CHAPTER III

STUDIES IN THE SYNTHESIS OF XANTHONE DERIVATIVES

Section I

A NEW ONE STEP SYNTHESIS OF XANTHONES

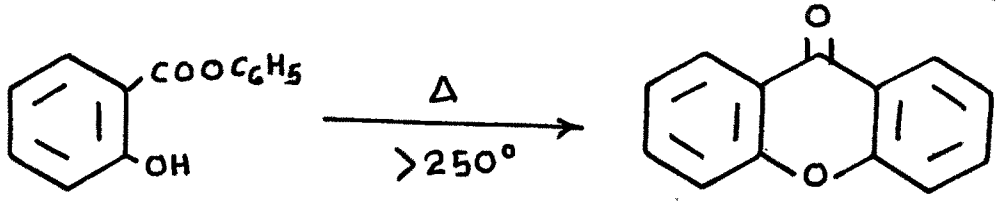
THEORETICAL

A NEW ONE STEP SYNTHESIS OF XANTHONES :

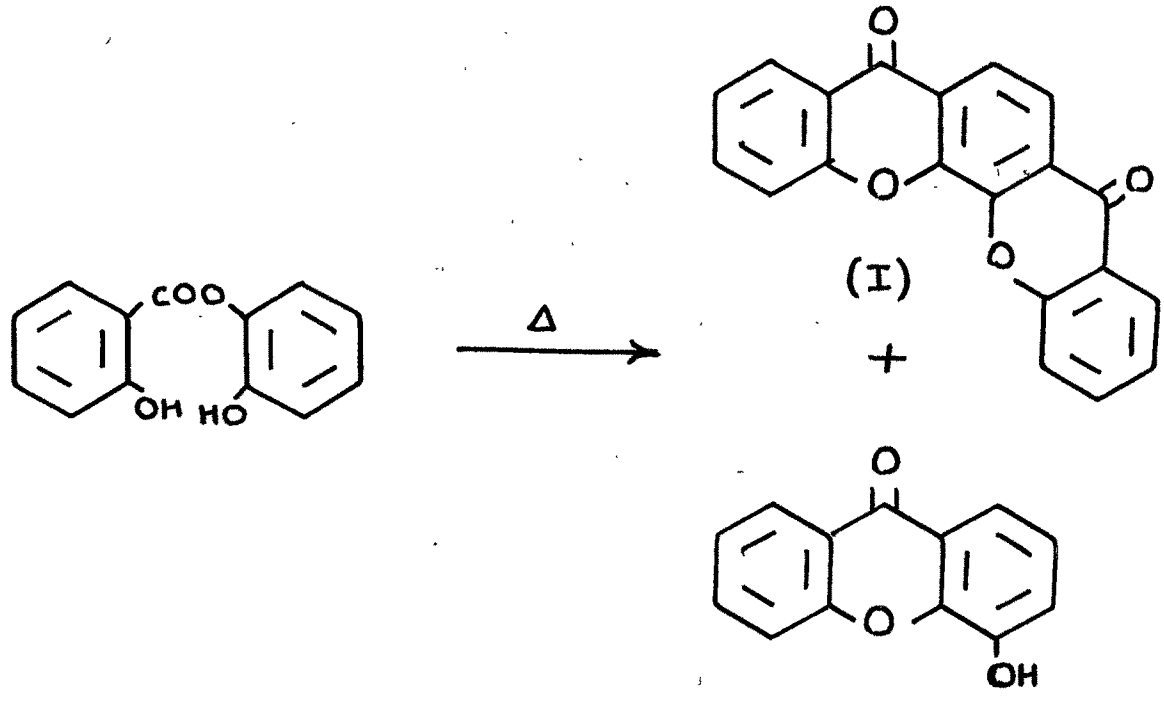
A number of methods have been reported for the synthesis of xanthones and they are recently reviewed[1] in the " Total Synthesis of Natural Products". Some general methods are briefly described here.

Pyrolysis of benzoic acid derivatives :

2-Hydroxybenzoic acid and 2-hydroxynaphthoic acid are converted into xanthone and benzoxanthone by distillation of the acid either alone[2] or in the presence of tungsten oxide or vanadium pentoxide[3] and the distillation of the aryl ester[4] or the acetates[5]. Preparation of simple xanthone from salol by its distillation is the best example of this method. Still the mechanism of this pyrolysis is not clear.

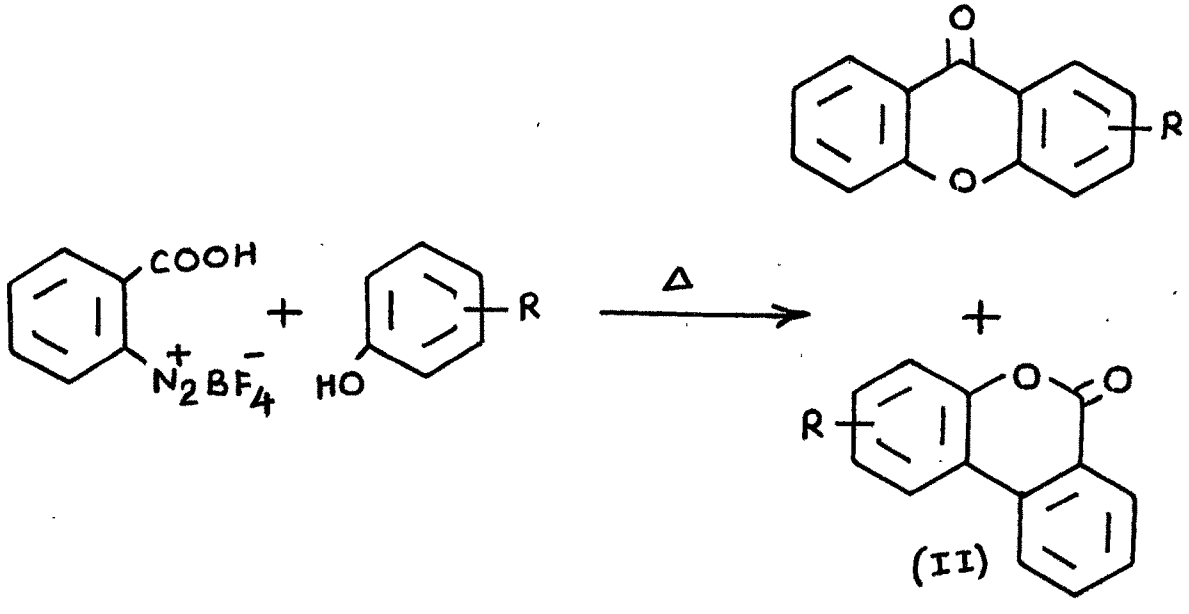


Many dibenzoxanthones have been prepared by Kamel and Shoeb[6] and Parija et al[7]. In the preparation of hydroxyxanthones by this method, dixanthone(I) is often produced as a by product. Moreover, side reactions like decarboxylation and autocondensation are also possible.



Kochi[8] has reported that the alkali salts of 2-halobenzoic acids decompose smoothly at 325-80° in vacuum to produce xanthone in 50 to 70 % yield, The synthesis of octafluoroxanthone[9] and other haloxanthones is reported[10].

Sellers and Suschitzky[11] have developed a novel pyrolysis method for the preparation of xanthones, They have



done pyrolysis of 2-carboxyphenyldiazonium tetrafluorobotate in phenols and aryldiazonium tetrafluoroborate in substituted salicylic acid. In some case xanthones are accompanied by 3,4-benzocoumarins (II). The thermolysis in phenols can be illustrated as mentioned above.

From diphenyl ether derivatives :

The synthesis starts with preparation of diphenyl ether-2-carboxylic acid or with diphenyl ether where 2,2-positions are not occupied. Diphenyl ether-2-carboxylic acid or 2-aryloxy-benzoic acids are prepared directly either by the Ullmann reaction[12] or by treating 2-diazoniumbenzoic acid with phenol[13]. The cyclization can be carried out in excellent yields by heat or with sulphuric acid, acetyl chloride, thionyl chloride, phosphorus pentachloride or oxide, oxalyl chloride, stannic chloride.

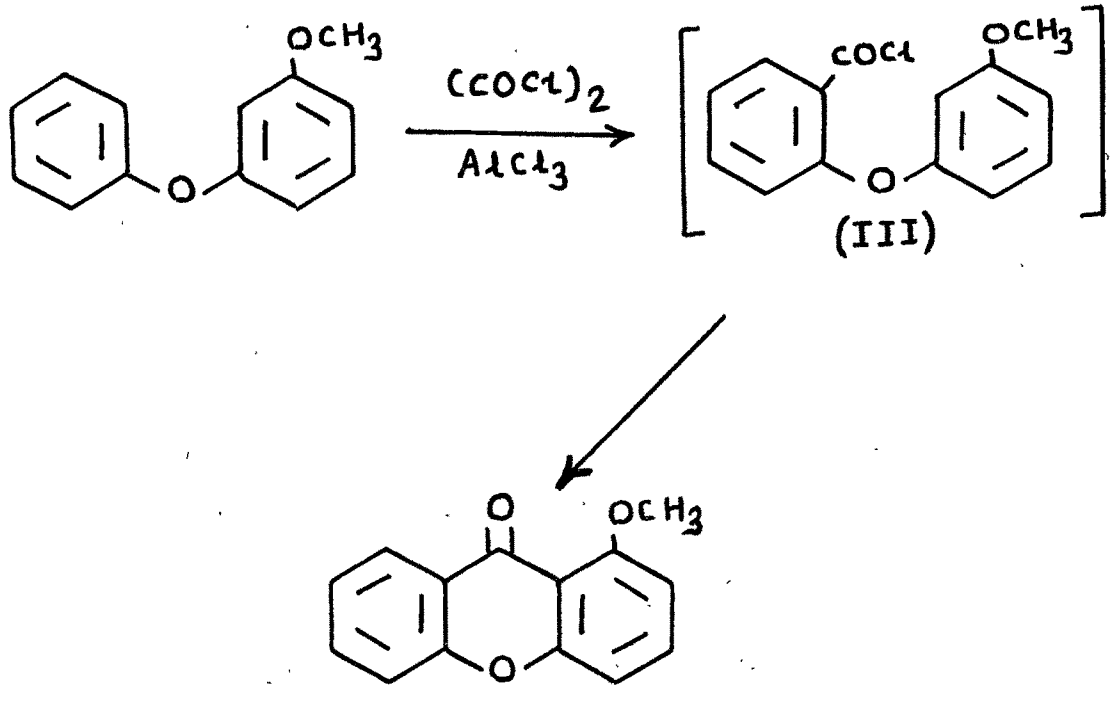
Koelsch and Lucht[14] carried out the condensation between 2-chlorobenzoic acid and 3-nitrophenol in presence of copper bronze and cuprous iodide in amyl alcohol. The use of other solvents like nitrobenzene, hexyl alcohol and anisole was also reported[15]. The synthesis of 2-hydroxyxanthone from 4-methoxyphenol and 2-chlorobenzoic acid was achieved in a better yield by Davies and colleagues[16]. The use of potassium carbonate along with copper bronze and cuprous iodide was reported[17].

Mauthner et al[18]. have successively used sodium

2-chlorobenzoate in place of 2-chlorobenzoic acid for the synthesis of different xanthones. Later on this method was adopted by many workers[19-23].

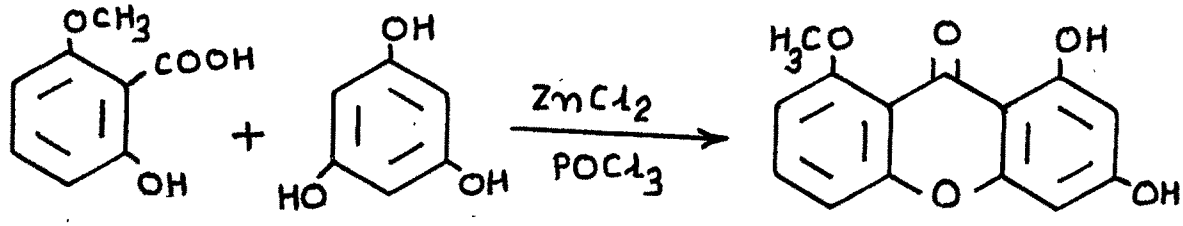
Recently, Okogun[24] has prepared 2-methoxyxanthone and substituted benzoxanthone from 2-(4-methoxyphenyloxy) benzaldehyde by the use of copper(II) halides.

In a second approach, xanthones are directly synthesised from substituted diphenyl ethers by the action of oxalyl chloride in presence of aluminum chloride[25,26]. 2-Phenoxy-benzoyl chloride(III) must be the intermediates in the formation of xanthones by this method. Recently, Gamoth et al[27]. have synthesised 2-chloro-6-bromo- and 2-fluoro-6-bromoxanthone by this method. The synthesis of 1-methoxyxanthone can be illustrated as :



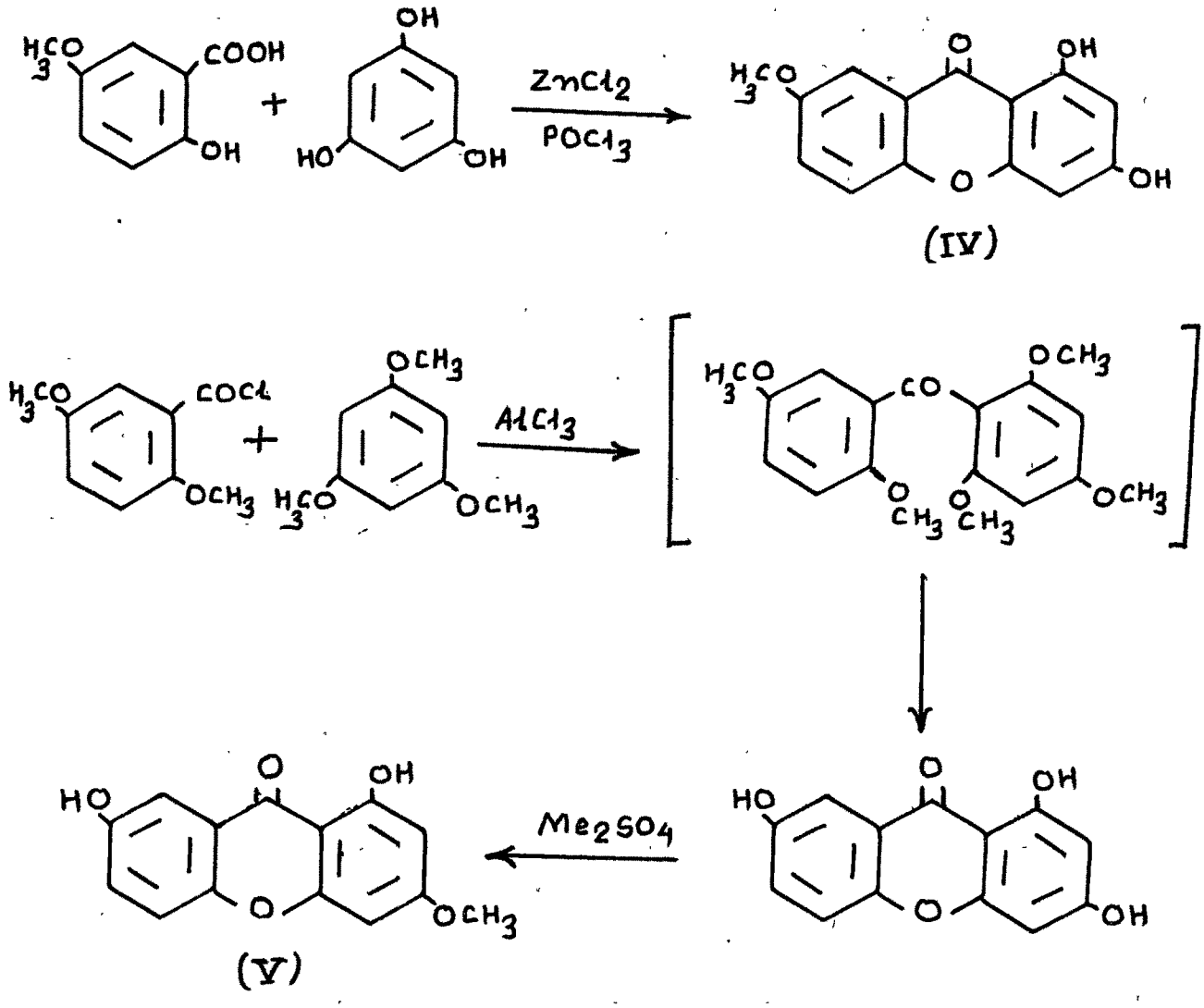
From benzophenone derivatives :

In this method a suitable benzophenone derivative obtained as an intermediate, can be cyclized further to get the desired xanthone. It requires usually a salicyclic acid derivative and a suitable pehnol. The equimolecular proportions of the components are merely heated with a condensing agent such as acetic anhydride[28], zinc chloride[29-31], PPA[32] to get 2,2'-dihydroxybenzophenone or xanthone derivative. A modification of this method by Grover, Shah and Shah[33,34] consists in the use of a mixture of phosphorus oxychloride and zinc chloride as a condensing agent. In this method a mixture of an o-hydroxybenzoic acid, a phenol, anhydrous zinc chloride and excess of phosphorus oxychloride was heated at 70-80° to obtain benzophenone or xanthone derivative. If hydroxybenzophenone was formed as an intermediate, it was dehydrated to the hydroxyxanthone by heating at 200-220° with water in a sealed tube[35]. The hydroxyxanthones were obtained directly when the acidic component is a 2,6-dihydroxybenzoic acid or phloroglucinol carboxylic acid or when phenol is phloroglucinol or orcinol i.e. when the intermediate hydroxybenzophenone carries another hydroxy group at the 6- or 6'-position, as the alternative site for the cyclization is available. The method also worked well when one or both the components are methylated. For example 2-hydroxy-6-methoxybenzoic acid on condensation with phloroglucinol gave 1,3-dihydroxy-8-methoxyxanthone.

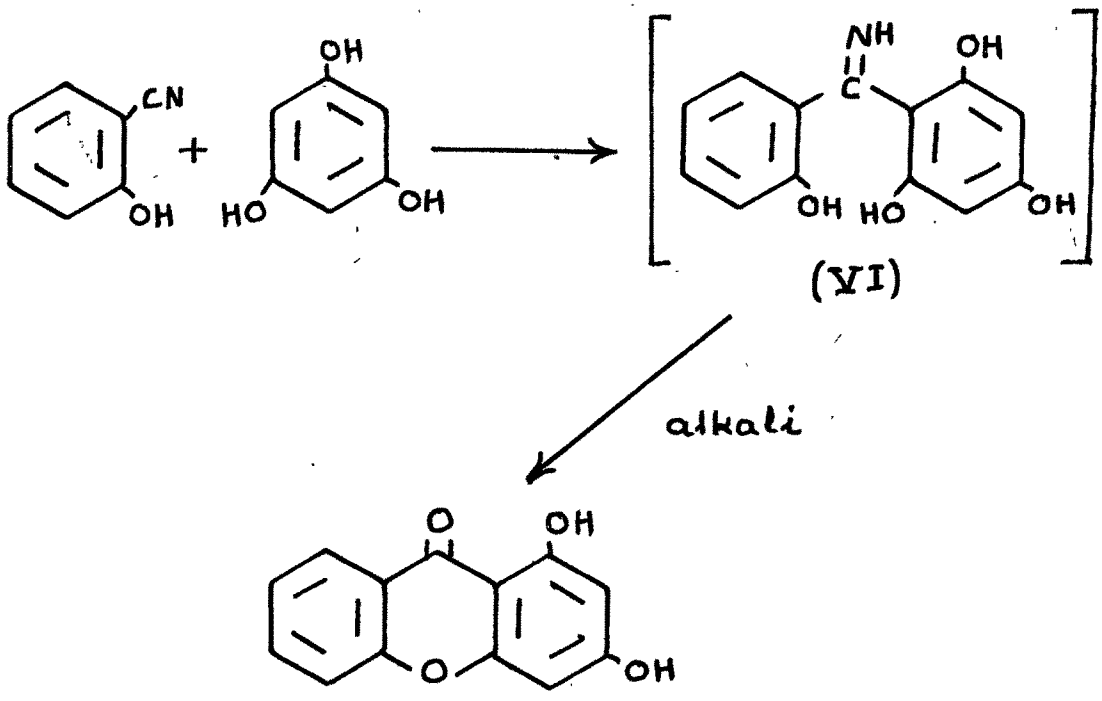


Kulkarini et al[36]. have condensed different acids like o-vanillic, o-veratric, o-cresotic, m-cresotic with reactive phenols such as phloroglucinol, orcinol, pyrogallol, resorcinol to obtain corresponding xanthone derivatives. At present this method has got greatest popularity among many research workers[37-45]. Scheinmann and coworkers[40] have recommanded the use of aluminium chloride alongwith zinc chloride and phosphorus oxychloride, when the mixture of the two condensing agents failed.

Gentisic acid(2,5-dihydroxybenzoic acid) provides great difficulty to react because quinol nucleus is resistant to electrophilic substitution. It was reported[46,47] that 2-hydroxy-5-methoxybenzoic acid condensed with phloroglucinol using phosphorus oxychloride and zinc chloride to give the corresponding xanthone derivative(IV). Rao and Seshadri[48] condensed 2,5-dimethoxybenzoyl chloride with phloroglucinol trimethyl ether in presence of aluminium chloride and obtained the demethylated xanthone which on selective methylation gave gentisin or 1,7-dihydroxy-3-methoxyxanthone(V).

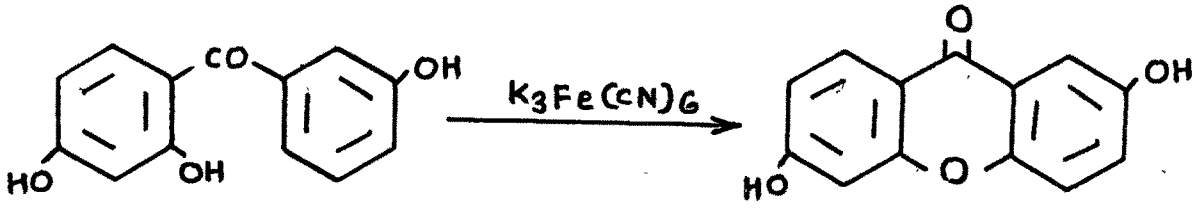


The intermediate benzophenone obtained through a ketimino compound(VI) on alkaline hydrolysis were cyclized to xanthones[49] by the use of conc.sulphuric acid, aluminium chloride[50], acetic anhydride[51] or water at 200-220°(in an autoclave)[35]. Thus 2,2',4,6-tetrahydroxydiphenylketimine(VI), obtained by the condensation of salicylonitrile and phloroglucinol, on treatment with alkali directly gave 1,3-dihydroxyxanthone[49].

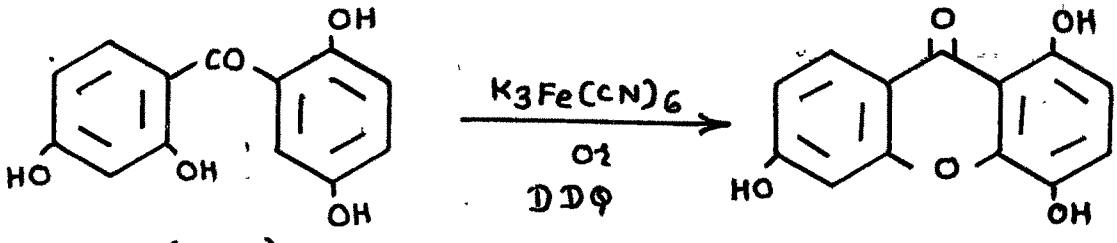


Stout et al.[52,53] have condensed methyl ether of phenols with acid chloride and the resulting 2-hydroxy-2'-methoxybenzophenones, were cyclized to xanthone derivatives, by tetramethyl ammonium hydroxide in pyridine. Scheinmann and Quillinan[54] have reported the use of different alkaline reagents such as aqueous sodium hydroxide in methanol, aqueous potassium carbonate in methanol, tetramethylammonium hydroxide in aqueous pyridine. They have also discussed the use of other effective reagents like boron trichloride and DDQ. The use of 2 % ethanolic potassium hydroxide[55] and 1N potassium hydroxide in ~~a~~ nitrogen atmosphere was also reported[56]. The synthesis of 2,5-dihydroxy- and 4,5-dihydroxyxanthone has been reported[57] using such reagents.

The cyclization of 2-hydroxybenzophenones can also be achieved by the use of some oxidants. Lewis[51] and other workers[58] have used potassium ferricyanide. Thus 2,3',4-trihydroxybenzophenone(VII)[51] and 2,2',4,5'-tetrahydroxybenzophenone (VIII)[58] have been cyclized to corresponding 2,6-dihydroxyxanthone and 1,4,6-trihydroxyxanthone in high yield by oxidative coupling with potassium ferricyanide.



(VII)

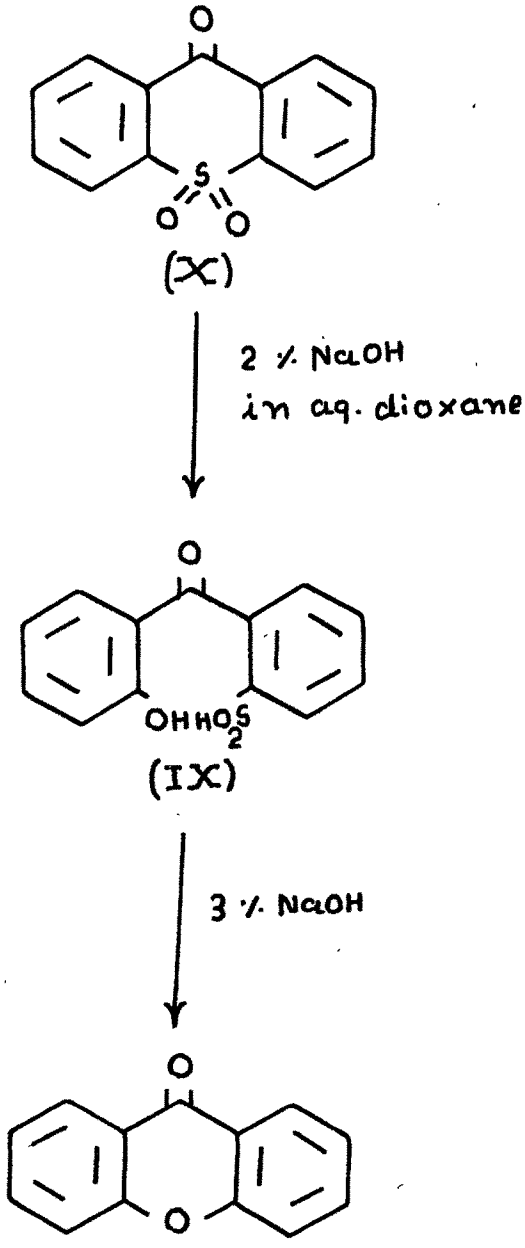


(VIII)

Lewis et al[59]. have also synthesised xanthone derivatives from benzophenones derivative using DDQ for oxidative coupling.

Royer et al[60]. have reported the synthesis of many xanthones such as 2-hydroxy-, 2-methyl-, 2-methyl-6-nitro-, and 3-hydroxy-6-chloroxanthone from corresponding 2-chloro-2'-methoxybenzophenones, by cyclizing them using pyridine-hydrochloride. Bennet et al[61]. have reported a method to

convert 2-hydroxybenzophenone-2'-sulphinic acid(IX) into xanthone by refluxing it with 3 % sodium hydroxide solution. The intermediate IX was prepared from thioxanthen-9-one-10,10-dioxide (X), by hydrolysing X by 2 % sodium hydroxide in aqueous dioxane (65 %).



PRESENT WORK

From the above review it is seen that a number of methods have been developed for the synthesis of xanthones. They all usually consist of more than one step and require a good condensing agent like zinc chloride, aluminium chloride, boron trichloride, zinc chloride and phosphorus oxychloride mixture or PPA. The condensing agent must almost be free from water and its purity becomes an important factor in the synthesis because an impure condensing agent leads to the failure of the reaction or to poor yields. Such difficulties are not observed in the present method. It is a simple and convenient method to be adopted for the general synthesis of xanthones.

The present one step synthesis of xanthones is the outcome of the method developed by Desai, Trivedi and Sethna[62] for the synthesis of chromones and flavones by the thermal condensation of phenols with β-ketonic ester in boiling diphenyl ether. They condensed ethyl acetoacetate and ethyl benzoylacetate with resorcinol, pyrogallol, phloroglucinol, 1-naphthol and 2-naphthol in different solvents like diphenyl ether, nitrobenzene, phenetole, acetylene tetrachloride. The yields of 2-methylchromones in the condensations with ethyl acetoacetate have been found to be less in comparison with those of ethyl benzoylacetate, probably because a part of the ethyl acetoacetate decomposes

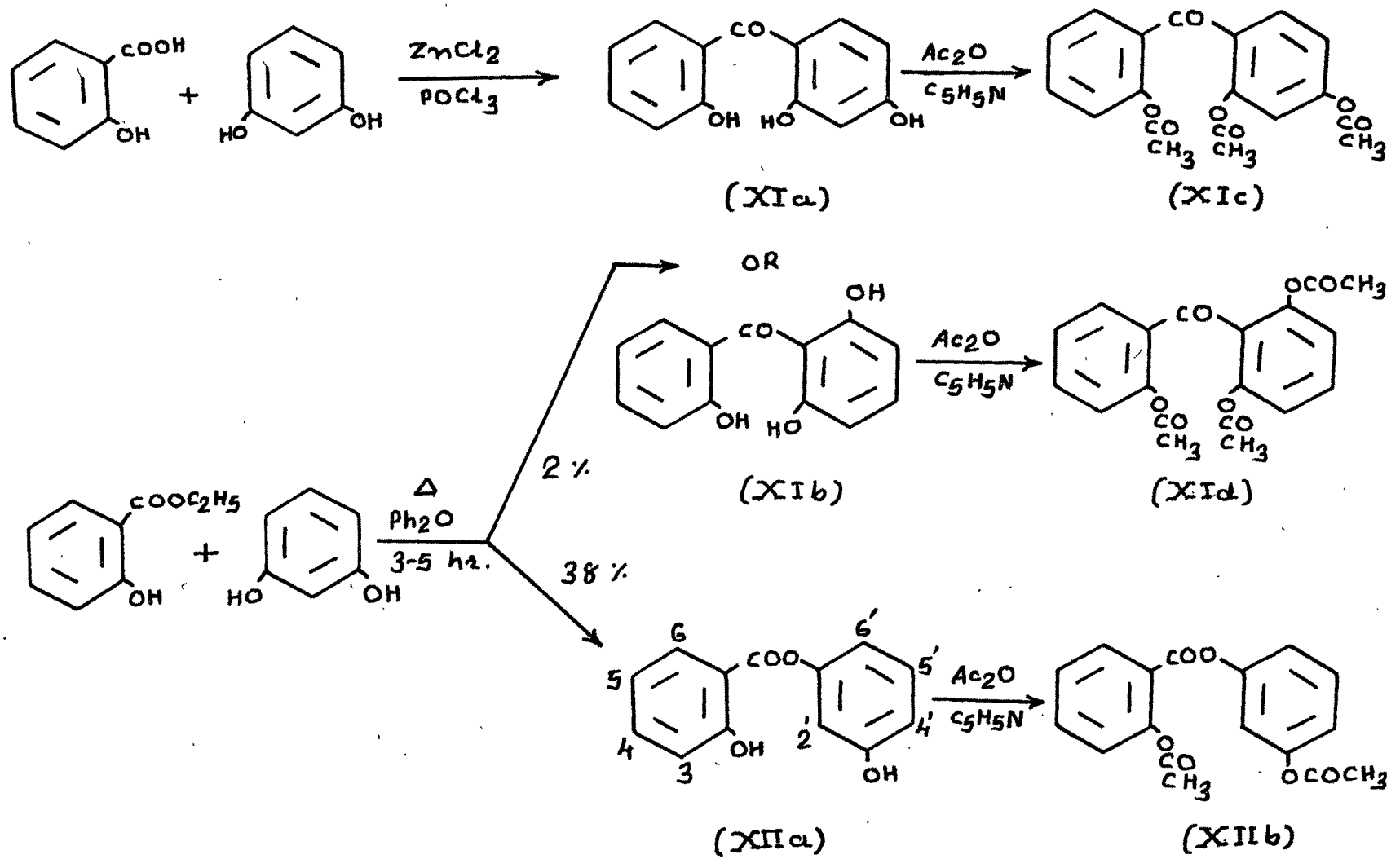
at the reaction temperature. They found that the condensation took place easily with greater yields, when high boiling solvent like diphenyl ether is used. In their method the formation of chromones instead of coumarins was of a great interest.

In the present work, a smooth condensation between ethyl salicylate and a phenol was effectively brought about to obtain xanthone derivatives by refluxing the mixture in diphenyl ether without the use of any condensing agent. Further it was observed that the intermediate phenyl salicylate derivatives could be isolated. Thus the method can also be used to prepare thermally more stable ester derivatives. Where as in Grover, Shah and Shah's method[33,34] intermediate benzophenones or xanthones could be obtained depending upon the nature of the phenols.

Condensation of resorcinol with ethyl salicylate :

3'-Hydroxyphenyl salicylate (XIIa) and 2,2',4-trihydroxybenzophenone (XIa) :

Resorcinol on thermal condensation with ethyl salicylate for 3 to 5 hr. in boiling diphenyl ether afforded 3'-hydroxyphenyl salicylate(XIIa), yield 38 %, m.p. 138° and 2,2',4-trihydroxybenzophenone(XIa), yield 2 %, m.p. 133° (lit.,[37] m.p. 133°). Both were separated by crystallization


COOH
OH
HO
OH
$ZnCl_2$
$POCl_3$
CO
OH
HO
OH
Ac_2O
C_5H_5N
CO
O CO CH_3
O CO CH_3
O CO CH_3
(XIa)
(XIc)
OR
OH
CO
OH
HO
(XIb)
Ac_2O
C_5H_5N
$OCOCH_3$
CO
O CO CH_3
O CO CH_3
(XId)
$COOC_2H_5$
OH
HO
OH
Δ
Ph_2O
3-5 hr.
2 %
38 %
6
COO
6'
5
5'
4
OH
3
2'
4'
OH
Ac_2O
C_5H_5N
COO
O CO CH_3
$OCOCH_3$
(XIIa)
(XIIb)

from ethanol or benzene, where former crystallized out first and latter remained in mother liqueur. They were also separated on preparative TLC with R_f 0.65 and R_f 0.40 by using chloroform as a solvent. The 2,2',4-trihydroxybenzophenone(XIa) was identical with the one prepared, according to Grover, Shah and Shah's method[37] from resorcinol and salicylic acid using a mixture of zinc chloride and phosphorus oxychloride with respect to their mixed m.p. 133° and co-TLC Rf 0.40 in chloroform.

Acetylation of XIIa (major product) gave a diacetate derivative(XIIb) and not triacetate derivative(XIc) or (XId). This was confirmed by the elemental analysis of XIIb and also from its NMR spectrum. Thus this excludes the benzophenone structure XIa or XIb for the above compound XIIa. Finally the structure of XIIa was confirmed from its spectral data obtained as follows :

The IR spectrum in nujol (Fig. 1) showed bands at 1675 cm^{-1} (-COO-Ph phenyl ester group) and two broad bands at 3280 cm^{-1} and 3420 cm^{-1} (aromatic -OH groups). If it had structure XIa or XIb the carbonyl stretching band would appear around 1650 cm^{-1} instead of 1675 cm^{-1}.

The NMR spectrum of diacetate derivative(XIIb) of XIIa in $CDCl_3$ (Fig. 2) showed following signals : δ 2.18 and 2.23, two singlets, each 3H, two $-OCOCH_3$ groups. This indicated that resorcinol initially condensed to give the

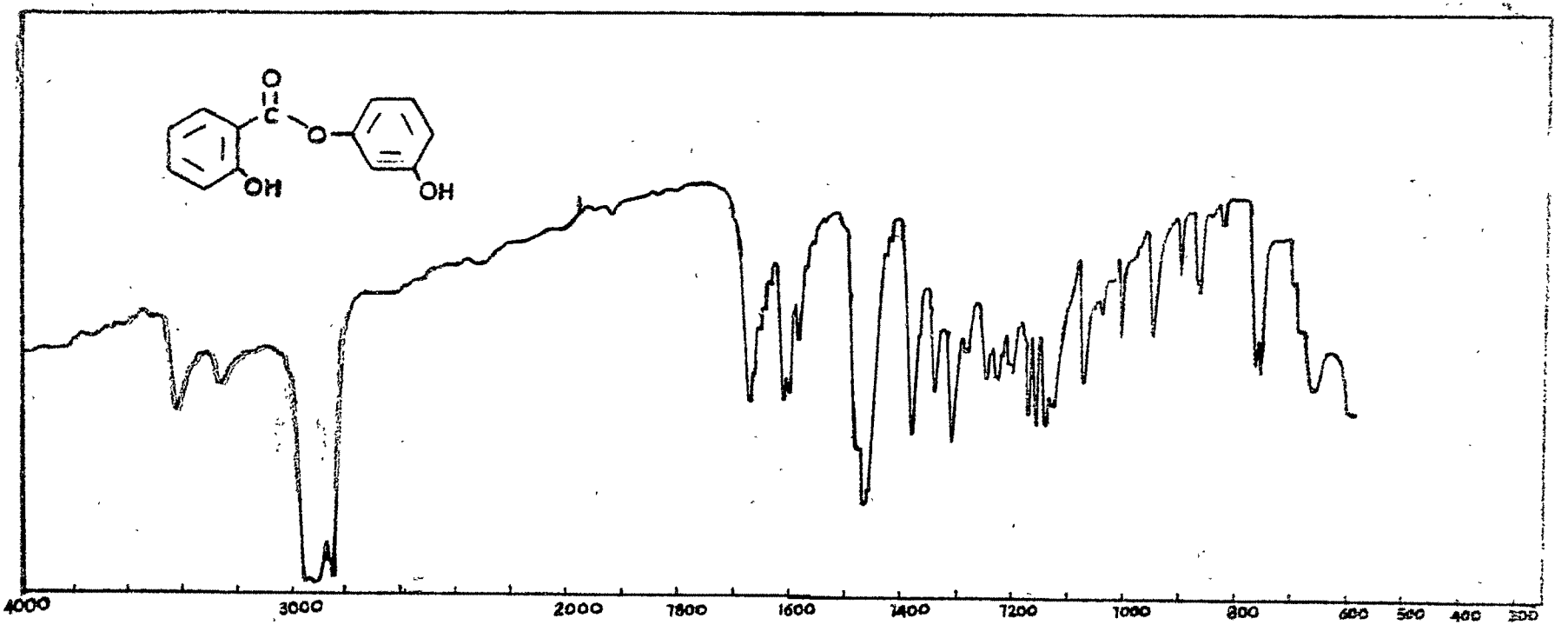


Fig. 1 : IR spectrum of 3'-Hydroxyphenyl salicylate(XIIa) in nujol .

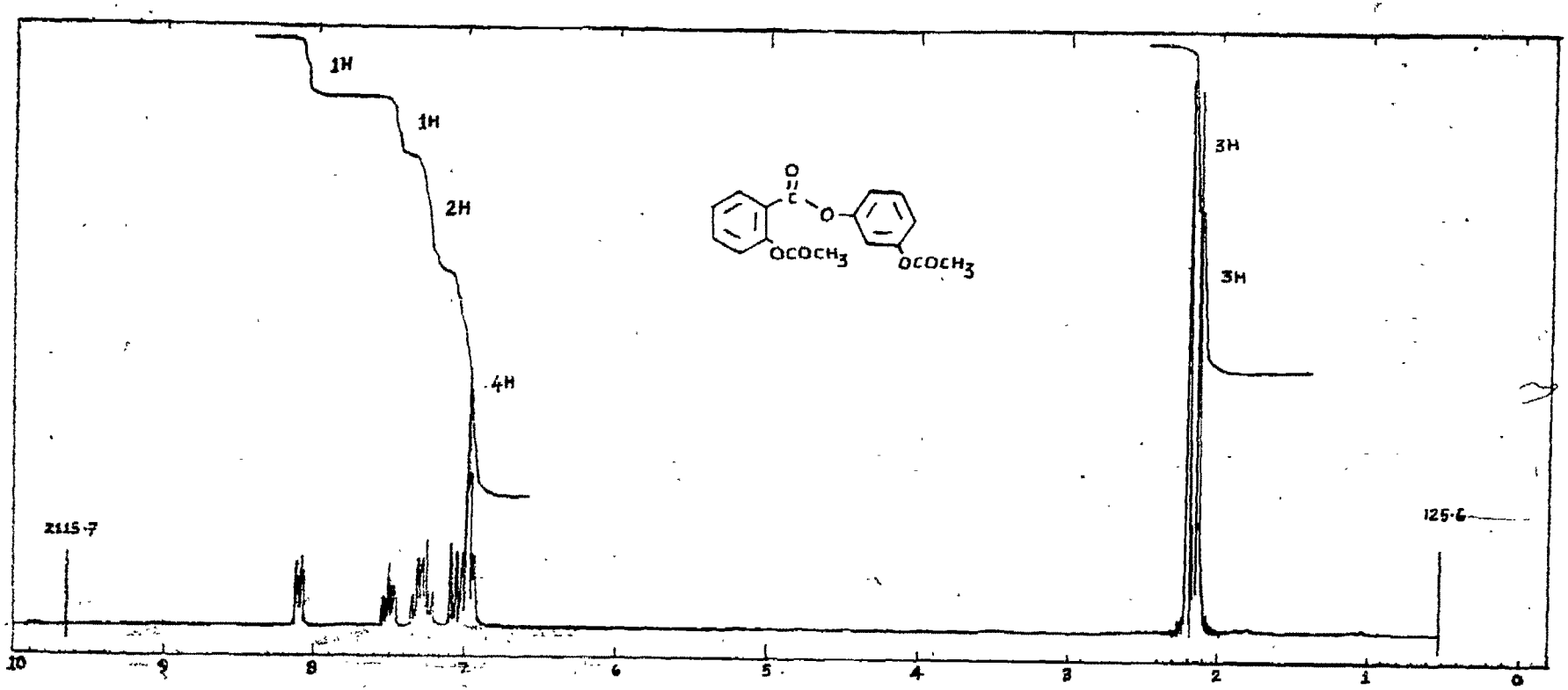


Fig. 2 : NMR spectrum of 3'-Acetoxyphenyl 2-acetoxybenzoate(XIIb) in $CDCl_3$ (220 MHz)

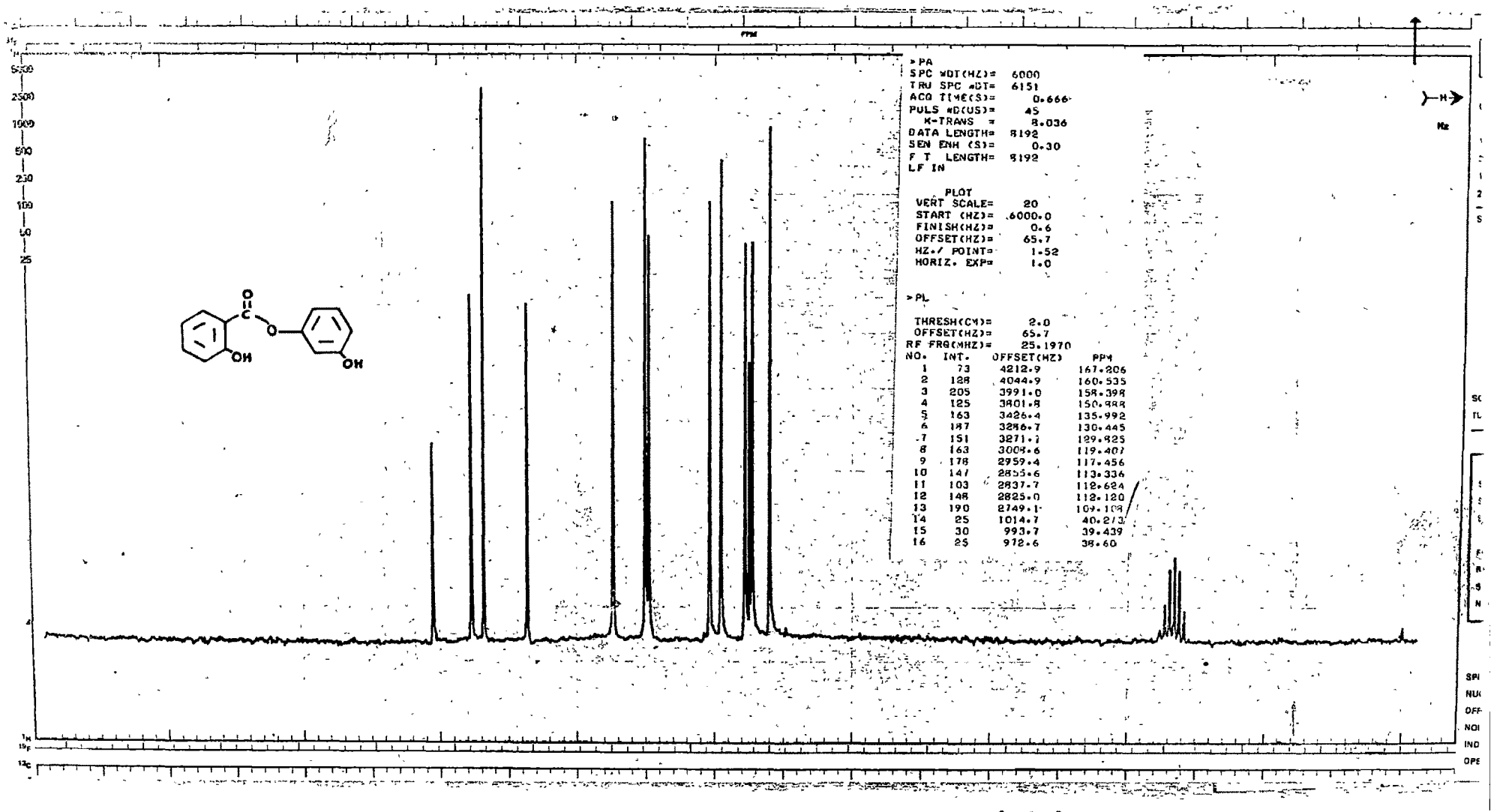
product XIIa. δ6.98-7.14, multiplet, 4H, aromatic protons at 2'-, 3-, 4'-, and 6'-position ; 7.26, double doublets, J=9Hz, J=1.6Hz, 2H at 4- and 5-position ; 7.54, triplet, J=9Hz, J=1.6Hz, 1H at 5'-position ; 8.14, double doublet, J_{65}=9Hz, J_{64}=1.4Hz, 1H at 6-position.

The ^{13}C NMR spectrum of XIIa in DMSO-d_6 (Fig. 3): It showed a down field peak at δ167.206. This confirmed the presence of phenyl ester carbonyl group (Ph-COO-Ph) and not of the benzophenone (Ph-CO-Ph). In case of latter, the signal would appeared around δ200. This proved that the major product of this condensation had structure XIIa.

