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Reaction of Spironaphthalenones with Hydroxylamine Hydrochloride : Part IV[1]

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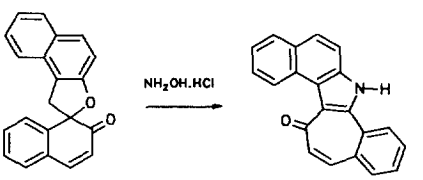
Abstract

Reaction of 1-methoxynaphthalene with 1-formylnaphthalene in presence of n-BuLi/TMEDA, followed by deoxygenation and demethylation gave the bisnaphthol **6**. Oxidation of **6** with KOBr yielded the spironaphthalenones **4a-b** and **5a-b**. The spironaphthalenones **3a-c** on reaction with $NH_2OH.HCl$ gave naphth[2,1-c]isoxazole derivatives **9a-c**. While similar reaction of **4a-b** gave the pyrrolotropones **11a-b**, spironaphthalenones **5a-b** afforded the naphth[1,2-c]isoxazole derivatives **12a-b**.

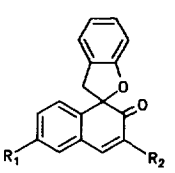
INTRODUCTION

We have recently[1,2] established the mechanism of formation of pyrrolotropone **2** in the reaction of spironaphthalenone **1** with hydroxylamine hydrochloride by trapping the isopyrrole intermediate. It is clear that ring A of the spironaphthalenone **1** is converted to the tropone ring, while the ring B is transformed to the naphthopyrrole system in **2**. In order to generalise this reaction, we have continued the

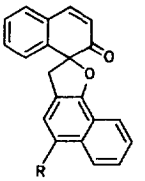


1 2

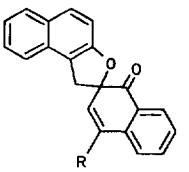
study of this interesting rearrangement reaction with other spironaphthalenones **3**, **4** and **5**. The results obtained in this investigation are discussed below.



3a; $R_1 = R_2 = H$
b; $R_1 = Me$, $R_2 = H$
c; $R_2 = Br$, $R_1 = H$



4a; R = H
b, R = Br



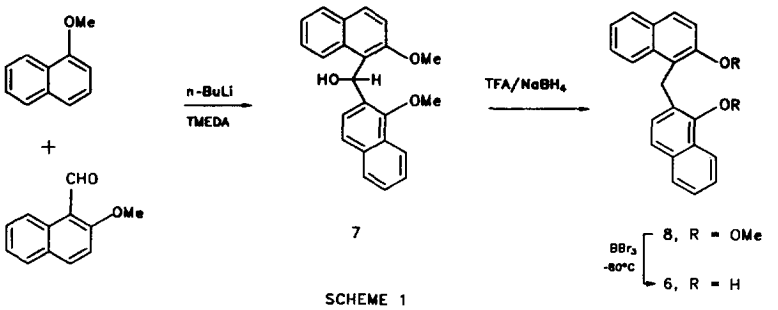
5a; R = H
b, R = Br

RESULTS and DISCUSSION

Synthesis of Spironaphthalenones

Synthesis of spironaphthalenones **3a-c** has already been reported from our laboratory[3].

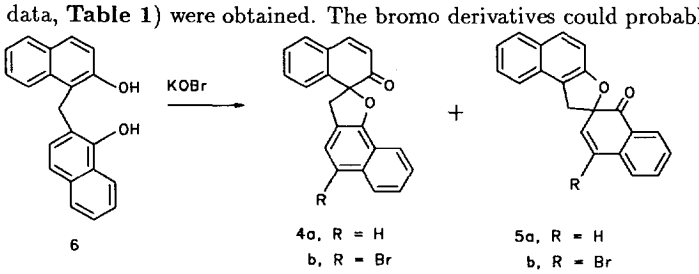
2-Hydroxy-1-naphthyl-1′-hydroxy-2′-naphthylmethane **6** (bisnaphthol) could act as a common precursor for the synthesis of spironaphthalenones **4** and **5** (**Scheme 1**). A solution of 1-formyl-2-methoxynaph-



