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# ABSTRACT OF THESIS ENTITLED "STUDIES IN DIARYL CHEMISTRY" PRESENTED BY

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FOR THE DEGREE OF Ph.D. IN THE UNIVERSITY OF LONDON.

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An outline is given of the application of electronic theories of organic chemical reactions to the problems of aromatic substitution and previous work on substitution reactions in the diphenyl series is reviewed in the light of such theories.

The preparation and nitration of 2-halogeno-4:4'-dimethyldiphenyls are described and the conclusion is drawn that nitration occurs mainly or entirely in position 2' in 2-fluoroditolyl, and in position 2' to the extent of about 60% in 2-chloro, bromo and iododitolyls, a second mono-nitration product being formed in each case, which it is suggested may be a 6-nitro-2-halogenoditolyl, with possibly a small amount of a third substance which it is suggested may be a 3-nitro-2-halogenoditolyl.

<u>Supplementary Work.</u>

(I) Attempted asymmetric syntheses of 2:4-dinitro-2'-methyldiphenyl-6-carboxylic acid and 2:4:2':4'-tetranitrodiphenyl-6:6'-dicarboxylic acid are described.

(II) An investigation of the reactions of 2:4:6-trinitrodiphenyl is described, only indefinite products being obtained.

(III) The replacement of the chlorine atoms in 3:3'-dinitro-4:4'-dichlorodiphenyl sulphone is described, crystalline compounds being obtained by the action of (a) hydroxy compounds, (b) aromatic bases and (c) ammonia. Diamines obtained by reduction of these products are also described.

(IV) An investigation of the decomposition of diazonium borofluorides in the presence of methyl alcohol is described, the results being similar to those obtained by previous workers using diazonium sulphates.

(V) Improved methods are described for the preparation of 2-nitro-2'-aminodiphenyl, 2-nitro-2'-aminoditolyl, 3:4-dichlorodiphenyl and 2:5-dichlorodiphenyl.

(VI) The preparation of an arsenic acid from 2-aminoditolyl, its conversion into a tricyclic compound and the preparation of a chloroarsine from this are described.

THESIS ENTITLED

# "STUDIES IN DIARYL CHEMISTRY"

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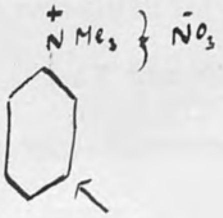
## Supplementary Work.

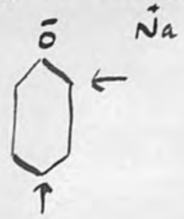
# STUDIES IN DIARYL CHEMISTRY.

The results of all investigations which have so far been carried out upon the positions of entry of substituents of a kationoid or electron-seeking type into the molecule of diphenyl and of its derivatives agree in showing that the phenyl group, whether substituted or not, resembles other hydrocarbon radicals in having a decidedly activating and ortho-para-directing effect. By examination of the products of nitration, chlorination, bromination etc. of diphenyl itself and of diphenyl derivatives containing such substituent groups as $NO_2$, $NH_2$, NHR, halogens, OH, $CO_2H$, CHO, alkyl, Oalkyl etc. it is possible to form some estimate of the strength of the directive power of a phenyl group on substitution in another benzene-ring in which it is substituted for hydrogen, as compared with the directive powers, already well-known, of the above-mentioned groups. Before the results of such investigations of substitution reactions in diphenyl derivatives are described an outline will be given of the theoretical basis upon which their interpretation rests.

The results obtained are capable of explanation in accordance with electronic theories of aromatic substitution, which regard the factor chiefly governing substitution in an aromatic nucleus as being the electron-availability at different points in that nucleus. The ordinary substituting agents, e.g. $HNO_3$, $H_2SO_4$ and halogens, are considered to be kationoid, i.e. electron-seeking reagents, being capable of incipient ionisation in the manner shown: $\overset{-}{OH}—\overset{+}{NO_2}$, $\overset{-}{Cl}—\overset{+}{Cl}$, $\overset{-}{OH}—\overset{+}{SO_3H}$ etc., and will therefore attack the nucleus in the positions where electron-availability is greatest. In the unsubstituted nucleus, i.e. in benzene, all positions will be equivalent in this respect. The effect of a substituent group on further substitution in the same nucleus is regarded as being due to its power to modify the electron-availability at the carbon atoms of the nucleus, and in so doing to differentiate between one carbon atom and another. Such a modification of the electronic configuration of the nucleus by a substituent atom or group must be due to the power of the latter either to attract electrons away from the nucleus or to repel electrons towards the nucleus.

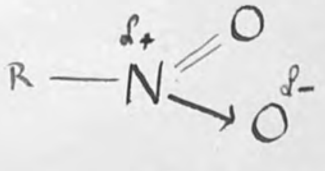
It has long been known, from purely empirical observation, that certain substituents, such as $NO_2$, $CO_2H$, CHO, $SO_2$, $SO_3H$, CN, when present in the benzene ring caused further substitution by a kationoid reagent to give derivatives substituted mainly or entirely in the meta-position to the first substituent, whilst other groups, such as OH, O alkyl, $NH_2$, NHR, alkyl, halogens etc. led to products mainly or entirely substituted in the ortho and para positions to themselves. The orientation rules of Crum-Brown and Gibson and of Hammick simply classified these facts without explaining them. It was also observed that meta-direction was always associated with decreased reactivity as compared with benzene, and ortho-para-direction with increased reactivity (except in the case of the halogens). The key to the explanation is found by considering the extreme cases of (a) phenyltrimethylammonium nitrate which undergoes nitration exclusively in the meta-position and (b) phenols in alkaline solution which couple with extreme ease, in the ortho-position, with diazonium salts (the diazonium salt being a kationoid reagent, $RN_2$ X) or in the case of a phenol substituted in the ortho-position, in the para-position.

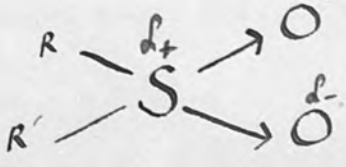




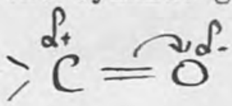
In the case of the phenylammonium salt, the substituent attached to the nucleus must, on account of ionisation, be a positive pole and in the case of the phenol in alkaline solution there must, for the same reason, be a negative pole attached to the nucleus. The meta-directing substituent is thus a positively-charged centre, which must have the effect of attracting electrons away from the nucleus, and the ortho-para-directing substituent is a negatively-charged centre, which must be repelling electrons towards the nucleus. It is found possible to group all the other substituent groups into two classes of which these are the extreme examples.

Both the nitro and sulphone groups, which are strongly meta-directing, contain semi-polar double bonds, an oxygen atom being linked to nitrogen or sulphur by a bond of which both electrons are provided by the latter atom. The effect of this must be to give a more or less positive character to the depleted atom, which is the point of attachment to the aromatic nucleus, and a corresponding negative character to the oxygen atom.

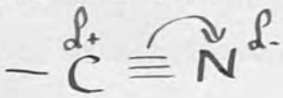




The effect of such groups as carboxyl and aldehydo, which are also meta-directing, is ascribed to an unequal sharing of electrons between unlike atoms on account of the difference between their nuclear charges. It is believed that the electrons of the double bond are displaced so that they are nearer to oxygen with nuclear charge 6 than to carbon with nuclear charge 4, thus causing the carbon atom, which is the point of attachment to the nucleus, to have a slight positive charge. This explanation is applied only to the case of doubly-linked oxygen, the behaviour of groups containing singly-linked oxygen atoms will be mentioned later. The meta-directing power of the cyanide group is ascribed to a similar displacement.



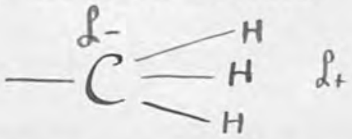
$$>\overset{\delta+}{C}=\overset{\delta-}{O}$$



$$-\overset{\delta+}{C}\equiv\overset{\delta-}{N}$$

It is obvious that such an effect must also be present in, for instance, the nitro-group, which contains a doubly-linked oxygen atom in addition to that concerned in the semi-polar double bond. An early attempt to classify substituents according to their directive powers was based on the observation that groups which directed meta contained double bonds. It would be expected that the effect of such groups, in which the separation of charges is only partial, the negative pole or poles remaining attached to the molecule, would be less than in the case of the phenyl ammonium compounds, where the negative pole is removed by ionisation, and this is found to be the case. A reduction of meta-directive power is also observed in the analogues of the phenylammonium compounds, such as phosphonium, stibonium etc. compounds, the proportion of ortho-para substitution increasing with increasing size of the positively charged atom. This is ascribed to the damping effect of the outer electron-shells of the larger charged atoms. A similar decrease in the proportion of meta-substitution is observed when the charged atom is separated from the nucleus by a side-chain.

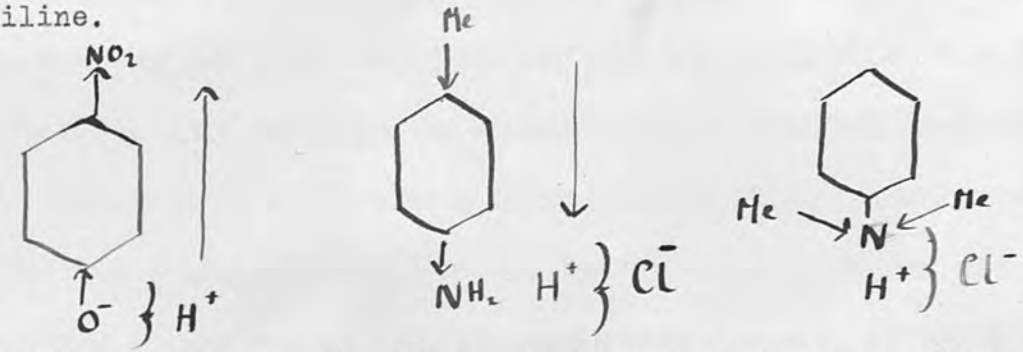
Considering now the ortho-para-directing groups, the effect of the methyl group is considered to be due to the unequal sharing of electrons between unlike atoms on account of the difference in nuclear charges, the displacement in this case being towards the point of attachment of the group to the nucleus, that is away from the hydrogen atoms towards the carbon. This argument applies also to other hydrocarbon radicals, but in the case of larger groups there may be a steric effect preventing substitution in the ortho-position. Experiments on the nitration of alkyl benzenes, (Brady and Day, J., 1934, 114) indicate that the activating and ortho-para directing power of the methyl group is high in comparison with other alkyl groups; evidence of an abnormal effect of methyl groups is also obtained independently of aromatic substitution.



The amino and hydroxyl groups are found to be strongly ortho-para-directing; we have already considered groups such as CO and CN which contain oxygen or nitrogen and in which these atoms are regarded as tending to attract to themselves more than their share of the electrons of a double bond, such groups being meta-directing. Here on the other hand we find these atoms forming part of strongly ortho-para-directing groups. The main differences between the two cases are, that the oxygen or nitrogen atom is here singly-linked, and that it is directly attached to the aromatic nucleus. Both these atoms have unshared electron pairs and it is suggested by Ingold, Robinson and others that when they are singly-linked and in their lower valency states a tendency for their unshared electrons to become shared with the aromatic nucleus comes into play. It may also be pointed out that any displacement of the bond electrons of the group, due to unequal sharing between atoms of different nuclear charge in the manner already described, will in this case help to give a negative character to the atom attached to the nucleus. This argument applies to amines and their derivatives, to phenols and thio-phenols in the absence of ionisation, and to ethers and thio-ethers.

It thus appears that the characteristic property of meta-directing substituents is a more or less positive character of the atom attached to the nucleus, and consequent attraction of electrons away from the latter, whilst that of ortho-para-directing substituents is a negative character of the attached atom, causing repulsion of electrons towards the nucleus. Evidence of such attraction and repulsion effects can be obtained independently of aromatic substitution reactions. For instance if a nitro-group attracts electrons away from the rest of the molecule we should expect a nitrophenol to be more acidic than phenol itself, since recession of electrons should facilitate the separation of a proton from the hydroxyl group, and this is found to be the case.

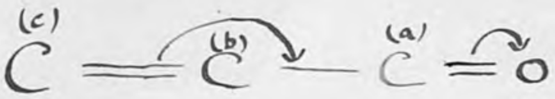
On the other hand, if a methyl group repels electrons towards the rest of the molecule a methyl-substituted base should be stronger than aniline, as the availability of the unshared electron-pair of the nitrogen atom for donation to a proton in the process of salt-formation should be increased, and in fact this is so, p-toluidine and the methyl-anilines being stronger bases than aniline.



Measurements of the dipole moments of compounds such as toluene, nitrobenzene etc. also indicate the existence of such electron displacements.

Two kinds of mechanism are postulated for the action of such a positive or negative character of a substituent on the electron availability at the carbon atoms of the aromatic nucleus. The first, which is known as the Inductive Effect, is an attraction or repulsion of all the electrons of the nucleus by the substituent group, it is relayed through a chain of atoms by electrostatic induction and decreases with distance, its order of intensity in the benzene ring will therefore be ortho > meta > para. Such an effect can be present equally well in a straight-chain saturated molecule as in an aromatic nucleus, it is a drift of electrons throughout the molecule, the number of electrons shared by any atom with its neighbour remaining unaltered. This effect is considered to be a permanent state of polarisation of the molecule and is measured by the dipole moment.

This explains the lowering of reactivity always associated with positive (meta-directing) substituents and the increase of reactivity with **negative** (ortho-para-directing) substituents, as compared with unsubstituted benzene since we are dealing with kationoid substituting agents. To explain the differentiation between the ortho and para and the meta positions, i.e. the alternating effect, we must consider the second type of electron displacement, called by Robinson the Electromeric Effect and by Ingold the Tautomeric effect. This is a displacement that can happen only in chains of alternate double and single bonds, i.e. in conjugated systems, of which the aromatic nucleus is an example.



If the carbon atom (a) becomes depleted of electrons by a positive atom or group attached to it, it will endeavour to make up its deficiency by making a call on the **electrons** of the neighbouring atom (b). In addition to the inductive effect, causing a general drift of electrons (b) is able to supply the deficiency of (a) by transferring wholly or in part to (a) one of the electron pairs of the double bond which it is sharing with (c). The deficit of electrons at (a) is therefore made up at the expense of (c), but the electronic configuration of the intermediate carbon atom (b) is left unaffected, it still has the same electrons in its octet, but is now sharing with (a) a pair that it formerly shared with (c). Such a change is not necessarily complete, if it were it would involve a transference of double bonds.

In the case of a negative substituent which repels electrons towards (a) the mechanism is the same, (a) partially transfers its excess of electrons to (c) leaving (b) unaltered. The order of intensity of such effects in the aromatic molecule will therefore be in both cases (ortho and para)>meta. This electromeric effect is not regarded as a permanent state of polarisation of the molecule, but as a potential mobility of electrons which is called into play by the approach of a reagent. In some cases hiwever the existence of some degree of permanent effect of this kind is suggested.

Since the meta position is the least affected either by attraction or repulsion of electrons, and since substitution should take place at the positions of greatest electron-availability, it would be expected that with a positive substituent, which deactivates all positions and therefore lowers reactivity, the meta position would be the least deactivated, and that with a negative substituent, which activates all positions, the meta position would be the least activated, and this agrees with the experimental facts.

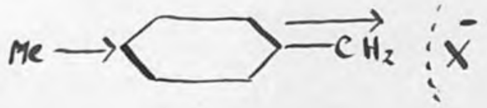
The halogens present an apparent anomaly, although they undoubtedly have strongly electron-attracting effects, as shown by the strengths of their acids, and by the fact that chloracetic acid is stronger than acetic acid, when present in the aromatic nucleus they direct substitution almost entirely ortho and para. Ingold and Shaw showed however (J.,1927,2918) that the velocity of nitration of the halogeno-benzenes (except iodobenzene) was less than that of benzene, the order of effectiveness of substituents in promoting reaction being; $F < Cl < Br < H < I$. In other words, the deactivating effect so far associated only with meta-direction appears to be associated in these three halogens with ortho-para-direction. In explanation of this it has been suggested by Ingold and others that, whereas in the cases so far considered the inductive and electromeric effects have been in the same direction, in the halogens they are opposing each other. Dipole moment measurements on chlorobenzene indicate a permanent inductive displacement in the direction to be expected, i.e.attraction of electrons; this would account for the observed lowering of reactivity in the order of the strengths of acids, iodine which forms a weak acid being slightly activating On the other hand the halogens, like oxygen, nitrogen etc. have unshared electron pairs next to the nucleus, and it is suggested that on the approach of an electron-seeking reagent the tendency of these electrons to become shared with the nucleus is called into play, the electrons being passed on from the ortho to the para position by electromeric change, leading to ortho and para substitution.

Such an electron-sharing tendency of the halogens must obviously be least for the smallest atom, fluorine, and greatest for the largest atom, iodine, the outer electrons of which must be less tightly held by the atomic nucleus on account of the intervening electron-shells. The electromeric effect, if due to such a sharing tendency must therefore be in the reverse order of intensity to the inductive effect:

Inductive Effect, electron attraction, F > Cl > Br > I.

Electromeric Effect, electron donation, I > Br > Cl > F.

Differences of opinion as to the origin of the electromeric effects of the halogens have however arisen as a result of the apparently anomalous behaviour of the halogens in their effect upon side-chain reactivity. In such reactions as the hydrolysis of benzyl halides it would be expected that an electron-donating substituent would , by virtue of its inductive effect, increase the velocity of reaction by facilitating the separaration of the side-chain halogen as a negative ion, and conversely that an electron-attracting substituent, e.g. halogen, should decrease the velocity of hydrolysis. It is found that the groups whose orienting effects have already been mentioned do, when present as para-substituents in the benzene nucleus, fall into the expected order of effectiveness in promoting hydrolysis: Me > H > halogens > $NO_2$ .

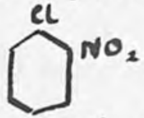


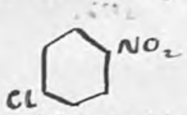
But although the halogens as a group are in the position which would be expected in this table, their effects are reversed among themselves, being in the order: F > Cl > Br > I. It would be expected that the velocity of hydrolysis would be least with the substituent with the largest inductive effect (electron-affinity), and greatest with that with the smallest inductive effect, but the reverse is found to be true. This indicates that some effect in the opposite direction to the inductive effect of the halogens must be at work, i.e. in the same direction as the electromeric effect It has long been considered likely that there exists some permanent component of the electromeric effect which can retard as well as accelerate reactions, and it is conceivable that such an effect could be transmitted to some extent through a short side-chain, even although electromeric changes of the type described cannot occur in this. It has been pointed out by Baddely and Bennett (J., 1933, 261, 1112 ) that such a reversal of of the inductive by the electromeric effect of the halogens requires that the latter effect should be in the same order of intensity as the inductive effects: F > Cl > Br > I ,since it cannot be supposed that an electromeric effect in the form of a tendency to share electrons, which must obviously be small in the case of fluorine, could counteract the known large inductive effect of this atom, and yet p-fluorobenzyl bromide is hydrolysed twice as fast as benzyl bromide. If the electromeric effects of the halogens are in this order, F > I, they cannot be due to the electron-sharing tendency indicated by Ingold and Robinson, and it is suggested by Bennett that they may originate instead from the same type of "reversed external

field" already suggested to exist in the case of the methyl group, (Bennett and Mosses, J., 1930, 2364 ). It is pointed out that if the substituent atom or group is exerting an attraction or repulsion of electrons along the line of attachment to the molecule, there must be a force along this same line outside the group, in the opposite direction to the inductive effect, and that some component of this effect should be eble to reach the rest of the molecule. In the case of the halogens this would be an

electron-repelling effect, and since its origin would be the same as that of the inductive effect its order of intensity would be the same, viz: F > Cl > Br > I .The fact that *p*-chloroaniline is a stronger base than *p*-bromoaniline is also cited in support of this view. Such a "reversed field effect" is considered to act directly through space, like the Direct Polar Effect of Ingold and Robinson, but unlike this it is of opposite sign to the inductive effect. It can presumably set up the kind of electromeric displacement to which the nucleus, by reason of its conjugated structure, is liable, hence activation of the ortho and para positions.

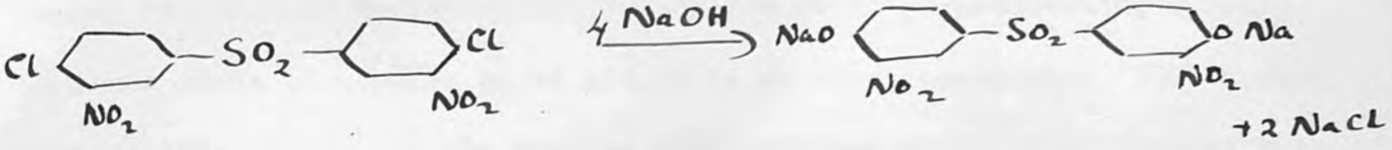
The substitution reactions so far considered have been of the type in which the hydrogen atoms of the aromatic nucleus have been replaced by the action of kationoid or electron-seeking reagents. Another type of substitution reaction is that in which such a kationoid substituent, already present in the molecule, is replaced by the action of an anionoid reagent, (electron-donating or positive centre-seeking), such as hydroxyl, alkyloxy, amino or substituted amino groups. Such replacements do not occur with any ease except under the influence of a second nuclear substituent, and the effect of such a substituent is found to be the reverse of that observed in the the replacement of hydrogen by a kationoid group. Substituents which are normally deactivating and meta-directing now become activating, particularly on the ortho and para positions, whilst groups which are normally ortho-para-directing and activating now become deactivating, but favour replacement of a group in the meta rather than in the ortho or para position. For instance the influence of a nitro-group on the replacement of halogens by the action of hydroxy compounds or bases is found to be one of activation, particularly in the ortho and para positions.



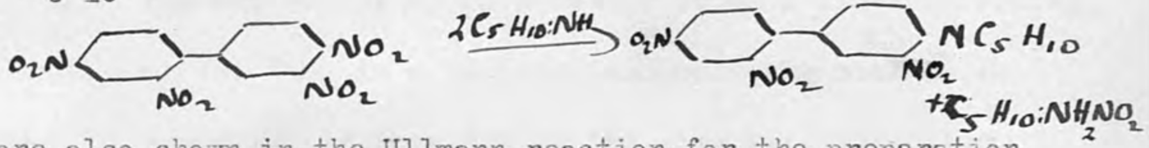


In a compound such as ortho- or para-chloronitrobenzene we have the nitro-group which tends to withdraw electrons from the nucleus as a whole, and particularly from the ortho and para positions, that is to say these positions are (comparatively) positively charged. The chlorine atom which is occupying one of these positions is partly making up for this by sharing its electrons with the carbon atom. If however there is in the neighbourhood a reagent such as $\overset{+}{M}—\overset{-}{OH}$ or $\overset{+}{R}—\overset{-}{NH_2}$ with greater electron-donating power than chlorine, this can make a better offer to the positive carbon atom, the chlorine is therefore replaced by OH or $NH_2$ and is left free to follow its strong inclination to go into solution as a negative ion; this will involve its taking away one of the electrons which it formerly held in common with the nucleus, but the entering group can make up for this.

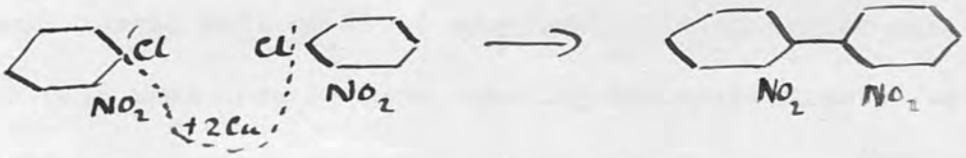
The lability of halogen atoms in the ortho or para position to a nitro-group is well-known; replacement occurs on treatment with alkali hydroxides, alkyloxides and phenoxides, and with ammonia and primary and secondary bases. An example of a compound subject to this type of replacement is 4:4'-dichloro-3:3'-dinitrodiphenyl sulphone, in which each chlorine atom has, besides a nitro-group in the ortho-position to it, the $SO_2$ group, the effect of which is similar, in the para-position. This compound undergoes replacement of the chlorine atoms with great ease. A number of its reactions are described in the experimental part of this thesis.



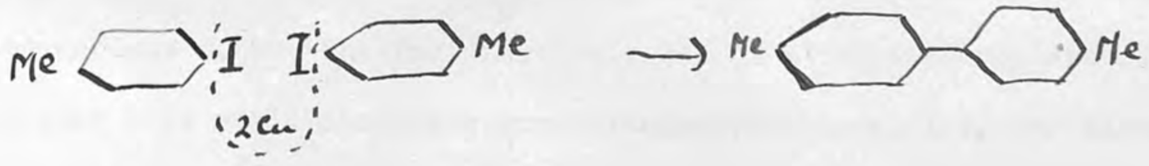
A nitro-group can also render another nitro-group labile, e.g. towards piperidine, for example in 2:4:2':4'-tetranitrodiphenyl the 4'-nitro-group is replaced by $NC_5H_{10}$.



These effects are also shown in the Ullmann reaction for the preparation of derivatives of diphenyl by the action of finely-divided copper on halogeno-benzenes when heated.

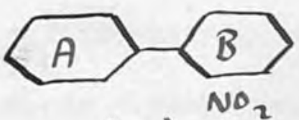


This reaction is found to occur much more readily when there is a nitro- or other positive group in the ortho or para position to the halogen atom. On the other hand, a group such as methyl which has an activating effect on ordinary substitution reactions is found to decrease the reactivity, reaction occurs only when the iodo-derivative is used and then with considerable difficulty; the preparation of 4:4'-dimethyldiphenyl (ditolyl) from p-iodotoluene, described in the experimental part, is a case in point.

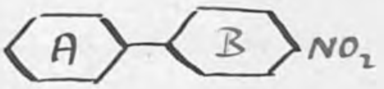


It has already been remarked that the course of substitution reactions in the diphenyl series shows the phenyl group to to resemble other hydrocarbon radicals in having an activating and ortho-para-directing effect, in other words it appears to be acting as an electron-donator. This appears contradictory as in all the benzene substitutions so far mentioned we have been concerned with the phenyl group as an acceptor of electrons. It is considered however that the aromatic nucleus, on account of its flexible conjugated structure, can act either as an acceptor or as a donor according to the demands made upon it. Thus in a diphenyl compound the nucleus in which substitution is occurring is regarded as the acceptor, the other , which controls substitution, being the donor. It follows then that the reactivity gained by the one nucleus is lost by the other.

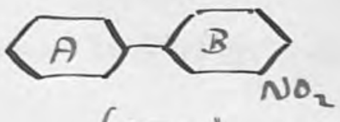
Diphenyl itself will be first considered. It undergoes mono-nitration with greater ease than does benzene, showing the activation effect, and gives exclusively a mixture of ortho and para derivatives, (I) and (II).



(I)

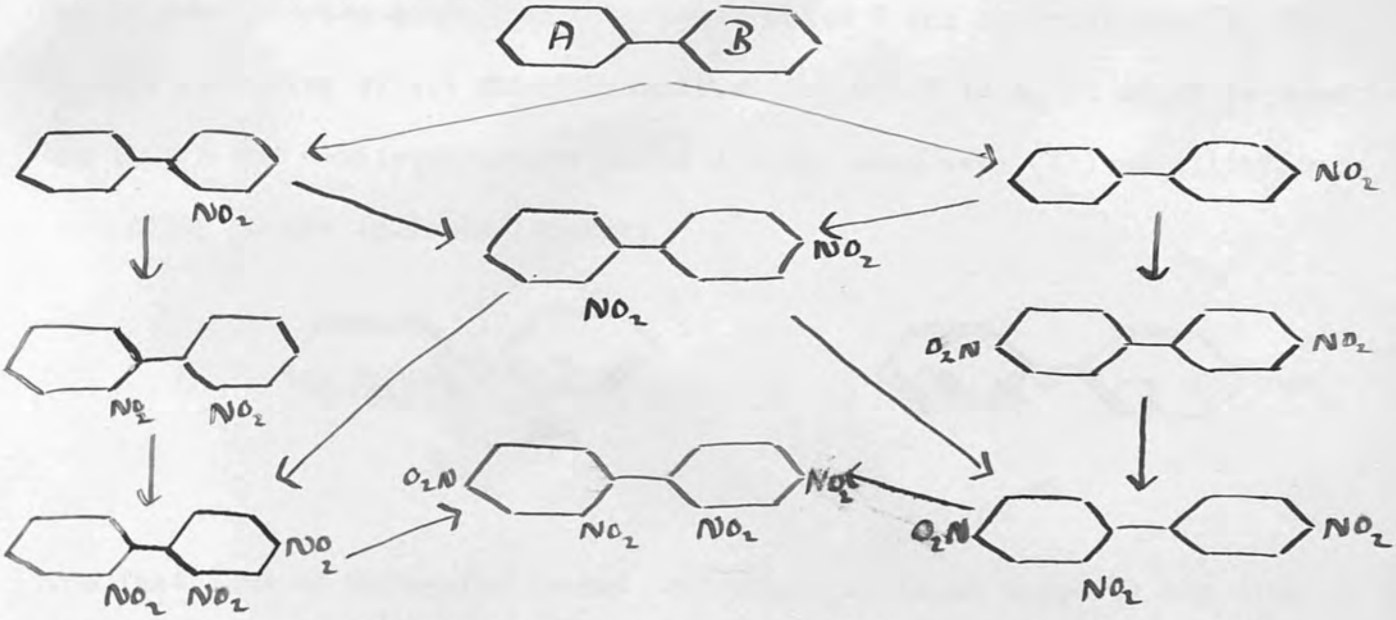


(II)

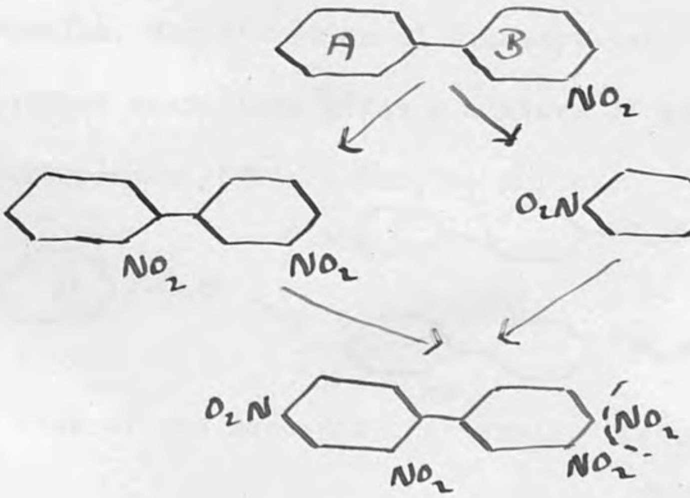


(III)

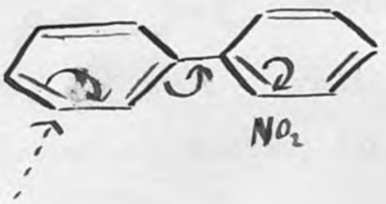
The meta-isomer (III) can only be obtained indirectly. All three isomers undergo further nitration in the unsubstituted nucleus only, in positions 2' and 4'. It appears that the first nitro-group in nucleus B has so deactivated that nucleus as to prevent further substitution in it under the conditions for dinitration. The second nitro-group therefore enters the unsubstituted nucleus A, but the fact that only 2' and 4' derivatives are obtained shows that B is still directing exclusively ortho-para, i.e. the nitro-group in B, although it must have reduced the electron-source properties of that nucleus, has not done so to the extent of permitting any meta-substitution in A. These nitrations have been studied quantitatively by Gull and Turner (J.,1929, 441 ).