1-Hydroxyxanthone(XIIIa) :

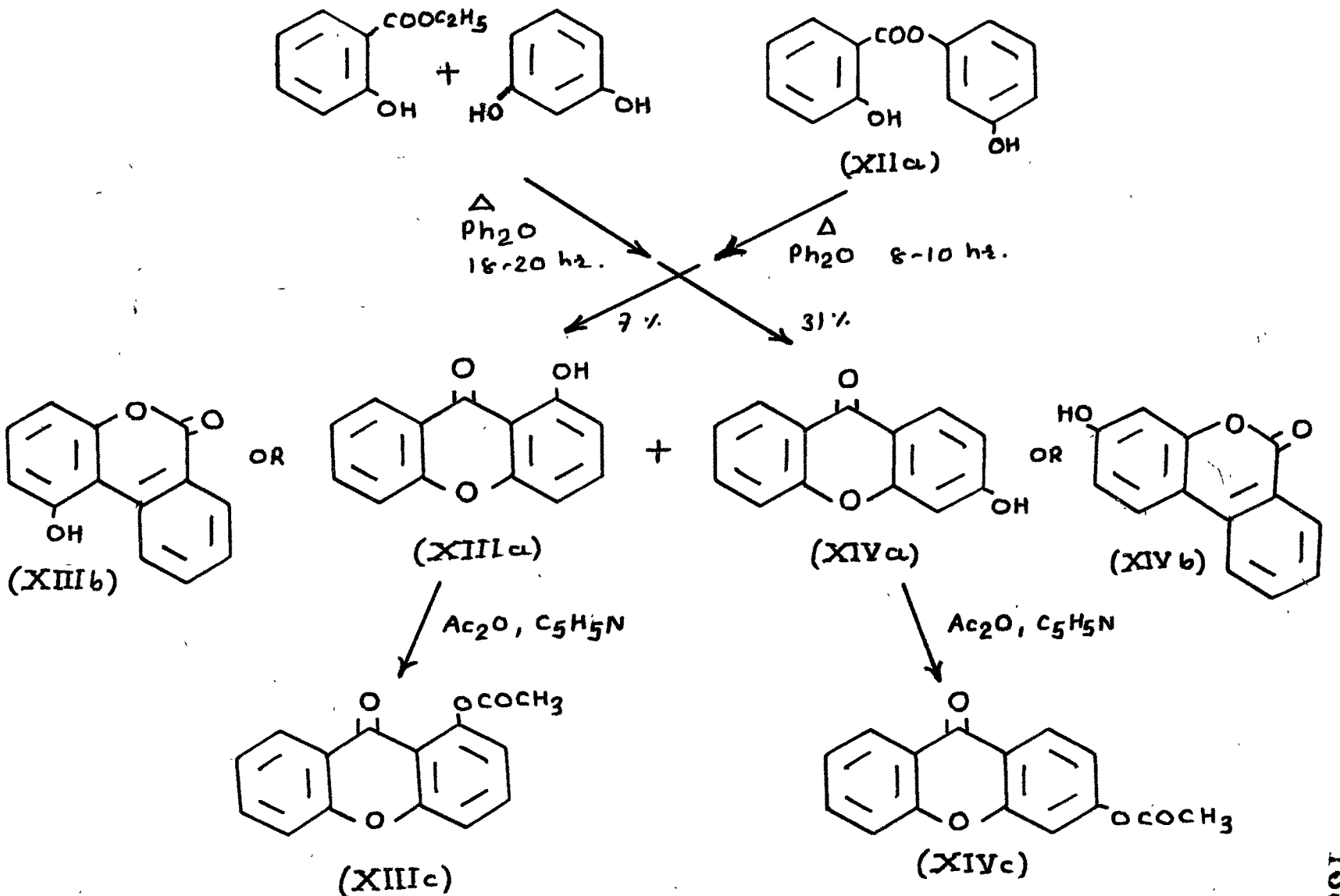
Resorcinol on prolonged heating with ethyl salicylate in boiling diphenyl ether for 18 to 20 hr. gave a mixture of 1-hydroxyxanthone(XIIIa), m.p. 149° (lit.,[32] m.p. 148°), yield 7 % and 3-hydroxyxanthone(XIVa), m.p. 246° (lit.,[37] m.p. 242°), yield 31 %. Both were separated by the treatment with sodium hydroxide solution (10 %). The compound (XIIIa) formed a yellow insoluble sodium salt. The salt was decomposed by dilute hydrochloric acid and chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (1:9) to give 1-hydroxyxanthone(XIIIa).

Its IR spectrum in nujol showed bands at 1650 cm^{-1} (γ-pyronyl >C=O group) and a broad band at 3420 cm^{-1}(chelated



(XII a)

Fig. 3 : ^{13}C NMR spectrum of 3'-Hydroxyphenyl salicylate in DMSO-d_6 (25.2. MHz).


COOC2H5
OH
HO
OH
COO
OH
OH
(XIIa)
Δ
Ph2O
18-20 hr.
Δ
Ph2O 8-10 hr.
7 %
31 %
O
OH
O
O
OR
OH
(XIIIb)
(XIIIa)
+
O
OH
O
(XIVa)
HO
O
O
OR
(XIVb)
Ac2O, C5H5N
Ac2O, C5H5N
O
OCOCH3
O
(XIIIc)
O
O
OCOCH3
(XIVc)

-OH group). If the compound had α-pyrone structure(XIIIb), the IR spectrum would have shown the carbonyl stretching band around 1720 cm^{-1} and not at 1650 cm^{-1}. The structure of XIIIa was further confirmed on the basis of the NMR spectrum in $CDCl_3$ (Fig. 4) of its monoacetate derivative(XIIIc) : δ2.44, singlet, 3H, $-OCOCH_3$ group at 1-position. Here the signal shifted to somewhat downfield, because the $-OCOCH_3$ group was ortho to γ-pyrone carbonyl group. (In case of XIVc, the singlet for $-OCOCH_3$ group appeared at δ2.32, somewhat upfield). δ6.85, doublet, J_{23}=9Hz, J_{24}=1.5Hz, 1H at 2-position ; 7.12-7.70, multiplet, 5H, aromatic protons at 3-, 4-, 5-, 6- and 7-position ; 8.11, doublet, J_{87}=10Hz, J_{86}=1.5Hz, 1H, at 8-position. The downfield doublet at δ8.11 integrated for only one proton which indicated that only one peri-position -8 was free, and second peri-position -1 carried a $-OCOCH_3$ group.

It is interesting to note here that the γ-substitution in resorcinol nucleus is taking place to give 1-hydroxyxanthone(XIIIa) in poor yield (7 %), which is rather difficult without a condensing agent. The same was obtained in good yield when PPA was used for the condensation of resorcinol with salicylic acid[32]. It was also observed by Shah and co-workers[63] that the γ-substitution in resorcinol was taking place when anhydrous aluminium chloride was used as a condensing agent. Desai, Trivedi and Sethna[62] observed such γ-substitution in resorcinol when it was thermally

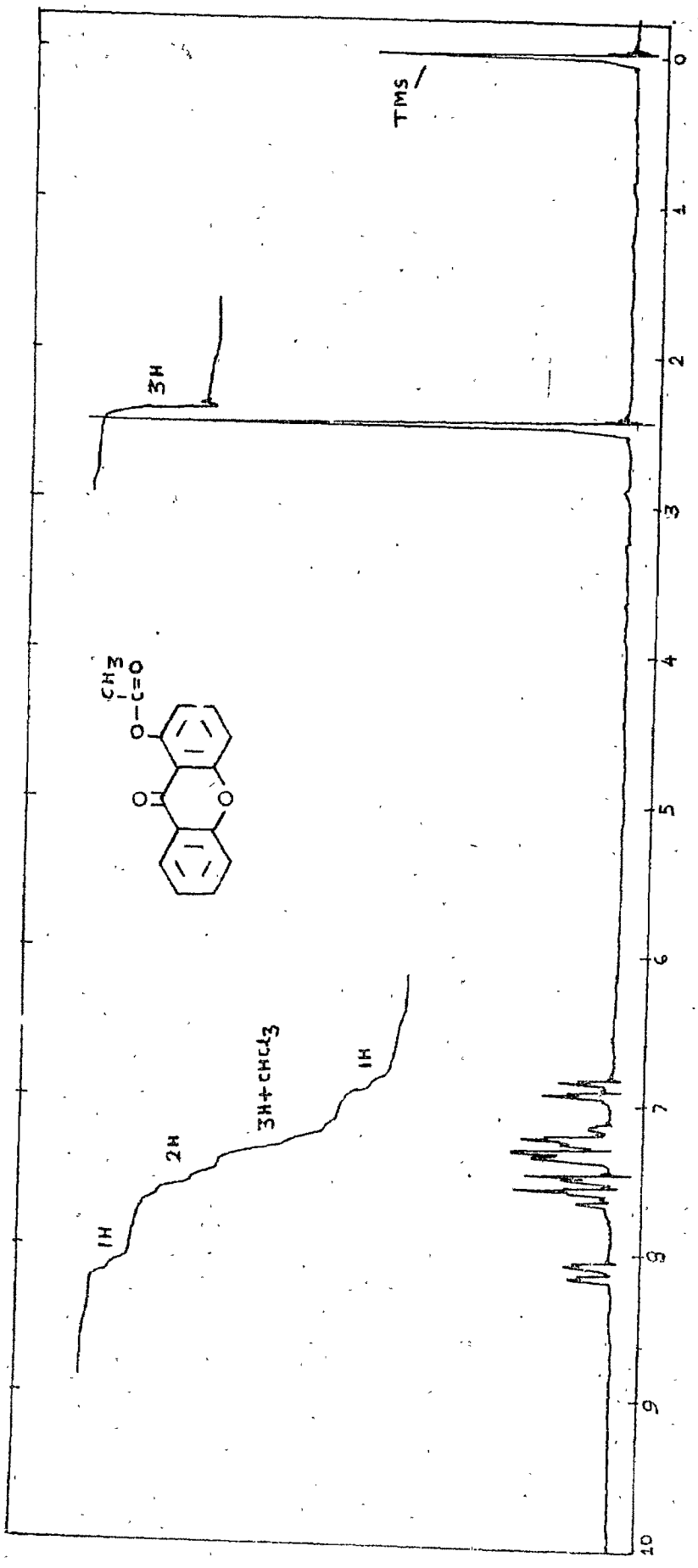


Fig. 4 : NMR spectrum of 1-Acetoxyxanthone (XIIIc) in $CDCl_3$ (90 MHz).

condensed with ethyl benzoyl acetate to give 5-hydroxy-flavone in poor yield. While Trivedi[64] observed that when resorcinol was condensed with ethyl benzylmalonate in diphenyl ether, it exclusively gave the γ-substituted product 4,5-dihydroxy-3-benzylcoumarin.

3-Hydroxyxanthone(XIVa) :

Acidification of the sodium hydroxide extract gave 3-hydroxyxanthone(XIVa), m.p. 246°, yield 31 %. Its IR spectrum in nujol (Fig. 5) showed a shoulder at 1632 cm^{-1} (γ-pyronyl >C=O group) and a weak band at 3100 cm^{-1} (-OH group). If it had α-pyrone structure XIVb (lit.,[65] m.p. 233°), the pyrone carbonyl stretching band would have appeared around 1720 cm^{-1} and not at 1632 cm^{-1}. Its mono-acetate derivative(XIVc) was prepared and characterized by its IR and NMR spectrum. The

The IR spectrum in nujol (Fig. 6) showed bands at 1650 cm^{-1} (γ-pyronyl >C=O group) and sharp band at 1746 cm^{-1} ($-OCOCH_3$ group).

The NMR spectrum in $CDCl_3$ (Fig. 7) showed following signals : δ2.32, singlet, 3H, $-OCOCH_3$ group at 3-position. The singlet was somewhat upfield as compared to that of $-OCOCH_3$ group at 1-position in case of XIIIc (δ2.44). δ7.25, multiplet, 5H, aromatic protons at 2-, 4-, 5-, 6- and 7-position ; 8.20, doublet, J=10Hz (ortho coupling), J=1.5Hz (meta coupling), 2H, aromatic protons at peri-position 1 and 8.

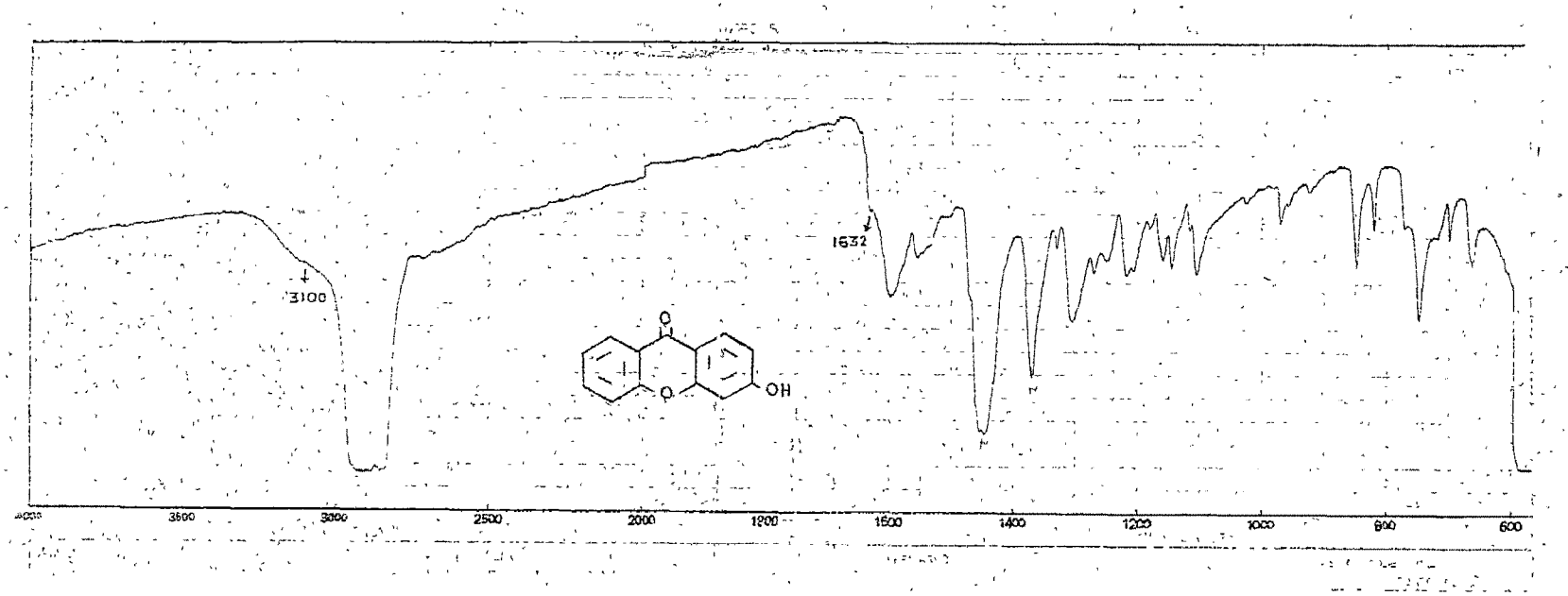


Fig. 5 : IR spectrum of 3-Hydroxyxanthone (XIVa) in nujol.

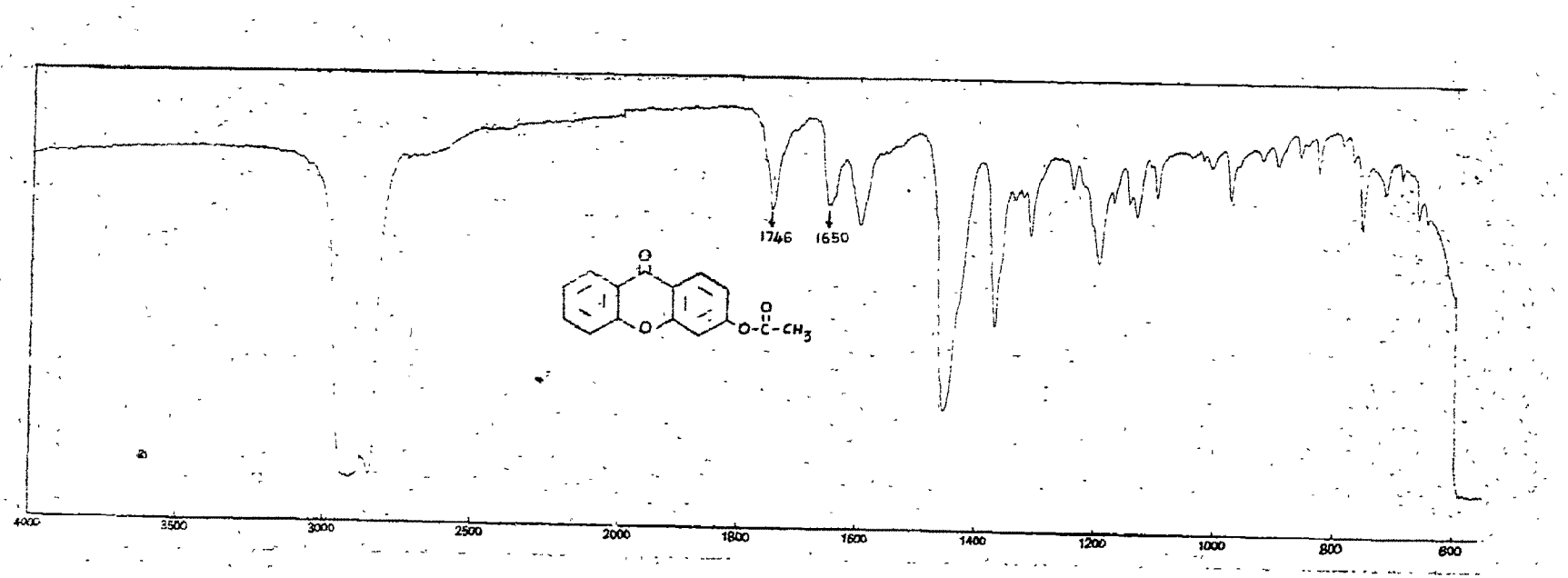


Fig. 6 : IR spectrum of 3-Acetoxyxanthone (XIVc) in nujol.

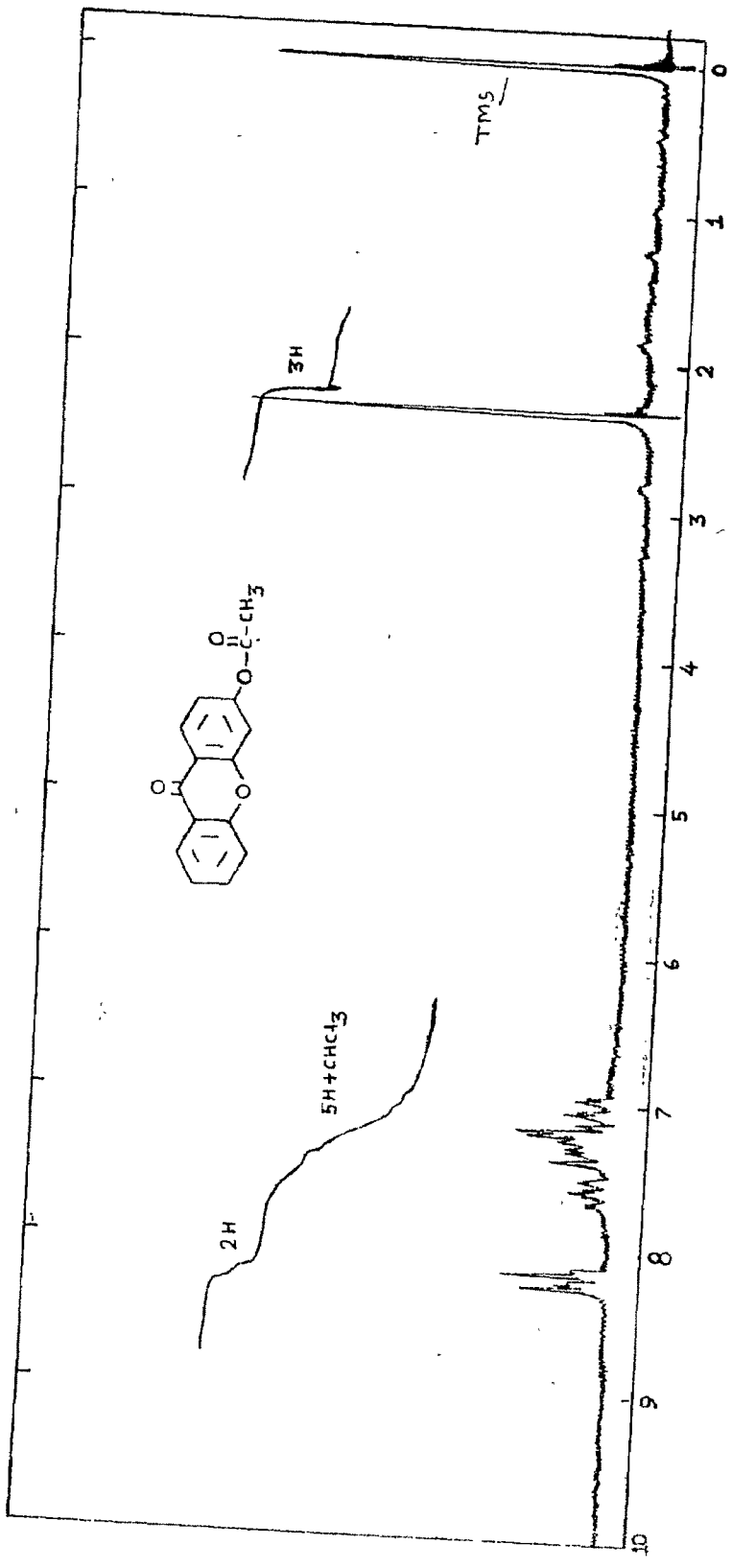


Fig. 7 : NMR spectrum of 3-Acetoxyxanthone (XIVc) in $CDCl_3$ (90 MHz).

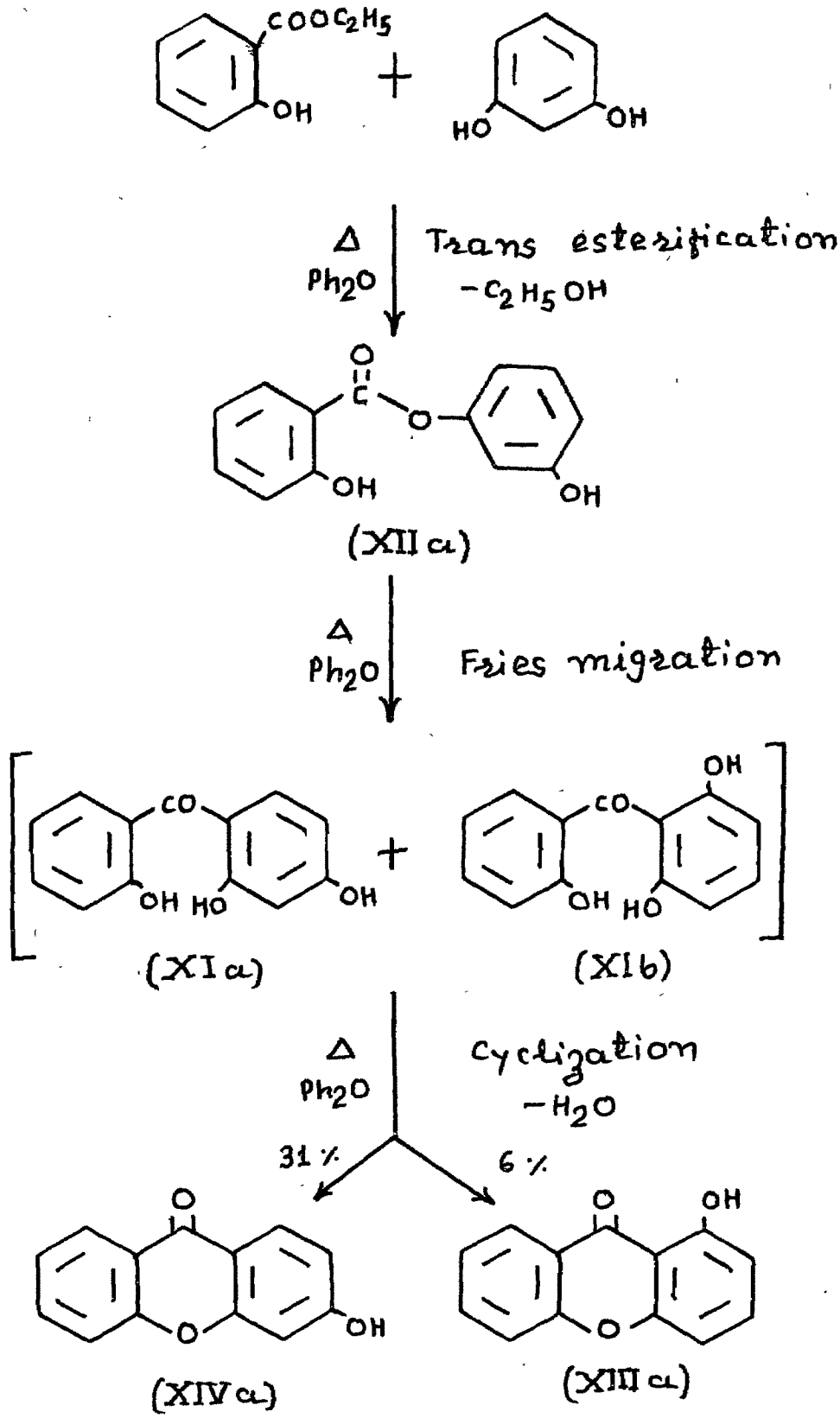
This showed that both the peri-positions of XIVa were unsubstituted.

Formation of 1-hydroxyxanthone(XIIIa) and 3-hydroxyxanthone (XIVa) from 3'-hydroxyphenyl salicylate(XIIa) :

3'-Hydroxyphenyl salicylate(XIIa), when refluxed alone in diphenyl ether for 8 to 10 hr. gave a mixture of 1-hydroxyxanthone(XIIIa), yield 9 % and 3-hydroxyxanthone (XIVa), yield 58 %. Both were separated as described before. The formation of 3-hydroxyxanthone(XIVa) along with XIIIa as a major product is explained in the following mechanism.

Mechanism of the condensation :

The formation of phenyl salicylate derivative(XIIa), 2,2',4-trihydroxybenzophenone(XIa), 1-hydroxyxanthone(XIIIa) and 3-hydroxyxanthone(XIVa) can be explained as follows : Ethyl salicylate when heated with resorcinol, it underwent trans esterification to give 3'-hydroxyphenyl salicylatee (XIIa), with the liberation of ethanol. The product XIIa, at high temperature, underwent Fries migration with the formation of 2,2',4-trihydroxybenzophenone(XIa) and 2,2',6-trihydroxybenzophenone(XIb), which simultaneously cyclized to corresponding xanthone derivatives XIVa and XIIIa respectively with the elimination of water. Thus the proportion, in which two benzophenones formed, will determine the yield of hydroxyxanthones XIIIa and XIVa. The reaction scheme is shown on next page.


COOC2H5
OH
HO
OH
Δ
Ph2O
Trans esterification
-C2H5OH
O
C
O
OH
OH
(XII a)
Δ
Ph2O
Fries migration
CO
OH HO
OH
(XI a)
OH
CO
OH HO
(XI b)
Δ
Ph2O
Cycligation
-H2O
31 %
6 %
O
OH
(XIV a)
O
OH
(XIII a)

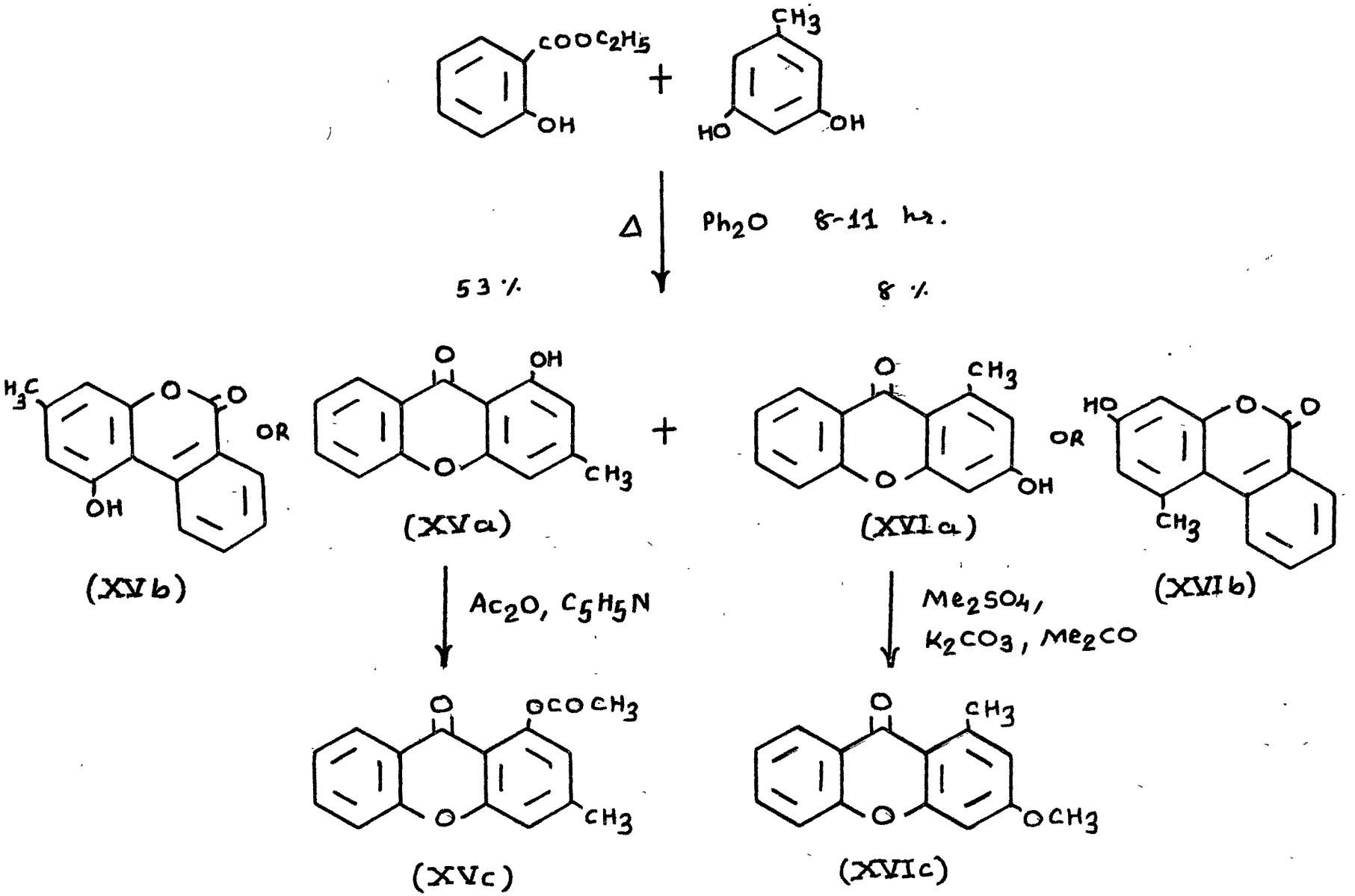
Condensation of orcinol with ethyl salicylate :

1-Hydroxy-3-methylxanthone(XVa) and 3-hydroxy-1-methylxanthone (XVIa) :

When a mixture of orcinol and ethyl salicylate was refluxed with diphenyl ether for 8 to 11 hr. afforded a mixture of 1-hydroxy-3-methylxanthone(XVa), yield 53 %, m.p. 148° (lit.,[32] m.p. 148° and lit.,[36] m.p. 142-3°) and 3-hydroxy-1-methylxanthone(XVIa), yield 8 %, m.p. 285° (lit.,[66] m.p. 285°). This indicates that γ-substitution in orcinol took place easily, which is rather difficult without a condensing agent. The formation of XVIa is also interesting because it is a xanthone derivative, which is not reported in the literature. Moreover, it could not be synthesized by the usual condensing agents like anhydrous aluminium chloride, zinc chloride or a mixture of zinc chloride and phosphorus oxychloride.

1-Hydroxy-3-methylxanthone(XVa) :

The product, obtained after steam distillation was treated with sodium hydroxide solution (8 %), whereby 1-hydroxy derivative (XVa) forms a yellow insoluble sodium salt, which was treated with dilute hydrochloric acid and chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (1:4) to obtain 1-hydroxy-3-methyl-xanthone(XVa).


COOC2H5
OH
CH3
HO
OH
Δ
Ph2O 8-11 hr.
53 %
8 %
H3C
O
O
OR
OH
(XVb)
O
OH
CH3
(XVa)
+
O
CH3
OR
HO
O
O
OH
CH3
(XVIa)
(XVIb)
Ac2O, C5H5N
Me2SO4,
K2CO3, Me2CO
OCOCH3
CH3
(XVc)
CH3
OCH3
(XVIc)

The IR spectrum showed bands at 1654 cm^{-1} (γ-pyronyl >C=O group) and a broad band at 3380 cm^{-1} (intramolecular hydrogen bonded -OH group). On the basis of IR spectrum the α-pyrone structure XVb was rejected. The NMR spectrum of its monoacetate derivative(XVc) in $CDCl_3$ (Fig. 8) showed the following signals : δ2.51, singlet, 6H, $-OCOCH_3$ group at 1-position and $-CH_3$ group at 3-position ; 6.70, singlet, 1H at 2-position ; 7.07, singlet, 1H at 4-position ; 7.21-7.60, multiplet, 3H, aromatic protons at 5-, 6-, and 7-position ; 8.12, doublet, J_{87}=9Hz, J_{86}=1.5Hz, 1H at 8-position.

3-Hydroxy-1-methylxanthone(XVIa) :

Acidification of the sodium hydroxide extract gave 3-hydroxy-1-methylxanthone(XVIa), yield 8 %, m.p. 285° (lit.,[66], 285°) .

Its monomethyl ether derivative(XVIc) had m.p. 133° (lit.,[66] m.p. 130-32°). The IR spectrum of XVIa in nujol showed bands at 1645 cm^{-1}(γ-pyronyl >C=O group) and a broad band at 3215 cm^{-1} (aromatic -OH group). If the product had structure XVIb the carbonyl stretching band would have appeared around 1720 cm^{-1}, thus the possible structure for the product is XVIa and not XVIb.

Condensation of phloroglucinol with ethyl salicylate :

1,3-Dihydroxyxanthone(XVIIa) :

Phloroglucinol was dissolved in minimum quantity of

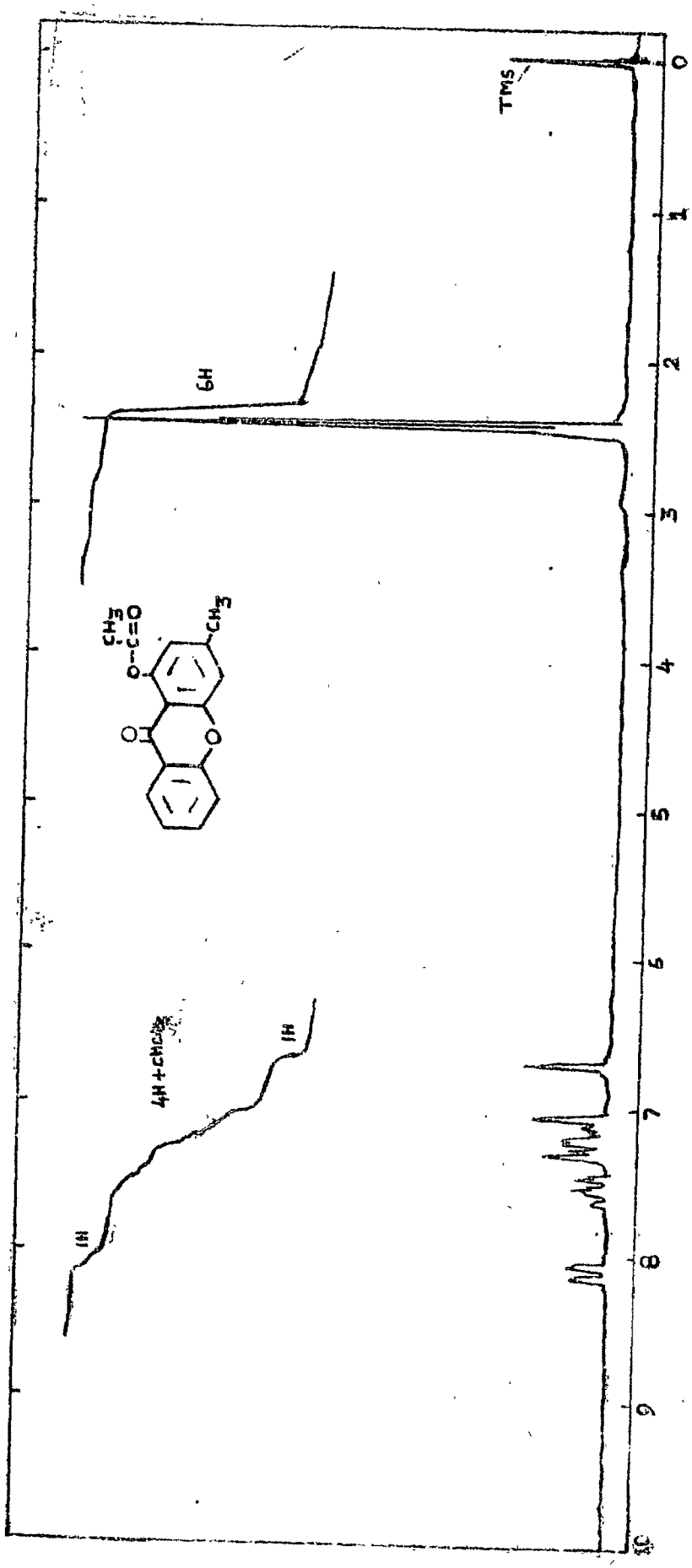


Fig. 8 : NMR spectrum of 1-Acetoxy-3-methylxanthone (XVc) in $CDCl_3$ (90 MHz).

hot diphenyl ether in presence of excess amount of ethyl salicylate and the reaction mixture was refluxed for 50 minutes. On working up a the reaction mixture 1,3-dihydroxyxanthone(XVIIa) could be obtained in 57 % yield, m.p. 257° (lit.,[32] m.p. 256°).

The IR spectrum in nujol showed bands at 1670 cm^{-1} (γ-pyronyl >C=O group) and two broad bands at 3200 cm^{-1} and at 3460 cm^{-1} (aromatic -OH groups at 3- and 1-position). On the basis of IR spectrum the α-pyrone structure XVIIb for the product is untenable.

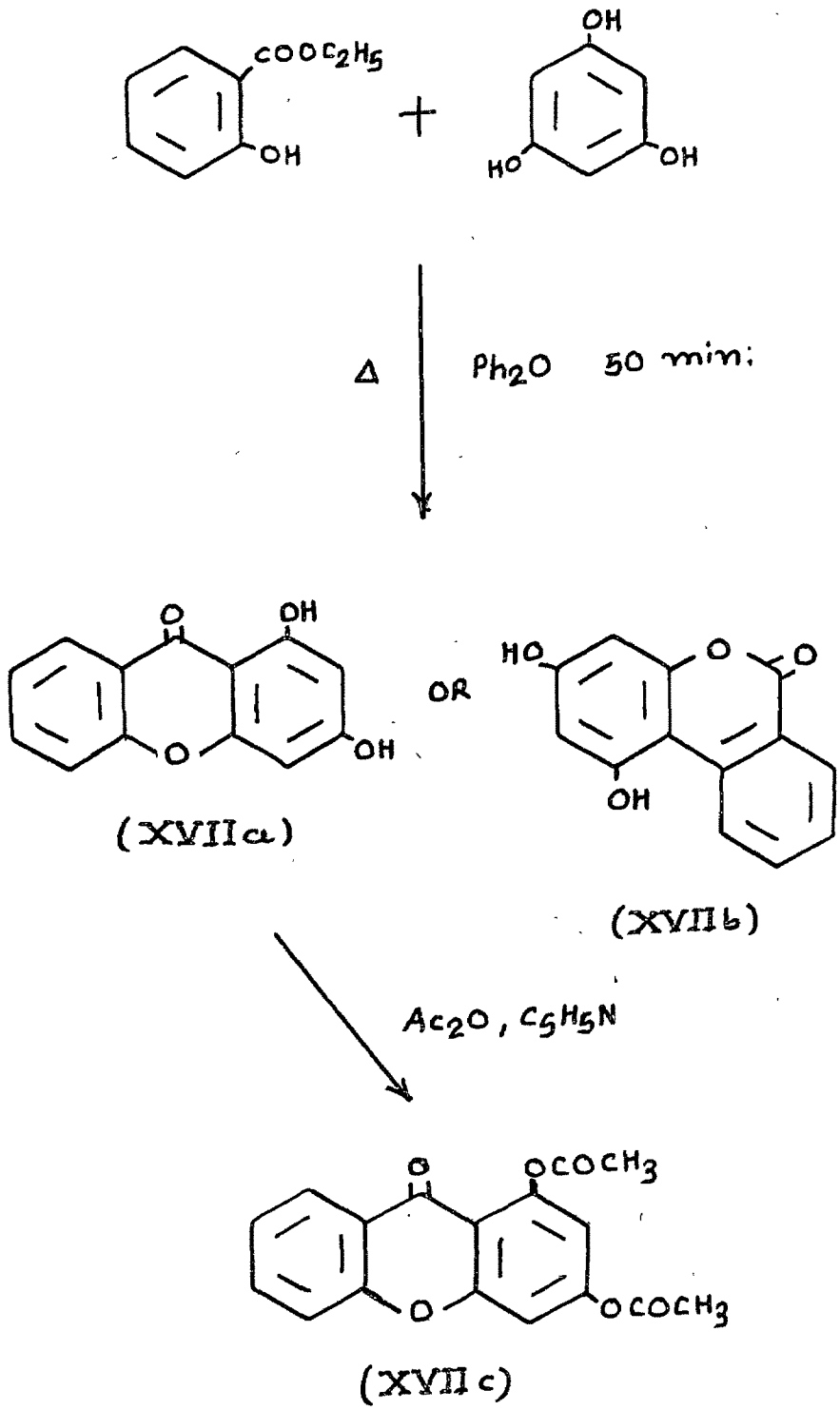
The product XVIIa on acetylation with acetic anhydride and pyridine gave diacetate derivative(XVIIc), m.p. 148° (lit.,[32] m.p. 148°) and methylation with dimethyl sulphate in dry acetone gave 1,3-dimethoxyxanthone, m.p. 170° (lit.,[36] m.p. 169-70°).

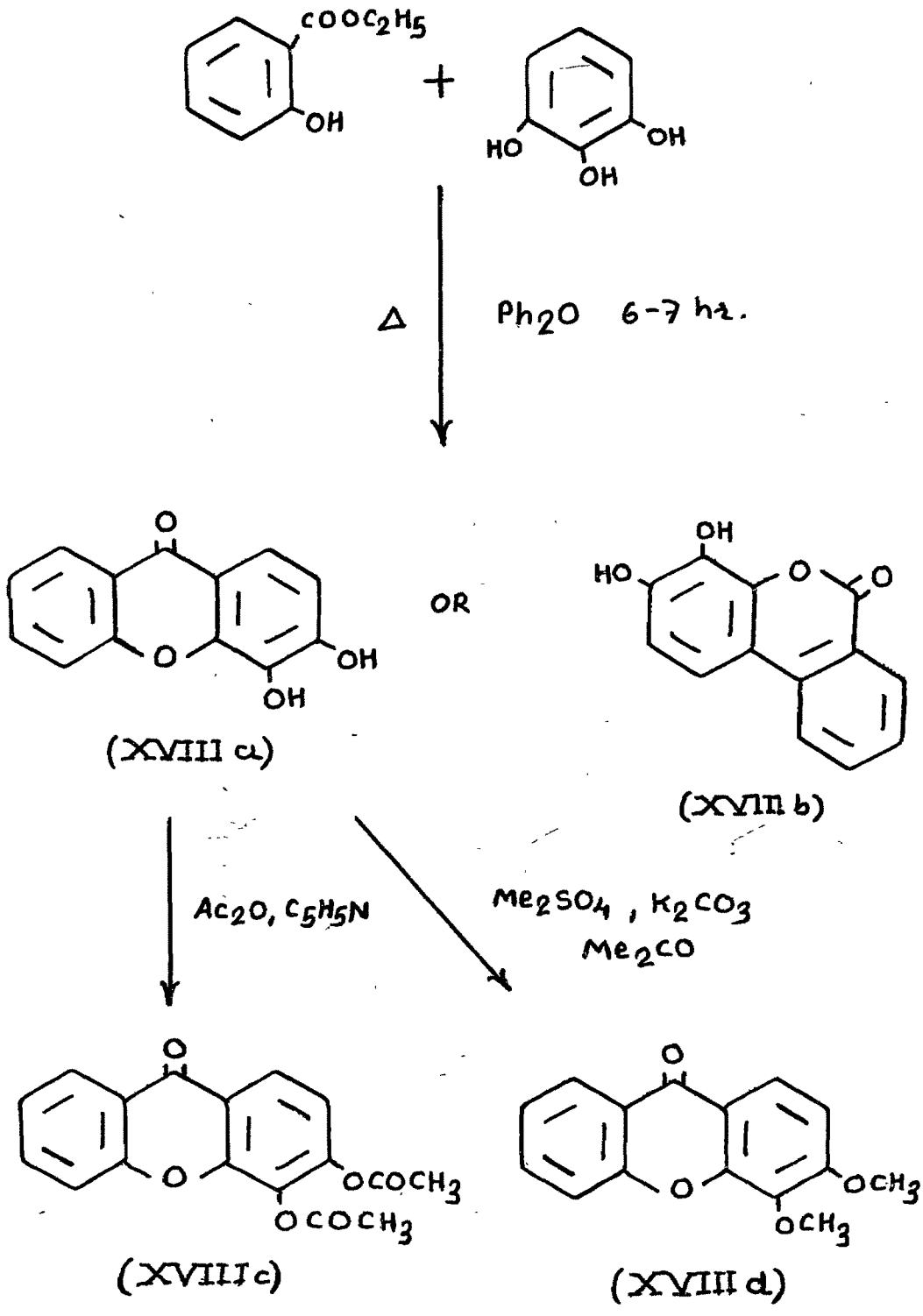
Condensation of pyrogallol with ethyl salicylate :

3,4-Dihydroxyxanthone(XVIIIa) :

A mixture of equimolecular quantities of pyrogallol and ethyl salicylate was refluxed in diphenyl ether for 6 to 7 hr. The dark product obtained after steam distillation was passed through the column of alumina and eluted with a mixture of benzene-chloroform (1:9) to give 3,4-dihydroxyxanthone (XVIIIa), yield 48 %, m.p. 240° (lit.,[33] m.p. 240-41°).

The IR spectrum in nujol showed bands at 1645 cm^{-1} (γ-pyronyl >C=O group) and two broad bands at 3225 cm^{-1} and


COOC2H5
OH
OH
HO
OH
Δ
Ph2O
50 min.
O
OH
O
OH
(XVIIa)
OR
HO
O
O
OH
(XVIIb)
Ac2O, C5H5N
O
OCOCH3
O
OCOCH3
(XVIIc)


COOC2H5
OH
+
HO
OH
OH
Δ
Ph2O 6-7 hr.
O
O
OH
OH
OR
HO
OH
O
O
(XVIII a)
(XVII b)
Ac2O, C5H5N
Me2SO4 , K2CO3
Me2CO
OCOCH3
OCOCH3
OCH3
OCH3
(XVIII c)
(XVIII d)

at 3340 cm^{-1} (aromatic -OH groups). The α-pyrone structure XVIIIb is not tenable on the basis of low carbonyl stretching in the IR spectrum. The product XVIIIa on acetylation with acetic anhydride and pyridine gave diacetate derivative(XVIIIc), m.p. 161° and on methylation with dimethyl sulphate in presence of anhydrous potassium carbonate in dry acetone yielded 3,4-dimethoxyxanthone(XVIIId), m.p. 157° (lit.,[33] m.p. 156-57°).

Condensation of 1-naphthol with ethyl salicylate :

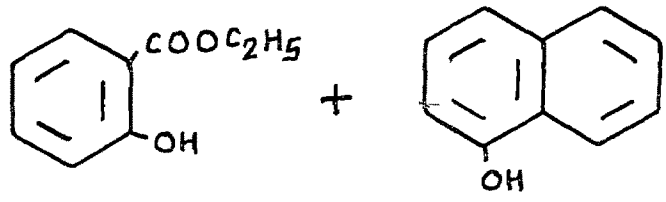
3,4-Benzoxanthone(XIXa) :

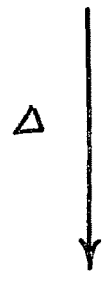
1-Naphthol was condensed with ethyl salicylate in boiling diphenyl ether for 8 hr. The crystalline product obtained after cooling the reaction mixture, was washed successively with petroleum ether, sodium hydroxide solution (2 %) and finally with water and the structure was assigned as 3,4-benzoxanthone(XIXa), yield 74 %, m.p. 156° (lit.,[32] m.p.155°), on the basis of elemental analysis and its IR spectrum in nujol : 1645 cm^{-1} (γ-pyronyl >C=O group). Thus other possible structures XIXb and XIXc are untenable. In this case the benzoxanthone(XIXa) is obtained in very high yield as compared to other methods of the synthesis of xanthones.

