CHAPTER I

SYNTHESIS OF SOME α-AND γ-PYRONE DERIVATIVES FROM DIHYDROXY NAPHTHALENES

Synthesis of some α- and γ-pyrone derivatives from dihydroxy naphthalenes :

Many oxygen heterocycles such as coumarins, chromones, flavones, isoflavones and xanthones are found in nature. Many of these naturally occurring compounds have been synthesised and a number of others, not found in nature have also been synthesised. A good deal of work has been done on the synthesis of oxygen heterocycles from α- and β-naphthol and their derivatives and naphtho α- and γ-pyrones (also called benzocoumarins, benzochromones etc.) have been synthesised. This work has been briefly reviewed here as the present chapter deals with the synthesis of some α- and γ-pyrones from dihydroxynaphthalenes.

The condensation of β-ketonic esters with phenols known as the Pechmann reaction, has been a very convenient reaction for the synthesis of benzo-α-pyrone derivatives and has been extensively used by numerous workers. The condensation of a β-ketonic ester with a phenol may give either a benzo-α-pyrone derivative or a benzo-γ-pyrone derivative depending on the nature of the phenol, the β-ketonic ester and the condensing agent. These and other aspects of the Pechmann reaction have been reviewed by Sethna and Phadke[1].

Bartsch[2] obtained naphtho (1,2:6,5')α-pyrone(I) on heating α-naphthol with conc.sulphuric acid and malic acid. The condensation of α-naphthol with ethyl acetoacetate in the presence of sulphuric acid at 0°C or in the presence

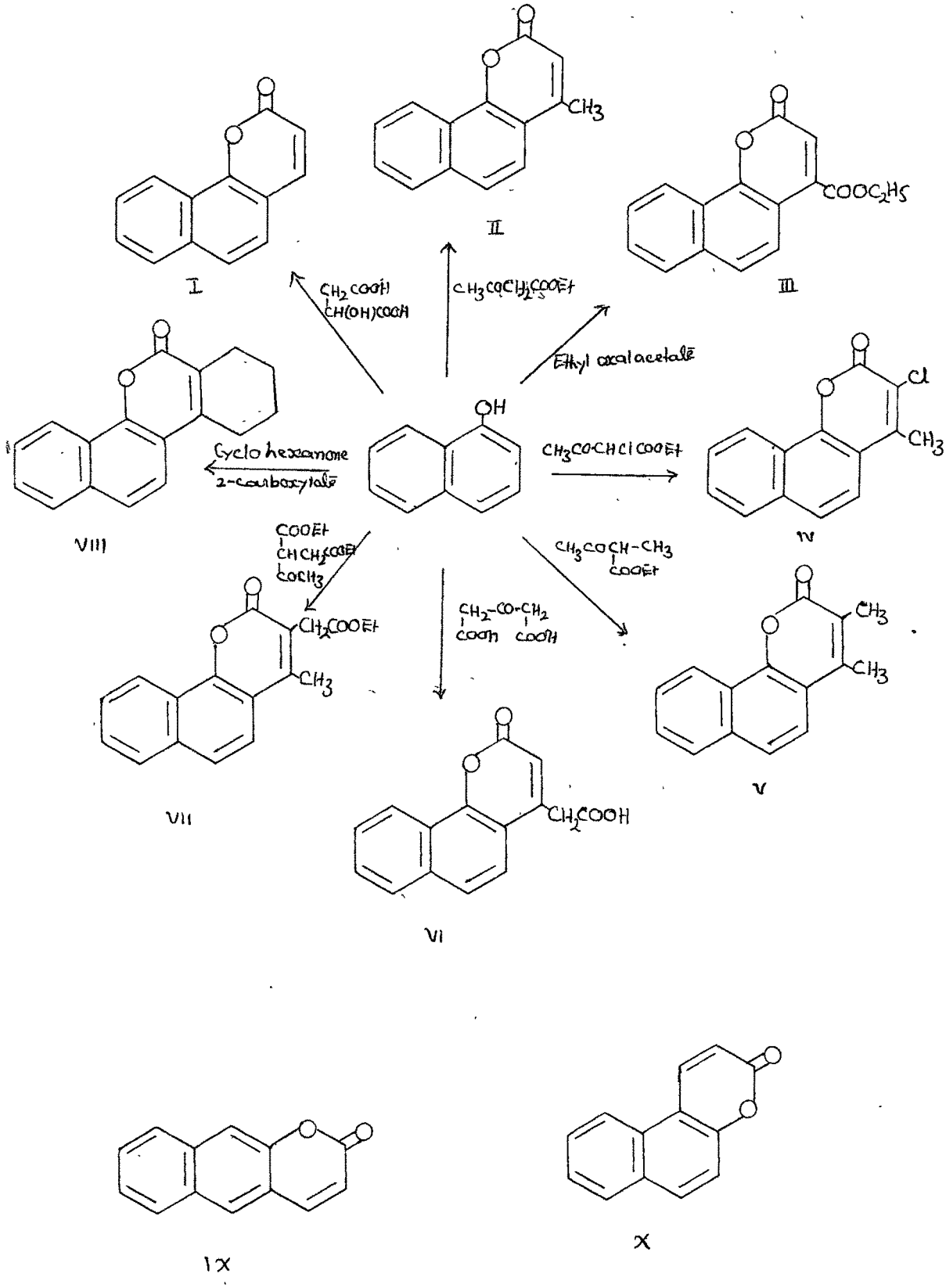
of alcoholic hydrogen chloride[3] or phosphorus pentoxide gave 4'-methyl naphtho(1,2:6',5')α-pyrone (II). α-Naphthol condensed with ethyl oxalacetate to give ethyl naphtho (1,2:6',5')α-pyrone-4'-carboxylate(III). It condensed with ethyl α-chloro acetoacetate and ethyl-α-methyl acetoacetate to give 3'-chloro-4'-methyl (IV) and 3',4'-dimethyl naphtho (1,2:6',5')α-pyrone (V) respectively. Acetone dicarboxylic acid condensed with α-naphthol in the presence of sulphuric acid to give naphtho(1,2:6',5')α-pyrone-4'-acetic acid[5](VI).

α-Naphthol on Pechmann condensation with ethyl aceto succinate gave ethyl -4'-methylnaphtho(1,2:6',5')-α-pyrone-3'-acetate[6](VII) and on condensation with benzyl acetoacetic ester in the presence of phosphorus oxychloride it gave 3'-benzyl-4'-methylnaphtho(1,2:6',5')α-pyrone derivative.[7] Dieckmann[8] condensed α-naphthol with cyclohexanone-2-carboxylate and obtained the naphtho-α-pyrone derivative(VIII).

Kaufmann[9] obtained a naphtho-α-pyrone derivative by Perkin acetylation of the aldehyde obtained from β-naphthol. Assuming that the aldehyde was 2-hydroxy-3-formyl naphthalene be assigned naphtho(2,3:6',5')α-pyrone (IX) structure to this product.

In view of the great mobility of the α-hydrogen atom in β-naphthol, Gattermann[10] formulated the same aldehyde as 1-formyl-2-hydroxy naphthalene and assigned the angular structure (X) to the above naphtho-α-pyrone.

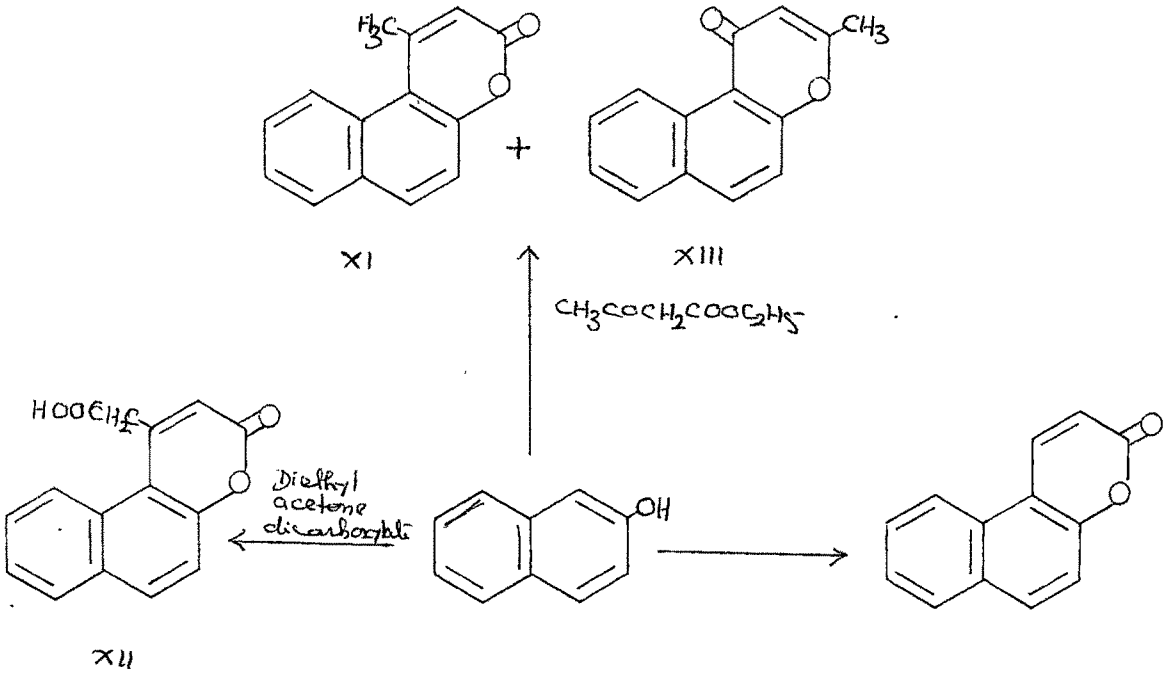
Pechmann and Welsh[11] carried out the condensation of β-naphthol with malic acid in the presence of hot conc.

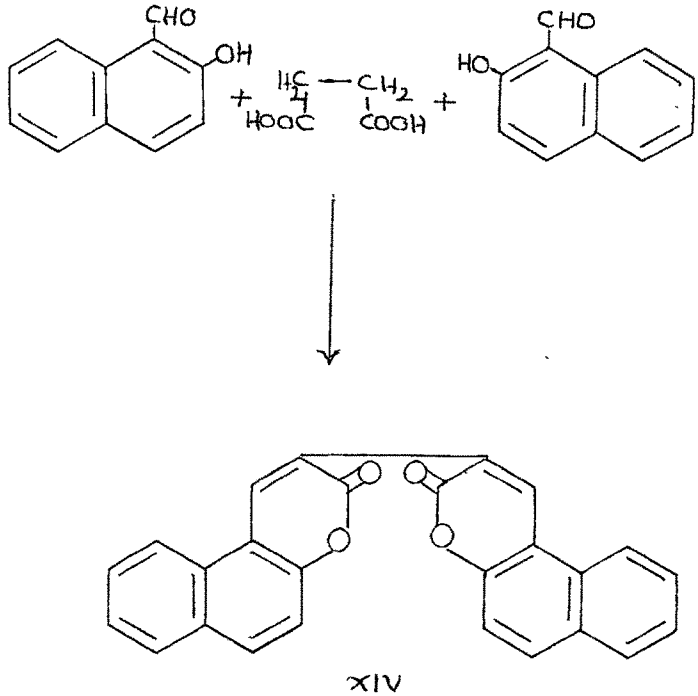

I
II
III
IV
V
VI
VII
VIII
IX
X
CH_2COOH
$CH(OH)COOH$
CH_3COCH_2COOEt
Ethyl acetoacetate
$CH_3COCHClCOOEt$
Cyclo hexanone
2-carboxylate
$CH_3COCH-CH_3$
$COOEt$
$CH_2-CO-CH_2$
$COOH$ $COOH$
CH_2COOEt
CH_2COOH
CH_3
$COOC_2H_5$
Cl
OH

sulphuric acid and obtained a naphtho-α-pyrone, different from that described by Kaufmann[9]. Boehm and Profft[12] synthesised 2-hydroxy-3-formyl naphthalene and subjected it to Perkin acetylation and obtained a product, which was different from that obtained by either Kaufmann or Pechmann and Welsh. This compound should therefore have structure (IX) and that of Kaufmann structure (X). Dey, Rao and Sankaranarayanan[13] repeated Pechmann and Welsh's work and found that the product they obtained was the naphtho-α-pyrone (X) described by Kaufmann and not the one reported by Pechmann.

Pechmann[14] condensed β-naphthol with ethyl acetoacetate in the presence of sulphuric acid and obtained the 4'-methyl naphtho-α-pyrone derivative (XI). Bacovescu[15] also prepared the same product by the same method. Dey[16] obtained this product by the decarboxylation of naphtho (2,1:6',5') α-pyrone 4'-acetic acid (XII) obtained by Pechmann condensation of β-naphthol with diethyl acetone dicarboxylate.