3-Nitrodiphenyl, obtained indirectly, shows the same orienting effects, undergoing first heteronuclear substitution in the 2' or 4' positions, and on more vigorous nitration (Blakeley and Scarborough, J., 1927, 3009) 2:4:3':4'-tetranitrodiphenyl, in which the 4' nitro-group is labile, e.g. towards piperidine.

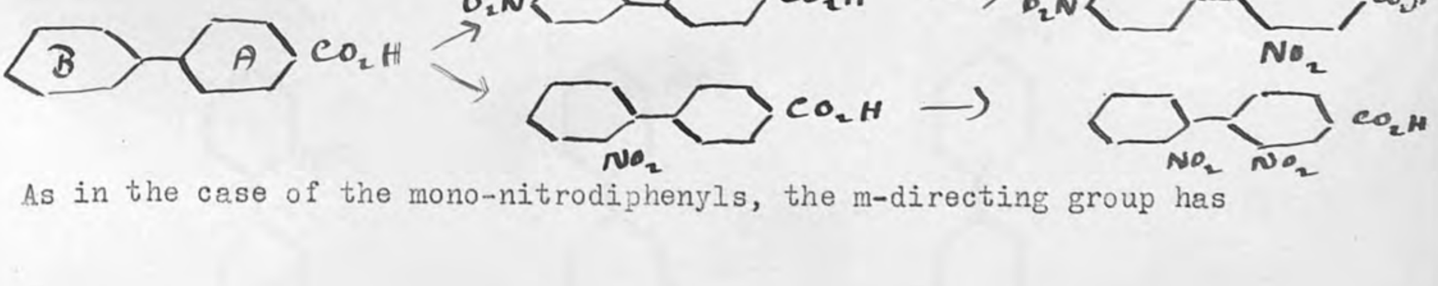


It would appear that the substituent already present in nucleus B can affect further substitution in nucleus A only indirectly, by modifying ( in the case of the nitro-group, reducing ) the electron-donating and consequently ortho-para-directing power which B can exercise over A. If a direct orienting effect were transmitted through B to A, it might be expected that 2 and 4-nitrodiphenyls would undergo some meta (3') substitution, according to the following scheme:

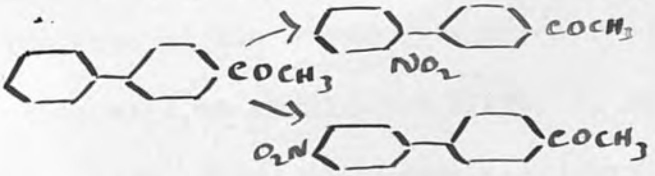


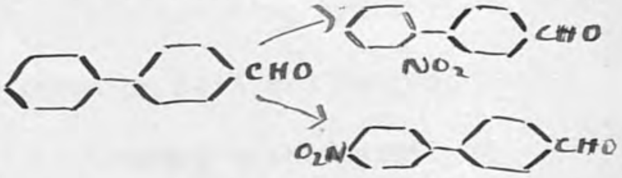
The fact that no meta-substituted derivative is found supports the view that the two nuclei in diphenyl are independent, the connecting **single** bond not being a **link in a true conjugated system.** This point is discussed by Le Fevre and Turner, (J., 1927, 2485.)

Grieve and Hey (J., 1933, 968 ), have investigated the nitration of diphenyl derivatives containing other meta-directing substituents, with similar results. Mononitration of diphenyl-4-carboxylic acid under carefully regulated conditions gives a mixture of almost equal proportions of 2- and 4-nitrodiphenyl 4'-carboxylic acids.

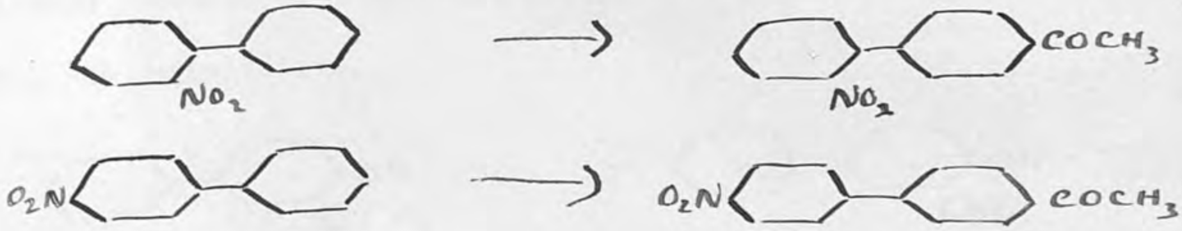


As in the case of the mono-nitrodiphenyls, the m-directing group has sufficiently reduced the reactivity of its own phenyl-group to prevent substitution in that nucleus, but this deactivated nucleus has still enough electron-source character to direct exclusively ortho-para substitution in nucleus B. Similar results are obtained with 4-acetyldiphenyl and diphenyl-4-aldehyde. Dinitration of diphenyl-4-carboxylic acid (Gull and Turner loc.cit.) gives a mixtue of 2:2'- and 2:4'-dinitrodiphenyl-4-carboxylic acids.



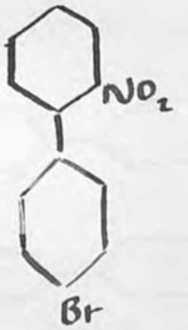


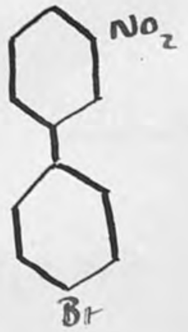
The same authors obtained 4'-acetyl-derivatives from 2- and 4-nitrodiphenyls by the Friedel-Crafts reaction, using a large excess of aluminium chloride.

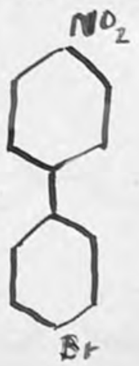


The observation of these authors that benzene can be used as an almost inert solvent in the preparation of 4-acetyldiphenyl from diphenyl by the Friedel-Crafts reaction gives further evidence of the enhanced reactivity of an aromatic nucleus which has a second phenyl-group attached to it. Such reactivity is especially noticeable in the 4-position.

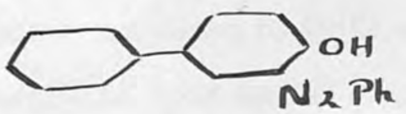
The three mono-nitrodiphenyls can be monobrominated, in the 4' position in each case, but further bromination cannot be effected.

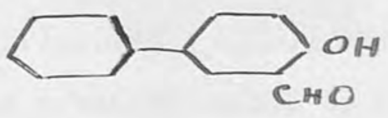




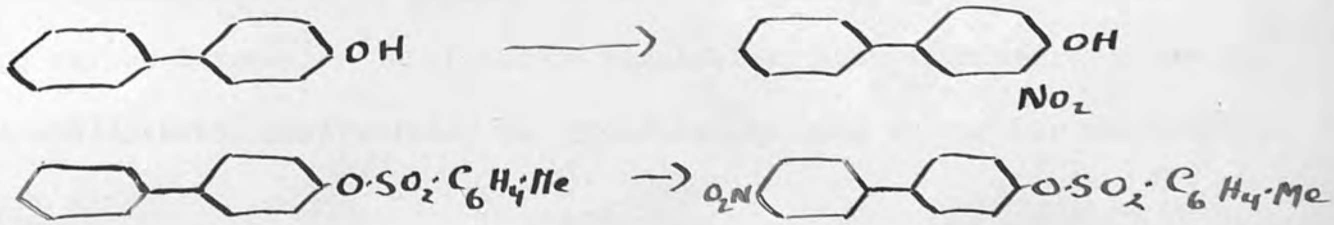


It would appear, from what has already been said, that to cause substitution in the 3 or 5 position in the diphenyl molecule, that is in the meta position to a phenyl group, the influence of a group already present in the 2, 4 or 6 position in the nucleus to be substituted is necessary. This must, of course be an ortho-para directing group, and will by its activating effect, favour homonuclear substitution, the halogens being excepted.
The case of the strongly ortho-para-directing and activating hydroxyl-group will be considered first. It has been shown by Bell and Kenyon, (J., 1926, 3004) that when 4-hydroxydiphenyl is treated with diazotised aniline it undergoes coupling entirely in the 3-position. The Reimer-Tiemann reaction on 4-hydroxydiphenyl also gives a single aldehyde, probably the 3-derivative.

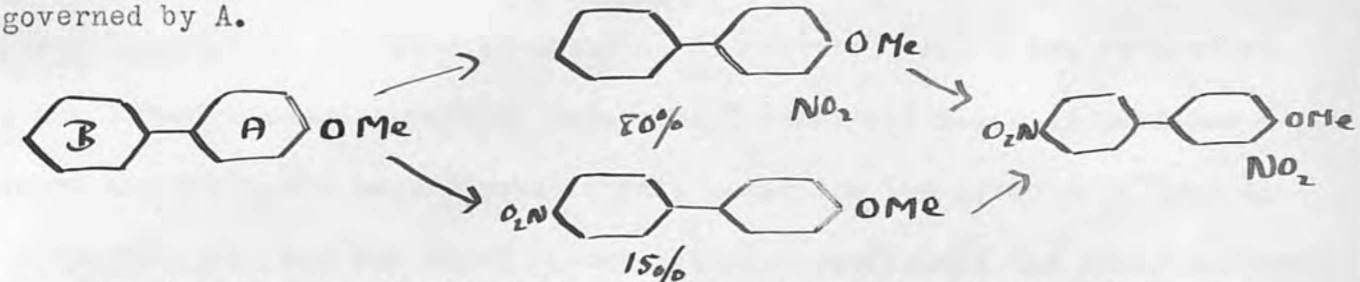




Since both these substitutions take place in alkaline solution, we have here the most effective ortho-para-directing and activating substituent, namely a negative pole attached to the nucleus.
4-Hydroxydiphenyl on treatment with nitrous acid does not form a nitrosodiphenyl but is mononitrated, exclusively in position 3. The p-toluenesulphonyl derivative of 4-hydroxydiphenyl is however nitrated mainly, if not exclusively in position 4'. This is presumably due to the effect of the positive $SO_2$ group.

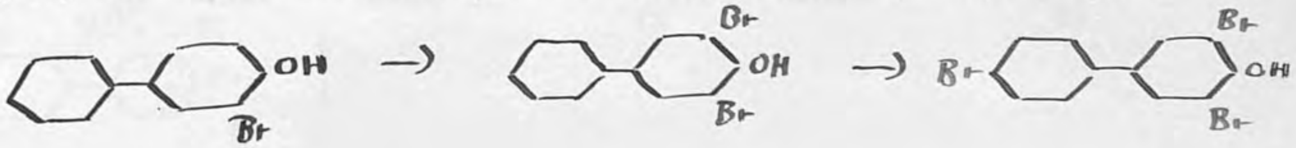


The same authors have shown that the mononitration of 4-methoxydiphenyl gives mainly the 3-nitro derivative, with some 4'-nitro, dinitration giving 3:4'-dinitro-4-methoxydiphenyl, the first nitro-group in A having reduced the reactivity of that nucleus so that further nitration occurs in B and is governed by A.

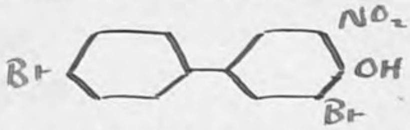


The occurrence of some 4'-nitration, the absence of 3:5-dinitration and the fact that somewhat drastic conditions are required for nitration might be attributed to a "reversed external field effect" of the methyl group, of the type suggested by Bennett and Mosses (loc.cit.).

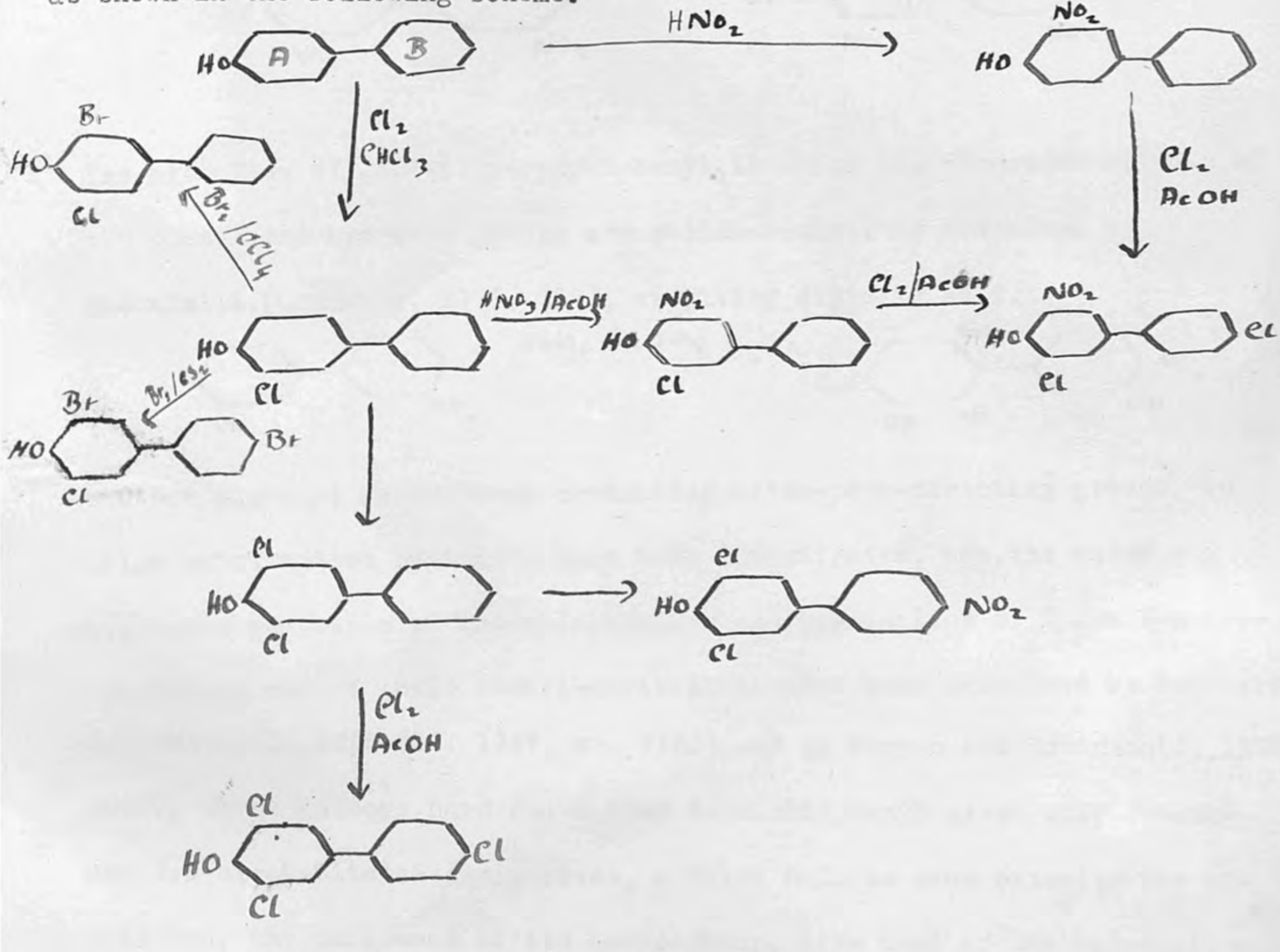
It has been shown by Bell and Robinson, (J., 1927, 1127), that 4-hydroxydiphenyl is mono and dibrominated in the ortho-positions to the hydroxyl group and tribrominated to give 3:4':5-tribromo-4-hydroxydiphenyl.



One of the bromine atoms can be replaced by a nitro-group by the action of nitrous acid, giving 3:4'-dibromo-5-nitro-4-hydroxydiphenyl.



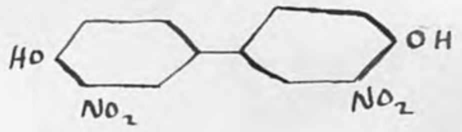
Colbert, Meigs and Stuerke, (J.Am. Chem. Soc., 1934, 2128 and 1935, 202 ) by the action of chlorine on suspensions of 4-hydroxydiphenyl in chloroform, carbon tetrachloride or carbon disulphide, have obtained mono and di-ortho-chlorinated derivatives; the dichloro-compound is further chlorinated in acetic acid to give a mixture containing some 3:4';5-trichloro-4-hydroxydiphenyl. Bromination of the monochloro-derivative in carbon tetrachloride gives 3-chloro-5-bromo- and bromination in carbon disulphide 3-chloro-4':5-dibromo-4-hydroxydiphenyl. The same authors have found that 3-chloro-4-hydroxydiphenyl is nitrated in position 5, and that this nitro-derivative like the 3:5-dichloro-derivative, undergoes further nitration in position 4'. In short the first and second substituents enter the two ortho-positions to the hydroxyl-group and the third enters the para-position in the other nucleus as shown in the following scheme.

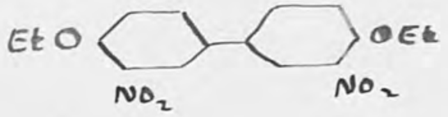


(and other substances)

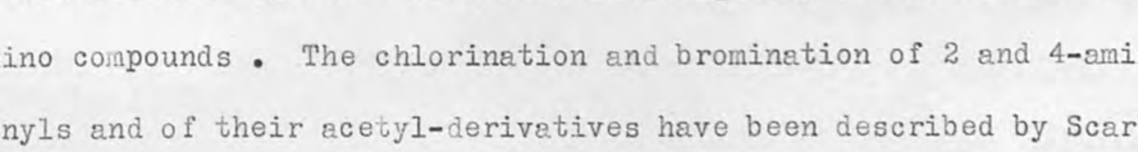
It appears that the directing influence of the phenyl-group is here entirely outweighed in the first two stages of substitution by that of the hydroxyl group, no 2-substitution being observed. In the third stage when heteronuclear substitution occurs the influence of the substituted phenyl group A shows itself in promoting 4'-substitution.

Similarly the dinitration of 4:4'-dihydroxydiphenyl and of its ethyl ether (Brady and Mc.Hugh, J., 1923, 2047), gives symmetrical 3:3'-dinitro-derivatives, substitution in both nuclei being governed by the hydroxyl-groups.

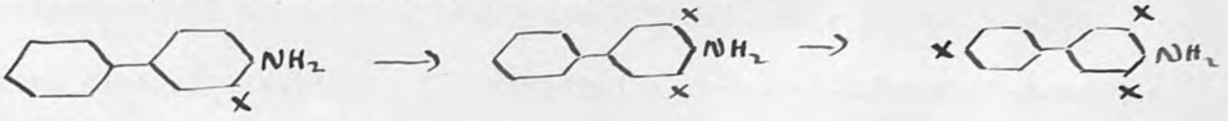




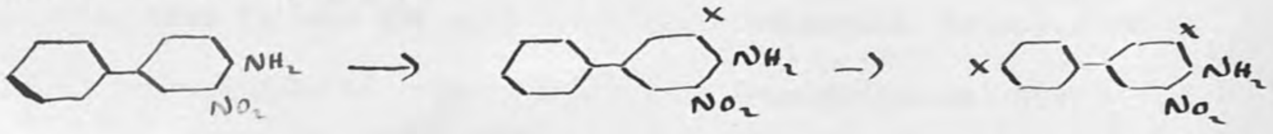
The nitration of 3:3'-dihydroxydiphenyl, in which the directive effects of the phenyl and hydroxyl groups are collaborating, is described by Mascarelli, (Gazzetta, 1932, 359), as giving dipicric acid.



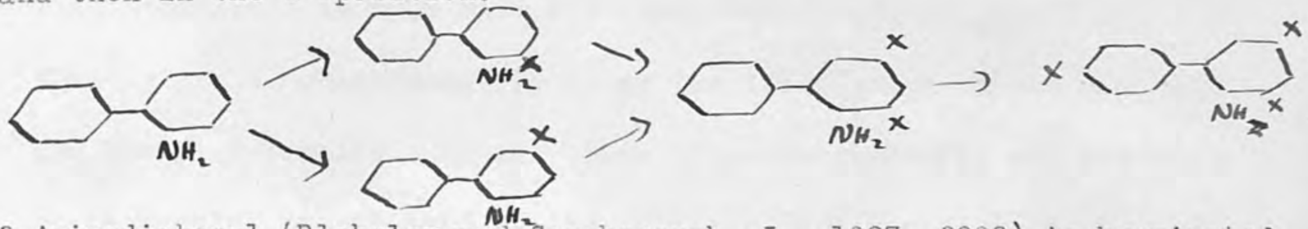
Other diphenyl derivatives containing ortho-para-directing groups, in which substitution reactions have been investigated, are the amino and acylamino compounds . The chlorination and bromination of 2 and 4-amino-diphenyls and of their acetyl-derivatives have been described by Scarborough and Waters(J.,1926,557; 1927, 89, 1133) and by Kenyon and Robinson(J.,1926, 3050). These authors have shown that 4-aminodiphenyl gives only 3-mono- and 3:5-disubstituted derivatives, a third halogen atom entering the 4'-position, the influence of the amino-group, like that of the hydroxyl, being sufficiently great completely to outweigh that of the phenyl-group until the two ortho-positions have been filled.



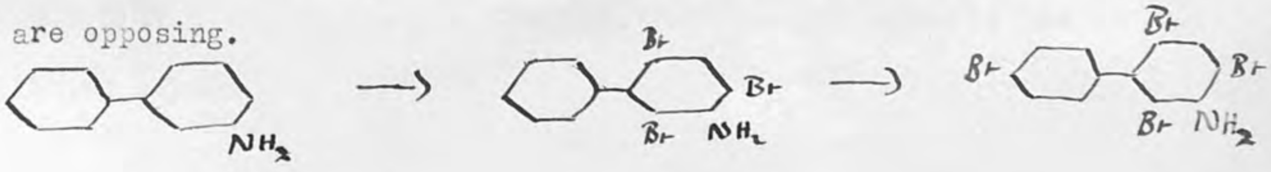
The 3-halogeno-4-aminodiphenyls and also 3-nitro-4-aminodiphenyl readily undergo further substitution by halogens in position 5, at the ordinary temperature, more vigorous treatment being required to introduce the third substituent in the 4'-position.



2-Aminodiphenyl is halogenated in the 5 (para) and in the 3 (ortho) positions and then in the 4'-position.

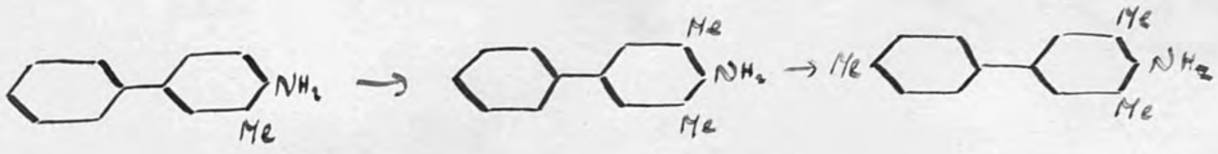


3-Aminodiphenyl (Blakeley and Scarborough, J., 1927, 3000) is brominated in the 2, 4 and 6 (ortho and para) positions, a fourth substituent entering the 4'-position. Chlorination of the free base gives a resinous product; both this and the fact that heteronuclear substitution does not occur until three substituents have entered the first nucleus indicate a particularly high reactivity. In this case the directive effects of the amino and phenyl groups are reinforcing each other, whereas in the 2 and 4-amino compounds they are opposing.



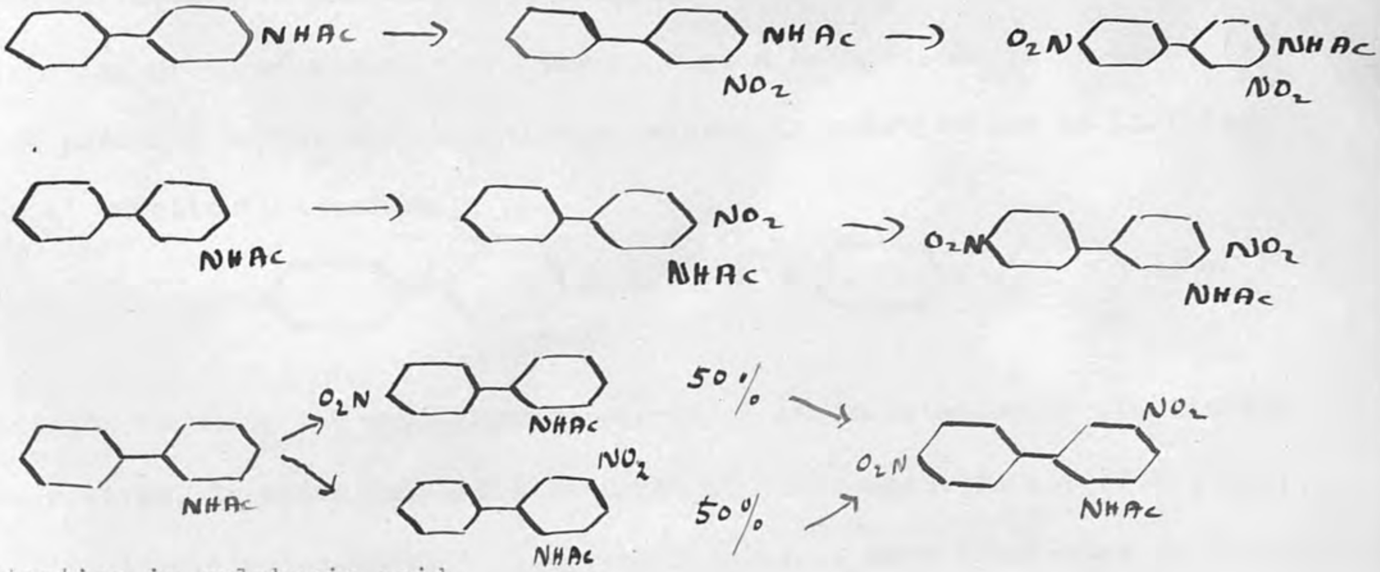
(X is Cl or Br.)

Jackson and Hey (J., 1934, 645) describe the nuclear methylation of 4-aminodiphenyl by heating its hydrochloride under pressure with methyl alcohol; 3-methyl, 3:5-dimethyl and 3:5:4'-trimetnyl-4-aminodiphenyls were thus obtained.

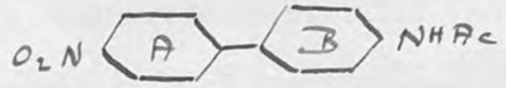


Methylation thus follows the same course as bromination. Attempts to obtain nuclear-methylated primary bases from 2-aminodiphenyl hydrochloride in this way were unsuccessful. The authors do not consider this surprising, as it has been shown by Bell (J., 1930, 1071 ) that 2-aminodiphenyl is much more resistant than 4-aminodiphenyl to N-methylation, which they regard as the first stage of the reaction. The acetyl-derivatives of the three monoaminodiphenyls are mononitrated in glacial acetic acid in the ortho or para position to the acetamido-group, but the entry of a second nitro-group in each case takes place exclusively in the unsubstituted nucleus, in the 4'-position; further nitration cannot be effected. If however nitration is carried out with fuming nitric acid or in the presence of strong sulphuric acid exclusively heteronuclear substitution occurs, in position 4'. This is probably due to salt-formation and consequent deactivation of nucleus B by a positive pole. These nitrations are shown by the following scheme:

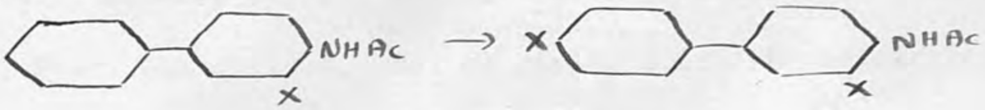
Nitration in acetic acid.



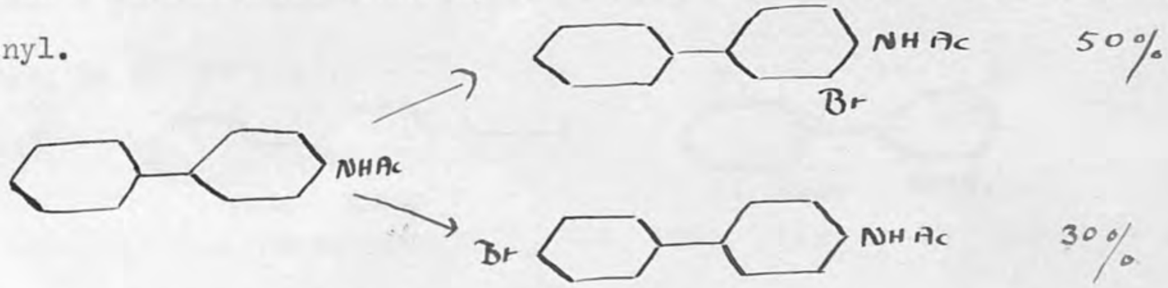
Nitration in sulphuric acid.



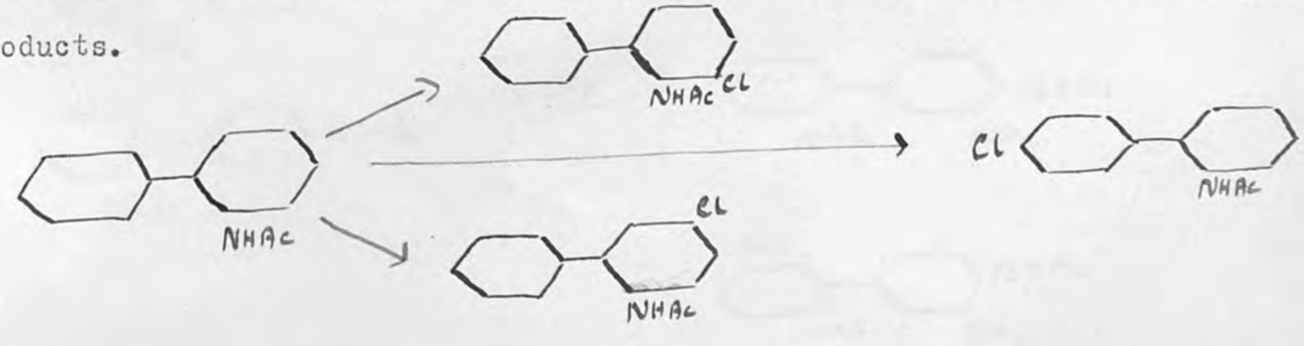
Halogenation of the three monoacetamidodiphenyls,(with the exception of the chlorination of 2- and bromination of 4-acetamido) follows a similar course. All three form stable N-chloramines which give ortho nuclear-substituted products by migration, but these chloroacetamido-compounds on further chlorination give only unstable N-chloramines from which no nuclear-substituted products can be obtained. Mono and dihalogeno, and by more vigorous treatment trihalogeno, derivatives can be obtained by direct halogenation in organic solvents, but substitution occurs less readily than in the free bases, the first substituent enters only the nucleus containing the acetamido group, and the second enters the unsubstituted nucleus in the 4'-position exclusively. Kenyon and Robinson (loc. cit.) consider that migration substitution from the N-halogeno compound can occur only in the positions adjacent to the acetamido-group, whilst direct substitution which takes place less readily can occur either in the substituted nucleus or in the unsubstituted, (in position 4'), and also that, when a second ortho-para-directing group of almost equal power, e.g. a halogen, is in an ortho or para position to the acetamido-group, migration substitution is inhibited and 4' substitution occurs.



