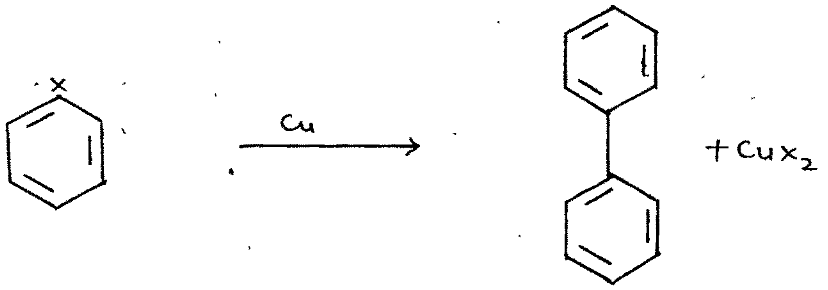
Part III

THEORETICAL

Ullmann reaction on some iodochromones and flavones : Synthesis of some bichromonyls, biflavonyls and 8-phenyl derivatives of 7-methoxy-2-methylchromone and 7-methoxyflavone

Ullmann reaction involves the removal of ~~a~~ halogen atoms from aromatic halocompounds by the use of copper bronze with the resulting union of two carbon atoms, giving biaryls.

This reaction is of general applicability and is of considerable help in the preparation of many symmetrical and unsymmetrical biaryls, which would otherwise be difficult to obtain. Ullmann reaction has been reviewed by Fanta (Chem. Revs., 1946, 38, 139).

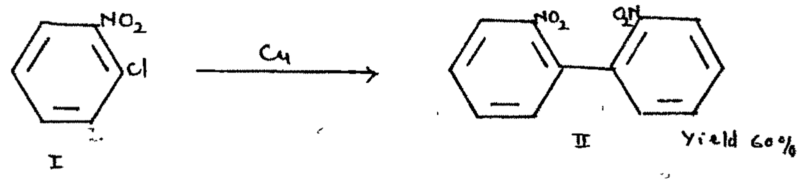


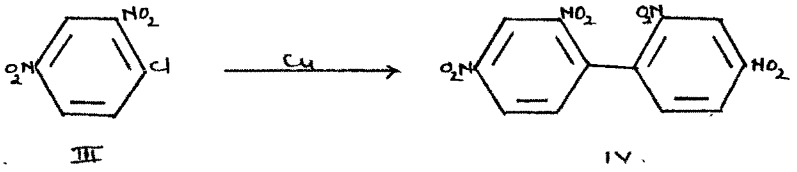
X = Cl, Br or I

The success of the Ullmann reaction is dependent upon the nature of the aromatic halide. It has been observed that chlorine, bromine and iodine may be eliminated with biaryl formation. Fluorine atom in the aromatic nucleus has not been reported to be active in the Ullmann reaction. The order of reactivity of halogens is I > Br > Cl . In general the latter two substituents undergo the reaction only when activating groups are present in the aromatic nucleus.

Ullmann (Ann., 1904, 332, 38) observed decrease in yield of biaryls when groups such as $-NH_2$, $-NHCOCH_3$, $-COOH$ and $-OH$ are present in the aromatic nucleus, because they give rise to amination, decarboxylation or ether formation as a side reaction. The amino groups must be protected by alkylation or acylation, the carboxyl group by esterification and the hydroxyl group by etherification.

The electronegative groups in the ortho and para-positions with respect to the halogen atom are found to activate the molecule. The nitro group is the most effective activator. Thus Ullmann (Ber., 1901, 34, 2174) obtained the biaryls (II and IV) by carrying out the reaction in nitrobenzene in good yield from different o-nitro derivatives of chlorobenzene (I and III).





Bulky substituents in ortho positions adjacent to the reactive halogen hinder biaryl formation. Thus Ullmann

(Ann., 1904, 332, 387) obtained the biaryl derivative from 2,4,6-trichloro-iodobenzene in 52 % yield but the yield of the biaryl derivative from 2,4,6-trimethyl-iodobenzene was poor.

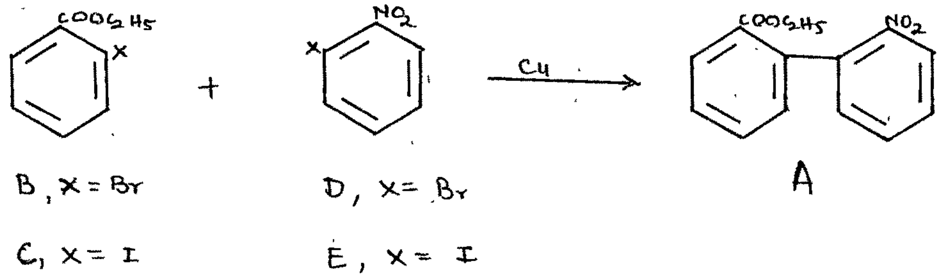
Mascarelli and Ravera (Gazz. Chim. Ital., 1938, 68, 33 ; C.A., 1938, 32, 4565) studied the Ullmann reaction with a great variety of aromatic compounds and determined the amount of activation required in order that the Ullmann reaction may occur.

The generalisations regarding the effect of substituents on the Ullmann reaction on derivatives of benzene may be applied to other aromatic compounds according to the usual concepts of aromaticity.