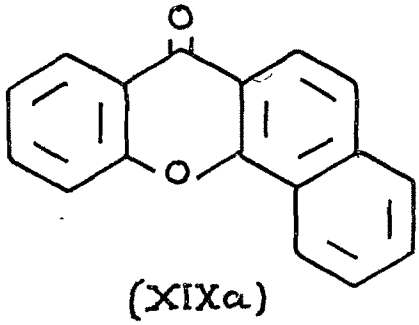
Condensation of 2-naphthol with ethyl salicylate :

1,2-Benzoxanthone(XXa) :

A mixture of 2-naphthol and ethyl salicylate was refluxed with diphenyl ether for 8 to 9 hr. The crystalline

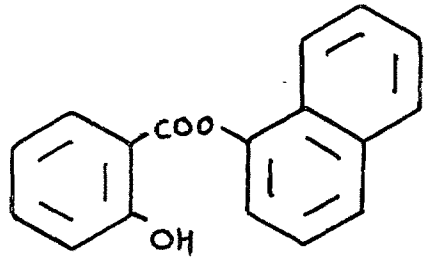






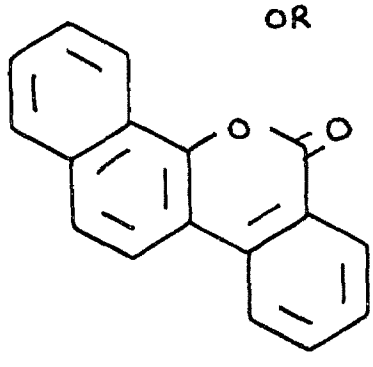
(XIXa)

OR

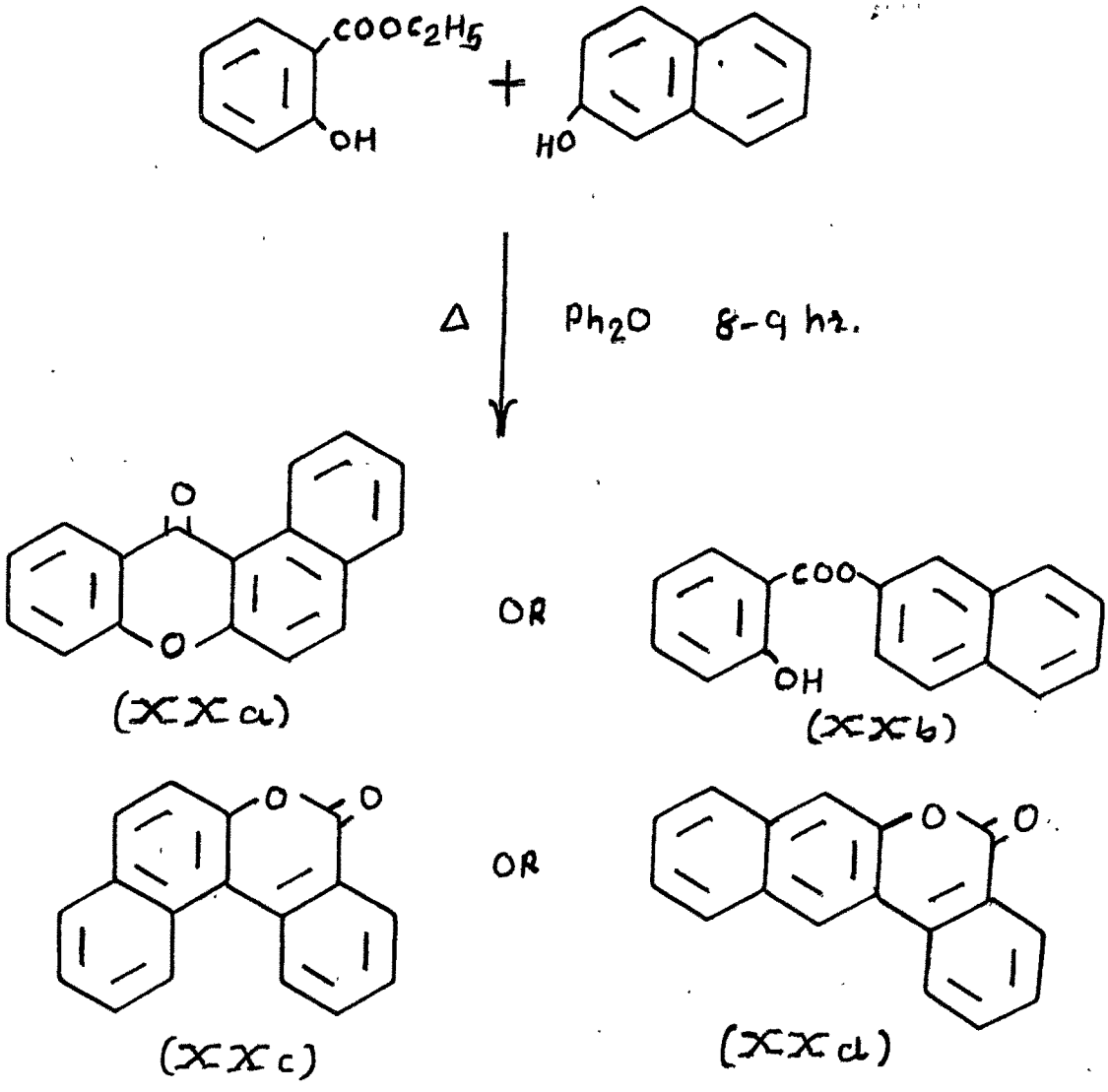


(XIXb)

OR



(XIXc)



product separated after cooling the reaction mixture, was washed with petroleum ether, for several times, sodium hydroxide solution (2 %) and finally with water and was characterized as 1,2-benzoxanthone(XXa), yield 65 %, m.p. 141° (lit.,[32] m.p. 138-40°) on the basis of its elemental analysis and its mixed m.p. 140° with authentic sample[32]. The IR spectrum in nujol showed band at 1648 cm^{-1} (γ-pyronyl >C=O group). The α-pyrone structures XXc and XXd (lit.,[11] m.p. 186°, 5H-benzo[b]naphtho-

[3,2-d]pyran-5-one) are untenable on the basis of IR spectrum .

Condensation of 2-methylresorcinol with ethyl salicylate :

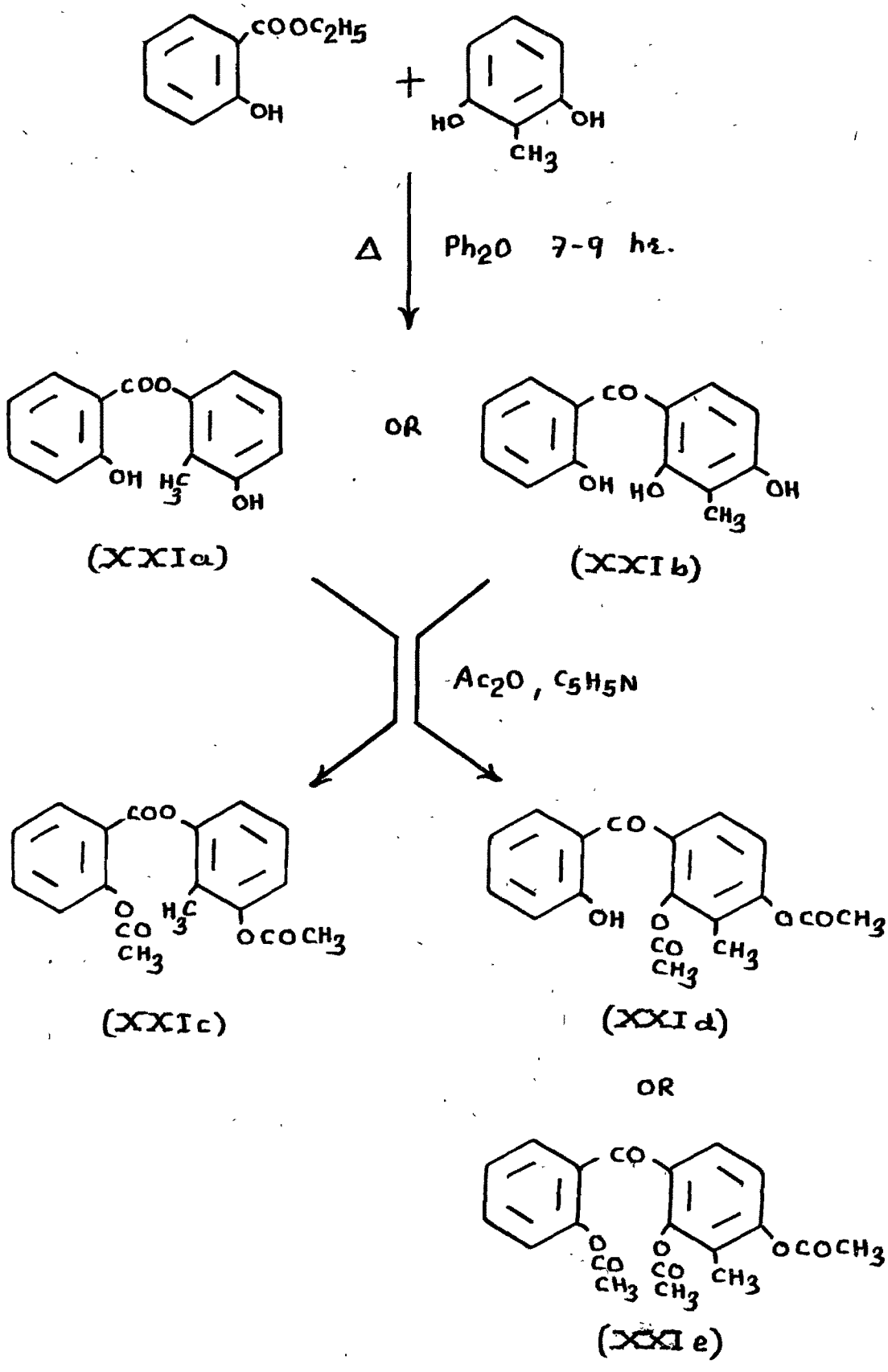
2'-Methyl-3'-hydroxyphenyl salicylate(XXIa) :

A mixture of 2-methylresorcinol and ethyl salicylate was refluxed in diphenyl ether for 7 to 9 hr. The product obtained after steam distillation, was chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (3:2) to obtain 2'-methyl-3'-hydroxyphenyl salicylate (XXIa), yield 52 %, m.p. 102°.

The IR spectrum in nujol showed bands at 1682 cm^{-1} (-COO-Ph ester group) and two broad bands at 3200 cm^{-1} and 3460 cm^{-1} (aromatic -OH groups). If the product had benzophenone structure XXIb, it would have shown carbonyl stretching band around 1655 cm^{-1} .

The product XXIa on acetylation with acetic anhydride and pyridine gave diacetate derivative(XXIc), m.p. 64°. If it had structure XXId, with one free hydroxy group, which is ortho to carbonyl group, it would have developed colour with ethanolic ferric chloride. No colour was developed with ethanolic ferric chloride and therefore, structure XXIc was assigned for the diacetate derivative. The elemental analysis also corresponds to diacetate structure(XXIc).

Finally the structure XXIa was confirmed by the NMR spectrum of its diacetate derivative(XXIc) in $CDCl_3$ (Fig. 9) : δ 2.02, singlet, 3H, CH_3 group at 2'-position ; 2.38, two singlets, 6H, two $-OCOCH_3$ groups at 3'- and 2-position.


COOC2H5
OH
HO
OH
CH3
Δ
Ph2O 7-9 hr.
COO
OH
H3C
OH
OR
CO
OH
HO
OH
CH3
(XXIa)
(XXIb)
Ac2O, C5H5N
COO
O
CO
CH3
H3C
OCOCH3
CO
OH
O
CO
CH3
CH3
OCOCH3
(XXIc)
(XXId)
OR
CO
O
CO
CH3
O
CO
CH3
CH3
OCOCH3
(XXIe)

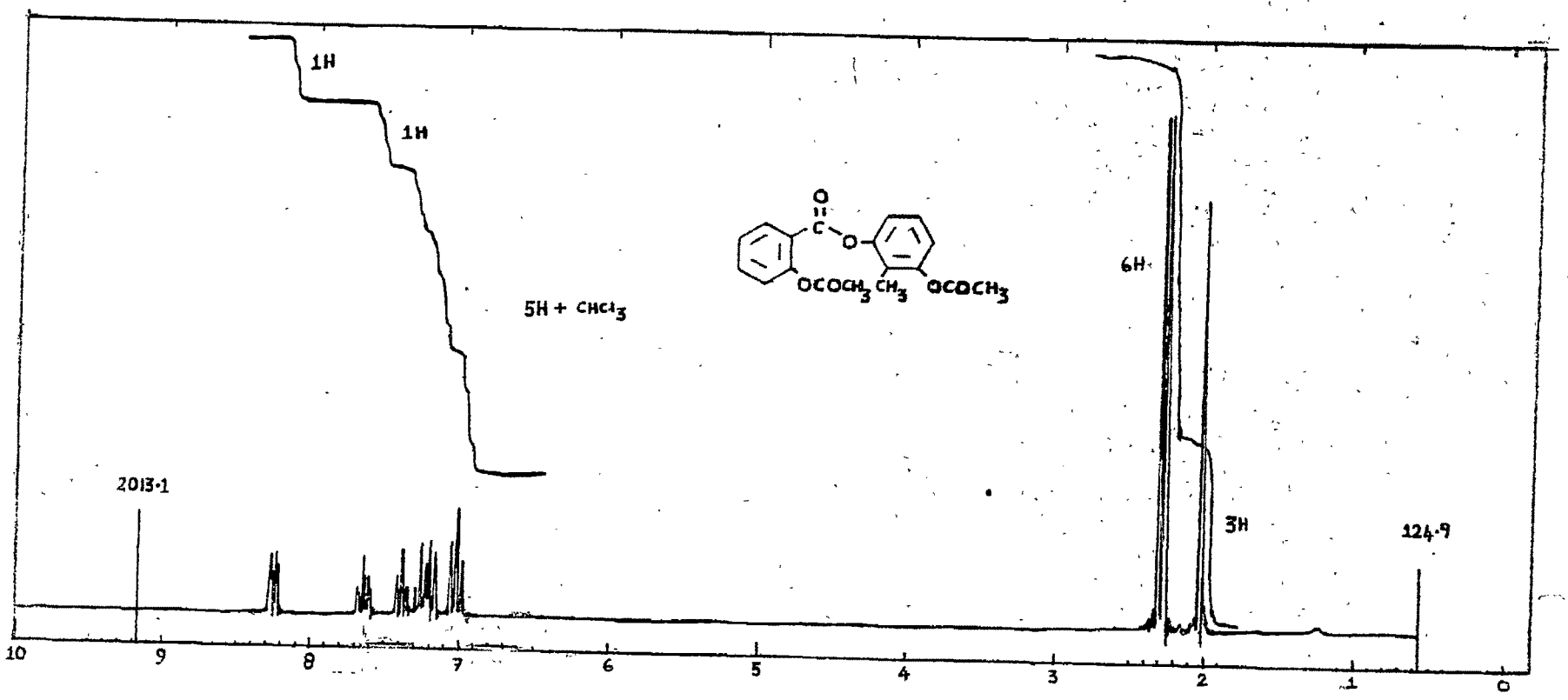


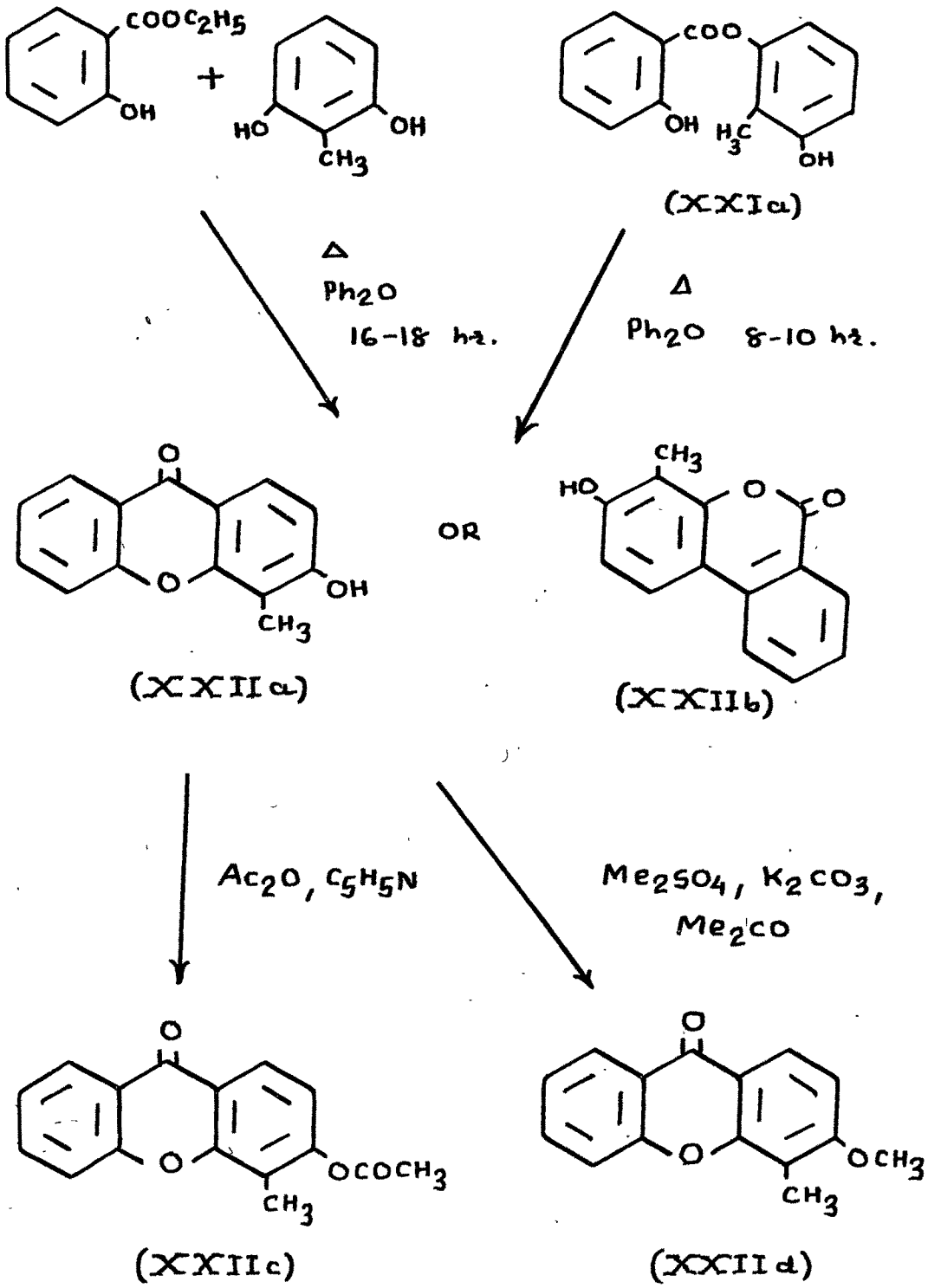
Fig. 9 : NMR spectrum of 2'-Methyl-3'-acetoxyphenyl 2-acetoxybenzoate (XXIc) in $CDCl_3$ (220 MHz).

The presence of two $-OCOCH_3$ groups confirmed the structure XXIc and not the benzophenone structure XXIe, which would have given signal for nine proton of three $-OCOCH_3$ groups. δ 6.98-7.42, multiplet, 5H, aromatic protons at 3-, 4-, 5-, 4'-, and 6'-position ; 7.65, triplet, J=9Hz, J=1.5Hz, 1H at 5'-position ; 8.25, doublet, J_{65}=10Hz, J_{64}=1.5Hz, 1H at 6-position. The one proton down field doublet also showed the presence of only one proton ortho to >C=O group and confirmed the structure XXIc. In case of XXId or XXIe two protons doublet would have appeared in the downfield region of the spectrum.

3-Hydroxy-4-methylxanthone(XXIIa) :

2-Methylresorcinol on prolonged heating with ethyl salicylate for 16 to 18 hr. gave directly 3-hydroxy-4-methyl-xanthone(XXIIa), yield 37 %, m.p. 268° (lit.,[67] m.p. 267°).

Its IR spectrum in nujol showed bands at 1648 cm^{-1} (γ-pyronyl >C=O group) and a broad band at 3240 cm^{-1} (aromatic -OH group). On the basis of IR spectrum the α-pyrone structure XXIIb is found to be untenable. The structure of XXIIa was also confirmed by preparing its mono-acetate derivative(XXIIc), m.p. 154° and monomethyl ether derivative(XXIId), m.p. 177° (lit.,[68] m.p. 177-80°). The IR spectrum of XXIId in nujol (Fig. 10) showed band at 1640 cm^{-1} (γ-pyronyl >C=O group).


COOC2H5
OH
HO
OH
CH3
COO
OH
H3C
OH
(XXIa)
Δ
Ph2O
16-18 hr.
Δ
Ph2O
8-10 hr.
O
O
OH
CH3
OR
CH3
HO
O
O
(XXIIa)
(XXIIb)
Ac2O, C5H5N
Me2SO4, K2CO3,
Me2CO
O
O
OCOCH3
CH3
O
O
OCH3
CH3
(XXIIc)
(XXIId)

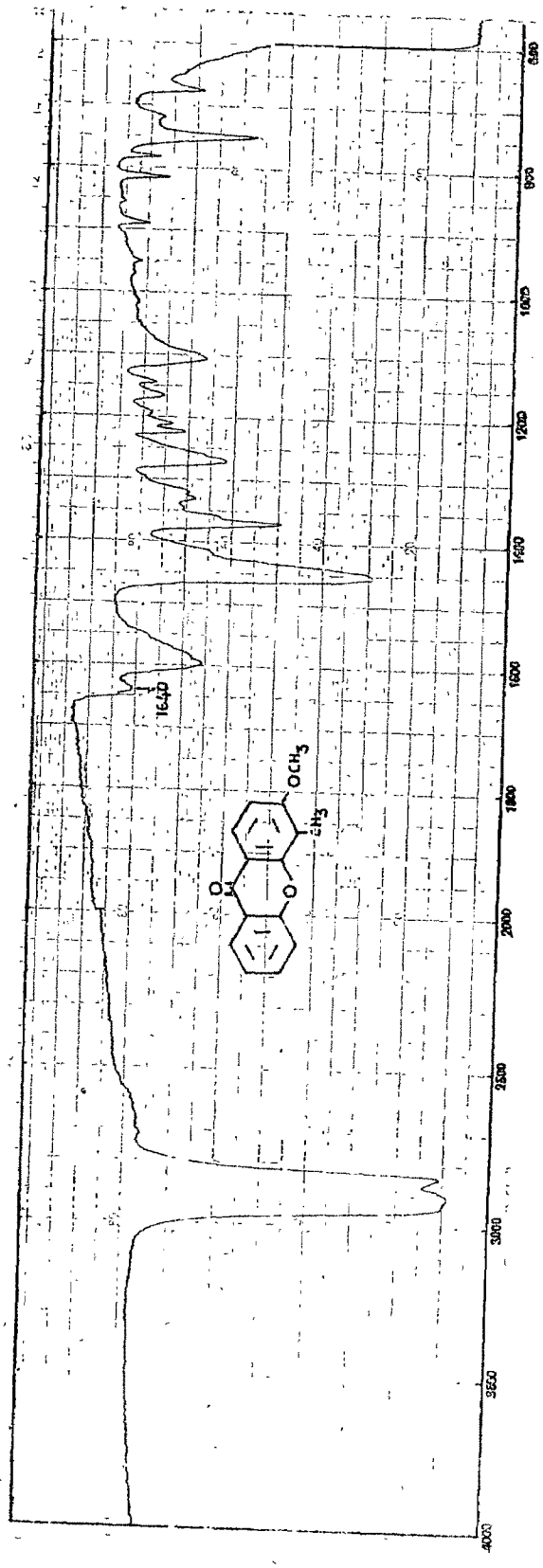


Fig. 10 : IR spectrum of 3-Methoxy-4-methylxanthone (XXIId) in nujol.

Formation of 3-hydroxy-4-methylxanthone(XXIIa) from 2'-methyl-3'-hydroxyphenyl salicylate(XXIa) :

2'-Methyl-3'-hydroxyphenyl salicylate(XXIa), which was formed as a result of trans esterification, when refluxed alone in diphenyl ether for 8 to 10 hr. afforded 3-hydroxy-4-methylxanthone(XXIIa), yield 55 %, m.p. 268° (lit.,[67] m.p. 267°). The formation of XXIIa from XXIa can be explained by high temperature Fries migration followed by cyclization with elimination of water.

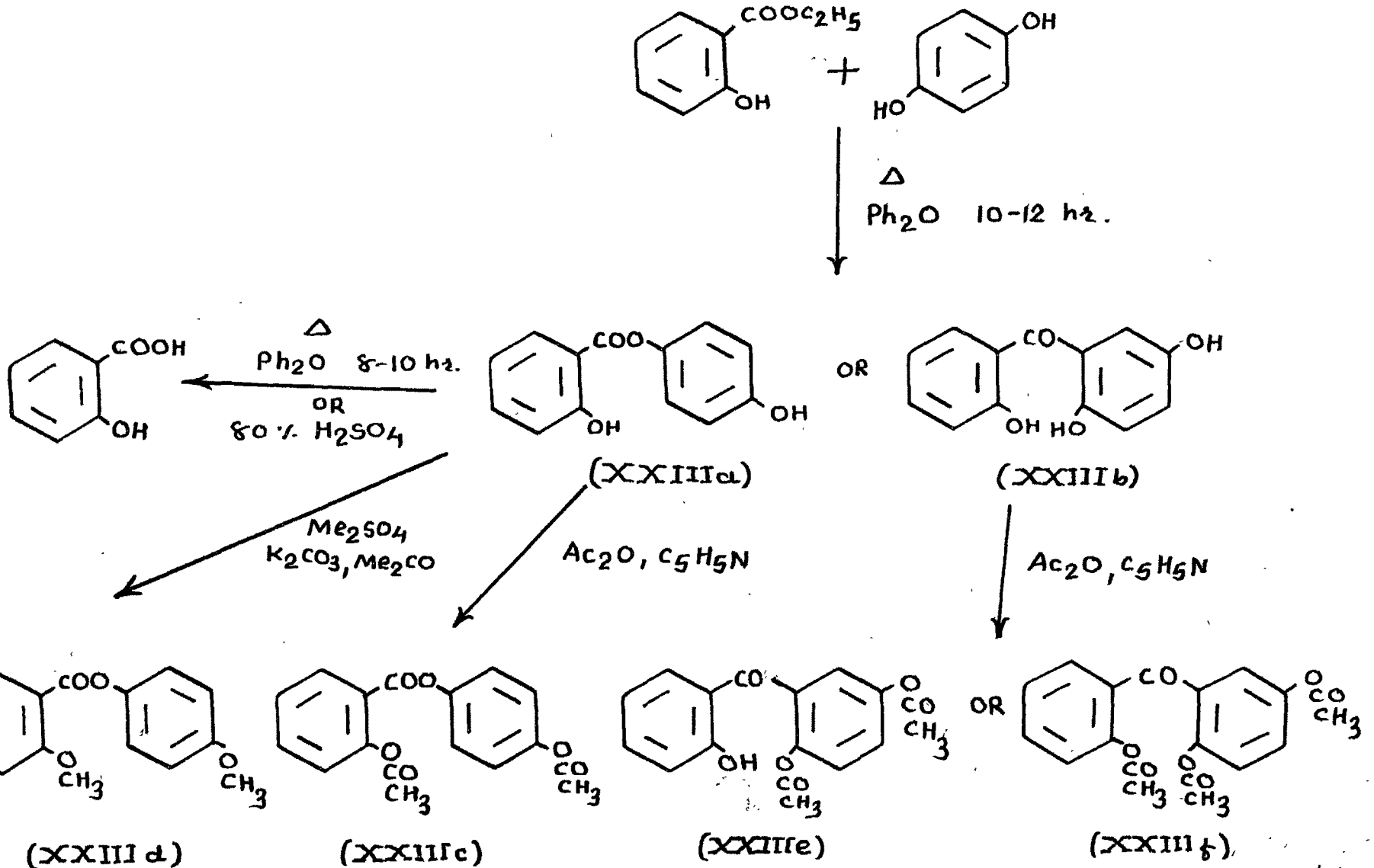
Condensation of hydroquinone with ethyl salicylate :

4'-Hydroxyphenyl salicylate(XXIIIa) :

Hydroquinone on thermal condensation with ethyl salicylate in diphenyl ether for 10 to 12 hr. gave 4'-hydroxyphenyl salicylate(XXIIIa) in good yield (55 %), m.p. 102-3°.

Its IR spectrum in nujol showed bands at 1698 cm^{-1} (-COO- Ph ester group) and a broad band at 3420 cm^{-1} (aromatic -OH group). If the product had benzophenone structure XXIIIb, the IR spectrum would have shown the carbonyl stretching band around 1655 cm^{-1}.

The product XXIIIa, on acetylation with acetic anhydride and pyridine gave diacetate derivative(XXIIIc), m.p. 146-8°. If it had a structure XXIIIe, it would have developed colour with ethanolic ferric chloride but the product did not develop any colour. Therefore, structure


COOC2H5
OH
OH
HO
Δ
Ph2O 10-12 hr.
COOH
OH
Δ
Ph2O 8-10 hr.
OR
80 % H2SO4
COO
OH
OH
(XXIIIa)
OR
CO
OH
OH HO
(XXIIIb)
Me2SO4
K2CO3, Me2CO
Ac2O, C5H5N
Ac2O, C5H5N
(XXIIId)
(XXIIIc)
(XXIIIe)
OR
(XXIIIf)

XXIIIc was assigned for the diacetate derivative. The possibility of triacetate structure XXIIIf is rejected on the basis of elemental analysis. Further the structure of XXIIIc was confirmed by its NMR spectrum in $CDCl_3$ (Fig. 11) : δ2.28, singlet, 6H, two $-OCOCH_3$ groups at 2- and 4'-position. This reslut further support the phenyl salicylate structure XXIIIc. δ7.16, multiplet, 5H, aromatic protons at 3-, 2'-, 3'-, 5'- and 6'-position ; 7.38, multiplet, 1H at 5-position ; 7.62, multiplet, 1H at 4-position ; 8.18, doublet, J_{65}=9Hz, J_{64}=1.5Hz, 1H at 6-position. The one proton down field doublet showed that there must be one proton ortho to >C=O group and if the product had benzophenone structure XXIIIe or XXIIIf then there should be two protons doublet in the down field region of the spectrum.

The product XXIIIa on methylation with dimethyl sulphate in presence of anhydrous potassium carbonate in dry acetone yielded dimethyl ether derivative(XXIIId), m.p. 85°.

4'-Hydroxyphenyl salicylate(XXIIIa) on treatment with sulphuric acid (80 %) at 70° for 15 minutes or by refluxing it alone in diphenyl ether for 9 to 10 hr. decomposed to give salicylic acid. Thus in this condensation 2-hydroxyxanthone could not be isolated.

Condensation of 3,4-o-xylenol with ethyl salicylate :

3',4'-Dimethylphenyl salicylate(XXIVa) :

A mixture of 3,4-o-xylenol (3,4-dimethylphenol),

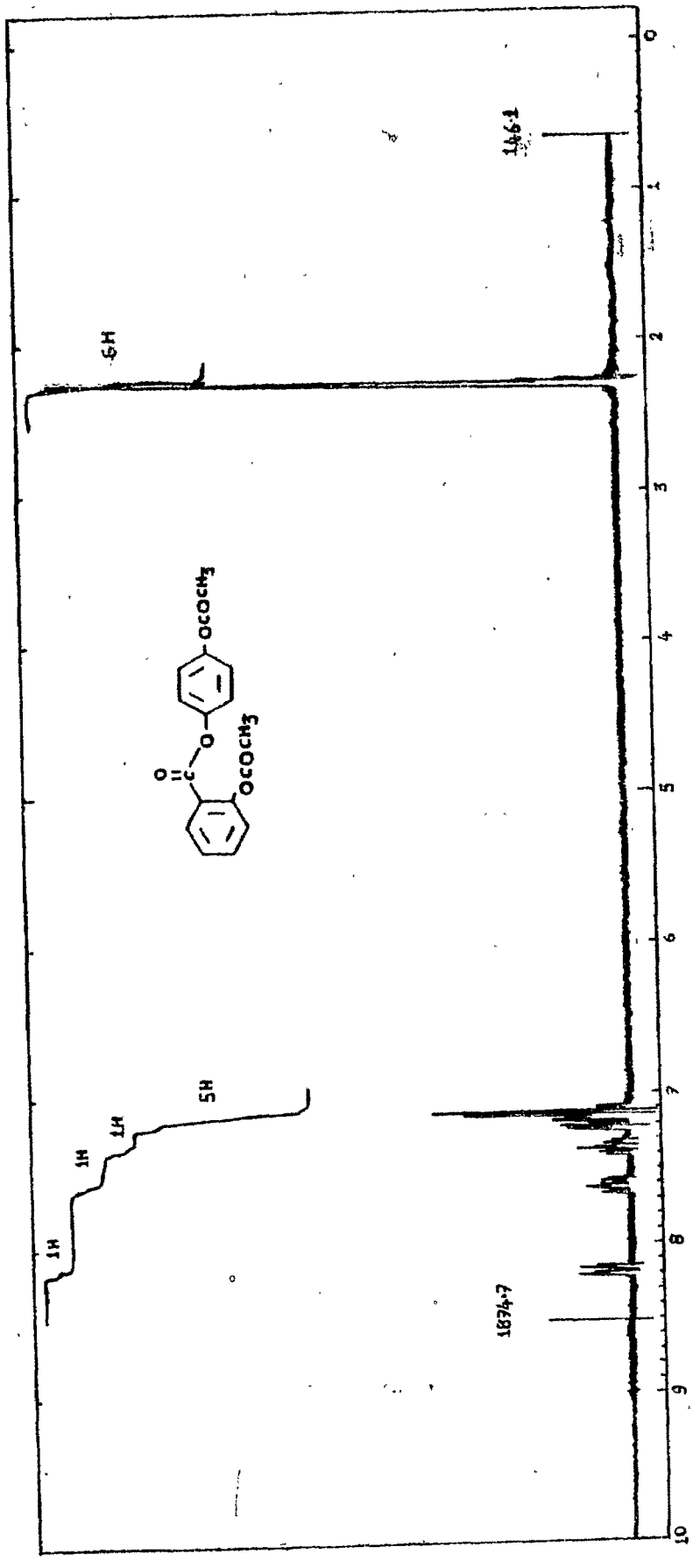


Fig. 11 : NMR spectrum of 4'-Acetoxyphenyl 2-acetoxybenzoate (XXIIIc) in $CDCl_3$ (220 MHz).

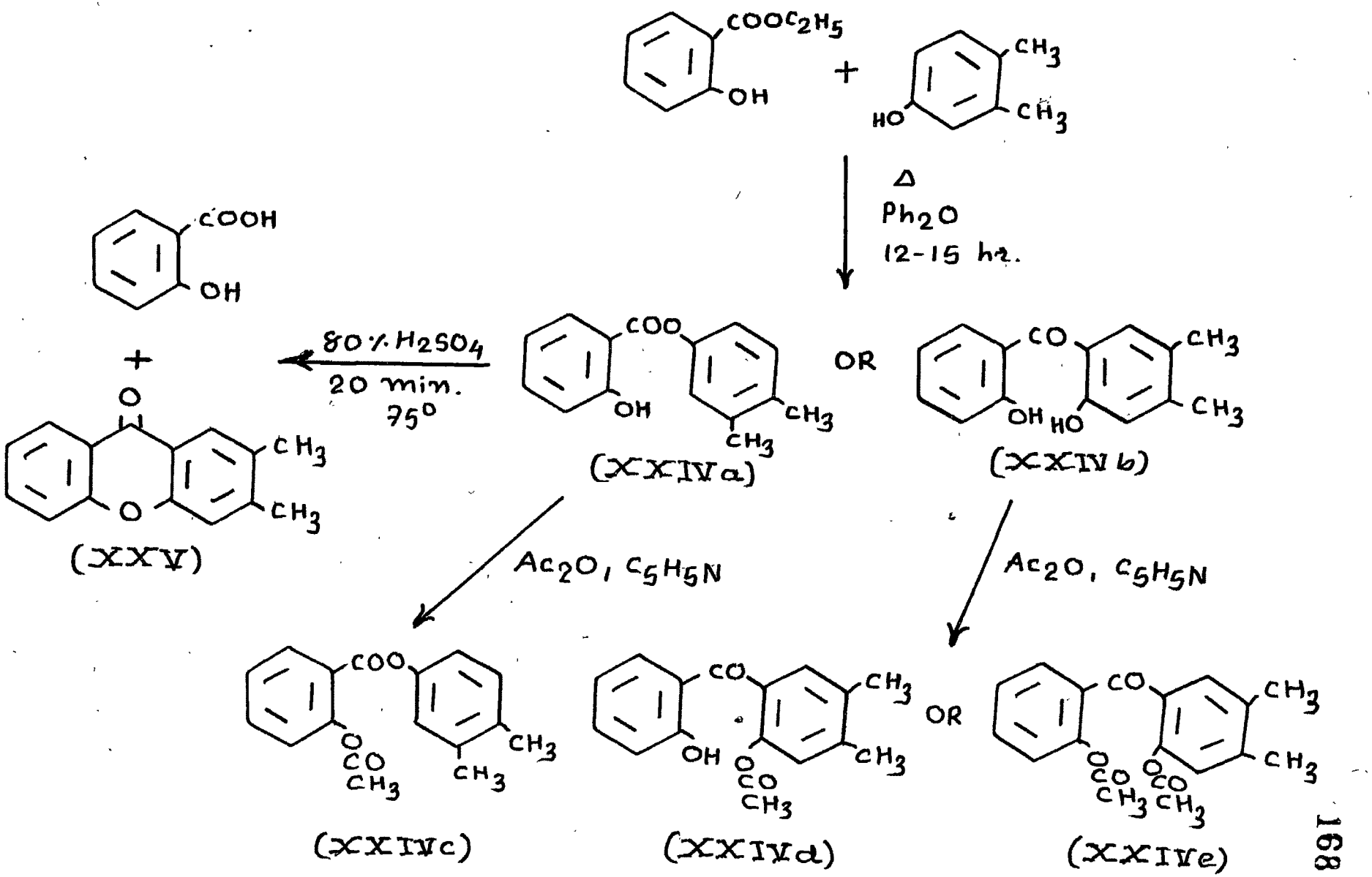
ethyl salicylate and diphenyl ether was refluxed for 12 to 15 hr. The reaction mixture was steam distilled to give an oily product 3',4'-dimethylphenyl salicylate(XXIVa), yield 40 %.

The IR spectrum in nujol showed bands at 1700 cm^{-1} (-COO- Ph ester group) and a broad band at 3440 cm^{-1}(chelated -OH group).

It on acetylation with acetic anhydride and pyridine gave a monoacetate derivative(XXIVc), m.p. 82-4° and this did not give any colour with ethanolic ferric chloride, therefore, structure XXIVd was ruled out and diacetate structure XXIVe was also ruled out on the basis of elemental analysis. Further the structure of XXIVc, was confirmed by the NMR spectrum in $CDCl_3$ (Fig. 12) : δ 2.25, overlapping of two singlets, 9H, two Ar-CH_3 groups at 3'- and 4'-position and one -OCOCH_3 group at 2-position ; 6.90, overlapping of a doublet and a singlet, 2H, at 2'- and 3-position ; 7.15, doublet, J=10Hz, 2H, at 5'- and 6'-position ; 7.35, triplet, J=10Hz, 1H at 5-position ; 7.58, triplet, J=10Hz, 1H at 4-position ; 8.22, doublet, J=10Hz, (ortho coupling), J=1.4Hz (meta coupling), 1H at 6-position. This one proton down field doublet agrees with the ester structure XXIVc and not with XXIVd or XXIVe.

2,3-Dimethylxanthone(XXV) :

The compound XXIVa on the treatment with sulphuric acid (80 %) at 75° for 20 minutes yielded a mixture of 2,3-dimethylxanthone(XXV) and a salicylic acid. The former one


COOC2H5
OH
+
CH3
HO
CH3
Δ
Ph2O
12-15 hr.
COOH
OH
+
80% H2SO4
20 min.
75°
O
O
CH3
CH3
(XXV)
COO
OH
CH3
CH3
(XXIVa)
OR
CO
CH3
OH HO
CH3
(XXIVb)
Ac2O, C5H5N
Ac2O, C5H5N
COO
O
CO
CH3
CH3
CH3
(XXIVc)
CO
CH3
OH
O
CO
CH3
CH3
(XXIVd)
OR
CO
CH3
O
CO
CH3
CH3
(XXIVe)

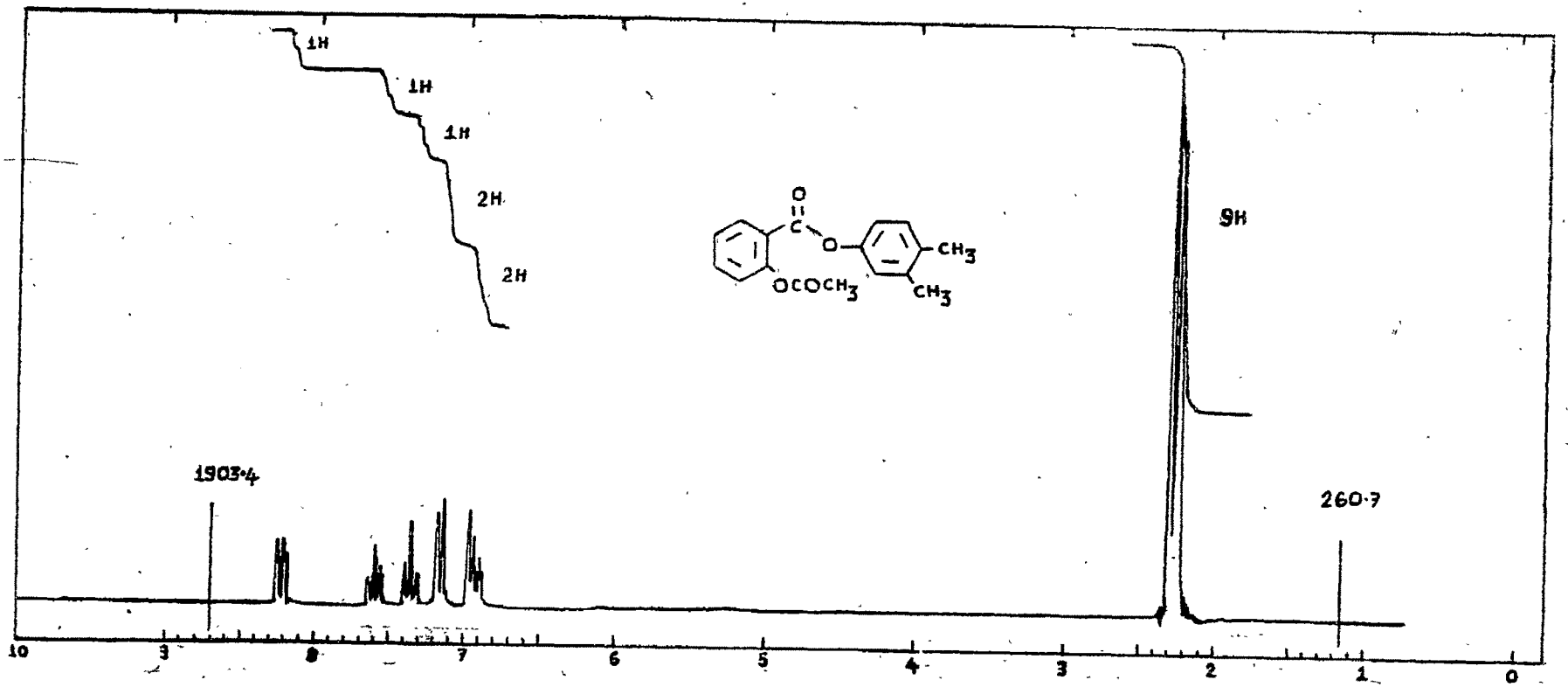


Fig. 12 : NMR spectrum of 3',4'-Dimethylphenyl 2-acetoxybenzoate (XXIVc) in $CDCl_3$ (220 MHz).

was separated by the treatment of saturated sodium bicarbonate solution, yield 12 %, m.p. 160-61°.

The IR spectrum in nujol showed band at 1670 cm^{-1} (γ-pyronyl >C=O group). The NMR spectrum in $CDCl_3$ (Fig. 13) : δ 2.45, two overlapped singlets, for 6H, corresponds to two CH_3 groups at 2- and 3-position ; 7.25-7.85, multiplet, 4H, aromatic protons at 4-, 5-, 6- and 7-position ; 8.05, singlet, 1H, the peri-proton at 1-position. Here the singlet due to peri-proton, revealed that ortho position to peri-proton, i.e. 2-position is substituted by one CH_3 group and the second CH_3 group must be at 3-position. δ 8.25, doublet, J_{87}=10Hz, J_{86}=1.5Hz, 1H, at 8-position.

Condensation of catechol with ethyl salicylate :

2'-Hydroxyphenyl salicylate(XXVIa) :

Catechol on thermal condensation with ethyl salicylate in diphenyl ether for 10 to 12 hr. gave 2-hydroxyphenyl salicylate(XXVIa), yield 48 %, m.p. 80-81°.

The IR spectrum in nujol showed bands at 1699 cm^{-1} (-COO- Ph ester group) and two broad bands at 3207 cm^{-1} and at 3360 cm^{-1} (aromatic -OH groups). If the product had benzophenone structure XXVIb, it would have shown carbonyl stretching band around 1660 cm^{-1}.