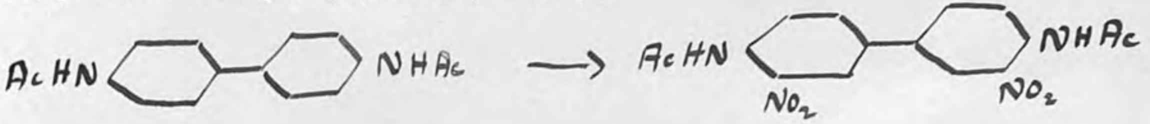
Attempts to study the substitution reactions of diacetamido or phthalamido derivatives, in which initial attachment of the reagent to the side-chain, leading to migration-substitution, was impossible, were frustrated by hydrolysis or decomposition, but evidence of still further lowering of reactivity was obtained. Monobromination of 4-acetaminodiphenyl is remarkable in that it gives a considerable quantity of 4'-bromo as well as 3-bromo-4-acetamido-diphenyl.



Chlorination of 2-acetamidodiphenyl also gives, according to de Crauw, (Rec. Trav.Chim., 1931, 753) 3-, 5- and 4'-monochloro-derivatives. The monobromination of 4- and the mononitration and chlorination of 2-acetamido-diphenyl thus differ from the other simple mono substitution reactions of mono-aminodiphenyls in giving appreciable amounts of heteronuclear substitution products.

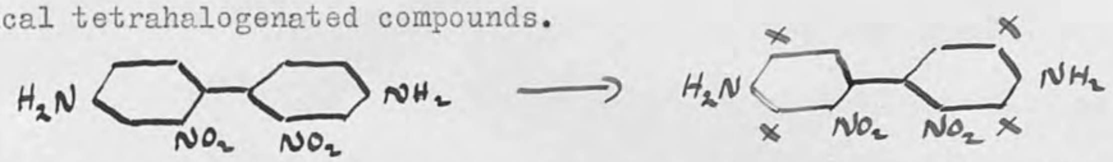


Nitration of diacetylbenzidine gives 3:3'-dinitro-4:4'-diacetamidodiphenyl, (Brady and Mc.Hugh, J., 1923, 3047).

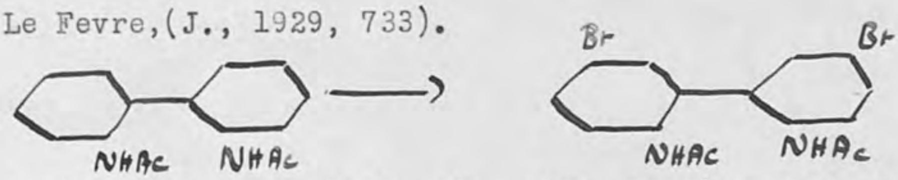


Chlorination of diacetylbenzidine gives 3:3'-dichloro-4:4'-diacetamidodiphenyl, (Levinstein, D.R.P., 97101), and further chlorination is described by Roosmalen (Rec. Trav. Chim., 1934, 259) as giving 3:5:3':5'-tetrachloro-4:4'-diacetamidodiphenyl.

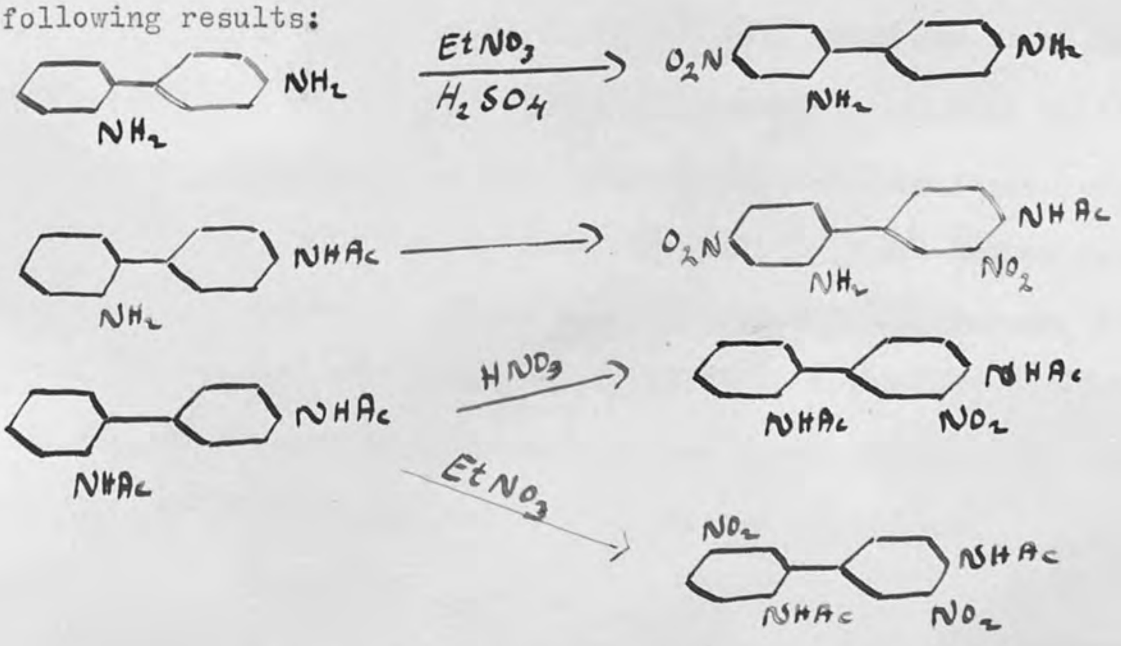
The chlorination and bromination of 2:2'-dinitrobenzidene also give rise to symmetrical tetrahalogenated compounds.



Bromination of 2:2'-diacetamidodiphenyl occurs in the 5 and 5'-positions according to Le Fevre,(J., 1929, 733).

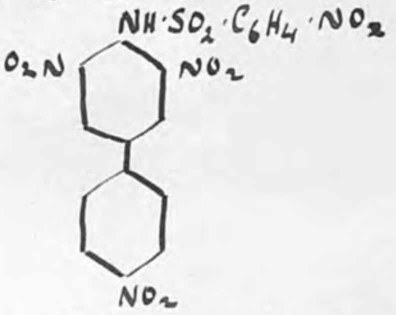


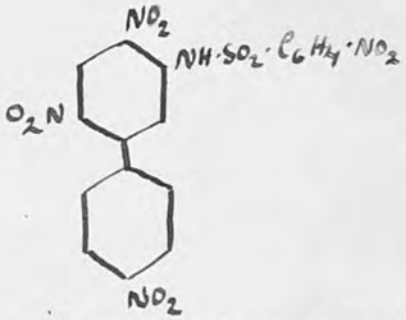
Finzi and Manganini (Gazzetta, 1932, 664, 1184, 1193) by the nitration of 2:4'-diaminodiphenyl and of its mono- and di-acetyl-derivatives obtained the following results:

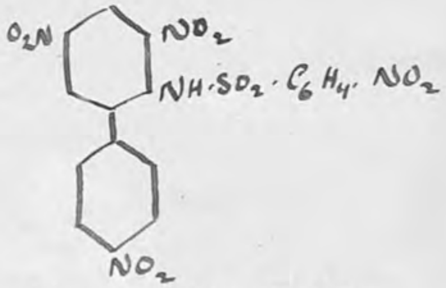


Comparison of the substitution reactions of the monoamino and monoacetamido diphenyls shows a lowering of reactivity and of ortho-para-direction in the latter, due to the partial counteraction of the electron-donating power of the amino-nitrogen by the positive carbonyl-group of the acetyl radical ,

Bell, (J., 1930, 1071), has found that the m-nitrobenzenesulphonyl derivatives of the monoaminodiphenyls, unlike the acetyl derivatives, are easily trinitrated in the ortho and para-positions in the substituted and in the para position in the unsubstituted nucleus, indicating that the deactivating effect of the $SO_2\cdot C_6H_4\cdot NO_2$ group on the amino-group is less than that of the acetyl-group.

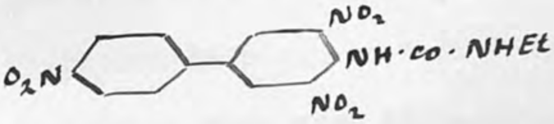


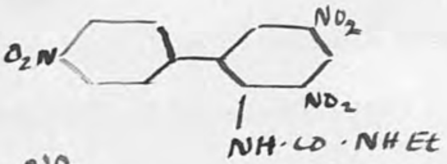


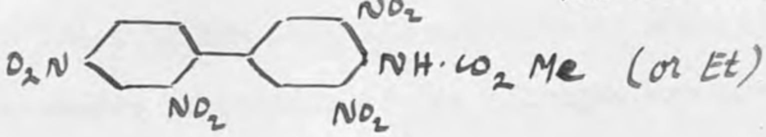


The same author (J.,1931, 2388) has studied the nitration and bromination of p-toluenesulphonyl-derivatives of the aminodiphenyls and found that the directive effect of the p-toluenesulphonamido-group is similar to that of the acetyl-group. The 4'-nitration of the p-toluenesulphonyl-derivative of 4-hydroxydiphenyl has been mentioned on p.20; Bell and Kenyon(loc.cit.) suggest that the 3-nitration of the p-toluenesulphonyl-derivative of the base is due to initial attachment of the reagent to the side-chain,i.e. to the directing group, in the derivative of the phenol however this cannot occur and direct substitution takes place in the 4'-position.

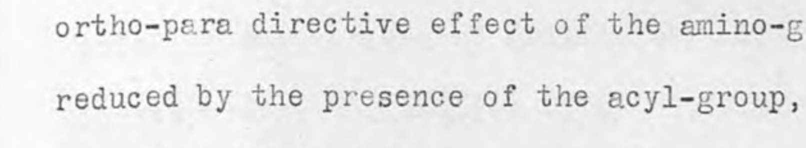
Werther, (Rec. Trav. Chim., 1933, 657 ) describes the nitration with "absolute" $HNO_3$ at 0° of N-2 and 4-diphenylyl-N'-ethyl carbamides as giving 3:5:4'-trinitro- derivatives and of methyl and ethyl diphenylyl-4-carbamates as giving 3:5:2':4'-tetranitro-derivatives, giving on hydrolysis the corresponding nitroaminodiphenyls.





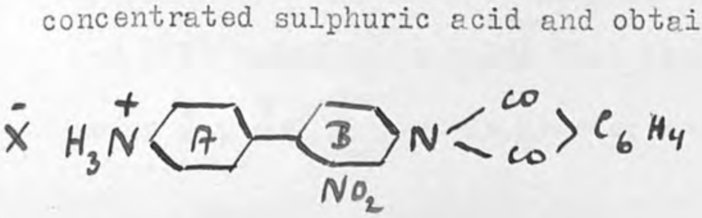


In all the derivatives of aminodiphenyls so far mentioned the normal ortho-para directive effect of the amino-group is still operative, although reduced by the presence of the acyl-group, and with the exceptions already mentioned it entirely controls mono-substitution. In other words the directive effect of th phenyl group is weaker than that of the acetamido etc. groups. It was however shown by Le Fevre and Turner, (J., 1926, 1759), that the product of nitration of diphthalylbenzidine was a 2:3'-dinitro-derivative, unsymmetrical substitution of the type previously observed in the dihalogenodiphenyls having occurred.



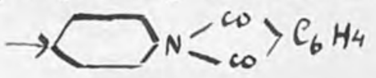
(I)

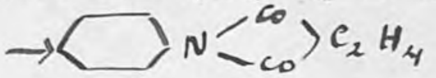
The same authors subsequently nitrated phthalylbenzidine in excess of concentrated sulphuric acid and obtained on hydrolysis 2-nitrobenzidine.

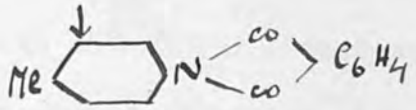


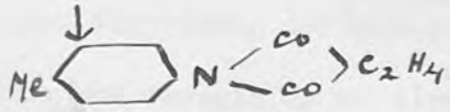
(II)

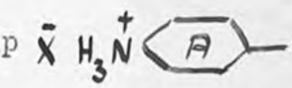
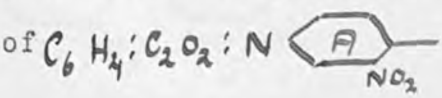
It was considered unlikely that nitration had occurred in nucleus A in (II), since if ionisation had occurred there must have been a strongly deactivating positive pole present, whilst in the absence of ionisation the effect of the amino-group would have been to cause nitration in position 3 in A. Assuming that ionisation had occurred, the fact of nitration in position 2 in B indicates that the directive powers of the nucleus A, even when it contains a deactivating substituent, are strong enough to overcome those of the phthalyl-substituted amino-group in which the electron-source properties of the nitrogen are now counteracted by two C:O groups. A similar case is that described by Brady, Quick and Welling, (J., 1925, 2264) who found that although the succinyl and phthalyl derivatives of aniline were nitrated in the p-position, the corresponding derivatives of p-toluidine were nitrated mainly in the ortho-position to the methyl-group, the directive power of the amino group being sufficiently reduced to allow the methyl group to take control.



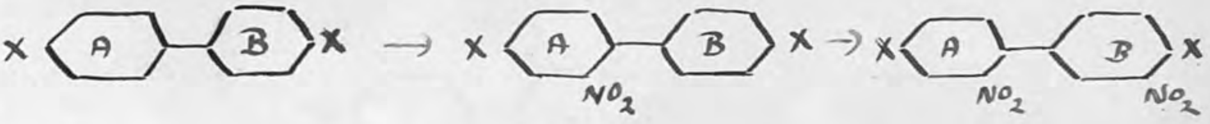




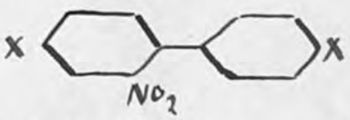


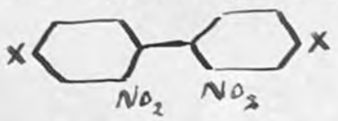
In the formation of 2:3'-dinitrodiphthalylbenzidine (I), 2-nitration presumably occurs first and the presence of this first nitro-group in A has the effect (a) of preventing further substitution in A and (b) of reducing the directive powers of A so that nitration in B is now controlled by the phthalamido-group and occurs in position 3'. Comparison of (I) and (II) seems to indicate that the ortho-para-directive power of the group  $\bar{X}\,H_3\overset{+}{N}$ is greater and that of  $C_6H_4{:}C_2O_2{:}N$ less than that of the phthalamido-group, but it must be remembered that the degree of ionisation of (II) in concentrated sulphuric acid would be small, and it is also possible that a"direct effect" of the positive field of the 2-nitro-group in (I) might have some deactivating action on the 2'-position in the other nucleus.

It has been shown by Dennett and Turner ,(J.,1926 476), Le Fevre and Turner (J., 1926, 2041; 1930, 1158) and Shaw and Turner (J, 1932, 285,509) that 4:4'-dibromo, dichloro and difluoro-diphenyls are readily mononitrated in position 2 exclusively, substitution being controlled by the p-halogenophenyl group B rather than by the halogen in A. Further nitration gives mainly the 2:3'-dinitroderivative, the nitro-group in A having reduced the electron-source properties of that nucleus so that it is less able to compete with the halogen in B, which therefore mainly controls substitution.



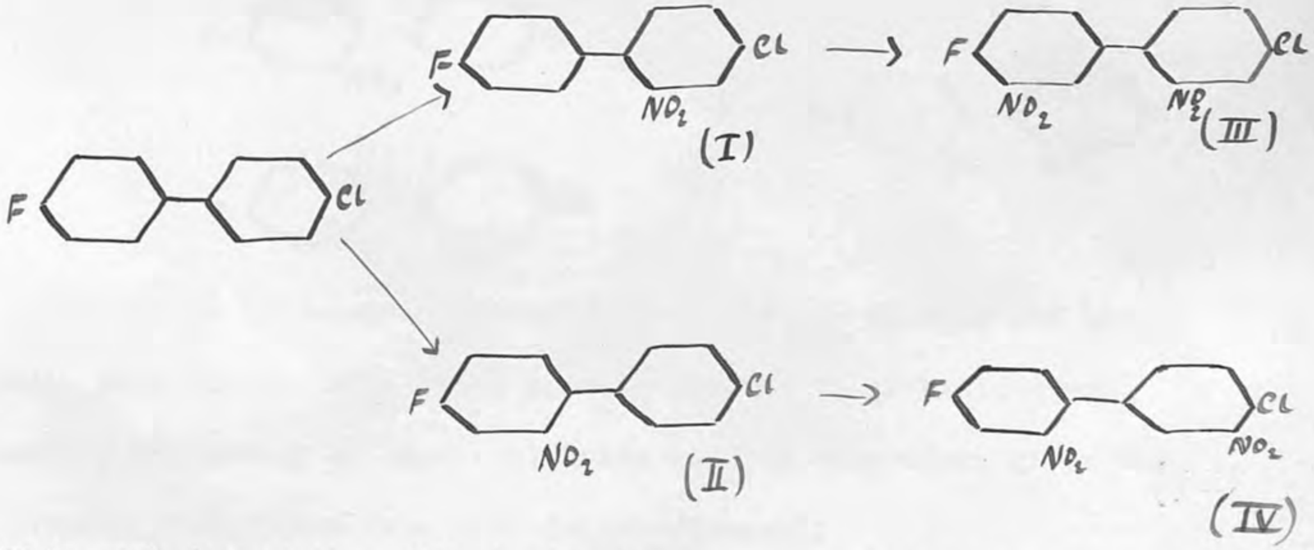
Some 2'-nitration however does occur in B, 19% in the chloro and bromo and 35% in the fluoro-compound, this is not surprising in view of the known deactivating effects of the halogens and especially of fluorine.





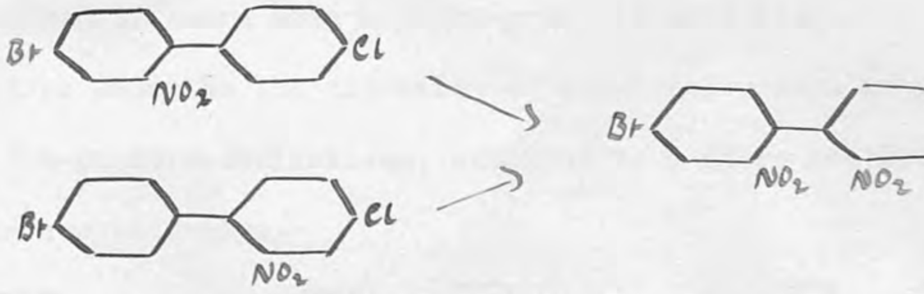
By the nitration of 4:4'-di-iododiphenyl, Hodgson and Nixon (J., 1926, 2384) obtained only the 2:3'-dinitro-derivative, indicating that the first nitro-group enters only the 2-position.

The nitration of unsymmetrical 4:4'-dihalogenodiphenyls (Marler and Turner, J., 1931, 1359; Shaw and Turner, J., 1932, 285) gives results in accordance with the comparative directive powers of the halogens as established by Hollemann and others by the nitration of halogeno-benzenes, (Rec. Trav. Chim., 1915, 131, 216). In the mononitration of, for instance, 4-chloro-4'-fluorodiphenyl it would be expected that a mixture of the 2 and 2'-mononitro-compounds should be the only product, by analogy with the symmetrical dihalogeno-compounds already mentioned; more of the compound with the nitro-group in the nucleus containing the larger and less deactivating halogen should be formed, and further nitration of either mononitro-compound should give a dinitro-compound with a nitro-group in the 3-position in the other nucleus. Dinitration of the dihalogeno-compound should therefore give a mixture of the dinitro-compounds (III) and (IV) containing more of (III).

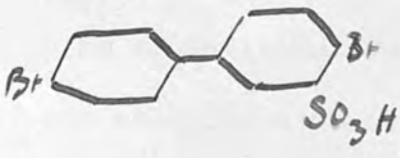


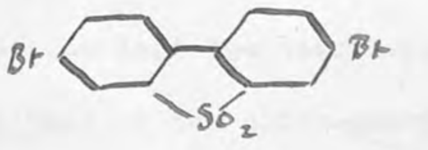
(This work formed the subject of a thesis presented by the writer in November 1930 for the degree of M.Sc. in this University.)

The halogen atom with a nitro-group in the ortho-position to it should be labile and react with piperidine. Treatment of the mixture of dinitro-compounds with piperidine and estimation of the relative amounts of the two halogens liberated as their acids should therefore give the proportions of (III) and (IV) and thence of (I) and (II) formed during nitration. This method has been successfully applied to 4-chloro- and 4-bromo-4'-fluoro and to 4-bromo-4'-chlorodiphenyls, and the relative directive powers of the halogens when they are in the 4- and 4'-positions in the diphenyl molecule have been shown to be approximately the same as when they are in the para-positions in the benzene nucleus. In no case could the mono-nitro-derivatives be isolated. Shaw and Turner (loc. cit.) have shown that in the dinitration stage some 2:2'-dinitro-compound is formed, as in the case of the symmetrical 4:4'-dihalogenodiphenyls.

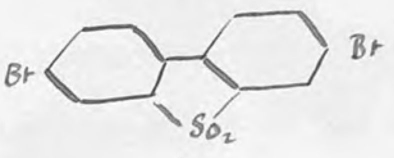


Sulphonation of halogenodiphenyls, described by Courtot and Lin, (Bull. Soc. Chim., 1931, 1047) appears however to give different results; the action of chlorosulphonic acid in chloroform gives the following derivatives from 4:4'-dibromodiphenyl:

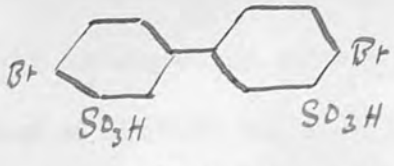




Chlorosulphonic acid alone at 60° gives some disulphonated derivative but no unsymmetrical substitution is observed.



44%

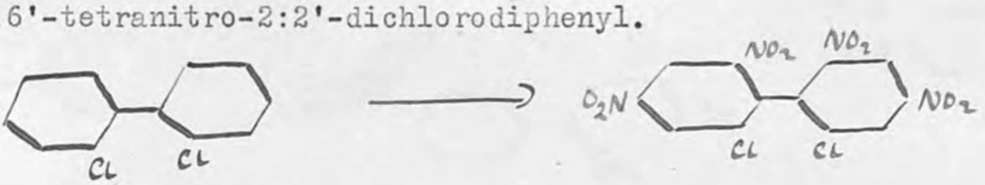


42%

and 12% of acid chloride of above.

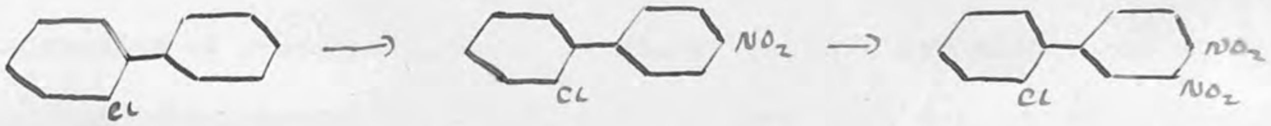
When sulphuric acid is used as the sulphonating agent a higher concentration of oleum is said to favour 3:3'-substitution.

Van Alphen (Rec. Trav. Chim., 1932, 453) describes the nitration of 2:2'-dichlorodiphenyl as giving a tetranitro-derivative, regarded as 4:6:4':6'-tetranitro-2:2'-dichlorodiphenyl.



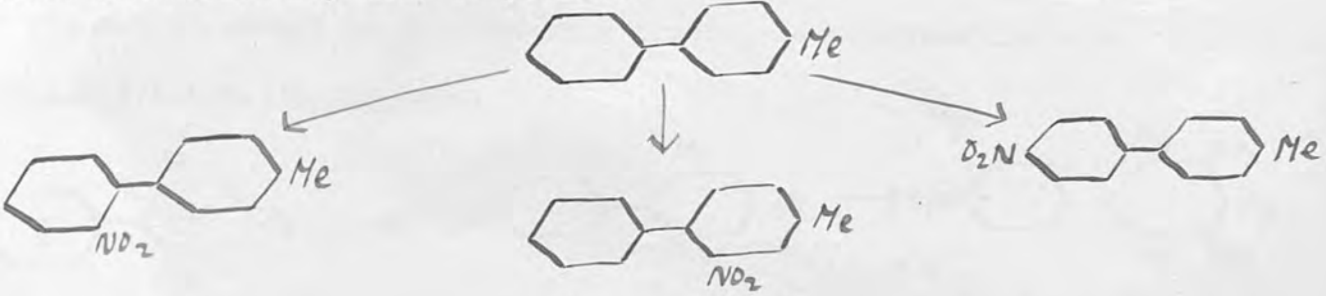
Mascarelli and Gatti (Gazzetta, 1933, 654) obtained under milder conditions a dinitro-2:2'-dichlorodiphenyl; this compound resisted oxidation, as would be expected if there were a nitro-group in each ring.

The same authors describe the nitration of 2-chlorodiphenyl as giving 4'-nitro and 3':4'-dinitro-derivatives, oxidised to 4-nitro and 3:4-dinitro-benzoic acids respectively.



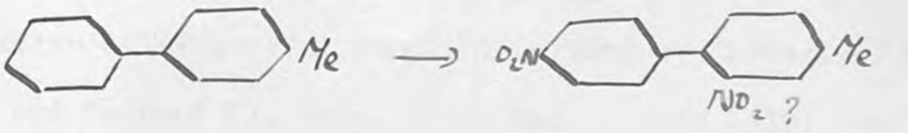
This result is in disagreement with the orientation rules so far observed in that it involves the entry of a second nitro-group into the same ring as the first and in the ortho-position to it, and moreover in the meta-position to an aromatic nucleus. The indication that the deactivating effect of the chlorine atom is greater than that of the nitro-group is also surprising.

Grieve and Hey (J., 1932, 1888, 2245, 2367) describe the nitration of some methyldiphenyls. Nitration of 4-methyldiphenyl proceeds under milder conditions than that of diphenyl, as would be expected from the known activating effect of the methyl-group, and a mixture of mononitro-derivatives substituted in positions 2, 2' and 4' is obtained, indicating that the controlling effect of the methyl-group upon substitution is outweighed by that of the phenyl and p-tolyl radicals; it is however possible that some 3-nitro-derivative may also be present.

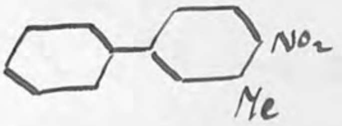


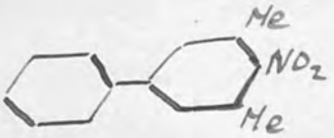
not more than 5%.

Dinitration gives, probably, the 2:4'-dinitro-derivative, this may be the 3:4'-dinitro-compound, but there is certainly one nitro-group in the other nucleus from the methyl-group.

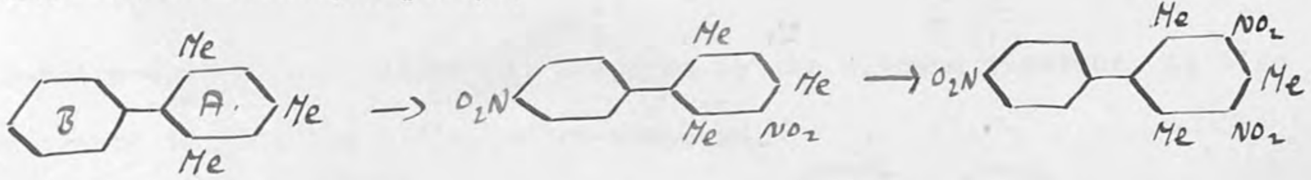


Mononitration of 3-methyldiphenyl, in which the directive effects of the phenyl and methyl-groups are collaborating, gives only 4-nitro-3-methyldiphenyl, and similarly 3:5-dimethyldiphenyl is nitrated in position 4, no heteronuclear-substituted product being formed.

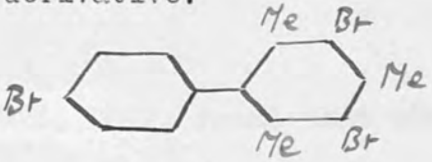




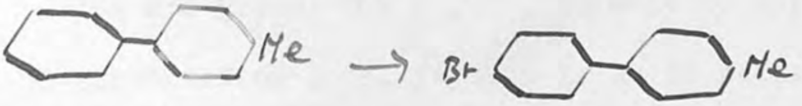
The same authors nitrated 2:4:6-trimethyldiphenyl in order to ascertain whether the effect of three methyl-groups in nucleus A could sufficiently activate that nucleus to counteract the tendency to 4'-substitution in B. Nitration occurred very readily and could not be stopped at the mono- and only with difficulty at the di-nitration stage; 3:4'-dinitro-2:4:6-trimethyldiphenyl was however isolated, showing that some heteronuclear substitution had occurred, although the reagent still had the choice of a position ortho to two methyl-groups in A. The only product of trinitration was 3:5:4'-trinitro-2:3:6-trimethyldiphenyl.



Bromination gave a tribromo-derivative.

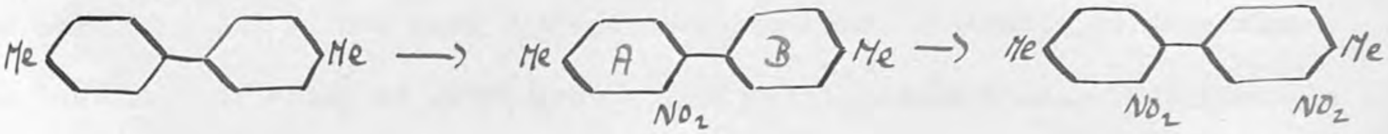


Bromination of 4-methyldiphenyl, described by Carnelly(J., 1876, 20) and Gomberg and Pernert (J. Amer. Chem. Soc., 1926, 1372) occurs mainly in the unsubstituted nucleus; this agrees with the above results in showing that the methyl-group is only able to a limited extent to compete with a phenyl or p-tolyl radical for the control of substitution.



67%.

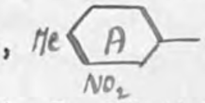
4:4'-Dimethyldiphenyl (Dennett and Turner, J., 1926, 476; Marler and Turner, J., 1932, 2391) is more readily mononitrated than diphenyl, as would be expected, and gives only the 2-mononitro-derivative; further nitration gives 2:3'-dinitro-4:4'-dimethyldiphenyl. The orienting effect of methyl-groups in the 4 and 4' positions is thus similar to that of the halogens.



(I)

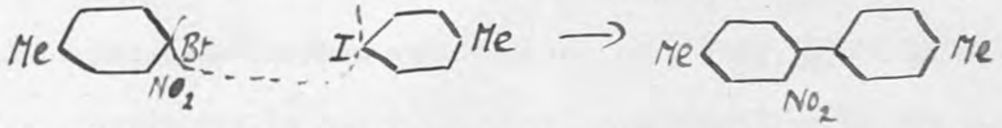
3-Nitro-4:4'-dimethyldiphenyl, prepared by the Ullmann reaction, is also nitrated to give the 2:3'-dinitro-compound.

(II)

(Le Fevre and Turner, J., 1926, 2041, found that nitration of 3-nitro-4:4'-dibromodiphenyl gave the 2:3'-dinitro-compound, together with an isomer.) It is suggested that when the first nitro-group is in position 2, as in (I), it may exert a deactivating field effect (possibly also a steric effect) upon the adjacent 2'-position in the other nucleus, and that this, rather than reduction of the directive powers of nucleus A, may partly account for the large preponderance of 3'-nitration in B. (See also p. 32.) When the first nitro-group is in position 3, as in (II), this effect is not operative and group,  is able to oppose the methyl-group and cause 2-substitution in B. If this is so it seems probable that there may be some 2:2'-dinitration, deactivation of the 2'-position by the 2-nitro-group not being complete, and this is also suggested by analogy with the 4:4'-dihalogenodiphenyls, which have been shown to undergo some 2:2'-dinitration, (p.32). Although no second substance has been isolated from the dinitration-product of 4:4'-dimethyldiphenyl, the melting-point of this product is raised 20° by three recrystallisations, so that it seems possible that a small amount of another dinitro-compound may be present. The dinitro-compound obtained by nitrating 3-nitrodimethyldiphenyl requires less purification before showing the melting-point of the pure 2:3'-dinitro-compound. Attempts to determine the positions of entry of nitro-groups into 2-halogeno-4:4'-dimethyldiphenyls are described in detail in a later part of this thesis.