SCHEME 1

thalene in hexane was added to the anion generated[4] from 1- methoxynaphthalene by reaction of n-BuLi in presence of TMEDA to give the hydroxy compound, **7** [IR: 3300 cm^{-1}; ^1H NMR: δ 4.01 (s, 6H, 2 X OMe), and 4.85 (d, J = 9Hz, 1H)]. Deoxygenation of the hydroxy compound **7** was carried out using Gribble's[5] protocol to give compound **8** which on demethylation with BBr_3 at -80°C gave the bisnaphthol **6** [IR: 3500-3400 cm^{-1}; ^1H NMR: δ 4.56(s, 2H, CH_2), 8.7 (D_2O exchangeable) and 9.5 (D_2O exchangeable)].

Initial attempts at oxidation of bisnaphthol **6** with $K_3Fe(CN)_6$ did not yield any oxidation product. Alternately, KOBr was used for the oxidation of a benzene solution of **6**, when four compounds **4a-b** and **5a-b** (Spectral data, **Table 1**) were obtained. The bromo derivatives could probably be formed by



scheme 2

bromination of the α-naphthol moeity in **6**, prior to oxidation.

Table 1

Compound	IR (cm^{-1})	^1H NMR (doublets, δ)
4a	1762	3.39, 3.95, 6.22
4b	1765	3.38, 3.9, 6.2
5a	1704[6]	3.48, 3.9, 6.42, 6.62
5b	1701[5]	3.6, 3.98

Reaction of Spironaphthalenones with $NH_2OH.HCl$

Reaction of spironaphthalenones **3a-c** with $NH_2OH.HCl$: The reaction of **3a** with hydroxylamine hydrochloride was carried out according to the reported general procedure[2]. After the workup, the residue was purified on column (silica gel, 10% EtOAc-$CHCl_3$) to give a white crystalline solid **A** in 60% yield. [MS: m/e M^+ 261 and analysed for $C_{17}H_{11}NO_2$; IR: 3220-3010 and 1630 cm^{-1}; ^1H NMR : δ 9.1 (s, 1H, D_2O exchangeable), ^{13}C NMR: δ 157.3, 157.8 and 164.6]. The presence of phenolic OH (not -NH)[7] in compound **A** was indicated by benzylation [^1H NMR: δ 5.1 O-$C\underline{H}_2$Ph; ^{13}C NMR: δ 70.2 $\underline{C}H_2$Ph].

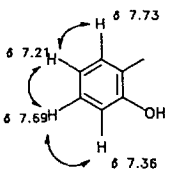
Before arriving at the structure of this compound, the generality of this reaction was studied. Thus, when the reaction of spironaphthalenones **3b-c** was carried out with hydroxylamine hydrochloride, compounds designated **B** and **C** respectively having spectral properties similar to those of **A** (Table 2) were obtained.

Table 2.

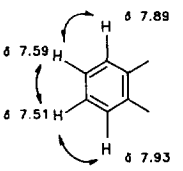
Compound	IR (cm^{-1}	^1H NMR (δ) (D_2O exchangeable proton	^{13}C NMR (δ) downfield carbons	Mass (m/e)
A	3210-3100 & 1630	9.3	157.3, 157.8 & 164.4	261, 233, & 204
B	3210-3100 & 1641	9.3	155, 156.5 & 163	275, 247, 204
C	3200-3100 & 1635	10.1		339(^{79}Br), 260, 232, 204

Structure of Compounds **A, B** and **C** : The spectral data of compounds **A, B** and **C** indicate the presence of a phenolic group, perhaps a C=N moiety and definitely the absence of the carbonyl group (around δ 185 in its ^{13}C NMR). As the NMR spectra of compound **B** was highly resolved, a detailed spectral analyses of this compound was undertaken to elucidate its structure.