Dey and Lakshminarayan[17] later isolated the isomeric γ-pyrone derivative (XIII) from the reaction between β-naphthol and ethyl acetoacetate in the presence of sulphuric acid, which was also prepared by other workers (1) by condensing β-naphthol methyl ether with sulpho acetic acid (a mixture of sulphuric acid and acetic anhydride) and treating the resulting 2'-methyl-3'-acetyl naphtho(2,1:6',5') γ-pyrone with alcoholic ammonia[18] (II) by Kostanecki-Robinson


H3C
CH3
+
XI
XIII
CH3COCH2COOC2H5
HOOCH2C
Diethyl acetone dicarboxylate
OH
XII

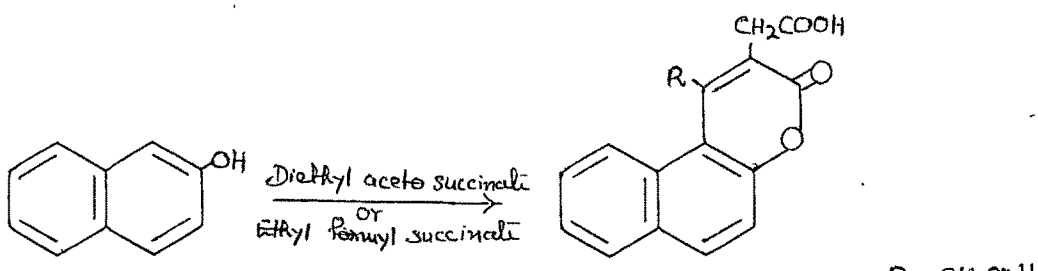

CHO
OH
+
H2C
CH2
HOOC
COOH
+
CHO
HO
XIV

acetylation of 1-acetyl-2-naphthol[19,20].

Dey et al.[13] obtained 3,3'-dibenzocoumarinyl (XIV) by the reaction between 2-naphthol-1-aldehyde and sodium succinate.

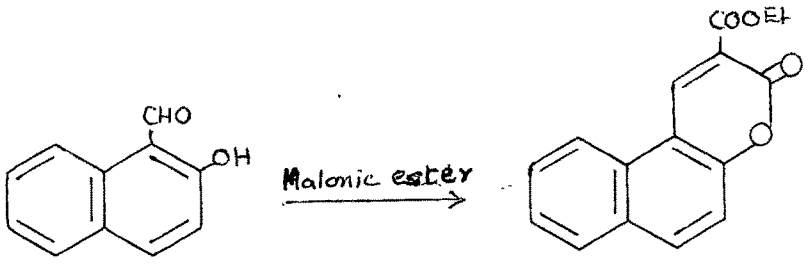
The condensation of β-naphthol with diethyl aceto succinate in the presence of sulphuric acid gave 4'-methyl naphtho (2,1:6',5') α-pyrone-3'-acetic acid (XV : R = CH_3) and with ethyl formylsuccinate it afforded naphtho (2,1:6',5') α-pyrone-3'-acetic ester[21] (XV : R = H). Ethyl naphtho (2,1:6',5') α-pyrone-3'-carboxylate (XVI) has been synthesised by the condensation of 2-hydroxy-1-naphthaldehyde with malonic ester[22].

Pechmann condensation[23] of 4-chloro-1-naphthol with malic acid, ethyl acetoacetate and ethyl-α-chloro-acetoacetate afforded 4-chloro, 4-chloro-4'-methyl and 3',4-dichloro-4'-methyl naphtho (1,2:6',5') α-pyrone.



XV

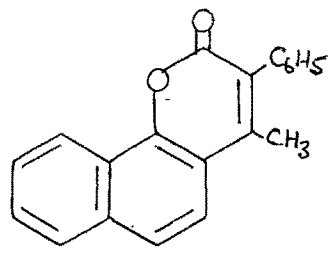
R = CH_3 or H



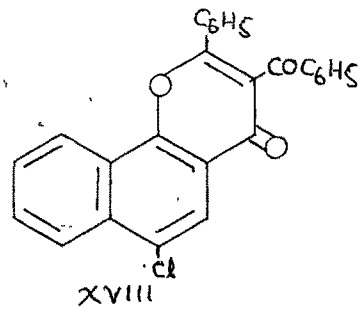
XVI

Several naphtho-γ-pyrone derivatives have been synthesised by the application of different methods of syntheses.

Bhullar and Venkataraman[24] obtained a mixture of 2'-methylnaphtho (1,2:6,5')γ-pyrone and its 3'-acetyl derivative by the reaction of 2-acetyl-1-naphthol with acetic anhydride and sodium acetate. They found that even though the 3-acetyl group in 3-acylated chromones can be easily removed by boiling them with alkali, 3'-acylated naphtho-γ-pyrones were either unaffected or the pyrone ring was broken down on prolonged boiling with alkali. Kostanecki-Robinson acetylation of 4-chloro-2-acetyl-1-naphthol and 4-chloro-2-propionyl-1-naphthol gave 4-chloro-2'-methyl-3'-acetyl naphtho (1,2:6',5')γ-pyrone and 4-chloro-2',3'-dimethyl naphtho(1,2:6',5') γ-pyrone. Heating a mixture of 4-chloro-2-acetyl-1-naphthol, phenyl acetic anhydride and sodium phenyl acetate gave 4-chloro-4'-methyl-3'-phenyl naphtho (1,2:6',5')α-pyrone(XVII), identical with the condensation product of 4-chloro-1-naphthol and ethyl-α-phenylacetoacetate in the presence of sulphuric acid. They also obtained 4-chloro-2'-phenyl-3'-benzoyl naphtho (1,2:6',5')γ-pyrone (XVIII) through the Kostanecki-Robinson benzoylation of 4-chloro-2-aceto-1-naphthol.



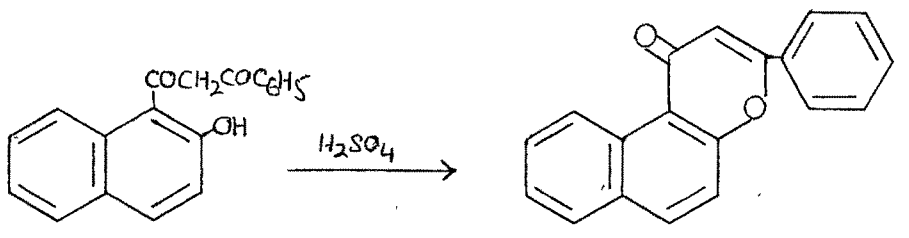
XVII



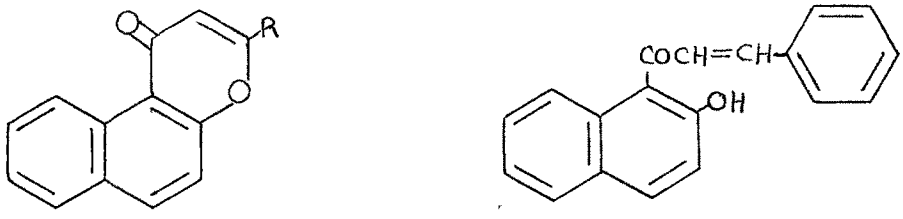
XVIII

The simple 2'-phenylnaphtho-γ-pyrone derivative (XIX) was prepared by Venkataraman et al.[25] by treating the benzoyl derivative of 1-acetyl-2-naphthol with sodamide to get the β-diketone (XX) (Baker-Venkataraman transformation) and then subjecting it to cyclisation with sulphuric acid. This method has been applied to the synthesis of other substituted naphtho (1,2:6',5')γ-pyrones.

1-Acetyl-2-naphthol on Kostanecki-Robinson acylation with sodium benzoate and benzoic anhydride and with sodium anisate and anisic anhydride gave the γ-pyrone derivative (XXI ; R = C_6H_5 or p-$C_6H_4OCH_3$) and their 3'-acyl derivatives[24]. The same compounds were earlier prepared by Kostanecki[26,27] by treating dibromides of the naphthyl styryl ketones (XXII, R = C_6H_5 or p-$C_6H_4OCH_3$) with alcoholic potassium hydroxide. Other 2'-phenyl naphtho (1,2:6',5') γ-pyrone derivatives with one or more hydroxyl group in 2'-phenyl ring have also been prepared by this method[24,28].

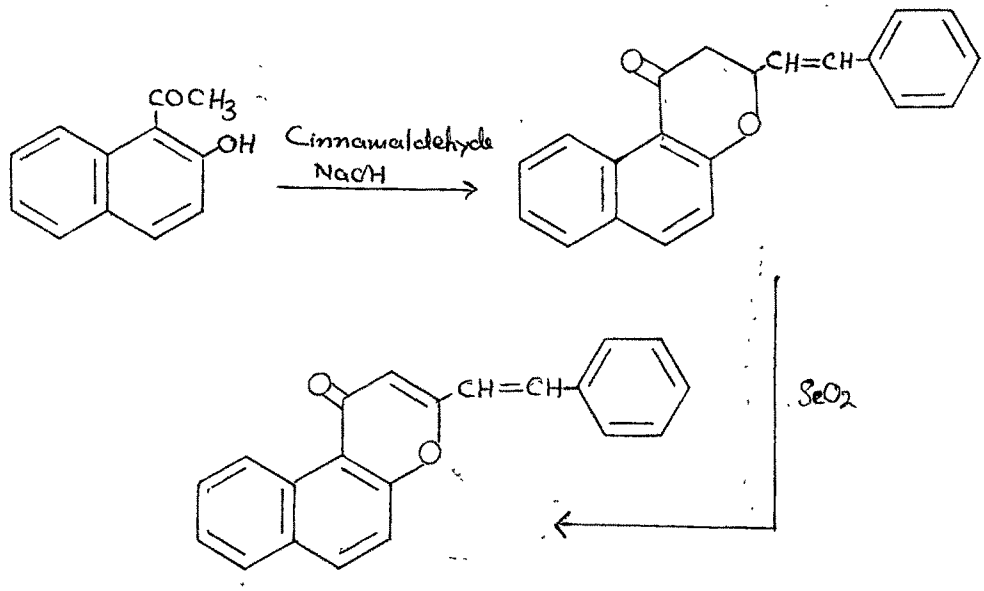


XX XIX



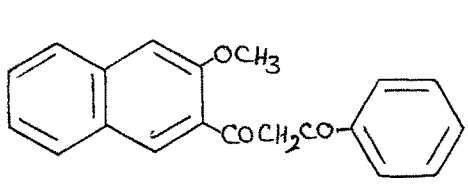
XXI R = C_6H_5 or p-$C_6H_4OCH_3$ XXII

The γ-pyrone derivative (XXIII) has been synthesised[29] by condensing 1-acetyl-2-naphthol with cinnamaldehyde in the presence of alkali to get 2'-styryl-2',3'-dihydronaphtho-γ-pyrone derivative and its treatment with selenium dioxide.

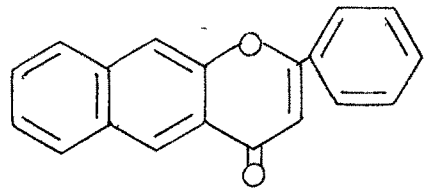


XXIII

Virkar and Wheeler[30] prepared the linear naphtho-γ-pyrone derivative (XXIV) by cyclisation of the β-diketone (XXV) with hydriodic acid in acetic anhydride. The β-diketone was prepared by the Claisen condensation of 2-methoxy-3-naphthoic acid with acetophenone.

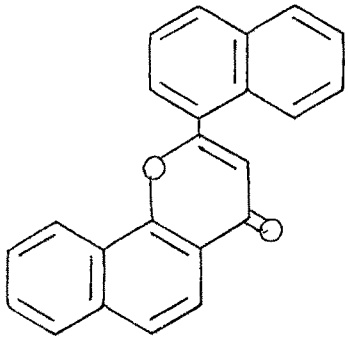


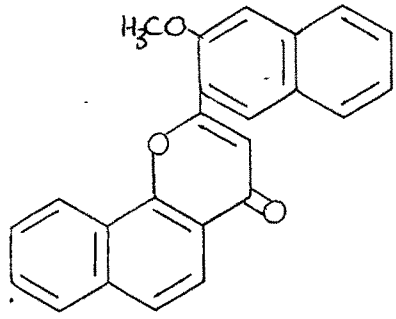
XXV

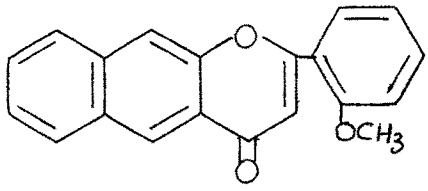


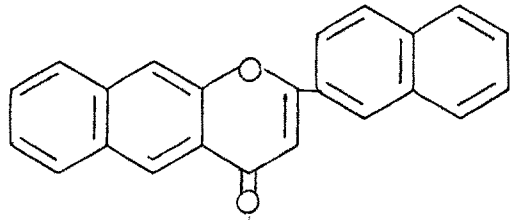
XXIV

A number of other naphtho-γ-pyrone derivatives such as the following are also reported in the literature[30].