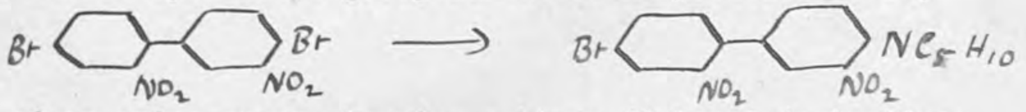
The following are among the chief methods used to identify the positions of entry of substituent groups into the diphenyl molecule.

(a) Synthesis by the Ullmann reaction from benzene derivatives of known orientation and comparison with the substitution products, e.g.;

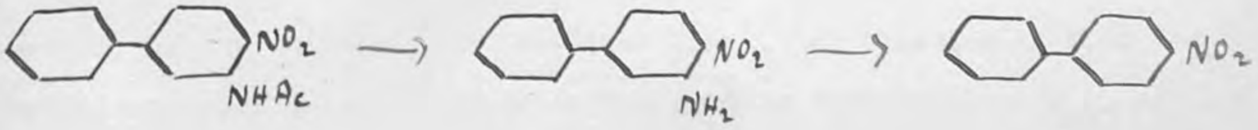


(b) Destruction of one nucleus of the substitution-product by oxidation, giving a known derivative of benzoic acid; a nucleus containing a nitro-group is stable towards oxidation, e.g.;

(c) Replacement, by the action of piperidine, of a halogen atom which is rendered labile by a nitro-group in the ortho-position to it;



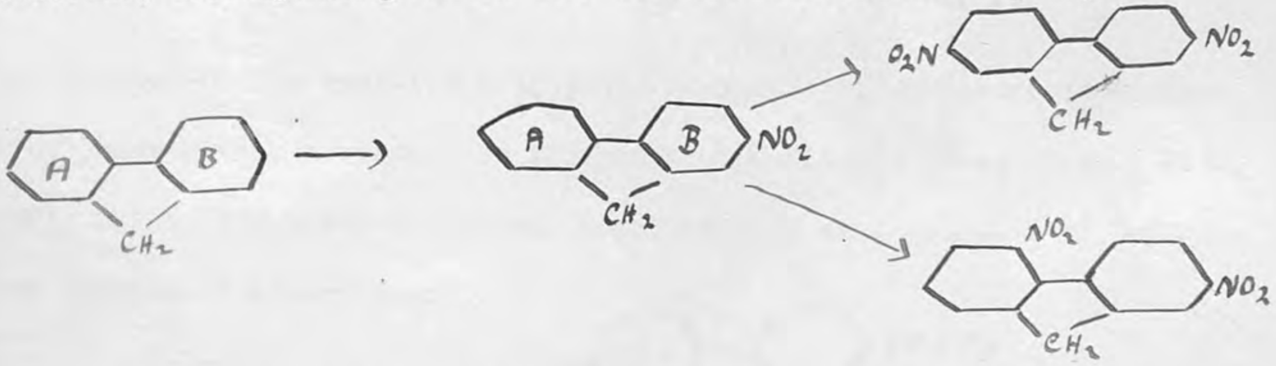
(d) Removal of an amino-group, leaving a known diphenyl derivative;



Diphenyl derivatives substituted in the 2 and 2'-positions can in many cases be converted into tricyclic compounds in which these two positions are joined through a divalent atom or group. The substitution reactions of some of these compounds have been studied, e.g.; fluorene, fluorenone, carbazole and diphenylene oxide, and indicate that the same orientation rules hold good as in the case of diphenyl compounds, the directive effects of the aromatic nucleus and of the group X being similar in the two cases illustrated:

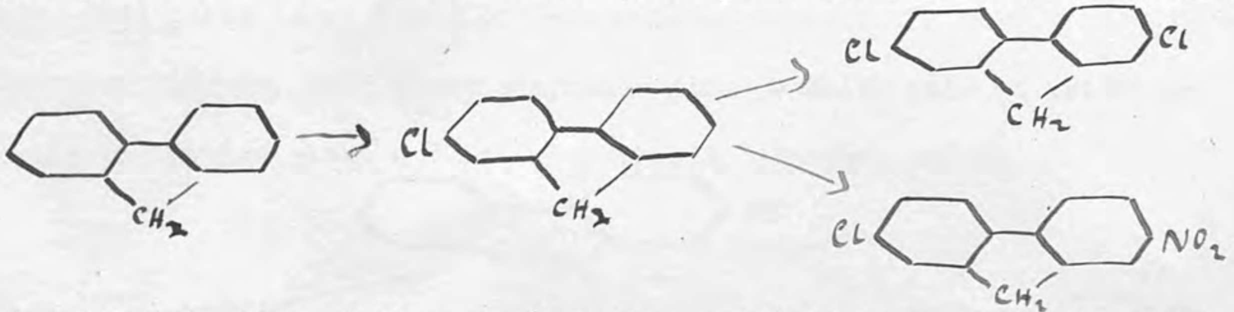
(X is $CH_2$, C:O, NH or O.)

The nitration, halogenation etc. of fluorene and its derivatives show **that** the orienting influences are similar to those in the diphenyl series. Nitration of fluorene (Morgan and Thomason, J., 1926, 2691) gives a derivative substituted in the 2-position, corresponding to the 4-position in diphenyl, and further nitration gives mainly 2:7 and some 2:5-dinitrofluorene, corresponding to the 4:4' and 2:4'-substituted diphenyls.

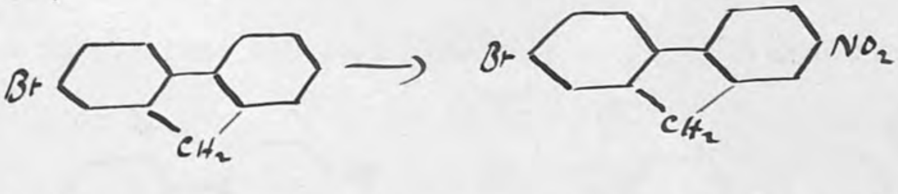


It thus appears that the course of substitution is controlled, as in diphenyl, by the nucleus A in the first place. Deactivation of **B** by the first nitro-group leads to substitution in **A** on further nitration, and, again as in diphenyl, this occurs exclusively in the ortho or para position to the nitro-substituted nucleus B. The influence of the methylene-group, like that of the methyl-group in methyldiphenyls, is outweighed by that of the aromatic nucleus.

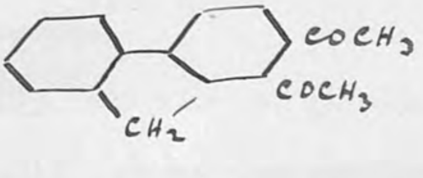
Courtot and Vignati, (Compt. Rend., 1927, 1179) describe the direct chlorination of fluorene in chloroform at 0--5° as giving 2-chloro and 2:7-dichloro-derivatives, nitration of this mixture in glacial acetic acid giving 2-chloro-7-nitrofluorene and leaving the dichloro-compound unchanged.

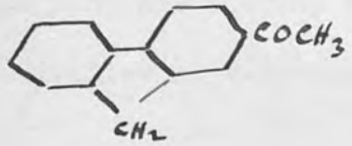


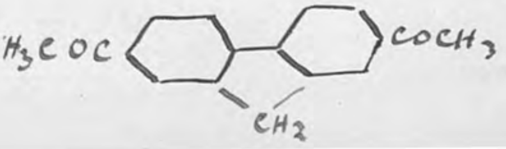
Direct bromination of fluorene (Matthews and Hodgkinson, J., 1883, 163; Courtot and Vignati, Bull. Soc. Chim., 1927, 5864) gives the 2-monobromo- and some dibromo-derivative; nitration of the 2-bromo-compound gives 2-bromo-7-nitrofluorene.



The Friedel-Crafts reaction with fluorene and acetyl chloride in carbon disulphide gives, according to Dziewoński and Kleszcz (Rocz. Chem., 1932, 176), mainly 1:2-diacetofluorene, together with small amounts of 2-aceto- and 2:7-diacetofluorenes.

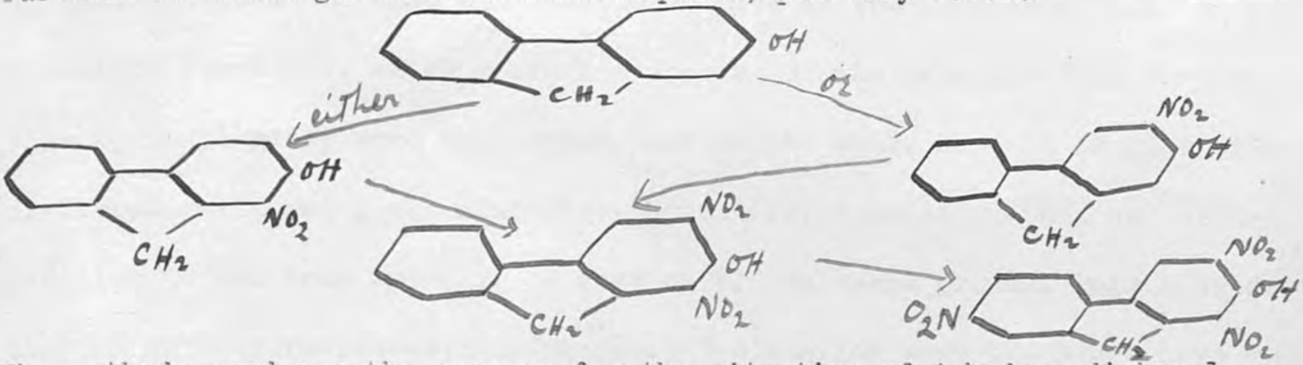






When substitution occurs in a fluorene derivative containing an ortho-para-directing substituent in position 2, there are two ortho-derivatives theoretically possuble, since the 1 and 3 positions, unlike the 3 and 5 positions in a 4-substituted diphenyl, are not equivalent. In the nitration etc. of 2-hydroxy and aminofluorenes and their derivatives only one ortho-substituted product is however formed in all cases.

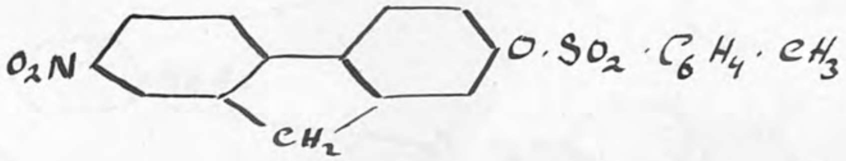
The nitration of 2-hydroxyfluorene (Ruiz, Anal. Asoc. Quim. Argentina, 1928, 170) gives first the 1 or 3-mononitro-compound and then 1:3-dinitro-2-hydroxyfluorene. Both these compounds give phthalic acid on oxidation. Further nitration gives a trinitro-compound, probably 1:3:7.



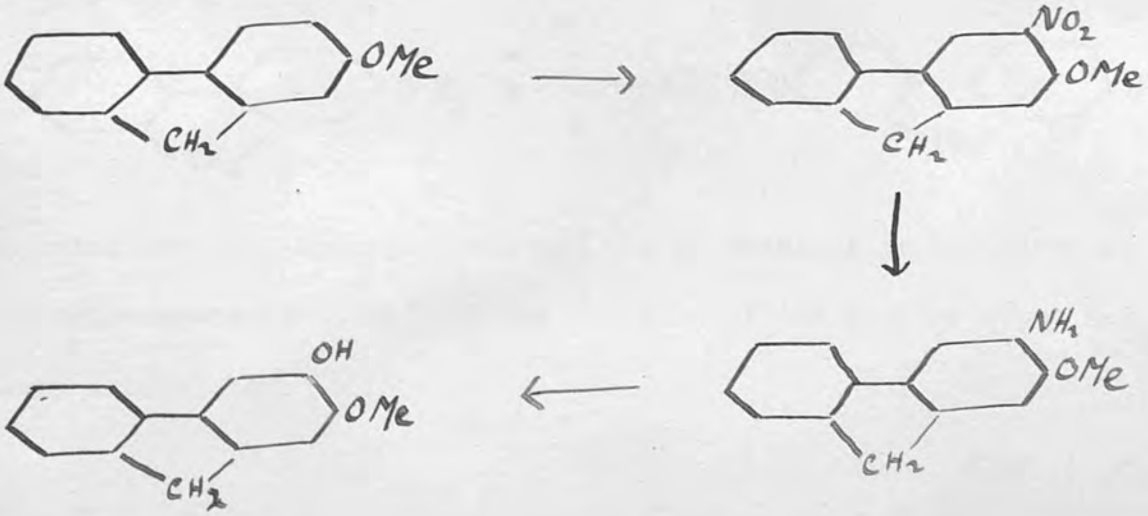
The methods used are the same as for the nitration of 4-hydroxydiphenyl. 2-Hydroxyfluorene in alkaline solution undergoes coupling with diazonium salts in position 1 or 3.

No nitrosated derivatives of 2-hydroxyfluorene have been obtained, the action of nitrous acid giving only an ortho-nitrated product in small amount. This is like the behaviour of hydroxydiphenyls.

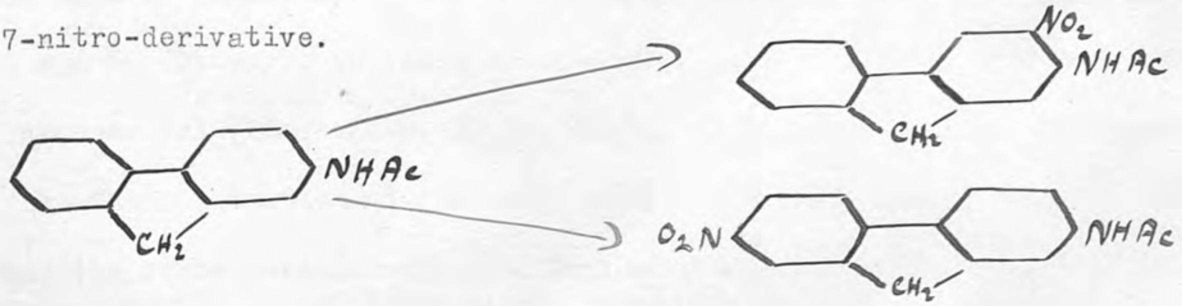
The fact has already been mentioned (p. 20) that the p-toluenesulphonyl-derivative of 4-hydroxydiphenyl, unlike that of 4-aminodiphenyl, undergoes mainly heteronuclear nitration in position 4'. The same effect is observed in the case of the p-toluenesulphonyl-derivative of 2-hydroxy fluorene, which gives mainly the 7-nitro-derivative.



Nitration of 2-methoxy fluorene occurs more easily than that of 4-methoxydiphenyl (p.21) and gives an ortho-substituted derivative. The guiacol obtained by reduction of this compound and replacement of the amino-group by hydroxyl does not show the reactions, such as the indophenol and phthalein reactions, which would be expected if the para-position to the free hydroxyl group were unoccupied, and on the other hand it couples with diazonium salts and gives a nitroso-derivative, indicating that one ortho-position to the free hydroxyl is available. On these grounds Ruiz considers that it is 3-hydroxy-2-methoxyfluorene; 3-nitration must therefore have occurred. Under the conditions for nitration of 2-hydroxyfluorene, 4-hydroxydiphenyl is unaffected. Ruiz suggests that the methylene-group has an activating effect and favours substitution in the para-position to itself.

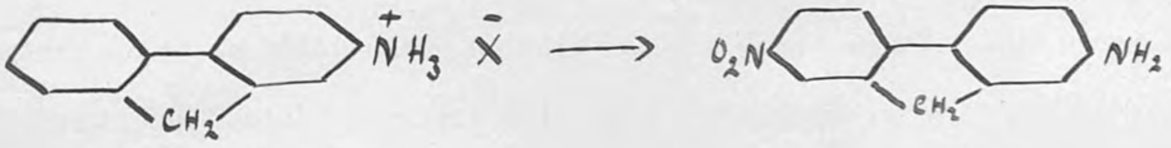


Nitration of 2-acetamidofluorene, (Diels, Schiel and Tolson, Ber., 1902 3285) gives a mixture of an ortho-nitro-2-acetamidofluorene and the 7-nitro-derivative.



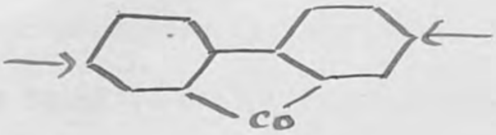
Diels regarded the homonuclear-substituted compound as the 1-nitro-derivative, but it has since been shown by Eckert and Langeckner, (J. Pr. Chem., 1928, 263) to be the 3-nitro-derivative, since it gives on oxidation a nitroaminofluorenone deamination of which gives the known 3-nitrofluorenone.

These authors describe the nitration of urethano and benzamido-derivatives of 2-aminofluorene as giving also 3-nitro-derivatives. Nitration of 2-aminofluorene itself gives almost entirely the 7-nitro-compound, presumably on account of salt-formation and consequent deactivation of the nucleus containing the amino-group.

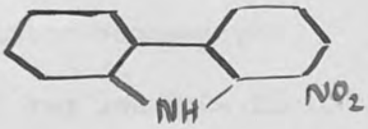


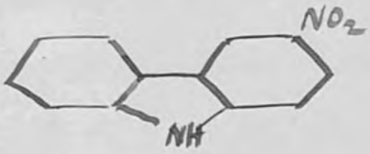
The bromination of 2-aminofluorene and its derivatives is described as giving tribromo-derivatives, but the position of the bromine atoms has not been established.

Fluorenone and its derivatives are nitrated and halogenated (Courtot, Bull. Soc. Chim., 1927, 58) in the same positions as fluorene, i.e 2 and 7. Attempts to cause substitution in positions 1 or 8 have been unsuccessful (Langeckner, J. Pr. Chem., 1939, 145) as would be expected from the combination of the meta-directing effect of the carbonyl-group and the ortho-para-directing effect of the aromatic nucleus.



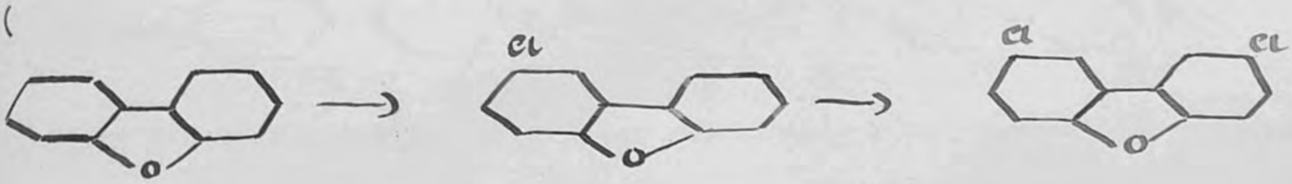
In carbazole and diphenylene oxide, as in the amino and hydroxy diphenyls the ortho-para-directing influence of the nitrogen or oxygen atom predominates. Nitration of carbazole (Morgan and Mitchell, J., 1931,3283) gives as the only product a mixture of equal amounts of the 1 and 3 nitro-compounds.



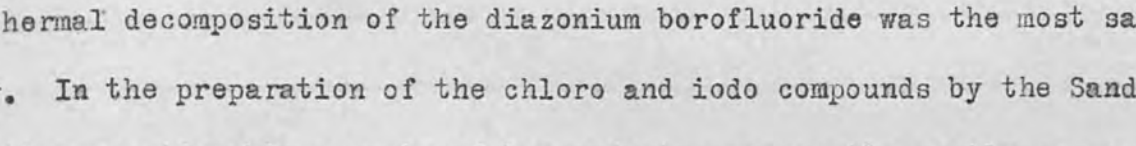


Diphenylene oxide is chlorinated to give 3-mono-chloro and 3:6-dichloro-derivatives. The 7-nitro-derivative is also brominated in position 3,

(

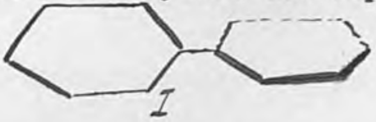


The work described in the following pages has been concerned with the preparation and nitration of 2-halogeno-4:4'-dimethyldiphenyls (ditolyls). It seemed probable that the nitration of halogeno-ditolyls would give results of interest in showing the comparative directive effects of the halogens and the methyl and p-tolyl groups. As 2-nitroditolyl was easily obtained in a pure state by nitration of ditolyl, the preparation of halogeno-derivatives from the corresponding amino-compound was attempted. This was accomplished with a certain amount of diffculty, the yields being poor. The salts of 2-aminoditolyl were found to be sparingly soluble, it was therefore necessary to diazotise in rather dilute solution and a considerable amount of phenol and tarry substances was always formed. The preparation of the fluoro-compound by thermal decomposition of the diazonium borofluoride was the most satisfactory. In the preparation of the chloro and iodo compounds by the Sandmeyer reaction considerable amounts of by-products, apparently mostly azo-compounds, were formed, and also some ditolyl. The bromo-compound was obtained in two ways, (i) from the diazonium perbromide, decomposition of which to give 2-bromoditolyl presented however some difficulty. Decomposition in glacial acetic acid in the usual way led to a product which was, at any rate partly, dibrominated. This was not unexpected in view of the experience of Le Fevre and Turner, (J., 1926, 2041) that decomposition in acetic acid of the bis- diazonium perbromide derived from 2-nitro benzidine gave a tribromo-derivative.



This was presumably due to the greater reactivity of the diphenyl as compared with the benzene molecule, and such behaviour would be even more probable in a ditolyl derivative with the additional activating effects of the two methyl groups. Decomposition of the perbromide in absolute alcohol was tried, but this gave a mixture, the main constituent of which was certainly not a monobromoditolyl, and was probably a bromo-ethoxy-compound. Better results were obtained by thermal decomposition of the dry perbromide, 2-bromoditolyl being obtained in a fairly pure state by distillation of the product under reduced pressure, after treatment with alkali to remove the small amount of phenolic substance formed, a considerable amount of a high-boiling, dark-coloured, viscous substance remaining in the distilling-flask. On analysis however this specimen of 2-bromoditolyl gave a high value for bromine, indicating that it contained about 7% of a dibromo-compound. (ii) 2-Aminoditolyl was converted into its hydrobromide, diazotised and treated with a solution of cuprous bromide by the Sandmeyer method. The yield of 2-bromoditolyl by this method was only slightly less than by the perbromide method. Direct bromination of ditolyl was also attempted, but led to mixtures containing compounds with more than one bromine atom.

2-Fluoro and 2-chloroditolyls were colourless, crystalline solids with m.p.s 73-74° and 32-33° respectively, 2-bromo and 2-iododitolyls were oils which on cooling in a freezing mixture or in liquid sulphur dioxide merely became more viscous but did not crystallise. The bromo-compound boiled at 182-184° at 18 mm. and the iodo-compound at 200-205° at 15 mm. This gradation of physical properties is similar to that observed in the diphenyl series, 2-chlorodiphenyl has m.p. 34°, (Krammers, Ann., <u>198</u>, 142), 2-bromodiphenyl is a liquid at -20° and boils at 296-298° under atmospheric pressure (Beilstein, Handbuch) and 2-iododiphenyl (Cook, J., 1930, 1091) is a viscous oil, b.p. 140° at 3--4 mm. It has been suggested that this gradation of physical properties in the reverse of the usual order may be due to the effect of the larger halogen atoms on the configuration of the molecule, causing the two nuclei to take up positions in which they are not coplanar.



Such an effect would only be likely to show when the halogen is in the 2-position. The melting-points of the 2:2'-dihalogenoditolyls (symmetrical) are however in the normal order, rising from fluorine to iodine; this is also true of the 2:2'-dihalogenodiphenyls.

The formation of ditolyl during the diazo-reaction with 2-aminoditolyl also has its analogy in the 2-substituted diphenyl series, Cook, (loc. cit.) mentions the formation of diphenyl in the preparation of 2-iododiphenyl.

Mononitration of 2-fluoroditolyl was accomplished without difficulty by the use of excess of nitric acid, d. 1.42, in an equal volume of glacial acetic acid, as for mononitration of ditolyl, the mixture being however heated for 5 minutes on the water-bath, which was not necessary in the case of ditolyl. The fluoro-nitro-compound was a solid, m.p. 89-90°, which was apparently the only substance formed. Reduction with stannous chloride gave a solid amino-compound from which 2:2'-difluoroditolyl, identical with that from 2:2'-diamino ditolyl (obtained by the Ullmann reaction on *m*-nitro-*p*-bromotoluene and reduction of the product) was prepared via the diazonium borofluoride. 2-Nitration had therefore occurred.

In the nitration of 2-chloro, bromo and iodo ditolyls difficulty was experienced in finding conditions which avoided either (a) partial or complete absence of nitration, or (b) more than mono-nitration. The best results were obtained by using from 1.5-2 molecular proportions of fuming nitric acid (d. 1.5 ) in an equal volume of glacial acetic acid, and warming

for a short time on the water-bath. It is not certain that nitration was complete by this method, but the formation of poly-nitro-compounds was avoided. When the nitrations were carried out without acetic acid the action was too violent and phenolic substances were formed. The chloro, bromo and iodo-compounds all differed from the fluoro-compounds but strongly resembled each other in their behaviour. In no case could any individual nitro-compound be isolated from the viscous oils produced by nitration.
The 2-nitro-2'-chloro, bromo and iodo ditolyls have been prepared by Angeletti and Brambilla (Gazzetta, 1930, 967) from 2+nitro-2'-aminoditolyl and are described as solids, melting at 85-86°, 73-74° and 83-85° respectively (the 2-fluoro-2'-nitro-compound, m.p. 89-90°, fits into this series which shows, except for iodine, the inverted order of melting-points). These substances must have been present in the nitration-products, since reduction followed by diazotisation of the more soluble of the mixed base hydrochlorides and introduction of a second halogen atom gave in each case a symmetrical 2+2'-dihalogenoditolyl, identical with that prepared from 2:2:-dinitroditolyl, but they could not be isolated from the mixtures. In each case the total crude nitration-product was reduced in acetic acid solution with stannous chloride in hydrochloric acid, some dark-coloured, gummy residue remaining; this was probably dimethyl carbazole, but it may have contained some un-nitrated material. From the reduction-product in each case, after treatment with strong caustic soda solution and extraction with ether, two substances (at least) were obtained, in addition to the above-mentioned dark residue insoluble in hot hydrochloric acid.

The hydrochloric acid solution in each case had a brown or purple colour,

(a) on cooling a highly crystalline base hydrochloride separated, addition of concentrated hydrochloric acid causing further precipitation; it was sparingly soluble in dilute hydrochloric acid, and was hydrolysed by water. The free base was semi-solid and could not be made to crystallise. A crystalline acetyl derivative was obtained in each case by the action of acetic anhydride and was shown by analysis to be a monoacetamidomonohalogenoditolyl. All three hydrochlorides melted sharply (with decomposition) after one crystallisation.

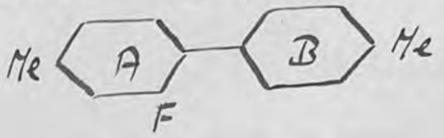
(b) Concentration of the filtrate from the above gave a brown, gummy base hydrochloride, from which only a little of the colour could be removed by filtration of its solution. After being left to stand for some time all three hydrochlorides were found to have a small quantity of yellowish-white , very small crystals in the supernatant liquid. These were shown to be hydrochlorides of the same base as the gummy substances. They all melted somewhat indefinitely between 100° and 120°, giving off bubbles apparently of water and possibly some hydrochloric acid. On cooling they set to hard, brown, glassy substances which softened about 100°. It is suggested that they were hydrated. As with the substances (a) the free bases were gummy and could not be crystallised. They were weighed as their acetyl-derivatives, ammonia being added to the whole of the filtrate from (a), the precipitated bases extracted with ether and treated with acetic anhydride. The acetyl-derivatives were crystalline solids but it was not possible to free them from the last traces of colouring matter. Recrystallisation from aqueous acetic acid in the presence of charcoal however removed most of the coloured impurity. Analysis showed them to be monoacetamidomonohalogenoditolyls. They depressed the melting-points of the isomeric acetamido-compounds (a).

The m.p.s of the hydrochlorides (a) were much higher and those of the acetyl-derivatives (a) slightly higher than those of the (b) isomers. The m.p.s rose in each case from Cl to I. Gradation of properties was also shown by the ease of hydrolysis of the acetyl-derivatives (b). The iodo-compound required at least 1 hour's boiling with concentrated hydrochloric acid, with the addition of a little alcohol, the bromo-compound required only $\frac{1}{2}$ hour, and the chloro-compound was hydrolysed in a few minutes by hot, concentrated hydrochloric acid, while the fluoro-compound did not appear to form an acetyl-derivative at all. This order of strengths of bases $F < I$ was to be expected. Attempts were made to establish the proportions of the isomers (a) and (b) in each case, but although fairly constant results were obtained by repeated experiments the figures given in the experimental part cannot be regarded as exact on account of (i) the small quantities of halogenoditolyls available for nitration owing to the difficulty of preparing them, (ii) the difficulty of finding ideal conditions for nitration and (iii) the presence of coloured impurities, difficult to remove from the basic products and possibly masking the presence of other impurities. The figures indicate that more of (b) than of (a) was produced in each case, (b/a being 2.7 for chlorine, 1.7 for bromine and 2.4 for iodine.) It must also be pointed out that the probability of loss in working-up was greater for (b) than for (a), since (a) was isolated as the sparingly soluble hydrochloride, whilst the isolation of the acetyl-derivative (b) involved several operations , with consequently greater risk of loss, so that the figure given for (b) is probably low.

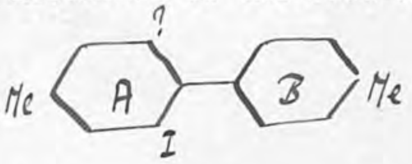
It is possible that small amounts of other substances may have been present. Replacement of the amino-group in (b) by a second atom of the halogen already present, by the diazo-reaction, gave in each case a small quantity of a symmetrical 2:2'-dihalogenoditolyl, shown by the method of mixed melting-points to be identical with that prepared from 2:2'-diaminoditolyl. In the preparation of these 2:2'-dihalogeno-compounds the same difficulties were encountered as are described by Masacrelli and co-workers (Gazzetta, 1929, 859; 1931, 320, 782) and by Angeletti (loc.cit.) in connection with the diazo-reaction on 2 and 2:2'-aminodiphenyl derivatives. The yields of the desired dihalogeno-compounds were very small, the main products being high-melting, coloured substances, probably containing a third (heterocyclic) nucleus. The dihalogeno-compounds were purified by distillation in steam; this was found found to be more satisfactory than extraction with solvents, although distillation was extremely slow, as it was the only way of getting products free from coloured substances. The steam-volatile product in each case seemed to consist of only one substance. It was therefore shown that the bases (b) were 2-halogeno-2'-aminoditolyls, nitration of the monohalogenoditolyls must therefore have occurred in position 2', to the extent of not less than 60%.