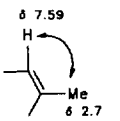
The proton-proton connectivities in the molecule were arrived at with the help of the ^1H-^1H COSY spectrum which indicated the presence of the fragments I, II and III accounting for $C_{15}H_{13}O$. Only three more carbons (quaternary), a nitrogen and an oxygen remain to be accounted.



I

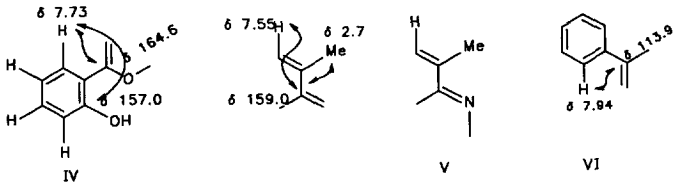


II

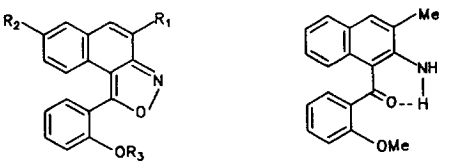


III

A study of the long range heteronuclear shift correlation spectrum, a COLOC spectrum[8], allowed us to extend these fragments to IV, V and VI which together account for all the carbons, hydrogens, nitrogen and oxygens present in the molecule. A logical arrangement of these fragments led us to naphthisoxazole



structure **9b**. Hydrogenolysis[9] of **9d** gave β-aminoketone **10**, corroborating the assigned structure **9b**.



9a; $R_1 = R_2 = R_3 = H$
b; $R_1 = Me$, $R_2 = R_3 = H$
c; $R_2 = Br$, $R_1 = R_3 = H$
d; $R_1 = R_3 = Me$, $R_2 = H$

10

This structure was further confirmed by single crystal X-ray analysis (Fig. 1).

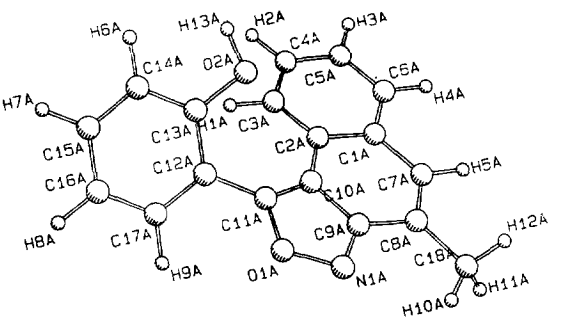


Fig. 1 : PLUTO diagram of **9b**

The assignment of high field ^1H and ^{13}C NMR signals for **9b** is given in Table 3. The carbon-carbon connectivities as seen from the COLOC spectrum are indicated in Fig. 2.

Table 3. High resolution ^1H and ^{13}C NMR assignments of **9b** in acetone-d_6 (δ)

Position	^{13}C	^1H	HC-COLOC ($^3J_{CH}$)
1	164.6	-	C1 → H6′
3a	159.0	-	C3a → H5, H10
4	126	-	C4 → H10 ($^2J_{CH}$)
5	-	7.55	-
5a	133.0	-	C5a → H9
6	132.4	7.89	C6 → H5
7	127.8	7.59	C7 → H9
8	128.0	7.51	C8 → H6
9	-	7.95	-
9a	127.0	-	C9a → H6, H8
9b	113.9	-	C9b → H9
10	16.6	2.7	-
1′	117.0	-	C1′ → H5′
2′	157.0	-	C2′ → H6′
3′	-	7.36	-
4′	133.5	7.69	C4′ → H6′
5′	117.5	7.28	C5′ → H3′
6′	132.2	7.73	C6′ → H4′