The product XXVIa on acetylation with acetic anhydride and pyridine gave diacetate derivative(XXVIc), m.p. 108-10°. It did not give any colour reaction with ethanolic

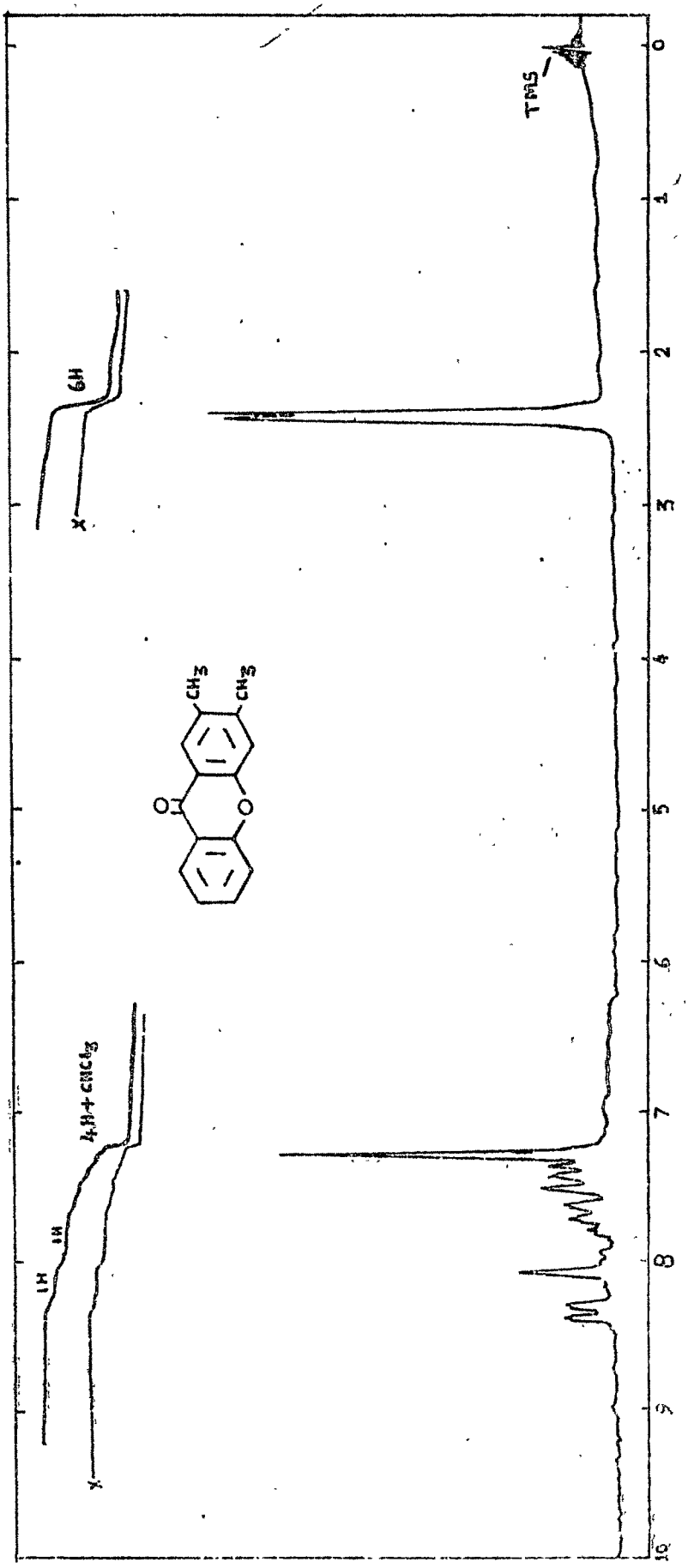
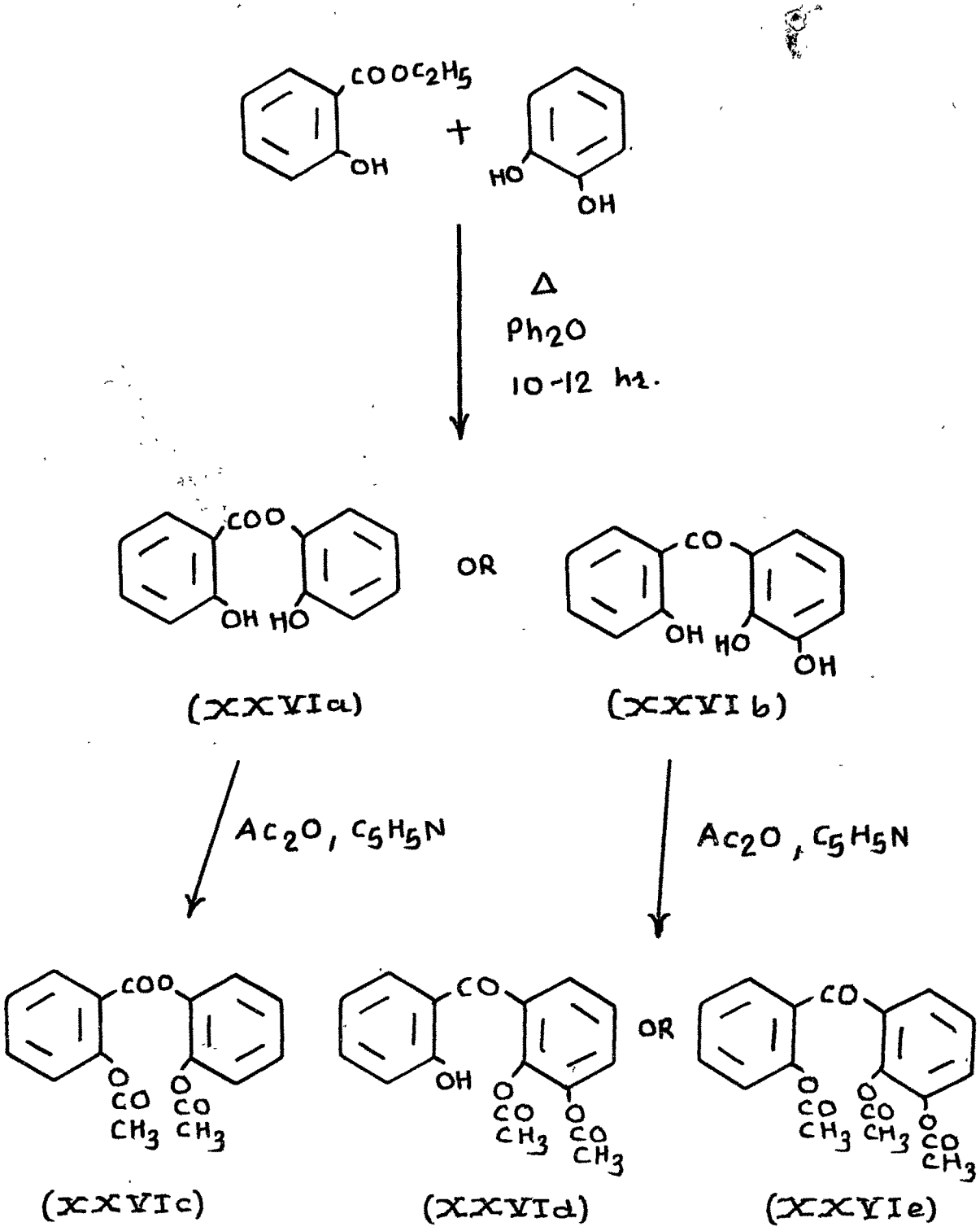


Fig. 13 : NMR spectrum of 2,3-Dimethylxanthone (XXV) in $CDCl_3$ (90 MHz).


COOC2H5
OH
HO
OH
Δ
Ph2O
10-12 hr.
COO
OH HO
OR
CO
OH HO
OH
(XXVIa)
(XXVIb)
Ac2O, C5H5N
Ac2O, C5H5N
COO
O CO CH3
O CO CH3
CO
OH
O CO CH3
O CO CH3
OR
CO
O CO CH3
O CO CH3
O CO CH3
(XXVIc)
(XXVId)
(XXVIe)

ferric chloride. The triacetate structure XXVIe was untenable on the basis of elemental analysis. The structure of XXVIa was also confirmed from the NMR spectrum in $CDCl_3$ (Fig. 14) of its diacetate derivative : δ 2.17, singlet, 3H, $-OCOCH_3$ group at 2'-position ; 2.28, singlet, 3H, $-OCOCH_3$ group at 2-position ; 7.14-7.40, multiplet, 6H, aromatic proton at 3-, 5-, 3'-, 4'-, 5'-, and 6'-position ; 7.63, triplet, J=10Hz, 1H at 4-position ; 8.20, doublet, J_{65}=10Hz, J_{64}=1.6Hz, 1H at 6-position. The one proton down field doublet showed the presence of only one proton ortho to >C=O group, confirmed the structure XXVIc. If the product had either XXVId or XXVIe, a benzophenone structure then there should be two protons doublet in the down field region of the spectrum.

4-Hydroxyxanthone(XXVIIa) :

The salicylate derivative XXVIa, when further refluxed in diphenyl ether for 8 to 9 hr. or catechol on prolong condensation with ethyl salicylate in diphenyl ether for 19 to 21 hr. afforded 4-hydroxyxanthone(XXVIIa), yield 12 %, m.p. 240° (lit.,[69] m.p. 240-41°) along with the formation of salicylic acid.

The IR spectrum in nujol showed band at 1641 cm^{-1} (γ-pyronyl >C=O group), and a broad band at 3190 cm^{-1}(aromatic -OH group). If the product had α-pyrone structure XXVIIb, it would have shown the carbobyl stretching around 1720 cm^{-1}.

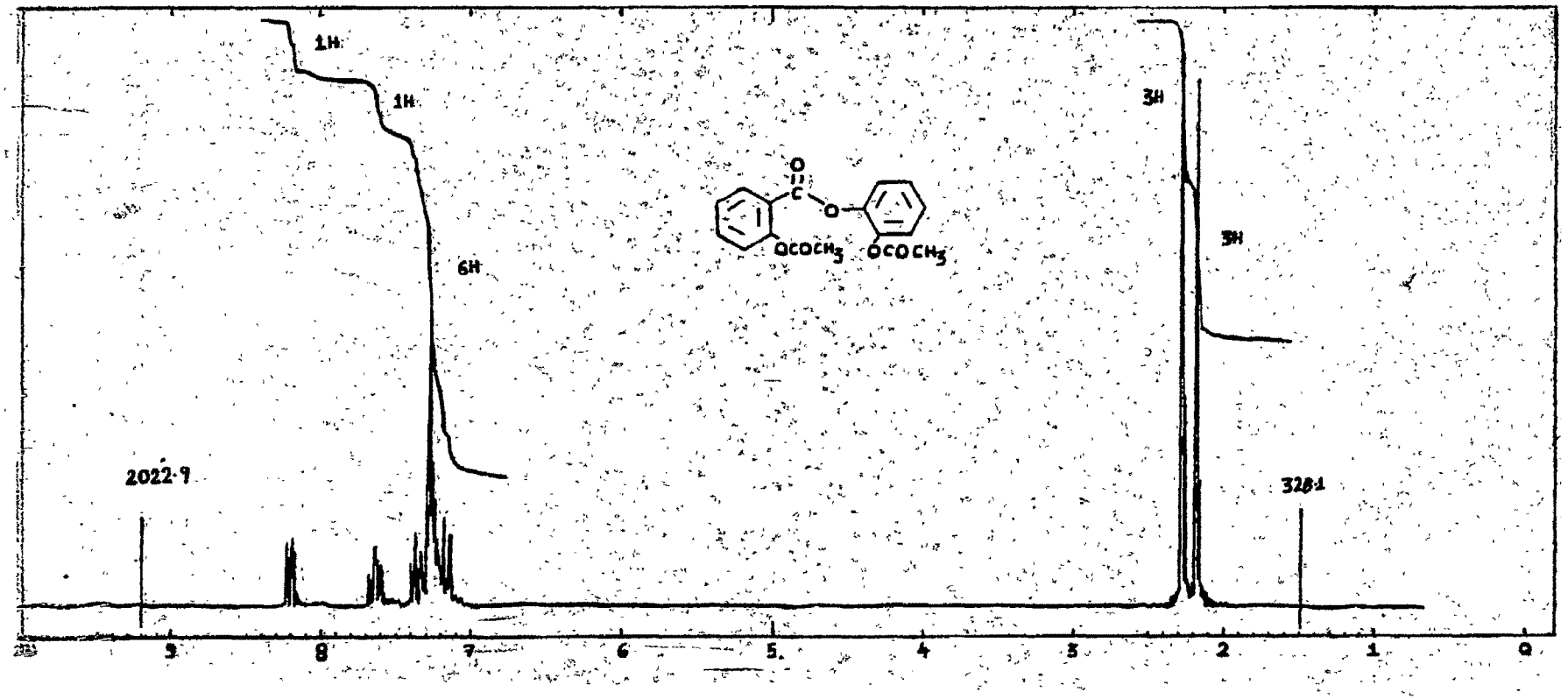
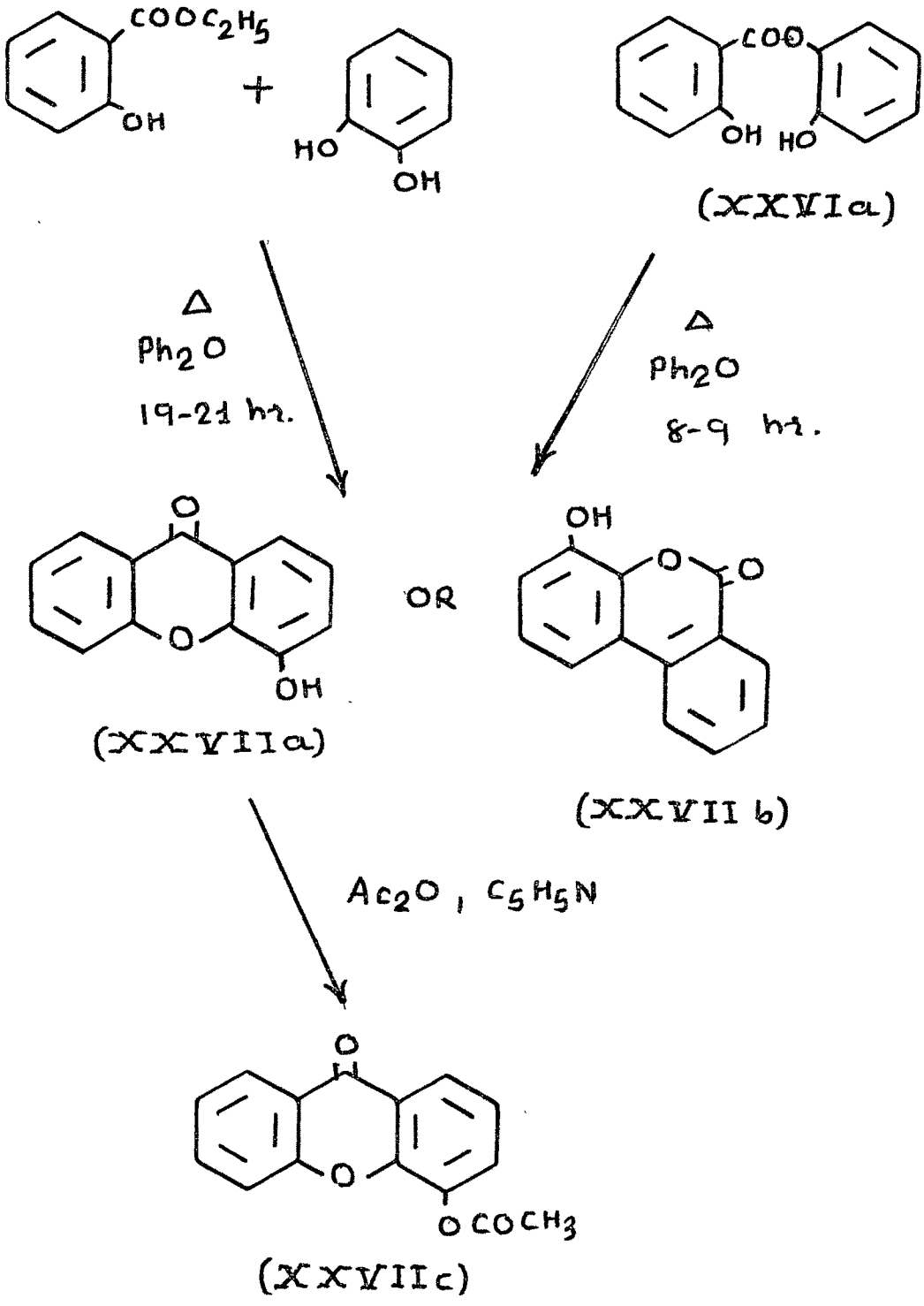


Fig. 14 : NMR spectrum of 2'-Acetoxyphenyl 2-acetoxybenzoate (XXVIc) in $CDCl_3$ (220 MHz).


COOC2H5
OH
+
HO
OH
COO
OH HO
(XXVIa)
Δ
Ph2O
19-21 hr.
Δ
Ph2O
8-9 hr.
O
O
OH
OR
OH
O
O
(XXVIIa)
(XXVII b)
Ac2O , C5H5N
O
O
O COCH3
(XXVIIc)

The product XXVIIa on acetylation with acetic anhydride and pyridine gave monoacetate derivative, m.p. 141° (lit.,[69] m.p. 139°).

Condensation of m-cresol with ethyl salicylate :

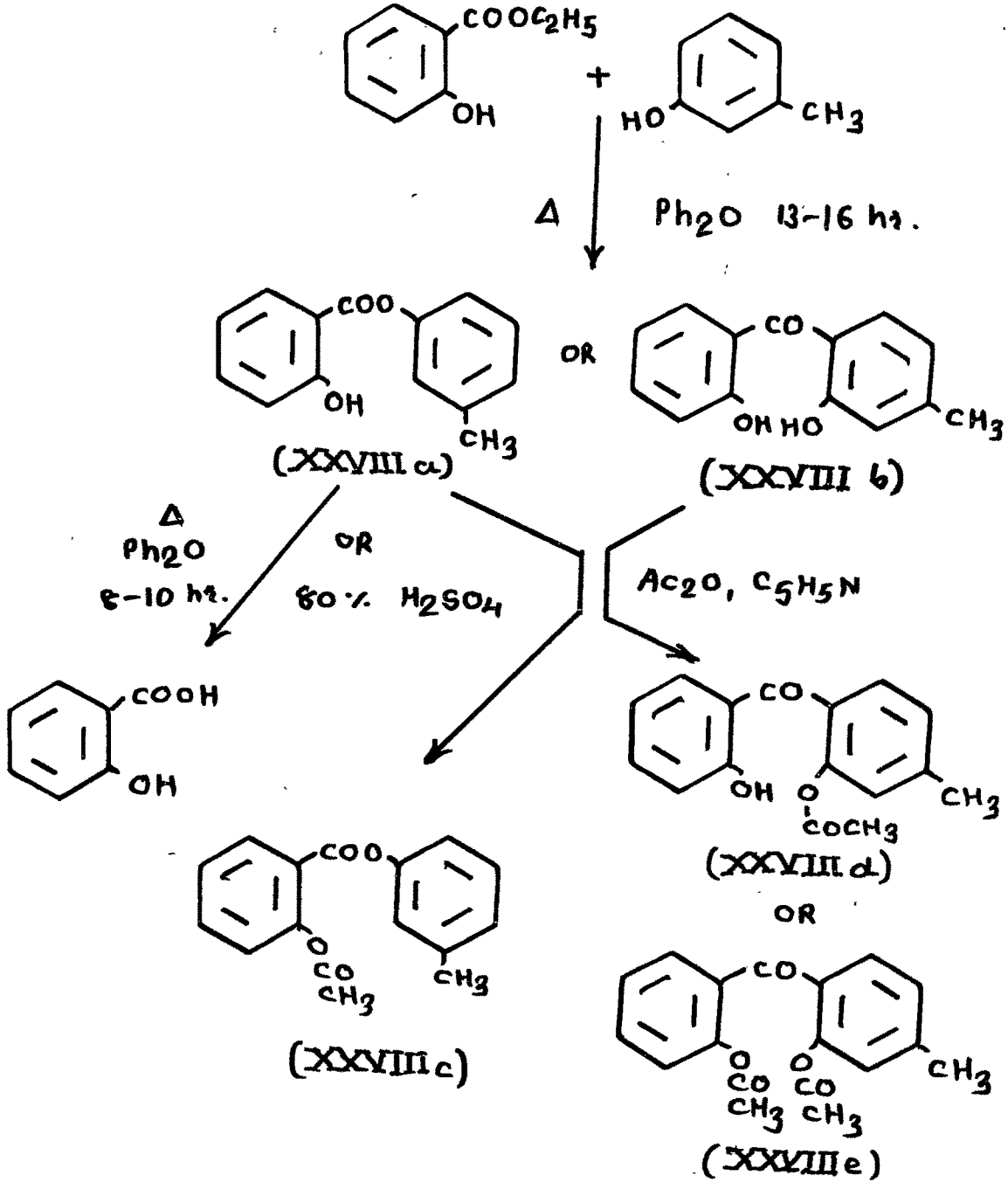
3'-Methylphenyl salicylate(XXVIIIa) :

m-Cresol when condensed with ethyl salicylate in boiling diphenyl ether for 13 to 16 hr. gave 3'-methylphenyl salicylate(XXVIIIa), yield 50 %, m.p. 76-8°.

The structure of XXVIIIa was confirmed from the spectral data shown as below :

The IR spectrum in nujol showed bands at 1695 cm^{-1} (-COO- Ph ester group) and a broad band at 3140 cm^{-1} (aromatic -OH group). On the basis of the IR spectrum the benzophenone structure XXVIIIb was untenable. The NMR spectrum of XXVIIIa in $CDCl_3$ (Fig. 15) showed the following signals : δ 2.36, singlet, 3H, CH_3 group at 3'-position ; 6.90-7.13, multiplet, 5H, aromatic protons at 3-, 5-, 2'-, 4'- and 6'-position ; 7.29, triplet, J=10Hz, 1H at 5'-position ; 7.50, triplet, J=10Hz, J=1.5Hz, 1H at 4-position ; 8.06, doublet, J=10Hz, (ortho coupling), J=1.5Hz (meta coupling), 1H at 6-position ; 10.53, singlet, 1H, -OH group at 3'-position. The down field signal at δ10.53, integrating only for one proton, showed that the product had one -OH group, therefore, the structure XXVIIIa is assigned for the product and the structure XXVIIIb with two -OH groups is not tenable.

The product XXVIIIa, on treatment with sulphuric acid (80%) at 70° for 20 minutes or by further refluxing it in diphenyl ether for 8 to 10 hr. decomposed to give salicylic acid.



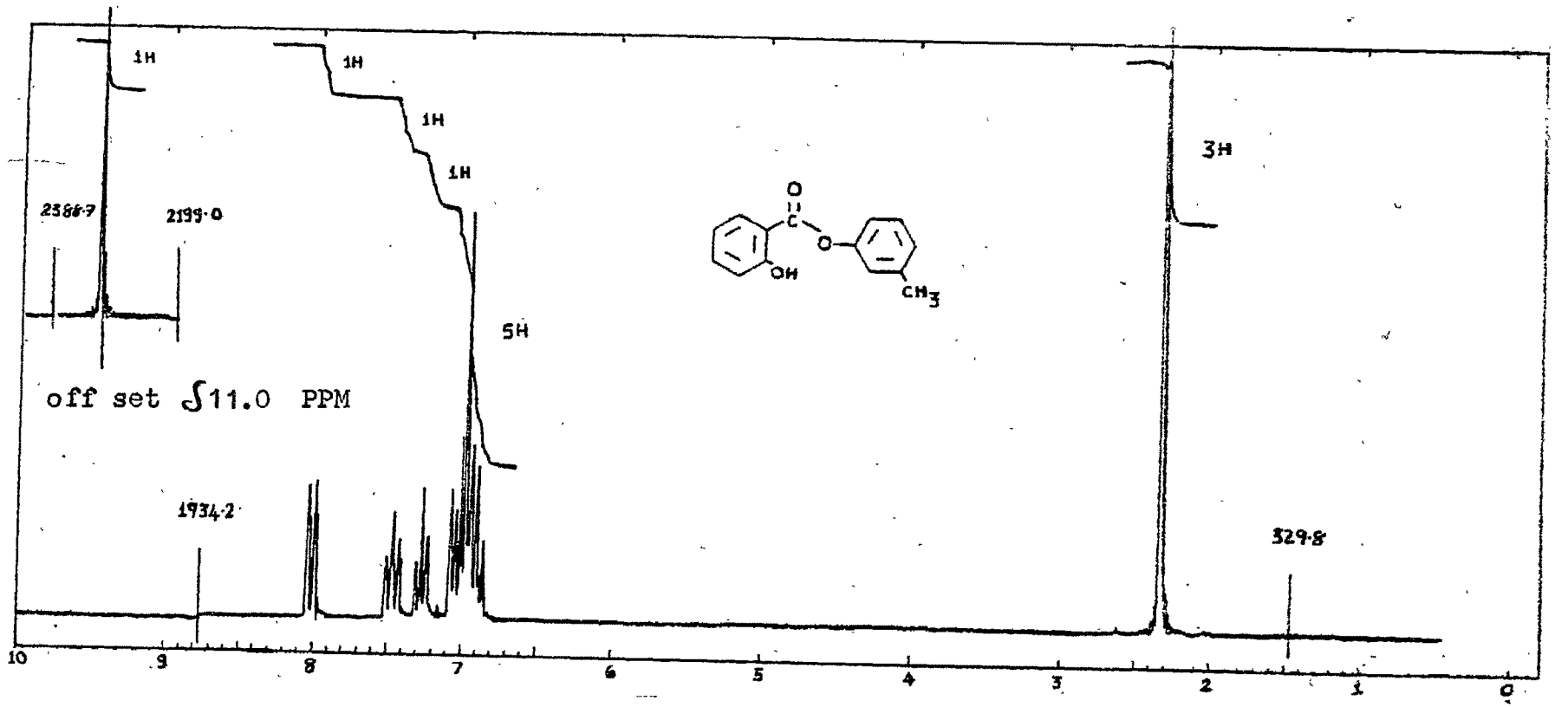


Fig. 15 : NMR spectrum of 3'-Methylphenyl salicylate (XXVIIIa) in $CDCl_3$ (220 MHz).

The product XXVIIIa on acetylation with acetic anhydride and pyridine, yielded a monoacetate derivative (XXVIIIc), m.p. 82°. It did not develop any colouration with ethanolic ferric chloride and therefore, structure XXVIIId, with one free -OH group was rejected. The elemental analysis agreed with monoacetate derivative. Finally the structure of XXVIIIc was confirmed from the NMR spectrum in $CDCl_3$ (Fig. 16): δ2.29, singlet, 3H, $-OCOCH_3$ group at 2-position ; 2.37, singlet, 3H, $Ar-CH_3$ group at 3'-position ; 7.00-7.70, multiplet, 7H, aromatic protons at 3-, 4-, 5-, 2'-, 4'-, 5'- and 6'-position ; 8.20, doublet, J_{65}=10Hz, J_{64}=1.6Hz, 1H at 6-position. This down field doublet, which appeared only for one proton was agreed with phenyl salicylate structure XXVIIIc and not with benzophenone structure XXVIIId or XXVIIIe.

Condensation of 7-hydroxy-4-methylcoumarin with ethyl salicylate :

4'-Methyl-2'-pyrono(6',5'-1,2)xanthone(XXIXa) :

A equimolar mixture of 7-hydroxy-4-methylcoumarin and ethyl salicylate was refluxed in diphenyl ether for 9 to 12 hr. The reaction mixture was steam distilled and the separated product was washed with sodium hydroxide solution (2 %). Alkali soluble product on acidification gave unreacted coumarin back, while alkali insoluble residue was washed with hot and cold water, dried and chromatographed over alumina and eluted with benzene gave 4'-methyl-2'-pyrono(6',5'-1,2)xanthone (XXIXa), yield 35 %, m.p. 280°.

The IR spectrum in nujol (Fig. 17) showed bands at

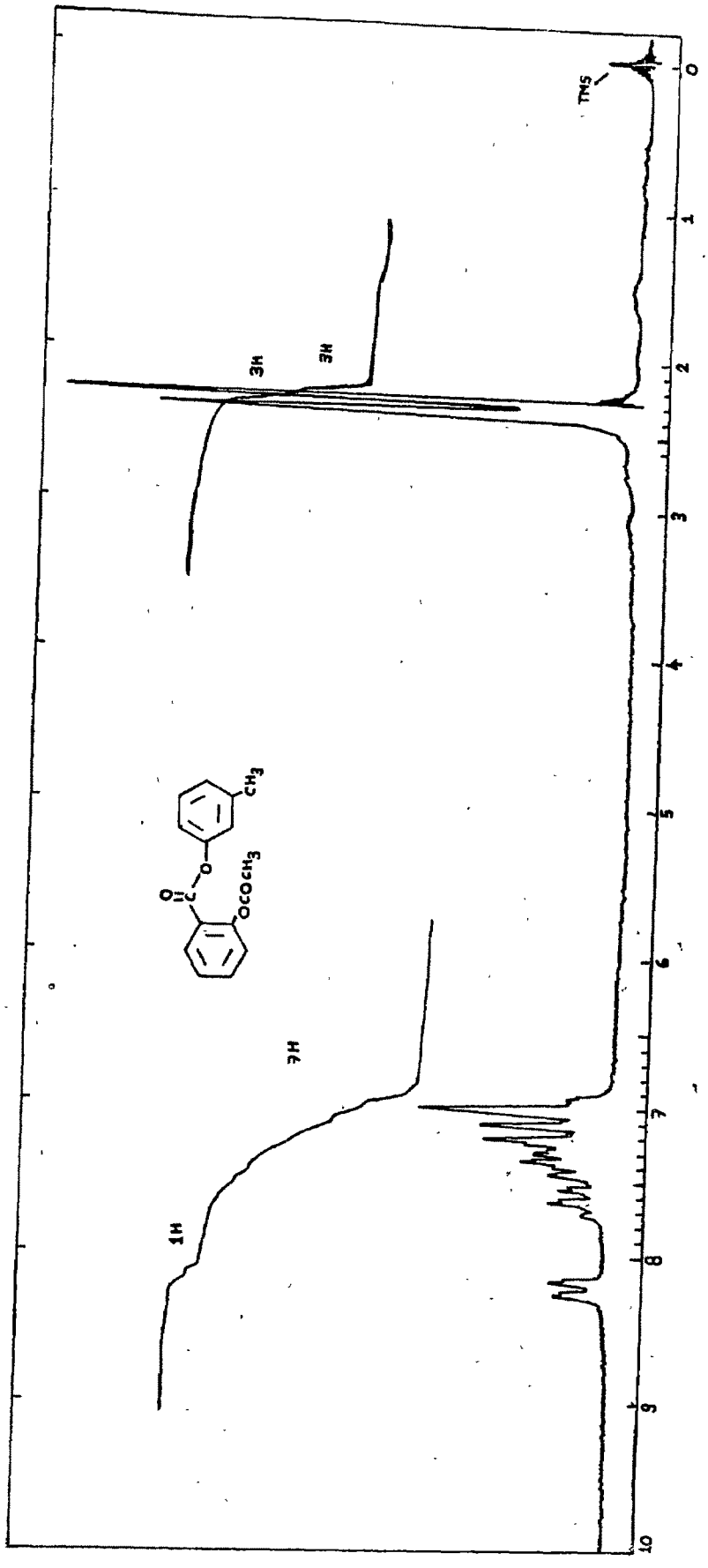
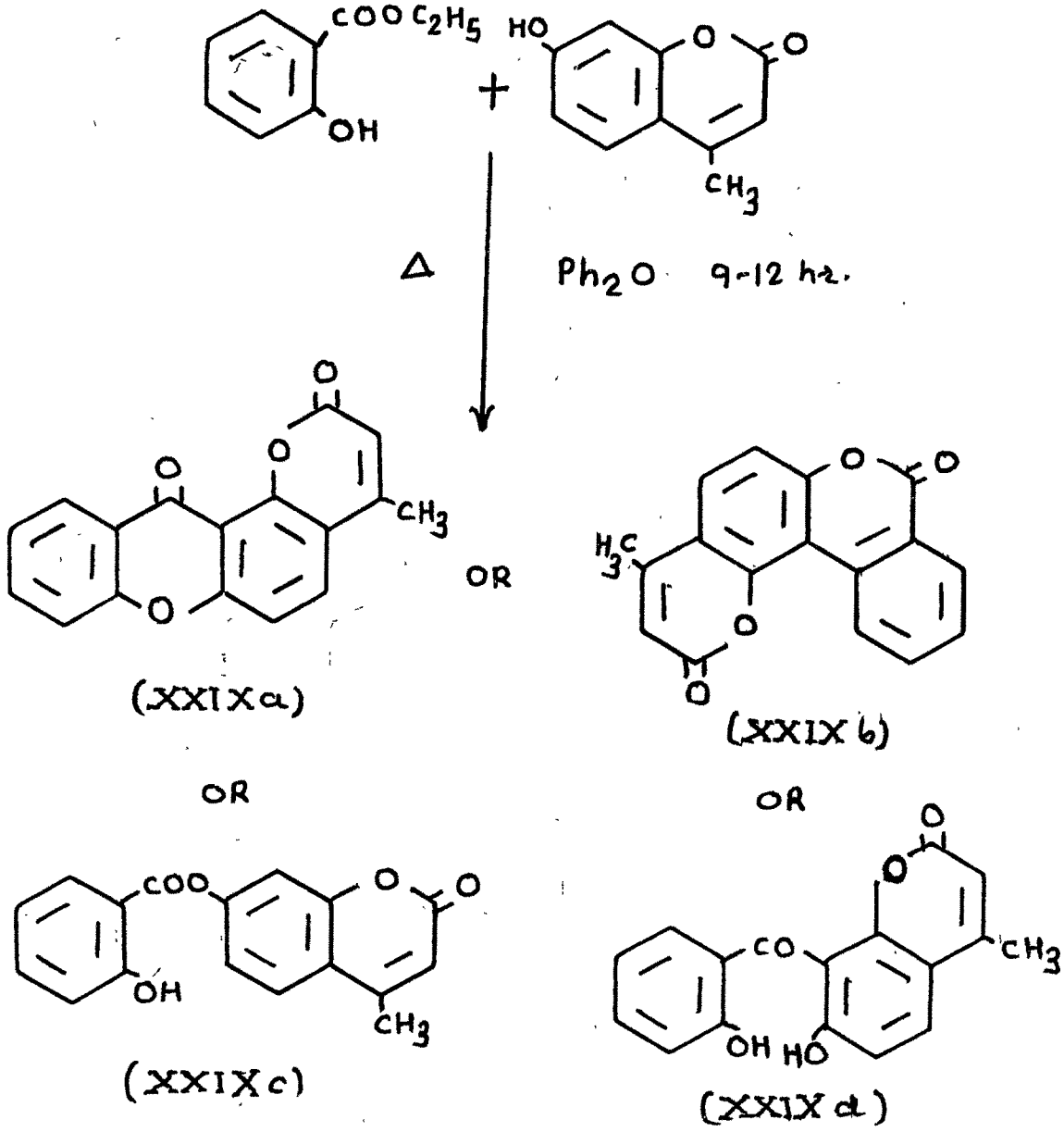


Fig. 16 : NMR spectrum of 3'-Methylphenyl 2-acetoxybenzoate (XXVIIIc) in $CDCl_3$ (90 MHz).

1670 cm^{-1} (γ-pyronyl >C=O group) and 1735 cm^{-1} (α-pyronyl >C=O group). If the product had dibenzo-α-pyrono structure (XXIXb), the IR spectrum would have shown two carbonyl stretching bands around 1730 cm^{-1} only. Further the absence of -OH group band in the IR spectrum showed that the intermediate coumaryl salicylate(XXIXc) or benzophenone(XXIXd) structure is not tenable.



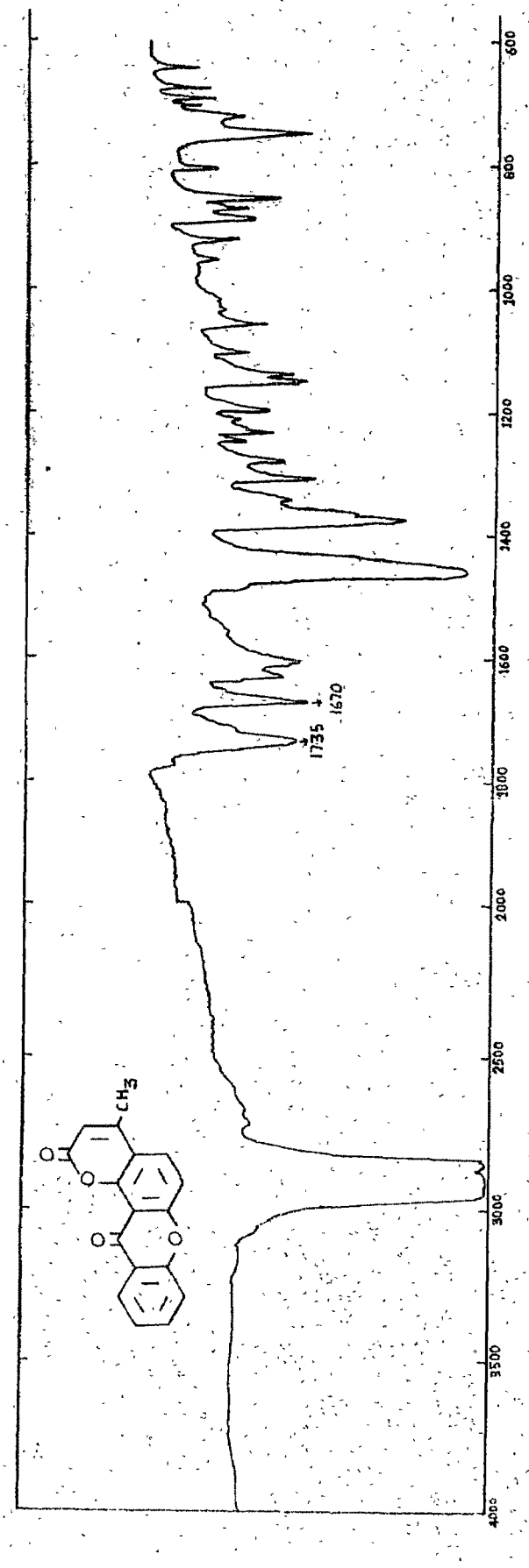


Fig. 17 : IR spectrum of 4'-Methyl-2'-pyrono (6',5'-1,2)xanthone (XXIXa) in nujol.

The formation of 2'-pyronoxanthone in the present condensation is of great interest. Scheinmann et al. have reported[70] that the condensation of 1-hydroxyxanthone with ethyl acetoacetate under the conditions of either Pechmann reaction or Simonis reaction was unsuccessful.

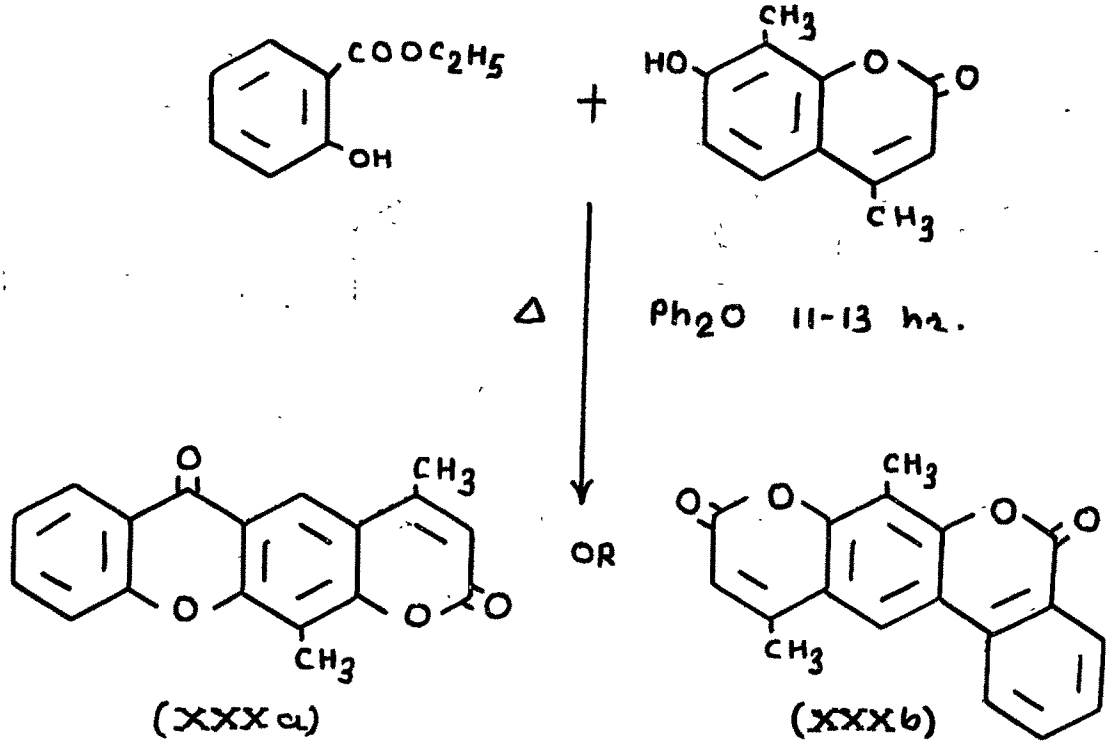
Condensation of 7-hydroxy-4,8-dimethyl coumarin with ethyl salicylate :

4,4'-Dimethyl-2'-pyrono(5',6'-2,3)xanthone(XXXa) :

A mixture of 7-hydroxy-4,8-dimethylcoumarin and ethyl salicylate was refluxed in diphenyl ether for 11 to 13 hr. On working up the reaction mixture an alkali insoluble product was obtained. It was chromatographed over alumina and eluted with a mixture of benzene-chloroform (9:1) gave pure 4,4'-dimethyl-2'-pyrono(5',6'-2,3)xanthone(XXXa), yield 30 %, m.p. 287-8°.

The IR spectrum in nujol (Fig. 18) showed bands at 1660 cm^{-1} (γ-pyronyl >C=O group). and 1735 cm^{-1} (α-pyronyl >C=O group). Thus on the basis of IR spectrum dibenzo-α-pyrono structure(XXXb) is rejected. Further the structure of XXXa was confirmed from the NMR spectrum in CF_3COOH (Fig. 19): δ 2.75, singlet, 6H, two CH_3 groups at 4- and 4'-position ; 6.66, singlet, 1H at 3'-position ; 7.30-8.10, multiplet, 3H, aromatic protons at 5-, 6- and 7-position ; 8.40, doublet, J_{87}=10Hz, J_{86}=1.5Hz, 1H, peri-proton at 8-position ; 8.76, singlet, 1H, peri-proton at 1-position. The appearance of a

down field singlet, at δ8.76 showed that dibenzo-α-pyrono structure(XXXb) is untenable.



(XXXa) (XXXb)

Condensation of 5-hydroxy-4,7-dimethylcoumarin with ethyl salicylate :

1,4'-Dimethyl-2'-pyrono(6',5'-3,4)xanthone(XXXIa) :

A mixture of 5-hydroxy-4,7-dimethylcoumarin and ethyl salicylate was refluxed in diphenyl ether for 12 to 13 hr. On working up the reaction mixture, an alkali insoluble dark product was obtained. It was chromatographed over silica gel and eluted with chloroform-methanol mixture (49;1), to give pure 1,4'-dimethyl-2'-pyrono(6',5'-3,4)xanthone(XXXIa), yield 40 %, m.p. 299-300°.

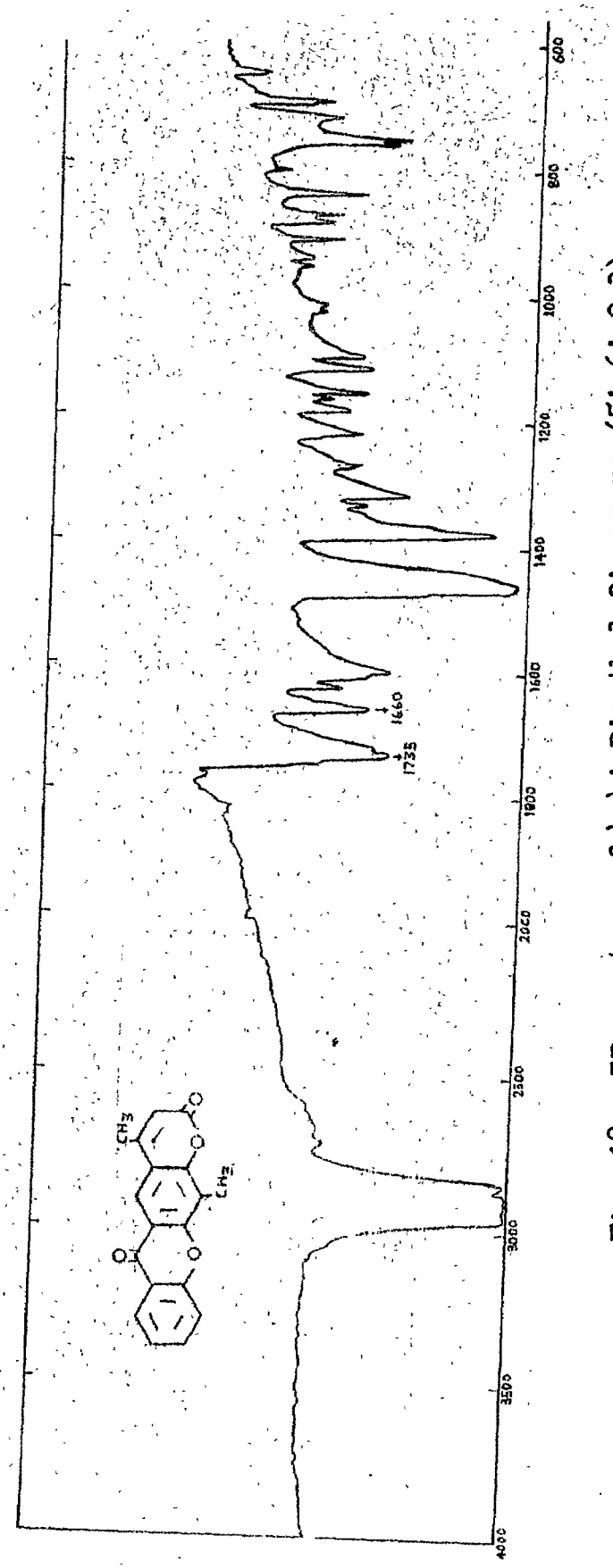


Fig. 18 : IR spectrum of 4,4'-Dimethyl-2'-pyrono (5',6'-2,3)-xanthone (XXXa) in nujol.

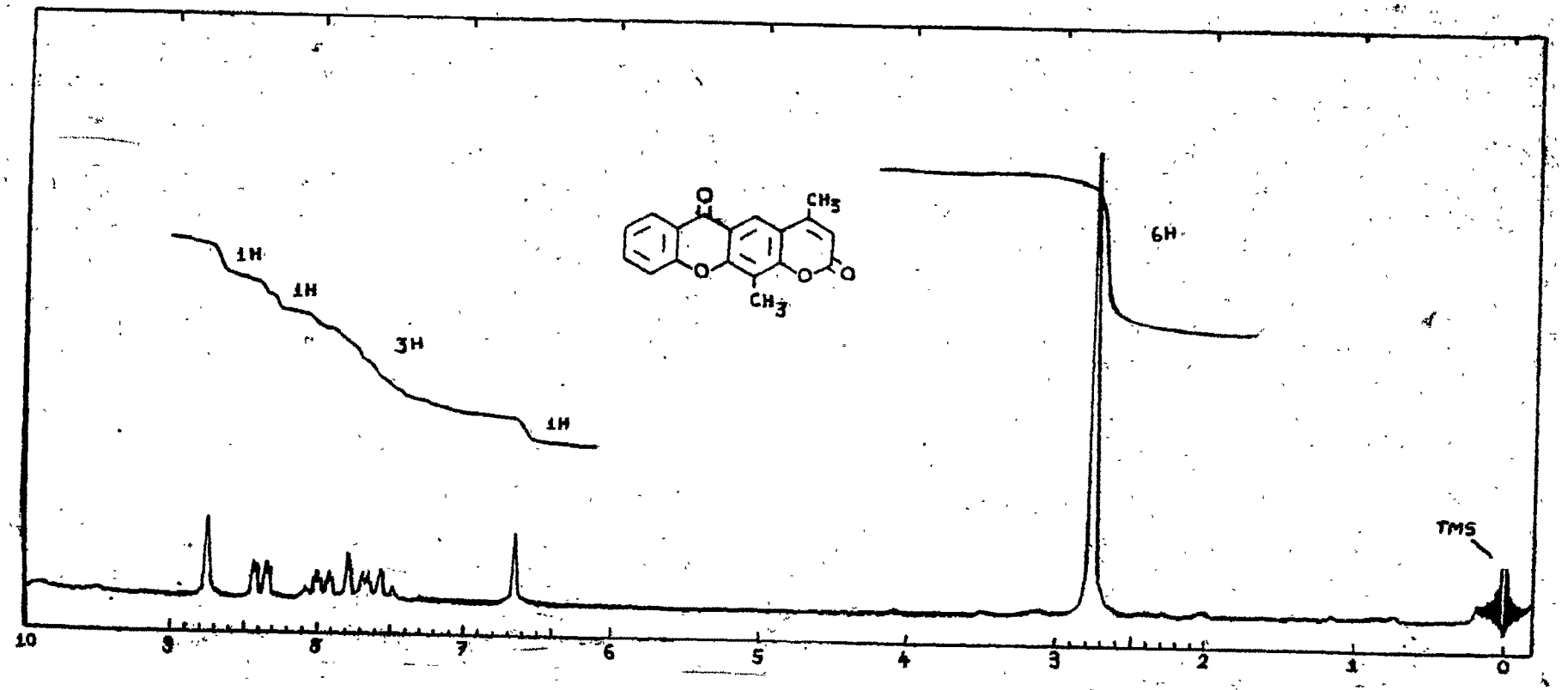
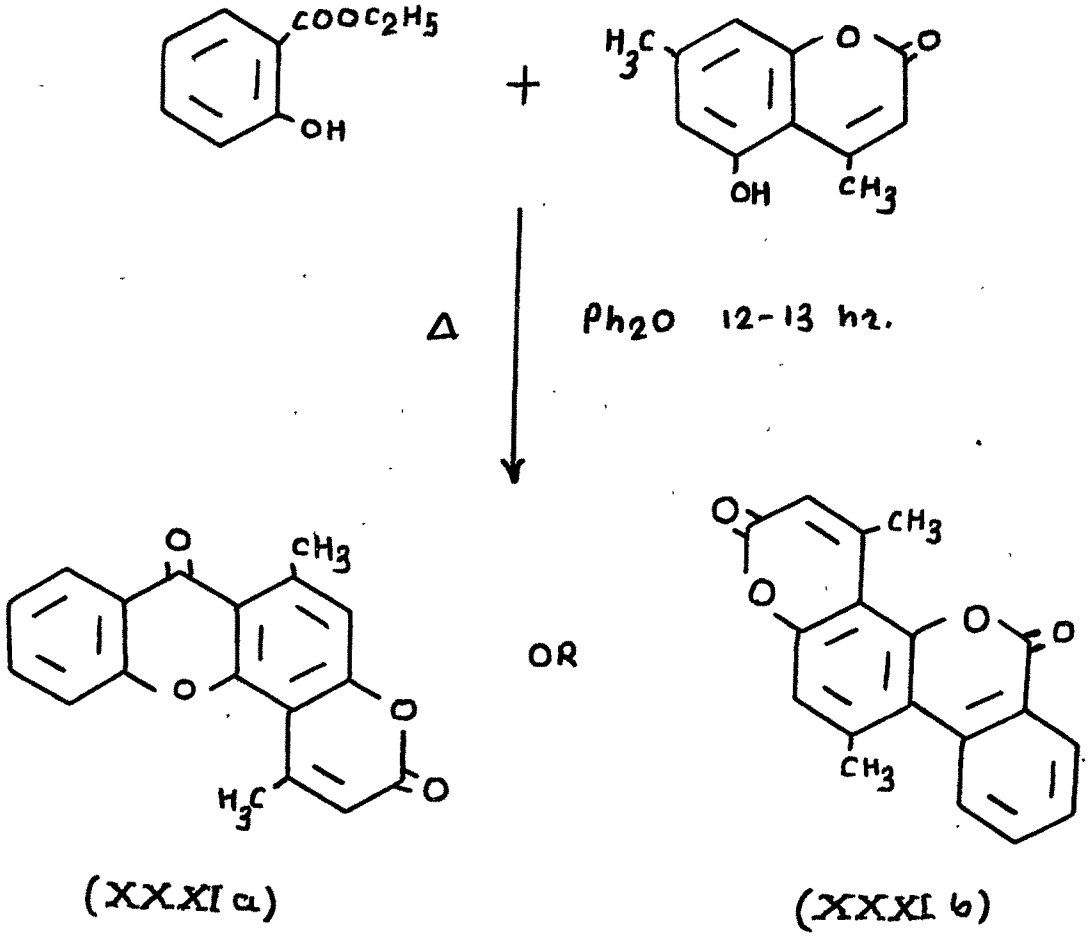


Fig. 19 : NMR spectrum of 4,4'-Dimethyl-2'-pyrono(5',6'-2,3)xanthone (XXXa) in CF_3COOH (90 MHz).