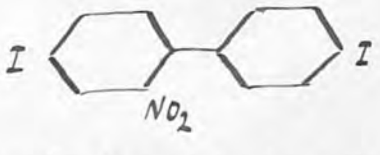
In the case of 2-fluoroditolyl nitration occurred mainly, if not entirely, in position 2', no indication of the presence of any other nitro-compound was found, the only impurity being apparently a small amount of yellow, phenolic substance. The chloro, bromo and iodo compounds showed, as would be expected, a much greater difference from the fluoro-compound than from each other, all being nitratied mainly in position 2' but with appreciable amounts of another mono-nitro-compound, corresponding to the base (a). The ratios b/a were in the order $\mathrm{Cl} > \mathrm{I} > \mathrm{Br}$ . The reversal of the order of bromine and iodine is paralelled in the melting-points given by Angeletti for the 2-halogeno-2'-nitroditolyls (see p. 49).

In view of the known deactivating effects of the halogens, particularly fluorine, it would be expected that 2-fluoroditolyl would be mononitrated mainly or entirely in the unsubstituted nucleus B. It has already been shown, by the exclusive 2-nitration of ditolyl, that the directive influence of the p-tolyl radical can entirely outweigh that of the methyl group. Apparently the p-tolyl radical can still exert this influence even when it contains a fluorine atom in position 2'. This persistence of o-directive power by an aromatic nucleus with fluorine as a substituent has already been shown by the exclusive 2-nitration of 4:4'-difluorodiphenyl. The experimental fact is thus in accordance with theoretical considerations.



For the same reasons it would be expected that chloro, bromo ~~and iodo~~ ditolyls should be mononitrated mainly in the unsubstituted nucleus B, in the 2'-position, but to a less extent than fluoroditolyl, the electron affinity of these halogens being smaller, and that chloroditolyl should give the greatest and iododitolyl the least amount of 2'-nitration, some homonuclear nitration occurring, especially in the case of iodine which being slightly activating should cause mainly homonuclear substitution. Experimentally the chloro and bromo compounds behaved as expected, giving a second nitration-product (a) the amount of which was greater with bromine than with chlorine. 2-Iododitolyl however, far from undergoing mainly homonuclear nitration, actually gave more 2'-nitro-compound than bromoditolyl, nearly as much as chloroditolyl. Apparently the deciding factor in all these cases is the tendency for nitration to occur in the ortho-position to an aromatic nucleus, i.e. in position 2', but even this does not account for the preponderance of heteronuclear nitration of the iodo-compound, since the 6-position in nucleus A is

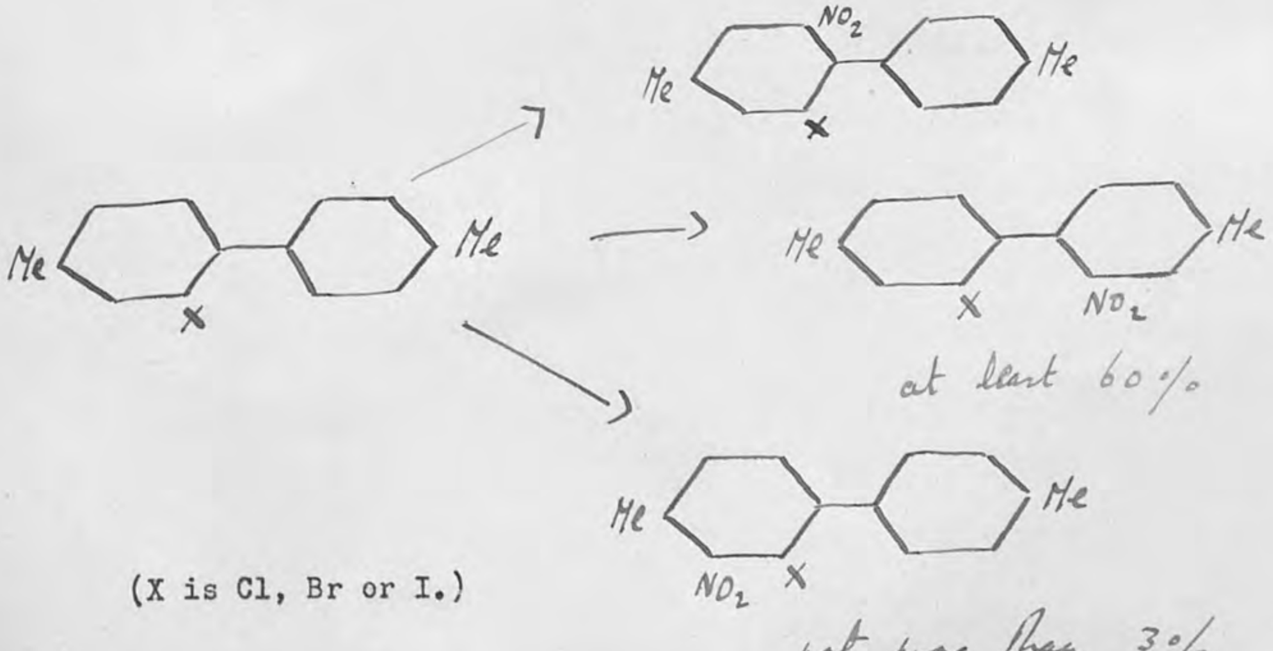




free, and the nitration of 4:4'-dihalogenodiphenyls has already shown that the phenyl group is well able to cause substitution in the meta-position to a halogen atom. It may be that the iodine atom, on account of its size, is near enough to the 2'-position in the other nucleus to have a considerable effect upon it, possibly a greater effect than upon the 6-position in its own nucleus, the shortest route to which must be blocked to some extent by the electrons of the 1' carbon atom. Regarding this effect as a tendency to donate electrons, (activation) due to a Bennett "reversed field" acting directly through space, it appears that it must certainly be smaller for iodine than for the other halogens, but it is suggested that owing to the greater size, and consequent nearer approach of the iodine atom, it may be more effective. Such an explanation might account not only for the preponderance of hetero over homonuclear nitration of the iodo-compound, but also for the inverted order of the bromo and iodo-compounds indicated by the experimental data for the proportion of (b) to (a)viz:F > Cl > Br < I. Assuming for the moment that the bases (a) were derived from nitrocompounds having the nitro-group in the already substituted nucleus A, they might have been 3, 5 or 6-substituted derivatives. If a 2-halogeno-3-nitrocompound were present it should have certainly reacted with piperidine, although the labile halogen might have been stabilised to some extent by the methyl-group. The 5-nitro-compound (para to halogen) should have been less and the 6-nitro still less likely to react with piperidine . All three crude nitration products were treated with excess of piperidine, but only a small proportion (about 1.5% ) of labile halogen was indicated in each case . No piperidino-compounds were isolated and the mixture of unchanged nitro-compounds when recovered and reduced as usual showed the same proportion of (a) to (b) as that which had not been treated with piperidine. The experimental error was however certainly large enough to mask a difference so small as 1.5% . It is therefore possible that (i) the compound (a) was 5-nitro, and reacted to a small extent only with piperidine under the conditions used, or (ii) the compound (a) was 6-nitro and did not react at all with piperidine, but a small amount of a third substance (probably 3-nitro) was present and reacted with piperidine. If such a third substance had been present to the extent of only 1.5% it would certainly have been undetected in the recrystallisation of acetyl-derivatives, but might have accounted for the impossibility of obtaining either of the free bases in a solid state. The proportion of nitro-compound containing labile halogen may actually have been higher than than 1.5%, as it is not certain that the products analysed thus were completely nitrated, it could not however have been more than 3%. Of the two suggestions (ii) seems the more probable, as the o-directing effect of the *p*-tolyl group B would favour 6 rather than 5-nitration in A.

A third possibility is that (a) was the 3'-nitroderivative, but if this were so it seems difficult to account for its non-formation in the case of fluoroditolyl. The only explanation would be an overwhelmingly large activation of the adjacent 2'-position by the "reversed field" of the fluorine atom. Since no 3-mononitration of ditolyl occurs, if 3'-nitration of 2-halogenoditolyls could occur, on account of reduction of the directive powers of nucleus A by the halogen atom, it should surely be more likely to occur in the case of the most deactivzting substituent, fluorine, and most unlikely to occur in the case of iodine. Attempts were made to prepare 2:3'-dihalogenoditolyls and to compare them with the substances obtained by introduction of a second halogen atom in place of the nitro-group in (a). Reduction of 2:3'-dinitroditolyl gave however a somewhat indefinite product, from which was obtained by the Sandmeyer reaction a small amount of colourless uncrystallisable oil, not enough for a boiling-point determination. The dihalogeno(?) compounds obtained from the bases (a) were also colourless, uncrystallisable oils, too small quantities being obtained for comparison with the 2:3'-compounds. Certainly there was nothing to indicate that they were not identical, but in view of the theoretical considerations already mentioned, it seem unlikely that they were identical.

The following is therefore suggested as the most probable scheme for the mononitration of 2-halogenoditolyls.

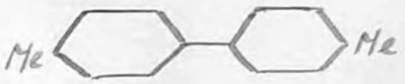


at least 60%

(X is Cl, Br or I.)

not more than 30%

## Preparation of 4:4'-dimethyldiphenyl (ditolyl).

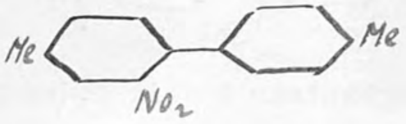


p-Iodotoluene was placed in a Pyrex boiling-tube in a metal-bath which was heated to about 220 . An equal weight of copper bronze was added in small quantities to the boiling iodotoluene. At first there was no sign of reaction except that the copper which floated on the surface of the liquid assumed a whitish appearance; on some occasions, when copper bronze of an inferior quality was used, this appearance was not observed and it was then found that practically no ditolyl had been formed. After all the copper had been added the temperature of the bath was raised, care being taken not to let the iodotoluene boil away. The contents of the tube gradually became thick and pasty and the iodotoluene could no longer be seen refluxing in the tube. No appreciable rise in boiling-point was observed. The temperature of the bath was finally raised to 280 and kept at this point for 1--1½ hours; only occasional stirring was necessary as there did not appear to be any tendency to a violent reaction or to the formation of hard lumps. At the end of this time cuprous iodide could be seen adhering to the sides of the tube when the mixture was stirred. The tube was then removed from the bath, allowed to cool somewhat and the product extracted from the copper with chlorobenzene. The solution was filtered on a Buchner funnel and the residue of copper and cuprous iodide washed several times with hot chlorobenzene and well pressed. The chlorobenzene was distilled from the reddish-brown solution, some unchanged iodotoluene also being removed by distillation. It was found impracticable to separate the ditolyl from iodotoluene by fractional distillation as the temperature rose continuously from the boiling-point of the one substance to the other, any distillate which came over above 220° being found to contain a considerable amount of ditolyl. All the distillate above this temperature was therefore collected in one receiver, a short, wide air-condenser being used. Most of the ditolyl came over mixed with iodotoluene before its true boiling-point was reached (290°). Above this temperature the black, tarry residue in the flask began to decompose, giving off yellow fumes. The ditolyl in the distillate was easily freed from iodotoluene by treatment with alcohol in which it is very sparingly soluble in the cold, iodotoluene being readily soluble. The ditolyl was filtered, washed with a little cold alcohol and dried on the water-bath. It was a pure white, highly crystalline solid, m.p. 121°.

The average yield, calculated on the amount of iodotoluene taken, less that recovered, was 60% theoretical. Unchanged iodotoluene was recovered from the alcoholic solution and also by slow distillation of the mixture of it with chlorobenzene, obtained from the first distillation. The amount recovered was on an average 25 % of that taken.

The boiling-tube used was of 200 cc. capacity. It was not found desirable to use more than 80 g. of iodotoluene at a time as the mixture could not be kept hot enough at the later stage if its level was much above that of the metal in the bath. The prolonged heating was found to be necessary, when heating was continued for only ½ hour a considerably larger amount of iodotoluene remained unchanged.

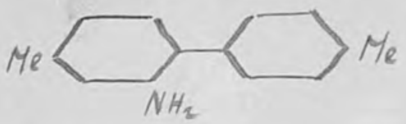
Preparation of 2-nitroditolyl.



40 G. of ditolyl were dissolved in 400 cc. of glacial acetic acid by warming on the water-bath, when all was in solution the temperature was allowed to fall to between 60 and 50° and 400 cc. of concentrated nitric acid (d. 1.43) were added rapidly with stirring, the temperature fell to about 40° and the ditolyl was at first precipitated in a finely divided state, but after being stirred for two or three minutes it all dissolved, leaving a clear, yellow solution. This was poured into excess of cold water, when a yellow oil was precipitated which solidified almost immediately to a crystalline mass.This was melted under water to remove traces of yellow, phenolic compounds; it melted at 67--70°, and after crystallisation from alcohol at 69--70°. The yield was 98 % theoretical.

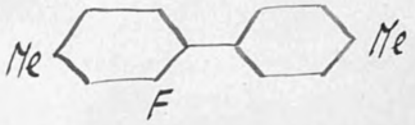
The above method is a modification of that previously described (Marler and Turner, J., 1932, 2391) in that only half the quantities of acetic and nitric acids are used. The yield obtained and the purity of the product are the same as with the first method. The analysis and proof of constitution are described in the above-mentioned paper.

### Preparation of 2-aminoditolyl.



The reduction of 2-nitroditolyl with a mixture of iron filings and water was found more convenient for the preparation of this base than the stannous chloride method already described (Marler and Turner, loc. cit). 80 G. of iron filings were made into a paste with water and heated in a large beaker on a boiling water-bath, a few drops of acetic acid were added and then 40 g. of 2-nitroditolyl. After about 10 minutes heating the mixture began to froth, but the reaction was not very vigorous; heating was continued for 1 hour, some boiling water being added when the mixture became too dry. The product was extracted with boiling acetone, after addition of a little ammonia the iron allowed to settle and the liquid decanted through a Buchner funnel. This was repeated several times. Alcohol was found unsuitable as a solvent, as the base tended to crystallise out during filtration. The acetone was distilled off and the base dissolved in hot,dilute hydrochloric acid. The hydrochloride solution was filtered to remove a small quantity of insoluble, black,tarry substance (mainly dimethyl carbazole) and the hydrochloride, which was sparingly soluble, crystallised on cooling in large plates. It was still slightly coloured, but by recrystallisation from dilute hydrochloric acid in the presence of charcoal it was obtained colourless. Yield, 80 % theoretical. A small quantity of base, contaminated with coloured substances was precipitated from the mother-liquors by ammonia. This was purified by re-conversion into the hydrochloride.

## Preparation of 2-fluoroditolyl.



20 G. of 2-aminoditolyl hydrochloride were suspended in a mixture of 14 cc. of concentrated hydrochloric acid and 30 cc. of water, cooled in a freezing-mixture and diazotised with 6.5 g. of sodium nitrite. Hydrofluoroboric acid was added until precipitation was complete, the precipitate was filtered, washed with ether, pressed and dried in vacuo. The yield of diazonium borofluoride was 21 g.

The dry diazonium borofluoride was introduced, in small quantities at a time, into a large flask, heated on the boiling water-bath. When the evolution of nitrogen and boron trifluoride had ceased the residue, which was a dark-coloured oil, was made alkaline with caustic soda and diatilled in steam, 2-fluoroditolyl coming over somewhat slowly. 11 G. were obtained, m.p. ex methyl alcohol, 73-74°. It crystallised in long, colourless needles.

## Analysis of 2-fluoroditolyl.

Microanalysis by Dr. Weiler gave: C, 83.32%; H, 6.42 %.

$C_{14}H_{13}F$ requires: C, 23.90%; H, 6.51 %.

## Nitration of 2-fluoroditolyl.

6 G. of 2-fluoroditolyl were dissolved in 30 cc. of glacial acetic acid and 30 cc of nitric acid (d. 1.43) were added, in the cold the fluoroditolyl was precipitated, but after being warmed for 2 minutes on the boiling water-bath it all redissolved. The clear, yellow solution was poured into excess of cold water, giving a yellow oil which solidified on standing. 7.2 G. were obtained of a pale-yellow, crystalline solid, m.p. 82-86° (s.at 78°) crystallisation from alcohol gave 6.3 g., m.p. 89-90°.
The theoretical yield of mononitro-2-fluoroditolyl is 7.6 g.

## Analysis of mononitro-2-fluoroditolyl. (Dumas estimation of nitrogen.)

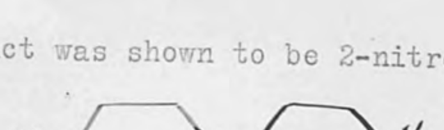
Weight of nitro-compound taked, 0.2381 g.

Volume of nitrogen observed, 12.2 cc. at 20° and 769 mm.

%age weight of nitrogen 5.9.

$C_{14}H_{12}O_2N\,F$ requires 5.7% of nitrogen.

The nitration-product was shown to be 2-nitro-2'-fluoroditolyl.



It crystallised in small, pale-yellow prisms.

## Reduction of mononitro-2-fluoroditolyl.

The mononitro-compound was dissolved in 10 times its weight of boiling glacial acetic acid and a solution of stannous chloride (4molecules) in an equivalent amount of concentrated hydrochloric acid was gradually added. Heating was continued for ½ hour and the resulting clear solution was cooled and poured into excess of strong caustic soda solution. The precipitated base was extracted with ether, the ether removed and the product treated with hot,dilute hydrochloric acid, in which it was entirely soluble. The hydrochloride crystallised in leaflets, The free base was obtained by the addition of ammonia. It crystallised from aqueous alcohol in rectangular needles having a slightly pink colour. M.p. 105-106°.

Yield of monoaminomonofluoroditolyl, 96% theoretical.

## Analysis of monoamino-2-fluoroditolyl.(Dumas estimation of nitrogen.)

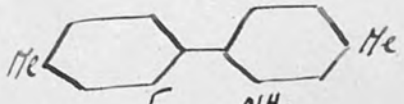
Weight of amino-compound taken, 0.3415 g.

Volume of nitrogen observed, 18.6 cc. at 19° and 776 mm.

% age weight of nitrogen, 6.5.

$C_{14}H_{14}NF$ requires 6.5% of nitrogen.

This was 2-amino-2'-fluoroditolyl.



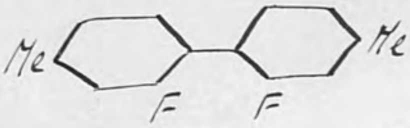
Treatment with acetic anhydride did not give an acetyl-derivative, if formed it must have been very easily hydrolysed.

Preparation of difluoroditolyl.

6 G. of monoamino-2-fluoroditolyl were dissolved in 20 cc. of hydrofluoroboric acid and 2.3 g. of sodium nitrite were added with constant stirring, the solution being cooled in a freezing-mixture. The diazonium borofluoride crystallised and was filtered, washed with ether and dried in vacuo. The yield was 8 g. It was dropped in small amounts at a time into a large flask heated on the boiling water-bath, when it decomposed with evolution of nitrogen and boron trifluoride. The product, which was dark coloured, was made alkaline with caustic soda and distilled in steam. Difluoroditolyl distilled rather slowly as a faintly yellow oil which readily solidified. It crystallised from alcohol in shining, colourless, very long needles.

Yield, 4 g. M.p. 97-98°.

2:2'-Difluoroditolyl was prepared in exactly the same way from 2:2'-diaminoditolyl and was found by the method of mixed melting-points to be identical with the above difluoroditolyl.

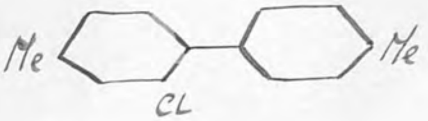


Analysis of 2:2'-difluoroditolyl.

Microanalysis by Dr. Weiler gave: C, 76.92%; H, 5.80%.

$C_{14}H_{12}F_2$ requires: C, 76.98%; H, 5.51%.

## Preparation of 2-chloroditolyl.



46 G. of 2-aminoditolyl hydrochloride were suspended in 30 cc. of concentrated hydrochloric acid and 300 cc. of water (the hydrochloride was very sparingly soluble) and cooled in a freezing-mixture. A strong solution of sodium nitrite (14 g.) was slowly added. A dark orange-coloured solution resulted, from which there separated a considerable amount of dark. tarry matter having the characteristic odour of 2-hydroxydiphenyl ( described elsewhere). The diazo-solution was poured into a cold solution of cuprous chloride in hydrochloric acid and a dark-brown, gummy mass was produced, which slowly swelled up as nitrogen was evolved. It was left for 1 hour, being frequently stirred, and then warmed for a short time on the water-bath. When decomposition was complete the mixture was made alkaline with caustic soda and distilled in steam. The first product was ditolyl (about 3 g.) and the second a very pale yellow oil which distilled rather slowly and readily solidified on cooling. 24 G. were obtained of the crude substance, m.p. 30-32°. Crystallisation from methyl alcohol gave 20 g., m.p. 32-33°.
This was about 50% of the theoretical yield.

Analysis of 2-chloroditolyl.(Carius estimation of halogen.)
Weight of chloroditolyl taken, 0.2456 g.
" " silver chloride obtained, 0.1592 g.
%age weight of chlorine, 16.0.
$C_{14}H_{13}Cl$ requires 16.4% of chlorine.

It crystallised in very long, colourless needles.

## Nitration of 2-chloroditolyl.

Attempted nitration under the same conditions as those used for the mononitration of ditolyl, i.e. addition of excess of nitric acid, d. 1.43 to a solution of the substance in acetic acid at a temperature below 60°, gave a negative result, the chloro-compound being thrown out of solution in acetic acid by the addition of nitric acid and failing to redissolve. When the mixture was heated for 10 minutes on the boiling water-bath all the oil dissolved, but the product was found to be a mixture of substances with m.p.s ranging from 45-75°; these were partially separated by treatment with methyl alcohol and cooling in a freezing-mixture, but no pure substance was isolated. The mixture was analysed (Dumas estimation of nitrogen) and the result indicated that dinitration and possibly some trinitration had occurred.

Several attempts were made to mononitrate chloroditolyl by using one molecular proportion of nitric acid in acetic acid but partially-nitrated products were obtained, both with acid of d. 1.4 and with fuming nitric acid; this was shown by reduction of the product with stannous chloride, unchanged chloroditolyl being recovered from the acid-insoluble residue. About half the quantity used was recovered in this way. On the other hand, if more than 2 molecules of nitric acid were used more than mononitration occurred. The most satisfactory results were obtained as follows:

5 G. of chloroditolyl were heated tp the m.p., 33°, and a mixture of 2 cc., (1.8 molecularproportions) of fuming nitric acid in 2 cc. of acetic acid was slowly added with shaking, the mixture became hot and darkened,with evolution of oxides of nitrogen, but the oil did not all dissolve. The mixture was heated for 5 minutes on the water-bath, when all the oil dissolved but reappeared on cooling. The mixture was poured into water, when a reddish

yellow oil separated; this did not solidify in a freezing-mixture, nor was it found possible, by treatment with organic solvents, to extract any solid nitrocompound. The oil was extracted with ether, the solution washed with water and dried over sodium sulphate and the ether distilled off. The residue, which seemed to contain some phenolic substance, was dissolved in about 10 times its weight of glacial acetic acid and heated with a solution of stannous chloride in hydrochloric acid, the quantities used being calculated on the assumption that complete mononitration had occurred. After the mixture had been heated to boiling for 10 minutes some dark-coloured oil remained undissolved, the mixture was heated for ½ hour on the boiling water-bath to ensure complete reduction, but the dark residue remained. The solution which was reddish-brown in colour was poured into excess of strong caustic soda solution, cooled and extracted with ether.The dark, oily substance which remained after removal of the ether was treated with hot, dilute hydrochloric acid, which dissolved most of it, giving a brown solution,and leaving a black, acid-insoluble, oily residue which was removed by filtration through a wet filter-paper. On cooling the filtrate deposited slightly sticky, brownish coloured crystals of a base hydrochloride (a), hydrolysed by water and only sparingly soluble in dilute hydrochloric acid. The mother-liquor was concentrated by boiling, but no more crystals of this hydrochloride were obtained. After the solution had been reduced to ½ its original volume it became turbid on cooling and a brown gum appeared, which became hard on standing, and small whitish crystals appeared in the supernatant liquid, which were quite distinct from the hydrochloride (a) both in appearance and in solubility. The whole of this residue redissolved in dilute hydrochloric acid on heating, except for a small amount of brown scum, it was therefore regarded as a second base hydrochloride (b). It was not found possible completely to free it from brown colouring matter by recrystallisation in the presence of charcoal, a little of the colour was however removed in this way. Both the crystalline and the gummy portions of the hydrochloride (b) were treated with ammonia which gave in each case a brownish, gummy base which could not be made to crystallise. The base was extracted with ether, the ether removed, the residue dissolved in acetic acid with a little water, and acetic anhydride added; on pouring into water a pinkish-coloured, solid acetyl-derivative was precipitated, which was purified by crystallisation from aqueous acetic acid in the presence of decolourising charcoal, giving an almost colourless product. The two portions of the residue (b) gave the same acetyl derivative, shown by the method of mixed melting-points. The hydrochloride (a) also gave, on addition of ammonia, a brown, gummy base which could not be obtained in a solid state. This was also converted into the acetyl derivative, which depressed the melting point of the acetyl derivative (b). Both the acetyl derivatives (a) and (b) were analysed and found to correspond to monochloromonoacetamidoditolyls. Nitration of 2-chloroditolyl must therefore have produced a mixture of two(at least) mononitro-derivatives.

The base (b) was shown, by conversion into 2:2'-dichloroditolyl, to be 2-amino-2-chloroditolyl.

The mixture of crude nitro-compounds was heated in a sealed tube with piperidine at 100° for 3 hours. Only a small amount of labile halogen was thus indicated. Reduction of the mixture of unchanged nitro-compounds recovered from the piperidine treatment, and separation of the constituents as described above, gave the smae proportions of (a) and (b) as did the mixture of nitro-compounds which had not been subjected to treatment with piperidine, as far as could be determined. This was not however conclusive as the difficulty of freeing both (a) and (b) from coloured substances prevented accurate determination of the proportions in which they were present. The nitration, reduction and separation of derivatives of bases (a) and (b) were repeated several times in order to ascertain as nearly as possible the composition of the mixtures produced. The results were fairly constant. Numerical details of yields, analyses and melting points follow:

## Nitration of 2-chloroditolyl and reduction of product.

Quantities of from 3 to 7 g. of 2-chloroditolyl were nitrated as described on the previous pages. The total yields of nitration products varied between 93 and 96% of the theoretical for mononitration. Reduction of the total crude nitration product gave yields from 88-92% theoretical of crude product. Only from 35-40% of this was however soluble in hot, dilute hydrochloric acid, the remainder being a dark-brown oil; this probably contained some chloroditolyl which had escaped nitration, but none could be recovered from it, and some carbazole was probably present. The acid-soluble portion was separated as described into two parts, (a) and (b), the quantities of which are given below. The combined amounts of (a) and (b) represent 35-40% of the total reduction-product.

## Piperidine analysis of total crude nitration-product from 2-chloroditolyl.

7.1160 G. of nitration-product, a red oil which seemed to contain some phenolic substance, were placed in a tube with excess of piperidine, owing to the colour of the original substance it was difficult to decide whether there was any change of colour on mixing, but a slight darkenung seemed to occur. The tube was sealed and heated for 3 hours at 100°. A little 10% caustic potash was added to the contents of the tube, and then ether to dissolve organic substances. The ether layer was washed several times with water. Both solutions were very dark and it was difficult to separate them sharply. The combined aqueous extracts which still contained some organic matter, presumably phenolic, were heated on the water-bath to remove ether, acidified with nitric acid, which caused a small amount of sticky precipitate to be formed, and treated with silver nitrate solution. The mixture was boiled until the silver chloride coagulated, filtered through a Gooch crucible and washed with hot chloroform to remove organic matter. The weight of AgCl was 0.0636 g., corresponding to elimination of halogen from 1.6% of the nitration-product taken. This figure may be somewhat high as the small amount of organic matter was difficult to remove from the crucible. Only 82% of the nitration-product was recovered from the ether solution, after washing with hydrochloric acid, but there was undoubtedly some loss in the extraction, owing to the difficulty of getting a sharp separation.

Constituents of acid-soluble part of total reduction-product.

| | (a) Hydrochloride. | (b) Acetyl-derivative. | Approx. Ratio, b/a, of free bases. |
|---|---|---|---|
| (I)<br>Crude. | 1.0 g., slightly sticky. | 2.92 g., m.p. 108-111°, much coloured. | 2.8/1. |
| Recryst. | 0.75 g. Brown scum remained insol. in dil HCl. | 2.2 g., m.p. 114-115°, remainder was dark-coloured, melted about 100°, but m.p. raised by pure acetamido (b), depressed by acetamido (a). | 2.6/1. |
| (II) | 0.62 g. | 1.82 g., m.p. 108-111°. | 2.9/1. |
| (III) Recovered from piperidine treatment, and reduced as usual. | | | |
| Crude. | 0.54 g. | 1.36 g. m.p. 107-112°. | 2.6/1. |
| Recryst. | 0.40 g. | 1.08 g., m.p. 114-116°. | 2.6/1. |

These figures appear to justify the conclusion that not less than 2.5 times as much of (b) as of (a) was present. This is probably a low estimate of the amount of (b), as there was undoubtedly some loss in recrystallisation, the acetamido compound was very soluble in all the common organic solvents, and when crystallisation was effected from aqueous alcohol or acetic acid it tended to come out of solution at first as an oil, bringing with it most of the purple colouring-matter, further cooling giving almost colourless crystals m.p. 114-115°. Decolourising charcoal removed some, but by no means all of the colour.

2-Chloro-x-acetamidoditolyl (a) crystallised in small, colourless needles, m.p. 123-124 (ex aqueous alcohol or acetic acid.)

2-Chloro-2'-acetamidoditolyl (b) crystallised in small, almost colourless needles, m.p. 115-116 (ex aqueous alcohol or acetic acid ).

Mixed m.p. 90-105 .

<u>Analysis of 2-chloroacetamidoditolyls.</u> (Dumas estimation of nitrogen.)

2-Chloro-x-acetamidoditolyl (a) 0.2292 g. gave 10.4 cc.nitrogen at 19° and 754 mm.
%age weight of nitrogen 5.2.

2-Chloro-2'-acetamidoditolyl (b) 0.3294 g. gave 15.0 cc. nitrogen at 19° and 754 mm.
%age weight of nitrogen 5.2.

$C_{16}H_{16}NOCl$ requires 5.12% of nitrogen.

Analysis of the mixture of acetamido-compounds obtained by acetylation of the total acid-soluble portion of the reduction product gave 4.9 % of N.

The hydrochloride (a) formed long, yellow needles, m.p. 233-234° (decomp.)

The hydrochloride (b) was mainly a gum, the small amount of solid formed small plates, melting indefinitely about 110° with loss of water .

Note.

The monochloromonoaminoditolyl, obtained by addition of ammonia to the the less soluble hydrochloride (a), which had previously remained gummy (like the other mono-amino compounds of this series) suddenly solidified. Inoculation of other specimens of this base caused them also to solidify immediately. Crystallisation from alcohol gave small rhombohedra, slightly coloured. M.p. 75- 77°.

Analysis of chloroaminoditolyl (a). (Dumas estimation of nitrogen.)

0.1810 G. gave 10.4 cc. of nitrogen at 20° and 754 mm.

%age weight of nitrogen 6.5.

$C_{14}H_{14}NCl$ requires 6.1% of nitrogen.

## Preparation of dichloroditolyl.

The base obtained by hydrolysis with hot, concentrated hydrochloric acid of the purified chloroacetamido-compound (b) was converted in the usual manner into the diazonium chloride, the resulting solution was poured into a solution of freshly-prepared cuprous chloride in hydrochloric acid. A dark-brown gummy mass separated and nitrogen was slowly evolved. The mixture was made alkaline with caustic soda and distilled in steam. A pale yellow oil came over very slowly; it solidified on standing and melted at 86-87°. After crystallisation from alcohol in which it was readily soluble it had m.p. 90°. About0.5 g. were obtained from 3 g. of acetamido-compound.