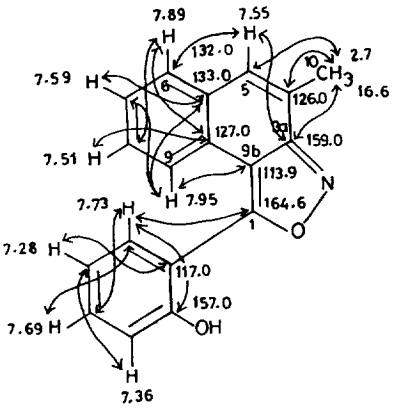
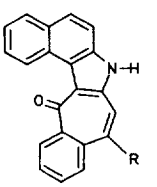


Fig. 2

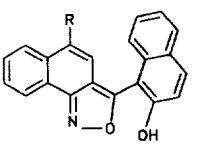
On the basis of structure **9b**, compounds **A** and **C** were assigned the structures **9a** and **9c** respectively.

Reaction of Spironaphthalenones **4a-b** *and* **5a-b** *with* $NH_2OH.HCl$

Spironaphthalenone **4a** reacted with $NH_2OH.HCl$ under the usual reaction conditions to give the pyrrolotropone **11a** [m/e 295 (M^+), 267 (M^+ - CO) analysing for $C_{21}H_{13}NO$; IR: 3300-3200 and 1620 cm^{-1}; ^1H NMR: δ 11.9, (s, D_2O exchangeable, NH); ^{13}C NMR: δ 184.8 (tropone carbonyl)]. Similarly,



11 a, R = H
b, R = Br



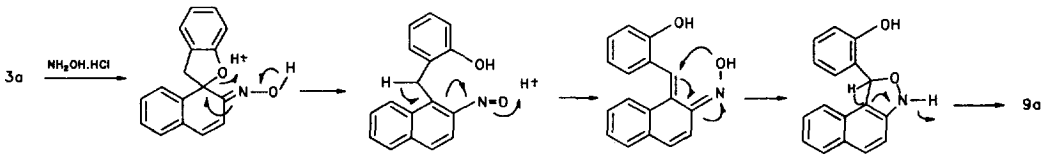
12 a, R = H
b, R = Br

spironaphthalenone **4b** gave the pyrrolotropone **11b** [m/e 373 (M^+, ^{79}Br), 345 (M^+ - CO); IR: 3300-3200 and 1625 cm^{-1}; ^1H NMR: 12.1 (s, D_2O exchangeable, NH)].

Reaction of spironaphthalenone **5a** with hydroxylamine hydrochloride gave a yellow compound [M^+ m/e 311, $C_{21}H_{13}NO_2$, IR 3330 cm^{-1}; ^1H NMR δ 9.93 (s, D_2O exchangeable)] for which the isoxazole structure **12a** was assigned . The presence of the phenolic OH group[7] **12a** in was confirmed by methylation [K_2CO_3, MeI, Acetone; ^1H NMR δ: 3.9 (s, 3H, OMe)]. The methyl derivative **13c** exhibited in its ^{13}C NMR spectrum characteristic downfield signals at 158.1, 161.8 and 164.2. Similarly, the reaction of spironaphthalenone **5b** with hydroxylamine hydrochloride gave the isoxazole derivative **12b** [M^+ m/e 389 (^{79}Br); $C_{21}H_{12}BrNO_2$; ^1H NMR δ 9.85 (s, D_2O exchangeable, 1H)].

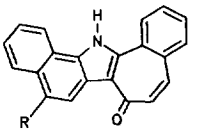
MECHANISM

A plausible mechanism for the formation of the products is depicted in **Scheme 3**. Under the acidic conditions, the furan ring of the initially formed oxime may open up to give a nitroso intermediate which tautomerises to the conjugated oxime. An intramolecular 1,4-addition of -OH followed by aromatisation gives the isoxazole. Formation of the pyrrolotropones **11a-b** instead of the isomeric pyrrolotropone



scheme 3

13a-b as expected from Dean's mechanism, further substantiates the mechanism proposed by us.[2] It



13a-b

is not, however, clear from the above study, why the rearrangemnt reaction should take two different pathways.