The IR spectrum in nujol showed bands at 1665 cm^{-1} (γ-pyronyl >C=O group) and 1752 cm^{-1} (α-pyronyl> C=O group). The structure XXXIb was rejected on the basis of IR spectrum. Further the structure of XXXIa was confirmed by the NMR spectrum in CF_3COOH (Fig. 20) : δ 3.15, two overlapped singlet, 6H, two CH_3 groups at 1-position and 4'-position ; 6.67, singlet, 1H, at 3'-position ; 7.36, singlet, 1H at 2-position ; 7.48-8.08, multiplet, 3H, aromatic protons at 5-, 6- and 7-position ; 8.38, doublet, 1H, J_{87}=10Hz, J_{86}=1.5Hz at 8-position



(XXXI a) (XXXI b)

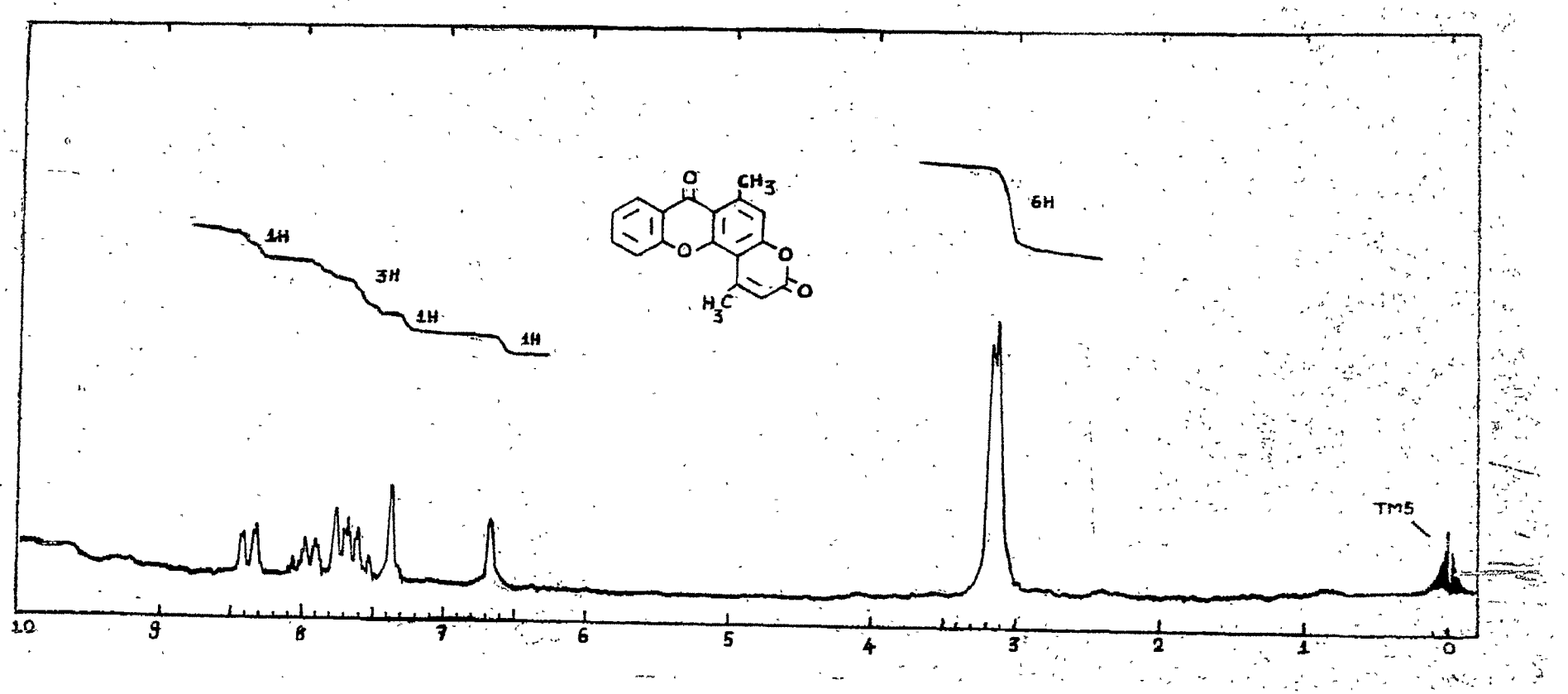


Fig. 20 : NMR spectrum of 1,4'-Dimethyl-2'-pyrono(6',5'-3,4)xanthone (XXXIa) in CF_3COOH (90 MHz).

It is interesting to note here that Gaekwad[72] has tried to condensed ethyl acetoacetate with 2-hydroxyxanthone, 3-hydroxyxanthone and 3,6-dihydroxyxanthone under different conditions like hydrochloric acid gas in methanol[71], 80 % sulphuric acid at 0-5°, conc. sulphuric acid at room temperature or heating the mixture in diphenyl ether, but no condensation occurred to give 2'-pyronoxanthones. While by using this method similar 2'-pyronoxanthones could be synthesised.

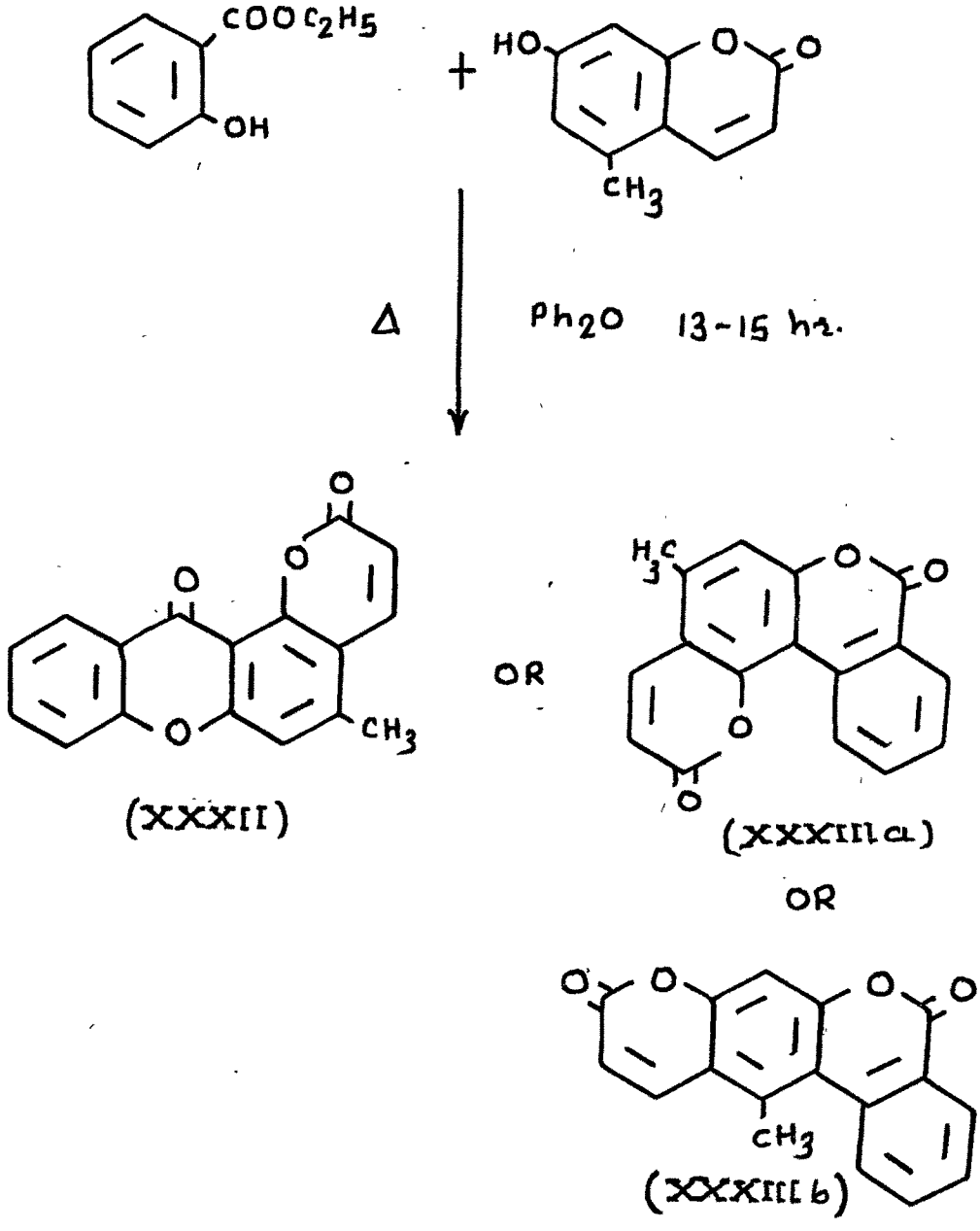
Condensation of 7-hydroxy-5-methylcoumarin with ethyl salicylate:

3-Methyl-2'-pyrono(6',5'-1,2)xanthone(XXXII) :

A mixture of 7-hydroxy-5-methylcoumarin and ethyl salicylate was refluxed in diphenyl ether for 13 to 15 hr. The reaction mixture was steam distilled and the dark product obtained was washed with sodium hydroxide solution (2 %) and with water, dried, chromatographed over alumina and eluted with a mixture of chloroform-methanol (49:1) to give pure 3-methyl-2'-pyrono(6',5'-1,2)xanthone(XXXII), yield 35 %, m.p. 316°.

The IR spectrum in nujol showed bands at 1652 cm^{-1} (γ-pyronyl >C=O group) and 1750 cm^{-1} (α-pyronyl >C=O group). The dibenzo-α-pyrono structures(XXXIIIa) and (XXXIIIb) were rejected on the basis of IR spectrum. Further the structure of XXXII was confirmed by its NMR spectrum in

CF_3COOH (Fig. 21) : δ 3.28, singlet, 3H, CH_3 group at 3-position ; 6.72, doublet, J=10Hz, 1H, at 3'-position ; 7.45-8.06, multiplet, 4H, aromatic protons at 4-, 5-, 6- and 7-position ; 8.28, doublet, J_{87}=10Hz, J_{86}=1.5Hz, peri-proton at 8-position ; 8.55, doublet, J=10Hz, 1H at 4'-position.



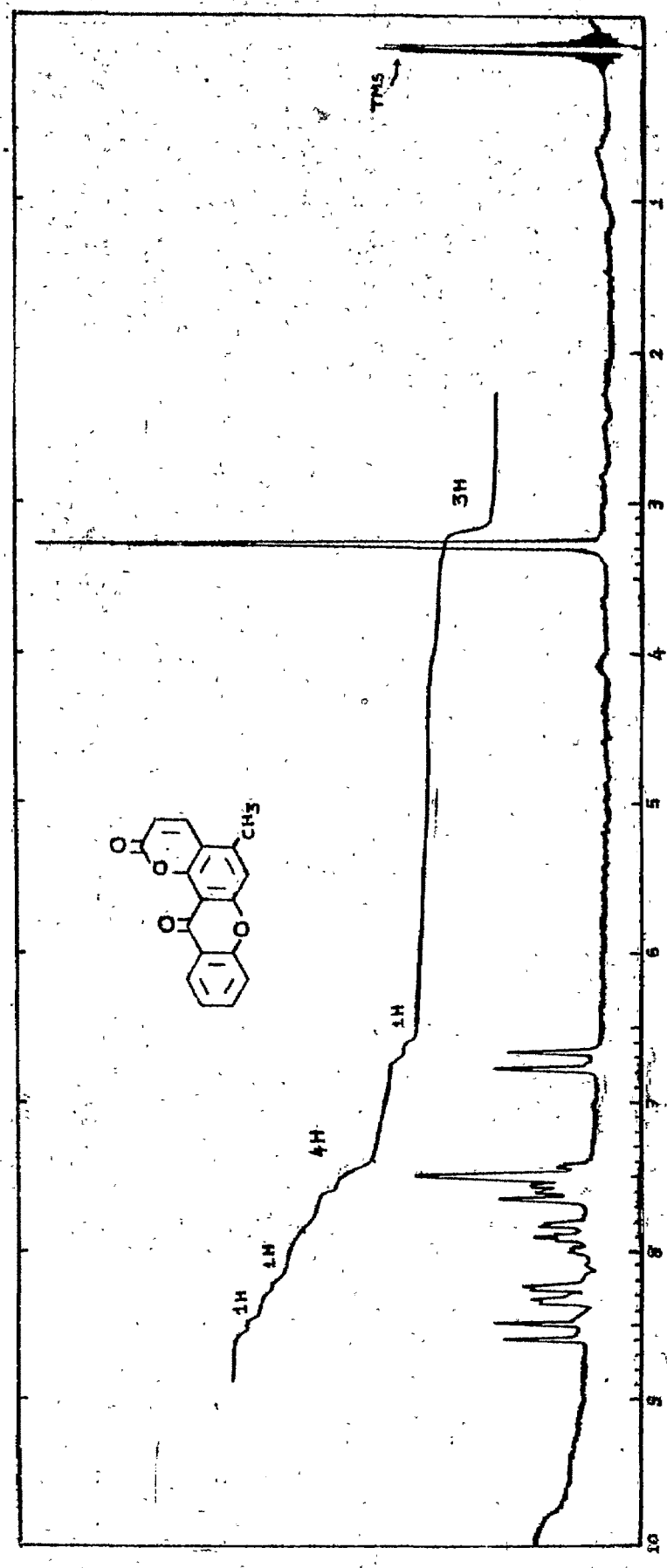


Fig. 21 : NMR spectrum of 3-Methyl-2'-pyrono(6',5'-1,2)xanthone (XXXII) in CF_3COOH (90 MHz).

Conclusion

Highly reactive phenol such as phloroglucinol condensed with ethyl salicylate in very short period 40 to 60 minutes, to give corresponding xanthones(XVIIa) in very good yield (50 %). Pyrogallol, orcinol, 1-naphthol and 2-naphthol condensed with ethyl salicylate to give directly the corresponding xanthone derivatives when refluxed for a period of 8 to 12 hr. In case of orcinol a mixture of 1-hydroxy-3-methylxanthone(XVa) and 3-hydroxy-1-methylxanthone (XVIa) was obtained in which XVa was preponderant. Resorcinol when condensed with ethyl salicylate for a short period of time 3 to 5 hr. gave 3'-hydroxyphenyl salicylate (XIIa) in very good yield (38 %) along with 2,2',4-trihydroxybenzophenone(XIa) in traces (2 %). The reaction mixture on refluxing for a longer period (18-20 hr.) gave a mixture of 1-hydroxyxanthone(XIIIa) and 3-hydroxyxanthone (XIVa), where latter was obtained as the major product. 2-Methylresorcinol initially condensed with ethyl salicylate to give 2'-methyl-3'-hydroxyphenyl salicylate(XXIa) an ester derivative as an intermediate, while the reactiom mixture on further refluxing for a longer period (16-18 hr.) yielded 3-hydroxy-4-methylxanthone(XXIIa) in better yield (38 %). Catechol also behaved similarly to give 2'-hydroxyphenyl salicylate(XXVIa) as an intermediate product and finally 4-hydroxyxanthone(XXVIIa) in very poor yield (12 %).

Hydroquinone, 3,4-o-xylenol and m-cresol condensed with ethyl salicylate to give only the corresponding phenyl salicylate derivatives which on further heating gave salicylic acid and phenols back and not the corresponding xanthone derivatives. In case of 3,4-o-xylenol, 2,3-dimethyl-xanthone(XXV) was obtained in poor yield (12 %), when the phenyl salicylate derivative(XXIVa) was treated with sulphuric acid (80 %).

Monohydroxycoumarins viz., 7-hydroxy-4-methyl-, 7-hydroxy-4,8-dimethyl-, 5-hydroxy-4,7-dimethyl- and 7-hydroxy-5-methylcoumarin, when condensed with ethyl salicylate for 10 to 15 hr. gave the corresponding pyronoxanthone derivatives. While Pechmann and Simonis reactions of hydroxyxanthones with ethyl acetoacetate ~~were py~~ failed to give such pyronoxanthones[70,72].

The IR data of the different condensations products are given in the following tables.

Table 1

IR data of the phenyl salicylate derivatives (ν_{max} in cm^{-1})

Compounds	OH stretching (broad band)		>C=O stretching		-C=C- stretching		-C-O-C- stretching
3'-Hydroxyphenyl salicylate (XIIa)	3420	3280		1675	1605	1580	1230
3'-Acetoxyphenyl 2-acetoxy-benzoate (XIIb)	-	-	1770	1745	1608	-	1218
2'-Methyl-3-hydroxyphenyl salicylate(XXIa)	3460	3200		1682	1620	1600	1230
2'-Methyl-3'-acetoxyphenyl 2-acetoxybenzoate(XXIc)	-	-	1762	1740	1608	1580	1200
4'-Hydroxyphenyl salicylate (XXIIIa)	3420	-		1698	1620	1590	1185
4'-Acetoxyphenyl 2-acetoxy-benzoate(XXIIIc)	-	-	1765	1742	1610	-	1175
4'-Methoxyphenyl 2-methoxy-benzoate (XXIIId)	-	-	-	1740	1600	1581	1240
3',4'-Dimethylphenyl salicylate(XXIVa)	3440	-		1700	1625	1595	1215

Table 1 (Contd..)

3',4'-Dimethylphenyl 2-acetoxybenzoate(XXIVc)	-	-	1775	1747	1612	-	1248
2'-Hydroxyphenyl salicylate (XXVIa)	3360	3207		1699	1622	1589	1210
2'-Acetoxyphenyl 2-acetoxy-benzoate(XXVIc)	-	-	1764	1747	1611	1584	1225
3'-Methylphenyl salicylate (XXIIIa)	-	3140		1695	1620	1588	1240
3'-Methylphenyl 2-acetoxy-benzoate(XXIIIc)	-	-	1768	1740	1610	-	1240

Table 2

IR data of xanthone derivatives(ν_{max} in cm^{-1})

Compounds	OH stretching (broad band)		>C=O Stretching	-C=C- stretching			-C-O-C- stretching
1-Hydroxyxanthone(XIIIa)	3420	-		1650	1620	1572	1241
1-Acetoxyxanthone(XIIIc)	-	-	1750	1668	1612	-	1221
3-Hydroxyxanthone(XIVa)	-	3100		1632	1611	1598	1218
3-Acetoxyxanthone(XIVc)	-	-	1746	1650	1610	1595	1195
1-Hydroxy-3-methylxanthone (XVa)	3380	-		1654	1610	1565	1205

Table 2 (Cond..)

1-Acetoxy-3-methylxanthone (XVc)	-	-	1770	1669	1632	1615	1218
3-Hydroxy-1-methylxanthone (XVIa)	-	3215		1645	1615	1595	1235
3-Methoxy-1-methylxanthone (XVIc)	-	-		1656	1630	1612	1245
1,3-Dihydroxyxanthone (XVIIa)	3460	3200		1670	1620	1575	1231
1,3-Diacetoxyxanthone (XVIIc)	-	-	1755	1662	1615	1585	1240
3,4-Dihydroxyxanthone (XVIIIa)	3340	3225		1645	1605	1512	1232
3,4-Diacetoxyxanthone (XVIIIc)	-	-	1800 1777	1665	1610	1590	1198
3,4-Dimethoxyxanthone (XVIIId)	-	-		1670	1611	1595	1230
1,2-Benzoxanthone (XXa)	-	-		1648	1618	1610	1248
3,4-Benzoxanthone (XIXa)	-	-		1665	1642	1618	1240
3-Hydroxy-4-methylxanthone (XXIIa)	-	3240		1648	1613	1600	1230
3-Methoxy-4-methylxanthone (XXIId)	-	-		1640	1608	1595	1231
2,3-Dimethylxanthone (XXV)	-	-		1670	1636	1620	1260
4-Hydroxyxanthone (XXVIIa)	-	3190		1641	1611	1595	1220
4-Acetoxyxanthone (XXVIIc)	-	-	1778	1667	1615	1600	1192

E X P E R I M E N T A L

^{13}C-NMR spectra were measured on 25.2 MHz instrument and ^{1}H-NMR spectra were measured on Perkin Elmer 90MHz and 220 MHz spectrometers using TMS as an internal standard. IR spectra were recorded on Perkin Elmer 457 grating and on Backmann IR-20 spectrophotometer. UV spectra were takne on Beckmann DU-2 spectrophotometer.

Condensation of resorcinol with ethyl salicylate :

3'-Hydroxyphenyl salicylate (XIIa) :

A mixture of resorcinol (5.5 g ; 0.05 mole) and ethyl salicylate (8.5 g ; 0.052 mole) was refluxed in diphenyl ether (7 ml) for 3 to 5 hr. The reaction mixture was left over night. The separated product was filtered and washed sevaral times with petroleum ether, dried and then washed with saturated sodium bicarbonate solution (40 ml) and with water. The crude product showed two spots on TLC in chloroform, where one has R_f 0.65 and second one has R_f 0.40. They were quantitatively separated on preparative TLC in the ratio 44:1. Further the crude product was decolourized by activated charcoal and crystallized from aqueous ethanol and also from a mixture of benzene-petroleum ether gave only one product 3'-hydroxyphenyl salicylate(XXIIa), R_f 0.65 on TLC, m.p. 138°, yield 4.0 g, 38 %.

Analysis : Found : C, 67.89 ; H, 4.33 %

$C_{13}H_{10}O_4$ requires : C, 67.82 ; H, 4.35 %.

Acetylation of 3'-hydroxyphenyl salicylate (XIIa) :

3'-Acetoxyphenyl 2-acetoxybenzoate (XIIc) :

The product XIIa (1.5 g) was acetylated with acetic anhydride (6 ml) and pyridine (0.1 ml) by heating the reaction mixture on a water bath for 10 hr. The content was poured into ice cold water (30 ml) containing conc.hydrochloric acid (5 ml). The separated product was filtered, washed with very dilute sodium hydroxide solution and with water. It crystallized as colourless needles from a mixture of benzene-petroleum ether, m.p. 81°, yield 1.6 g.

Analysis : Found : C, 64.49 ; H, 4.59 %

$C_{17}H_{14}O_6$ requires : C, 64.96 ; H, 4.46 % .

2,2',4-Trihydroxybenzophenone (XIa) :

The second product, R_f 0.40 isolated (2 %) from the above crude product by preparative TLC in chloroform was found identical (m.p., mixed m.p. and co-TLC) with the reported[37] 2,2',4-trihydroxybenzophenone(XIa), which was prepared as follows :

Salicylic acid (5 g), resorcinol (6 g), anhydrous zinc chloride (20 g) and phosphorus oxychloride (25 ml) were heated on a water bath at 75-80° for 1.5 hr. The red reaction mixture was poured into crushed ice (300 ml) containing conc. hydrochloric acid (30 ml). A orange colour solid product separated was filtered washed with water and then transfered into a beaker containing saturated sodium bicarbonate solution

(50 ml), stirred for 15 minutes and the insoluble product was collected at the pump and washed with water. It crystallized from benzene as colourless plates, m.p. 133° and the mixed m.p. with the above isolated product remained the same, yield 1.2 g. It gave red colour with ferric chloride in water.

Analysis : Found : C, 68.13 ; H, 4.70 %

$C_{13}H_{10}O_4$ requires : C, 67.82 ; H, 4.35 % .

2,2',4-Triacetoxybenzophenone (XIb) :

The product XIa (0.5 g), on acetylation with acetic anhydride (4 ml) and pyridine (0.1 ml) gave triacetate derivative (XIb) in the usual way and crystallized from a mixture of benzene-petroleum ether as colourless needles, m.p. 69-70° (lit.,[37] m.p. 69-70°).

1-Hydroxyxanthone (XIIIa) :

A mixture of resorcinol (5.5 g, 0.05 mole), ethyl salicylate (8.5 g ; 0.052 mole) and diphenyl ether (10 ml) was refluexed for 18 to 20 hr. The reaction mixture was subjected to steam distillation to remove diphenyl ether. The separated product was treated with sodium hydroxide solution (10 % ; 400 ml). A yellow insoluble, salt was filtered and filterate 'A' was collected separately. The yellow coloured salt was washed with water, boiled with hydrochloric acid (12 % ; 40 ml) for 20 minutes and extracted with ethyl acetate

and on evaporation of the solvent gave brown solid. It was chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (1:9) gave 1-hydroxy-xanthone(XIIIa). It was crystallized from benzene as yellow coloured needles, m.p. 149° (lit.,[32] m.p. 148°), yield 0.6 g, 7 %.

Analysis : Found : C, 73.48 ; H, 3.93 %

$C_{13}H_8O_3$ requires : C, 73.58 ; H, 3.80 % .

1-Acetoxyxanthone (XIIIc) :

The product XIIIa (0.5 g) was taken in acetic anhydride (4 ml) and pyridine (0.2 ml) and was heated in a water bath for 8 hr. It was worked up as usual. The mono-acetate derivative(XIIIc), crystallized from a mixture of benzene-petroleum ether as colourless prisms, m.p. 172° (lit.,[32] m. p. 170°), yield 0.45 g.

Analysis : Found : C, 71.36 ; H, 4.14 %

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.94 % .

3-Hydroxyxanthone (XIVa) :

Acidification of filterate 'A' by ice cold conc. hydrochloric acid (30 ml) gave the product which was filtered washed with saturated sodium bicarbonate (35 ml) to remove any salicylic acid formed during the reaction and finally with water. It crystallized from ethanol (charcoal) in needles , m.p. 246° (lit.,[37] m.p. 242°), yield 3.3 g, 31 %.

Analysis : Found : C, 73.70 ; H, 3.80 %

$C_{13}H_8O_3$ requires : C, 73.58 ; H, 3.80 % ;

3-Acetoxyxanthone (XIVc) :

3-Hydroxyxanthone (1.5 g) was heated with acetic anhydride (5 ml) and pyridine (0.2 ml) in a water bath for 5 hr. to obtained monoacetate derivative (XIVc), which crystallized from benzene, m.p. 157° (lit.,[37] m.p. 156°), yield 1.4 g.

Analysis : Found : C, 70.55 ; H, 4.38 %

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.94 % .

Formation of 1-hydroxyxanthone (XIIIa) and 3-hydroxyxanthone (XIVa) from 3'-hydroxyphenyl salicylate (XIIa) :

3'-Hydroxyphenyl salicylate (2.3 g) ; 0.01 mole) was refluxed in diphenyl ether (8 ml) for 8 to 10 hr. The reaction mixture was steam distilled to remove diphenyl ether and the residuel product was worked up as shown above gave 1-hydroxyxanthone(XIIIa), m.p. 149°, yield 0.18 g (9 %) and 3-hydroxyxanthone(XIVa), m.p. 246°, yield 1.2 g (56 %). They were found identical with previously obtained xanthones.

Condensation of orcinol with ethyl salicylate :

1-Hydroxy-3-methylxanthone (XVa) :

Dry orcinol (2.48 g ; 0.02 mole) and ethyl salicylate (3.32 g ; 0.02 mole) were refluxed in diphenyl ether (7 ml)

for 8 to 11 hr. The solvent was removed by steam distillation The residue obtained was treated with sodium hydroxide solution (8 % ; 200 ml). The separated yellow coloured salt was filtered, washed with water and the filterate 'A' was collected. The salt was then boiled with hydrochloric acid (10 % ; 80 ml) for 20 minutes, extracted with ethyl acetate and washed with water, on evaporation of the solvent gave a brown solid. It was chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (1:4) to obtained 1-hydroxy-3-methylxanthone(XVa), which crystallized from benzene as orange needles, m.p. 148° (lit.,[32] m.p. 148° ; lit.,[36] m.p. 142-3°), yield 2.4 g, 53 %.

Analysis : Found : C, 74.80 ; H, 4.78 %

$C_{14}H_{10}O_3$ requires : C, 74.32 ; H, 4.43 % .

1-Acetoxy-3-methylxanthone (XVc) :

1-Hydroxy-3-methylxanthone (1.2 g), acetic anhydride (8 ml) and pyridine (0.1 ml) were heated in a water bath for 8 hr. The reaction mixture was worked up as usual. It crystallized from benzene as fine white prisms, m.p. 155°, yield 1.1 g.

Analysis : Found : C, 71.97 ; H, 4.61 %

$C_{16}H_{12}O_4$ requires : C, 71.64 ; H, 4.48 % .

3-Hydroxy-1-methylxanthone (XVIa) :

The alkaline filterate 'A' collected with the

removal of yellow sodium salt, was acidified by cold conc.hydrochloric acid (30 ml), gave 3-hydroxy-1-methylxanthone (XVIa) as cream coloured solid. It was filtered, washed with saturated sodium bicarbonate solution (30 ml) and with water, dried and crystallized from ethanol as small needl es m.p. 285° (lit.,[66] m.p. 285°), yield 0.35 g, 8 % .

Analysis : Found : C, 74.01 ; H, 4.22 %

$C_{14}H_{10}O_3$ requires : C, 74.32 ; H, 4.43 % .

3-Methoxy-1-methylxanthone (XVIc) :

A mixture of 3-hydroxy-1-methylxanthone (0.2 g), dimethyl sulphate (0.3 ml) and anhydrous potassium carbonate (8 g) was refluxed in dry acetone (250 ml) on a water bath for 6 hr. The solvent was distilled off and the product was extracted with ether and washed with dilute sodium hydroxide solution (2 x 20 ml) and with water. It crystallized from a mixture of benzene-petroleum ether and also from aqueous ethanol as colourless crystals, m.p. 133° (lit.,[66] m.p. 130-32°), yield 0.15 g.

Analysis : Found : C, 74.62 ; H, 5.39 %

$C_{15}H_{12}O_3$ requires : C, 74.98 ; H, 5.04 % .

Condensation of phloroglucinol with ethyl salicylate :

1,3-Dihydroxyxanthone (XVIIc) :

Dry phloroglucinol (1.3 g ; 0.01 mole) was dissolved in hot ethyl salicylate (5.9 g ; 0.035 mole) and to this

solution diphenyl ether (2 ml) was added and refluexed for 50 minutes. The reaction mixture was subjected to steam distillation and the separated product was filtered, washed with saturated sodium bicarbonate solution (30 ml) and with water, dried and crystallized from aqueous ethanol, gave 1,3-dihydroxyxanthone (XVIIa) as pale yellow needles, m.p. 257° (lit.,[32] m.p. 256°0, yield 1.3 g, 57 % .

Analysis : Found : C, 68.01 ; H, 3.70 %

$C_{13}H_8O_4$ requires : C, 68.42 ; H, 3.51 % .

1,3-Diacetoxyxanthone (XVIIc) :

1,3-Dihydroxyxanthone (0.6 g), acetic anhydride (8 ml) and pyridine (0.2 g) were heated in a water bath for 8 hr. The reaction mixture was worked up as usual. It crystallized from ethanol as colourless plates, m.p. 148° (lit.,[32] m.p. 147°), yield 0.75 g.

Analysis : Found : C, 65.63 ; H, 3.38 %

$C_{17}H_{12}O_6$ requires : C, 65.38 ; H, 3.85 % .

Condensation of pyrogallol with ethyl salicylate :

3,4$\frac{3}{4}$Dihydroxyxanthone (XVIIIa) :

A mixture of pyrogallol (5 g ; 0.04 mole) ethyl salicylate (6.8 g ; 0.04 mole) and diphenyl ether (10 ml) was refluxed for 6 to 7 hr. The reaction mixture was subjected to steam distillation to remove the solvent. The

separated dark pasty product was washed with saturated sodium bicarbonate solution (3 x 40 ml) and with water, dried, chromatographed over alumina and eluted with a mixture of benzene-chloroform (1:9) to obtain 3,4-dihydroxyxanthone (XVIIIa). It crystallized from aqueous ethanol as needles m.p. 240° (lit.,[36] 240-41°), yield 4.3 g, 48 %.

Analysis :	Found	: C, 67.95 ; H, 3.36 %
$C_{13}H_8O_4$	requires	: C, 68.42 ; H, 3.51 % .

3,4-Diacetoxyxanthone (XVIIIc) :

The product XVIIIa (0.8 g) on acetylation with acetic anhydride (10 ml) in pyridine (0.2 ml) on a water bath for 6 hr. gave 3,4-diacetoxyxanthone (XVIIIc), which crystallized from a mixture of benzene-petroleum ether as colourless long needles, m.p. 161°, yield 1.0 g.

Analysis :	Found	: C, 65.19 ; H, 3.63 %
$C_{17}H_{12}O_6$	requires	: C, 65.38 ; H, 3.85 % .

3,4-Dimethoxyxanthone (XVIIId) :

A mixture of 3,4-dihydroxyxanthone (1 g), dimethyl sulphate (1.4 ml) anhydrous potassium carbonate (6 g) and dry acetone (150 ml) was refluxed on a water bath for 10 hr. The solvent was distilled off and the product was extracted with ether (3 x 40 ml) and washed with dilute sodium hydroxide solution and with water . On evaporation of ether gave 3,4-dimethoxyxanthone(XVIIId), which crystallized from a

mixture of benzene-petroleum ether as colourless needles, m.p. 157° (lit.,[33] m.p. 156-7°), yield 0.8 g.

Analysis : Found : C, 69.85 ; H, 4.78 %

$C_{15}H_{12}O_4$ requires : C, 70.33 ; H, 4.69 % .

Condensation of 1-naphthol with ethyl salicylate :

3,4-Benzoxanthone (XIXa) :

1-Naphthol (4.4 g ; 0.03 mole) and ethyl salicylate (5 g ; 0.03 mole) were refluxed in diphenyl ether (10 ml) for 8 hr. The reaction mixture was cooled and diluted with petroleum ether (100 ml) and kept at room temperature for 3 hr. The crystalline white solid separated, was filtered and washed successively with petroleum ether, and then with sodium hydroxide solution (2 % ; 50 ml) and with water. It crystallized from ethanol and also from benzene as colourless long needles, m.p. 156° (lit.,[32] m.p. 155°), yield 5.5 g , 74 % .

Analysis : Found : C, 82.47 ; H, 4.52 %

$C_{17}H_{10}O_2$ requires : C, 82.91 ; H, 4.07 % .

Condensation of 2-naphthol with ethyl salicylate :

1,2-Benzoxanthone(XXa) :

2-Naphthol (4.3 g ; 0.03 mole) and ethyl salicylate (5 g ; 0.03 mole) were refluxed in diphenyl ether (8 ml) for 8 to 9 hr. The crystalline product separated, after the addition of petrolum ether was dried, washed with sodium hydroxide solution (2 % ; 80 ml) and with water. It

crystallized from ethanol as colourless needles, m.p. 141° (lit.,[32] m.p. 138-40°), yield 4.8 % g , 65 % .

Analysis : Found : C, 82.83 ; H, 4.22 %

$C_{17}H_{10}O_2$ requires : C, 82.91 ; H, 4.07 % .

Condensation of 2-methylresorcinol with ethyl salicylate :

2'-Methyl-3'-hydroxyphenyl salicylate (XXIa) :

A mixture of 2-methylresorcinol (6.2 g ; 0.05 mole), ethyl salicylate (8.3 g ; 0.05 mole) and diphenyl ether (10 ml) was refluxed for 7 to 9 hr. The reaction mixture was subjected to steam distillation and the separated product was extracted with ether (120 ml) and washed with saturated sodium bicarbonate solution (2 x 50 ml) and with water. The red colour pasty product thus obtained was chromatographed over silica gel and eluted with mixture of petroleum ether-benzene (3:2) to obtain 2'-methyl-3'-hydroxyphenyl a salicylate (XXIa). It crystallized from petroleum ether (b.p. 80-120°) as a colourless needles m.p. 102°, yield 6.2 g ; 52 % . It developed red colour with ethanolic ferric chloride.

Analysis : Found : C, 69.34 ; H, 4.80 %

$C_{14}H_{12}O_4$ requires : C, 68.85 ; H, 4.92 % .

Acetylation of 2'-methyl-3'-hydroxyphenyl salicylate(XXIa) :

2'-Methyl-3'-acetoxyphenyl 2-acetoxybenzoate (XXIc) :

The product XXIa (2 g), acetic anhydride (15 ml) and pyridine (0.2 ml) were heated on a water bath for 12 hr.

at 75°. The reaction mixture was poured into crushed ice (60 ml) containing conc. hydrochloric acid (5 ml). The separated pasty product was extracted with ether (80 ml) and washed with sodium hydroxide solution (1 % ; 2 x 40 ml) and with water. Evaporation of the solvent gave a product with crystallized from a mixture of benzene-petroleum ether as colourless plates, m.p. 64°, yield 1.9 g. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 66.27 ; H, 5.06 %

$C_{18}H_{16}O_6$ requires : C, 65.85 ; H, 4.88 % .

3-Hydroxy-4-methylxanthone (XXIIa) :

2-Methylresorcinol (6.2 g ; 0.05 mole) ethyl salicylate (8.5 g ; 0.052 mole) and diphenyl ether (13 ml) were refluxed for 16 to 18 hr. and subjected to steam distillation to remove diphenyl ether. The red pasty product obtained was washed with saturated sodium bicarbonate solution (80 ml) and with water. It was decolourised by activated charcoal and crystallized from ethanol and also from benzene as colourless small needles, m.p. 268°(lit.,[67] m.p. 267°), yield 4.2 g, 37 % .

Analysis : Found : C, 74.25 ; H, 4.28 %

$C_{14}H_{10}O_3$ requires : C, 74.32 ; H, 4.43 % .

Formation of 3-hydroxy-4-methylxanthone (XXIIa) from 2'-methyl-3'-hydroxyphenyl salicylate (XXIa) :

2'-Methyl-3'-hydroxyphenyl salicylate (2.5 g)

was refluxed in diphenyl ether (6 ml) for 8 to 10 hr. and the reaction mixture was worked up as described before to obtain 3-hydroxy-4-methylxanthone (XXIIa), which was found identical (m.p., mixed m.p. 268° and co-IR) with the above product, yield 1.8 g, 55 % .

Analysis : Found : C, 74.47 ; H, 4.11 %

$C_{14}H_{10}O_3$ requires : C, 74.32 ; H, 4.43 % .

3-Acetoxy-4-methylxanthone (XXIIc) :

3-Hydroxy-4-methylxanthone (1.5 g), acetic anhydride (12 ml) and pyridine (0.5 ml) were heated on a water bath for 8 hr. The reaction mixture was worked up as usual. It crystallized from a mixture of benzene-petroleum ether as colourless plates, m.p. 154°, yield 1.2 g.

Analysis : Found : C, 72.14 ; H, 4.32 %

$C_{16}H_{12}O_4$ requires : C, 71.64 ; H, 4.48 % .

3-Methoxy-4-methylxanthone (XXIId) :

A mixture of 3-hydroxy-4-methylxanthone (1 g), dimethylsulphate (1.5 ml), anhydrous potassium carbonate (6 g) and dry acetone (120 ml) were refluxed on a water bath for 5 hr. The reaction mixture was worked up as described before. It crystallized from ethanol as colourless crystals, m.p. 177° (lit.,[68] m.p. 177-8°), yield 0.7 g .

Analysis : Found : C, 74.48 ; H, 5.09 %

$C_{15}H_{12}O_3$ requires : C, 74.98 ; H, 5.04 % .

Condensation of hydroquinone with ethyl salicylate :

4'-Hydroxyphenyl salicylate (XXIIIa) :

A mixture of hydroquinone (5.5 g ; 0.05 mole) and ethyl salicylate (8.5 g ; 0.05 mole) was refluxed in diphenyl ether (9 ml) for 10 to 12 hr. and the reaction mixture was steam distilled to remove diphenyl ether. The separated product was extracted with ether and washed with saturated sodium bicarbonate solution (2 x 60 ml) and with water. The crude product thus obtained was decolourised by activated charcoal and crystallized from a mixture of benzene-petroleum ether and also from ethanol as colourless needles, m.p. 102-3°, yield 6.3 g, 55 % . It developed red colour with ethanolic ferric chloride.

Analysis : Found : C, 68.17 ; H, 4.11 %

$C_{13}H_{10}O_4$ requires : C, 67.82 ; H, 4.35 % .

Acetylation of 4'-hydroxyphenyl salicylate (XXIIIa) :

4'-Acetoxyphenyl 2-acetoxybenzoate (XXIIIc) :

4'-Hydroxyphenyl salicylate (2 g) acetic anhydride (12 ml) and pyridine (0.2 ml) were heated on a water bath for 10 hr. at 75°. The reaction mixture was poured into crushed ice (80 ml) containing conc.hydrochloric acid (5 ml). The separated solid product was filtered and washed with sodium hydroxide solution (1 % ; 60 ml) and with water. It crystallized from benzene as colourless prisms, m.p. 146-8°,

yield 1.8 g. It developed no colour with ethanolic ferric chloride.

Analysis : Found : C, 65.40 ; H, 4.64 %

$C_{17}H_{14}O_6$ requires : C, 64.96 ; H, 4.46 % .

Methylation of 4'-hydroxyphenyl salicylate :

4'-Methoxyphenyl 2-methoxybenzoate (XXIIId) :

4'-Hydroxyphenyl salicylate (1.5 g), dimethyl sulphate (2 ml), anhydrous potassium carbonate (9 g) and dry acetonee (80 ml) were refluxed on a water bath for 12 hr. The solvent was distilled off and the product was extracted with ether (3 x 30 ml) and the organic layer was washed with dilute sodium hydroxide solution (1 % ; 40 ml) and with water. Evaporation of the ether gave 4'-methoxyphenyl-2-methoxybenzoate (XXIIId), which crystallized from ethanol as colourless plates, m.p. 85°, yield 1.2 g. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 70.15 ; H, 5.45 %

$C_{15}H_{14}O_4$ requires : C, 69.76 ; H, 5.42 % .

Treatment of 4'-hydroxyphenyl salicylate with sulphuric acid :

4'-Hydroxyphenyl salicylate (1.5 g) was taken with sulphuric acid (80 % ; 20 ml) and the content was heated on a water bath at 70° for 20 minutes. The reaction mixture was poured into crushed ice (40 ml) and the separated solid product was filtered and washed with water. The product on

treatment with saturated sodium bicarbonate, dissolved completely and repricipitated with addition of dilute hydrochloric acid. The product developed violet colour with aqueous ferric chloride, m.p. 157° and it was characterized as salicylic acid.

Salicylic acid was also isolated, when 4'-hydroxyphenyl salicylate (XXIIIa) (2.5 g) was refluxed in diphenyl ether (6 ml) for 9 to 10 hr. and the reaction mixture was worked up as usual.

Condensation of 3,4-o-xylenol with ethyl salicylate :

3',4'-Dimethylphenyl salicylate (XXIVa) :

A mixture of 3,4-o-xylenol (3.7 g ; 0.03 mole), ethyl salicylate (5 g ; 0.03 mole) and diphenyl ether (8 ml) was refluxed for 12 to 15 hr. The reaction mixture was steam distilled to remove diphenyl ether and the separated oily product was extracted with ether (120 ml) and washed thrice with saturated sodium bicarbonate solution (30 ml) and with water. Evaporation of ether gave a pale yellow colour oily residue, yield 3.0 g, 40 %. It developed red colour with ethanolic ferric chloride.

Acetylation of 3',4'-dimethylphenyl salicylate (XXIVa) :

3',4'-Dimethylphenyl 2-acetoxybenzoate (XXIVc) :

The above oily product (2 g), acetic anhydride (10 ml) and pyridine (0.2 ml) were heated on a water bath for

8 hr. The content was poured into crushed ice (60 ml) containing conc.hydrochloric acid (4 ml). The separated solid product was filtered, washed with sodium hydroxide solution (1 % ; 60 ml) and with water, dried and crystallized from a mixture of benzene-petroleum ether as colourless shining needles, m.p. 82-4°, yield 2.1 g. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 71.37 ; H, 5.59 %

$C_{17}H_{16}O_4$ requires : C, 71.83 ; H, 5.63 % .

Treatment of 3',4'-dimethylphenyl salicylate (XXIVa) with sulphuric acid :

2,3-Dimethylxanthone (XXV) :

The oily product XXIVa (1.5 g) was dissolved in sulphuric acid (80 % ; 15 ml) and the content was kept on a water bath at 75° for 20 minutes. The reaction mixture was poured into crushed ice (50 ml). The separated white product was filtered, washed with saturated sodium bicarbonate solution (50 ml) and with water. It crystallized from aqueous ethanol as colourless plates, m.p. 160-1°, yield 0.16 g, 12 %. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 80.87 ; H, 5.76 %

$C_{15}H_{12}O_5$ requires : C, 80.37 ; H, 5.36 % .

Condensation of catechol with ethyl salicylate :

2'-Hydroxyphenyl salicylate (XXVIa) :

A mixture of catechol (5.5 g ; 0.05 mole), ethyl

salicylate (8.5 g ; 0.052 mole) and diphenyl ether (9 ml) was refluxed for 10 to 12 hr. The reaction mixture was steam distilled to remove diphenyl ether. The oily residue was extracted with ether (150 ml) and washed with saturated sodium bicarbonate solution (3 x 40 ml) and with water. The pasty product obtained on evaporation of ether, was chromatographed over alumina and eluted with a mixture of petroleum ether-benzene (9:1), to obtain 2'-hydroxyphenyl salicylate (XXVIa), which crystallized from petroleum ether (b.p. 60-80°) as colourless prisms, m.p. 80-1°, yield 5.5 g, 48 %. It gave red colour with ethanolic ferric chloride-.