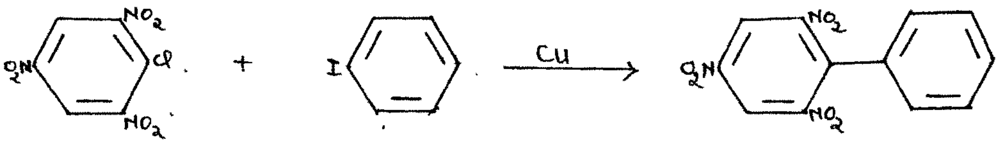
This reaction has been applied with considerable success to the synthesis of unsymmetrical biaryls. In addition to the consideration of the previously discussed conditions, the synthesis of an unsymmetrical biaryl requires the selection of an optimum ratio of the two component starting materials.

$$RX + R'X' \longrightarrow RR + RR' + R'R'$$

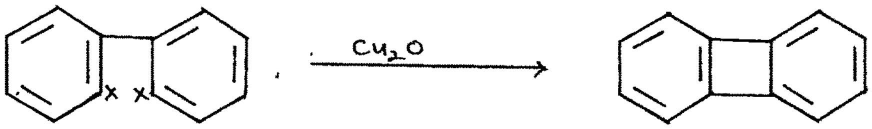
In the reaction if one of the components, say RX, is more reactive, then it would be completely used up in the formation of RR. When the reaction is continued for a longer time or under more drastic conditions, another component, R'X' reacts to give R'R'. Thus symmetrical biaryls are the only products of the reaction. In such a case the formation of RR' may be favoured by changing either -X or - X' in the starting materials so that aromatic halides are of equal reactivity, for example, Sadler and Powell (J. Amer. Chem. Soc., 1934, 56, 2650) obtained (A) from (B) and (E) in 20 % yield; while Stewart and co-workers (J. Chem. Soc., 1944, 71) obtained it in 68 % yield from (C) and (D). In the latter case both the components are of more nearly equal reactivity, since the lower activity of bromine as compared to iodine is compensated by the greater activation effect of the nitro group as compared to the carboethoxy group.



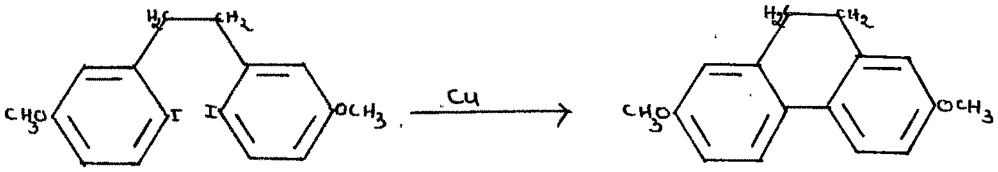
The success of such a reaction also depends on the feasibility of separating the desired product from the symmetrical biaryls. This may be accomplished if the chemical or physical properties of the biaryls differ sufficiently. Another condition which favours the unsymmetrical biaryl formation is the presence of an excess of less reactive component. Rule and Smith (J. Chem. Soc., 1937, 1096) studied the reaction of picryl chloride and iodobenzene and obtained 2,4,6-trinitrodiphenyl as the only detectable product.



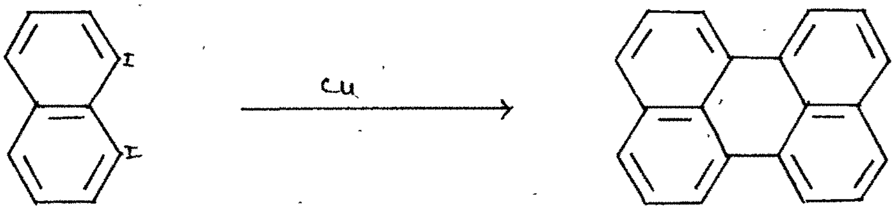
Several intramolecular Ullmann reactions have also been reported in literature. Lothrop (J. Amer. Chem. Soc., 1941, 63, 1187 ; 1942, 64, 1698) synthesised biphenylene and several of its derivatives by the treatment of appropriately substituted 2,2'-dihalogen biphenyls with cuprous oxide.



Cornforth and Robinson (J. Chem. Soc., 1942, 684) synthesised 2,7-dimethoxy-9,10-dihydrophenanthrene by intramolecular Ullmann reaction on appropriately substituted dibenzyl derivative.



Cyclic products may also be obtained when polyhalogenated compounds are subjected to the conditions of Ullmann reaction. Thus Scholl et al. (Ber., 1910, 43, 2202) obtained perylene from 1,8-diiodonaphthalene.



As regards the experimental conditions copper bronze has long been one of the most commonly employed forms of the metal. Brady and McHugh (J. Chem. Soc., 1923, 2047) successfully used freshly precipitated copper. This was prepared by treatment of zinc dust with copper sulphate solution followed by washing with alcohol and ether and drying. However Ullmann (loc. cit.) and Schreiner (J. Prakt. Chem., 1910, 81, 422) observed that mechanically pulverised copper was preferable to the chemically precipitated copper. Kleiderer and Adam~~e~~s (J. Amer. Chem. Soc., 1933, 55, 4219) recommended activation of copper bronze by treatment with iodine in acetone followed by washing with hydrochloric acid and acetone and drying in a desiccator. They state that ordinary copper bronze at times gives poor results in the Ullmann reaction, this simple treatment ensures more uniform results and frequently makes possible a more rapid reaction at a lower temperature,

A generous excess of copper is always used in the Ullmann reaction. Since the reaction is exothermic only a small portion of the copper is placed in the reaction mixture at the outset, the remainder of the metal is added in small portions during the course of the reaction. The temperature employed in the Ullmann reaction varies from 100-360° depending upon the activity of the aromatic halide. Reactions of the compounds containing the nitro group must not be carried out at a temperature exceeding 240°, otherwise reduction of the nitro group by the copper occurs. Usually the exothermic reaction may be moderated by the use of a diluent. The organic substances used as diluents are nitrobenzene, p-cymene, biphenyl, anthracene and diphenyl ether. Sand has also been employed as a diluent. Mann~~ed~~ and his co-workers (J. Chem. Soc., 1940, 1379) reported improvement in yield when the reaction was carried out in an atmosphere of nitrogen. Copper powder added to the reaction mixture rapidly settles to the bottom of the reaction vessel and must be stirred to expose the active surface of the metal.

Mechanism

Rapson and Shuttleworth (Nature, 1941, 147, 675) suggested the possibility of a free radical mechanism for this reaction. However, in all cases in which the Ullmann reaction has been carried out in the usual way, biaryl bond formation was observed to occur at the carbon atom from which a reactive halogen atom had been displaced. Since the existence of the free radical intermediate would be expected often to lead to a variety of products, it cannot be considered a plausible mechanism for the normal reaction. Gilman and Straley (Rec. Trav. Chim., 1936, 55, 821) who studied the preparation and reaction of organocopper compounds pointed out that although R-Cu compounds are known to undergo coupling to yield RR compounds , it is not known whether the organocopper compound of this type is formed as an intermediate in the Ullmann reaction. An R_2-Cu compound has also been suggested as a possible intermediate in the coupling reaction but there is no experimental evidence for the existence of such a compound.