Experimental and References

All melting points are uncorrected. IR(cm^{-1}) spectrum were recorded on Perkin-Elmer model 781 spectrophotometer. PMR spectra were recorded on a Bruker AMX-400 or a JEOL FX-90Q FT NMR spectrometer with an operating frequency of 400 and 90 MHz respectively. CMR spectra were recorded on a Bruker AMX-400 or a JEOL FX-90Q FT NMR spectrometer with an operating frequency of 100.2 and 22.49 MHz respectively. MS (70 eV) were recorded on a JEOL MS-DX 303 spectrometer fitted with a built-in direct inlet system.

Reaction of the spiro{naphthalene-1 (2*H*), 2′ (1′*H*)-benzo[2,1-b]furan}- 2-one (3a) with hydroxylamine hydrochloride

To a solution of the spiroketone **3a** (850 mg in 8ml THF) was added a solution of $NH_2OH.HCl$ (1gm in 10ml EtOH) and stirred well. To this was then added two drops of conc. HCl and refluxed for 12 hr. The reaction mixture was then cooled, concentrated and diluted with EtOAc. The organic layer was washed with water, 5 % $NaHCO_3$ solution, water and then dried over an. Na_2SO_4. The solvent was removed *in vacuo* and the residue purified by column (silica gel, 5 % EtOAc - $CHCl_3$) to give 1-(*o*-hydroxyphenyl)- naphth[2,1-c]isoxazole (**9a**) as white solid which was crystallised from acetone to give white crystals. (490 mg). m.p. 184-5 °C ; I.R. (nujol): 3220-3010 and 1630 cm^{-1} ; ^1H NMR (400 MHz, Acetone-d_6) : 7.28 (dt, J = 7.5, 0.75 Hz, 1H), 7.34 (d, J = 8.2 Hz, 1H), 7.59-7.75 (m, 5H), 7.88 (d, J = 9.4 Hz, 1H), 7.98 (d, J = 7.5 Hz, 1H), 7.99 (d, J = 4.8 Hz, 1H), 9.3 (s, D_2O exchangeable, 1H, OH) ; ^{13}C NMR (22.5 MHz, Acetone-d_6) : 113.3, 115.2, 117.1, 117.8, 120.5, 125.4, 127.5, 129.0, 130.1, 131.9, 132.0, 133.4, 135.1, 157.3, 157.8, 164.4 ; MS: m/e 261, 244, 233, 217, 204 ; Anal. Cald. for $C_{17}H_{11}NO_2$, C, 78.6 : H, 4.2 : N, 5.36 % ; Found : C, 77.92 : H, 4.16 : N, 5.31 % .

Benzylation of 9a

To a hexane washed suspension of NaH (60 %, 45 mg) in hexane was added **10a** (240 mg) and stirred for one hr. To this solution under N_2 atmosphere, was added freshly distilled benzyl bromide (188 mg) and stirred overnight. The reaction mixture was then refluxed for one hr. The solvent removed *in vacuo* and the product purified over column (alumina, benzene-hexane, 1:1) to give the O-benzyl derivative as a viscous yellow liquid (210 mg). ^1H NMR (90 MHz, $CDCl_3$) : 5.1 (s, 2H, $\underline{CH_2}$-Ph), 7.1-7.8 (m, 15 H) ; ^{13}C NMR (22.5 MHz, $CDCl_3$) : 70.2, 113.2, 114.3, 118.5, 121.0, 124.1, 126.6, 127.5, 127.7, 128.1, 128.8, 130.8, 131.3, 132.2, 133.8, 136.0, 156.5, 157.0, 162.7 ; MS: m/e 351, 260, 232, 204, 91 ; Anal. Cald. for $C_{24}H_{17}NO_2$; C, 82.05 : H, 4.8 : N, 3.98 % ; Found : C, 82.12 : H, 4.81 : N, 4.1 %.

