CCCXIII.—*The Fission of Some Methoxylated Benzophenones.*

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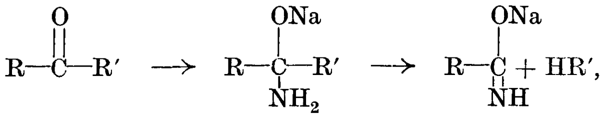
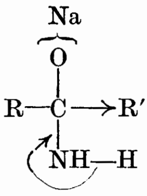
THE study of the nitration of catechol and quinol dialkyl ethers gave results which Allan, Oxford, Robinson and Smith (this vol., p. 401) found to be in harmony with a theory of general and alternating polar effects of substituents due to electron displacements of three types. These are (1) a general unidirectional displacement experienced in a particular chain of atoms, (2) a similar general displacement distributed over the molecule, and (3) a displacement which involves co-valency changes and which, in conjunction with the tendency for electronic configurations of the atoms to be retained undisturbed, is responsible for alternating polarity effects in conjugated systems. We have now investigated the direction of fission of the unsymmetrical benzophenones containing phenyl, *m*-methoxyphenyl, anisyl, and veratryl groups, and in considering the subject we propose to employ the above-mentioned electronic theory. When our experiments were nearing completion, Schönberg, Abelsdorff, Kirchrath, Malchow, and Rosenbach (*Annalen*, 1924, **436**, 205) published an account of an investigation of the fission of various substituted benzophenones by means of sodamide, a reaction first observed by Haller and Bauer (*Compt. rend.*, 1908, **147**, 824). The suggested mechanism of the reaction (Schönberg) was

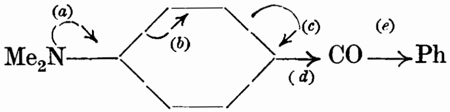


$$\mathrm{R{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}R'} \longrightarrow \mathrm{R{-}\underset{\underset{\displaystyle NH_2}{|}}{\overset{\overset{\displaystyle ONa}{|}}{C}}{-}R'} \longrightarrow \mathrm{R{-}\underset{\underset{\displaystyle NH}{\|}}{\overset{\overset{\displaystyle ONa}{|}}{C}} + HR'},$$

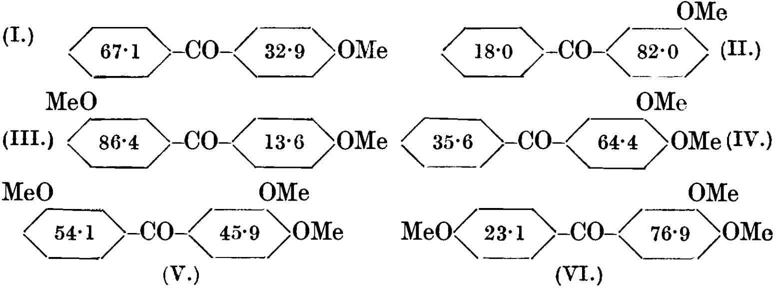
and with this we are in full agreement. The electronic changes



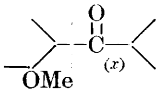
nvolved in the final phase are illustrated in the annexed expression in which the chief points involved are (1) that the free energy of the anion is reduced as the result of the formation of the carboxylamide group (compare Robinson, *Ann. Report*, 1923, **20**, 118, for a similar consideration relating to the benzil–benzilic acid transformation) and (2) that the group R′ retains possession of the electrons covalently held with carbon, and hydrogen is removed from the amino-group as a proton. It follows that $R{\cdot}CO{\cdot}NH_2$ and R′H should be obtained in relatively greater amount than $R'{\cdot}CO{\cdot}NH_2$ and RH if (*a*) $R{\cdot}CO{\cdot}NH_2$ is a stronger acid than $R'{\cdot}CO{\cdot}NH_2$, the comparison being almost certainly parallel with that of the corresponding carboxylic acids, and if (*b*) R′ adheres to electrons more tenaciously than R. The factors work in opposite directions and from the data already accumulated it is clear that (*a*) is of small significance compared with (*b*), a circumstance which is doubtless connected with the irreversible character of the reaction under the conditions obtaining. For example, in phenyl *tert.*-butyl ketone the general effects of the methyl and phenyl groups are represented in the expression $Ph\leftarrow CO\leftarrow C\leftarrow Me_3$, and it is obvious that this harmonises, so far only as (*b*) is concerned, with the production of benzene and trimethylacetamide from the ketone by the action of sodamide (Haller and Bauer, *Compt. rend.*, 1909, **148**, 70). In the case of *p*-dimethylaminobenzophenone there are electronic displacements due to conjugation (*a, b, c*) :