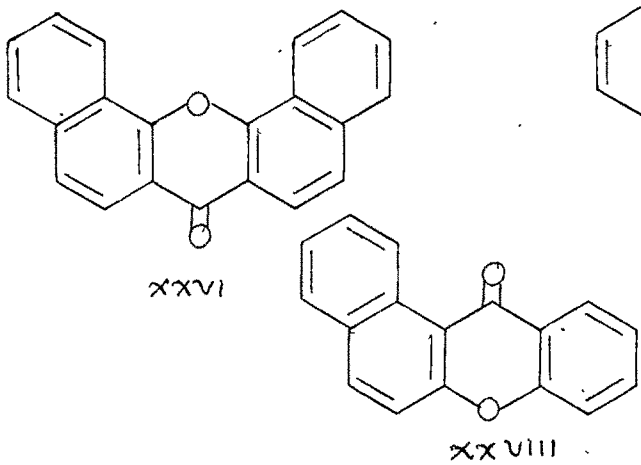




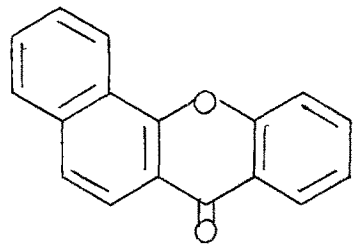




Preparation of some xanthone derivatives from α- and β-naphthol have also been reported in the literature. Baeyer[31], Grabowski[32] and Clar[33] synthesised 3,4,5,6-dibenzoxanthone (XXVI) by heating α-naphthol with anhydrous oxalic acid and con.sulphuric acid at 130°. Kostanecki[34] obtained 3,4-benzoxanthone (XXVII) by distilling α-naphthol with salicyclic acid and acetic anhydride. He also prepared 1,2-benzoxanthone (XXVIII) by distillation of β-naphthol with salicyclic acid and acetic anhydride.



XXVI

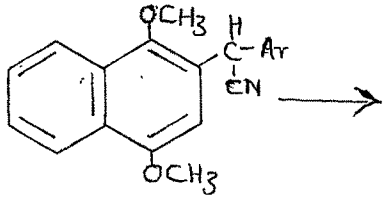


XXVII

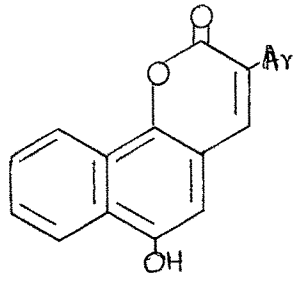
XXVIII

While considerable work has been done on the synthesis of oxygen heterocycles from mono hydroxy naphthalenes, the work on the synthesis of such compounds from dihydroxy naphthalenes has been comparatively meagre.

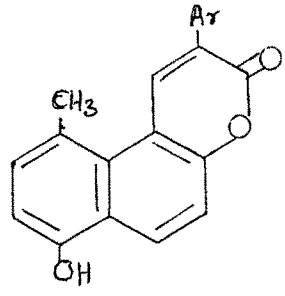
Buu Hoi and Lavit[35] prepared some hydroxy naphtho α-pyrones. They formylated 1,4-dimethoxynaphthalene to 1,4-dimethoxy-2-naphthaldehyde and proved the constitution of the aldehyde by the preparation of aryl acetonitriles of acrylonitrile (XXIX) which gave 3'-aryl-4-hydroxy naphtho (1,2:6',5') α-pyrone (XXX) on demethylation with pyridine hydrochloride.



XXIX



XXX



XXXI

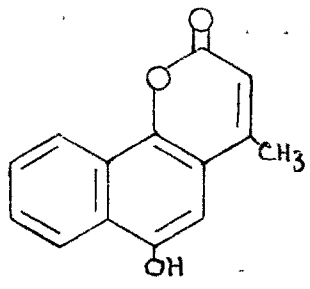
Similarly the product obtained on formylation of 1,6-dimethoxy-4-methyl naphthalene was converted through its condensation with benzyl cyanide into hydroxy naphtho-α-

pyrone (XXXI).

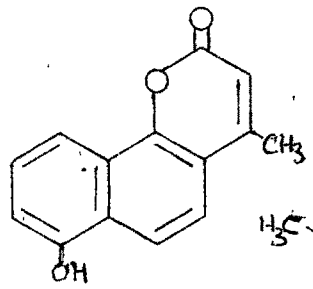
2,7-Dimethoxy-1-naphthaldehyde and 2,7-dimethoxy-8-methyl-1-naphthaldehyde have been condensed with aryl acetonitriles and the acrylonitriles obtained, have been converted into 3'-aryl-7-hydroxy-, and 3'-aryl-7-hydroxy-8-methyl naphtho(2,1:6',5')α-pyrones. Similarly coumarins were obtained by demethylation of acrylonitriles derived from 2,6-dimethoxy and 2,6-dimethoxy-5-methyl-1-naphthaldehyde. Although condensation of α- and β-naphthol with β-ketonic esters has been carried out for the preparation of benzo-coumarins[36] the behaviour of dihydroxynaphthalenes in this reaction has hitherto been investigated only in a few cases

Buu-Hoi et al.[35] found that 1,4-dihydroxy - naphthalene condenses with ethyl acetoacetate in the presence of hydrogen chloride gas. They assigned 4-hydroxy-4'-methyl naphtho(1,2:6',5')α-pyrone (XXXII) structure to the product obtained. Robinson and Weygand[37] condensed 1,5-dihydroxy naphthalene with ethyl acetoacetate and obtained 5-hydroxy-4'-methyl naphtho(1,2:6',5')α-pyrone (XXXIII). The same authors also prepared 4',4"-dimethyl naphtho(1,2:6',5' and 5,6:6",5") di-α-pyrone (XXXIV). 1,6-Dihydroxynaphthalene and its 4-methyl homologue have been condensed with ethyl acetoacetate and the products are assigned 6-hydroxy-4'-methyl(XXXVa) and 6-hydroxy-4,4'-dimethyl naphtho(1,2:6',5')α-pyrone(XXXVb) structures in view of the known higher reactivity of α-naphthol compared with that of the β-isomer[38].

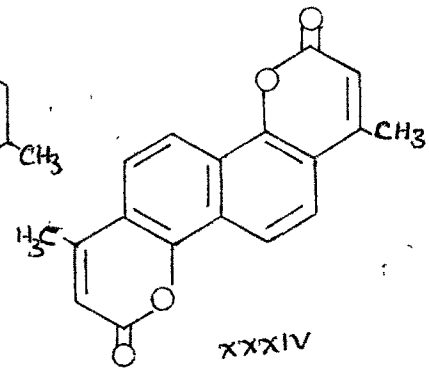
On the same basis the 7-hydroxy-4,4'-dimethyl naphtho(1,2:6',5')α-pyrone(XXXVI) structure is assigned to the condensation product of 1,7-dihydroxy-4-methyl naphthalene with ethyl acetoacetate in presence of hydrogen chloride gas. An interesting difference had been noted between 2,6- and 2,7-dihydroxy naphthalene, the former did not condense with ethyl acetoacetate in the presence of hydrogen chloride gas whilst the latter gave 7-hydroxy-4'-methyl naphtho(2,1:6',5') α-pyrone[35] (XXXVII). 1-Hydroxy-5-methoxy naphthalene readily gave 5-methoxy-4'-methyl naphtho(1,2:6',5')α-pyrone which underwent demethylation with pyridine hydrochloride to 5-hydroxy-4'-methyl naphtho(1,2:6',5')α-pyrone (XXXIII) previously described by Robinson and Weygand[37].



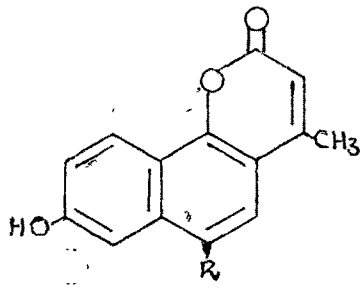
XXXII



XXXIII

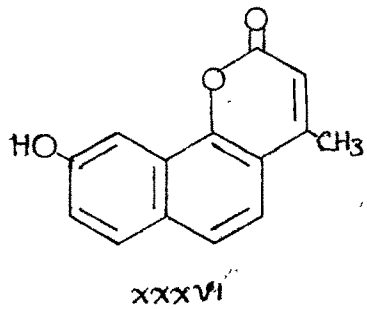


XXXIV

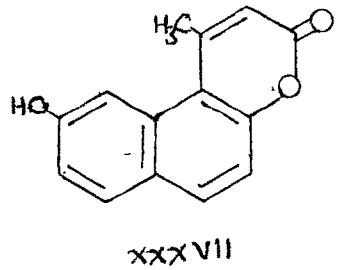


XXXV

XXXVa R=H
XXXVb R=CH3

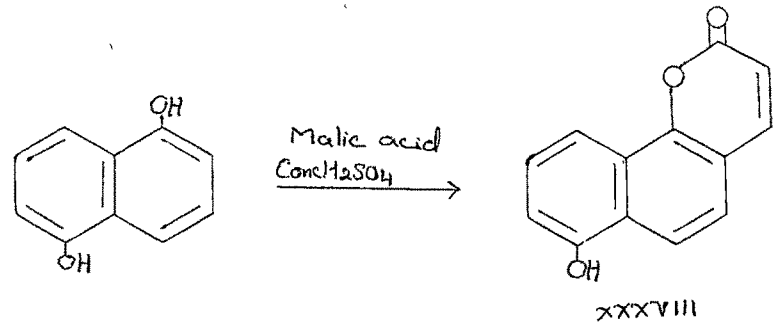


XXXVI

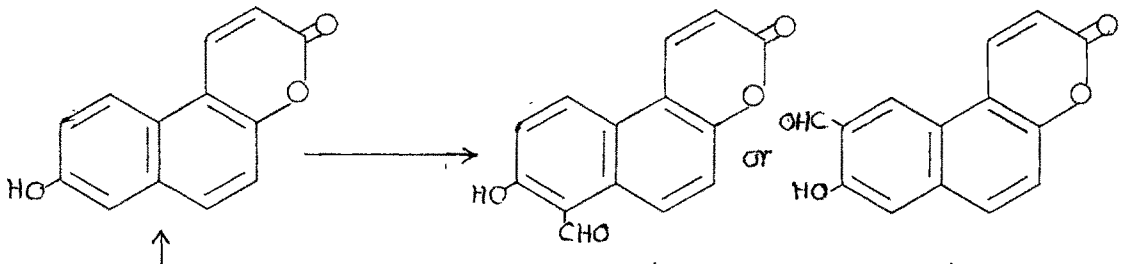


XXXVII

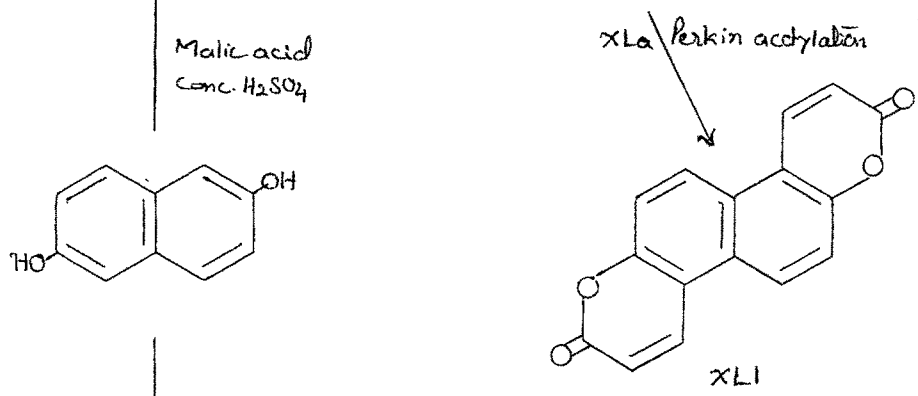
The hydroxy naphtho-α-pyrone (XXXII) was also prepared by Mehta[39] through the condensation of 1,5-dihydroxy naphthalene with ethyl acetoacetate in the presence of conc. sulphuric acid. Kuriakose and Sethna[40] synthesised 5-hydroxy naphtho(1,2:6',5')α-pyrone (XXXVIII) from 1,5-dihydroxy naphthalene by condensing it with malic acid in the presence of conc.sulphuric acid.They studied the synthesis of oxygen heterocycles from 2,6-dihydroxynaphthalene. 2,6-Dihydroxy-naphthalene on Pechmann condensation with malic acid gave 6-hydroxy naphtho(2,1:6',5')α-pyrone (XXXIX). The structure was assigned by them on the following evidence.The above product when heated with hexamethylene tetramine in glacial acetic acid gave a hydroxy formyl derivative. The product could have either of the structures (XLa or XLb). That it has the structure (XLa) was proved by the following reactions. The formyl derivative on Perkin acetylation with acetic anhydride and sodium acetate afforded a product in low yield; identical with the product (XLI) obtained on Perkin acetylation of the known 1,5-diformyl-2,6-dihydroxynaphthalene,prepared by direct formylation of 2,6-dihydroxynaphthalene with hexamethylene tetramine. The synthesis of naphtho(2,1:6',5' and 6,5:6'',5'')di-α-pyrone (XLI) was also attempted using Knoevenagel condensation[22] method. The building up of the two α-pyrone rings in stages and simulteneously was tried successfully,but attempt to hydrolyse the diethyl naphtho (2,1:6',5' and 6,5:6'',5'')di-α-pyrone-3',3''-dicarboxylate(XLII) did not succeed.