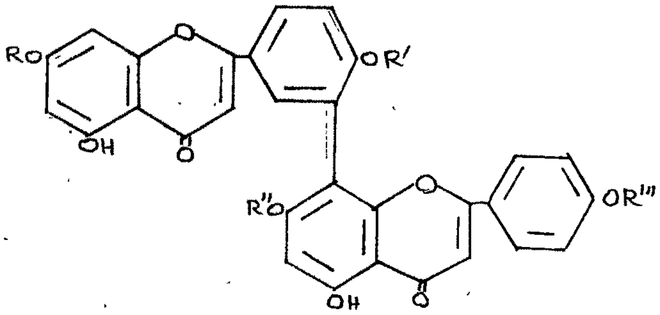
A possible mechanism of the reaction suggested by Fanta (loc. cit.) consists of two consecutive steps (i) a nucleophilic reaction of copper with the aromatic halide to form an activated complex at the metal surface. The occurrence of this step is governed largely by the nature of the aromatic halide, and (ii) the reaction of the activated complex with a second molecule of aromatic halide to form a biaryl molecule plus copper halide. This reaction is governed by steric effects to a greater extent.

Synthesis of bichromonyls, biflavonyls and phenyl chromones and flavones

Chen and Liu (J. Taiwan Pharm. Soc., 1953, 5, 53 ; C.A. 1955, 49, 5464) synthesised 3,3'-biflavonyl by the Ullmann reaction on 3-bromoflavone. They further reported that the Ullmann reaction on 6-bromo-, 7-bromo-, 4'-iodo- and 6-bromo-4'-methoxy flavanol derivatives did not succeed. Mahesh and Seshadri (J. Chem. Soc., 1955, 2503) obtained a biflavonyl derivative as a by-product in the oxidation of 5,7,4'-triacetoxyflavanone with Fenton's reagent in acid medium by dehydrogenative coupling in the 3-position. Chen et al. (Proc. Chem. Soc., 1959, 232) have synthesised symmetrical biflavonyls from ~~3-bromo-~~, 6-iodo-, 6-iodo-4'-methoxy-, 7-iodo-, 7-iodo-4'-methoxy-, 8-iodo-, 8-bromo-, 8-chloro-, 3'-iodo- and 4'-iodo-flavone derivatives by the Ullmann reaction. Very recently after the present work was complete Jurd (Chem. and Ind., 1961, 322) reported the synthesis of 7,7'-dimethoxy-8,8'-biflavonyl and 7,7',4,4'-tetramethoxy-8,8'-biflavonyl from the corresponding

8-iodoflavone derivatives by the Ullmann reaction.

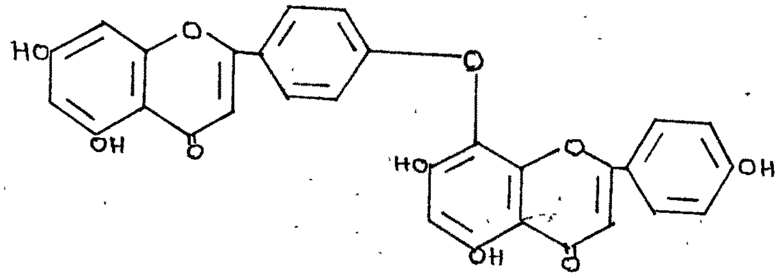
The interest in this field has increased in recent years because of the discovery that biflavonyl derivatives occur in nature. Thus Sotetsuflavone, Ginkgetin, Isoginkgetin Kayaflavone and Sciadopitysin isolated from various plants have been found to be biflavonyl derivatives, with carbon-carbon linkage, by degradation, spectroscopic and other evidences (Furukawa, Sci. Papers. Inst. Phys. Chem. Res. Tokyo, 1932, 19, 27; 1933, 21, 278 ; Nakazawa, J. Pharm. Soc. Japan, 1941, 61, 174, 228 ; Kariyone and Kawano, J. Pharm. Soc., Japan, 1956, 76, 448 etc ; Baker et al. Proc. Chem. Soc., 1959, 91, 269 ; Kawano and Yamada, Yakugaku Zasshi, 1960, 80, 1576 ; C.A., 1961, 55, 10424).



	R	R'	R''	R'''
Sotetsuflavone	H	H	H	H
Ginkgetin	Me	Me	H	H
Isoginkgetin	H	Me	H	Me
Kayaflavone	H	Me	Me	Me
Sciadopitysin	Me	Me	H	Me

Hinokiflavone isolated from the leaves of

Cryptomeria japonica has been shown to be a biflavonyl ether (Fukui and Kawano J. Amer. Chem. Soc., 1959, 81, 6331)



Hinokiflavone

No. bichromonyls appear to have been reported so far in literature.