Analysis : Found : C, 68.30 ; H, 4.22 %

$C_{13}H_{10}O_4$ requires : C, 67.82 ; H, 4.35 % .

Acetylation of 2'-hydroxyphenyl salicylate (XXVIa) :

2'-Acetoxyphenyl 2-acetoxybenzoate (XXVIc) :

2'-Hydroxyphenyl salicylate (2 g) was acetylated with acetic anhydride (12 ml) in presence of pyridine (0.2 ml) by heating the reaction mixture on a water bath for 8 hr. The reaction mixture on working up as before gave diacetate derivative (XXVIc), which crystallized from a mixture of benzene-petroleum ether as colourless needles, m.p. 108-10°, yield 2.1 g, It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 65.09 ; H, 4.52 %

$C_{17}H_{14}O_6$ requires : C, 64.96 ; H, 4.46 % .

4-Hydroxyxanthone (XXVIIa) :

A mixture of catechol (5.5 g ; 0.05 mole) ethyl salicylate (8.5 g ; 0.052 mole) and diphenyl ether (12 ml) was refluxed for 19 to 21 hr. The reaction mixture was subjected to steam distillation to remove diphenyl ether . The dark pasty product obtained was washed with saturated sodium bicarbonate solution (60 ml) and with water, dried, chromatographed over alumina and eluted with a mixture of benzene-chloroform (1:1). It crystallized from ethanol as white plates, m.p. 240°(lit.,[69] m.p. 240-1°), yield 1.3 g, 12 %.

Analysis : Found : C, 74.03 ; H, 4.25 %

$C_{13}H_8O_3$ requires : C, 73.58 ; H, 3.80 % .

Formation of 4-hydroxyxanthone (XXVIIa) from 2'-hydroxyphenyl salicylate (XXVIa) :

2'-Hydroxyphenyl salicylate (XXVIa), (4 g) was refluxed in diphenyl ether (10 ml) for 8 to 9 hr. and the reaction mixture was worked up as usual. It gave 4-hydroxyxanthone (XXVIIa), which was found identical (m.p., mixed m.p. 240° and co-IR) with the above product, yield 0.9 g .

Analysis : Found : C, 73.93 ; H, 4.27 %

$C_{13}H_8O_3$ requires : C, 73.58 ; H, 3.80 % .

Acetylation of 4-hydroxyxanthone (XXVIIa) :

4-Acetoxyxanthone (XXVIIc) :

4-Hydroxyxanthone (1 g),acetic anhydride (6 ml) and

pyridine (0.4 ml) were heated on a water bath for 6 hr. The reaction mixture on working up as before gave 4-acetoxyxanthone (XXVIIc). It crystallized from a mixture of benzene-petroleum ether as colourless prisms, m.p. 141° (lit.,[69] m.p. 139°), yield 0.9 % g.

Analysis : Found : C, 70.84 ; H, 4.28 %

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.94 % .

Condensation of -m-cresol with ethyl salicylate :

3'-Methylphenyl salicylate (XXVIIIa) :

A mixture of m-cresol (5.4 g ; 0.05 mole) and ethyl salicylate (8.5 g ; 0.052 mole) was refluxed in diphenyl ether (10 ml) for 13 to 16 hr. The solvent was removed by steam distillation. The oily residue was extracted with ether (80 ml) and washed with saturated sodium bicarbonate solution (3 x 40 ml) and with water, dried and chromatoraphed over silica gel and eluted with a mixture of petroleum ether-benzene (9:1). It crystallized from aqueous ethanol and also from petroleum ether (b.p. 60-80°) as colourless plates, m.p. 76-8° , yield 5.7 g , 50 % . It developed red colour with ethanolic ferric chloride.

Analysis : Found : C, 73.60 ; H, 4.80 %

$C_{14}H_{12}O_3$ requires : C, 73.68 ; H, 5.26 % .

Acetylation of 3'-methylphenyl salicylate (XXVIIIa) :

3'-Methylphenyl 2-acetoxybenzoate (XXVIIIc) :

3'-Methylphenyl salicylate (2 g) was heated with

acetic anhydride (12 ml) and pyridine (0.3 ml) on a water bath for 8 hr. The reaction mixture was worked up as described before, to obtain monoacetate derivative (XXVIIIc), which crystallized from a mixture of benzene-petroleum ether as fine colourless needles, m.p. 81-2°, yield 1.8 g. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 70.99 ; H, 5.03 %

$C_{16}H_{14}O_4$ requires : C, 71.11 ; H, 5.18 % .

Treatment of 3'-methylphenyl salicylate with sulphiruc acid :

3-Methylphenyl salicylate (1.2 g) was dissolved in sulphuric acid (80 %; 14 ml) and heated on a water bath at 70° for 20 minutes. The reaction mixture was poured into crushed ice (40 ml) and the separated solid product was filtered and washed with water. The product dissolved in saturated sodium bicarbonate solution (30 ml) and was repricipitated with addition of dilute hydrochloric acid. It developed violet colour with ethanolic ferric chloride and characterized as salicylic acid, m.p. 157°.

3-Methylphenyl salicylate (2.5 g) was refluxed in diphenyl ether (7 ml) for 8 to 10 hr. On working up of the reaction mixture as described before gave only salicylic acid, m.p. 157°.

Condensation of 7-hydroxy-4-methylcoumarin with ethyl salicylate :

4'-Methyl-2'-pyrono(6',5'-1,2)xanthone (XXIXa) :

A mixture of 7-hydroxy-4-methylcoumarin (4.8 g ; 0.03 mole) and ethyl salicylate (5 g ; 0.03 mole) was refluxed in diphenyl ether (12 ml) for 9 to 12 hr. The reaction mixture was subjected to steam distillation to remove diphenyl ether and the residue was extracted with ethyl acetate (120 ml) and washed with sodium hydroxide solution (1 % ; 3 x 30 ml) and with water. On evaporation of ethyl acetate gave pasty product, which was chromatographed over alumina and eluted with benzene to obtain 4'-methyl-2'-pyrono (6',5'-1,2)xanthone (XXIXa) which crystallized from benzene as colourless fine needles, m.p. 280°, yield 2.9 g, 35 %. It gave no colour with ethanolic ferric chloride.

Analysis : Found : C, 72.91 ; H, 3.80 %

$C_{17}H_{10}O_4$ requires : C, 73.38 ; H, 3.59 % .

Condensation of 7-hydroxy-5,8-dimethylcoumrin with ethyl salicylate :

4,4'-Dimethyl-2'-pyrono (5',6'-2,3)xanthone (XXXa) :

7-Hydroxy-4,8-dimethylcoumarin (5.2 g ; 0,03 mole) and ethyl salicylate (5 g ; 0.03 mole) were refluxed in diphenyl ether (12 ml) for 11 to 13 hr. The solvent was removed by steam distillation and the residual product was

extracted with ethyl acetate (140 ml), washed with sodium hydroxide solution (1 % ; 3 x 30 ml) and with water, dried over anhydrous sodium sulphate and solvent was distilled off. The crude dark product obtained was chromatographed over alumin and was eluted with a mixture of benzene-chloroform (9:1) to obtain 4,4'-dimethyl-2'-pyrono(5',6'-2,3)xanthone (XXXa), which crystallized from benzene and also from acetic acid as colourless needles, m.p. 289° , yield 2.6 g, 30 %. It developed no colour with ethanolic ferric chloride.

Analysis : Found : C, 73.64 ; H, 4.32 %

$C_{18}H_{12}O_4$ requires : C, 73.98 ; H, 4.11 % .

Condensation of 5-hydroxy-4,7-dimethylcoumarin with ethyl salicylate :

1,4'-Dimethyl-2'-pyrono(6',5'-3,4)xanthone (XXXIa) :

A mixture of 5-hydroxy-4,7-dimethylcoumarin (2.6 g ; 0.015 mole) ethyl salicylate (2.5 g ; 0.015 mole) and diphenyl ether (8 ml) was refluxed for 12 to 13 hr. The reaction mixture was subjected to steam distillation and the product obtained was extracted with ethyl acetate (70 ml) and washed with sodium hydroxide solution (1 % ; 3 x 20 ml) and with water. It was chromatographed over silica gel and eluted with a mixture of chloroform-methanol (49:1) to give pure 1,4'-dimethyl-2'-pyrono(6',5'-3,4)xanthone (XXXIa), which crystallized from acetic acid as colourless shining

needles, m.p. 299-300°, yield 1.75 g, 40 %. It developed no colour with ethanolic ferric chloride.

Analysis :	Found	: C, 74.44 ; H, 4.13 %
$C_{18}H_{12}O_4$	requires	: C, 73.98 ; H, 4.11 % .

Condensation of 7-hydroxy-5-methylcoumarin with ethyl salicylate :

3-Methyl-2'-pyrono(6',5'-1,2)xanthone (XXXII) :

7-Hydroxy-5-methylcoumarin (3.2 g ; 0.02 mole) and ethyl salicylate (3.35 g ; 0.02 mole) were refluxed in diphenyl ether (10 ml) for 13 to 15 hr. The reaction mixture was steam distilled and the oily product obtained was extracted with ethyl acetate (90 ml) and washed with sodium hydroxide solution (1 % ; 3 x 25 ml) and with water. It was dried, chromatographed over alumina and eluted with a mixture of chloroform-methanol (49 : 1) gave 3-methyl-2'-pyrono(6',5'-1,2)xanthone (XXXII). It crystallized from acetic acid as colourless crystals, m.p. 316°, yield 1.9 g, 35 %. It developed no colour with ethanolic ferric chloride.

Analysis :	Found	: C, 73.80 ; H, 3.91 %
$C_{17}H_{10}O_4$	requires	: C, 73.38 ; H, 3.59 % .

REFERENCES

1. F.M. Dean, in " The total synthesis of natural products ", Edited by J. ApSimon, Wiley-Interscience, John Wiley and Sons, New York, Part-1, P. 534 (1973).
2. K. Kunz-Krause and P. Manicke, Ber., 53, 190 (1920).
3. G.R. Clemo and R. Spence, J. Chem. Soc.,2811 (1928).
4. A.F. Hollemann, Org. Syn.,1, 552 (1941).
5. L.J. Simon, Bull. Soc. chim. Biol., 8, 203 (1926).
6. M. Kamel and H. Shoeb, Tetrahedron, 20, 491 (1964).
7. (Miss) K. Parija, A. Nayak and M.K. Rout, J. Inst. Chem. (India), 43, 230 (1971).
8. J.K. Kochi, J. Org. Chem., 26, 932 (1961).
9. P. Sartori and M. Weidenbruch, Angew. Chem. Intern. Ed., 4, 1072 (1965) ; C.A., 64, 8070 (1966).
10. E.J. McNelis, U.S., 3, 178, 450 (1965) ; C.A., 63, 2960^{e} (1965).
11. C.F. Sellers and H. Suschitzky, J. Chem. Soc. (C), 2139 (1969).
12. F. Ullmann and M. Zlokasoff, Ber., 38, 2111 (1905).
13. P. Griess, Ber., 21, 978 (1888).
14. O.F. Koelsch and F.J. Lucht, J. Am. Chem. Soc., 71, 3556 (1949).
15a. A.A. Goldberg and H. A. Walker, J. Chem. Soc., 1348 (1953).
15b. H. Mauss, Ber., 81, 19 (1948).
16. J.H.S. Davies, F. Lambs and H. Suschitzky, J. Chem. Soc., 1790 (1958).

17. A.A. Goldberg and R.H. Wragg, J. Chem. Soc., 4227 (1958).

18. N. Mauthner, Math. Naturw. Anz. Ungar. Akad. Wiss., 62, 360 (1943) ; C.A., 42, 1267 (1948).

19. Y.S. Agasimundin and S. Rajagopal, Ber., 100, 383 (1967).

20. G.S. Puranik, Y.S. Agasimundin and S. Rajagopal, Indian J. Appl. Chem., 31, 105 (1968).

21. C.S. Angadiyavar and S. Rajagopal, Monatsh., 99, 1044(1968).

22. F.L. Allen, P. Koch and H. Suschitzky, Tetrahedron, 6, 315 (1959).

23. P. Arendi and P. Heboe, Dan Tidsskr. Farm., 46, 133 (1972).

24. J.I. Okogun, J. Chem. Soc. Perkin 1, 2241 (1976).

25. Y. Asahima and Y. Tanse, Proc. Imp. Acad. (Tokyo), 16, 297 (1940); C.A., 34, 7906 (1940).

26. Y. Tanase, J. Pharm. Soc. Japan, 61, 341 (1941).

27. J. Granoth, Y. Segal and A. Kalir, J. Chem. Soc. Perkin 1, 1972 (1973).

28. S.N. Dhar, J. Chem. Soc., 117, 1053 (1920).

29. St. von Kostanecki and B. Nessler, Ber., 24, 3980 (1891).

30. N.A. Lund, B. Robertson and W.B. Whalley, J. Chem. Soc., 2434 (1953).

31. K.S. Pankajamani and T.R. Seshadri, J. Sci. Ind. Res. (India), 13 B, 396 (1954).

32. B.M. Desai, P.R. Desai and R.D. Desai, J. Indian Chem. Soc., 37, 57 (1960).

33. P.K. Grover, G.D. Shah and R.C. Shah, J. Chem. Soc., 3982 (1955).

34. P.K. Grover, G.D. Shah and R.C. Shah, J. Sci. Ind. Res. (India), 15 B, 629 (1956).

35. R. Meyer and A. Conzethi, Ber., 32, 2103 (1899).

36. V.V. Kane, A.B. Kulkarini and R.C. Shah, J. Sci. Ind. Res. (India), 16 B, 28 (1959).

37. J.H.S. Davies, F. Scheinmann and H. Suschitzky, J.Org. Chem., 23, 307 (1958).

38. J. Moron, J. Polansky and H. Pourrat, Bull. Soc. chim. France, 130 (1967).

39. B. Jackson, H.D. Locksley and F. Scheinmann, J. Chem. Soc. (C), 785 (1967).

40. H.D. Locksley, A.J. Quillinan and F. Scheinmann, J. Chem. Soc. Chem. Comm., 1505 (1969).

41. B.R. Samant and A.B. Kulkarni,Indian J. Chem., 7, 463(1969).

42. P.R. Iyer and G.D. Shah, Indian J. Chem., 8, 691 (1970).

43. Y.S. Agasimundin and S. Rajagopal, J. Org. Chem., 36, 845 (1971).

44. M.M. Pinto and J. Polonia, Helv. Chim. Acta., 57, 2613 (1979).

45. N.A. Kudav, B.K. Trivedi and A.B. Kulkarni, Indian J. Chem., 12, 1045 (1974).

46. M.L. Wolfrom, F. Komitsky and J.H. Looker, J. Org. Chem., 30, 144 (1965).

47. H.D. Locksley, I. Moore and F. Scheinmann, J. Chem. Soc. (C), 430 (1966).

48. G.V. Rao and T.R. Seshadri, Proc. Indian Acad. Sci., 37 A, 710 (1953).

49. H. Atkinson and I.M. Heilborn, J. Chem. Soc., 128, 2688 (1926).

50. H. Raistrick, R. Robinson and D.E. White, Biochem. J., 30, 1303 (1936),

51. J.R. Lewis, Proc. Chem. Soc., London, 363 (1963).

51a. J.R. Lewis and B.H. Wrrington, J. Chem. Soc., 5074 (1964).

52. G.H. Stout and W.J. Balkenhol, Tetrahedron, 25, 1947 (1969).

53. G.H. Stout, E.N. Christensen, W.J. Balkenhol and K,L. Stevens, Tetrahedron, 25, 1961 (1969).

54. F. Scheinmann and A.J. Quillinan, J. Chem. Soc. Perkin 1, 1329 (1973).

55. W.J. McMaster, A.I. Scott and S. Trippett, J. Chem. Soc., 4628 (1960).

56. A. Rhodes, B. Boothroyd, M.P. McGonyle and G.A. Summerfield, Biochem. J., 81, 28 (1961).

57. R.A. Finnegan and K.E. Merkel, J. Org. Chem., 37, 2986 (1972).

58. R.C. Ellis, W.B. Whalley and K. Ball, Chem. Comm., 803 (1967).

59. J.W.A. Findlay, P. Gupta and J.R. Lewis, Chem. Comm., 206 (1969).

60. R. Royer, J.P. Lechartier and P. Demerseman, Bull. Soc. chim. France, 1707 (1971).

61. O.F. Bennet, N.J. Bouchard, R. Malloy, P. Dervin and G. Saluti, J. Org. Chem., 37, 1356 (1972).

62. K.B. Desai, K.N. Trivedi and S. Sethna, J. M.S. Univ. Baroda, 4, 1 (1955).

63. S. Sethna, N.M. Shah and R.C. Shah, J. Chem. Soc., 228 (1938).

64. K.N. Trivedi, Curr. Sci. (India), 30, 54 (1961).

65. R. Ghosh, J. Chem. Soc., 1393 (1940).

66. St. von Kostanecki and B. Nessler, Ber., 24, 1894 (1891).

67. Y.S. Agasimundin and S. Rajagopal, Monatsh., 97, 423 (1966).

68. S.B. Cavitt and P.D. Gardner, J. Org. Chem., 27, 1211 (1962).

69. F. Ullmann and M. Zlokasoff, Ber., 38, 2118 (1905).

70. F. Scheinmann and S. Suschitzky, Tetrahedron, 7, 31 (1959).

71. NG. PH. Buu Hoi' and D. Lavit, J. Chem. Soc., 1743 (1956).

72. Y.G. Gaekwad, Ph.D. Thesis, M.S. Univ. Baroda (India), (1976).

CHAPTER III

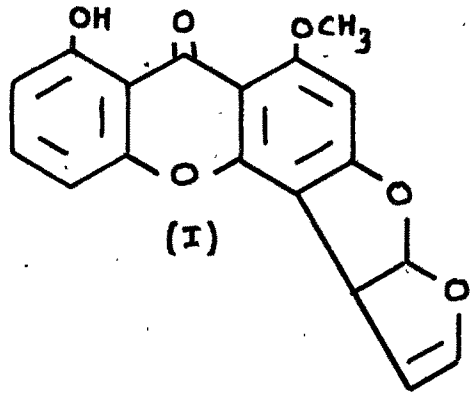
Section II

SYNTHESIS OF FUROXANTHONES

THEORETICAL

STUDIES IN THE SYNTHESIS OF FUROXANTHONES:

Xanthones have been found in plants and in fungi, but the furoxanthones are not known to occur in nature, except sterimatocystin[1,2] 3a, 12a-dihydro-8-hydroxy-6-methoxy-7H-furo (3',2'-4,5)furo(2,3-c)xanthen-7-one (1), which is isolated as a metabolite of Aspergillus verisicolor from mycelium.



(I)

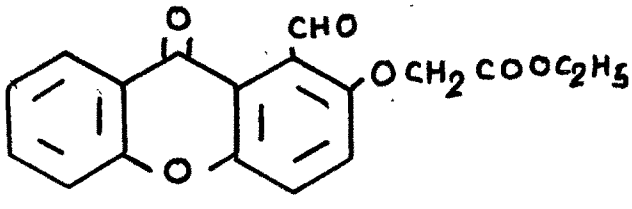
At present, many simple, 4'-methyl-, 4'-phenyl-, and 5'-methyl- synthetic furoxanthones have been prepared so far from the corresponding o-hydroxyformyl-, o-hydroxyacetyl-, o-hydroxybenzoyl- and o-hydroxyallylxanthones and 4',5'-diphenylfuroxanthones were reported from hydroxyxanthones by direct condensation with benzoin. The literature survey about the synthesis of furoxanthones is reviewed here :

By Claisen or internal aldol condensation :

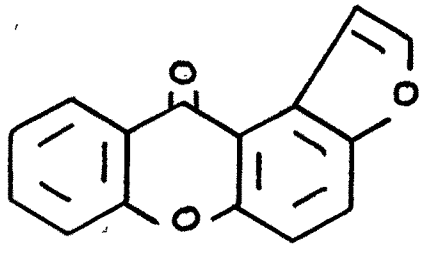
In this approach o-hydroxyaldehyde or ketone derivative is treated with bromoacetic or bromomalonic ester to get xanthyloxy ester, which either on hydrolysis followed by cyclization with sodium acetate and acetic anhydride or on cyclization with sodium ethoxide in ethanol followed by

hydrolysis and decarboxylation gives simple, 4'-methyl- or 4'-phenylfuroxanthone.

Devies et al[3] have condensed 1-formyl-2-hydroxyxanthone with ethyl bromacetate to obtain 1-formyl-2-xanthyloxyacetate (II). This was cyclized in ethanol with sodium ethoxide to yield 5'-carbethoxyfuro(3',2'-1,2)xanthone. Hydrolysis of this ester, followed by decarboxylation gave furo(3',2'-1,2)xanthone (III). This was also obtained by hydrolysis of II in alkali, followed by ring closure of acid accompanied by decarboxylation. Similarly, 4-formyl-3-hydroxyxanthones when condensed with bromomalonic ester, which effected simultaneous esterification and internal aldol condensation followed hydrolysis and decarboxylation, yielded furo(2',3'-3,4)xanthones (IVa)[4].



(II)

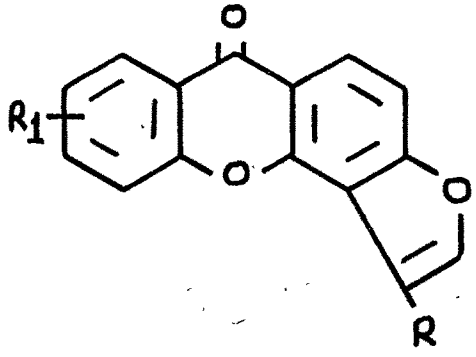


(III)

4-Acetyl derivatives of 3-hydroxyxanthones condensed with ethyl bromacetate to yield the corresponding 3-o-carbethoxy derivatives, which on hydrolysis followed by internal Claisen condensation with sodium acetate and acetic anhydride, was converted into 4'-methylfuro(2',3'-3,4)xanthones (IVb)[5,6].

Similarly from 4-benzoyl derivatives of 3-hydroxyxanthones the synthesis of 4'-phenylfuro(2',3'-3,4)xanthones(IVc)

is reported[7].

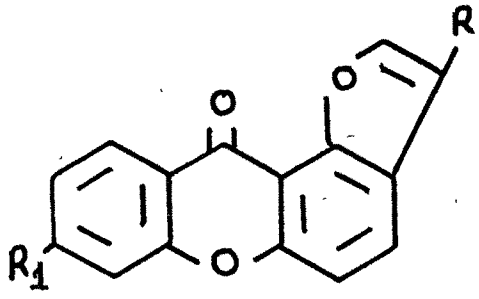


(IVa) R = H, R_1 = H or CH_3

(IVb) R = CH_3, R_1 = H, or CH_3

(IVc) R = Ph, R_1 = H or CH_3

The synthesis of a few angular furo(2',3'-1,2)-xanthones (V) carring a methyl or phenyl group in 4'-position of furan ring, starting with a hydroxyxanthone is also reported[8].



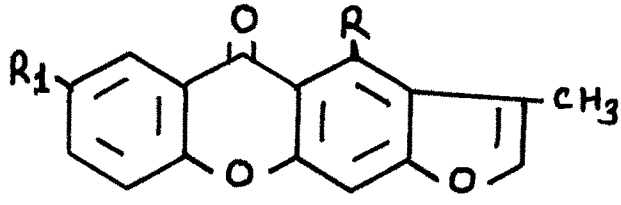
(V)

(a) R = CH_3, R_1 = H

(b) R = R_1 = CH_3

(c) R = Ph, R_1 = H

(d) R = Ph, R_1 = CH_3



(VI)

(a) R = R_1 = H

(b) R = H, R_1 = CH_3

(c) R_1 = OH, R_1 = H

The synthesis of linear furoxanthones viz., 4'-methyl-furo(3',2'-2,3)xanthone (VIa), 4',7-dimethylfuro(3',2'-2,3)-xanthone (VIb)[9] and 4'-methyl-1-hydroxyfuro(3',2'-2,3)xanthone (VIc)[10] is also reported.

From o-hydroxyallylxanthone derivatives :

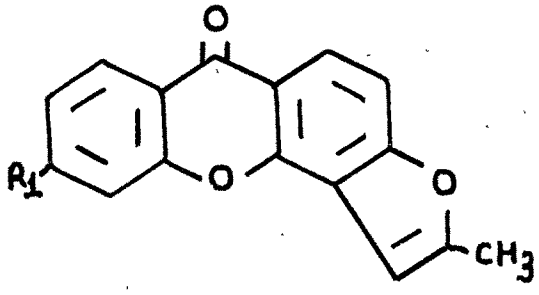
There are three different approaches leading to

the formation of a furan ring and in the present work one more is added to it. In the first approach Scheinmann and Suschitzky reported[11] the formation of dihydro furo compounds, which were brominated by treatment with N-bromosuccinamide in the presence of benzoyl peroxide and dehydrobrominated with pyridine to 5'-methylfuroxanthones. The second approach by Adams and Rindfusz[12], involving the addition of bromine to o-acetoxyallyl derivative, followed by cyclization and dehydrobromination. The third approach by Scheinmann and coworker[13] for the preparation of simple furoxanthones consisted of ozonolysis of the o-hydroxyallyl derivatives followed by cyclization with polyphosphoric acid. The fourth one which is the part of the present work consists of cyclization of the o-hydroxyallylxanthone into dihydrofuroxanthone, by trituration with conc. sulphuric acid followed by it dehydrogenation. This method is very convenient and gives quantitative yields of dihydro derivatives, This was initially developed by Shaikh and Trivedi for the synthesis of furocoumarins[14]. The dihydro derivatives on dehydrogenation with DDQ or with palladized charcoal gave 5'-methylfuroxanthones.

4-Allyl derivatives of 3-hydroxy- and 3-hydroxy-6-methylxanthone were converted into 5'-methylfuro(2',3'-3,4) xanthone (VIIa) and 5',6-dimethylfuro(2',3'-3,4)xanthone(VIIb)[15] respectively using first two approaches.

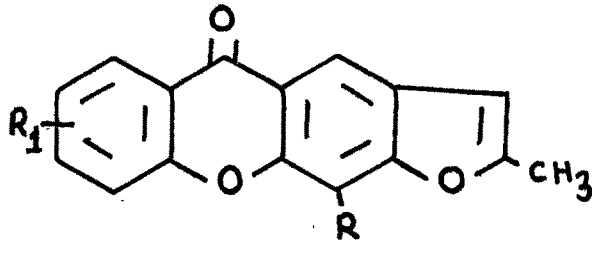
The synthesis of linear 5'-methylfuroxanthones (VIII) was reported by Rajagopal and his coworkers[16,17]. 2-Allyl

derivetives of 3-hydroxy-4-methyl- and 3-hydroxy-4-acetyl-xanthones on acetylation followed by bromination and cyclization with ethanolic potassium hydroxide were converted into corresponding 5'-methylfuro(3',2'-2,3)xanthones (VIII R = CH_3 or $COCH_3$ and R_1 = H, CH_3 etc.)[16,17].

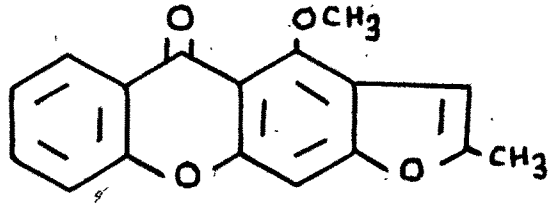


(VIIa) R = H

(VII b) R = CH_3

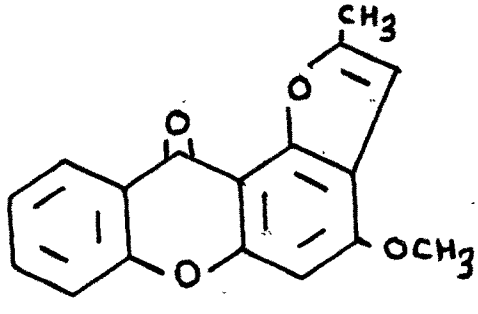


(VIII)

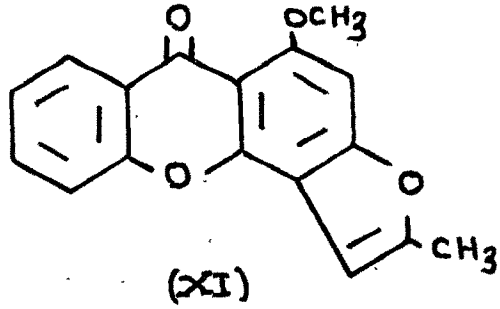


(IX)

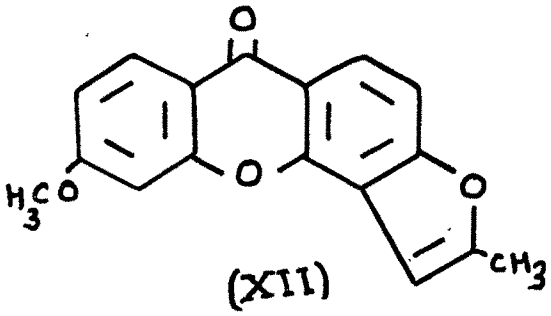
They have also synthesised three different 5'-methyl-furoxanthones (IX, X and XI)[18] from 1-hydroxy-3-tosyloxy-xanthone by combination of allylation, Claisen migration, methylation, detosylation, acetylation, bromination and cyclization reactions.



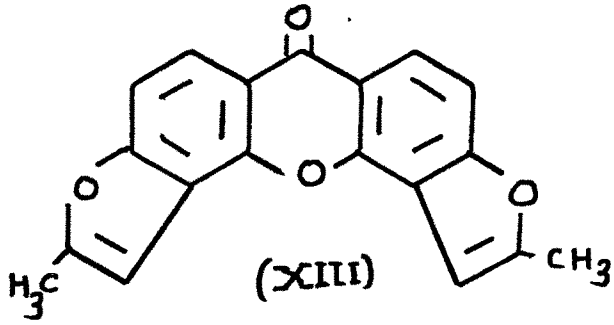
(X)



(XI)

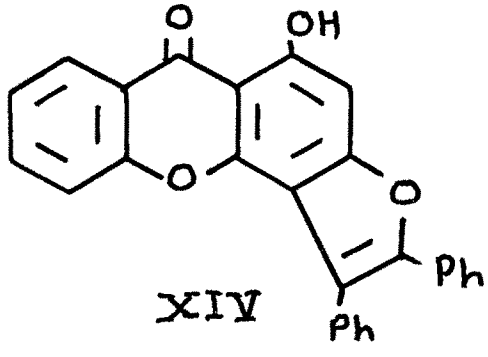


(XII)

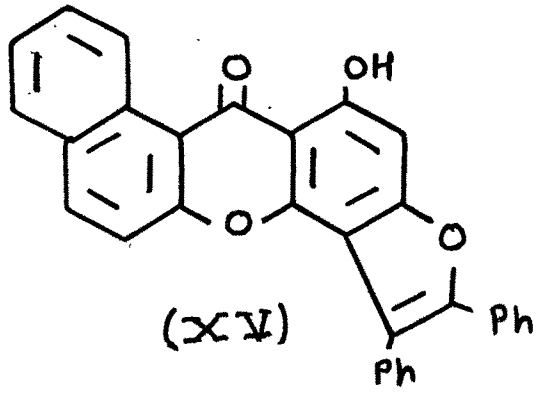


(XIII)

Gaekwad and Sethna[19] recently reported the synthesis of 5'-methyl-6-methoxyfuro(2',3'-3,4)xanthone (XII) and 5',5"-dimethyldifuro (2',3'-3,4) and (3",2"-5,6)xanthone(XIII) adopting the method of Adams and Rindfusz[12].

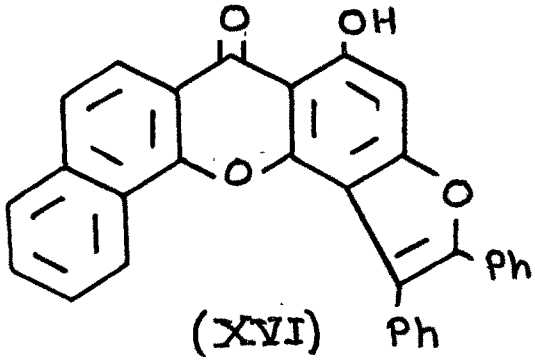


XIV



(XV)

Rao and Rajagopal have prepared 1-hydroxy-4',5'-diphenylfuro-xanthone (XIV)[20] and -benzoxanthones (XV)and (XVI)[21] with possible antifertility activity by condensation of 1,3-dihydroxy-xanthone and -benzoxanthone with benzoin in presence of PPA.



(XVI)

Present work :

The linear and angular type of furoxanthones, synthesised in the present work are as follows :

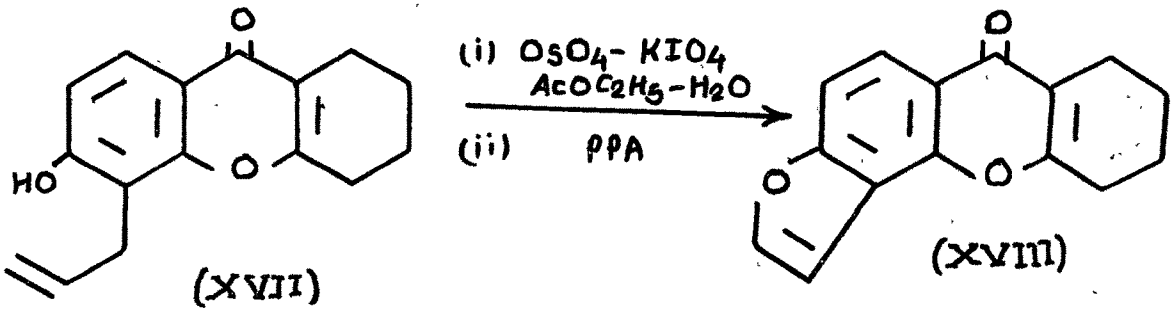
1. Furo(2',3'-3,4)xanthone (XIX)
2. 5'-Methylfuro(2',3'-3,4)xanthone (XXIII)
3. 1,5'-Dimethylfuro(2',3'-3,4)xanthone (XXVII)
4. 4-Methylfuro(3',2'-3,4)xanthone (XXX)
5. 4,5'-Dimethylfuro(3',2'-2,3)xanthone (XXXV)
6. 4,4'-Dimethylfuro(3',2'-2,3)xanthone (XXXIX)
7. 4,5',5"-Trimethyldifuro(3',2'-2,3) and (3",2"-5,6)-xanthone (XLIV)

Synthesis of furo(2',3'-3,4)xanthone (XIX) :

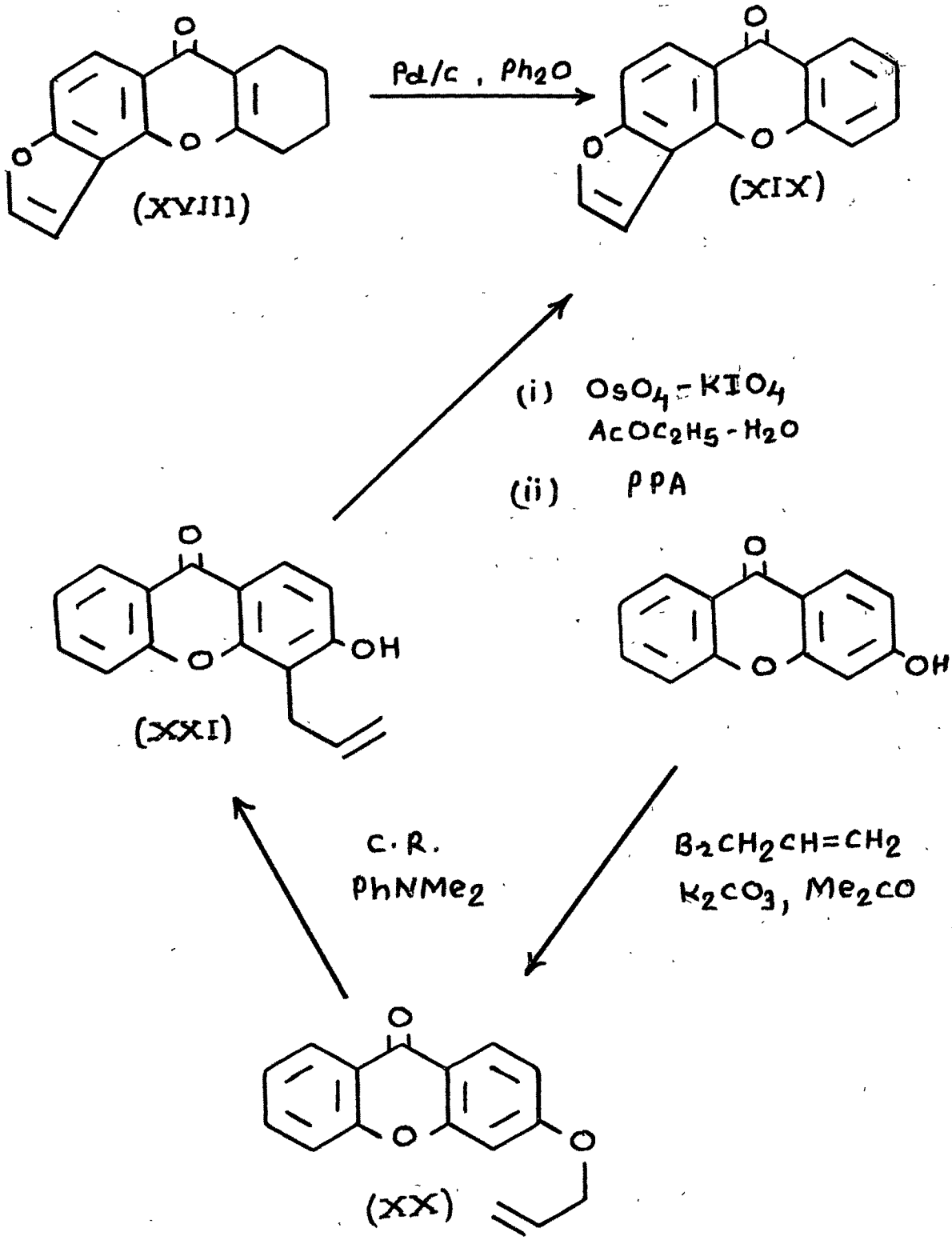
5-Allyl-6-hydroxy-1,2,3,4-tetrahydroxanthone(XVII), prepared as described in Chapter - II of the thesis, starting from resorcinol and ethyl cyclohexanone-2-carboxylate, was subjected to oxidation with osmium tetroxide-potassium periodate in ethyl acetate-water to give corresponding 6-hydroxy-5-acetaldehydo derivative, which was cyclized to 1,2,3,4-tetrahydrofuro(3',2'-5,6)xanthone (XVIII) with PPA. The structure of this was confirmed by its NMR spectrum in ($CDCl_3$ (Fig. 1) : δ 2.05 and 2.63 two broad signals, each corresponds to 4H, methylene groups in cyclohexane ring at 1-, 2-, 3-, and 4-position ; 7.08, doublet J=2.2Hz, 1H at 4'-position ; 7.46, doublet, J=10Hz, 1H at 7-position ; 7.70, doublet, J=2.2Hz, 1H, at 5'-position ; 8.15, doublet, J=10Hz, 1H, at 8-position.

The compound XVIII, on dehydrogenation with palladized charcoal (10 %) in diphenyl ether afforded furo(2',3'-3,4)xanthone (XIX). The structure of which was confirmed by its indepemdent synthesis and its NMR spectrum in $CDCl_3$ (Fig. 2):δ 7.10, doublet, J=1.8Hz, 1H, at 4'-position ; 7.78-7.68, multiplet, 4H, aromatic protons at 2-, 5-, 6- and 7-position ; 7.75, doublet, J=1.8Hz, 1H, at 5'-position ; 8.20, overlapping two doublets, J=10Hz, 2H, aromatic peri-ptotons at 1- and 8-position.

The synthesis of XIX was also achieved by carrying out allylation of 3-hydroxyxanthone (prepared as described in section I), with allyl bromide in presence of anhydrous potassium carbonate in dry acetone to give 3-allyloxyxanthone (XX), which on Claisen rearrangement in dimethylaniline afforded 4-allyl-3-hydroxyxanthone (XXI). IR spectrum in nujol (Fig.3) : 1632 cm^{-1} (γ-pyronyl >C=O group), and a broad band at 3120 cm^{-1} (aromatic -OH group). This on treatment with osmium tetroxide potassium periodate followed by cyclization with PPA afforded the same XIX.



(XVII) (XVIII)


Pd/c , Ph2O
(XVIII)
(XIX)
(i) OsO4 - KIO4
AcOC2H5 - H2O
(ii) PPA
OH
(XXI)
OH
C.R.
PhNMe2
B2CH2CH=CH2
K2CO3, Me2CO
(XX)

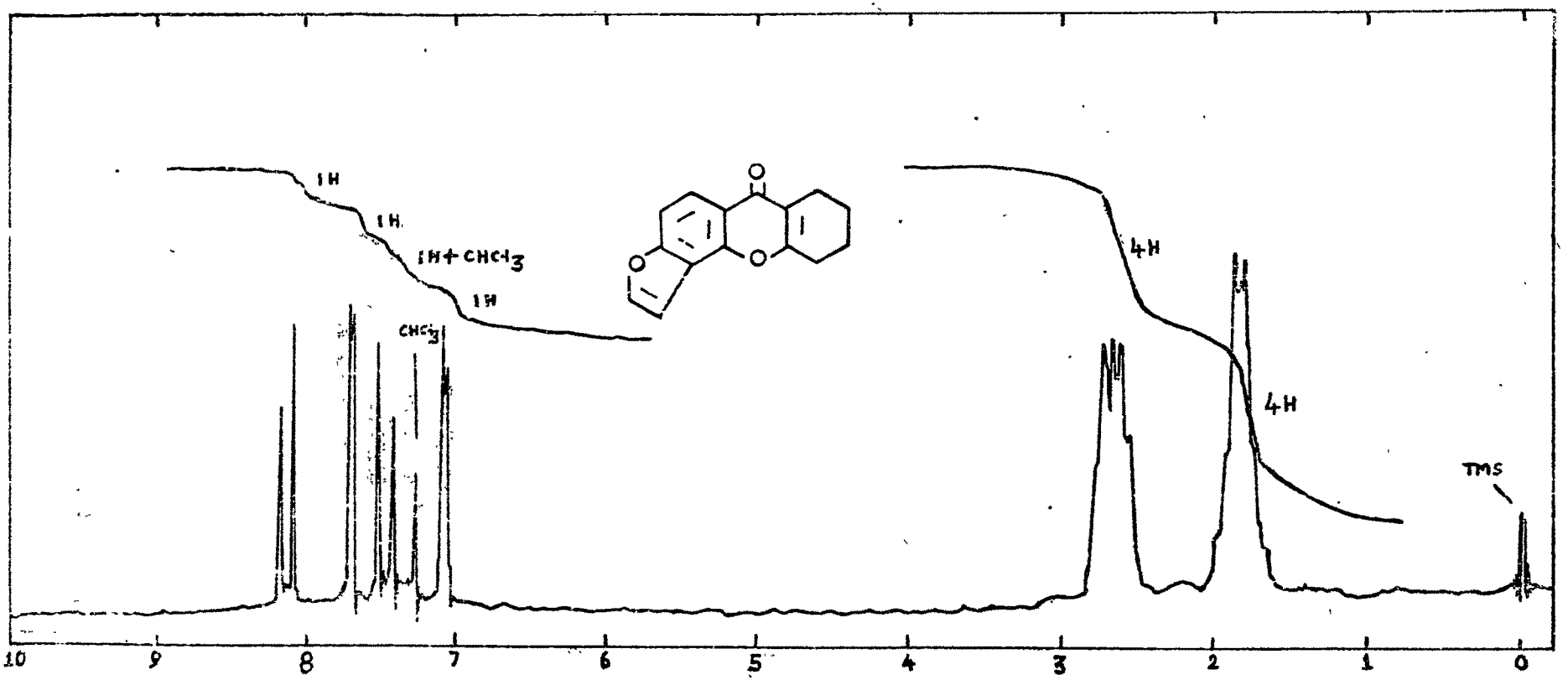


Fig. 1 : NMR spectrum of 1,2,3,4-Tetrahydrofuro(3',2'-5,6)xanthone (XVIII) in $CDCl_3$ (90 MHz).

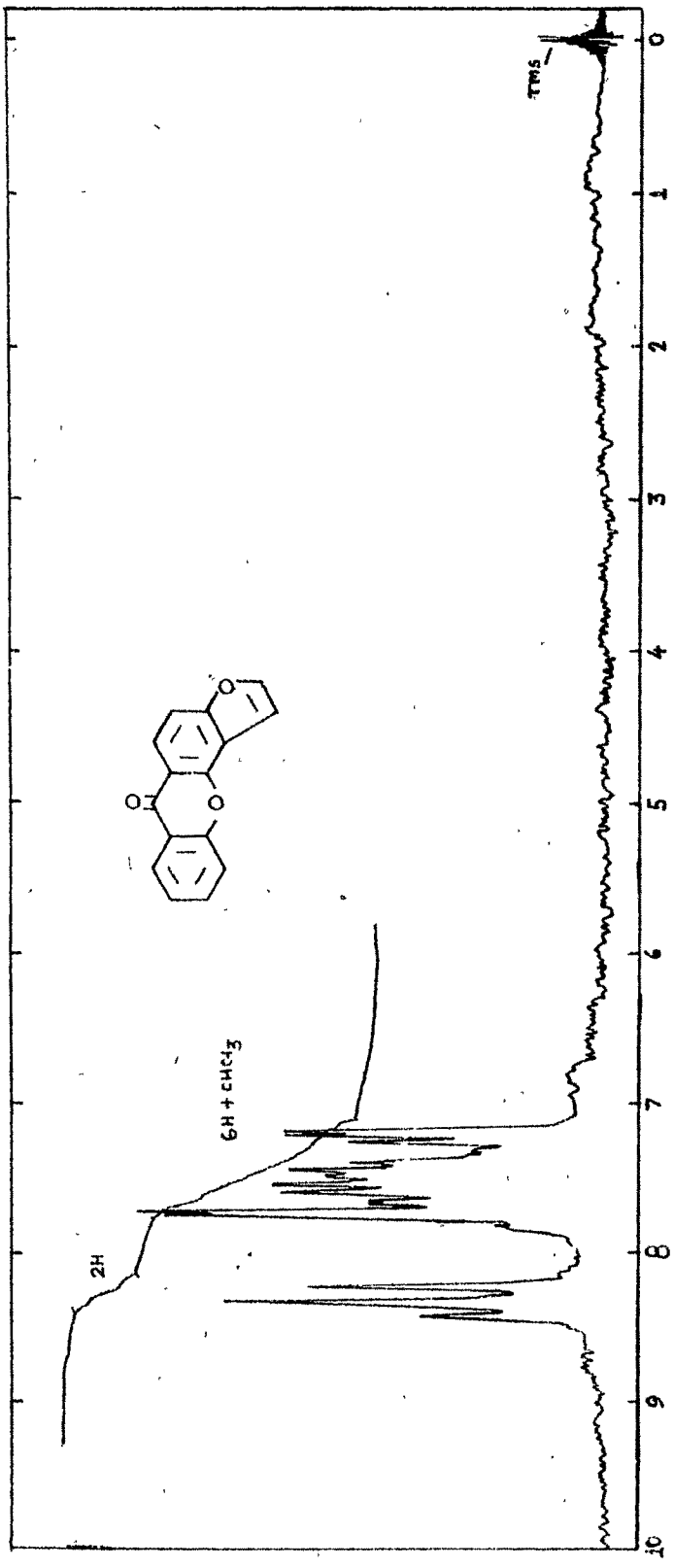


Fig. 2 : NMR spectrum of Furo(2',3'-3,4)xanthone (XIX) in $CDCl_3$ (90 MHz).