Reaction of the 3-methyl-spiro{naphthalene-1 (2*H*), 2′ (1′*H*)- benzo[2,1-b]furan}-2-one (3b) with hydroxylamine hydrochloride

To a solution of spiroketone **3b** (500 mg) in 4 ml of THF was added $NH_2OH.HCl$ (416 mg) in 5 ml ethanol and stirred for 5 min. To this was then added 0.3 ml of conc. HCl and refluxed for 12 hr. The usual work up followed by purification on column (silica gel, 5 % EtOAc-$CHCl_3$) gave 4-methyl-1- (*o*-hydroxyphenyl)-naphth[2,1-c]isoxazole (**9b**) as a white solid which was then recrystallised from acetone (280 mg). m.p. 194-5 °C; I.R. (nujol): 3210-3100, 1641 cm^{-1} ; ^1H NMR (400 MHz, Acetone-d_6) : 2.69 (s, 3H, Me), 7.28 (t, J = 7.5 Hz, 1H), 7.35 (d, J = 8.2 Hz, 1H), 7.51 (t, J = 7.3 Hz, 1H), 7.53-7.61 (m, 2H), 7.72 (d, J = 7.6 Hz, 1H), 7.88 (d, J = 7.8 Hz, 1H), 7.92 (d, J = 7.9 Hz, 1H), 9.3 (s, D_2O exchangeable, 1H) ^{13}C NMR (100.6 MHz, Acetone) : 15, 111, 114.6, 115.4, 118.1, 122.7, 123, 124, 125.3, 125.7, 126.8, 128.7, 130, 130.2, 131, 155, 156.5, 163 ; MS: m/e 275, 247, 218, 204 ; Anal. Cald. for $C_{18}H_{13}NO_2$: C, 78.16: H, 4.21 : N, 5.3 % ; Found : C, 78.51 : H, 4.6 : N, 5.16 %.

Reaction of 6-bromo-spiro{naphthalene-1 (2*H*),1′ (2′*H*)- benzo[2,1-b]furan}-2-one (3c) with $NH_2OH.HCl$

To a solution of spiroketone **3c** (450 mg) in 3.5 ml THF was added a solution of $NH_2OH.HCl$ (280 mg) in 4.5 ml EtOH and stirred for 5 min. To this was then added 0.2 ml drop of conc. HCl and refluxed for 12 hr. After the work up as above followed by purification on column (silica gel, chloroform) gave 7-bromo-1- (*o*-hydroxyphenyl)-naphth[2,1-c]isoxazole (**9c**) as a white solid. This was then crystallised from acetone to give colourless crystals (250 mg). m.p. 220-1 °C (decomp.); I.R. (nujol): 3200-3100 and 1635 cm^{-1} ; ^1H NMR (270 MHz, Acetone-d_6) : 7.09 (t, J = 7.4 Hz, 1H), 7.22 (d, J = 8.1 Hz, 1H), 7.48-7.77 (m, 6H), 8.09 (d, J = 1.9 Hz, 1H), 10.1 (s, D_2O exchangeable, 1H, OH) ; MS: m/e 339, 341 (M^+, M^+ + 2), 260, 232, 204 ; Anal. Cald. for $C_{17}H_{10}BrNO_2$: C, 60.0 : H, 2.94 : N, 4.1 % ; Found : C, 59.78 : H, 3.01 : N, 4.08 % .