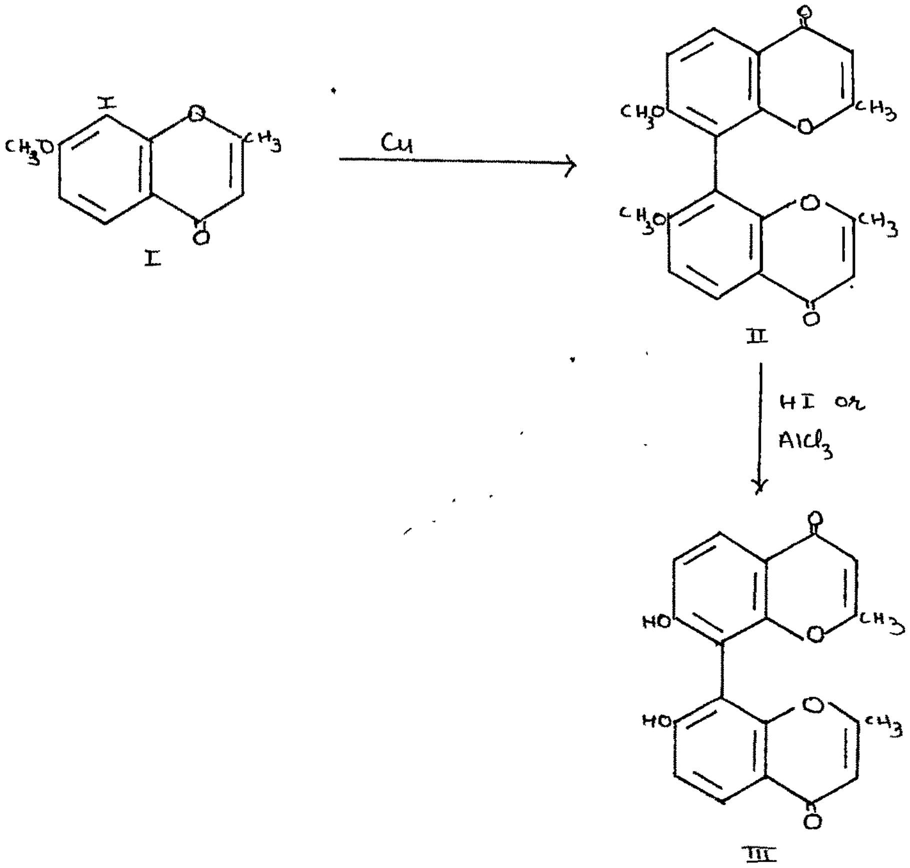
Only a couple of chromones with a phenyl substituent in the benzenoid part have been reported. Watson (J. Chem. Soc., 1916, 109, 305) reported the synthesis of 8-phenylchromone-2-carboxylic acid from 2-diphenylyloxyfumaric acid by sulphuric acid treatment. Later Cheetham and Hey, (J. Chem. Soc., 1937, 770) reported the synthesis of 6-phenyl-3-acetyl-2-methylchromone by the Kostanecki-Robinson acetylation of 4-hydroxy-3-acetylbiphenyl. The same authors reported the synthesis of 6-phenyl-2-methylchromone by the cyclisation of the β-diketone obtained by condensation of 4-hydroxy-3-acetylbiphenyl with ethyl acetate and sodium.

Symmetrical bichromonyls and biflavonyls have now been synthesised by the Ullmann reaction on 8-iodo- and 6-iodo-7-methoxy-2-methylchromone, 7-methoxy-8-iodoflavone and 7-methoxy-6-iodo-3-benzoylflavone. 8-Phenyl derivatives have been obtained from 7-methoxy-8-iodo-2-methylchromone and 7-methoxy-8-iodoflavone by the crossed Ullmann reaction with iodobenzene.

Ullmann reaction on 7-methoxy-8-iodo-2-methylchromone

7-Methoxy-8-iodo-2-methylchromone (I) when subjected to Ullmann reaction with copper bronze at 230-235°, gave a mixture of two products (A) m.p. 249° and (B) m.p. 110° both of which had no iodine. The product (B) was found to be 7-methoxy-2-methylchromone. The less soluble product has been assigned 7,7'-dimethoxy-2,2'-dimethyl-8,8'-bichromonyl structure (II).

The 8,8'-bichromonyl derivative (II) with either hydriodic acid in acetic anhydride or aluminium chloride in dry benzene gave the demethylated product 7,7'-dihydroxy-2,2'-

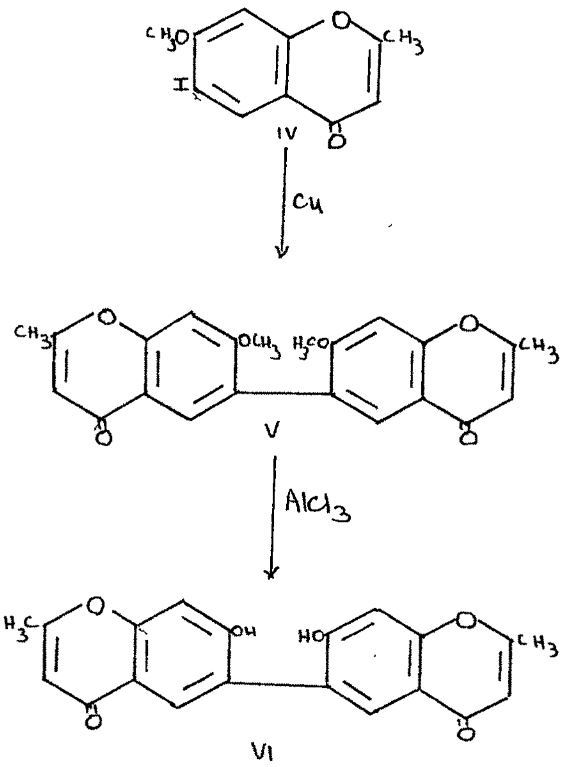


dimethyl-8,8'-bichromonyl (III).

When the above reaction was carried out by slowly raising the temperature to 230° the yield was inferior. Use of diphenyl ether as a diluent in the above reaction yielded only a brown gummy mass which could not be purified.