This substance was found, by the method of mixed melting-points, to be identical with 2:2'-dichloroditolyl which was prepared in the same way from 2:2'-diaminoditolyl.

## Analysis of 2:2'-dichloroditolyl. (Carius estimation of halogen.)

| | |
|---|---|
| Weight of chloro-compound taken, | 0.1044 g. |
| Weight of silver chloride, | 0.1192 g. |

%age weight of chlorine, 28.3.

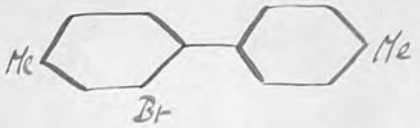
$C_{14}H_{12}Cl_2$ requires 28.3% of chlorine

## Attempted replacement of the amino-group im monoamino-2-chloroditolyl(a) by chlorine.

---

3 G. of the hydrochloride (a), obtained as described, were diazotised in hydrochloric acid in the usual way and the diazo-solution poured into a solution of cuprous chloride in hydrochloric acid. The product was made alkaline and distilled in steam, when a small amount was obtained of an almost colourless oil which could not be made to solidify. The quantity was too small to allow of a determination of boiling-point, or of analysis. The substance was only very slowly volatile in steam, and to avoid this disadvantage a second attempt was made in which the product of decomposition of the diazonium chloride was extracted with ether. This however gave a product very much contaminated with dark-coloured substances, and since only a small amount of the hydrochloride (a) was available it was not possible to obtain enough of the dichloro(?)compound to vacuum distil.

## Preparation of 2-bromoditolyl.



Attempts were made to prepare this compound by various methods:

(i) Direct bromination of ditolyl.

Ditolyl was dissolved in twenty times its weight of glacial acetic acid by warming, 1 molecular proportion of anhydrous sodium acetate was added and a solution of 2 molecular proportions of bromine in four times its volume of glacial acetic acid was slowly added with shaking. No visible change occurred; the solution was boiled for ½ hour, when the colour of the bromine disappeared and sodium bromide separated. On pouring the solution into excess of water a white precipitate was obtained. It appeared unlikely that the desired monobromo-compound was present, as it was expected from consideration of the melting-points of the previously prepared 2-halogenoditolyls (F, 74-75°; Cl, 33°; I, an uncrystallisable oil) that the 2-bromocompound would be a liquid at ordinary temperatures. (This was also indicated by analogy with the 2-monosubstituted diphenyl derivatives.)
The bromination-product was found to be a mixture, and fractions with the following m.p.s were obtained by crystallisation from alcohol:
(a) 101-123°; (b) 99-113°; (c) 90-103°; (d) 86-91°. This was taken to indicate that the product was a mixture of unchanged ditolyl with one or more (probably) dibromo-derivatives. No pure substance was isolated from the mixture. All the fractions were colourless. It thus appears that bromination of ditolyl does not follow the same course as nitration.

An attempt was made to brominate ditolyl in cold glacial acetic acid solution in presence of sodium acetate, but after the mixture had stood for two days the colour of bromine remained and no sodium bromide was deposited.

(ii) Decomposition of ditolyl-2-diazonium perbromide in alcohol.

2-Aminoditolyl was diazotised in hydrochloric acid in the usual way and a solution of bromine in five times its volume of hydrobromic acid was added with stirring to the cold solution of the diazonium chloride, until precipitation was complete. The diazonium perbromide separated as a sticky, orange-red mass, but after about five minutes it became hard. The lump was broken up as much as possible and filtered, it was then washed repeatedly wirh cold water and finally with ether, which dissolved out a considerable amount of dark-red colouring matter. The substance was well pressed and washed with ether until no more colour was removed; it was now an orange-yellow powder. The yield of perbromide, dried in vacuo, was 27 g. from 18 g. of base hydrochloride.

The dry perbromide was dropped into alcohol at about 60°, when it decomposed with vigorous evolution of nitrogen. The alcohol was removed by distillation, leaving a red, oily residue. It was treated with aqueous alkali to remove phenol, of which only a small quantity was found. Decomposition of 17 g. of perbromide gave 10 g. of residue which yielded about 7 g. of a solid product, the remainder being a dark-red oil; this last was probably the desired monobromoditolyl but it could not be freed from colouring-matter. The solid portion which had m.p. 67-68° on crystallisation from alcohol, was thought to be either a bromoethoxy-derivative or a dibromo-derivative, analysis indicated that it was the former. It depressed the m.p. of synthetic 2:2'-dibromoditolyl.

<u>Analysis of substance, m.p. 67-68°</u>.(Carius estimation of halogen.)

Weight of substance, 0.1532 g. Weight of silver bromide, 0.0968 g.
%age weight of bromine, 26.9.
Monobromomonoethoxyditolyl, $C_{16}H_{17}OBr$ requires 26.2% of bromine.
Monobromoditolyl, $C_{14}H_{13}Br$ requires 30.7% of bromine

## Decomposition of ditolyl-2-diazonium perbromide in acetic acid.

The dried perbromide was dropped in small quantities into glacial acetic acid at about 50°, immediate decomposition occuring. The dark-red solution was poured into a water giving a mixture which contained some solid substances and also some phenol. The product was not further investigated as it was thought that the desired 2-bromo-ditolyl,would be a liquid at ordinary temperatures (see p. 47). This supposition was later found to be correct. Dibromination had probably occurred.

(iii) Thermal decomposition of dry diazonium perbromide.

38 G. of dry ditolyl-2-diazonium perbromide, prepared as already described, were dropped in small quantities at a time into a large flask heated on the water-bath; decomposition took place rapidly but quietly with evolution of nitrogen and bromine, and also of hydrobromic acid. This last might have been due to the fact that, as the perbromide was precipitated in lumps, it was difficult to wash it quite free from hydrobromic acid, or it might have been caused by the liberated bromine attacking the organic molecule, (the analytical result which is given on th next page indicates that further bromination did occur to some extent.)

When effervescence had ceased the dark-coloured oil was dissolved in carbon tetrachloride and the solution shaken several times with aqueous alkali to remove a small quantity of phenol, the solution was washed with water, dried over calcium chloride and distilled. When most of the solvent had been removed the residue was distilled under reduced pressure. At a pressure of 20 mm. Hg. about 18 g. of a yellow oil came over at temperatures between 175° and 250°, no steady boiling-point being observed. A black, tarry residue remained in the distilling flask. The viscous oil thus obtained would not crystallise in a freezing mixture of ice and hydrochloric acid. It was redistilled under a pressure of 18 mm., the following fractions being collected:

(I) B.p., 170-180°, 3.5 g.; (II) 180-190°, 9 g.; (III) 185-210°, 3.5 g.

Fractions (I) and (II) were almost colourless, (III) was yellow and more viscous than the other two. A brownish-yellow residue remained in the distilling-flask; part of this was soluble in hot alcohol, the remainder being a dark, glassy substance. The yellow, alcohol-soluble portion of the residue could not be made to solidify, although it became viscous in a freezing-mixture.

Redistillation of fractions (I) and (II) gave 9 gm. of a nearly colourless oil, b.p. 183-187° at 12 mm. This could not be made to crystallise, although it became more viscous when cooled in a freezing—mixture. It was analysed and the bromine content was found to correspond to a monobromoditolyl, containing about 7% of a dibromoditolyl.

Analysis of bromocompound described above. (Carius estimation of halogen.)

Weight of bromoditolyl taken, 0.6098 g.
" " silver bromide obtained, 0.4709 g.
% age weight of bromine , 32.8.
$C_{14}H_{13}Br$ requires 30.7% of bromine.
$C_{14}H_{12}Br_2$ requires 47.1% of bromine.

(iv) Sandmeyer method.

28 g. of 2-aminoditolyl were dissolved by heating in a mixture of 50 cc. of hydrobromic acid (constant-boiling) and 200 cc. of water, on cooling and stirring the hydrobromide crystallised. The substance was diazotised in the usual manner and poured into a solution of freshly prepared cuprous bromide in hydrobromic acid. A dark-brown gummy mass was precipitated, which slowly swelled up as nitrogen was evolved. Decomposition was slow and after the mixture had been stirred for 20 minutes it was heated on the water-bath to about 45° . Nitrogen was evolved and a dark-brown oil settled. Finally the mixture was heated on the boiling water-bath. The oil was extracted with carbon tetrachloride and the solution shaken with aqueous alkali to remove hydroxy compound. Although there was only about 2 g. of this present it was

extremely difficult to remove, fifteen washings with alkali being necessary. The hydroxy-compound was recovered from the alkaline solution, it is described on another page. The dark-red oil remaining after removal of the solvent was distilled under reduced pressure, giving 11 g. of a yellow oil, b.p. 184-189° at 18 mm.; 5 g. of a dark-red, gummy, non-volatile residue remained. A second distillation gave 9 g., b.p. 182-184° at 18 mm. The colour was still faintly yellow.

The yield from the Sandmeyer method was about the same as that from the perbromide method, 25-27% theoretical.

Analysis of 2-bromoditolyl. (Carius estimation of halogen)

**Weight of bromo-compound taken, 0.3273 g.**

**Weight of silver bromide, 0.2221 g.**

**% age weight of bromine, 28.9.**

**$C_{14}H_{13}Br$ requires 30.7% of bromine.**

**The low result is probably due to the presence of some ditolyl, which was formed in the diazo-reaction, and may not have been completely removed by distillation.**

## Nitration of 2-bromoditolyl.

The methods employed and the results obtained were similar to those in the cases of 2-chloro and 2-iododitolyls.

Fuming nitric acid (1.5 molecular proportions) in an equal volume of glacial acetic acid was added cautiously with shaking to the cold bromo-compound, the mixture became dark and there was some rise of temperature. The mixture was heated on the water-bath for 5 minutes, when all the oil dissolved, but reappeared on cooling; it was poured into water, the light-yellow oil extracted with ether, the ether removed, the residue dissolved in 10 times its weight of glacial acetic acid and treated with a solution of stannous chloride in hydrochloric acid, the quantities being calculated on the assumption that complete mononitration had occurred. After the solution had been heated for ½ hour there was still some dark oil undissolved, which was not affected by further heating. The mixture was made strongly alkaline and extracted with ether. After removal of the ether a residue remained which was mostly soluble in hot, dilute hydrochloric acid, some insoluble, dark oily matter being removed by filtration. Two base hydrochlorides were, as usual obtained, (a) crystalline and sparingly soluble, and (b) gummy, coloured and readily soluble. The solution of hydrochlorides had a purplish-pink colour. By recrystallisation from dilute hydrochloric acid the hydrochloride (b) was obtained in small, nearly colourless crystals, quite distinct in appearance from the hydrochloride (a) As in the case of the chloro-compound the two bases were separated by filtering off the hydrochloride (a), concentrating the solution by boiling, no more of (a) being obtained, precipitating the base (b) by addition of ammonia, extracting this with ether and treating the whole of the residue with acetic anhydride. It was found particularly difficult to free this acetyl-derivative (b) from the purple colouring-matter, more so than in the case of the chloro and iodo compounds, as decolourising charcoal seemed to have very little effect upon it.

The mixture of crude nitro-compounds was heated for 3 hours at 100 in a sealed tube with piperidine in order to determine the proportion of labile halogen. This was shown (by a gravimetric estimation of silver bromide) to be small. The mixture of unchanged nitro-compounds, recovered from the piperidine treatment, was reduced with stannous chloride and the proportions of (a) and (b) in the resulting mixture of bases were found to be about the same as from the mixture of nitro-compounds which had not been treated with piperidine. The difficulty of removing coloured substances however prevented an accurate determination of the proportions of (a) and (b).

As in the case of the chloro and iodo-compounds the nitration, reduction and separation of bases were repeated several times, in order to determine as nearly as possible the the proportions of isomeric mononitro-compounds formed. The results obtained were fairly constant.

The acetyl derivatives of the bases (a) and (b) were analysed and found to correspond to monobromomonoacetamidoditolyls.

Details of yields, analyses, melting-points etc. follow on the next page.

## Nitration of 2-bromoditolyl and reduction of product.

Quantities of from 3 to 10 g. of 2-bromoditolyl were nitrated as described on the previous page; the total yields of nitration-products varied from 94-97% of the theoretical for mononitration. Reduction of the total crude nitration products gave yields from 94-97% theoretical of crude reduction-product. The acid-soluble portion of this was separated as described into two parts, (a) and (b) the quantities of which are given below. The combined amounts of (a) and (b) represent in each case from 58-62% of the total reduction-product, the remainder being the acdi-insoluble residue, which was a dark-brown, gummy substance. It may have been a carbazole and it is possible that it contained some bromoditolyl which had escaped nitration, but no recognisable substances could be isolated from it.

## Piperidine analysis of total crude nitration-product from 2-bromoditolyl.

4.5200 G. of nitration-product ( a yellow oil) were placed in a tube with excess of piperidine, a red colour being observed on mixing. The tube was sealed and heated for 3 hours at 100°. A little 10% caustic potash solution was added to the contents of the tube and then ether to dissolve organic substances. The ether layer was washed several times with water and the combined aqueous extracts were washed with ether, heated on the water-bath until the smell of ether had gone, acidified with nitric acid and treated with silver nitrate solution. The mixture was boiled until the silver bromide coagulated and filtered through a Gooch crucible. The precipitate was washed several times with hot chloroform to remove organic matter.

The weight of silver bromide was 0.0363 g., corresponding to elimination of halogen from 1.3% of the nitration-product taken. Only 87% of the nitration-product was recovered from the ether solution, but there was undoubtedly some loss in the extraction. The value thus obtained for the proportion of labile halogen is possibly too high, as the aqueous solution contained a small amount of organic matter, presumably of a phenolic nature, which was precipitated on the addition of nitric acid and which was difficult to remove completely from the Gooch crucible.

### Constituents of acid-soluble part of total reduction-product.

| | (a) Hydrochloride. | (b) Acetyl-derivative. | Approx Ratio, b/a. of free bases. |
|---|---|---|---|
| (I) | Crude. 1.06 g., slightly sticky. | 1.90 g., much coloured, m.p. 121-126°. | 1.8/1. |
| | Recryst. 0.90 g., some brown scum insol. in dil HCl. | 1st.Crop. slightly coloured, 1.60 g., m.p. 132-134°. Remainder much coloured, softened at 100°, but m.p. raised by pure acetamido (b) depressed by acetamido (a). | 1.8/1. |
| (II) | Crude. 0.42 g.<br>Recryst. 0.25 g. | 0.70 g.<br>0.45 g. | 1.7/1. |
| (III) | 0.60 g. | 1.10 g. | 1.8/1. |
| (IV) (Recovered from piperidine treatment and reduced as usual.) | 0.47 g., free from colouring matter. | Crude. 1.22 g., m.p. 120-126°, much coloured.<br>Recryst. 0.80 g., m.p. 132-134°<br>0.18 g., m.p. 124-126°, raised by pure (b)<br>Purple, sticky residue. | 1.6/1. |

These figures appear to justity the conclusion that the mixtures contained more of (b) than of (a), probably nearly twice as much, the possibility of loss in working-up being greater for (b) than for (a). The acetyl derivative (b) was particularly difficult to free from colouring matter. The specimen, m.p. 134-135, which was analysed had a faintly pink colour.

2-Bromo-x-acetamidoditolyl (a) crystallised in small, colourless needles, m.p. 146-147° (ex aqueous AcOH).

2-Bromo2'-acetamidoditolyl (b) crystallised in clusters of very small, slightly pink needles, m.p. 134-135° (ex aqueous AcOH).

Mixed m.p. 120-132.°

Analysis of 2-bromoacetamidoditolyls. (Dumas estimation of nitrogen.)

2-Bromo-x-acetamidoditolyl (a). 0.1559 g. gave 6.8 cc. nitrogen at 21 & 761mm

%age weight of nitrogen 4.4.

2-Bromo-2'-acetamidoditolyl (b) 0.2494 g. gave 10.4 cc.nitrogen at 16 & 768 mm.

% age weight of nitrogen 4.7.

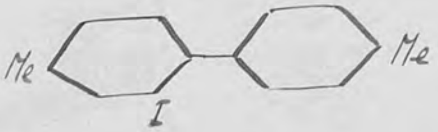
$C_{16}H_{16}NOBr$ requires 4.40% of nitrogen.

The hydrochloride (a) crystallised in yellow needles, m.p. 227-229° (decomp.) The hydrochloride (b) was mostly a brown gum, the small amount of solid formed very small hexagonal plates, melting indefinitely between 100° and 120° with loss of water, leaving a brown, glassy substance.

## Preparation of 2:2'-dibromoditolyl.

The gummy base obtained by hydrolysis with hydrochloric acid of the purified bromo-acetamido compound (b) was converted into the hydrobromide which was similar to the hydrochloride in appearance and solubility, being deposited as a brown gum from strong solution and becoming hard; small almost colourless crystals appearing in the supernatant liquid on standing. A yellow diazo-solution was obtained from this and was poured into a solution of cuprous bromide in hydrobromic acid, giving a light-brown, solid product. The mixture was made alkaline and steam-distilled, giving a small quantity of an almost colourless oil which came over very slowly; this solidified after standing for 24 hours but it obviously contained some oily substance and melted somewhat indefinitely about 50°. Crystallisation from alcohol im which (as in other solvents) it was very soluble raised the m.p. to 73-75°, but some oily substance appeared still to be present. On account of the small yield (0.4 g. from 2.6 g. of acetamido-compound) further purification could not be effected. The m.p. of this substance was raised by admixture with the substance, m.p. 114-115°, obtained (also in very small yield, the main product being a brown substance) from 2:2'-diaminoditolyl by the Sandmeyer reaction. It is therefore probable that the the compound obtained from bromoaminoditolyl (b) was 2:2'-dibromoditolyl; it is suggested that the oily impurity was 2-bromoditolyl, due to deamination during the diazotisation.

Carius estimation of halogen in both specimens was attempted, but the tubes burst during heating and there was not enough of either specimen for a second attempt at analysis.



### Preparation of 2-iododitolyl.

(i) 30 G. of 2-aminoditolyl sulphate were suspended inaa mixture of 10 cc. of concentrated sulphuric acid and 100 cc. of water, cooled in a freezing-mixture and treated with a solution of 9 g. of sodium nitrite in the least amount of water. The resulting diazo-solution was dark-coloured and some tarry matter separated, as always in diazotisations of this base. Urea was added to decompose excess of nitrous acid and the solution was poured into a solution of 35 g. of potassium iodide and 60 g. of crystallised sodium acetate in 50 cc. of water at a temperature of 30°. The tarry matter was left behind, adhering to the sides of the beaker. The solution was stirred for 1 hour, decomposition taking place slowly, and then warmed for a short time on the water-bath. When decomposition was complete the mixture was made alkaline with sodium hydroxide and distilled in steam. Between 1 and 2 g. of ditolyl came over first and then a nearly colourless oil which distilled exceedingly slowly. The oil was extracted with chloroform, the solution was dried over calcium chloride and the chloroform was distilled off. The residue was distilled under reduced pressure. 12 G. were obtained of an oil which had a brown colour owing to the presence of free iodine, boiling at 198-208° at 15 mm. Hg. A tarry residue remained in the flask (about 1 g.) and decomposed giving off iodine. The oil was freed from iodine by shaking it with a small quantity of mercury; it could not by any means be caused to crystallise, but in a freezing-mixture (ice and hydrochloric acid) it became more viscous. It was redistilled under 15 mm. pressure and boiled at 200-205°.

A considerable quantity of dark-red, semi-solid matter was left in the flask after the steam-distillation.

(ii) In order to avoid the inconvenience of the very slow distillation in steam and the consequent neceesity of separating a small amount of oil from a large volume of water the following method was tried:

The diazotisation and the decomposition in the presence of potassium iodide were carried out as before and the dark-red oil thus obtained was extracted with carbon tetrachloride. The solution was repeatedly shaken with aqueous alkali to remove a phenol which, although present in small quantity, was not readily removed. The solvent was removed by distillation and the residue which was almost black was left to stand. A bright red, crystalline solid slowly separated from it, a further quantity being obtained by cooling in a freezing-mixture. After three days no more of this substance appeared and the filtered oil, which was still dark-coloured, was distilled under a pressure of 15 mm. About 1 g. of ditolyl came over first and then 12.5 g. of a viscous oil, b.p. 200-210°, coloured with free iodine which was removed as in method (1) On redistillation 11 g. were obtained of a clear, viscous oil, b.p. 200-205°, having a pink colour which could not be removed by any of the usual methods for removing free iodine.

About 3 g. were obtained of the red solid described above, it contained nitrogen and was undoubtedly an azo-compound.

Analysis of 2-iododitolyl. (Carius estimation of halogen)

Weight of iododitolyl taken, 0.6254 g.

" " silver iodide formed, 0. 4717 g.

% age weight of iodine, 40.8.

$C_{14}H_{13}I$ requires 41.2% of iodine.

Nitration of 2-iododitolyl.

When 2-iododitolyl was subjected to the same conditions as were used for the mononitration of ditolyl (addition of an excess of nitric acid d. 1.42, to an equal volume of a cold acetic acid solution of the iodo-compound) it was not nitrated, being precipitated by the addition of the nitric acid and failing to redissolve on stirring. The mixture was then heated on the water-bath for about 20 minutes, when all the oil dissolved. The solution was poured into water, giving a semi-solid product. Attempts at recrystallisation from alcohol gave the following products , from 4 g. of iodocompound with 40 cc. each of nitric and acetic acids:

1 G. of a yellow solid, m.p. 126-134° (turbid till 144°)

3 g. of a yellow solid, m.p. 122-133°.

1.5 G. of a dark-red gum.

Analysis of the substance melting at 122-133° indicated that it was mostly a dinitro-compound containing some trinitro. (Nitrogen estimation)

Repeated attempts were made, using nitric acid of densities betwee 1.42 and 1.5, and it was found that when excess of nitric acid (more than 2 molecules) was used more than mononitration occurred. With 1 molecule of nitric acid, d.1.42 there appeared to be no change, while 1 molecule of acid, d. 1.5, caused a rise of temperature, but gave a product which was only partially nitrated; this was shown by treatment with stannous chloride only a small part of the substance thus obtained being soluble in hydrochloric acid.

The best results were obtained as follows:

To 2-iododitolyl was added cautiously with shkaing a mixture of fuming nitric acid (2 molecular proportions) with an equal volume of glacial acetic acid, the mixture became hot and darkened, giving off oxides of nitrogen, but the oil did not all dissolve. The mixture was warmed for 10 minutes on the water-bath, when it all dissolved, but reappeared on cooling. The mixture was poured into excess of cold water, giving a reddish, viscous oil. No solid appeared on standing. The oil was extracted with ether, the ether removed, the residue dissolved in 10 times its weight of glacial acetic acid, the solution boiled and a solution of stannous chloride in concentrated hydrochloric acid gradually added, the quantities being calculated on the assumption that complete mononitration had occurred. After heating for ½ hour there was still some dark-coloured oily matter undissolved, further heating seemed to have no effect on this. The solution was poured into excess of strong caustic soda solution and the oily product extracted with ether. The residue after removal of the ether was treated with hot, dilute hydrochloric acid which dissolved part of it, leaving a black, tarry residue, which was quite hard when cold. From the clear, light-brown filtrate there crystallised a base hydrochloride, sparingly soluble in dilute hydrochloric acid and insoluble in concentrated acid, hydrolysed by water. The crystals were contaminated with a brown, sticky substance, removed by recrystallisation from dilute acid and filtration of the solution. Concentration of the solution by boiling did not give any more of this hydrochloride (a) but some brown scum separated and was filtered off. When the solution had been reduced to ½ its original volume it became turbid on cooling, and a brown, gummy substance was deposited. This was almost entirely redissolved in dilute hydrochloric acid, only a small amount of brown scum remaining, it was therefore regarded as a second base hydrochloride (b). An attempt to recrystallise this gave mainly the same brown gum, but after standing for some time small, yellowish-white crystals appeared in the supernatant liquid, quite distinct in appearance and solubility from the hydrochloride (a). It was shown by treatment of the hydrochlorides with ammonia and acetylation of the liberated bases with acetic anhydride followed by comparison of the acetyl-derivatives by the method of mixed melting-points, that the gummy and the crystalline portions of the fraction (b) were the same base hydrochloride, but that (a) was different. There were therefore at least two bases present. They were separated in the same way as the chloro and bromo-compounds, the insoluble hydrochloride, (a) being removed by filtration, the filtrate treated with ammonia and the precipitated base (an oil) extracted with ether and treated, after removal of the ether, with acetic anhydride, giving a solid acetyl-derivative of a purplish colour, most of which was removed by recrystallisation from aqueous acetic acid in the presence of decolourising charcoal.

Neither of the bases (a) and (b) could be obtained in the solid state, even when obtained from the apparently thoroughly purified derivatives. Both were pale fawn-coloured, sticky substances and could not be made to solidify.

The mixture of nitration products was subjected to freezing, treatment with solvents and long drying in vacuo, but no crystalline product could be obtained from it. Freezing merely caused the oil to become more viscous.

The nitration, reduction and separation of isomers were repeated several times in order to ascertain as far as possible the proportions in which the latter were present. The acetyl-derivatives of the bases (a) and (b) were analysed and found to correspond to monoiodomonoacetamidoditolyls. Piperidine analysis of the total crude nitration-product showed only a small amount of labile halogen. Numerical details are given on the next page.

Nitration of 2-iododitolyl and reduction of product.

Quantities of from 3 to 9 g. of 2-iododitolyl were nitrated as described on the previous page, the total yields of nitration-products varied from 98.5-99.7% of the theoretical for mononitration. Reduction of the total crude nitration-products gave yields from 98-100% theoretical of crude reduction-product, but this included the acid-insoluble residue. The acid-soluble portion of the total reduction-product was separated as described into two parts (a) and (b), the quantities of which are given below. The combined amounts of (a) and (b) represent in each case from 57-63% of the total reduction-product, the remainder being the acid-insoluble residue, which was a black substance, oily at 100° and hard when cold. It may have been a carbazole and it is possible that it contained some iododitolyl which had escaped nitration, but no recognisable substance could be isolated from it.

Piperidine analysis of total crude nitration-product from 2-iododitolyl.

4.4190 G. of nitration-product, (a red oil), were placed in a tube with excess of piperidine, a slight darkening of colour being observed on mixing. The tube was sealed and heated for 3 hours at 100°. A little 10% caustic potash solution was added to the contents of the tube and then ether to dissolve organic substances. The ether layer was washed several times with water and the combined aqueous extracts were washed with ether, heated on the water-bath until the smell of ether disappeared, acidified with nitric acid and treated with silver nitrate solution. The mixture was boiled until the silver iodide coagulated and filtered through a Gooch crucible. The precipitate was washed several times with hot chloroform to remove organic matter. The weight of AgI was 0.0410 g., corresponding to elimination of halogen from 1.4% of the nitration-product taken. Only 84.6% of the nitration product was recovered from the ether solution, but there was undoubtedly some loss in the extraction. The value thus obtained for the proportion of labile halogen is possibly too high, as the aqueous solution contained organic matter, presumably of a phenolic nature, which was precipitated on addition of nitric acid, and which was difficult to remove from the Gooch crucible.

Constituents of acid-soluble part of total reduction-product.

| | (a) Hydrochloride. | (b) Acetyl-derivative | Approx. Ratio, b/a of free bases. |
|---|---|---|---|
| (I) | Crude; 1.0 g., dark and sticky | 2.2 g., m.p. 141-147°, coloured. | 2.2/1. |
| | Recryst.; 0.6 g., Black scum remained insoluble in dil. HCl. | 1st. Crop, 1.36 g., m.p. 158-160°.<br>2nd.Crop very coloured, melted about 125°, but m.p. raised by acetamido (b) lowered by acetamido (a). | 2.3/1. |
| (II) | (Recovered from piperidine treatment,and reduced as usual.) | | |
| | Crude; 0.61 g. | 1.35 g., coloured, m.p. 140-146°. | 2.2/1. |
| | Recryst. 0.40 g. | 1st.Crop, 0.91 g. m.p. 159-160°.<br>2nd.Crop, very coloured, m.p. about 120°, but raised by (b). | 2.3/1. |
| (III) | 0.36 g. | 0.86 g. | 2.4/1. |
| (IV) | 0.65 g. | 1.55 g. | 2.4/1. |
| (V) | 0.55 g. | 1.1 g. | 2.0/1. |
| (VI) | 0.45 g. | 0.91 g. | 2.1/1. |

These figures appear to justify the conclusion that the mixtures contained not less than twice as much of (b) as of (a), probably rather more than this since the probability of loss of (b) in the process of purification was the greater. Although no third isomer, corresponding to the labile halogen, was detected, it cannot be stated that none was present was present, since the presence of coloured impurities would prevent the detection of so small a quantity (1.4% of the total nitro-compounds.)

2-Iodox-acetamidoditolyl (a) crystallised in small, very nearly colourless prisms, m.p. 165-166° (ex aqueous AcOH).

2-Iodo-2'-acetamidoditolyl (b) crystallised in small, nearly colourless needles (clusters), m.p. 160-161° (ex aqueous AcOH).

Mixed m.p. 140-152°.

Analysis of 2-iodoacetamidoditolyls. (Dumas estimation of nitrogen.)

**2-Iodo-x-acetamidoditolyl (a) 0.1705 g. gave 6.4 cc.nitrogen at 21° and 754 mm.**
**5 %age weight of nitrogen 4.2.**

**2-Iodo-2'-acetamidoditolyl (b) 0.3783 g. gave 13.0 cc. of nitrogen at 18° and 760 mm.**
**%age weight of nitrogen 3.9.**

$C_{16}H_{16}NOI$ requires 3.85% of nitrogen.

Analysis of the mixture of acetamido-compounds obtained by acetylation of the total crude reduction-product (after removal of the acid insol.residue) indicated 3.9 % of nitrogen.

The hydrochloride (a) crystallised in yellow leaflets, **m.p. 222-224°, (decomp.)**

The hydrochloride (b) was mostly a brown gum **, the small amount of solid formed small plates, melting indefinitely about 120° with loss of water leaving a brown, glassy substance.**

Preparation of di-iododitolyl.

The base obtained by hydrolysis with hot, concentrated hydrochloric acid containing a little alcohol of the purified iodoacetamido-compound (b) was converted in the usual manner into the diazonium chloride and the solut- was poured into a concentrated solution of the calculated amount of potassium iodide. A light-brown, sticky mass was formed, and nitrogen was slowly evolved. This product was found to consist mainly of a yellow powder, insoluble in alcohol, together with a small amount of alcohol-soluble substance which crystallised in large hexagonal plates, m.p. 113-114°, having a red colour which could not be removed. The preparation was repeated with the difference that the mixture, after decomposition of the diazonium salt in the presence of potassium iodide, was made alkaline with caustic soda and steam-distilled. In spite of the slowness of the distillation, this method had the advantage that it gave a colourless product, which crystallised from methyl alcohol in large, colourless, shining, hexagonal plates, m.p. 116-117°. The yield was small, about 0.4 g. being obtained from 2.6 g. of acetyl-derivative.

This substance was found to be identical, by the method of mixed melting-points, with 2:2'-di-iododitolyl, prepared in the same way from 2 2:2'-diaminoditolyl.

Analysis of 2:2'-di-iododitolyl. (Carius estimation of halogen.)

Weight of iodo-compound, 0.0552 g.

Weight of silver iodide, 0.0598 g.

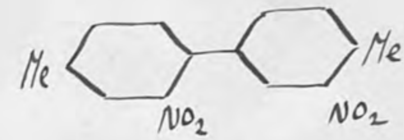
%age weight of iodine 58.4.

$C_{14}H_{12}I_2$ requires 58.5% of iodine.