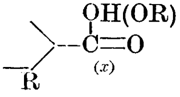


The increased density of electrons associated with the carbon atom in the *p*-position to the dimethylamino-group must tend to repel (*d*) those which are covalently held with the carbonyl carbon. The process (*e*) is thus favoured and therefore the chief products should be, as they are in fact (Schönberg, *loc. cit.*), *p*-dimethylaminobenzamide and benzene. Only one case is known which presents difficulty from the above point of view : Haller and Benoist [*Ann. Chim.*, 1922, (ix), **17**, 25] found that benzoyl*cyclo*propane is decomposed by sodamide in moist benzene with the formation of benzamide and *cyclo*propane. Evidently the *cyclo*propyl group has a strong tendency to retain its electrons, but, although this is unexpected, it should be recognised that our knowledge of the effects produced by the *cyclo*propyl group is not extensive. Haller and Benoist observed similar results with 1-benzoyl-1-methyl*cyclo*propane but 1-benzoyl-1-benzyl*cyclo*propane gave benzene and 1-benzyl*cyclo*propane-1-carboxylamide. Turning to the methoxybenzophenones, the effect of a *p*-situated group may be considered from the point of view already exemplified in the case of the *p*-dimethylamino-group, whilst, on the other hand, the *m*-methoxyphenyl group has a greater attraction for electrons than phenyl has (compare Oxford and Robinson, this vol., p. 385). The electronic theories accordingly lead us to anticipate that the bond between *p*-methoxyphenyl and carbonyl will be less readily broken than that between phenyl and carbonyl and that the latter bond will be less readily broken than the bond between *m*-methoxyphenyl and carbonyl. The results are given in the following scheme as percentage fissions of the bonds connecting the respective groups to carbonyl and it will be seen that the main conclusions are amply justified.



The results are tolerably consistent with one another, since the groups concerned range themselves in the same order whichever is taken as the standard of comparison. We fully concur with Schönberg and his collaborators in regard to the fundamental soundness of their method of calculation of limiting values dependent on the yields obtained, but we have taken the view that the losses are due to incomplete reaction and to side-reactions of the benzophenones rather than of their fission products. We have carefully avoided loss of the fission products and the use of methods of isolation which could lead to a separation. Finally, we have observed once more the overwhelming effect of an *o*-substituent. 2-Methoxybenzophenone, and 2 : 4- and 2 : 5-dimethoxybenzophenones gave almost pure benzamide on decomposition with sodamide. The bond which is broken is that which attaches the carbonyl to the group bearing the *o*-substituent, and it is the bond (*x*) which is relatively strengthened.





Steric hindrance often appears to operate in this manner, and in the annexed figure the case of the *o*-substituted benzoic acids (esters) is represented for comparison.

EXPERIMENTAL.

It was found best to make no attempt, by the use of a large excess of sodamide or a prolonged period of reaction, to bring about the decomposition of the whole of the benzophenone derivative. The following conditions were employed in all cases. A solution of the ketone (10 g.) in purified toluene (75 c.c.), to which powdered sodamide (4 g.) had been added, was boiled under reflux for 2—3 hours. After the addition of dilute aqueous sodium hydroxide, the mixture was boiled until ammonia was no longer evolved, then steam-distilled, cooled, and filtered. The filtrate was concentrated and the acids precipitated, collected, washed, dried in a vacuum, and analysed, usually by a determination of methoxyl content. In this way 4-methoxybenzophenone (I) gave 4·6 g. of mixed acids (Found : MeO, 14·6, 14·7%, whence anisic acid in mixture = 71·6, 71·9%). A mixture containing 71·8% of anisic acid and 28·2% of benzoic acid contains 67·1% *molecules* of anisic acid and 32·9% *molecules* of benzoic acid. The other figures quoted in the introduction have been similarly calculated. The acid fission products from 2-methoxybenzophenone (Stoermer and Friderici, *Ber.*, 1908, **41**, 332), from 2 : 4-dimethoxybenzophenone (König and Kostanecki, *Ber.*, 1906, **39**, 4028) and from 2 : 5-dimethoxybenzophenone (Kauffmann and Grombach, *Ber.*, 1905, **38**, 796) were in each case proved to be almost pure benzoic acid. Moreover, the fission under the standard conditions proved difficult in these examples and the yields were poor. 4-Cyanobenzophenone (Ahrens, *Ber.*, 1887, **20**, 2957) gave no trace of benzoic or terephthalic acids, but only 4-benzoylbenzoic acid.