Ullmann reaction on 7-methoxy-6-iodo-2-methylchromone

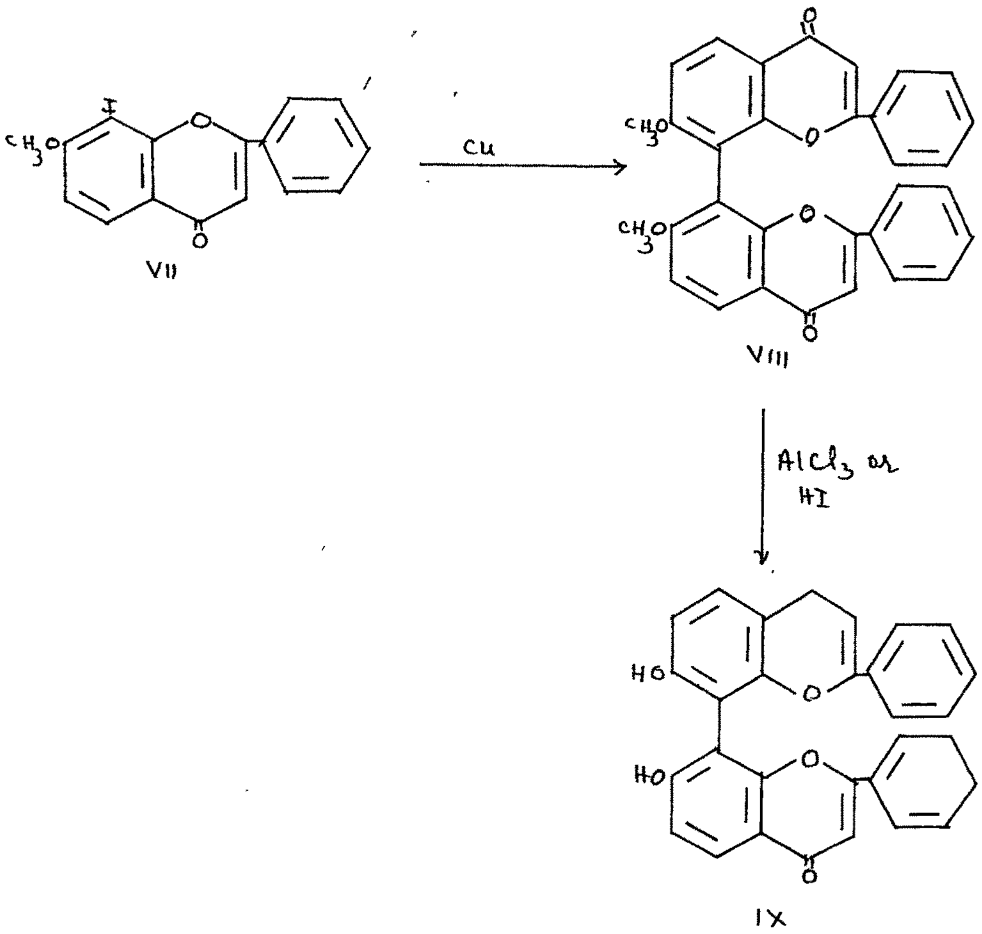
7-Methoxy-6-iodo-2-methylchromone (IV) on Ullmann reaction with copper bronze at 245-250° gave a mixture from which 7-methoxy-2-methylchromone and an iodine free product m.p. 282° to which 7,7'-dimethoxy-2,2'-dimethyl-6,6'-bichromonyl (V) structure has been assigned were isolated. With aluminium chloride the above bichromonyl derivative (V) gave the demethylated product 7,7'-dihydroxy-2,2'-



dimethyl-6,6'-bichromonyl (VI).

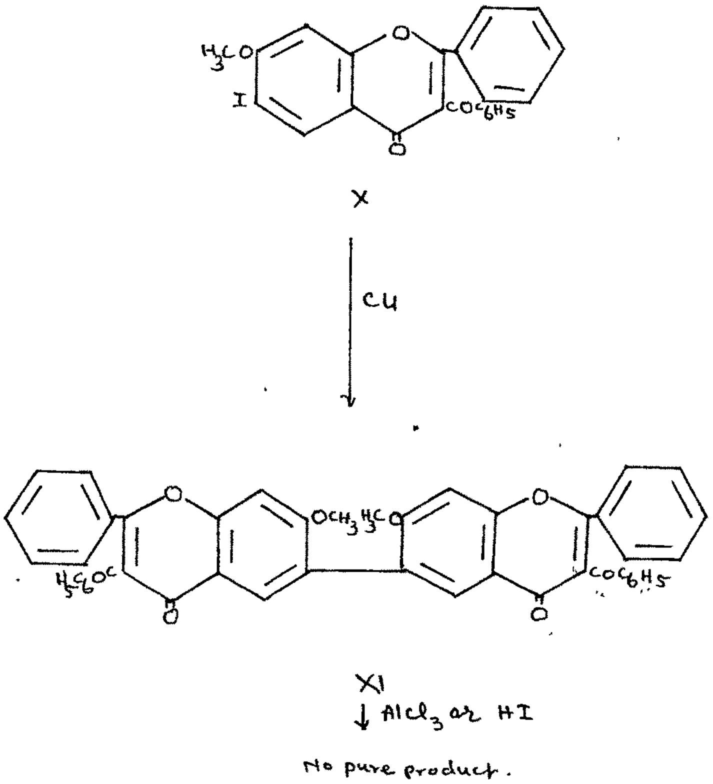
Ullmann reaction on 7-methoxy-8-iodoflavone

7-Methoxy-8-iodoflavone (VII) on Ullmann reaction with copper bronze at 240-250° gave an iodine free product m.p. 238-240° which was different from 7-methoxyflavone. It has been assigned 7,7'-dimethoxy-8,8'-biflavonyl (VIII) structure. It was obtained in inferior yield by carrying out the reaction in diphenyl ether. On demethylation with either aluminium chloride or hydriodic acid it gave 7,7'-dihydroxy-8,8'-biflavonyl (IX).



Ullmann reaction on 7-methoxy-6-iodo-3-benzoylflavone : 7,7'-Dimethoxy-3,3'-dibenzoyl-6,6'-biflavonyl

Attempts to synthesise 7-methoxy-6-iodoflavone did not succeed as mentioned earlier (p.103) as during the debenzoylation with alkali the heterocyclic ring was ruptured and iodo phenolic ketone and acid were obtained. In view of this 7-methoxy-6-iodo-3-benzoylflavone (X) was subjected to Ullmann reaction at 280-290°. A product which did not contain iodine and which melted at 315° was obtained to which 7,7'-dimethoxy-3,3'-dibenzoyl-6,6'-biflavonyl (XI) structure has been assigned. 7-Methoxy-3-benzoylflavone was also isolated from the mother liquor.