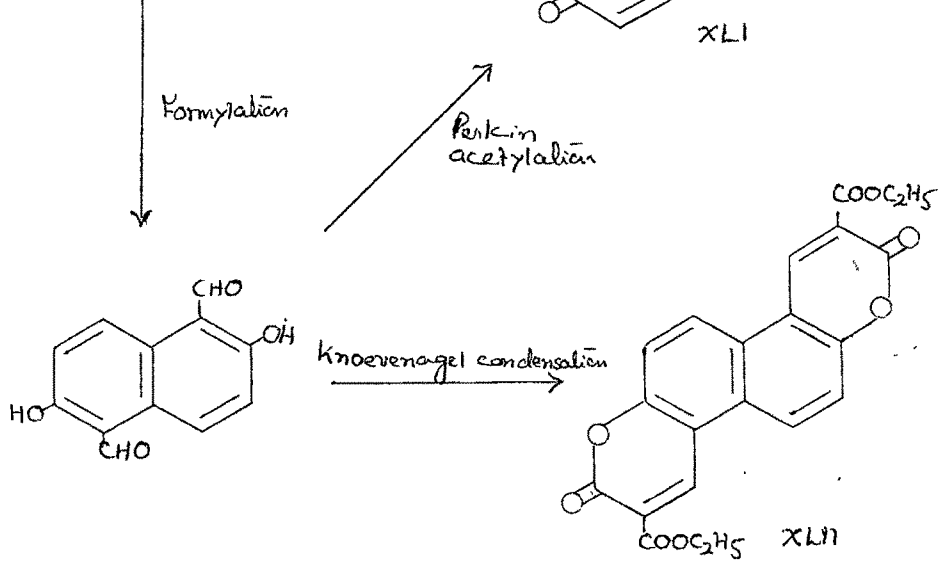
XXXVIII



XLa Perkin acetylation XLb

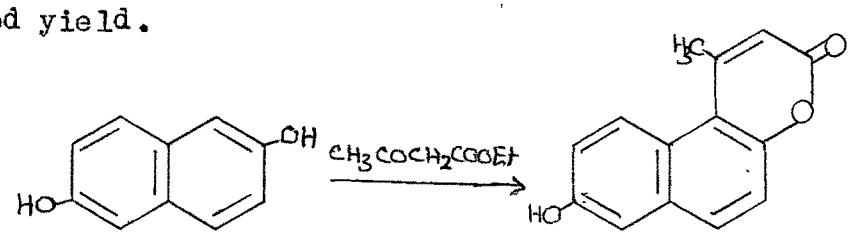


XLI



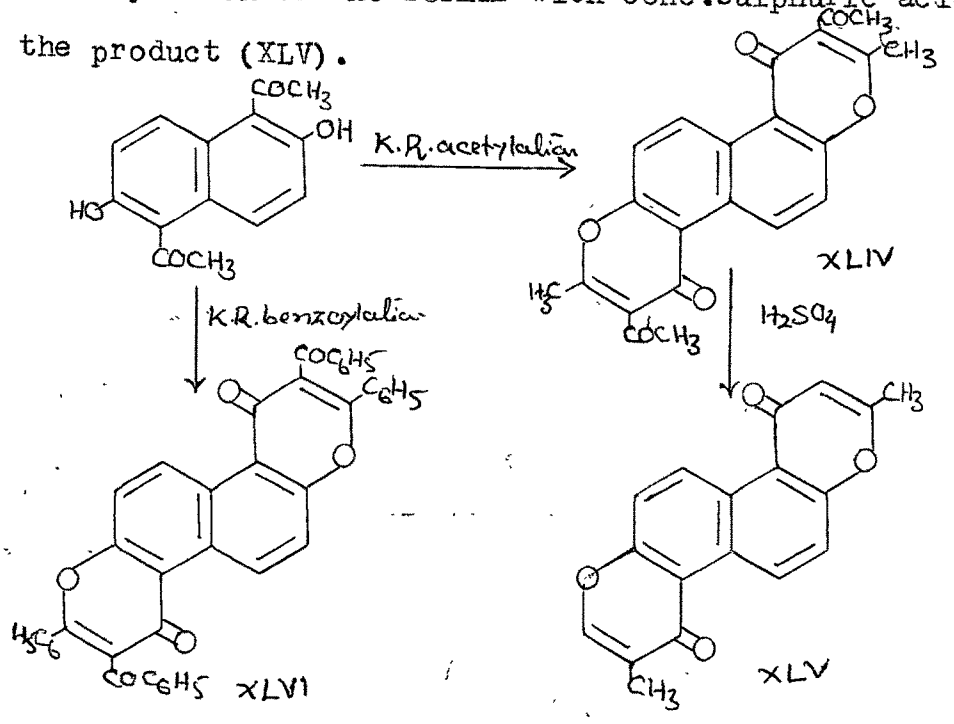
XLII

2,6-Dihydroxynaphthalene on Pechmann condensation with ethyl acetoacetate in the presence of sulphuric acid afforded 6-hydroxy-4'-methyl naphtho(2,1:6',5')α-pyrone(XLIII) in good yield.

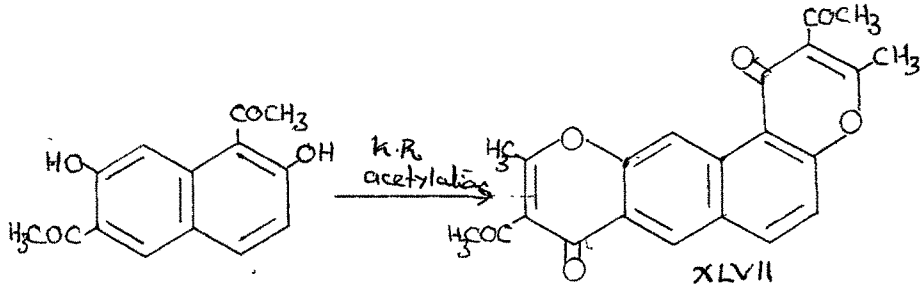


XLIII

The same authors carried out the Kostanecki-Robinson acetylation and benzoylation of 1,5-diacetyl-2,6-dihydroxy-naphthalene, prepared by the Fieser and Lothrop method[42] and assigned the 2',2''-dimethyl-3',3''-diacetyl naphtho(2,1:6',5' and 6,5:6'',5'')di-γ-pyrone(XLIV) and 2',2''-diphenyl-3',3''-dibenzoyl naphtho (2,1:6',5' and 6,5:6'',5'')di-γ-pyrone(XLVI) structuress respectively to the products obtained. The deacetylation of the former with conc.sulphuric acid gave the product (XLV).



Kuriakose and Sethna[49] also subjected 1,6-diacetyl-2,7-dihydroxynaphthalene prepared by Friedal-Craft's acetylation of 2,7-dihydroxynaphthalene, to Kostanecki-Robinson acetylation and obtained 2',2''-dimethyl-3',3''-diacetyl naphtho(2,1:6', 5' and 7,6:6'',5'')di-γ-pyrone (XLVII).



XLVII

This work has been now extended and several naphtho α-and γ-pyrone derivatives have been synthesised from dihydroxy naphthalenes and their structures established.

Synthesis of 7-hydroxy naphtho(2,1:6',5')α-pyrone :

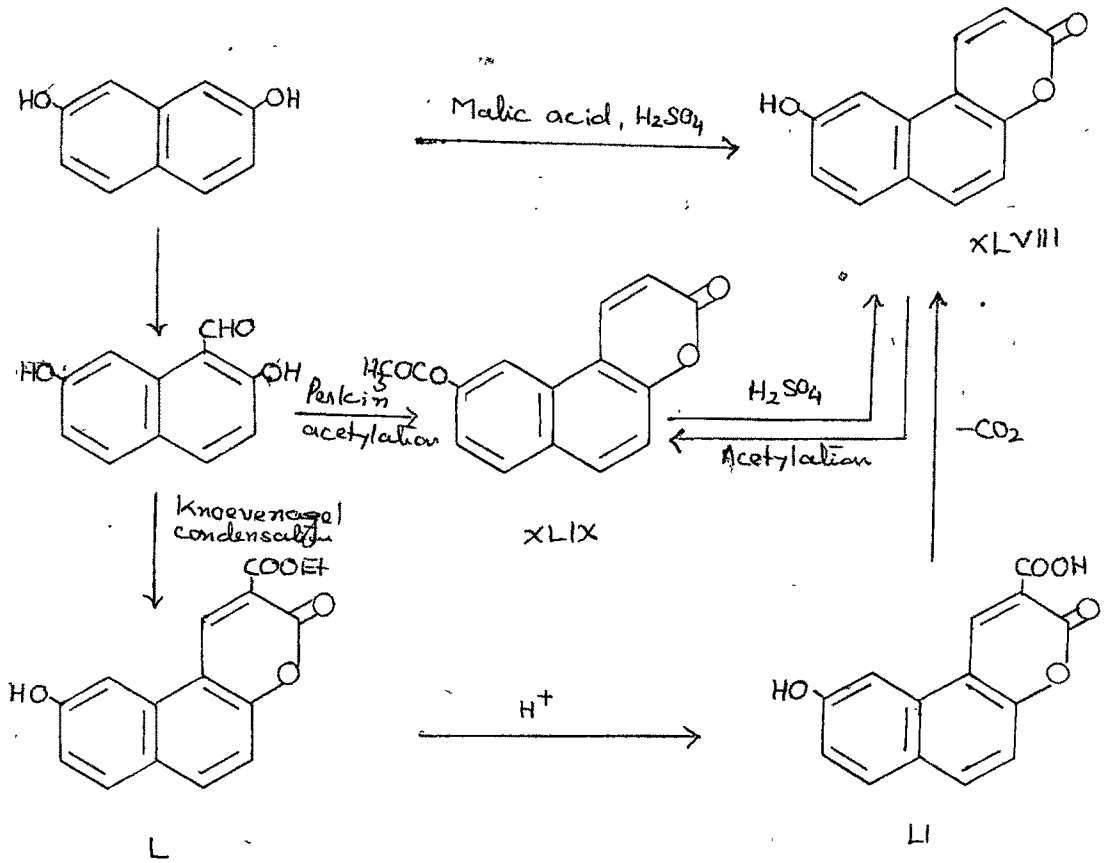
2,7-Dihydro xynaphthalene on Pechmann condensation with malic acid in the presence of sulphuric acid gave a product which was soluble in dilute alkali. It has been assigned the 7-hydroxy naphtho(2,1:6',5')α-pyrone structure (XLVIII) on the following evidence :

2,7-Dihydroxy-1-naphthaldehyde, prepared according to Gattermann, on Perkin acetylation gave 7-acetoxy naphtho (2,1:6',5')α-pyrone (XLIX), which on hydrolysis with conc. sulphuric acid gave 7-hydroxy naphtho(2,1:6'5')α-pyrone (XLVIII). Mixed m.p. with the above Pechmann product was not depressed. For further comparison, the Pechmann product was acetylated which gave the same product as was obtained

25

by Perkin acetylation of 2,7-dihydroxy-1-naphthaldehyde.

The above α-pyrone derivative was also prepared by the Knoevenagel condensation of 2,7-dihydroxy-1-naphthaldehyde with diethyl malonate in the presence of piperidine. Ethyl-7-hydroxy naphtho(2,1:6,5')α-pyrone-3'-carboxylate ~~derivative~~ (L) obtained was hydrolysed by refluxing it with a mixture of glacial acetic acid and hydrochloric acid. The acid (LI) on decarboxylation by refluxing with copper bronz and quinoline, gave a product which was identical with the product obtained through the Pechmann condensation.



When 2,7-dihydroxynaphthalene was condensed with ethyl acetoacetate in alcohol, in the presence of hydrogen chloride gas according to Buu Hoi[35] it gave 7-hydroxy-4'-methyl naphtho (2,1:6',5')α-pyrone m.p.276°. It showed blue fluorescence under UV light. On heating with alkali and dimethyl sulphate in acetone it gave an unsaturated acid as seen by the decolourisation of bromine water and dil. potassium permanganate solution. The formation of an unsaturated acid is a diagnostic test for a coumarin derivative[44]. However, when 2,7-dihydroxynaphthalene was condensed with ethyl acetoacetate in the presence of sulphuric acid (80%) by keeping the reaction mixture overnight a different product, m.p. around 226° was obtained, which was soluble in dilute alkali and it showed two spots in TLC, one showing blue fluorescence and the other with yellowish green fluorescence. The two isomers could be easily seen under UV light. The major part of the mixture was the product m.p. 267° and the other product was the one mentioned above, m.p.276°. Their mixed m.p. was depressed by over 40°. The product m.p.267° also gave an unsaturated acid on heating with alkali and dimethyl sulphate in acetone, which was different from the one obtained from the product m.p.276°. Therefore it was also an α-pyrone derivative. The unsaturated acid on oxidation gave an acid, m.p.186°. It has the same m.p. as that of 2,7-dimethoxy-3-naphthoic acid obtained by

Sunthankar and Gilman[45] by carboxylation of lithio derivative of 2,7-dimethoxynapthalene. It is therefore apparent that one is a linear and the other is an angular isomer and thus the products may have the structures (a) and (b). The m.p. of the methoxy derivatives prepared from the two isomers by refluxing with dimethyl sulphate and anhydrous potassium carbonate in dry acetone were also different. The methoxy derivative obtained from the product m.p.276° has m.p.128° and the other, prepared from the product m.p.267° has m.p.220°. The actual structures were established by the NMR data.

The NMR spectrum of compound m.p.276° showed two multiplets and a singlet of the 3'-proton appearing at the usual value[50] of δ 6.2 expected for the coumarin proton in the 3'-position.

The down field three proton multiplet situated at δ 7.86,7.66 must be comprising of three doublets due to protons H-3 and H-4 coupling with each other and H-5. The δ values of three protons H-3,H-4 and H-5 in the angular α-pyrone being very close they overlap each other.

The upfield two proton multiplet seems to be due to the singlet of H-8 and doublet of H-6 coupling with H-5.