The insoluble yellow powder which was the main product of the diazotisation and treatment with potassium iodide of 2-iodo2'-amino- and 2:2'-diamino-ditolyls was undoubtedly ditolylene iodonium iodide, which Angeletti and Brambilla (loc. cit.) describe as darkening at 198° and melting at 205-6° with decomposition. It began to darken at about 200°, and decomposed about 220°, leaving a dark-brown, infusible residue. About 1 g. of this substance was kept for some time in a metal-bath at a temperature of about 240°, white fumes were evolved and condensed on the cold upper portion of the tube containing the substance; only a very small quantity of this sublimate was obtained, but there was enough for a melting-point determination which showed it to be 2:2'-di-iododitolyl. The dark-brown residue appeared to consist mostly of carbon, but also contained potassium, probably due to the original substance not having been completely washed free from potassium iodide.

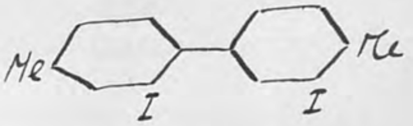
Mascarelli and Gatti, (Gazzetta, 1930, 464) describe the decomposition of some diphenylene iodonium salts by heat as giving mainly tarry products with only traces of crystalline substances.

## Reduction of 2:3'-dinitroditolyl.



2:3'-Dinitroditolyl was prepared by nitration of ditolyl with nitric acid of density 1.47, (Marler and Turner, J., 1932, 2391). It was dissolved in boiling glacial acetic acid and treated with a solution of stannous chloride (4molecules to each nitro-group) in concentrated hydrochloric acid. The solution, which was originally pale yellow, became red as the stannous chloride solution was added, probably corresponding to the reduction of one nitro-group; when all the stannous chloride had been added and the mixture had been heated for a few minutes the colour became lighter, a clear, orange-yellow solution being obtained. Heating was continued for 20 minutes, but no further change was observed and this was taken to indicate that reduction was complete. The solution was poured into excess of strong caustic soda solution and the precipitated oil extracted with ether. Removal of the ether left a dark-coloured, oily residue which was almost entirely soluble in dilute hydrochloric acid, a small amount of brown scum being removed by filtration. The solution was dark-brown; neither the base nor its hydrochloride could be isolated in a pure state. The hydrochloride was very soluble, it was obtained by evaporation of the solution as a dark-coloured, somewhat sticky substance. The free base was a brown gum, which could not be made to solidify. Attempts to prepare derivatives were also unsuccessful. After treatment with acetic anhydride no solid product was obtained on pouring into water. It is possible that partial acetylation had occurred (cf. Finzi and Manganini, Gazzetta, 1932, 664, partial acetylation of 2:4'-diaminodiphenyl.)

## Attempted preparation of 2:3'-di-iododitolyl.



As it was thought that the bases (a) produced by the reduction of the mixtures obtained by the nitration of 2-halogenoditolyls might be 2-halogeno-3'-aminoditolyls, it was hoped that it would be possible to prepare authentic 2:3'-dihalogenoditolyls and to compare them with the compounds obtained by replacement of the amino-group by halogen in the bases (a).

The iodo-compound was selected as it was thought the most likely to be formed in good yield.

The dark-brown hydrochloric acid solution of the reduction product from 2:3'-dinitroditolyl was treated with sodium nitrite on the assumption that it contained a diamine corresponding in amount to the dinitroditolyl originally used, (7 g.) A dark-green solution resulted. Diazotisation had undoubtedly occurred for a red precipitate was formed on addition of a drop of the solution to an alkaline solution of β-naphthol. The diazo-solution was treated with urea to destroy any excess of nitrous acid and poured into a solution of potassoum iodide. Effervescence occurred, and a black, semi-solid substance separated; this appeared to consist largely of iodine. It was extracted with carbon tetrachloride and the solution shaken with aqueous alkali which remived some phenolic substance and a little of the iodine. The solution, which was still very dark, was shaken with sodium thiosulphate solution , which removed most of the colour. The carbon tetrachloride was removed by distillation under reduced pressure, leaving a very small amount of reddish-brown oil. An attempt was made to distil this under a pressure of 15 mm., but it decomposed, giving off iodine, and no boiling-point could be recorded. All that could be gathered from this experiment was that the di-iodo-compound was probably a liquid at ordinary temperatures.

A second attempt was made, with the difference that the product of decomposition of the diazo-compound in the presence of potassium iodide, instead of being extracted and vacuum-distilled, was made alkaline and distilled in steam; this gave a small quantity of a colourless oil, but there was not enough of it to permit of a determination of boiling-point. It could not be made to crystallise.

The monoamino-2-iododitolyl hydrochloride (a), of which only a small amount was available, was also diazotised and treated with potassium iodide, distillation in steam gave a small amount of a colourless oil which could not by any means be caused to solidify. The quantity was too small for a determination of b.p. to be made. No satisfactory comparison of 2:3'-di-iododitolyl and 2:x-di-iododitolyl (a) could therefore be made. It can only be said that both products were colourless, uncrystallisable oils, containing iodine, and that there was nothing to indicate that they were not identical.

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An attempt was also made to prepare 2:3'-difluoroditolyl, from the reduction product of 2:3'-dinitroditolyl. A small amount of green solid, undoubtedly a diazonium borofluoride was obtained. Thermal decomposition, followed by steam-distillation from alkaline suspension gave a small amount of colourless, uncrystallisable oil. It thus appears that the 2:3'-dihalogenoditolyls are oils, but in view of the small yields, and of the doubtful composition of the base no definite statement is justified .

Attempted replacement of the amino group by chlorine and bromine respectively in the chloro and bromo-monoamines (a) also gave small amounts of colourless, uncrystallisable oils.

Note.

The 2-halogeno and 2:2'-dihalogenoditolyls were found to be somewhat resistant to decomposition by nitric acid in the Carius estimation of halogen, traces of organic matter being found in the tubes after several hours at 260°. On one occasion when an unusually large amount of the compound (2-bromoditolyl) was used the amount of organic matter was considerable and the value for bromine obtained was 5% low. Repetition of the analysis with a smaller quantity of the same specimen and a larger quantity of nitric acid, (2.5 cc.) gave a correct value.

In all cases the silver halide precipitates were washed with hot chloroform to remove organic matter.

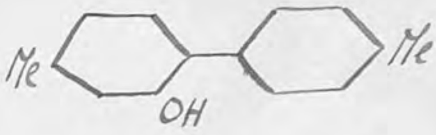
Cook (J., 1930, 1091) remarks that 2-iododiphenyl is resistant to decomposition by nitric acid in the Carius analysis.

## 2-Bromoditolyl-2'-diazonium perbromide.

Addition of bromine to the diazo solution obtained from 2-bromo-2'-aminoditolyl gave a red oil which went solid when treated with ether. An orange powder was obtained and was dried in vacuo. When decomposed in acetic acid or in alcohol it did not give 2:2'-dibromoditolyl but a colourless, sparingly soluble substance, melting indefinitely between 185° and 200° ; a tribromo-compound (or compounds) was probably present.

Unlike ditolyl-2-diazonium perbromide it did not decompose when heated on the water-bath, but when heated in a metal-bath at about 130° it decomposed, giving off bromine and leaving a brown, sticky product. Alcohol extracted from this a small amount of colourless, semi-solid matter, which may have contained 2:2'-dibromoditolyl, but which could not be made to crystallise.

## Preparation of 2-hydroxy ditolyl.



2-Aminoditolyl was converted into the sulphate and diazotised in the usual way. The yellow solution, which contained a small amount of tarry matter, was warmed on the water-bath until the evolution of nitrogen ceased. The product was extracted with ether, the ether removed and the residue treated with dilute sodium hydroxide solution. The solution was filtered to remove some reddish-brown substance, insoluble in alkali, and the filtrate was acidfied with hydrochloric acid giving a white turbidity which, after standing for a few minutes formed small, almost colourless crystals. The hydroxy-compound was very soluble in the common organic solvents; it was recrystallised from aqueous alcohol, forming clusters of fine, colourless needles, m.p. 57-58°, having a pleasant, floral odour. Yield, about 60%.

This substance was also obtained as a by-product in the preparation of halogeno-ditolyls; it was very difficult to remove from them by shaking their solutions with alkali, the solubility of its sodium salt in water being presumably small in comparison with the solubility of the OH compound in organic solvents.

The **p**-toluene sulphonate formed long, colourless needles, m.p. 130°.

## Analysis of 2-hydroxyditolyl.

Microanalysis by Dr. Weiler gave the following:

C, 84.61%. H, 7.14%.

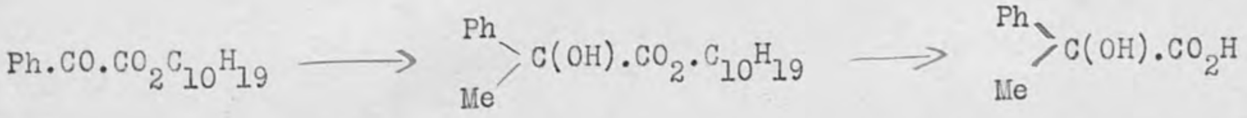
$C_{14}H_{14}O$ requires C, 84.82%; H, 7.086%.

## ATTEMPTED ASYMMETRIC SYNTHESES IN THE DIPHENYL SERIES.

It has been shown that certain diphenyl derivatives substituted in the 2 and 6 positions are capable of resolution into optically active forms, the dissymmetry of the molecule being ascribed to the "obstacle effect" of the substituent groups, which can prevent free rotation of the two nuclei about the single bond which joins them, thus causing them to take up positions in which they are not coplanar. Synthesis of such diphenyl derivatives, e.g. by the Ullmann reaction from ortho-substituted halogeno-benzenes, leads of course to racemic mixtures which are resolved by the usual methods.

The possibility of asymmetric synthesis of an optically active compound under the influence of an optically active reagent has been shown by McKenzie (J., 1904, 1249; 1906, 365) who by the synthesis of the l-menthyl esters of mandelic and atrolactinic acids obtained products which, on removal of the menthol by hydrolysis, showed optical activity, more of one form of the acid than of the other having been produced.

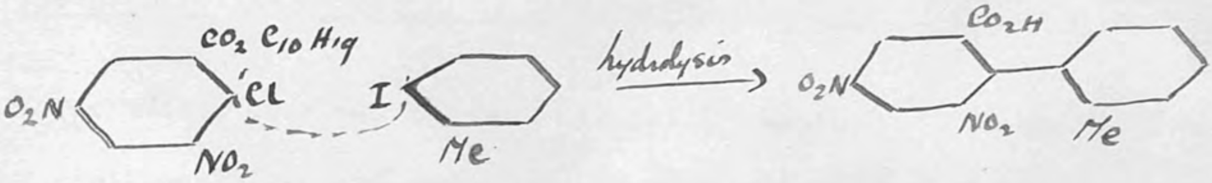
$$Ph.CO.CO_2.C_{10}H_{19} \longrightarrow Ph.CH(OH).CO_2.C_{10}H_{19} \longrightarrow Ph.CH(OH).CO_2H$$



$$Ph.CO.CO_2C_{10}H_{19} \longrightarrow \begin{matrix}Ph\\ Me\end{matrix}\!\!>C(OH).CO_2.C_{10}H_{19} \longrightarrow \begin{matrix}Ph\\ Me\end{matrix}\!\!>C(OH).CO_2H$$

Lesslie and Turner (J., 1930, 1758) accomplished an asymmetric synthesis in the diphenyl series by combining the l-menthyl ester of 3:5-dinitro-2-chlorobenzoic acid with o-iodotoluene by the Ullmann reaction, the

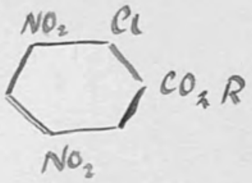
2:4-dinitro-2'methyldiphenyl-6-carboxylic acid obtained on hydrolysis being slightly dextrorotatory.



It was proposed to extend this application of the Ullmann reaction to the combination of the menthyl ester with other ortho-substituted halogenobenzene derivatives, and in particular with other esters of the same acid. The combination of the menthyl ester in this way with itself was first attempted, but it was found that the reactivity of the chlorine atom under the influence of the nitro-and carboxyl-groups in the ortho and para positions was so great that the reaction could not be controlled and partly carbonised products were always obtained. The solutions of diphenyl carboxylic acid obtained on hydrolysis were too dark to permit of satisfactory determinations of optical activity. If any such activity was present it was probably very small. Repeated attempts to reproduce the synthesis of Lesslie and Turner led to equally inconclusive results.

## The preparation of esters of 3:5-dinitro-2-chlorobenzoic acid.

The method used was the same for all the esters, a mixture of 20 g. of dinitrochlorobenzoic acid with 25 gram molecules of the desired alcohol and 10 cc. of concentrated sulphuric acid was boiled for 2--3 hours, the resulting solution was poured into cold water, sodium bicarbonate was added until there was no more effervescence, the precipitated ester was filtered off and recrystallised from alcohol and any unchanged acid was recovered from the solution of its sodium salt. The following esters were prepared:



| Ester. | M.P. | Yield. | Rec. acid. |
|---|---|---|---|
| Ethyl | 55-56° | 13 g. | 8 g. |
| Methyl | 91-92° | 11 " | 6 " |
| n-Butyl | 58-59° | 20 " | 2 " |
| n-Propyl | 51-52° | 16 " | 3 " |
| iso-Butyl | 56-57° | 18 " | 2 " |
| iso-Propyl | 64-75° | 12 " | 5 ". |

### Attempted asymmetric synthesis of 2:4-dinitro-2'-methyldiphenyl-6-carboxylic acid.

The l-menthyl ester of 3:5-dinitro-2-chlorobenzoic acid was prepared by the method of Lesslie and Turner (loc. cit.). 20 G. of this ester were mixed with an equal weight of o-iodotoluene in a Pyrex boiling-tube which was heated in a metal-bath at about 200°; 20 g. of copper bronze were added in small amounts and the temperature of the bath was slowly raised. At 220° a brisk reaction occurred with much frothing. The product was extracted with o-dichlorobenzene and the solvent was then distilled off until a thermometer immersed in the liquid registered 210.° About 30 g. of a black, partly solidified residue remained.

### Hydrolysis.

The 30 g. of black residue were dissolved in 200 cc. of glacial acetic acid and a mixture of 300 cc. of concentrated sulphuric acid and 150 cc. water was added, causing some precipitation, a further 200 cc. of acetic acid were added, when all passed into solution. The solution was boiled for 2 hours, poured into water and filtered. The residue was dissolved in sodium bicarbonate solution and some insoluble black substance was removed by filtration. The solution was almost black; it was acidified with hydrochloric acid and the precipitated carboxylic acid was filtered off, this was a black, slimy substance. It was dissolved again in sodium bicarbonate solution and twice boiled up with charcoal and filtered, giving a light-brown solution; acidification now precipitated a small quantity of a brown, gummy substance.

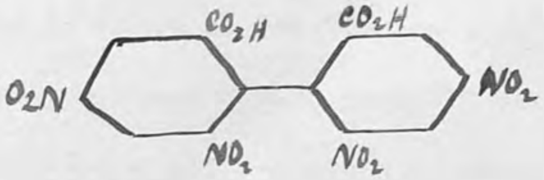
This synthesis was repeated with 34 g. each of menthyl ester and o-iodotoluene, the temperature of the mixture in the boiling-tube not being allowed to rise above 210° . Otherwise the process was as before, except that after hydrolysis the solution of the sodium salt was extracted with ether to remove any menthol. After boiling twice with charcoal an acid was obtained which was still gummy, but slightly lighter in colour than that from the first preparation.

Yield 4 g.

## Determination of optical rotatory power.

1.5100 G. of the acid were dissolved in A.R. acetone, the solution was made up to 20 cc. and placed in a polarimeter tube. It was too dark for any reading to be taken, It was then diluted to 100 cc., when it was still rather dark, but indicated (possibly) a very small dextrorotation. In the hope of decolourising the solution it was left to stand overnight over blood charcoal, it was then only pale yellow but was completely inactive. Evaporation of the solution showed it to consist of almost pure acetone.

Attempted asymmetric synthesis of 2:4:2':4'-tetranitrodiphenyl-6:6'-dicarboxylic acid.



Quantities used; 8 g. l-menthyl dinitrochlorobenzoate
2 g. copper bronze.

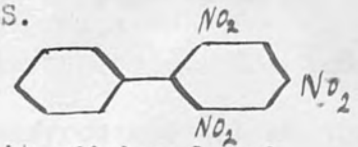
(i) At 220° the substance charred completely.

(ii) The ester was heated up very cautiously, the temperature of the metal-bath never being allowed to rise above 215° ; the copper was added slowly when the temperature was between 190° and 200° inside the boiling-tube, at first there was no apparent action but when the bath was at 212 the contents of the tube became dark and pasty and the temperature rose rapidly to 240°. The tube was at once removed from the bath and the contents stirred until the temperature began to fall, and o-dichlorobenzene was then added. 5 G. of black, apparently crystalline residue were obtained after removal of the solvent. Hydrolysis was effected as previously described. The product appeared to consist mainly of carbon. The solution of the sodium salt was dark red and gave on acidification with hydrochloric acid a very small quantity of brownish solid.

The synthesis was repeated with 5 g. of ester dissolved in 10 g. of nitrotoluene. At 120° it turned dark and showed signs of effervescence. The product was worked up in the usual way, but showed no improvement on those previously obtained.

The investigation was then abandoned.

# THE REACTIONS OF 2:4:6-TRINITRO AND TRIAMINODIPHENYLS.

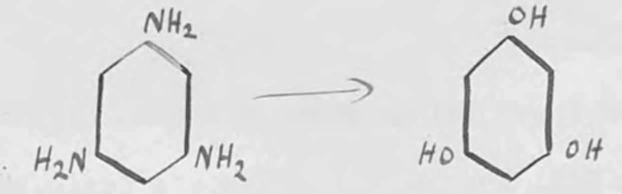


Evidence was obtained of reaction between trinitrodiphenyl and piperidine, two nitro-groups having probably been eliminated; this showed a loosening effect of one nitro-group upon another in a polynitro-compound, similar to that of a nitro-group upon a neighbouring halogen atom.

Attempts to cause replacement of one or more nitro-groups by amino-groups by the action of ammonia gave mostly unchanged trinitrodiphenyl, with small amounts of indefinite products.

It was found that trinitrodiphenyl was decomposed by boiling with dilute aqueous alkali.

The conversion of symmetrical triaminobenzene into phloroglucinol in 80-90% yield by boiling its hydrochloride with water in the absence of air has been described by Flesch (Monatsh., 1897, 18, 758). An attempt to carry out a similar transformation of the product of reduction of trinitrodiphenyl led only to an indefinite mixture of products, which was not further examined.



Reactions of trinitrodiphenyl.

(i) 1.5 G. of trinitrodiphenyl were placed with 2 g. of piperidine in a glass tube; an immediate crimson colour appeared in the cold. The tube was sealed and gently warmed, a vigorous reaction occurred and the mixture became very hot. The tube was heated for 1 hour in a boiling water-bath and the liquid became almost black. The product was extracted with boiling, dilute hydrochloric acid to remove piperidine and 1.94 g. of a dark-brown, apparently crystalline residue were obtained. The colour became slightly lighter when the substance was dried on the water-bath.

M.p. 165° (s. at 130° ).

Combination with one molecule of piperidine should give 1.7 g. of product.
"" "" two "" " "" "" " 1.9 g. " ""
"" "" three "" " "" "" " 2.1 " " ""

The substance obtained was therefore probably a mononitro-dipiperidino-diphenyl.

(ii) 2 G. of trinitrodiphenyl were heated for 2 hours on the water-bath with 20 cc. of ethylaniline. The original substance was recovered.

(iii) 2.45 G. of trinitrodiphenyl were heated for 2 hours on the water-bath with 60 cc. of ethyl alcohol and 50 cc. of .880 ammonia. There was no action.

(iv) 2 G. of trinitrodiphenyl with 6 cc. each of ethyl alcohol and .880 ammonia were heated in a sealed tube at 180° for 2 hours. There was a strong pressure in the tube when cold. Some phenolic substance was removed by treatment of the product with cold, dilute aqueous alkali. The remainder was a red, semi-solid substance. Petroleum ether (60-80°) extracted a small quantity of yellow substance which was found to be unchanged trinitrodiphenyl, leaving a red, amorphous solid from which no definite substance could be isolated.

The process was repeated but the sealed tube was heated only to 130°; there was no pressure in the tube when cold and the only substances found were unchanged trinitrodiphenyl and a little of a phenolic substance.

(v, a) 2 G. of trinitrodiphenyl were dissolved in 50 cc. of boiling dekalin and dry ammonia was passed in for 2 hours. Most of the trinitrodiphenyl was recovered unchanged but some dark-brown,amorphous solid was also present. This process was repeated with larger quantities and the mixture heated for 2 hours in a metal-bath at 200°. Treatment of the product with petroleum ether dissolved out some unchanged trinitrodiphenyl and left a dark-brown powder which was then dissolved in phenol and reprecipitated with petroleum ether. It was soluble in concentrated sulphuric acid from which it could be reprecipitated. This substance appeared to be mixed with carbon. It softened at 200° and was mostly melted at 300° probably with decomposition. A mixture of it with trinitrodiphenyl melted at 110-125°. Most of the trinitrodiphenyl was recovered unchanged from the reaction mixture, as in the two previous experiments.

(v,b) 5 G. of trinitrodiphenyl were heated alone in a metal-bath at about 200 and dry ammonia was passed in for 2 hours. The product consisted almost entirely of trinitrodiphenyl, with an even smaller quantity than in the previous experiment of a dark-brown substance, probably some polymer.

(vi) 2 G. of trinitrodiphenyl were boiled for 20 minutes with 200 cc. of dilute, aqueous caustic soda, it dissolved completely and the solution became nearly black, bright red on dilution. Addition of hydrochloric acid caused evolution of hydrocyanic acid and precipitation of a reddish-brown sludge.

## Reduction of 2:4:6-trinitrodiphenyl.

17 G. of trinitrodiphenyl were reduced with tin and hydrochloric acid, the quantities being calculated from the equation;

$$3\ \text{-NO}_2 + 9\ \text{Sn} + 36\ \text{HCl} \longrightarrow 3\ \text{-NH}_2\ \text{etc.}$$

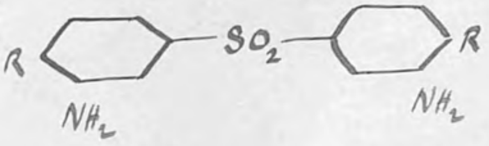
The nitro-compound was mixed with the granulated tin, the acid was added, the mixture being cooled during the addition, and the mixture was heated for $\frac{1}{2}$ hour on the water-bath. The solid was now all in solution. The solution was diluted and hydrogen sulphide passed in until no more tin sulphide was precipitated. The solution was evaporated on the water-bath under reduced pressure, leaving a crystalline, dirty pink, solid residue. The maximum theoretical yield of trihydrochloride would be 14 g. but 35.g. of the above residue were obtained; it was perhaps a hydrate. Isolation of the free base was not attempted.

## Attempted replacement of amino-groups in triaminodiphenyl by hydroxyl-groups.

The hydrochloride obtained as described was boiled with 700 cc. of air-free distilled water in an atmosphere of carbon dioxide for about 9 hours. The solution turned dark; this was found to be due to the deposition of tin sulphide which must have passed through the filter-paper when the hydrochloride solution was filtered. This precipitate was removed by filtration and the filtrate was then evaporated under reduced pressure on the water-bath. About 11 g. of a brown, gummy residue were obtained. This was redissolved in water, the solution acidfied and extracted with ether. Removal of the ether gave about 2 g. of brown, sticky matter. Ammonia was detected in the remaining solution, showing that some elimination of amino-groups must have occurred. The solution seemed to contain a basic substance or mixture of substances, it was evaporated down and the residue treated with acetic anhydride, in the hope of isolating an acetyl derivative or derivatives, but no definite substances were obtained.

The investigation was then abandoned.

## THE PREPARATION OF 4:4'-DISUBSTITUTED DERIVATIVES OF 3:3'-DIAMINODIPHENYL SULPHONE.



4:4'-Dichlorodiphenyl sulphone was nitrated by the method of Ullmann and Korselt (Ber., 1907, 642 ), giving 3:3'-dinitro-4:4'-dichlorodiphenyl sulphone. The reactions of this nitro-compound with the following compounds were investigated:

(a) Hydroxy compounds in alkaline solution.

Methyl, ethyl and _n_-butyl alcohols; _m_- and _p_-cresols; phenol.

Replacement of both chlorine atoms occurred.

(b) Primary and secondary aromatic bases.

Aniline, methyl and ethyl anilines and α-naphthylamine.

Replacement of one or both atoms of chlorine was effected. (The reaction with aniline, leading to the replacement of both atoms of chlorine had already been described by Ullmann and Korselt.)

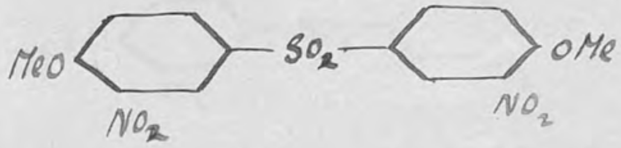
There was no reaction with diphenylamine.

All the dinitro-compounds thus obtained were reduced with stannous chloride in glacial acetic acid solution. (U. and K. used alcohol as a solvent but acetic acid was found to give better results.)

(c) Ammonia.

4:4'-Diamino-3:3'-dinitrodiphenyl sulphone and (probably) the 4-amino-4'-chloro-derivative were obtained by heating the dinitro-dichloro-sulphone with alcoholic ammonia under pressure.

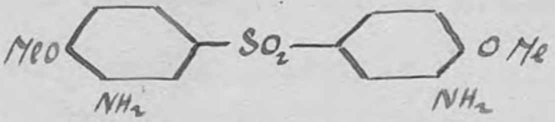
Preparation of 4:4'-dimethoxy-3:3'-dinitrodiphenyl sulphone.



15 G. of the dichloro-compound were heated under reflux on the water-bath with 200 cc. of acetone and 50 cc. of methyl alcohol until all was in solution, a solution of 4.5 g. (2 molecules) of sodium hydroxide in 50 cc. of methyl alcohol was added cautiously and the heating continued for 10 mins. The solution became bright crimson and sodium chloride separated. On cooling a bright pink, highly crystalline solid appeared, a further quantity being precipitated by the addition of water. This substance did not contain chlorine and was not alkali-soluble, it must therefore have been the 4:4'-dimethoxy compound. The pink colour disappeared slowly on standing, after several weeks the substance was pale yellow and remained so. The colour disappeared rapidly on warming to about 100°, either alone or in a solvent. The loss of colour was irreversible.

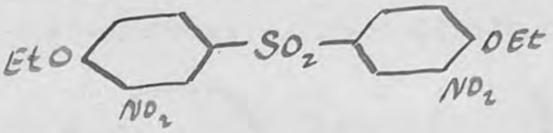
Yield, 15 g. M.p. (ex acetic acid) 230°.

4:4'-Dimethoxy-3:3'-diaminodiphenyl sulphone.



10 G. of the dinitro-compound described above were suspended in 60 cc. of boiling glacial acetic acid and a solution of 20 g. of stannous chloride in 20 cc. of conc. hydrochloric acid was added gradually. When all the solid had dissolved heating was continued for 10 minutes, the solution was cooled and made alkaline, filtered and the base extracted with boiling benzene from the residue. Yield, 80% theoretical. M.p. (ex benzene) 209-210°.

Preparation of 4:4'-diethoxy-3:3'-dinitrodiphenyl sulphone.

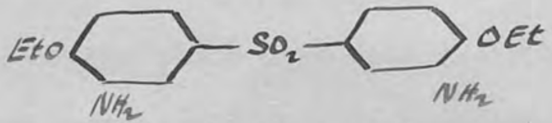


10 G. of the dichloro-compound were heated on the water-bath under reflux with 160 cc. of acetone and 100 cc. of ethyl alcohol until all was in solution, a solution of 3 g. ( 2 molecules) of sodium hydroxide in 100 cc. of ethyl alcohol was then added very cautiously. A vigorous reaction occurred and the solution became dark red; heating was continued for a further 10 minutes. On cooling a solid substance separated and a further quantity was obtained by precipitation with water. The substance was colourless, it contained no chlorine and was not alkali-soluble and must therefore have been the 4:4'-diethoxy-compound. A small quantity of hydroxy-compound was precipitated by the addition of acid to the the alkaline mother-liquor. (No hydroxy -compound was obtained in the preparation of the dimethoxy-compound.)

Yield of diethoxy-compound, 8 g. M.p. (ex acetic acid) 191-192°. The amount of caustic soda used was that theoretically required for the removal of both atoms of chlorine as sodium chloride; it was found that if excess was used the product was mainly a hydroxy-compound.

Acetone was used as a solvent in the preparation of both the methoxy and ethoxy compounds on account of the very small solubility of the dichloro-compound in methyl and ethyl alcohols.

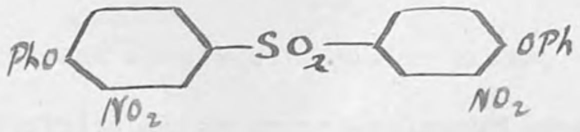
4:4'-Diethoxy-3:3'-diaminodiphenyl sulphone.



This was prepared by reduction of the above dinitro-compound with stannous chloride in precisely the same way as the dimethoxy-compound.

Yield of diamine, 79 % theoretical. M.p. 171-172° (ex benzene)

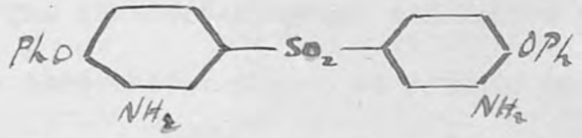
Preparation of 4:4'-diphenoxy-3:3'-dinitrodiphenyl sulphone.



20 G. of the dichloro-compound were dissolved in 80 g. of phenol, 8 g. of sodium hydroxide in 20 g. of phenol with a trace of water were added and the mixture was heated for 1 hour on the water-bath. Sodium hydroxide solution was added to dissolve the excess phenol and the precipitated solid was filtered off from the dark-green solution and crystallised from glacial acetic acid. The colourless, crystalline substance did not contain chlorine and must therefore have been the diphenoxy compound.

Yield 22 g. M.p., 175°.

4:4'-Diphenoxy-3:3'-diaminodiphenyl sulphone.



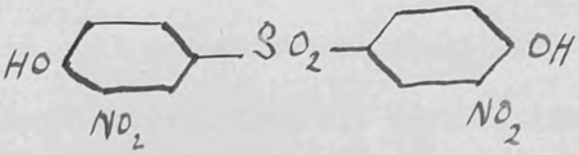
Reduction was effected in the usual way with stannous chloride, giving a 75 % yield of the diamine, m.p. 151-152°.

Exactly similar condensations of the dichloro-compound were also effected with (i) m-Cresol: dinitro-compound m.p. 177-180°, base did not crystallise, and (ii) p-cresol: dinitro-compound m.p. 171-173°, base m.p. 178°.

All the four diamines which have been described were nearly colourless, and crystalline. They underwent diazotisation and coupling with β-naphthol.

Hydrolysis of 4:4'-dichloro-3:3'-dinitrodiphenyl sulphone.

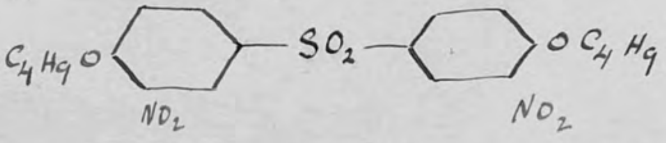
When the sulphone was boiled for a short time with aqueous caustic soda it dissolved completely, giving a deep orange-coloured solution. Addition of acid precipitated an orange-coloured crystalline solid. This redissolved completely in dilute aqueous alkali and contained no chlorine, it must therefore have been the 4:4'-dihydroxy-compound.



