respectively, according to mass spectrometric analysis of the product mixture at low voltage (7.5 V uncor). This method may be favored over the diazotization in dilute sulfuric acid for solubility reasons, if isolation of the phenol is not required.

B.—Compound XIX was diazotized as in method A and decomposed at room temperature after a solution of 1.6 g of cuprous chloride in 56 ml of 8% hydrochloric acid was added. Mass spectrometric analysis of the product mixture showed 43% fluorene, 43% phenol, and 5.5% chlorinated biphenyl.

C.—Compound XIX (2.4 g) was stirred with 80% sulfuric acid and diazotized at 0° by adding finely powdered sodium nitrite (0.8 g). The solution was cloudy. After 1 hr, the mixture was decomposed at 45°. Mass spectrometric analysis indicated 49% fluorene, 9% phenol, 26% dimeric hydrocarbons, and 7% dimeric ether or phenol in the product mixture.

D.—Boric acid (1.2 g) was stirred in concentrated hydrochloric acid (8 ml) and sodium fluoride (3.4 g) was slowly added in a fume hood. After standing 1 hr, the sodium chloride precipitate was suction filtered on a fiber-glass filter. The diazonium solution prepared from 2.4 g of compound XIX in 40 ml of 2.5% hydrochloric acid was added to the filtrate. The pale yellow diazonium fluoroborate precipitate was filtered, washed with distilled water, and vacuum dried over phosphorus pentoxide at 55°. The ir spectrum of the dried salt indicated the presence of crystal water (3320 cm^{-1}); its decomposition point was 95°. During overnight drying at 55° the salt decomposed. The product mixture, according to mass spectrometric and gas chromatographic analyses, was 65% fluorinated biphenyl and 25% fluorene. Decomposition of the diazonium fluoroborate at 100° gave 70% fluorinated biphenyl and 18% fluorene.

Registry No.—VIII, 17447-85-7; IX, 17449-10-4; X, 17477-84-8; XI, 17449-11-5; XII, 17449-12-6; XIII, 17477-85-9; XIV, 17416-89-6; XV, 17416-90-9; XVI, 17416-91-0; XVII, 17447-86-8; XVIII, 17416-92-1; XIX, 17447-87-9; XX, 17447-97-1; XXI, 17416-93-2; XXII, 17447-88-0; XXIII, 17447-89-1; XXIV, 17416-94-3; XXV, 17447-90-4; XXVI, 17447-98-2; XXVII, 17416-95-4; XXVIII, 17447-91-5; XXIX, 17447-92-6; XXX, 17447-93-7; XXXI, 17447-94-8; XXXII, 17447-95-9; XXXIII, 17447-96-0.

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Resolution of Trifluoromethylcarbinols[1,2]

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(±)-Phenyltrifluoromethylcarbinol and (±)-*t*-butyltrifluoromethylcarbinol have been resolved *via* the 3β-acetoxy-Δ^5-etienate esters, but (±)-methyltrifluoromethylcarbinol could not be resolved by this method. The completeness of the resolution of the first compound was confirmed by a gas chromatographic study of its O-methylmandelate ester, and the enantiomeric purity of a partially active sample of the methyltrifluoromethylcarbinol was determined by the same method. This glpc method was not applicable to the determination of enantiomeric purity of *t*-butyltrifluoromethylcarbinol.

As part of a continuing investigation[4,5] of asymmetric reductions of the corresponding ketones, it became necessary to know the absolute configuration and maximum rotation of phenyl-, *t*-butyl-, and methyltrifluoromethylcarbinols (IA, IB, and IC). The present paper describes the resolutions of two of these, and the subsequent paper[6] describes the experiments upon which the absolute configurations are based.

(±)-Phenyltrifluoromethylcarbinol (IA) was converted into the diastereomeric 3β-acetoxy-Δ^5-etienate esters[7] which were carried through an extensive systematic fractional crystallization using 2-propanol as solvent.[3] Both the less soluble and more soluble diastereomers were obtained, from which were regenerated by lithium aluminum hydride reduction, respectively, the (−)-carbinol, $[\alpha]^{25}\mathrm{D}$ $-31.85°$ (neat), and the (+)-carbinol, $[\alpha]^{26}\mathrm{D}$ $+31.82°$ (neat). The absolute enantiomeric purities of these samples were established by gas-liquid partition chromatographic (glpc) studies as described in the following section.

(±)-*t*-Butyltrifluoromethylcarbinol (IB) was also resolved *via* the 3β-acetoxy-Δ^5-etienate ester, but only the less soluble diastereomer could be obtained in purified form after exhaustive fractional crystallization from 2-propanol. The (+)-carbinol, $[\alpha]^{23}\mathrm{D}$ $+5.55°$ (neat, *d* 1.12), was regenerated by lithium aluminum hydride reduction. We presume this (+)-*t*-butyltrifluoromethylcarbinol to be enantiomerically pure; however there is no direct evidence for this beyond the normal recrystallization behavior of the etienate ester and the reasonable magnitude of its rotation since the glpc method and nmr method[8] were inapplicable as described in the following section.

Previous attempts to resolve methyltrifluoromethylcarbinol (IC) *via* the brucine salt of the acid phthalate failed for reasons similar to those reported in the earlier attempted resolution of phenyltrifluoromethylcarbinol.[4] The 3β-acetoxy-Δ^5-etienate was prepared but failed to crystallize; we, therefore, resorted to glpc methods for

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[1] We acknowledge with gratitude support for these studies from the National Science Foundation (GP 6738) and the National Institutes of Health (GM 05248).

[2] A preliminary report of some of these results has been published: D. M. Feigl and H. S. Mosher, *Chem. Commun.*, 615 (1965).

[3] Taken from the Ph.D. Thesis of D. M. Feigl, Stanford University, 1965.

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