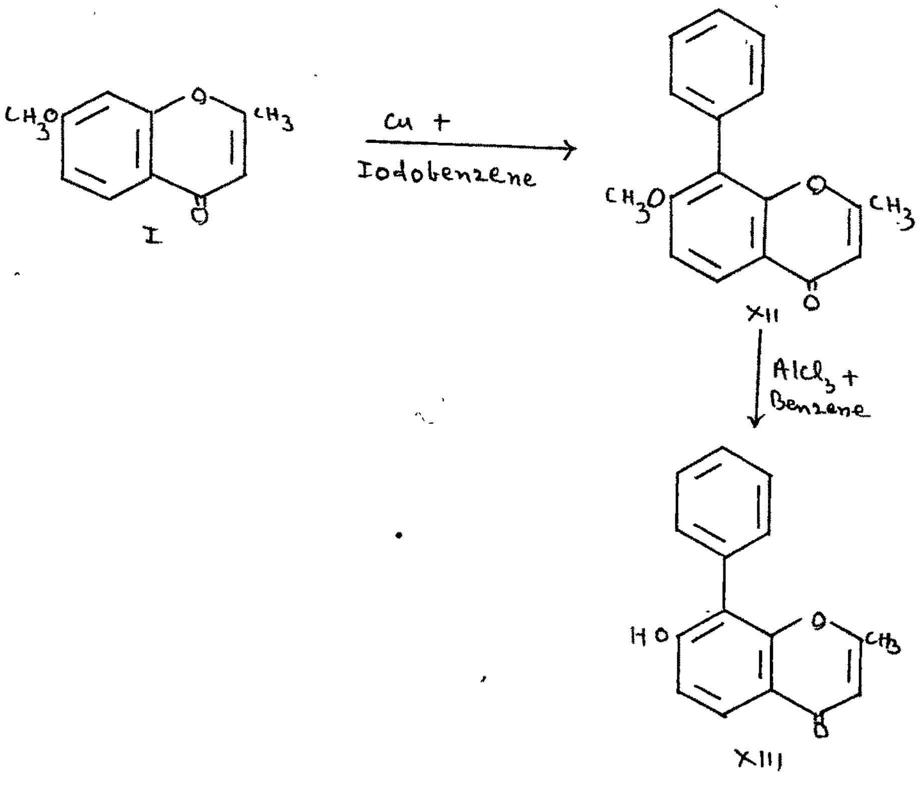


Attempts to demethylate the biflavonyl derivative either with aluminium chloride or hydriodic acid did not give a pure product. Attempts to debenzoylate the product with sulphuric acid also did not succeed.

<u>Crossed Ullmann reaction between 7-methoxy-8-iodo-2-methylchromone and iodobenzene</u>

7-Methoxy-8-iodo-2-methylchromone (I) on crossed Ullmann reaction with iodo-benzene in presence of copper bronze gave a mixture of various products from which the following products were isolated :

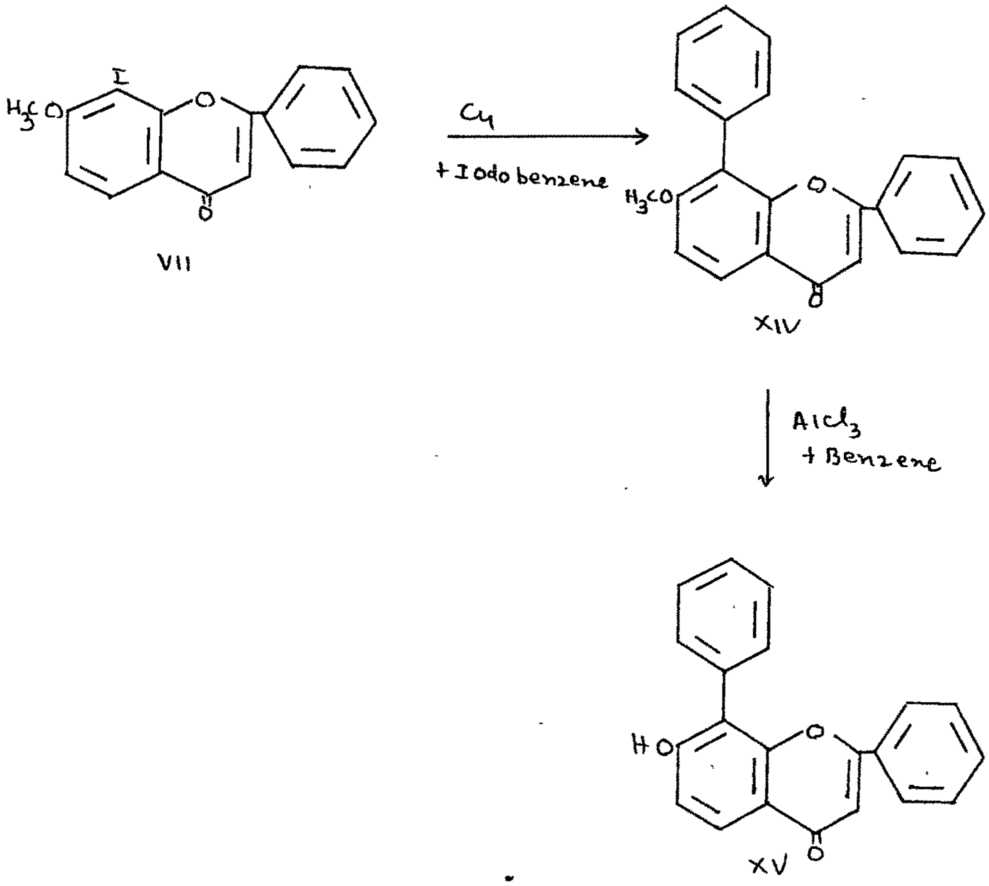
(i) biphenyl, (ii) 7,7'-dimethoxy-2,2'-dimethyl-8,8'-bichromonyl, (iii) 7-methoxy-2-methylchromone and (iv) an iodine free product m.p. 180° to which 7-methoxy-8-phenyl-2-methylchromone (XII) structure has been assigned. It was demethylated with aluminium chloride in dry benzene to 7-hydroxy-8-phenyl-2-methylchromone (XIII).



Crossed Ullmann reaction between 7-methoxy-8-iodoflavone and iodobenzene

7-Methoxy-8-iodoflavone (VII) when heated with iodobenzene in presence of copper bronze gave a mixture of various products from which the following products were isolated :

(i) biphenyl, (ii) 7,7'-dimethoxy-8,8'-biflavonyl, (iii) 7-methoxyflavone and (iv) an iodine free product m.p. 168° to which 7-methoxy-8-phenylflavone (XIV) structure has been assigned. This was demethylated with aluminium



chloride in dry benzene to 7-hydroxy-8-phenylflavone (XV).