The yield was theoretical. M.p. 234-236°.

Reaction with *n*-butyl alcohol.

The dichloro-compound was heated with *n*-butyl alcohol in the presence of the theoretical amount of caustic soda, giving a solution which was very dark red in colour, almost black. A small quantity of a substance containing no chlorine and insoluble in alkali was obtained; this must have been the 4:4'-di-*n*-butyloxy derivative. The main product was a hydroxy-compound.



M.p. 146-148°.

Reactions of 4:4'-dichloro-3:3'-dinitrodiphenyl sulphone with aromatic bases.

(I) Replacement of one atom of chlorine.

The dichloro-compound was dissolved in boiling toluene, two molecular proportions of the freshly-distilled base were added and the solution was boiled for 1 hour. In each case the solution was a bright orange-red colour. On cooling shining orange-coloured crystals appeared and were recrystallised from glacial acetic acid. The yields were about 70 % of the theoretical. All contained chlorine; they were probably 4-chloro-4'-anilino etc. derivatives. They all crystallised in lustrous, orange-yellow elongated, rectangular plates.

The nitro-compounds thus obtained were dissolved in glacial acetic acid and reduced with stannous chloride in hydrochloric acid, as previously described. The diamines were recrystallised from benzene and were almost colourless, crystalline solids.

Dinitro-compounds. Diamines.

| | |
|---|---|
| $R_1$ = H, $R_2$ = Ph, m.p. 198°. | m.p. 140°. |
| $R_1$ = Me, $R_2$ = Ph, m.p. 196-197°. | m.p. 140-141°. |
| $R_1$ = Et, $R_2$ = Ph, m.p. 197-198°. | m.p. 154-155°. |
| $R_1$ = H, $R_2$ = $\alpha$-naphthyl, m.p. 196-198°. | did not crystallise. |

Reactions of 4:4'-dichloro-3:3'-dinitrodiphenyl sulphone with aromatic bases. (II) Replacement of both atoms of chlorine.

The dichloro-compound was dissolved in excess (at least twenty molecules) of the base and heated on a boiling water-bath for about three hours. The excess of base was then removed by distillation in steam. A residue remained in each case of a dark-red, glassy solid which contained no chlorine. The substances were rather insoluble, except in acetic acid, and did not crystallise well, giving orange-red powders. The yields were nearly theoretical but the purity of the substances was doubtful.

The dinitro-compounds were reduced with stannous chloride in the usual way. The diamines were difficult to purify, being contaminated with coloured substances.

Dinitro-compounds. Diamines.

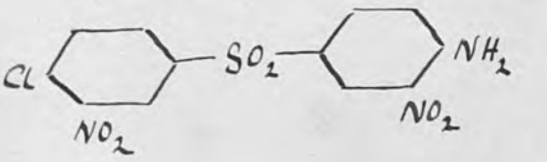
| | |
|---|---|
| $R_1$ = H, $R_2$ = Ph, m.p. 250-253°. | m.p. 180-183°. |
| $R_1$ = Me, $R_2$ = Ph, m.p. 219-222°. | m.p. 199-203°. |
| $R_1$ = Et, $R_2$ = Ph, m.p. 170-173°. | did not crystallise |

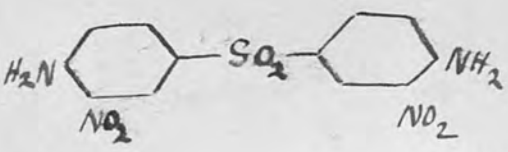
$\alpha$-Naphthylamine gave an indefinite product. Attempts to carry out the condensation at higher temperatures by heating in a metal-bath also gave indefinite results.

## Reaction of 4:4'-dichloro-3:3'-dinitrodiphenyl sulphone with ammonia.

Replacement of the chlorine atoms was attempted by passing dry ammonia into the dichloro-compound heated to its melting-point in a metal-bath, and into **boiling** solutions of the substance in high-boiling solvents, such as nitro-benzene and <u>cyclo</u>-hexanol. In each case a mixture was obtained of an extremely insoluble, bright-yellow powder containing no chlorine, probably the diamine, and a lighter-yellow powder, moderately soluble in benzene and containing chlorine, probably the 4-chloro-4'-amino-derivative. Both these were obtained in very small quantity, the chief product being a dark-brown, amorphous substance, probably some polymer.

Better results were obtained by heating the dichloro-compound to about 180° with alcoholic ammonia under pressure. An insoluble, high-melting (m.p. above 260°), bright yellow substance containing no chlorine and a more soluble, lower-melting (m.p. 225-233°) yellow substance containing chlorine were isolated, together with some hydroxy-compound.





The lower-melting substance containing chlorine may have been a mixture of the diamine with unchanged dichloro-compound.

These compounds were extremely weak bases, as would be expected from the presence of the electron-attracting $NO_2$ and $SO_2$ groups in the ortho and para positions to the amino-groups. They dissolved in concentrated sulphuric acid only.

Note (i). The substances described as mono-chloro-monoanilino etc. compounds, derived by replacing only one atom of chlorine, may have been mixtures of the unchanged dichloro-compound with the di-anilino etc. compounds. This was however considered unlikely, as these chlorine-containing compounds were definitely crystalline, whereas the compounds which had lost both atoms of chlorine were amorphous.

Note (ii) Various methods for reduction of the nitro-compounds of this series were tried, e.g. iron filings and a little hydrochloric acid in boiling alcohol (West method), iron filings and water, and tin and hydrochloric acid, but all gave unsatisfactory results, probably on account of the high melting-points of the nitro-compounds. The stannous chloride method was by far the most satisfactory.

# THE DECOMPOSITION OF DIAZONIUM BOROFLUORIDES IN THE PRESENCE OF METHYL ALCOHOL

Diazonium borofluorides were prepared from the following bases: *p*-toluidine, *o*-, *m*- and *p*-nitranilines, benzidine and α-naphthylamine, as described by Schiemann (Ber., 1927, 1186) and from *p*-bromo- and *m*-chloro-anilines, β-naphthylamine and 2-nitrobenzidine. All these were decomposed by boiling with excess of methyl alcohol in the presence of sulphuric acid, in the hope that this might be a convenient method for the preparation of ethers, since the diazonium borofluorides, unlike the sulphates, can be thoroughly dried and handled with perfect safety in this condition. The yields were however in most cases not sufficiently good to recommend this process as a method of preparing methyl ethers, considerable amounts of by-products, probably azo-compounds being obtained.

With the nitrobenzenediazonium borofluorides deamination occurred, the *o*-compound giving only nitrobenzene, the *m*-compound giving mainly nitrobenzene, (67%) with a trace of another substance , probably *m*-nitroanisole, and the *p*-compound giving a mixture of 60% of nitrobenzene and 30% of *p*-nitroanisole. These three borofluorides were also remarkable in being very highly crystalline and particularly stable. After several hours boiling with methyl alcohol and sulphuric acid some crystals of borofluoride were recovered unchanged in each case. The results obtained are similar to those of Weida (Am. Chem. J., 1897, 547) who found that decomposition in the presence of methyl alcohol of the diazonium sulphates from the phree nitranilines gave, from the *o*-compound only nitrobenzene, from the *m*-compound 51% of nitrobenzene and a little *m*-nitroanisole and from the *p*-compound 47% of nitrobenzene and 8-17% of *p*-nitroanisole.

The diazonium borofluorides obtained from p-toluidine and p-bromo- and m-chloro anilines also resembled the sulphates in their behaviour (Cameron, Am.Chem.J., 1897, 331; 1898, 229. Bromwell, ibid., 1897, 561)

The decomposition of a diazonium salt in the presence of an alcohol can lead to two reactions: for example with ethyl alcohol,

(I) $RN_2X + C_2H_5OH = RH + C_2H_4O + N_2 + HX$

(II) $RN_2X + C_2H_5OH = ROC_2H_5 + N_2 + HX$

Of these, ether-formation (II) is regarded as the narmal reaction (Cain, "Diazo-compounds", Chap. V, p. 46.), reduction (I) being favoured by (a) increasing molecular weight of the alcohol used and (b) by the presence of acid (i.e. electron attracting) groups, such as $NO_2$, $CO_2H$, halogens, the effect being greatest when such a group is in the o-position to the diazo-group and least when it is in the p-position.

Regarded from the point of view of electronic theories, the effect of such groups should be to stabilise the C--N bond (the nitro-diazonium salts are particularly stable) particularly when this is in the o-position, and also to confer oxidising properties. If the oxidation of the alcohol is a comparatively slow process it may not have time to occur in the case of the more rapidly decomposed salts , e.g. in a toluene derivative containing the electron-repelling methyl-group, hence ether-formation.

The decomposition of p-toluenediazonium borofluoride in excess of p-cresol gave ditolyl ether. Cain,("Diazo-compounds" p.48) mentions the formation of diphenyl ether from diazobenzene sulphate and phenol.

## Preparation and decomposition of p-nitrobenzenediazonium borofluoride.

p-Nitraniline hydrochloride, diazotised in the usual way, gave on addition of hydrofluoroboric acid until precipitation was complete a yield about 86% of the theoretical of the diazonium borofluoride. After being washed with water, alcohol and ether in succession and dried on the water-bath it was a pure white, highly crystalline powder.

70 G. of the borofluoride were added in small amounts at a timeeto a gently-boiling mixture of 500 g. of methyl alcohol and 70 g. of concentrated sulphuric acid. Violent ebullition occurred and the solution gradually turned dark red. After 2 hours boiling the solution was poured into cold, strong brine and extracted three times with ether. The ethereal solution was washed with dilute aqueous alkali to remove phenol, of which only a trace was found to be present. After removal of the ether the red oil was distilled under atmospheric pressure. 10 G. of a pale yellow oil with the odour of nitrobenzene came over between 208-220° (mostly at 210°) and 6 g. of a yellow substance which solidified on cooling came over between 220-268°; this melted at 51-53° and was undoubtedly p-nitroanisole, the m.p. of which is 54°.

The residue in the distilling-flask was a dark-red, tarry substance, from which petroleum ether extracted about 1.5 g. of an orange-yellow powder which melted between 140° and 151°, and after crystallisation from alcohol at 158-160°.

The combined yields of nitrobenzene and nitroanisole represent about 43% of the borofluoride used.

## Preparation and decomposition of *m*-nitrobenzenediazonium borofluoride.

The borofluoride was obtained in about 85% of the theoretical yield by addition of hydrofluoroboric acid to a solution of *m*-nitrobenzenediazonium chloride until precipitation was complete. After being washed successively with water, alcohol and ether and dried on the water-bath it was a white, crystalline powder.

25 G. of the borofluoride were added in small amounts to a gently-boiling mixture of 250g. methyl alcohol and 25 g. concentrated sulphuric acid. There was violent ebullition and the solution turned red. After 1½ hours boiling the solution was allowed to cool overnight. About 6 g. of white crystals were deposited and were found to be unchanged borofluoride. This was put back into the liquid and heating continued for a further ½ hour. The solution was poured into brine and extracted with ether as described on the previous page. Distillation of the red oil obtained after removal of the ether gave 8 g. of nitrobenzene and 1 g. of a substance boiling above 220°, the temperature rising rapidly to 260°; this did not solidify until it was treated with a little alcohol, it then gave a solid (½ g.) m.p. 109-111°, after a second crystallisation from alcohol it had m.p. 123-126° (s. at 115°). It is possible that this fraction contained a little *m*-nitroanisole mixed with the higher-melting substance, but none could be isolated. *m*-Nitroanisole melts at 38°.

A dark-coloured residue remained in the distilling-flask and decomposed with evolution of yellow fumes.

The amount of nitrobenzene obtained corresponded to about 65% of the borofluoride used.

The decomposition of m-nitrobenzenediazonium borofluoride was repeated with a larger quantity, the yield of nitrobenzene was the same as before, but no m-nitroanisole could be isolated. The process was repeated again but using Gattermann copper instead of sulphuric acid, but the result was the same as before. No fluoro-compound was obtained in either case .

It was found more convenient in this and most of the following experiments to remove most of the methyl alcohol, after the reaction, by distillation from the water-bath and then to steam-distil the residue. This avoided the inconvenience of ether-extracting a large volume of aqueous solution and gave the same results as the extraction method.

The red or orange, non-volatile solids obtained in these two decompositions and in those described later were probably azo-compounds.

## Preparation and decomposition of o-nitrobenzenediazonium borofluoride.

The borofluoride, which was similar in appearance to the two isomers already described, was obtained in 82% yield from o-nitraniline hydrochloride in the usual way. The decomposition was carried out as usual, 40 g. of borofluoride being used, with 40 g. of sulphuric acid and 400 g. of methyl alcohol. After 2 hours heating the methyl alcohol was distilled off, the residue was distilled in steam, the distillate extracted with ether and then distilled. 12 G. of nitrobenzene were obtained as the only product, there was no indication that any o-nitroanisole was present. The amount of nitrobenzene obtained corresponded to about 60% of the borofluoride used. A very small amount of red, tarry residue remained in the steam-distillation flask.

These three decompositions were repeated with varying amounts of sulphuric acid and of methyl alcohol, but the results did not vary to any appreciable extent. In no case was any fluoro-compound detected, and only traces of phenols were formed.

Preparation and decomposition of p-toluenediazonium borofluoride.

This was prepared (yield, 65%) and decomposed in the usual way, the solution being heated for 2 hours. The following products were obtained from 70 g. of borofluoride.

19 g., b.p. 170-185° (almost entirely at 177°.)

1 g., b.p. 200-240°.

2 g. non-volatile.

By shaking the ethereal solution of the above with caustic soda solution before distilling 4 g. of p-cresol were obtained.
The product was probably p-cresyl methyl ether, b.p. 175°. The theoretical yield of this would be 41 g.; the yield obtained was therefore about 46%.

35 G. of the above borofluoride were added in small amounts to 170 g. of p-cresol, heated on the water-bath. Violent frothing occurred, fumes of boron trifluoride were evolved and the solution became orange-coloured. The heating was continued for 2 hours, when no more fumes were evolved the excess cresol was removed with aqueous alkali and the residue steam-distilled to free it from coloured substances. 8 G. of a colourless substance, m.p. 48°, were obtained; ditolyl ether melts at 50°. The yield was about 25% of the theoretical.

## Preparation and decomposition of p-bromobenzenediazonium borofluoride.

This was obtained in 81% yield from p-bromoaniline hydrochloride, it was a white, crystalline substance which decomposed at 138° without blackening. 40 G. were heated for 4 hours with 40 g. of sulphuric acid and 400 g. of methyl alcohol, giving a dark-crimson solution. The product was worked up in the usual way and the following fractions were obtained by distillation under atmospheric pressure:

3 G., b.p. 180-212°.

9 G., b.p. 212-217°.

B.p. of bromobenzene, 154-155°.

B.p. of p-bromoanisole, 213-216°.

The product was therefore probably mostly p-bromoanisole, with perhaps a little bromobenzene, but the latter could not be isolated. The theoretical yield of p-bromoanisole, if it were the only product, would be 27 g.

The usual dark-red, non-volatile residue remained .

## Preparation and decomposition of *m*-chlorobenzenediazonium borofluoride.

From *m*-chloroaniline hydrochloride were obtained in the usual way 40 g. of a diazonium borofluoride, which decomposed at 153°. It was a white powder. The yield was 77% of the theoretical.

Decomposition of 40 g. in 400 g. of methyl alcohol and 40 g. of concentrated sulphuric acid gave a dark-red solution, decomposition was slow and heating was continued for 4 hours. Removal of the alcohol and distillation of the residue in steam gave about 1 g. of phenol and 5 g. of an oil which, distilled under atmospheric pressure, boiled at 193-205°, (mainly at 193-197°). A dark-red residue, not volatile in steam, remained. The volatile product was undoubtedly *m*-chloroanisole, b.p. 193-194°. The yield was 20% of the theoretical. No chlorobenzene was obtained.

Preparation and decomposition of β -naphthalenediazonium borofluoride.

Diazotisation of β-naphthylamine hydrochloride and addition of hydrofluoroboric acid gave a dark-brown powder; this was washed with water and then with ether, which removed some of the colour, and dried in a vacuum desiccator. The yield was 75%. When heated on a boiling water-bath it decomposed.

70 G. of borofluoride decomposed with methyl alcohol and sulphuric acid as usual gave 19 g. of methyl β-naphthyl ether, b.p. 273-278°, m.p. 70-71° (true b.p. 274°, true m.p. 72°). This was 49% of the theoretical yield of methyl ether. 4 G. of β-naphthol and some tarry residue were also obtained.

25 G. of the above borofluoride were decomposed in the presence of 125 g. of phenol by heating for 2 hours on the water-bath; the product was steam-distilled giving 5 g. of a colourless substance m.p. 49-50°, this may have been β-phenoxynaphthalene which is described in Beilstein as melting at 45° or 93°. From the non-volatile residue were obtained 2 g. of a colourless substance (by extraction with petroleum ether), m.p. 165-167°. This could hardly have been β:β'-dinaphthyl ether which is described as melting at 105°.

## Preparation and decomposition of α-naphthalenediazonium borofluoride.

The borofluoride was prepared in the usual way from α-naphthylamine hydrochloride, it was washed with water, alcohol and ether and dried in a vacuum desiccator. The yield was 60%. After being washed with ether, which removed much colour, it was a pinkish-fawn colour. An attempt was made to dry it on the water-bath, but it began to change colour and to smell of naphthalene.

20 G. of borofluoride were decomposed in the usual way with 15 g. of sulphuric acid and loo g. of methyl alcohol, the products were:

1 g. α-naphthol.

6 g., b.p. 240-265° (mostly at 258°)

α-Naphthalene methyl ether boils at 258°. Judging by the smell some naphthalene was also present. A considerable amount of tarry residue remained.

The yield of ether was 46%.

## Diphenyl-4:4'-*bis*-diazonium borofluoride.

From benzidine dihydrochloride a pale-green borofluoride was obtained by the usual method. The yield was 88% theoretical.

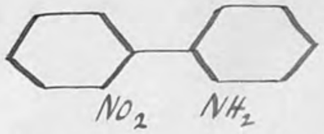
Decomposition of 28 g. was effected by boiling for 3 hours with 25 g. of sulphuric acid and 250 g. of methyl alcohol. On pouring into water a greenish-white, amorphous precipitate was obtained: this was filtered and dried with great difficulty as it formed a kind of gel. The yield of crude material was 12 g., being 75% of the theoretical yield of 4:4'-dimethoxydiphenyl, but it was probably not quite dry.

The decomposition of this borofluoride in ethyl alcohol was also attempted. 70 G. of borofluoride gave 8 g. of a white solid, m.p. 58-60°, presumably diphenyl, and a large residue of brown tar.

## 2-Nitrodiphenyl-4:4'-*bis*-diazonium borofluoride.

A borofluoride was prepared in 68% yield from 2-nitrobenzidine hydrochloride, it was pale yellow and decomposed at 142°. Attempts to deaminate this by decomposition in ethyl alcohol gave a small amount of phenol and a large residue of tar. Decomposition in methyl alcohol gave a similar result.

Preparation of 2-nitro-2'-aminodiphenyl.



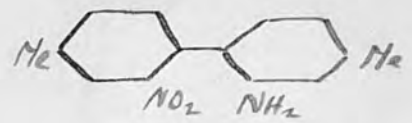
10 G. of 2:2'-dinitrodiphenyl were dissolved in 200 cc. of absolute alcohol, 60 cc. of .880 ammonia were added, the mixture was heated (not to boiling) on the water-bath and hydrogen sulphide was passed in for 1 hour. The mixture was then boiled for 10 minutes, when precipitation of sulphur occurred: this was filtered off and the alcohol was removed by distillation. The residue was extracted with hot, fairly strong hydrochloric acid and the acid solution diluted and filtered to remove some dark-coloured, sticky substance, on cooling a further small amount of this substance appeared and was filtered off. Ammonia was added to the solution until alkaline and the resulting oil was extracted with ether. The dark-coloured, semi-solid product remaining after the ether had been distilled off was recrystallised twice from aqueous alcohol in the presence of charcoal and finally from petroleum ether ( 80-100°), giving bright yellow needles, m.p. 72-73°. The yield was 3 g.

The acetyl derivative was obtained by treatment of the base with acetic anhydride and crystallised from aqueous alcohol in almost colourless plates, m.p. 161-163°.

Mascarelli and Gatti (Gazzetta, 1929, 858) described 2-nitro-2'-aminodiphenyl as an oil and its acetyl-derivative as having m.p. 145-146°.

On repeating this preparation it was found easier to convert the impure base into the acetyl-derivative and to purify this by crystallisation in the presence of charcoal, the base being finally obtained by hydrolysis.

Preparation of 2-nitro-2'-aminoditolyl.



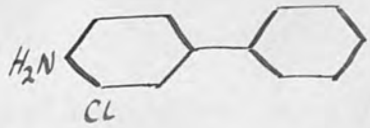
This base is described by Mascarelli and Gatti (A ., 1930, 205) as an oil.

The method was the same as that described on the previous page; 6 g. of 2:2'-dinitroditolyl were dissolved in 120 cc. of absolute alcohol, 30 cc. of .880 ammonia were added, the mixture was warmed (not to boiling) on the water-bath and hydrogen sulphide was passed for one hour. The orange -red solution obtained by extraction of the product with hot, fairly strong hydrochloric acid was filtered to remove some sticky substance. The free base was liberated as a red oil which was treated with acetic anhydride, giving a solid acetyl-derivative which was light-brown in colour and melted at 143-145°. Recrystallisation from aqueous acetic acid in the presence of decolourising charcoal gave a pale-yellow substance which formed rectangular needles, m.p. 149-150°. 2 G. of acetyl-derivative were obtained. From the acid-insoluble residue 3 g. of unchanged 2:2'-dinitroditolyl were recovered.

The acetyl-derivative was hydrolysed by boiling with concentrated hydrochloric acid. Addition of ammonia to the clear, pale-yellow solution of the hydrochloride precipitated a bright-yellow substance which was not crystalline and became gummy when filtered. Attempts to cause the base to crystallise were unsuccessful but it was too viscous to be described as an oil. The hydrochloride formed small, almost colourless rhombohedra.

# THE PREPARATION OF 3:4- AND 2:5-DICHLORODIPHENYLS.

## Preparation of 3-chloro-4-aminodiphenyl.



4-Nitrodiphenyl, obtained by nitration of diphenyl (Bell, Kenyon and Robinson, J., 1926, 1239) was added to a mixture of twice its weight of iron filings with a little water and a few drops of acetic acid, heated on a boiling water bath. A vigourous reaction occurred, the mixture was heated with continuous stirring until the frothing abated (about ½ hour). The base was then extracted from the iron with boiling alcohol, a few drops of ammonia having previously been added, and was purified by recrystallisation of its hydrochloride from water. The free base was treated with acetic anhydride, giving 4-acetamidodiphenyl, 50 G. of which were dissolved in 1½ litres of cold glacial acetic acid in the presence of 1 molecular proportion of fused sodium acetate. A solution of 18 g. (2 molecular proportions)of chlorine in 250 cc. of glacial acetic acid was added with stirring; no rise in temperature was observed and no precipitation. The solution was left to stand until the smell of chlorine had gone, and was poured into excess of water. 56G. of a solid melting between 120° and 130° were obtained: this crystallised from alcohol in almost coloiurless needles, leaving a red mother-liquor. A second crystallisation gave 26 g. of pure 3-chloro-4-acetamidodiphenyl, m.p. 147° .

(Scarborough and Waters, J., 1927, 1132)

Hydrolysis was effected with 75% sulphuric acid which seemed to cause some sulphonation. 15 G. of 3-chloro-4-aminodiphenyl were obtained . After recrystallisation from petroleum ether and further purification by recrystallisation of the hydrochloride from water it melted at 68-70°.

## Preparation of 3:4-dichlorodiphenyl..

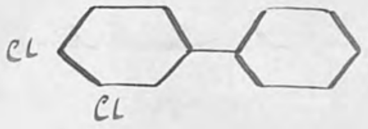
Scarborough and Waters (J., 1926, 557) mention the preparation of this compound "from the amine by the usual methods" but do not give experimental details.

(i) Gattermann reaction.

3-Chloro-4-aminodiphenyl was dissolved in 2½ molecular proportions of hydrochloric acid diluted with ¾ its volume of water and treated with 1 molecular proportion of sodium nitrite, giving a bright-yellow solution. The diazo-solution was treated with freshly precipitated copper but decomposition was extremely slow. The diazonium salt appeared to be remarkably stable, after being heated for 10 minutes with the copper on a boiling watwr-bath and then left to stand overnight it still showed, by coupling with β -naphthol, that undecomposed diazonium salt was present. A fresh lot of Gattermann copper was added and the mixture was heated 1 hour on the water-bath, when all the diazonium salt was found to be decomposed. The dark-yellow, solid product was filtered, dissolved in carbon tetrachloride to separate it from copper and the solvent removed by distillation. The residue was an orange-red, insoluble, high-melting powder which contained chlorine but no nitrogen: it was probably a dichlorobenzerythrene.

It was thought that the Sandmeyer method might give better results than the Gattermann, since the more intimate mixture of the diazo-solution with the reagent should give a better chance of decomposition without the application of heat. This was found to be the case.

## Preparation of 3:4-dichlorodiphenyl.



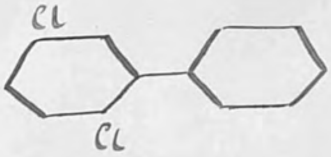
(ii) Sandmeyer method.

3-Chloro-4-aminodiphenyl was converted into the diazonium chloride as described on the previous page and the diazo-solution was poured into a solution of freshly-prepared cuprous chloride in hydrochloric acid. The mixture was well stirred and left for 1 hour, when the evolution of nitrogen, never vigorous, ceased. It was heated for 10 minutes on the water-bath to ensure complete decomposition. An orange-red oil was deposited which was steam-distilled, giving a pink oil which very readily solidified. This was melted under caustic soda solution, stirred until it solidified and filtered. When crystallised from aqueous alcohol it still had a pink colour and melted at 45-46°. It was redistilled in steam to remove the pink colour which was due to splashing in the first distillation. When recrystallised from aqueous alcohol it formed colourless needles having the melting-point given by Scarborough and Waters , 46-47°.

The yield was 41 % of the theoretical.

A considerable quantity of red substance remained in the flask after the first steam-distillation.

Preparation of 2:5-dichlorodiphenyl.



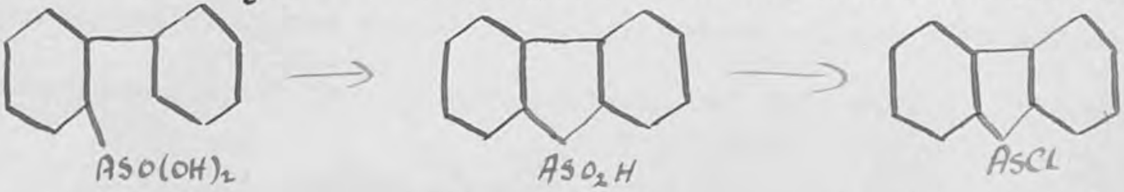
5-Chloro-2-aminodiphenyl was dissolved in 2½ molecular proportions of hydrochloric acid diluted with ½ its volume of water, and treated with sodium nitrite in the usual way (1 molecular proportion). A dark-green colour appeared momentarily as the nitrite was added. The resulting diazo-solution was yellow. It was poured into a solution of freshly-prepared cuprous chloride in hydrochloric acid, giving a dark-red oil. Distillation in steam gave a pale pinkish yellow oil which was extracted with ether. The ethereal solution was shaken with dilute aqueous alkali which removed most of the colour. The solution was dried over calcium chloride, the ether removed by distillation and the residue distilled under reduced pressure, giving a very pale yellow liquid which boiled at 172-174° at 12 mm. Hg. It could not be made to solidify.

The yield was 67 % of the theoretical.

De Crauw, (Rec. Trav. Chim., 1931, 1283) describes this compound as boiling at 182° at 3 mm. Hg.

Preparation of ditolyl arsenious acid.

Nicklin, Lees, Aeschlimann and McClelland, (J., 1925, 66 ) describe the preparation of diphenylyl-*o*-arsinic acid (I) from 2-aminodiphenyl, and its conversion into *o*;*o*'-diphenylylene arsinic acid (II)by the action of concentrated sulphuric acid, both (I) and (II) being converted by theaction of sulphur dioxide in CHCl$_3$/HCl in the presence of an iodide into chlorides.



(I), m.p. 205°.　(II) m.p. 290°.　(III) m.p. 161°.

An attempt was made to apply the methods of these authors to the preparation of the corresponding arsenic derivatives of 4:4'-dimethyl diphenyl.

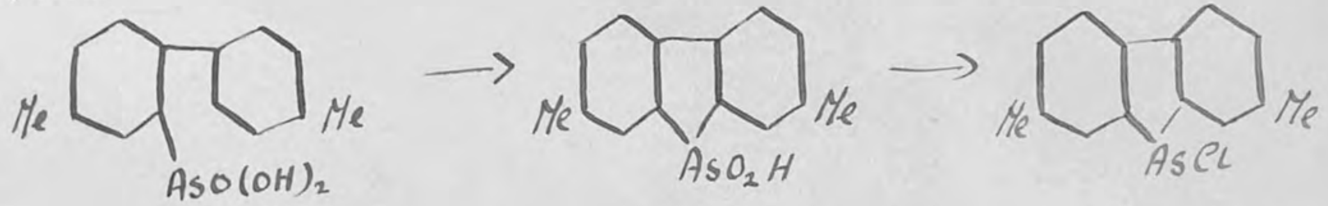
25 G. of 2-aminoditolyl were dissolved in a mixture of 14 cc. of concentrated hydrochloric acid and 100 cc. of water by heating, the solution was cooled and stirred and a further 20 cc. of hydrochloric acid added, causing immediate precipitation of the hydrochloride in a finely divided state. A solution of 8.5 g. of sodium nitrite in 25 cc. of water was added slowly to the suspension which was cooled in a freezing mixture. A dark-yellow diazo-solution was formed from which some tarry matter separated and was removed by filtration. The solution was added slowly, with continuous stirring to a solution of 25 g. of arsenious oxide and 140 g. of sodium carbonate in 120 cc. of water at 45°. A solution of 2.5 g. of crystallised copper sulphate in the least amount of water was added in small amounts from time to time to the reaction mixture. There was much effervescence and a large quantity of dark-coloured tar separated. This was filtered, washed

with water and pressed. The filtrate was acidified with hydrochloric acid to precipitate the arsenic acid, which was a white powder. The preparation was repeated several times; the yields were variable but always very low , (considerably lower than from 2-aminodiphenyl). The best yield obtained was 6 g. of acid from 25 g. of amino-compound. When the preparation was repeated with 50 g. of base the yield was only 4 g.

The method was varied by almost neutralising the diazo-solution with sodium bicarbonate before adding to the arsenic solution, but this gave ho improvement.

The acid (I) thus obtained underwent ring-shutting in the presence of cold, concentrated sulphuric acid, the acid (II) being a white powder.

By the action of sulphur dioxide on a suspension of (II) in hydrochloric acid and chloroform in the presence of an iodide a chloroarsine (III) was prepared.



(I) m.p. 210°

(II) m.p. 298° (decomp.)

(III) m.p. 148-9°

The investigation was abandoned owing to the poor yields obtained in the arsenic coupling.

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Elizabeth E. V. [illegible]