The NMR of compound m.p.267° showed two doublets, one upfield doublet centred at δ 7.16, which must be due to H-6 and the second downfield doublet due to H-5 appearing at δ 7.84 . The two upfield singlets at δ 7.10 and 7.48 can be attributed to H-8 and H-1 respectively. The third additional singlet at δ 8.1 which must be due to H-4

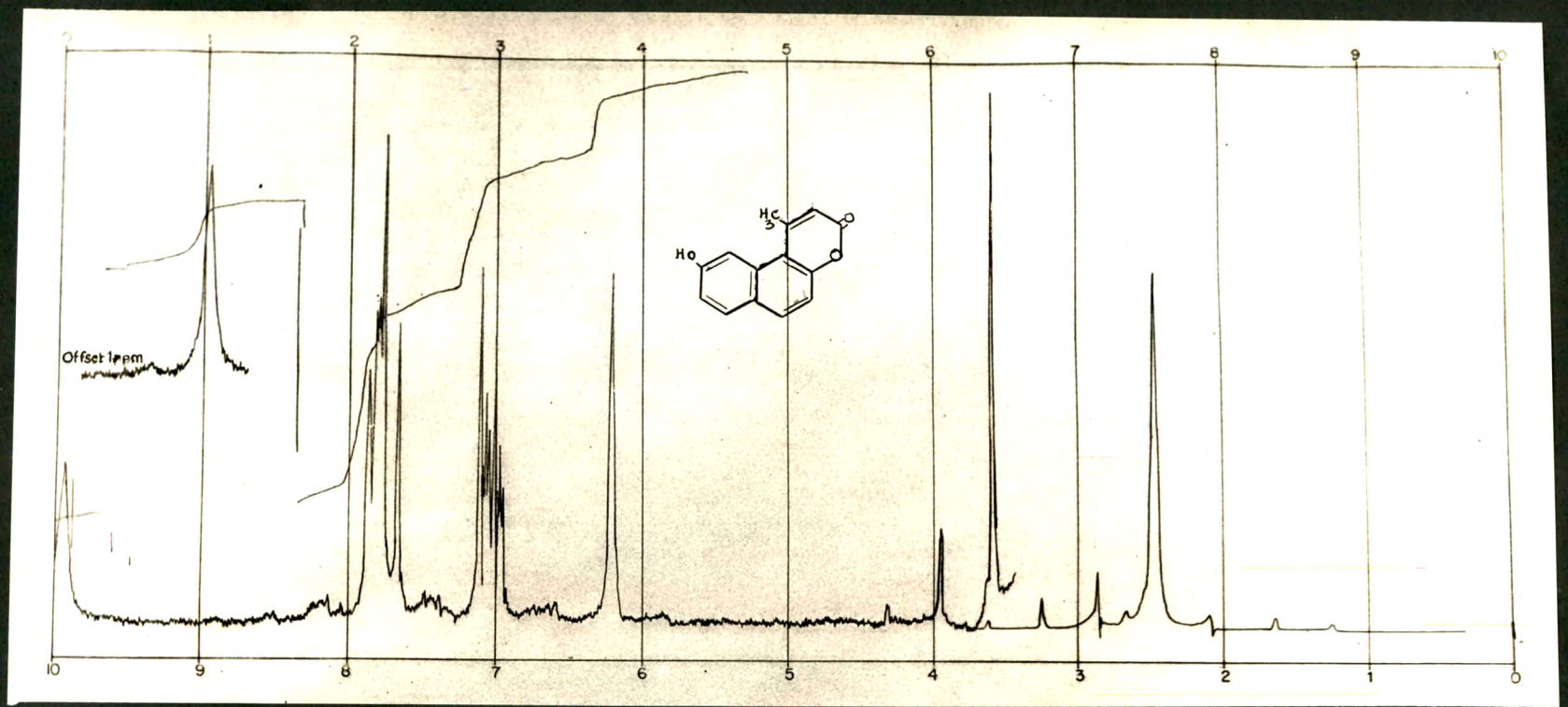
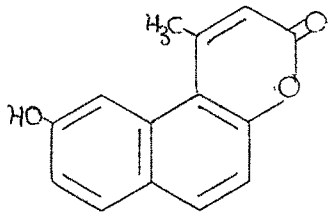
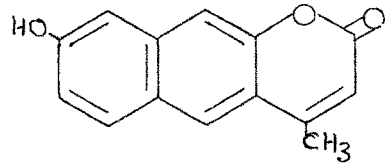


Fig. (LII) :- NMR spectrum of 7-hydroxy-4'-methyl naphtho(2,1:6',5') α-pyrone. (DMSO)

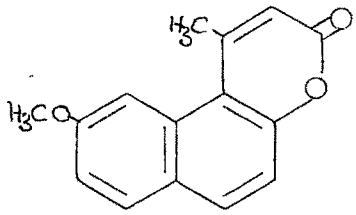
Fig. (LIII) :- NMR spectrum of 7-hydroxy-4'-methyl naphtho (2,3:6',5') a-pyrone. (DMSO)



a

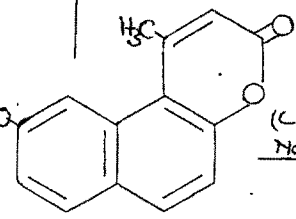


b



LVI

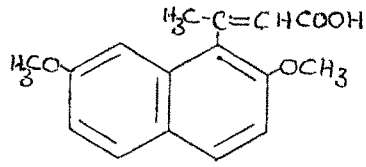
$(CH_3)_2SO_4$, acetone, K_2CO_3



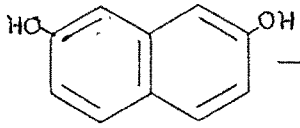
LII

Ethyl aceto acetate HCl

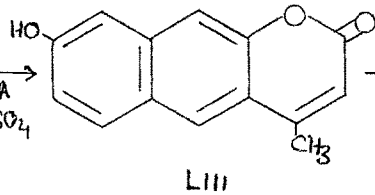
$(CH_3)_2SO_4$ NaOH



LIV

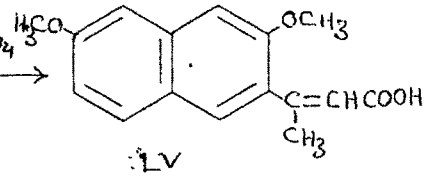


E.A.A H_2SO_4



LIII

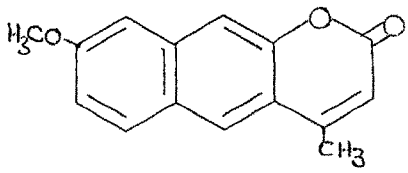
$(CH_3)_2SO_4$ NaOH



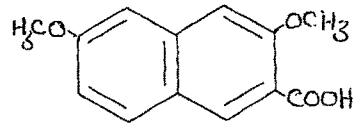
LV

$(CH_3)_2SO_4$, acetone K_2CO_3

oxidation $KMnO_4$



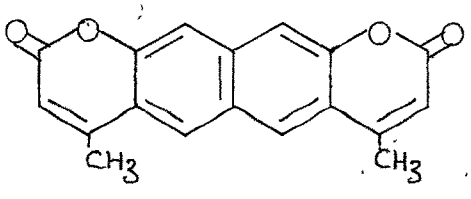
LVII



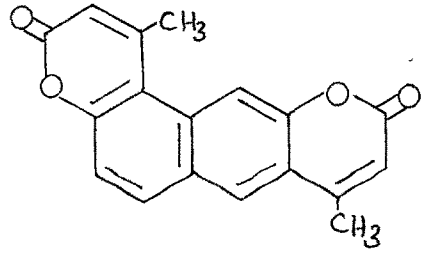
rules out the possibility of the angular structure of the α-prone. The 3'-H in the α-prone ring appears at δ 6.23 the expected value.

The product with m.p.267° was obtained by fractional crystallisation. The isomer with m.p.276° was obtained in a pure form when the condensation was carried out in the presence of hydrochloric acid gas. The product m.p.276° was assigned structure (LII) and that with m.p.267° structure (LIII) and the unsaturated acids and methoxy derivatives obtained from them are assigned the structures (LIV),(LV) and (LVI),(LVII).

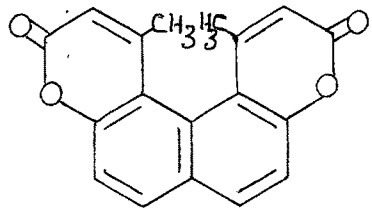
When the condensation was carried out with excess of ethyl acetoacetate in the presence of conc.sulphuric acid a product was obtained which was insoluble in dilute alkali and analysed for a di-α-pyrone derivative. Definate structure however could not be assigned, as the product was found to be insoluble in all the usual organic solvents and its NMR could not be obtained. This could have either of the structures (A) (B) or (C).



(A)



(B)



(C)

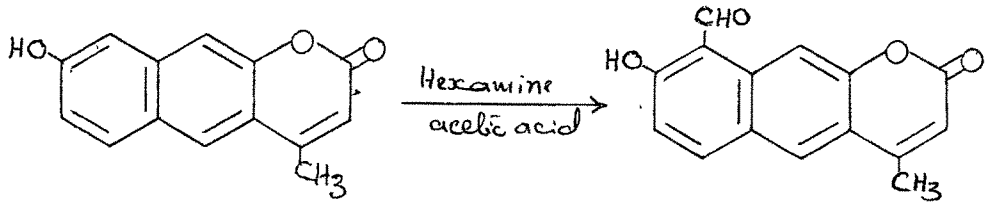
Of these structures (C) is unlikely as the mono-α-pyrone has a linear stfucture.

Formylation of 7-hydroxy-4'-methyl naphtho(2,3:6',5') α-pyrone : 7-Hydroxy-8-formyl-4'-methyl naphtho(2,3:6',5') α-pyrone :

7-Hydroxy-4'-methyl naphtho(2,3:6',5')α-pyrone was refluxed with hexamethylene tetramine in acetic acid. On decomposition of the complex formed with dilute hydrochloric acid a hydroxy formyl derivative was obtained which gave wine colour with alcoholic ferric chloride. The formyl derivative was assigned the 7-hydroxy-8-formyl-4'-methyl naphtho (2,3:6',5')α-pyrone (LVIII) structure on the basis of the NMR data. The NMR spectrum of this compound shows a sharp singlet at 10.61 , characteristic of the aldehyde proton. The other features are two doublets and two singlets in the aromatic region, confirming the position of the aldehyde

group to be at 8 and not at 6.

The two doublets at δ 8.1 and 7.14 with the ortho-coupling constant J of 9 Hz. are due to H-5 and H-6 respectively. The singlet at δ 8.57 and 8.11 are due to H-4 and H-1. The proton at 3'-position appears at δ 6.31 as a singlet and the methyl group at δ 2.48 as a three proton singlet.



LVIII

Synthesis of 4'-methyl naphtho (2,3:6',5' and 7,8:6",5") di-α-pyrone :

7-Hydroxy-8-formyl-4'-methyl naphtho (2,3:6',5') α-pyrone was condensed with diethyl malonate in the presence of a few drops of piperidine. The separated product(LIX) which was insoluble in alkali was washed with hydrochloric acid (1:1) and then hydrolysed with a mixture of acetic acid and hydrochloric acid by refluxing. 4'-Methyl-3"-carboxy naphtho (2,3:6',5' and 7,8:6",5") di-α-pyrone (LX) obtained was then decarboxylated by refluxing with copper bronze in quinoline solution to 4'-methyl naphtho (2,3:6',5' and 7,8:6",5") di-α-pyrone (LXI).