3-*Methoxybenzophenone* (II).—Ullmann and Goldberg (*Ber.*, 1902, **35**, 2814) obtained this substance from *m*-methoxybenzoyl chloride and benzene in the presence of aluminium chloride, but this method is unsatisfactory owing to the auto-condensation of the acid chloride to anthracene derivatives. Phenyl-3-methoxyphenylcarbinol was obtained as an oil (yield 90%) from *m*-methoxybenzaldehyde and phenyl magnesium bromide in the usual manner. The carbinol (50 g.) was oxidised at below 50° for 2 hours by means of a solution of hydrated sodium dichromate (100 g.) and sulphuric acid (80 g.) in water (500 c.c.). The product was collected by means of ether, freed from adhering oil, and crystallised from light petroleum (m. p. 38°; yield 25%). The mixed acids (4·5 g.) which were obtained by decomposition with sodamide and subsequent hydrolysis consisted of benzoic and *m*-methoxybenzoic acids (Found : MeO, 4·4, 4·4%, whence *m*-methoxybenzoic acid = 21·5%).

Fission of 3 : 4-*Dimethoxybenzophenone.*—The ketone, m. p. 103°, was prepared by the method of Bruggemann (*J. pr. Chem.*, 1896, **53**, 253) and, on fission, 4·5 g. of a mixture of benzoic and veratric acids were obtained (Found : MeO, 15·4, 15·4%, whence veratric acid = 45·2%).

3 : 4′-*Dimethoxybenzophenone* (III).—Powdered aluminium chloride (40 g.) was gradually added with cooling to a mixture of *m*-methoxybenzoyl chloride (40 g., b. p. 242—3°/733 mm.), anisole (30 g.) and carbon disulphide (30 c.c.). The reaction was completed by gentle heating on the steam-bath and the product isolated in the usual manner (yield, 20 g.). 3 : 4′-*Dimethoxybenzophenone* crystallised from alcohol in colourless, rhombic prisms, m. p. 55° (Found : C, 74·4; H, 6·1. $C_{15}H_{14}O_3$ requires C, 74·4; H, 5·8%). The acid mixture (4·3 g.) obtained in the sodamide fission consisted of *m*-methoxybenzoic and anisic acids and had f. p. 174·4°. From the data given below it follows that this is the f. p. of a mixture containing 86·4% of anisic acid and 13·6% of *m*-methoxybenzoic acid.

Mixtures of Anisic Acid and m-*Methoxybenzoic Acid.*

% Anisic acid	100·0	96·81	94·5	92·08	88·84	86·44	82·85
F. p.	183·0°	181·0°	179·6°	178·1°	176·1°	174·5°	172·2°

The corresponding graph is a straight line.

3 : 4 : 3′-*Trimethoxybenzophenone* (V).—This substance was prepared by the method described above for 3 : 4′-dimethoxybenzophenone, substituting veratrole for anisole. It was distilled under diminished pressure and then crystallised from methyl alcohol in small, colourless needles, m. p. 83—84° (Found : C, 70·3; H, 6·2. $C_{16}H_{16}O_4$ requires C, 70·6; H, 5·9%). The *oxime* crystallises from alcohol in rhombic prisms, m. p. 128°. The fission experiment gave 2·8 g. of the mixed acids (Found : MeO, 28·4, 28·5%, whence veratric acid = 58·5%) and a considerable amount of the ketone was recovered unchanged.

3 : 4 : 4′-Trimethoxybenzophenone (VI) (Kostanecki and Tambor, *Ber.*, 1906, **39**, 4026) gave 4·0 g. of the mixed acids (Found : MeO, 24·0, 24·0%, whence veratric acid = 26·4%).

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