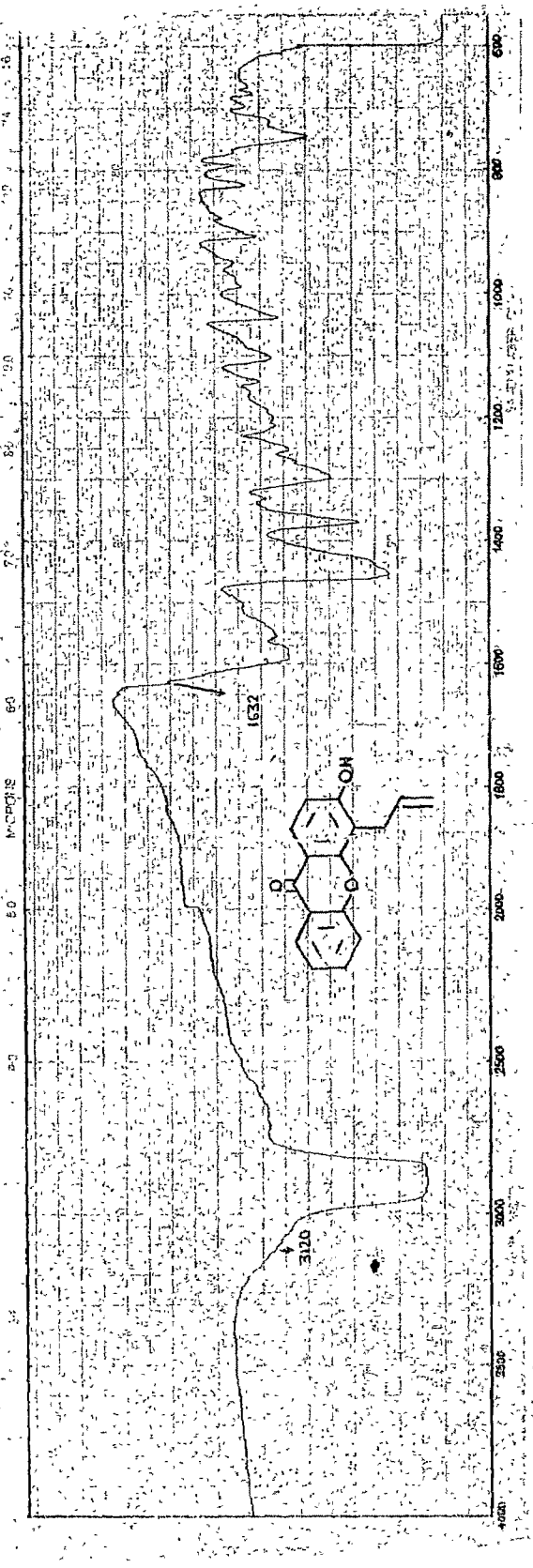


Fig. 3 : IR spectrum of 4-Allyl-3-hydroxyxanthone (XXI) in nujol.

Synthesis of 5'-methylfuro(2',3'-3,4)xanthone (XXIII) :

4-Allyl-3-hydroxyxanthone (XXI), was cyclized to 4',5'-dihydro-5'-methylfuro(2',3'-3,4)xanthone (XXII), by triturating with sulphuric acid (85 %)[14]. This method is very convenient and gives quantitative yields of dihydrofuroxanthones. The structure of XXII was confirmed on the basis of its NMR spectrum in $CDCl_3$ (Fig. 4) : δ 1.54, doublet, J=7Hz, 3H, CH_3 group at 5'-position ; 2.80,3.62, two symmetrical quartets, 2H, methylene group at 4'-position ; 6.70, doublet, J=9Hz, 1H, at 2-position ; 7.20-7.30, multiplet, 3H, aromatic protons at 5-, 6-, and 7-position ; 8.06, doublet, J=9Hz, 1H, at 1-position ; 8.25, doublet, J=9Hz, 1H, at 8-position. This on dehydrogenation with palladized charcoal (10 %) in diphenyl ether gave 5'-methylfuro(2',3'-3,4)xanthone (XXIII). The NMR spectrum in $CDCl_3$ (Fig. 5) :δ 2.6, singlet, 3H, CH_3 group at 5'-position ; 6.84, singlet, 1H, furan ring proton at 4'-position ; 7.45-7.80, multiplet, 4H, aromatic protons at 2-, 5-, 6- and 7-position ; 8.30, doublet, J=9Hz, 1H, at 1-position ; 8.50, double doublet, J=9Hz (ortho couppling), J=1.5Hz (meta coupling), 1H, at 8-position. The same was also prepared by Rajagopal et al.[15] by a different route as described before.

Synthesis of 1,5'-dimethylfuro(2',3'-3,4)xanthone (XXVII) :

The synthetic work on 3-hydroxy-1-methyl-xanthone (XXIV) is not reported in the literature. The starting compound

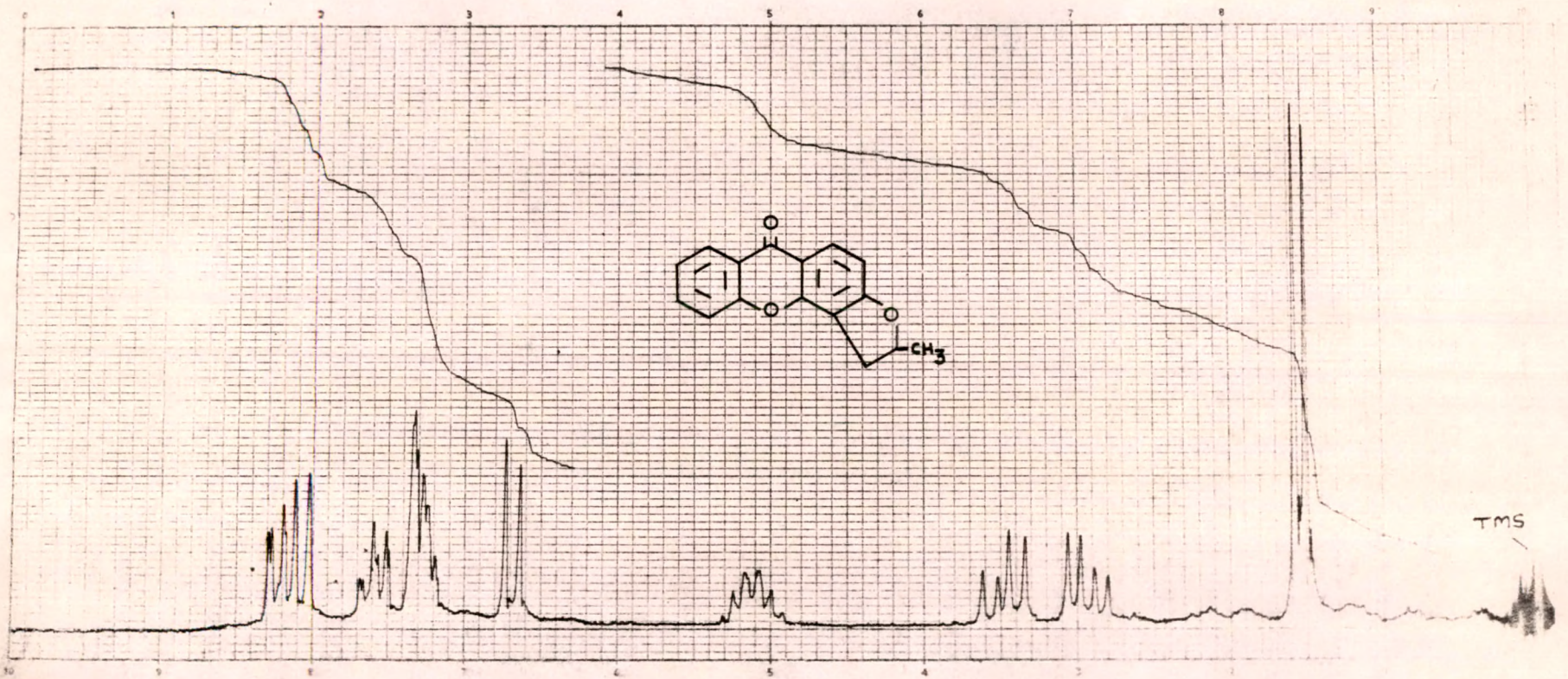
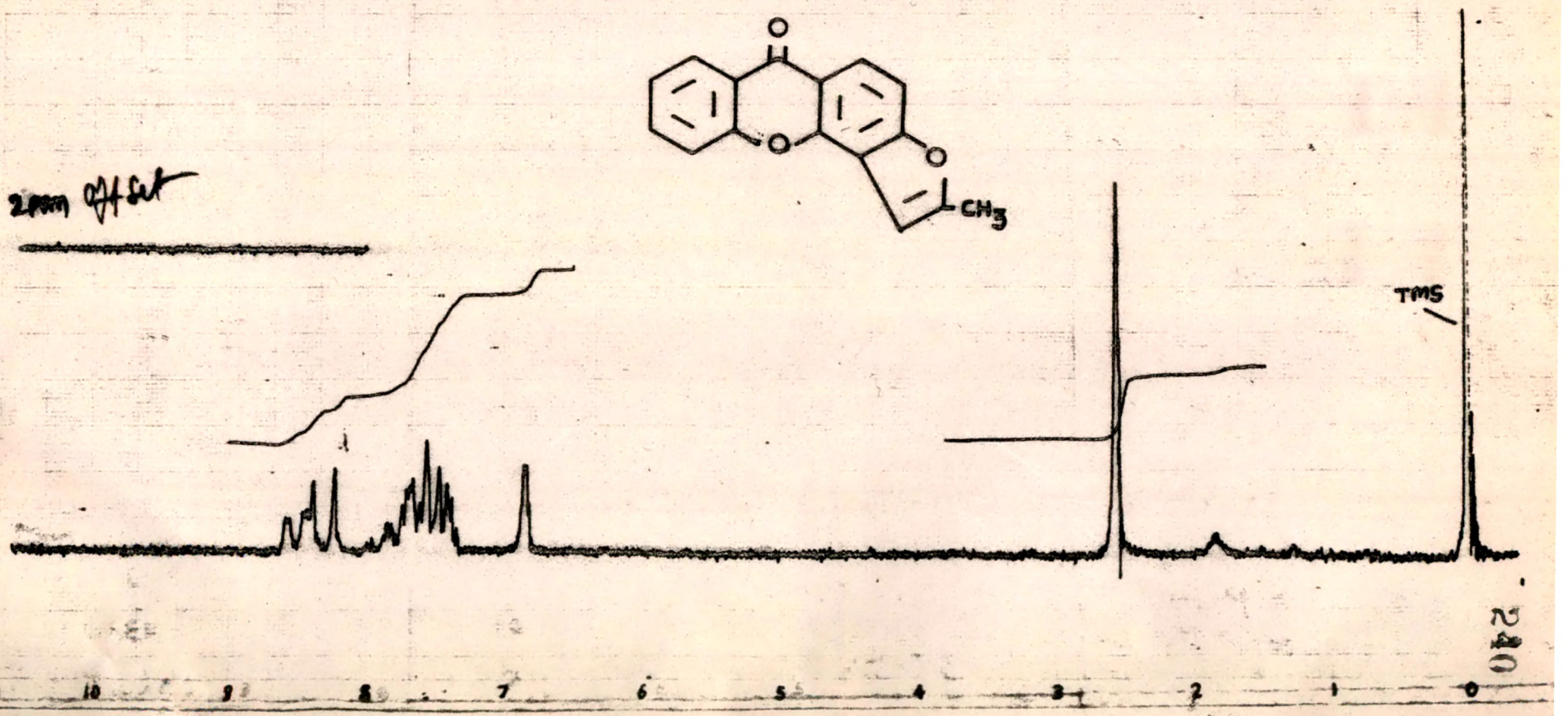
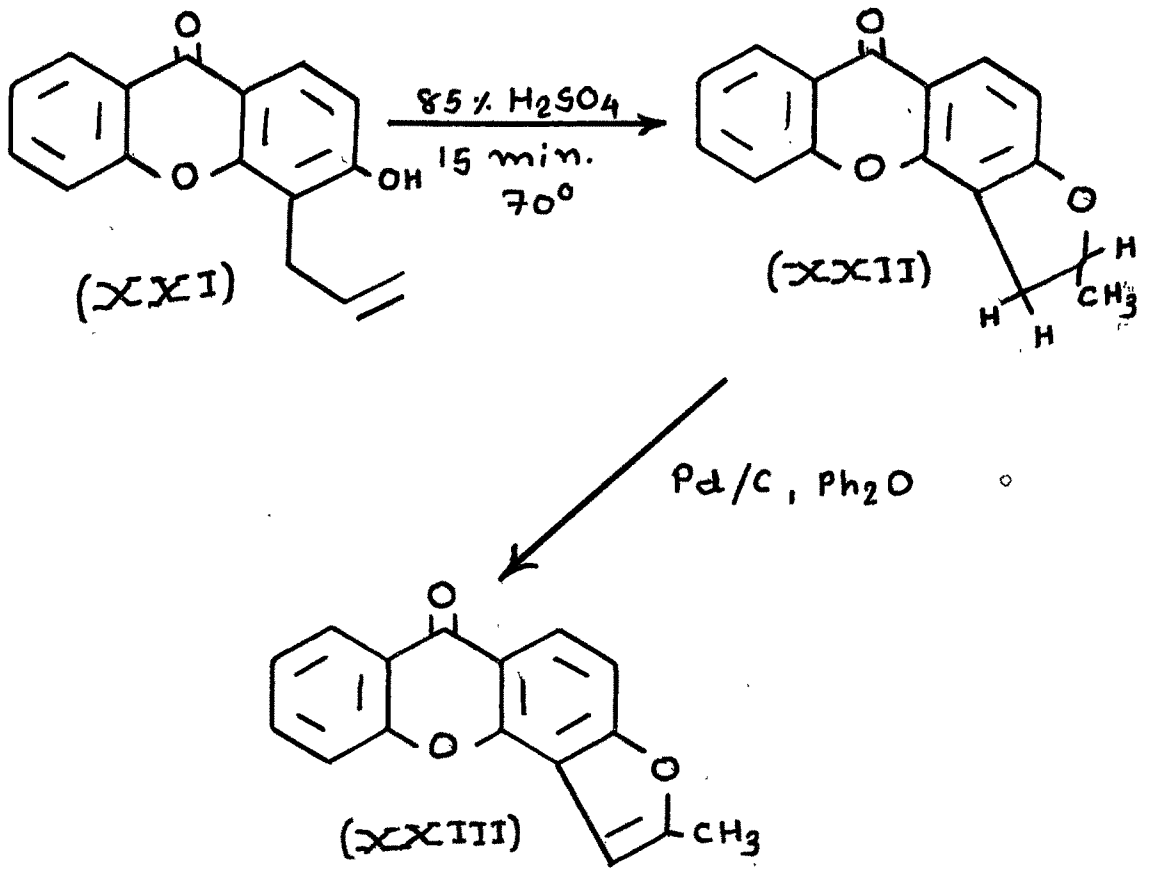


Fig. 5 4: : NMR spectrum of 4',5'-Dihydro-5'-methylfuro(2',3'-3,4)-xanthone (XXII) in $CDCl_3$ (90 MHz).

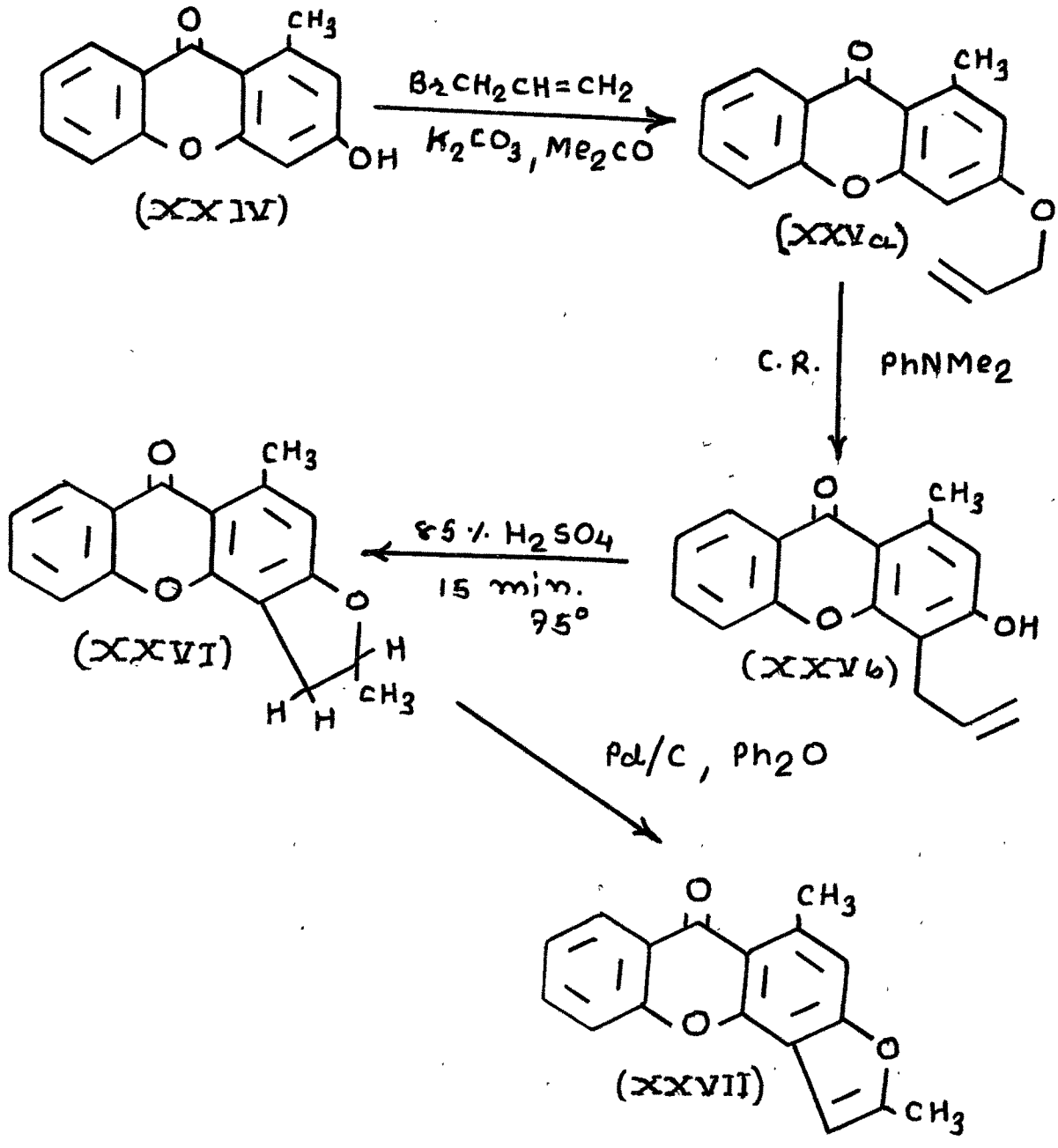
Fig. 5 : NMR spectrum of 5'-Methylfuro(2',3'-3,4)xanthone (XXIII) in $CDCl_3$ (EM-360 60 MHz NMR spectrometer).





XXIV for the synthesis of title compound is obtained in poor yield as discribed in earlier section, was subjected to allylation with allyl bromide in presence of anhydrous potassium carbonate in dry acetone, followed by Claisen rearrangement gave 4-allyl-3-hydroxy-1-methylxanthone(XXVb). This was cyclized to 4',5'-dihydro-1,5'-dimethylfuro(2',3'-3,4)-xanthone (XXVI). The structure of which was confirmed on the basis of its NMR spectrum in $CDCl_3$ (Fig. 6) : δ 1.42, doublet, J=7Hz, 3H, CH_3 group at 5'-position ; 2.83, singlet, 3H, slightly overlapped with the multiplet, Ar-CH_3 group, which is remarkably down field due to its attachment to the peri position -1.δ 2.50-3.55, two symmetrical quartets, 2H, methylene group

at 4'-position ; 4.83-5.13, multiplet, 1H, methine proton at 5'-position ; 6.40, singlet, 1H, aromatic proton at 2-position ; 7.25-7.52, multiplet, 3H, aromatic protons, at 5-, 6- and 7-position ; 8.08, doublet, J_{87}=10Hz, J_{86}=1.5Hz, 1H, peri-proton at 8-position. This was dehydrogenated to 1,5'-dimethylfuro-(2',3'-3,4)xanthone (XXVII) with palladized charcoal. The



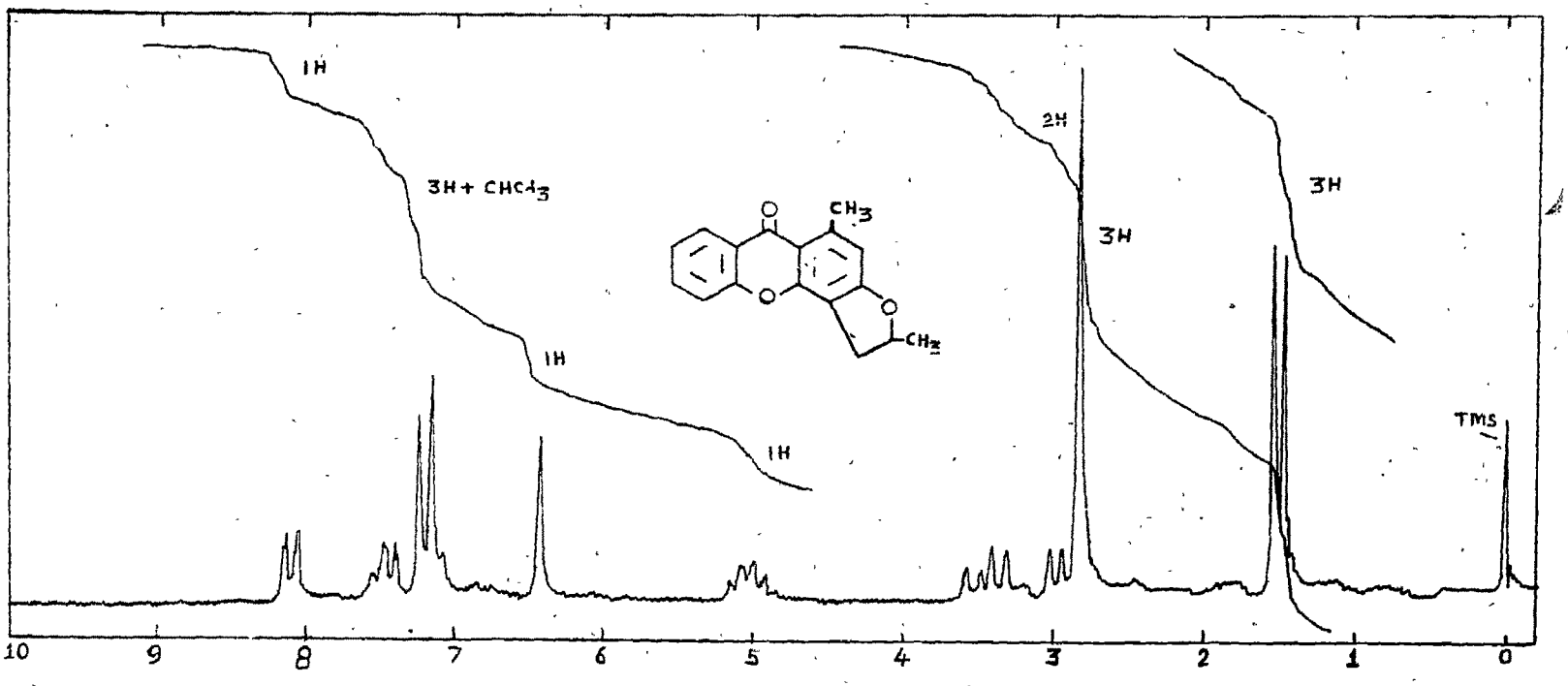


Fig. 6 : NMR spectrum of 4',5'-Dihydro-1,5'-dimethylfuro(2',3'-3,4)-xanthone (XXVI) in $CDCl_3$ (90 MHz).

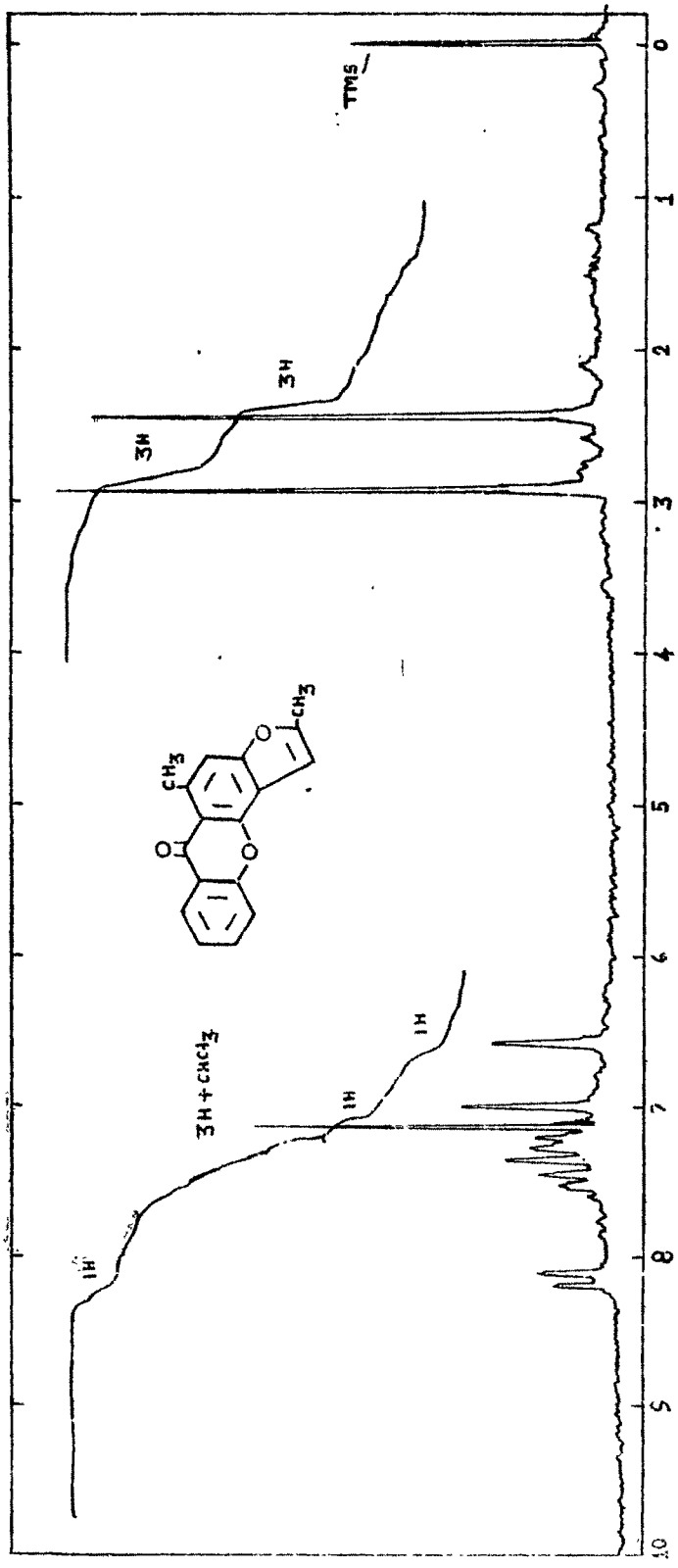


Fig. 7 : NMR spectrum of 1,5'-Dimethylfuro(2',3'-3,4)xanthone (XXVII) in $CDCl_3$ (90 MHz).

structure of XXVII was confirmed from its NMR spectrum in $CDCl_3$ (Fig. 7) : δ 2.40, singlet, 3H, CH_3 group at 5'-position ; 2.90, singlet, 3H, CH_3 group, which is remarkable down field at 1-position ; 6.58, singlet, 1H, proton at 2-position ; 6.95, singlet, 1H, β-proton of furan ring at 4'-position ; 7.20,7.55, multiplet, 3H, aromatic protons at 5-, 6- and 7-position ; 8.15, doublet, J_{87}=10Hz, J_{86}=1.5Hz, 1H, at 8-position.

Synthesis of 4-methylfuro(3',2'-2,3)xanthone (XXX) :

7-Allyl-6-hydroxy-5-methyl-1,2,3,4-tetrahydroxanthone (XXVIII) synthesised according to Sanghvi and Trivedi[22] by condensing 2-methylresorcinol with ethyl cyclohexanone-2-carboxylate followed by allylation and Claisen rearrangement of the xanthone formed, was subjected to oxidation with osmium tetroxide-potassium periodate in ethyl acetate-water to give corresponding 7-acetaldehydo-6-hydroxy- derivative, which was cyclized to 5-methyl-1,2,3,4-tetrahydrofuro(2',3'-6,7)xanthone (XXIX) with PPA. The structure of which, was confirmed on the basis of its NMR spectrum in $CDCl_3$ (Fig. 8) : δ 1.57-2.03, a broad multiplet, 4H, two methylene groups at 2- and 3-position ; 2.55, singlet, overlapped with a broad signal, 3H, CH_3 group at 4-position ; 2.40-2.80, a broad multiplet, 4H, two methylene groups at 1- and 4-position. Two doublets at δ 6.82 and 7.68, having J=2.2Hz, are assigned for β- and α- proton of furan ring at 4'-and 5'-position ; and one singlet at δ 8.25, is due to peri-proton at 8-position. The furoxanthone XXIX, was treated

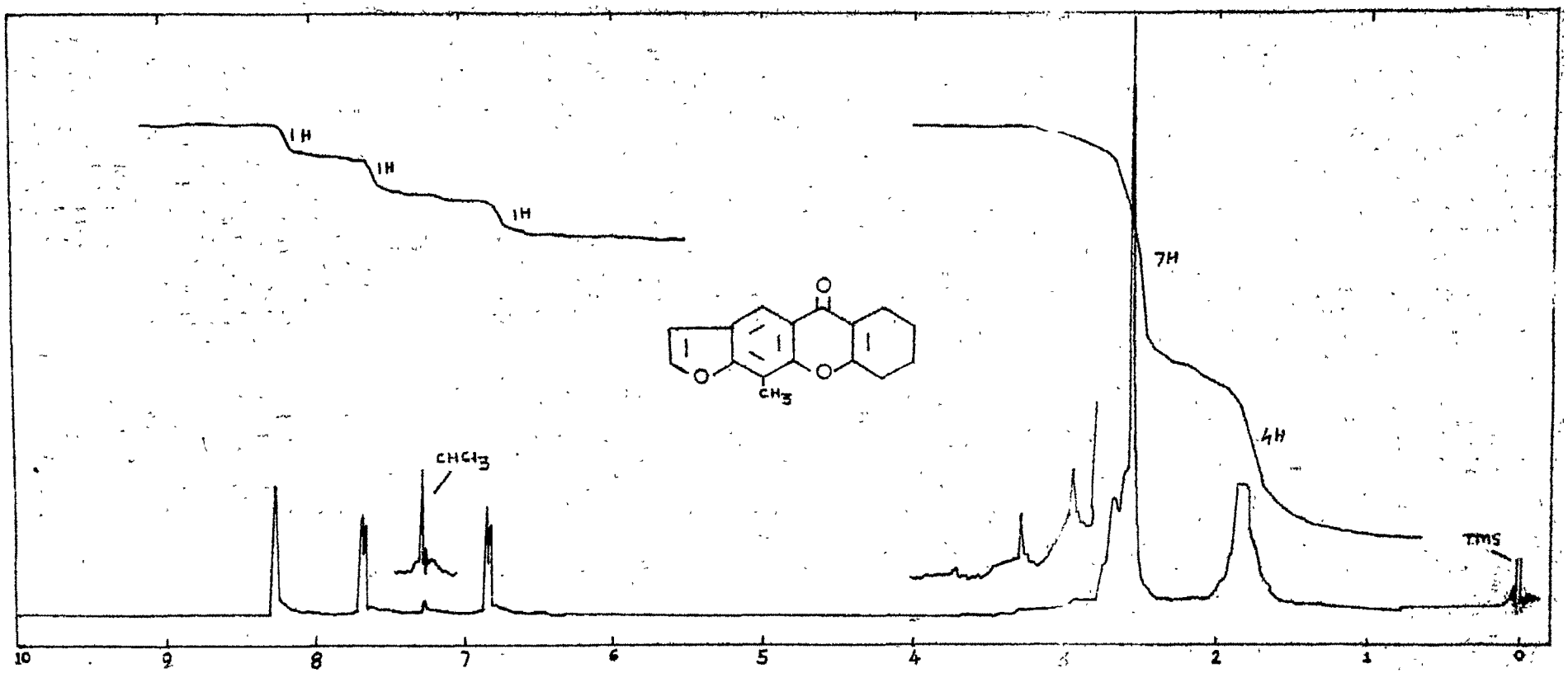
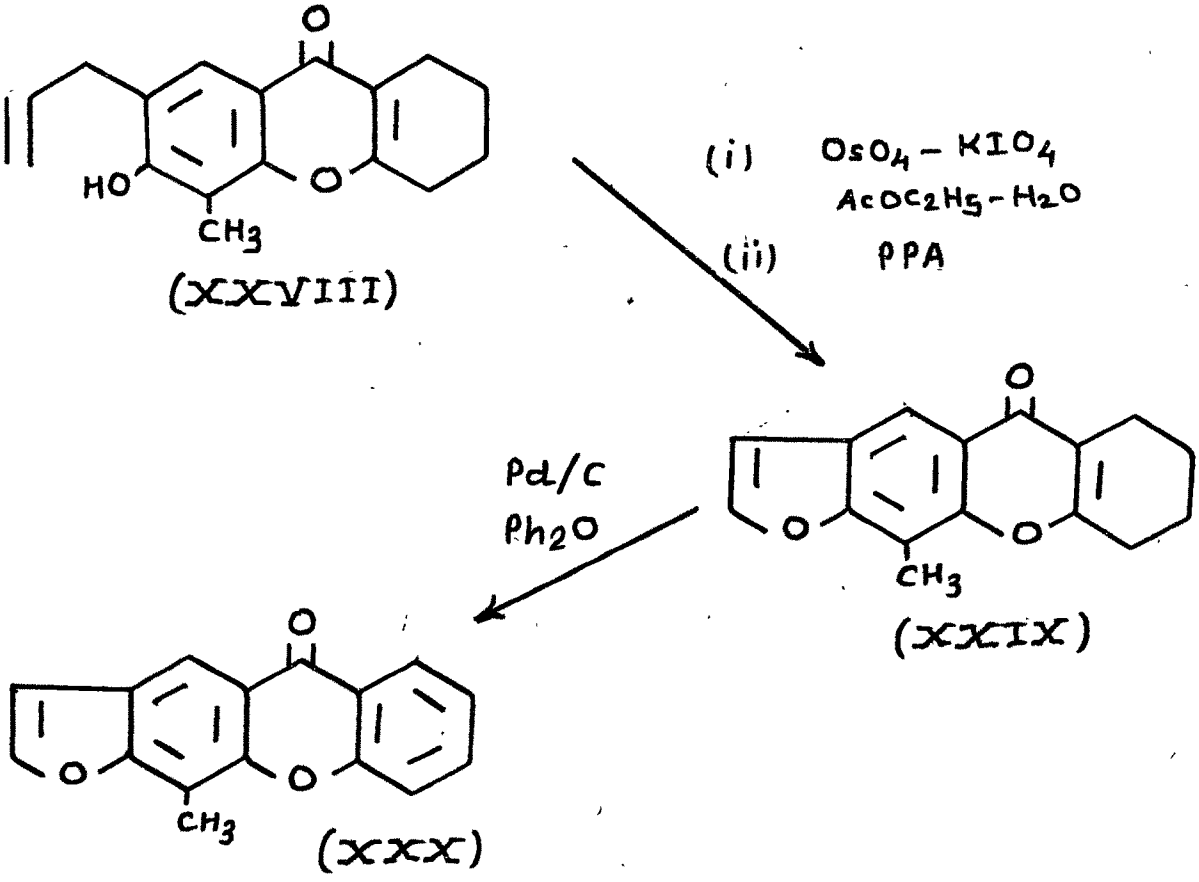
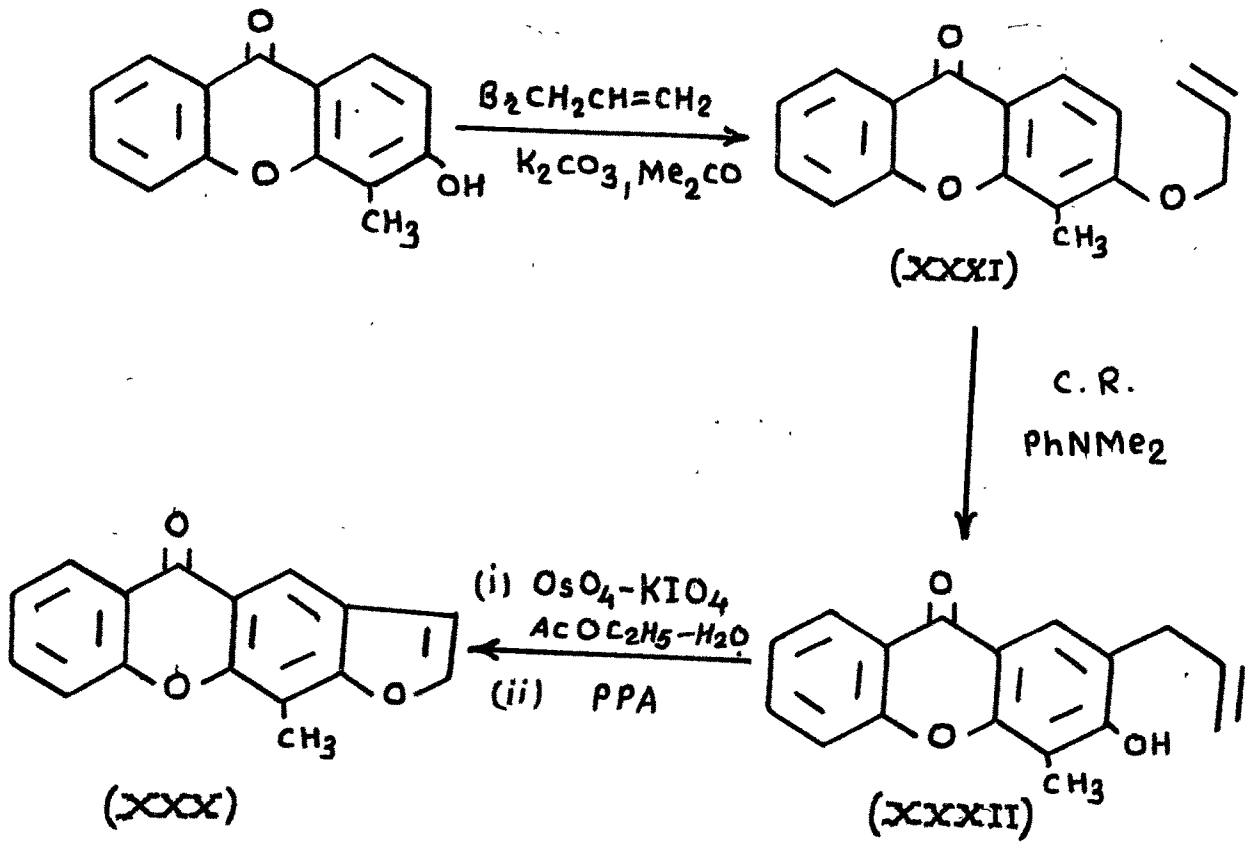


Fig. 8 : NMR spectrum of 5-Methyl-1,2,3,4-tetrahydrofuro(2',3'-6,7)-xanthone (XXIX) in $CDCl_3$ (90 MHz).

with palladized charcoal in diphenyl ether to give dehydrogenated product 4-methylfuro(3',2'-2,3)xanthone (XXX). Its NMR spectrum in $CDCl_3$ (Fig. 9) : δ 2.71, singlet, 3H, CH_3 group at 4-position ; 6.89, doublet, J=2Hz, 1H, at 4'-position ; 7.75, doublet, J=2Hz, 1H, at 5'-position ; 7.30-7.68, multiplet, 3H, aromatic protons at 5-, 6- and 7-position. The down field signals around δ 8.40 are due to overlapping of one doublet, J=10Hz and one singlet, integrating for two peri-protons at 8- and 1- position respectively. The product XXX was also synthesised from 3-hydroxy-4-methylxanthone which on allylation and Claisen rearrangement gave 2-allyl-3-hydroxy-4-methylxanthone (XXXII). This was subjected to osmium tetroxide-potassium periodate oxidation followed by cyclization with PPA to obtain the same product 4-methylfuro(3',2'-2,3)xanthone(XXX).





Synthesis of 4,5'-dimethylfuro(3',2'-2,3)xanthone(XXXIV) :

2-Allyl-3-hydroxy-4-methylxanthone (XXXII) obtained as above was triturated with sulphuric acid (85 %) for 15 minutes at 70° to obtain 4',5'-dihydro-4,5'-dimethylfuro(3',2'-2,3)-xanthone (XXXIII). The structure of which was confirmed by its NMR spectrum in $CDCl_3$ (Fig. 10) : δ 1.65, doublet, J=7Hz, 3H, CH_3 group at 5'-position; 2.47, singlet, 3H, CH_3 group at 4-position ; 2.90-3.70, two symmetrical quartates, 2H, methylene group at 4'-position ; 5.15, multiplet, 1H, methine proton at 5'-position ; 7.30-7.80, multiplet, 3H, aromatic protons at 5-, 6- and 7-position ; 8.00, singlet, 1H, at 1-position ;

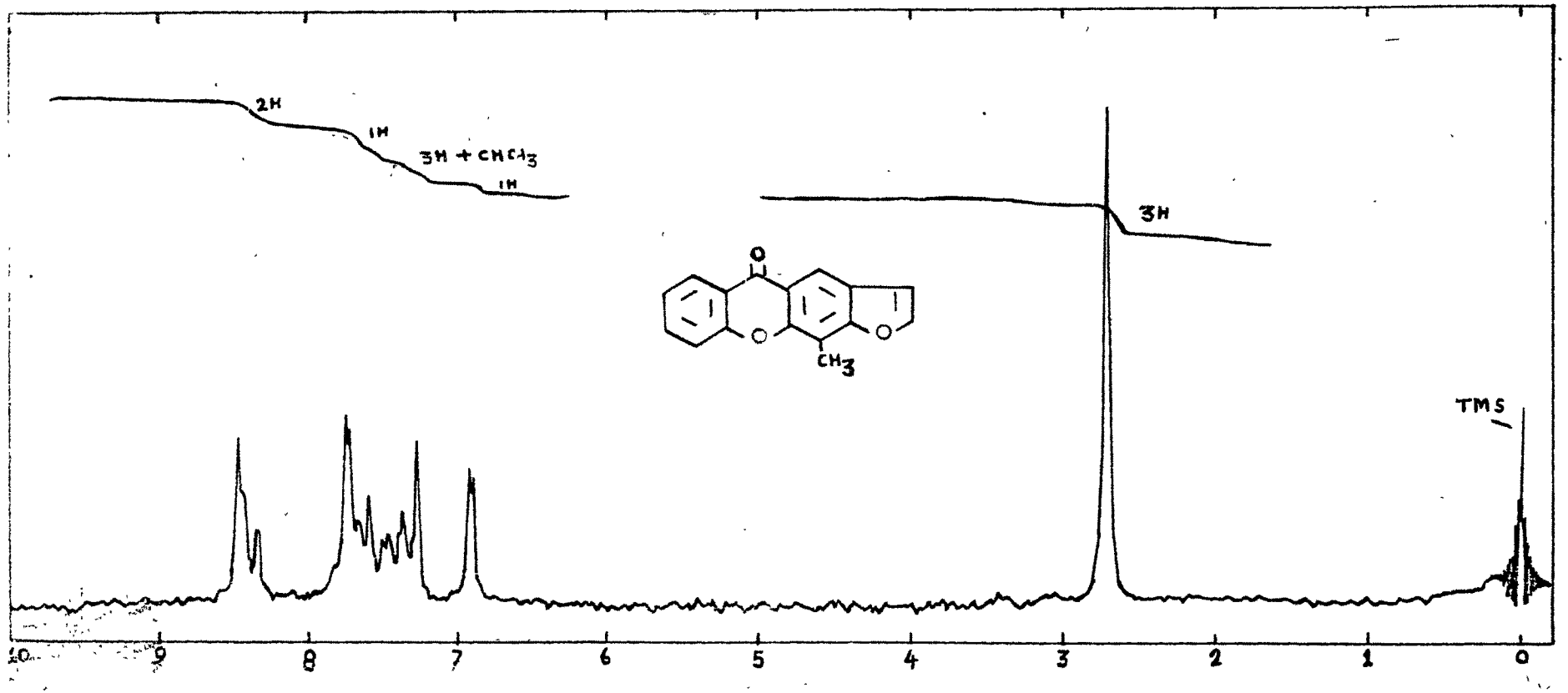
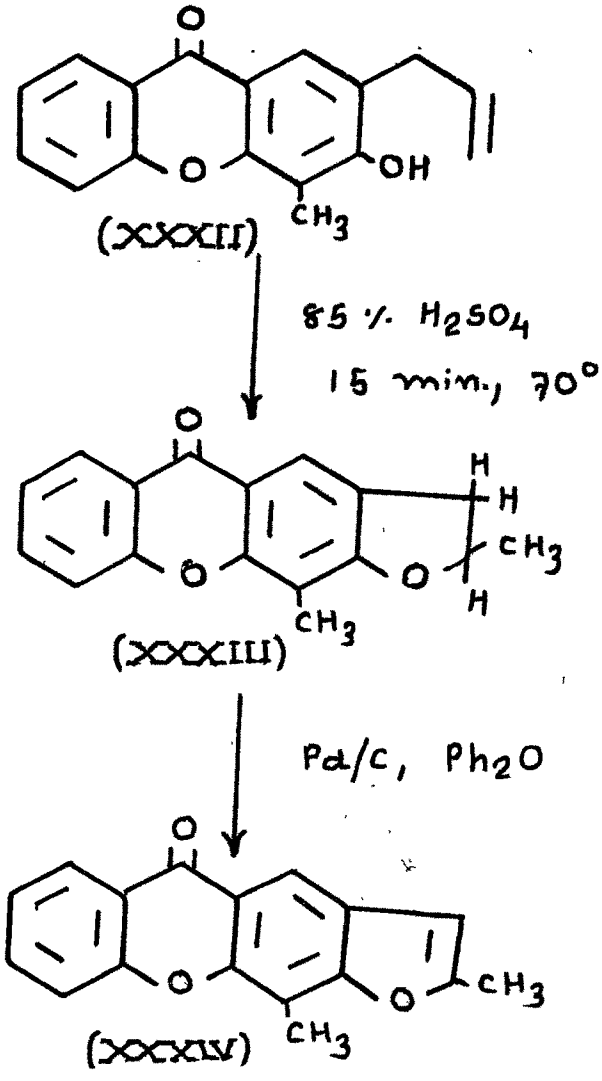


Fig. 9 : NMR spectrum of 4-Methylfuro(3',2'-2,3)xanthone (XXX) in $CDCl_3$ (90) MHz).

8.35, doublet, J_{87}=9Hz, J_{86}=1.5Hz, 1H, at 8-position. This on dehydrogenation with DDQ in dry benzne yielded 4,5'-dimethyl-furo(3',2'-2,3)xanthone (XXXIV). The same was also prepared by Sanghvi and Trivedi[22]. They condensed 2-methylresorcinol with ethyl cyclohexanone-2-carboxylate to get 6-hydroxy-5-methyl-1,2,3,4-tetrahydroxanthone, which on allylation with allyl bromide in presence of anhydrous potassium carbonate in dry acetone followed by Claisen migration in dimethylaniline, cyclization with conc.sulphuric acid and dehydrogenation with palladized charcoal (10 %), yielded the same furoxanthone (XXXIV)[16].