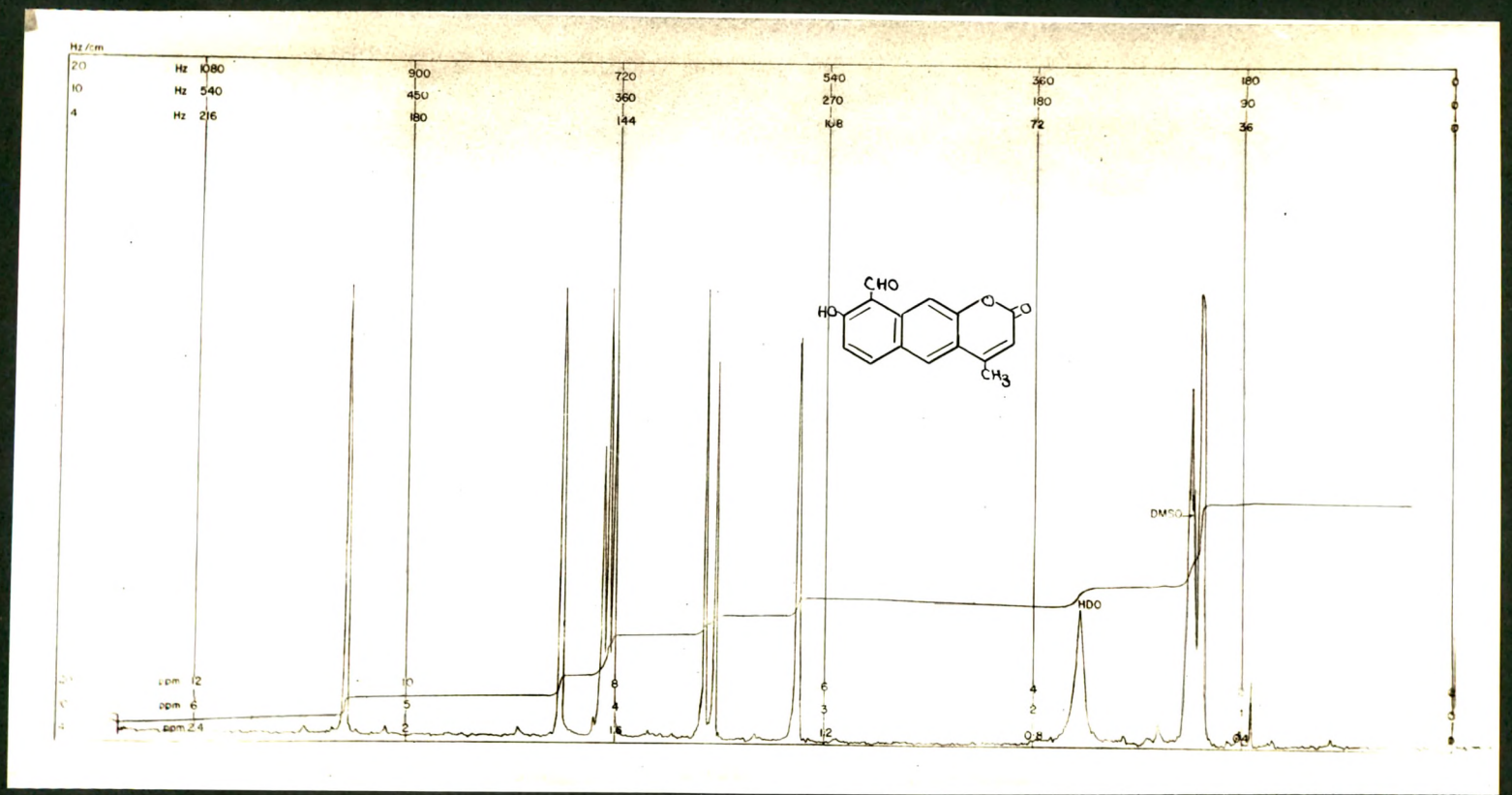
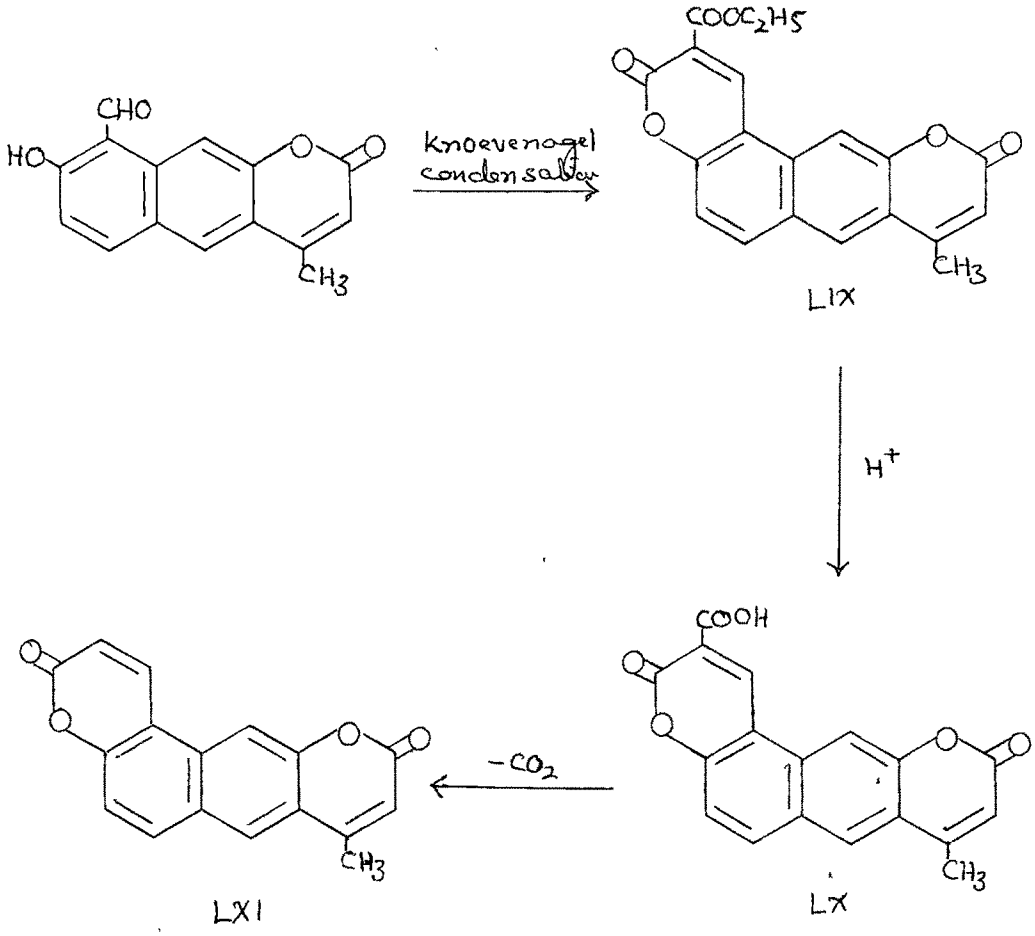


Fig. (LVIII) :- NMR spectrum of 7-hydroxy-8-formyl-4'-methyl naphtho (2,3:6',5') α-pyrone. (DMSO)

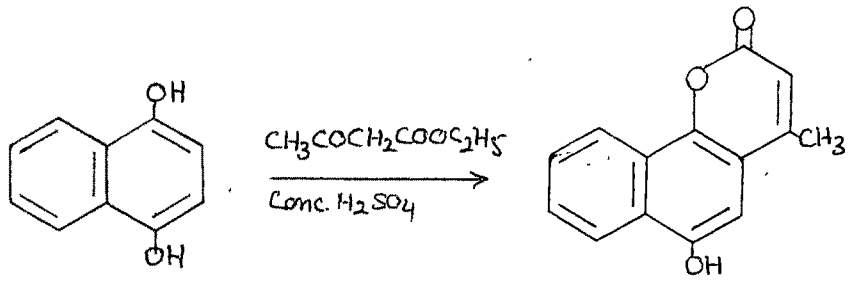


The I.R.showed absorption at 1725 cm^{-1} (lactonyl >C=O group)

Pechmann condensation of 1,4-dihydroxy naphthalene with ethyl acetoacetate : 4-Hydroxy-4'methyl naphtho (1,2:6',5')α-pyrone :

1,4-Dihydroxy naphthalene on condensation with ethyl acetoacetate in the presence of conc.sulphuric acid gave 4-hydroxy-4'methyl naphtho(1,2:6',5')α-pyrone (LXII) (m.p.282°) earlier prepared by Desai and Sethna[41] by persulphate oxidation of naphtho(1,2:6',5')α-pyrone. Buu Hoi[35] carried

out this condensation using hydrochloric acid gas as the condensing agent and obtained a product, m.p.206°. The corresponding γ-pyrone derivative was prepared by condensing 1,4-dihydroxy naphthalene with ethyl acetoacetate in boiling diphenyl ether (p. 51). The product obtained melted at 315°. This γ-pyrone derivative was hydrolysed to 1,4-dihydroxy-2-acetyl naphthalene which was obtained by Fries migration of 1,4-diacetoxy naphthalene. Repetition of Buu Hoi's work gave the product, m.p.206°. It did not give the acetoxy derivative. The product m.p.282° gave an acetoxy derivative showing the presence of a free hydroxyl group. It has not been possible to arrive at the structure of Buu Hoi's product.



LXII

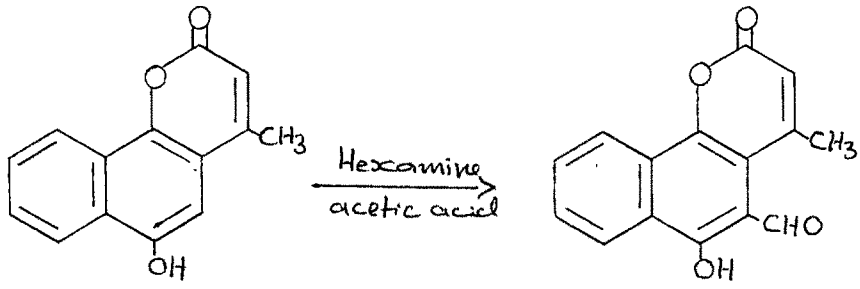
Attempted synthesis of 4-hydroxy-3-acetyl naphtho (1,2:6',5') α-pyrone :

With a view to build another heterocyclic ring on 4-hydroxy-4'methyl naphtho(1,2:6',5') α-pyrone, it was acetylated with acetic anhydride and sodium acetate to 4-acetoxy-4'methyl naphtho(1,2:6',5') α-pyrone. This was subjected to Fries migration with anhydrous aluminium chloride. The product obtained was soluble in alkali but

did not give any colour with alcoholic ferric chloride. Mixed m.p.with the original α-pyrone was not depressed which proved that deacetylation had taken place.

Formylation of 4-hydroxy-4'methyl naphtho(1,2:6,5') α-pyrone : 4-Hydroxy-3-formyl-4'methyl naphtho (1,2:6,5')α-pyrone :

4-Hydroxy-4'methyl naphtho(1,2:6,5')α-pyrone was formylated with hexamine in acetic acid. The product obtained was a formyl derivative. It gave a greenish brown colouration with alcoholic ferric chloride and hence it has been assigned the 3-formyl structure (LXIII). The yield was however very poor and hence no further work could be done.

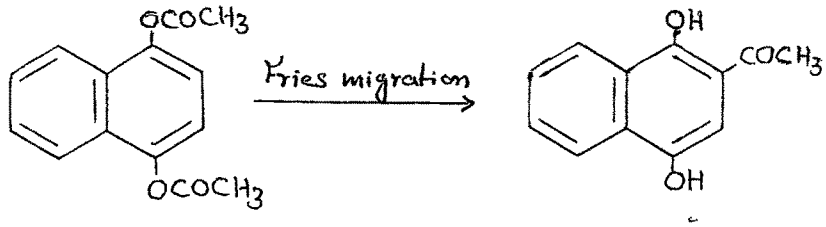


LXIII

Fries rearrangement of 1,4-diacetoxy naphthalene:

1,4-Dihydroxy naphthalene was acetylated with acetic anhydride and sodium acetate to get 1,4-diacetoxy naphthalene. On subjecting it to Fries rearrangement the diacetoxy naphthalene gave a product which was soluble in alkali and gave a wine red colour with alcoholic ferric chloride. It analysed for a mono acetyl derivative $C_{12}H_{10}O_3$.

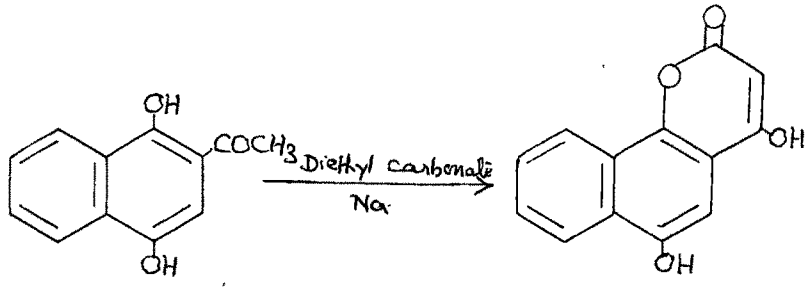
The structure assigned to this product is 1,4-dihydroxy-2-acetyl naphthalene (LXIV).



LXIV

Synthesis of 4,4'-dihydroxy naphtho(1,2:6',5')α-pyrone :

The above o-hydroxy ketone derivative was condensed with diethyl carbonate in the presence of pulverised sodium. The product obtained on working up the reaction mixture was soluble in sodium bicarbonate solution. 4,4'-Dihydroxy naphtho (1,2:6',5')α-pyrone structure (LXV) has been assigned to this product.



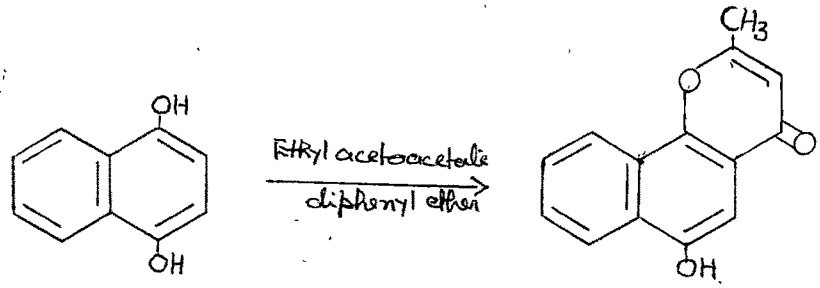
LXV

Synthesis of some naphtho-γ-pyrone derivatives :

While the Pechmann condensation of β-ketonic esters with phenols in the presence of sulphuric acid gives coumarins it has been found by Mentzer et al.[46,47] that if

the condensation is carried out without the use of a condensing agent chromones are obtained. Desai, Trivedi and Sethna[48] found that the reaction is speeded up and good yields of the chromones are obtained if the reaaction is carried out in boiling diphenyl ether. It was therefore thought of interest to apply this reaction to some dihydroxy naphthalenes.