As the hydroxy bichromonyl and biflavonyl derivatives (III ; ~~VI~~ , IX) were not available in sufficient quantity experiments to see if they could be resolved into optical isomers could not be carried out. It may be mentioned here that in Ginkgetin, Isoginkgetin and Sciadopitysin (p. 173) optical activity could not be detected (Baker et al. Proc. Chem. Soc., 1959, 91)

EXPERIMENTAL

Ullmann reaction on 7-methoxy-8-iodo-2-methylchromone: 7,7'-Dimethoxy-2,2'-dimethyl-8,8'-bichromonyl

7-Methoxy-8-iodo-2-methylchromone (3.16 g. ; 0.01 mole) was thoroughly mixed with copper bronze (1.89 g. ; 0.03 mole). The tube containing the reaction mixture was inserted in a previously heated oil bath at 230-235° stirred and kept there for five minutes. The reaction commenced immediately. A little product sublimed on the cooler part of the tube. This was found to be 7-methoxy-2-methylchromone. The brown reaction mixture was powdered and then extracted twice with hot petroleum ether (b.p. 60-80°). The petroleum extract yielded a small quantity of 7-methoxy-2-methylchromone.

The residue was further extracted repeatedly with benzene. The benzene extracts on dilution with petroleum ether gave a tarry mass which was removed and the solution was kept over-night in a refrigerator when a solid separated which crystallised from dilute alcohol in colourless lustrous plates, m.p. 249° . Yield 0.15 g.

Some decomposition of the iodo derivative occurred when the temperature was slowly raised to 230-235° and a poor yield of the biflavonyl derivative was obtained.

When diphenyl ether was used as a solvent in the above reaction no pure product could be isolated.

Analysis :-

4.746 mg. of the substance gave 12.142 mg. of carbon dioxide and 2.004 mg. of water.

Found : C = 69.82 % ; H = 4.72 %.

$C_{22}H_{18}O_6$ requires : C = 69.83 % ; H = 4.80 %.

7,7'-Dihydroxy-2,2'-dimethyl-8,8'-bichromonyl

The above bichromonyl derivative (0.2 g.) was dissolved in acetic anhydride (10 ml.) and heated with hydriodic acid (5 ml.) at 125-130° for 3 hr. The product obtained on adding the reaction mixture to sodium hydrogen sulphite solution was purified through dilute sodium hydroxide solution. It came out from dilute ethyl alcohol as a brown powder, m.p. 365° (decomp.).

The same demethylated product was obtained on refluxing the bichromonyl derivative (0.2 g.) in dry benzene (20 ml.) with aluminium chloride (0.4 g.) for 3 hr.

Analysis :

4.502 mg. of the substance gave 11.312 mg. of carbon dioxide and 1.698 mg. of water.

Found : C = 68.57 % ; H = 4.22 %.

$C_{20}H_{14}O_6$ requires : C = 68.57 % ; H = 4.03 %.

Ullmann reaction on 7-methoxy-6-iodo-2-methylchromone : 7,7'-Dimethoxy-2,2'-dimethyl-6,6'-bichromonyl

7-Methoxy-6-iodo-2-methylchromone (3.16 g. ; 0.01 mole) was intimately mixed with copper bronze (1.89 g. ;

0.03 mole) and taken in a tube which was inserted in a previously heated oil bath at 240-245° and kept there for five minutes. The reaction mixture was powdered and extracted with hot petroleum ether. The product obtained from the petroleum ether extract was 7-methoxy-2-methylchromone.

The residue after extraction with petroleum ether was further extracted with hot benzene. The benzene extract on dilution with petroleum ether gave a tarry mass which was removed by filtration. The filtrate on keeping over-night in the refrigerator gave a solid product which crystallised from dilute acetic acid in colourless needles, m.p. 282° . Yield 0.15 g.

Analysis :

4.362 mg. of the substance gave 11.03 mg. of carbon dioxide and 1.930 mg. of water.

Found : C = 69.08 % ; H = 4.95 % .

$C_{22}H_{18}O_6$ requires : C = 69.80 % ; H = 4.80 % .

7,7'-Dihydroxy-2,2'-dimethyl-6,6'-bichromonyl

The above bichromonyl derivative (0.1 g.) was refluxed in dry benzene (20 ml.) in presence of anhydrous aluminium chloride (0.3 g.) for 3 hr. The product obtained on working up as usual was purified through sodium hydroxide treatment. It came down from a large amount of acetic acid as a brown powder, m.p. > 400 .

Analysis :

4.146 mg. of the substance gave 10.434 mg. of carbon dioxide and 1.700 mg. of water.

Found : C = 68.57 % ; H = 4.56 %.
$C_{20}H_{14}O_6$ requires : C = 68.60 % ; H = 4.03 %.

Ullmann reaction on 7-methoxy-8-iodoflavone : 7,7'-Dimethoxy-8,8'-biflavonyl

7-Methoxy-8-iodoflavone (3.78 g. ; 0.01 mole) dissolved in dry diphenyl ether (20 ml.) was treated with copper bronze (1.89 g. ; 0.03 mole) and a trace of iodine and the reaction mixture refluxed on a wire gauze for half an hour with an air condenser. The reaction mixture was filtered while hot and the filtrate was steam distilled to remove the diphenyl ether. The brown pasty residue was dried and extracted with benzene. The benzene extract was diluted with petroleum ether, when a solid product was obtained which crystallised in colourless silky needles from dilute ethyl alcohol. It softens at 168° and melts at 238-240°. Jurd (loc. cit.) reports the same m.p.. Yield 0.1 g.

Analysis :

4.432 mg. of the substance gave 12.372 mg. of carbon dioxide and 1.830 mg. of water.

Found : C = 76.18 % ; H = 4.62 %.
$C_{32}H_{22}O_6$ requires : C = 76.49 % ; H = 4.38 %.

The same product was obtained in a little better yield (0.15 g.) by heating the iodoflavone (3.78 g. ; 0.01 mole) with copper bronze (1.89 g. ; 0.03 mole) without any solvent in an oil bath for 10 minutes at 240°.