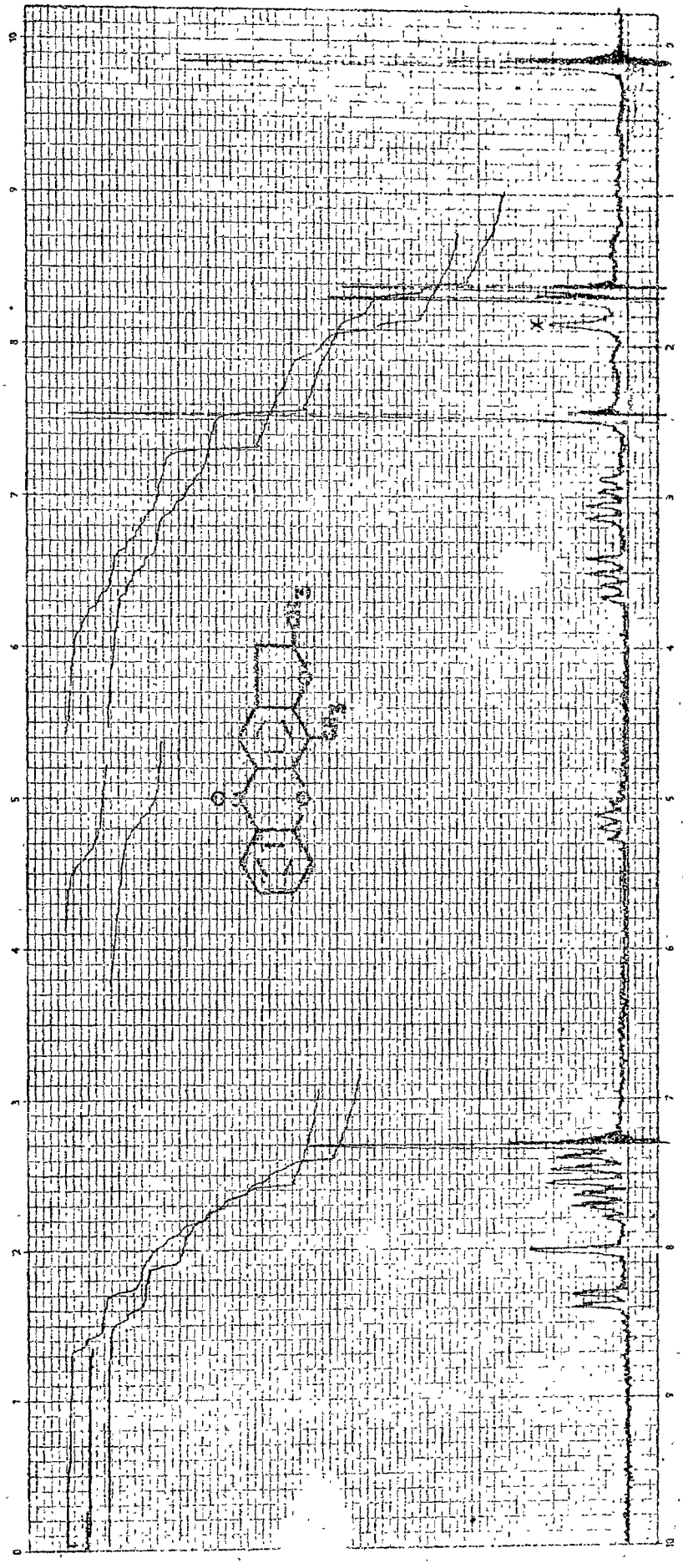
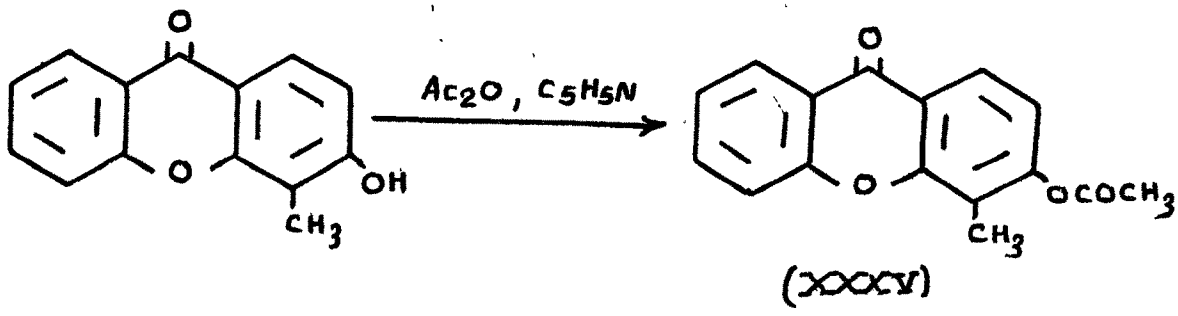


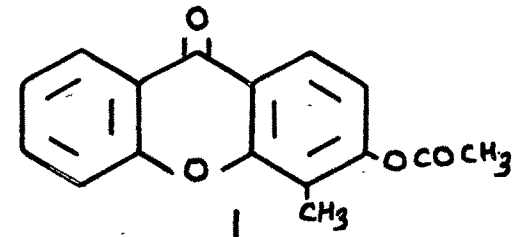
Fig. 10 : NMR spectrum of 4',5'-Dihydro-4,5'-dimethylfuro(3',2'-2,3)-xanthone (XXXIII) in $CDCl_3$ (90 MHz).

Synthesis of 4,4'-dimethylfuro(3',2'-2,3)xanthone(XXXIX) :

3-Hydroxy-4-methylxanthone on acetylation with acetic anhydride and pyridine followed by Fries migration with anhydrous aluminium chloride gave 2-acetyl-3-hydroxy-4-methyl-xanthone(XXXVI). This was condensed with ethyl bromoacetate in presence of anhydrous potassium carbonate in dry acetone to give ethyl 2-acetyl-4-methyl-3-xanthonyloxyacetate(XXXVII), which was hydrolysed by sodium hydroxide solution to corresponding acid derivative (XXXVIII). This on internal aldol condensation with sodium acetate and acetic anhydride furnished 4,4'-dimethylfuro(3',2'-2,3)xanthone (XXXIX). Its structure was confirmed on the basis of its NMR spectrum in $CDCl_3$ (Fig. 11) : δ 2.30, singlet, 3H, J=0.8Hz (meta couppling), CH_3 group at 4'-position of furan ring ; 2.65, singlet, 3H, CH_3 group at 4-position ; 7.32-7.82, multiplet, 4H, at 5-, 5'-, 6- and 7-position. A down field signal around δ 8.35 is due to overlappling of a doublet,J=9Hz and a singlet and is assinged for the peri-protons at 8- and 1-position.

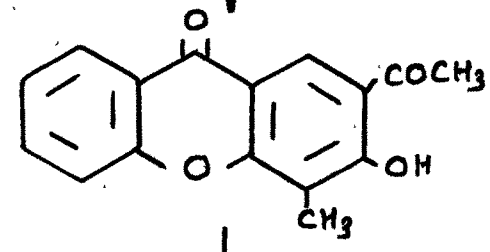


(XXXIV) (XXXV)



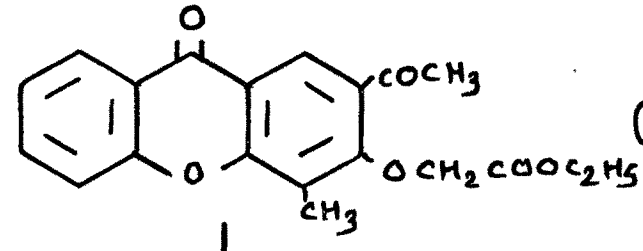
(XXXV)

F.M. Anhy. $AlCl_3$



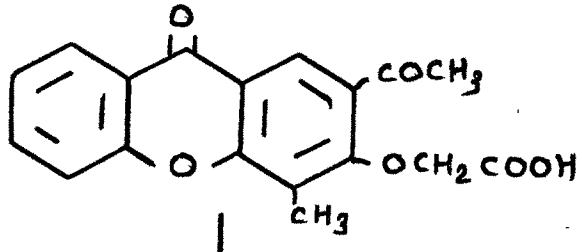
(XXXVI)

$BrCH_2COOC_2H_5$, K_2CO_3, Me_2CO



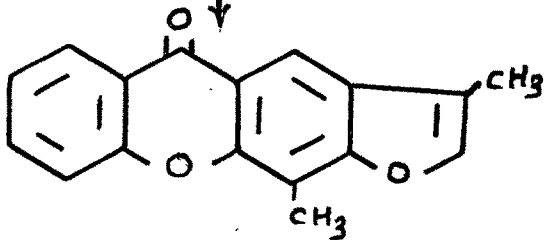
(XXXVII)

NaOH (8%)



(XXXVIII)

AcONa, Ac_2O



(XXXIX)

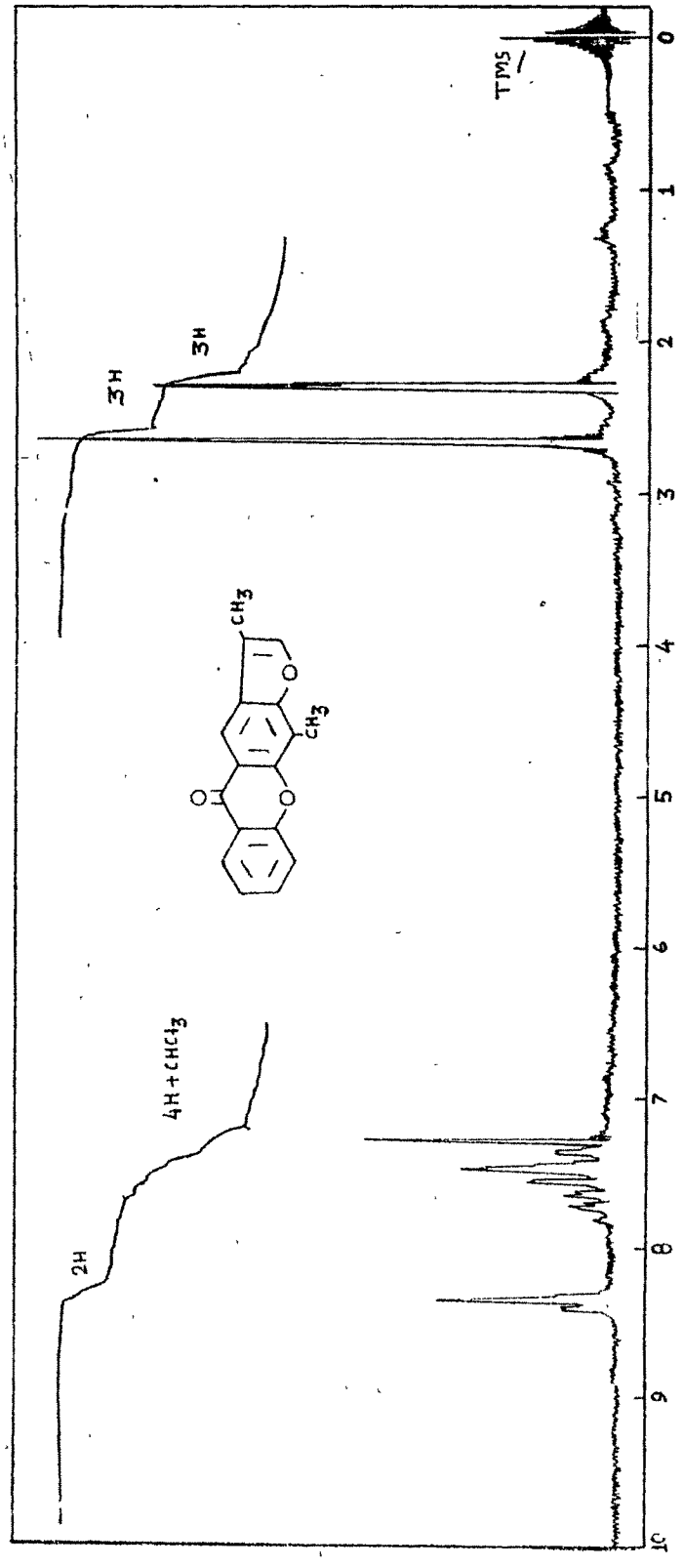
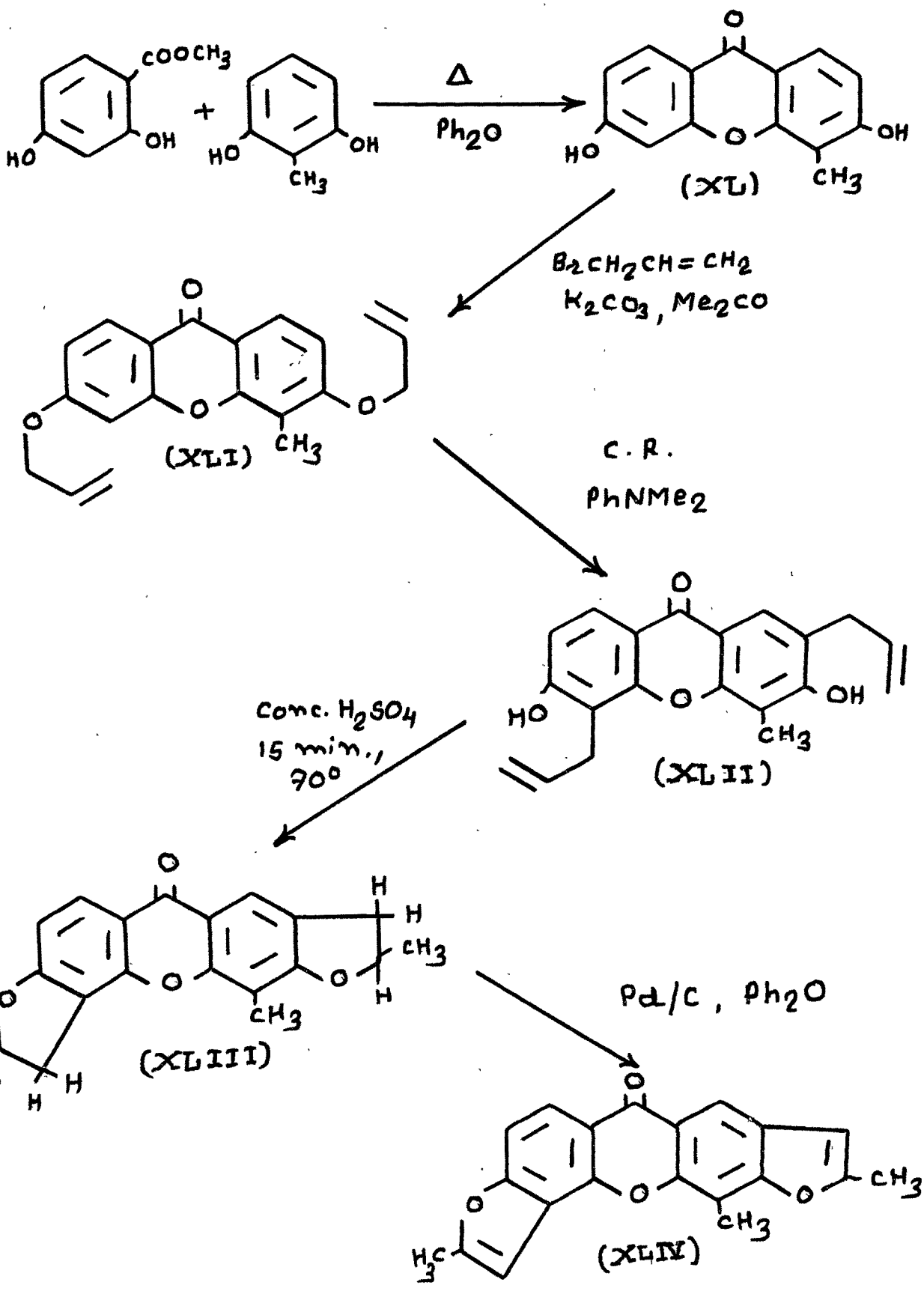


Fig. 11 : NMR spectrum of 4,4'-Dimethylfuro(3',2'-2,3)xanthone (XXXIX) in $CDCl_3$ (90 MHz).

Synthesis of 4,5',5"-trimethyldifuro(3',2'-2,3) and (3",2"-5,6)-xanthone (XLIV) :

Methyl 2,4-dihydroxybenzoate on thermal condensation with 2-methylresorcinol in diphenyl ether afforded 3,6-dihydroxy-4-methylxanthone (XL). This on allylation with allyl bromide in dry acetone, yielded 3,6-diallyloxy-4-methylxanthone (XLI), which was subjected to Claisen rearrangement in dimethyl aniline to give 2,5-diallyl-3,6-dihydroxy-4-methylxanthone (XLII). This was triturated with conc. sulphuric acid to obtain a cyclized product 4,5',5"-trimethyl-4',5',4",5"-tetrahydrodifuro-(3',2'-2,3) and (3",2"-5,6)xanthone (XLII). The NMR spectrum of XLII in $CDCl_3$ (Fig. 12) : Two doublets having J=7Hz are slightly overlapped at δ 1.56, integrating for six proton of two CH_3 groups at 5'- and 5"-position of furan rings. δ 2.31, singlet, 3H, CH_3 group at 4-position ; 2.88-3.58, multiplet, 4H, two methylene groups at 4'- and 4"-position of furan rings ; 4.95-5.30, multiplet, 2H, two methine protons at 5'- and 5"-position of furan rings ; 6.78, doublet, 1H, J=10Hz, at 7-position ; 7.97, singlet, 1H, peri-proton at 1-position ; 8.18, doublet, J=10Hz, 1H, peri-proton at 8-position. The compound XLIII, on dehydrogenation with palladized charcoal in diphenyl ether gave 4,5',5"-trimethyldifuro (3',2'-2,3) and (3",2"-5,6)-xanthone (XLIV).


COOCH3
OH
HO
+
HO
OH
CH3
Δ
Ph2O
O
O
HO
OH
CH3
(XL)
BrCH2CH=CH2
K2CO3, Me2CO
O
O
O
O
CH3
(XLI)
C.R.
PhNMe2
O
O
HO
OH
CH3
(XLII)
Conc. H2SO4
15 min.,
90°
O
O
O
H
H
CH3
H
CH3
(XLIII)
Pd/C, Ph2O
O
O
O
CH3
CH3
H3C
(XLIV)

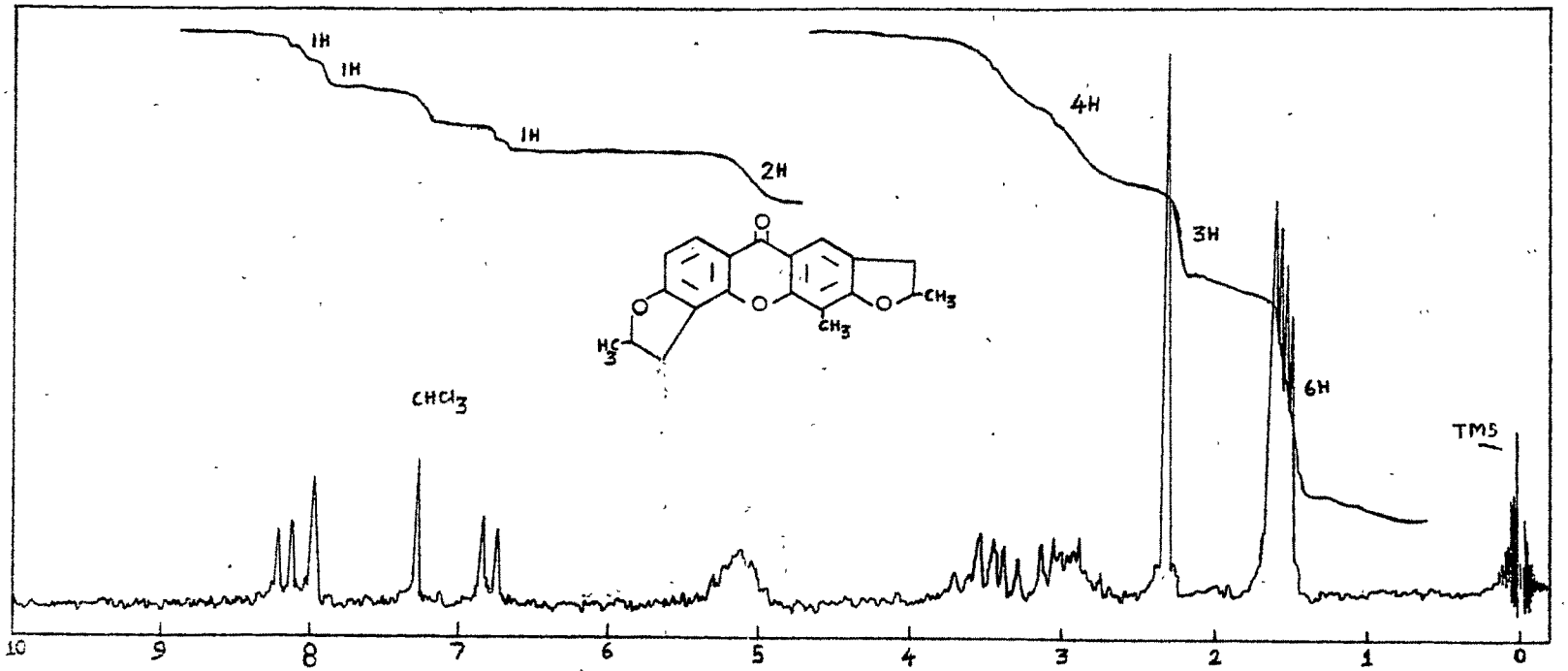


Fig. 12 : NMR spectrum of 4,5',5"-Trimethyl-4',5',4",5"-tetrahydrodifuro(3',2'-2,3) and (3",2"-5,6)xanthone (XLIII) in $CDCl_3$ (90 MHz).

EXPERIMENTAL

Synthesis of furo(2',3'-3,4)xanthone (XIX) :

1,2,3,4-Tetrahydrofuro(3',2'-5,6)xanthone (XVIII) :

5-Allyl-6-hydroxy-1,2,3,4-tetrahydroxyxanthone (0.7 g) in ethyl acetate (180 ml.) and osmium tetroxide (50 mg) in water (60 ml) were vigorously stirred for 20 minutes. Potassium-periodate (1.5 g) was added in small quantity to the dark solution over period of 1.5 hr. The reaction mixture was stirred for 2 hr. more. The acetate layer was separated, washed with water, dried with sodium sulphate and distilled. The resudue left, was dissolved in chloroform (3 ml) and the clear solution was percolated through a short column of alumina and eluted with benzene-chloroform mixture (3:7). The crude product obtained after evaporation of solvents, was treated with PPA (15 ml) for 4 hr.at 130°. It was then poured into ice cold water. The separated solid was filtered, washed with dilute sodium hydroxide solution and finally with water. It crystallized from benzene as fine needles, m.p. 205°, yield 0.160 g.

Analysis : Found :C, 74.84 ; H, 4.82 %

$C_{15}H_{12}O_3$ requires :C, 75.00 ; H, 5.00 % .

Furo(2',3'-3,4)xanthone (XIX) :

1,2,3,4-Tetrahydrofuro(3',2'-5,6)xanthone (0.25 g) and palladized charcoal (10 % ; 0.5 g) were refluxed in diphenyl ether (10 ml) for 12 hr. It was filtered hot and the solvent

was removed by steam distillation. The residue was extracted with ethyl acetate and the solvent was distilled off. The crude product was chromatographed over silica gel and eluted with benzene. The product crystallized from ethanol as colourless needles, m.p. 191°, yield 0.08 g.

Analysis : Found : C, 75.86 ; H, 3.56 %

$C_{15}H_8O_3$ requires : C, 76.28 ; H, 3.26 % .

3-Allyloxyxanthone (XX) :

A mixture of 3-hydroxyxanthone (2 g) allyl bromide (1.6 g) and anhydrous potassium carbonate (8 g) was refluxed in dry acetone (200 ml) in a water bath for 14 hr. The solvent was distilled off and reaction mixture was poured into water. The separated product was filtered, washed with very dilute sodium hydroxide solution to remove unreacted compound. The product crystallized from benzene petroleum ether,, m.p. 136° (lit.[15] m.p. 137°), yield 2.4 g.

Analysis : Found : C, 75.69 ; H, 4.53 %

$C_{16}H_{12}O_3$ requires : C, 76.19 ; H, 4.76 % .

4-Allyl-3-hydroxyxanthone (XXI) :

3-Allyloxyxanthone (2 g) was refluxed with dimethyl-aniline (10 ml) for 5 hr. After cooling, the reaction mixture was poured into conc. hydrochloric acid (40 ml) kept with crushed ice. The separated product was filtered and dissolved in sodium hydroxide solution. The solution was filtered and the filterate on acidification with conc.hydrochloric

acid gave the product which crystallized from ethanol, m.p. 240° (lit.,[15] 225-3°), yield 1.8 g.

Analysis : Found : C, 75.78 ; H, 4.76 %

$C_{16}H_{12}O_3$ requires : C, 76.19 ; H, 4.76 % .

Furo(2',3'-3,4)xanthone (XIX) :

4-Allyl-3-hydroxyxanthone (0.5 g) and osmium tetroxide (40 mg) were dissolve in ethyl acetate (200 ml) and water (50 ml). Potassium periodate (1.2 g) was added in small quantities as usual. The intermediate 4-acetaldehydo product obtained on working up of the reaction mixture as described before, was taken in PPA (12 ml) and the reaction mixture was heated at 130° for 3 hr. The reaction mixture was worked as before. The product crystallized from ethanol, m.p. 191° (lit.[4], m.p. 192°). The mixed m.p. with the above obtained product remained undepressed, mixed m.p. 191°. Yield 0.1 g.

Analysis : Found : C, 76.65 ; H, 3.26 %

$C_{15}H_8O_3$ requires : C, 76.28 ; H, 3.39 % .

Synthesis of 5'-methylfuro(2',3'-3,4)xanthone (XXIII) :

4',5'-Dihydro-5'-methyl(2',3'-3,4)xanthone (XXII) :

4-Allyl-3-hydroxyxanthone (1 g) was triturated with sulphuric acid (85 % ; 6 ml) in a water bath for 15 minutes. The content was poured into crushed ice, the separated product was filtered and washed with dilute sodium hydroxide solution to remove uncyclized compound. It crystallized from ethanol and also from benzene-petroleum ether mixture, m.p. 181°

(lit.,[15] m.p. 180°), yield 0.8 g.

Analysis : Found : C, 76.40 ; H, 4.66 %

$C_{16}H_{12}O_3$ requires : C, 76.19 ; H, 4.76 % .

5'-methylfuro(2',3'-3,4)xanthone (XXIII) :

A mixture of 4',5'-dihydro-5'-methylfuro(2',3'-3,4)-xanthone (0.5 g) and palladized charcoal (10 % ; 0.3 g) and diphenyl ether (8 ml) was refluxed for 12 hr. The reaction mixture was filtered hot and the solvent was removed by steam distillation. The product chromatographed over alumina and eluted with benzene-petroleum ether mixture (3:7) gave the product, which crystallized from ethanol, m.p. 172° (lit.,[15] m.p. 170°), yield 0.3 g.

Analysis : Found : C, 76.37 ; H, 3.87 %

$C_{16}H_{10}O_3$ requires : C, 76.81 ; H, 4.00 % .

IR spectrum ν_{max} (nujol) : 825 cm^{-1} (furan ring), 1645 cm^{-1} (γ-pyronyl >C=O group).

Synthesis of 1,5'-dimethylfuro (2',3'-3,4)xanthone (XXVII) :

3-Allyloxy-1-methylxanthone (XXVa) :

3-Hydroxy-1-methylxanthone (0.6 g), allyl bromide (0.5 g), anhydrous potassium carbonate (4 g) and acetone (350 ml) were refluxed in a water bath for 3 days. The solvent was distilled off and the reaction mixture was poured into water and the separated product was extracted with ether and washed with dilute sodium hydroxide solution and with water. It

crystallized from petroleum ether (60-80°) as colourless needles, m.p. 114°, yield 0.8 g.

Analysis : Found : C, 76.23 ; H, 5.38 %

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

4-Allyl-3-hydroxy-1-methylxanthone (XXVb) :

3-Allyloxy-1-methylxanthone (0.8 g) was refluxed with dimethylaniline (5 ml) for 6 hr. The reaction mixture was worked up as described before. The product crystallised from aqueous ethanol and also from benzene as fibrous crystallls, m.p. 234-5°, yield 0.5 g.

Analysis : Found : C, 76.74 ; H, 5.16 %

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

IR spectrum ν_{max}(nujol) : 1642 cm^{-1} (γ-pyronyl >C=O group), and a broad band at 3120 cm^{-1} (aromatic -OH group).

4',5'-Dihydro-1,5'-dimethylfuro (2',3'-3,4)xanthone (XXVI) :

4-Allyl-3-hydroxy-1-methylxanthone (0.4 g) was dissolved in sulphuric acid (85 % ; 3 ml) and heated in a water bath for 15 minutes at 75°. The content was poured into crushed ice, the separated product was extracted with ether and washed with dilute sodium hydroxide solution and with water. The crude product was chromatographed over silica gel and then eluted with petroleum ether-benzene mixture (7:3), It crystallized from petroleum ether-benzene mixture as colourless shining needles, m.p. 178-9°, yield 0.3 g.

Analysis : Found : C, 76.37 ; H, 5.06 @ %.

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

1,5'-Dimethylfuro(2',3'-3,4)xanthone (XXVII) :

A mixture of 4',5'-dihydro-1,5'-dimethylfuro(2',3'-3,4)-xanthone (0.25 g), ½ passladized charcoal (10 % ; 0.3 g) and diphenyl ether (5 ml) was refluxed for 10 hr. The reaction mixture waa filtered hot and the solvent was removed by steam distillation. The separated product was extracted with ethyl acetate, washed with water, dried with anhydrous sodium sulphate. The solvent on evaporation gave XXVII (0.1 g), which was purified by passing through the column of silica gel and eluted with petroleum ether-benzene mixture (1:1). It crystallized from ethanol, m.p. 160°,

Analysis : Found : C, 76.80 ; H, 4.75 %

$C_{17}H_{12}O_3$ requires : C, 77.27 ; H, 4.55 % .

Synthesis of 4-methylfuro (3',2'-2,3)xanthone (XXX) :

5-Methyl-1,2,3,4-tetrahydrofuro (2',3'-6,7)xanthone (XXIX) :

7-Allyl-6-hydroxy-5-methyl-1,2,3,4-tetrahydroxanthone (0.8 g) prepared according to Sanghvi and Trivedi[22], was dissolved in ethyl acetate (230 ml) and ½ osmium tetroxide (70 mg) in water (80 ml) were mixed and vigorously stirred for 15 minutes. Potassium periodate (1.8 g) was added in small quantities to the dark solution over a period of 1.5 hr. The reaction mixture was stirred for 2 hr. more and worked up as usual. The

intermediate 7-acetaldehydo product was treated with PPA (12 ml) in an oil bath at 110° for 2 hr. It was poured into ice cold water. The solid separated was filtered, washed with dilute sodium hydroxide solution and finally with water. It crystallized from benzene as fine small needles, m.p. 206°, yield 0.12 g.

Analysis : Found : C, 75.19 ; H, 5.51 %

$C_{16}H_{14}O_3$ requires : C, 75.55 ; H, 5.50 % .

IR spectrum ν_{max} (nujol) : 870 cm^{-1} (furan ring), 1640 cm^{-1} (γ-pyronyl >C=O group). UV λ_{max} (chloroform) : 246 nm (log e 4.74), 278 nm (log e 4.60).

4-Methylfuro (3',2'-2,3)xanthone (XXX) :

5-Methyl-1,2,3,4-tetrahydrofuro (2',3'-6,7)xanthone (0.25 g) and palladized charcoal (10 % ; 0.3 g) were taken in diphenyl ether (8 ml) and the mixture was refluxed for 10 hr. It was then filtered hot and the solvent was removed by steam distillation. The residue was extracted with ethyl acetate. The evaporation of the solvent gave the product which chromatographed over silica gel and eluted with petroleum-ether-benzene mixture (1:9). The product crystallized from benzene as small seeds, m.p.216°, yield 0.09 g.

Analysis : Found : C, 76.37 ; H, 3.87 %

$C_{16}H_{10}O_3$ requires : C, 76.81 ; H, 4.00 % .

3-Allyloxy-4-methylxanthone (XXXI) :

A mixture of 3-hydroxy-4-methylxanthone (2.5 g),

allyl bromide (2 g) and anhydrous potassium carbonate (12 g) was refluxed in dry acetone (300 ml) in a water bath for 11 hr. The reaction mixture was worked up as usual. The product crystallized from benzene-petroleum ether mixture, m.p. 149° (lit.,[16] m.p. 144°), yield 3 g.

Analysis : Found : C, 76.19 ; H, 5.02 %

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

2-Allyl-3-hydroxy-4-methylxanthone (XXXII) :

3-Allyloxy-4-methylxanthone (2.5 g) in dimethylaniline (8 ml) was refluxed for 4 hr. The reaction mixture was worked up as described before. The product crystallized from ethanol m.p. 168°, yield 2.2 g., (lit.,[16] m.p. 165°).

Analysis : Found : C, 76.47 ; H, 5.56 %

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

IR spectrum ν_{max}(nujol) : 1632 cm^{-1} (γ-pyronyl >C=O group), and a broad band at 3250 cm^{-1} (aromatic -OH group) (Fig. 13).

4-Methylfuro (3',2'-2,3)xanthone (XXX) :

2-Allyl-3-hydroxy-4-methylxanthone (0.5 g) in ethyl acetate (200 ml) and osmium tetroxide (65 mg) in water (70 ml) were vigorously stirred for 15 minutes. Potassium periodate (2 g) was added in small quantities. The reaction mixture worked up as before and the 2-acetaldehyde derivative so obtained was treated with PPA (15 ml) for 3 hr. at 120° to obtained furoxanthone XXX (0.11 g). It crystallized from benzene,

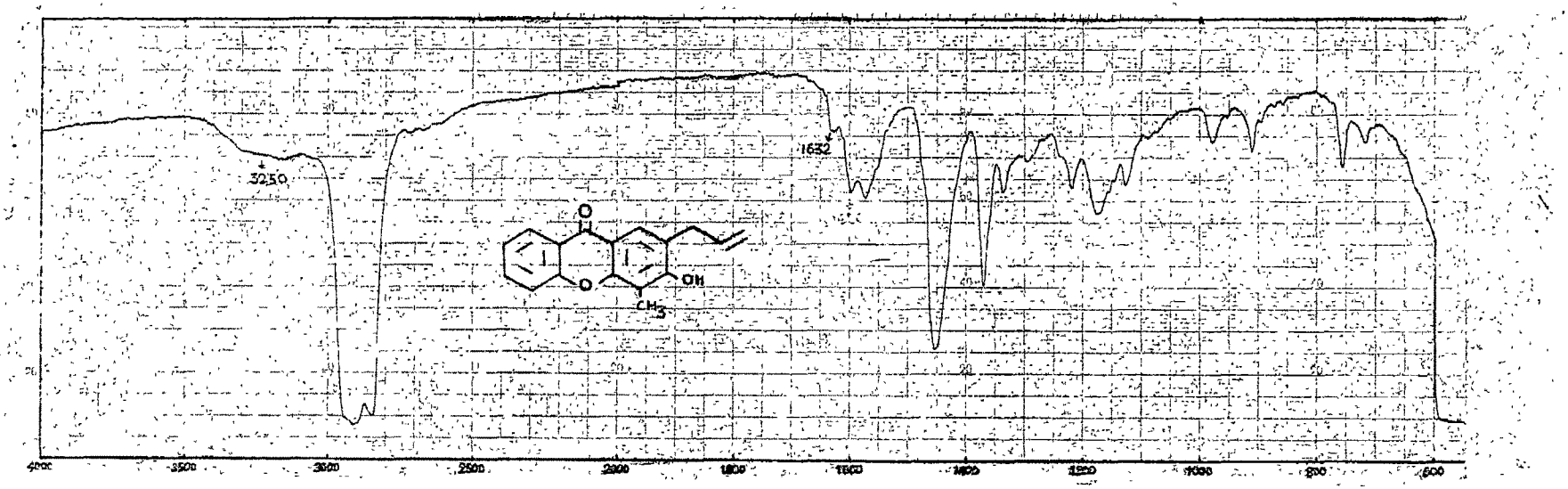


Fig. 13 : IR spectrum of 2-Allyl-3-hydroxy-4-methylxanthone (XXXII) in nujol.

m.p. 216°. The mixed m.p. with previously synthesised product was not depressed.

Analysis : Found : C, 77.21 ; H, 4.36 %

$C_{16}H_{10}O_3$ requires : C, 76.81 ; H, 4.00 % .

Synthesis of 4,5'-dimethylfuro (3',2'-2,3)xanthone (XXXIV) :

4',5'-Dihydro-4,5'-dimethylfuro (3',2'-2,3)xanthone (XXXIII) :

2-Allyl-3-hydroxy-4-methylxanthone (1.5 g) was triturated with sulphuric acid (85 % ; 9 ml) in a water bath at 75° for 15 minutes. The reaction mixture was worked up as described before. The product crystallized from ethanol as well as from benzene-petroleum ether mixture, m.p. 174°, yield 1 g.

Analysis : Found : C, 77.13 ; H, 5.14 %

$C_{17}H_{14}O_3$ requires : C, 76.67 ; H, 5.26 % .

4,5'-Dimethylfuro (3',2'-3,4)xanthone (XXXIV) :

A mixture of 4',5'-dihydro-4,5'-dimethylfuro(3',2'-2,3)-xanthone (0.6 g) and DDQ (0.535 g) was refluxed in sodium dried benzene (30 ml) in a water bath for 6 hr. The separated product was filtered off and filtrate on evaporation gave the solid, which crystallised from acetic acid as fine needles, m.p. 242° (lit.,[16] m.p. 235°), yield 0.4 g.

Analysis : Found : C, 77.29 ; H, 4.40 %

$C_{17}H_{12}O_3$ requires : C, 77.27 ; H, 4.55 % .

IR spectrum ν_{max}(nujol) : 880 cm^{-1} (furan ring), 1640 cm^{-1} (γ-pyronyl >C=O group).

Synthesis of 4,4'-dimethylfuro (3',2'-2,3)xanthone (XXXIX) :

3-Acetoxy-4-methylxanthone (XXXV) :

A mixture of 3-hydroxy-4-methylxanthone (2.5 g) acetic anhydride (6 ml) and a few drops of pyridine was heated in a water bath at 85° for 6 hr. The content was poured into ice cold water containing hydrochloric acid (3 ml). The separated product was filtered, washed with dilute sodium hydroxide solution, dried and crystallized from ethanol as shining plates, m.p. 154°, yield 2.2. g.

Analysis : Found : C, 72.14 ; H, 4.32 %

$C_{16}H_{12}O_4$ requires : C, 71.64 ; H, 4.48 % .

2-Acetyl-3-hydroxy-4-methylxanthone (XXXVI) :

3-Acetoxy-4-methylxanthone (2.5 g) and anhydrous alluminum chloride (4 g) was heated at 120° for 1.5 hr. and then the temperature was raised to 145° and kept for 2 hr. at this temperature. The reaction mixture was cooled and poured into crushed ice containing hydrochloric acid (15 ml). The separated product was filtered, washed with water and dissolved in sodium hydroxide solution (6 %), filtered and acidified. The product crystallized from benzene as fine colourless needles, m.p. 229°, yield 1.8 g.

Analysis : Found : C, 71.29 ; H, 4.83 %

$C_{16}H_{12}O_4$ requires : C, 71.64 ; H, 4.48 % .

IR spectrum ν_{max} (nujol) : 1641 cm^{-1} (γ-pyronyl >C=O group), and 1685 cm^{-1} ($-COCH_3$ group), and a broad band at 3220 cm^{-1} (aromatic -OH group).

Ethyl 2-acetyl-4-methyl-3-xanthonyloxy acetate (XXXVII) :

A mixture of 2-acetyl-3-hydroxy-4-methylxanthone (2 g), ethyl bromoacetate (1.5 g), anhydrous potassium carbonate (9 g) and dry acetone (250 ml) was refluxed in a water bath for 15 hr. The solvent was distilled off and the product was extracted with ether, washed with very dilute sodium hydroxide solution and with water. It crystallized from aqueous ethanol as shining rectangular plates, m.p. 154°, yield 2.2 g.

Analysis : Found : C, 68.23 ; H, 4.96 %

$C_{20}H_{18}O_6$ requires : C, 67.80 ; H, 5.08 % .

2-Acetyl-4-methyl-3-xynthonyloxyacetic acid (XXXVIII):

The ester XXXVII (2 g) was treated with potassium hydroxide solution (8 % ; 20 ml) and stirred for 2 hr. and then kept over night, The red coloured solution was acidified and separated product was dissolved in sodium bicarbonate solution, filtered and acidified. It crystallized from acetic acid, m.p. 237-8° (decom.), yield 1.2 g.

Analysis : Found : C, 66.81 ; H, 4.21 %

$C_{18}H_{14}O_6$ requires : C, 66.27 ; H, 4.20 % .

IR spectrum ν_{max} (nujol) : 1646 cm^{-1} (γ-pyronyl >C=O group), 1735 cm^{-1} (-COOH group), and a broad band at 3350 cm^{-1} (-OH group).

4,4'-Dimethylfuro (3',2'-2,3)xanthone (XXXIX) :

A mixture of 2-acetyl-4-methyl-3-xanthonyloxyacetic acid (0.8 g) in acetic anhydride (6 ml) and sodium acetate(2.5 g)

was heated under refluxed for 2 hr. The reaction mixture was diluted with water and the separated product was filtered, washed with sodium bicarbonate solution and with water, dried and crystallized from ethanol as colourless needles, m.p. 211°, yield 0.4 %.

Analysis : Found : C, 77.02 ; H, 4.73 %

$C_{17}H_{12}O_3$ requires : C, 77.27 ; H, 4.55 % .

3,6-Dihydroxy-4-methylxanthone(XL) :

A mixture of 2-methylresorcinol (6.2 g ; 0.05 mole), methyl 2,4-dihydroxybenzoate (8.4 g ; 0.05 mole) and diphenyl ether (15 ml) was refluxed for 13 to 16 hr. The reaction mixture was subjected to steam distillation to remove diphenyl ether. The residue was washed with saturated sodium bicarbonate solution (50 ml) and dissolved in sodium hydroxide solution (8 % ; 80 ml), filtered and acidified. The separated product was filtered, dried and crystallized from acetic acid, m.p. above 325°. IR spectrum ν_{max} (nujol) : 1646 cm^{-1} (γ-pyronyl >C=O group) and a broad band at 3280 cm^{-1} (aromatic -OH groups).

A mixture of the above compound (1 g), acetic anhydride (8 ml) and pyridine (0.3 ml) was heated on a water bath for 6 hr. The reaction mixture on working up as described before gave 3,6-diacetoxy-4-methylxanthone, which crystallized from benzene as colourless needles, m.p. 194°, yield 0.8 g.

Analysis : Found : C, 66.65 ; H, 4.18 %

$C_{18}H_{14}O_6$. requires : C, 66.27 ; H, 4.29 % .

IR spectrum ν_{max} (nujol) : 1658 cm^{-1} (γ-pyronyl >C=O group) and 1745 cm^{-1} ($-OCOCH_3$ groups).

3,6-Diallyloxy-4-methylxanthone(XLI) :

A mixture of 3,6-dihydroxyxanthone (2.5 g), allylbromide (3.2 g) and anhydrous potassium carbonate (8 g) was refluxed in dry acetone (400 ml) in a water bath for 20 hr. The solvent was distilled of and the reaction mixture was poured into water. The separated product was extracted with solvent ether and washed with dilute sodium hydroxide solution and with water. It crystallized from a mixture of benzene-petroleum ether as colourless long needles, m.p. 128° yield 2.2 g.

Analysis : Found : C, 74.16 ; H, 5.44 %

$C_{20}H_{18}O_4$ requires : C, 74.52 ; H, 5.59 % .

2,5-Diallyl-3,6-dihydroxy-4-methylxanthone(XLII) :

3,6-Diallyloxy-4-methylxanthone (1.8 g) was refluxed with dimethylaniline (10 ml) for 7 hr. The reaction mixture was worked up as described before. The product crystallized from ethanol as small prisms, m.p. 221°, yield 1.2 g.

Analysis : Found : C, 74.92 ; H, 5.51 %

$C_{20}H_{18}O_4$ requires : C, 74.52 ; H, 5.59 % .

IR spectrum ν_{max} (nujol) : 1642 cm^{-1} (γ-pyronyl)C=O group) and a broad band at 3160 cm^{-1} (aromatic -OH groups).

4,5',5"-Trimethyl-4',5',4",5"-tetrahydrodifuro(3',2'-2,3 : 3",2"-5,6)xanthone(XLIII) :

2,5-Diallyl-3,6-dihydroxy-4-methylxanthone (0.6 g) was dissolved in sulphuric acid (85 % ; 6 ml) and heated on a water bath for 15 mintes at 75°. The reaction mixture was worked up as usual. The crude product was chromatographed over silica gel and eluted with a mixture of petroleum ether-benzene (1 : 4). It crystallized from benzene-petroleum ether mixture as colourless shining needles, m.p. 198-9°, yield 0.4 g.

Analysis : Found : C, 75.00 ; H, 5.77 %

$C_{20}H_{18}O_4$ requires : C, 74.52 ; H, 5.59 % .

4,5',5"-Trimethyldifuro(3',2'-2,3 : 3",2"-5,6)xanthone(XLIV) :

A mixture of XLIII (0.5 g), palladized charcoal (10 % ; 0.9 g) and diphenyl ether (10 ml) was refluxed for 1½ hr. The reaction mixture was filtered hot and solvent was removed by steam distillation. The separated product was extracted with ethyl acetate, washed with water, dried ~~with~~ with anhydrous sodium sulphate. The solvent was removed by evaporation and the residue was chromatographed over siliga gel and eluted with a mixture of benzene-chloroform (2:3). It crystallized from acetic acid as colourless needles, m.p. 254°, yield 0.2 g.

Analysos :	Found	: C, 75.42 ; H, 4.83 %
$C_{20}H_{14}O_4$	requires	: C, 75.26 ; H, 4.40 % .

REFERENCES

1. J.E. Davies, J.C. Roberts and S.C. Wallwork, Chem. Ind., 178 (1956).
2. J.H. Birkinshaw and J.M.M. Hammady, Biochem. J., 65, 162 (1957).
3. J.S.H. Davies, F. Lambs and H. Suschitzky, J. Chem. Soc., 1790 (1958).
4. G.S. Puranik and S. Rajagopal, Chem. Ber., 96, 976 (1963).
5. G.S. Puranik and S. Rajagopal, J. Org. Chem., 29, 1089 (1964).
6. Y.S. Agasimundin and S. Rajagopal, Chem. Ber., 98, 1910 (1965).
7. C.S. Angadiyavar and S. Rajagopal, Indian J. Chem., 7, 1088 (1969).
8. C.S. Angadiyavar and S. Rajagopal, Monatsh., 98, 2282(1967).
9. Y.S. Agasimundin and S. Rajagopal, Chem. Ber., 100, 383 (1967).
10. Y.S. Agasimundin and S. Rajagopal, J. Org. Chem., 36, 845 (1971).
11. F. Scheinmann and H. Suschitzky, Tetrahedron, 7, 31 (1959).
12. R. Adams and B. Rindfusz, J. Am. Chem. Soc., 41, 648 (1919).
13. E.D. Burling, A. Jefferson and F. Scheinmann, Tetrahedron lett., 599 (1964); Tetrahedron, 21, 2653 (1965).
14. Y.A. Shaikh and K.N. Trivedi, Curr. Sci. (India), 38, 409 (1969).

15. G.S. Puranik and S. Rajagopal, J. Chem. Soc., 1522 (1965).

16. Y.S. Agasimundin and S. Rajagopal, Monatsh., 97, 423 (1966).

17. Y.S. Agasimundin and S. Rajagopal, J. Org. Chem., 30, 2084 (1965).

18. Y.S. Agasimundin and S. Rajagopal, J. Prakt. Chem., 314, 507 (1972).

19 Y.G. Gaekwad, Ph.D. Thesis , M.S. Univ. Baroda, (India) (1976).

20. M.K. Rao and S. Rajagopal, Indian J. Chem., 11, 708 (1973).

21. M.K. Rao and S. Rajagopal, Bull. Chem. Soc. Japan, 47, 2059 (1974).

22. K.P. Sanghvi, Ph.D. Thesis, M.S. Univ. Baroda (India) (1976).