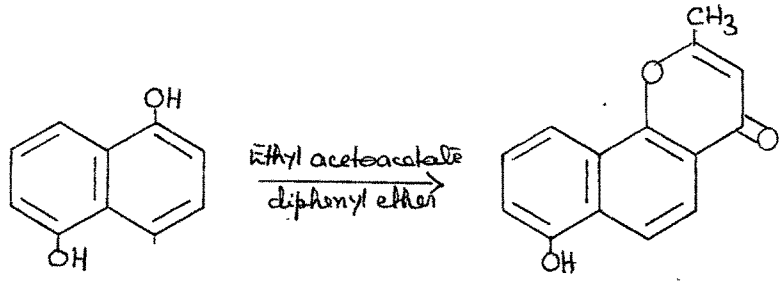
1,4-Dihydroxynaphthalene on refluxing with ethyl acetoacetate in diphenyl ether gave a product which was soluble in alkali and was different from the known 4-hydroxy-4'-methyl naphtho(1,2:6',5')α-pyrone. It analysed for $C_{14}H_{10}O_3$ and the 4-hydroxy-2'-methyl naphtho(1,2:6',5')γ-pyrone structure (LXVI) has been assigned to it. On alkaline hydrolysis it gave 1,4-dihydroxy-2-acetyl naphthalene.



LXVI

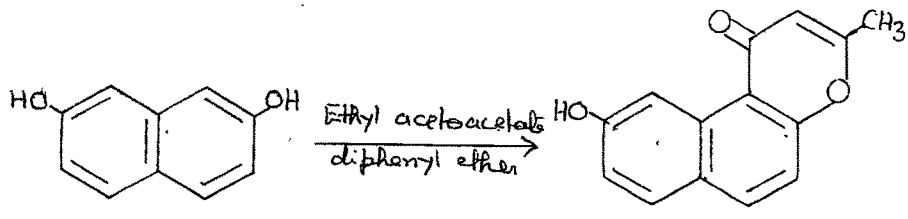
A similar condensation of 1,5-dihydroxy naphthalene with ethyl acetoacetate in boiling diphenyl ether gave a product which was soluble in alkali and was different from 5-hydroxy-4'-methyl naptho(1,2:6',5')α-pyrone. It was therefore

assigned the 5-hydroxy-2-methyl naphtho(1,2:6',5')γ-pyrone structure (LXVII).



LXVII

2,7-Dihydroxy naphthalene on condensation with ethyl acetoacetate in boiling diphenyl ether gave a product which analysed for $C_{14}H_{10}O_3$, was soluble in alkali and was different from both 7-Hydroxy-4'-methyl naphtho(2,1:6',5') α-pyrone and 7-hydroxy-4'-methyl naphtho(2,3:6',5')α-pyrone. It gave an intense yellow fluorescence under UV light. 7-Hydroxy-2'-methyl naphtho(2,1:6',5')γ-pyrone structure(LXVIII) has been assigned to the product, in view of the greater reactivity of the α-position.

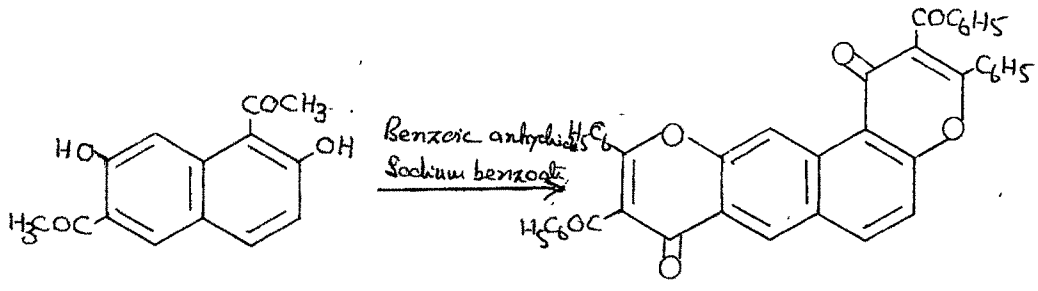


LXVIII

Synthesis of 2',2''-diphenyl-3',3''-dibenzoyl naphtho (2,1:6',5' and 7,6:6'',5'')di-γ-pyrone :

1,6-Diacetyl-2,7-dihydroxynaphthalene[49] on Kostanecki-Robinson benzoylation with sodium benzoate and benzoic anhydride gave a product which analysed for a dibenzoyl diphenyl di-γ-pyrone derivative (LXIX). It could not be debenzoylated either with alcoholic alkali or with sodium carbonate. On refluxing with alcoholic alkali only the original product could be recovered from the reaction mixture. It has been noted by Bhullar and Venkataraman[24] that even though the 3-acyl group in 3-acylated chromones can be readily removed by boiling them with alkali, 3'-acylated naphtho-γ-pyrones are either unaffected or the pyrone ring breaks down on prolonged boiling with alkali.

The I.R. showed two bands, at 1635 cm^{-1} (γ-pyronyl >C=O) and 1645 cm^{-1} (C=O of 3' and 3''-benzoyl group)



LXIX.

I.R. and UV spectra of the α-and γ-pyrone derivatives synthesised

I.R. spectra were recorded on Beckman I.R.20 and Perkin Elmer models and UV spectra were taken on Beckman DU-2 Spectrophotometer.

Structure of the compound	Name of the compound	-OH stretching band around cm^{-1}	Lactonyl >C=O stretching cm^{-1}	γ-pyronyl >C=O stretching cm^{-1}	λmax nm. solvent
1	2	3	4	5	6
XLVIII	7-Hydroxy naphtho (2,1:6',5')α-pyrone	3250 (nujol)	1710	-	278,300,344 (methanol)
LII	7-Hydroxy-4'-methyl naphtho(2,1:6',5')α-pyrone	3300 (nujol)	1690	-	282,294,346 (methanol)
LIII	7-Hydroxy-4'-methyl naphtho(2,3:6',5')α-pyrone	3325 (nujol)	1700	-	282,294,332 (methanol)
LXI	4'-Methyl naphtho(2,3:6',5') and 7,8:6",5")di-α-pyrone	-	1725, 1710 (nujol)	-	268,318 (chloroform)
LXII	4-Hydroxy-4'-methyl naphtho (1,2:6',5')α-pyrone	3150 (KBr)	1675	-	260,286,312 (chloroform)

1	2	3	4	5	6
LXV	4,4'-Dihydroxy naphtho (1,2:6',5')α-pyrone	3450,3250 (nujol)	1670	-	260,282 (chloroform)
LXVI	4'-Hydroxy-2'-methyl naphtho(1,2:6',5')γ-pyrone	3100 (nujol)	-	1620	262,308 (chloroform)
LXVII	5-Hydroxy-2'-methyl naphtho(1,2:6',5')γ-pyrone	3050 (KBr)	-	1635	260,306 (chloroform)
LXVIII	7-Hydroxy-2'-methyl naphtho(2,1:6',5')γ-pyrone	3360 (nujol)	-	1615	286 (methanol)
LXIX	2',2"-Diphenyl-3',3"-naphtho (2,1:6',5' and 7,6:6",5") di-γ-pyrone	-	-	1635 1645 (3-benzoyl group)	-

EXPERIMENTAL

Synthesis of 7-hydroxy naphtho (2,1:6',5')α-pyrone :

A mixture of 2,7-dihydroxynaphthalene (2 g.) malic acid (4 g.) and conc.sulphuric acid (8 ml.) was heated in an oil bath at 110° for 2 hr. The reaction mixture was poured into crushed ice and the separated product was filtered,washed with water and crystallised from diphenyl ether, m.p. 278°. It was soluble in dil. alkali.

Analysis : Found : C, 73.64 ; H, 3.67 %.

$C_{13}H_8O_3$ requires : C, 73.58 ; H, 3.77 %.

Perkin acetylation of 2,7-dihydroxy-1-naphthaldehyde: 7-Acetoxy naphtho (2,1:6',5')α-pyrone :

A mixture of 2,7-dihydroxy-1-naphthaldehyde(1 g.), fused sodium acetate (3 g.) and acetic anhydride (8 ml.) was refluxed at 170-80° for 12 hr. in an oil bath. The reaction mixture was then added to cold water. The separated product was washed with dilute alkali and crystallised from xylene in fine needles (0.4 g.), m.p.185°.

Analysis : Found : C, 70.79 ; H, 3.77 %.

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.93 %.

Hydrolysis :

The above acetoxy derivative (0.5 g.) was triturated with cold conc.sulphuric acid (6 ml.) for 10 minutes and poured into ice cold water. The product obtained was filtered and extracted with dilute alkali. On acidification,

of the alkaline extract 7-hydroxy naphtho (2,1:6',5') α-pyrone was obtained. It crystallised from dimethyl formamide in shining plates, m.p. 278°. Mixed m.p. with the Pechmann product was not depressed.

Analysis : Found : C, 73.14 ; H, 3.54 %.

$C_{13}H_8O_3$ requires : C, 73.53 ; H, 3.77 %.

Condensation of 2,7-dihydroxy-1-naphthaldehyde with diethyl malonate : Ethyl 7-hydroxynaphtho (2,1:6',5') α-pyrone-3'-carboxylate :

A mixture of 2,7-dihydroxy-1-naphthaldehyde(0.5 g.), diethyl malonate (8 ml.) and a few drops of piperidine was kept overnight. The reaction mixture was decomposed with ice cold hydrochloric acid. The product crystallised from alcohol in fine greenish yellow needles (0.2 g.), m.p.237°.

Analysis : Found : C, 67.74 ; H, 4.11 %.

$C_{16}H_{12}O_5$ requires : C, 67.61 ; H, 4.22 %.

7-Hydroxy-3'-carboxy naphtho (2,1:6',5') α-pyrone :

The above ester (0.4 g.) was dissolved in excess of glacial acetic acid (75 ml.) and conc.hydrochloric acid (30 ml.) was added to it. The mixture was refluxed for 4 hr. The reaction mixture was poured into excess of water. The separated solid was purified by sodium bicarbonate solution treatment. It was crystallised from dimethyl formamide, m.p. 312°. Yield 0.2 g.

Analysis : Found : C, 65.16 ; H, 2.81 %.

$C_{14}H_8O_5$ requires : C, 65.62 ; H, 3.12 %.

Decarboxylation : 7-Hydroxy naphtho (2,1:6',5')α-pyrone :

The above acid (0.4 g.) was refluxed with copper powder (0.2 g.) in quinoline (8 ml.) for 45 minutes and the reaction mixture was filtered hot. Conc.hydrochloric acid (1:1) was added to the filtrate. The separated product was crystallised from dimethyl formamide. M.P. 278°. Yield 0.15 g. Mixed m.p. with 7-hydroxy naphtho (2,1:6',5')α-pyrone mentioned above was not depressed.

Condensation of 2,7-dihydroxynaphthalene with ethyl acetoacetate: 7-Hydroxy-4'-methyl naphtho (2,1:6',5') α-pyrone :

A cooled solution of 2,7-dihydroxynaphthalene (4 g.) and ethyl acetoacetate (10 g.) in ethanol (40 ml.) was saturated with hydrochloric acid gas. The reaction mixture was left for 48 hr. The solid obtained was crystallised from acetic acid. M.P. 276°. Yield 1.1 g. Buu Hoi and Lavit[35] reported m.p.277°.

Analysis : Found : C, 74.83 ; H, 4.06 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

β-Methyl-β[1-(2,7-dimethoxy naphthyl)] acrylic acid :

7-Hydroxy-4'-methyl naphtho (2,1:6',5')α-pyrone (0.2 g.) was refluxed with potassium hydroxide (20 % ; 10 ml.) and dimethyl sulphate (0.5 ml.) in acetone (20 ml.) for 3 hr. The product obtained on acidification of the alkaline solution was purified by sodium bicarbonate treatment and crystallised from dilute alcohol in thick needles, m.p. 182°. It

decolourised bromine water and dilute potassium permanganate solution.

Analysis : Found : C, 71.08 ; H, 5.77 %.

$C_{16}H_{16}O_4$ requires : C, 70.58 ; H, 5.88 %.

7-Methoxy-4'-methyl naphtho (2,1:6',5') α-pyrone :

A mixture of 7-hydroxy-4'-methyl naphtho (2,1:6',5') α-pyrone (1 g.), dimethyl sulphate (1.5 ml.) and anhydrous potassium carbonate (5 g.) in dry acetone (50 ml.) was refluxed on a steam bath for 5 hr. After removal of acetone, water was added. The separated product was washed with dilute sodium hydroxide solution and crystallised from acetic acid in needles (0.4 g.). M.P. 128°.

Analysis : Found : C, 74.95 ; H, 4.80 %.

$C_{15}H_{12}O_3$ requires : C, 75.18 ; H, 5.00 %.

7-Hydroxy-4'-methyl naphtho (2,3:6',5') α-pyrone :

A mixture of 2,7-dihydroxynaphthalene (2 g.) ethyl acetoacetate (4 ml.) and sulphuric acid (80 % ; 15 ml.) was kept for 24 hr. It was then poured on crushed ice. The separated product was taken in dilute alkali. On acidification the product obtained was passed over alumina in methanol. The product obtained after the removal of the solvent was crystallised first from xylene and then from acetic acid when pure 7-hydroxy-4'-methyl naphtho (2,3:6',5') α-pyrone isomer was obtained which gave a single spot in TLC. M.P. 267°. Yield 0.9 g. Mixed m.p. with 7-hydroxy-4'-methyl

naphtho (2,1:6',5')α-pyrone was depressed by about 40°.