7-Methoxyflavone was recovered from the mother liquor.

7,7'-Dihydroxy-8,8'-biflavonyl

The above biflavonyl derivative (0.2 g.) was heated with acetic anhydride (10 ml.) and hydriodic acid (5 ml. ; d. 1.7) in an oil bath at 125-130° for 3 hr. The product obtained was purified through sodium hydroxide treatment and crystallised from a large amount of acetic acid, ~~in~~ yellowish powder, m.p. 392° (decomp.). Jurd (loc. cit.) reports that it melts above 350°.

Analysis :

4.080 mg. of the substance gave 11.296 mg. of carbon dioxide and 1.494 mg. of water.

Found : C = 75.55 % ; H = 4.10 %.

$C_{30}H_{18}O_6$ requires : C = 75.94 % ; H = 3.82 %.

Ullmann reaction on 7-methoxy-6-iodo-3-benzoylflavone : 7,7'-Dimethoxy-3,3'-dibenzoyl-6,6'-biflavonyl

7-Methoxy-6-iodo-3-benzoylflavone (1.73 g. ; 0.005 mole) was intimately mixed with copper bronze (0.95 g. ; 0.015 mole). The tube containing the reaction mixture was inserted in a previously heated oil bath at 280-290° and kept there for five minutes. The reaction mixture was powdered and extracted repeatedly with hot benzene. The benzene extract on dilution with petroleum ether (b.p. 60-80°) gave a tarry mass which was removed by filtration and the filtrate on keeping over-night in ~~the~~ a refrigerator gave a solid product which crystallised from dilute acetic acid in colourless needles, m.p. 315°. Yield 0.12 g. The mother liquor gave 7-methoxy-3-benzoylflavone.

Analysis :

4.108 mg. of the substance gave 11.658 mg. of carbon dioxide and 1.696 mg. of water.

Found : C = 77.45 % ; H = 4.62 %.
$C_{46}H_{30}O_8$ requires : C = 77.74 % ; H = 4.22 %.

Attempted demethylation of the biflavonyl derivative (0.1 g.) with aluminium chloride (0.3 g.) by refluxing in dry benzene or with hydriodic acid (10 ml.) and acetic anhydride (10 ml.) did not give any pure product.

Attempted debenzoylation of the above biflavonyl (0.1 g.) by gently refluxing its solution in 70 % sulphuric acid (20 ml.) gave the original biflavonyl.

Crossed Ullmann reaction between 7-methoxy-8-iodo-2-methylchromone and iodobenzene : 7-Methoxy-8-phenyl-2-methylchromone

7-Methoxy-8-iodo-2-methylchromone (3.16 g. ; 0.01 mole) was intimately mixed with copper bronze (4.40 g. ; excess) and iodobenzene (4.14 g. ; 0.02 mole) in a tube equipped with a short air condenser. The reaction mixture was heated in an oil bath at 235-240° for half an hour. The reaction mixture was then extracted with cold petroleum ether (b.p. 60-80°) to remove the unreacted iodobenzene and biphenyl. The residue was then repeatedly extracted with hot benzene and petroleum ether (50 %)

mixture. The residue from the extracts crystallised in colourless needles from dilute alcohol, m.p. 180°. Yield 0.15 g.

Analysis :

5.706 mg. of the substance gave 16.034 mg. of carbon dioxide and 2.756 mg. of water.

Found : C = 76.69 % ; H = 5.40 %.

$C_{17}H_{14}O_3$ requires : C = 76.67 % ; H = 5.30 %.

The residue remaining after extraction with benzene was 7,7'-dimethoxy-2,2'-dimethyl-8,8'-bichromonyl derivative described earlier.

7-Hydroxy-8-phenyl-2-methylchromone

7-Methoxy-8-phenyl-2-methylchromone (0.1 g.) was dissolved in dry benzene (20 ml.) and refluxed on a wire gauze in presence of anhydrous aluminium chloride (0.3 g.) for 3 hr. The product obtained on working up the reaction mixture as usual was purified through sodium hydroxide treatment. It crystallised from ethyl alcohol in colourless needles, m.p. 234°.

Analysis :

4.894 mg. of the substance gave 13.620 mg. of carbon dioxide and 2.016 mg. of water.

Found : C = 75.95 % ; H = 4.50 %.

$C_{16}H_{12}O_3$ requires : C = 76.12 % ; H = 4.80 %.

Crossed Ullmann reaction between 7-methoxy-8-iodoflavone and iodobenzene : 7-Methoxy-8-phenylflavone

7-Methoxy-8-iodoflavone (3.16 g. ; 0.01 mole)

Was intimately mixed with copper bronze (4.4 g. ; excess) and iodobenzene (4.14 g. ; 0.02 mole) and taken in a tube equipped with an air condenser. The reaction mixture was heated in an oil bath at 240-245° for 1 hr. It was then extracted with cold petroleum ether to remove the unreacted iodobenzene and biphenyl. The residue was repeatedly extracted with benzene and petroleum ether mixture (1:1). The residue from the combined extracts crystallised from dilute acetic acid in colourless needles, m.p. 168° . Yield 0.2 g.

Analysis: 4·616 mg. of the substance gave 13·56 mg. of carbon dioxide and 2·094 mg. of water.
Found: C = 80·17 % ; H = 5·07 %.
$C_{17}H_{14}O_3$ requires: C = 80·47 % ; H = 4·91 %

The residue after extraction with benzene gave 7,7'-dimethoxy-8,8'-biflavonyl described above.

7-Hydroxy-8-phenylflavone

The above 8-phenyl derivative (0.1 g.) was dissolved in dry benzene (25 ml.) and refluxed on a wire gauze with aluminium chloride (0.3 g.) for 3 hr. The reaction mixture on working up as usual yielded a product which after purification through sodium hydroxide treatment, crystallised from ethyl alcohol in colourless needles, m.p. 265° .

Analysis :

4.894 mg. of the substance gave 13.620 mg. of carbon dioxide and 2.016 mg. of water.

Found : C = 75.95 % ; H = 4.50 %.
$C_{16}H_{12}O_3$ requires : C = 76.12 % ; H = 4.80 %.