Analysis : Found : C, 73.85 ; H, 4.20 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

β-Methyl-β [3-(2,7-dimethoxynaphthyl)]acrylic acid :

7-Hydroxy-4'-methyl naphtho (2,3:6',5')α-pyrone (0.2 g.) was refluxed with potassium hydroxide (20 % ; 10 ml.) and dimethyl sulphate (0.5 ml.) in acetone(20 ml.) for3hr. The product obtained on acidification was purified by sodium bicarbonate solution treatment and crystallised from dilute alcohol in thin plates. It decolourised bromine water and dilute potassium permanganate solution, m.p.175°.

Analysis : Found : C, 70.55 ; H, 6.06 %.

$C_{16}H_{16}O_4$ requires : C, 70.58 ; H, 5.88 %.

2,7-Dimethoxy-3-naphthoic acid :

The above acrylic acid derivative (0.4 g.) was refluxed with potassium permanganate (1.5 g.) and sodium hydroxide (50 % ; 10 ml.) for 2 hr. More of potassium permanganate (0.5 g.) was added in small quantity at regular intervals. The reaction mixture was filtered and the filtrate was decolourised by adding sodium sulfite solution. The clear alkaline solution was acidified with hydrochloric acid. The separated product was purified by sodium bicarbonate treatment and crystallised from alcohol, m.p.186°. Sunthankar and Gilman[45] reported m.p.185.5°.

Analysis : Found : C, 67.73 ; H, 5.00 %.

$C_{13}H_{12}O_4$ requires : C, 67.24 ; H, 5.17 %.

7-Methoxy-4'-methyl naphtho(2,3:6',5')α-pyrone :

7-Hydroxy-4'-methyl naphtho(2,3:6',5')α-pyrone(1 g.) was refluxed with dimethyl sulphate (1.5 ml.) in dry acetone (75 ml.) in the presence of anhydrous potassium carbonate (4 g.) on a steam bath for 5 hr. Removal of acetone gave a product which was insoluble in dilute alkali. It crystallised from acetic acid in fine needles (0.5 g.), m.p.220°.

Analysis : Found : C, 75.43 ; H, 4.77 %.

$C_{15}H_{12}O_3$ requires : C, 75.13 ; H, 5.00 %.

Condensation of 2,7-dihydroxy naphthalene with excess of ethyl acetoacetate :

2,7-Dihydroxy naphthalene (2 g.) and ethyl acetoacetate (5 ml.) were mixed together and sulphuric acid (Conc. 20 ml.) was added gradually with shaking and external cooling. The reaction mixture was kept at room temperature for 24 hr. and then poured in ice cold water. The product obtained was found insoluble in dilute alkali. It was crystallised from dimethyl formamide in shining cream coloured plates (0.8 g.), m.p.above 325°.

Analysis : Found : C, 74.29 ; H, 4.27 %.

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

The analysis agrees with a di-α-pyrone structure, but the exact structure could not be assigned as it was found to be insoluble in all solvents and so the NMR could not be obtained.

Formylation of 7-hydroxy-4'-methyl naphtho(2,3:6',5') α-pyrone : 7-Hydroxy-8-formyl-4'-methyl naphtho(2,3:6',5') α-pyrone :

A mixture of 7-hydroxy-4'-methyl naphtho(2,3:6',5') α-pyrone (2 g.) and hexamine (6 g.) in glacial acetic acid (50 ml.) was refluxed directly on a wire gauze for 40 minutes. Hydrochloric acid (20 ml. 1:1) was then added and the heating continued for further 15 minutes. The cream coloured solid obtained on diluting the reaction mixture with ice cold water, crystallised from acetic acid in shining cream coloured plates (0.7 g.), m.p.275°. It gave wine colour with alcoholic ferric chloride.

Analysis : Found : C, 70.73 ; H, 3.77 %.

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.93 %.

Condensation of 7-hydroxy-8-formyl-4'-methyl naphtho (2,3:6',5') α-pyrone with diethyl malonate: 4'-Methyl naphtho(2,3:6',5' and 7,8:6",5") di-α-pyrone-3"carboxylate:

The above formyl derivative (0.5 g.) was dissolved in diethyl malonate (4 ml.) and piperidine(4 drops) was added. The reaction mixture was left overnight and treated with hydrochloric acid (1:1). The product which separated was washed with dilute alkali. It crystallised from dimethyl formamide in pale yellow shining needles(0.25 g.),m.p.293°.

Analysis : Found : C, 68.39 ; H, 3.97 %.

$C_{20}H_{14}O_6$ requires : C, 68.57 ; H, 3.99 %.

Hydrolysis :

The above ester (0.5 g.) was dissolved in glacial acetic acid (60 ml.), to which (30 ml.) conc.hydrochloric acid (A.R.) was added. The mixture was gently refluxed on a wire gauze for 4 hr. The reaction mixture was poured into excess of ice cold water. The solid separated was crystallised from acetic acid, m.p.320°. Yield 0.2 g.

Analysis : Found : C, 66.66 ; H, 3.00 %.

$C_{18}H_{10}O_6$ requires : C, 67.08 ; H, 3.10 %.

Decarboxylation: 4'-Methyl naphtho(2,1:6',5' and 7,8:6",5") di-α-pyrone :

The above acid (0.4 g.) was dissolved in quinoline (10 ml.) to which (0.3 g.) copper bronzewas added. The mixture was refluxed on a wire gauze for 45 minutes. The reaction mixture was filtered hot. The decarboxylated product separated in fine needles. These were washed with hydrochloric acid (1:1). It crystallised from dimethyl formamide in fine wooly needles (0.2 g.), m.p. above 350°.

Analysis : Found : C, 73.05 ; H, 3.37 %.

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

Pechmann condensation of 1,4-dihydroxy naphthalene with ethyl acetoacetate : 4-Hydroxy-4'-methyl naphtho (1,2:6',5')α-pyrone :

1,4-Dihydroxynaphthalene (2 g.) was condensed with ethyl acetoacetate (4 ml.) in the presence of conc.

sulphuric acid (8 ml.). The reaction mixture after keeping overnight was poured in cold water. The separated product was soluble in dilute alkali. It crystallised from acetic acid, m.p.282°. Desai and Sethna[41] reported m.p.285°.

Analysis : Found : C, 74.29 ; H, 4.15 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

The acetyl derivative :

A mixture of 4-hydroxy-4'-methyl naphtho(1,2:6',5') α-pyrone (1 g.), acetic anhydride (5 ml.) and sodium acetate (1.5 g.) was refluxed for 1 1/2 hr. The reaction mixture was poured in ice cold water. The separated product crystallised from ethyl acetate in fine needles, m.p.183°.

Analysis : Found : C, 71.37 ; H, 4.00 %.

$C_{16}H_{12}O_4$ requires : C, 71.64 ; H, 4.47 %.

The above acetoxy derivative (1.5 g.) was intimately mixed with powdered anhydrous aluminium chloride(5 g.) and the mixture was heated in an oil bath for 3 hr. at 140°. The reaction mixture was decomposed with cold dilute hydrochloric acid. The separated product was found to be 4-hydroxy-4'-methyl naphtho(1,2:6',5') α-pyrone on direct comparison.

Formylation of 4-hydroxy-4'-methyl naphtho(1,2:6',5') α-pyrone : 4-Hydroxy-3-formyl-4'-methyl naphtho (1,2:6',5') α-pyrone :

A mixture of 4-hydroxy-4'-methyl naphtho(1,2:6',5')

α-pyrone (1 g.) and hexamine (3 g.) in acetic acid (25 ml.) was heated for 40 minutes. Hydrochloric acid (10 ml. 1:1) was then added and heating was continued for further 15 minutes. The product separated when the reaction mixture was poured in excess of cold water. It crystallised from acetic acid, m.p.232°. The yield was very poor.

It gave a greenish brown colour with alcoholic ferric chloride.

Analysis : Found : C, 70.47 ; H, 3.60 %.

$C_{15}H_{10}O_4$ requires : C, 70.87 ; H, 3.93 %.

Synthesis of 1,4-dihydroxy-2-acetyl naphthalene :

1,4-Dihydroxy naphthalene was acetylated as usual and the diacetoxy derivative (2 g.) was mixed with powdered anhydrous aluminium chloride (6 g.) and the mixture was heated at 140° for 3 hr. The reaction mixture was decomposed with cold hydrochloric acid and the product obtained was taken in sodium hydroxide solution. The product obtained on acidification crystallised from benzene. It gave wine red colour with alcoholic ferric chloride, m.p.215°. Yield 0.6 g.

Analysis : Found : C, 71.61 ; H, 4.73 %.

$C_{12}H_{10}O_3$ requires : C, 71.29 ; H, 4.94 %.

Condensation of 1,4-dihydroxy-2-acetyl naphthalene with diethyl carbonate : 4,4'-Dihydroxy naphtho (1,2:6',5')α-pyrone :

A mixture of 1,4-dihydroxy-2-acetyl naphthalene (1.5 g.), diethyl carbonate (20 ml.) and pulverised

sodium (3 g.) was heated on a steam bath for 10 hr. After cooling the reaction mixture, a little alcohol was added to decompose the unreacted sodium. The reaction mixture was then poured in cold water and then acidified. The solid obtained was taken in conc.sodium bicarbonate solution. The acidification gave a product which crystallised from alcohol, m.p.295° (decomp.). Yield 0.2 g.

Analysis: Found : C, 68.58 ; H, 3.53 %.

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

4-Hydroxy-2-methyl naphtho(1,2:6,5)γ-pyrone :

A mixture of 1,4-dihydroxy naphthalene (1.5 g.) in diphenyl ether (12 ml) and ethyl acetoacetate(4 g.) was refluxed for 2 1/2 hr. Petroleum ether was then added to the reaction mixture after cooling. The solid obtained was soluble in dilute alkali. It crystallised from dimethyl formamide in tiny needles(0.5 g.), m.p.315°.

Analysis : Found : C, 74.04 ; H, 4.03 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

Hydrolysis :

The above γ-pyrone derivative (0.5 g.) was refluxed with sodium hydroxide (20 ml. 20 %) for half an hour. After cooling, the reaction mixture was diluted and acidified. The separated product crystallised from benzene, m.p.215°. Mixed m.p.with 1,4-dihydroxy-2-acetyl naphthalene obtained by Fries migration was not depressed. It gave wine red colour with alcoholic ferric chloride.

5-Hydroxy-2'-methyl naphtho(1,2:6,5')γ-pyrone :

1,5-Dihydroxy naphthalene (2 g.) in diphenyl ether (15 ml.) and ethyl acetoacetate (4 g.) were refluxed for 2 hr. The reaction mixture turned orange after an hour. A crystalline solid separated when the reaction mixture was cooled to room temperature. It crystallised from xylene in shining needles (1.2 g.), m.p.325°.

Analysis Found : C, 74.06 ; H, 4.46 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

7-Hydroxy-2'-methyl naphtho(2,1:6,5')γ-pyrone :

A mixture of 2,7-dihydroxy naphthalene (2 g.) dissolved in diphenyl ether (15 ml.) and ethyl acetoacetate (4 g.) was refluxed for 2 hr. A solid separated on adding petroleum ether to the reaction mixture. It separated from xylene as an orange powder, m.p.285°. Yield 0.5 g. The product was soluble in dil.alkali.

Analysis : Found : C, 74.67 ; H, 4.33 %.

$C_{14}H_{10}O_3$ requires : C, 74.33 ; H, 4.42 %.

Kostanecki-Robinson benzoylation of 1,6-diacetyl-2,7-dihydroxy naphthalene : 2',2''-Diphenyl-3',3''-dibenzoyl naphtho (2,1:6,5' and 7,6:6'',5'')di-γ-pyrone :

An intimate mixture of 1,6-diacetyl-2,7-dihydroxy naphthalene (1 g.) freshly fused sodium benzoate (3 g.) and benzoic anhydride (7 g.) was heated in an oil bath at 190-200° for 10 hr. The reaction mixture was then treated

repeatedly with hot water to remove benzoic anhydride and sodium benzoate and finally washed with sodium bicarbonate solution. The product came out from xylene as yellow powder, m.p.242°. Yield 0.4 g.. The product was insoluble in alkali and did not give any colouration with alcoholic ferric chloride.

Analysis : Found : C, 80.30 ; H, 4.07 %.

$C_{42}H_{24}O_6$ requires : C, 80.76 ; H, 3.84 %.

Attempted hydrolysis of 2',2''-diphenyl-3',3''-dibenzoyl-naphtho(2,1:6',5' and 7,6:6'',5'')di-γ-pyrone :

The above γ-pyrone (0.5 g.) was dissolved in alcohol (100 ml.) and anhydrous sodium carbonate (2 g.) was added and the mixture was refluxed on a steam bath for 4 hr. The solvent was removed and the mixture was diluted with water. The solid obtained was crystallised from xylene. Mixed m.p. of the product with 2',2''-diphenyl-3',3''-dibenzoyl naphthp (2,1:6',5' and 7,6:6'',5'')di-γ-pyrone was not depressed.

Similarly, the original product was obained back when the above γ-pyrone (0.5 g.) in alcohol (100 ml.) was refluxed with alcoholic potassium hydroxide (20 ml.; 5 %) for 2 hr. and working up the reaction as above.

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