Synthesis of 1-methoxy-2-naphthyl-2′-methoxy-1′-naphthyl methanol (7)

A solution of 5 gms of 1-methoxynaphthalene in 12 ml cyclohexane was added under N_2 atmosphere to a mixture of 20 ml of 1.6 M n-BuLi in hexane, 3.6 gms TMEDA, and 6 ml of cyclohexane. The mixture was stirred at rt for 2 hr. To this was then added a solution of 2-methoxy-1-naphthaldehyde in hexane and stirred overnight. The reaction mixture was quenched by adding cold solution of dil. HCl and extracted with ether. The ether layer was washed with water, $NaHCO_3$, and H_2O, dried over Na_2SO_4. The solvent was evaporated to give **7** as a yellow viscous oil (7.54 gm); I.R. (neat): 3460 cm^{-1}; ^1H NMR ($CDCl_3$, 90 MHz): 4.01 (s, 6H, 2 × OMe), 4.85 (d, J = 9 Hz, 1H, $\underline{H}$O-C-H), 7.18-7.5 (m, 5H), 7.7-7.9 (m, 3H), 8.1 (d, J = 7.7 Hz, 2H). MS: m/e 344. Anal. Cald. for $C_{23}H_{20}O_3$: C,80.2; H,5.8; Found: C,80.45; H,5.78 %.

Synthesis of 2-methoxy-1-naphthyl-1′-methoxy-2′-naphthyl methane (8)

To a magnetically stirred solution of trifluoroacetic acid (1.5 ml) at 0-5 °C under N_2, was added sodium borohydride (60 mg) over 5 min. and stirred for further 15 min. at 15 °C. To this was then added, dropwise over 10 min., a solution of **7** (100 mg), in dry methylene chloride (10 ml). The deep blue colouration that developed at the junction of two liquids disappeared rapidly. The reaction mixture was further stirred at rt for 10 hr. The trifluoroacetic acid was removed *in vacuo* and the residue taken

up in ether. The ether layer was washed with water, 5% $NaHCO_3$ solution and water. The solvent layer dried over an. Na_2SO_4 and evaporated to give **8** (68 mg). m.p. 91-93°C (benzene- hexane). ^1H NMR (90 MHz, $CDCl_3$): 3.97 (s, 3H, OMe), 4.1 (s, 3H, OMe), 4.7 (s, 2H, CH_2), 6.9 (d, J = 7.9 Hz, 1H), 7.21-8.0 (m, 10H). MS: m/e 328. Anal. Cald. for $C_{23}H_{20}O_2$: C, 84.15; H, 6.1%. Found: C, 84.29; H,6.1%.

Synthesis of 1-hydroxy-2-naphthyl-2′-hydroxy-1′-naphthyl methane (6)

To a solution of dimethoxy compound **8** (412 mg) in methylene chloride at -80°C was added a solution of BBr_3 in methylene chloride (632 mg in 1 ml). The reaction mixture was stirred at the same temperature for 1/2 hr and then allowed to rise to room temperature at which it was further stirred for 2 hr. The reaction was quenched by slow addition of 10% NaOH solution with constant stirring. The alkaline layer was acidified and extracted with ether, washed with 5% $NaHCO_3$ solution, water and dried over an. Na_2SO_4. Evaporation of the solvent gave a solid which was crystallised from EtOAc-hexane to give crystalline **6** (325 mg), m.p. 192-3 °C. I.R. (nujol): 3310 cm^{-1}; ^1H NMR (90 MHz, Acetone-d_6): 4.56 (s, 2H), 7.2-8.4 (m, 12 H), 8.7 (s, D_2O exchangeable, 1H), 9.5 (s, D_2O exchangeable, 1H); MS: m/e 300; Anal. Cald. for $C_{21}H_{16}O_2$: C, 84.0; H,5.3 % ; Found : C, 83.79; H, 5.23 %.

Oxidation of bisnaphthol 6

To a solution of bisnaphthol **6** (1 gm) in 80 ml benzene was added 65 ml of ice cold solution of KOBr (2.25 ml Br_2 in 65 ml 10 % KOH) and stirred for 4 hr. The benzene layer was separated, washed with water and dried over an. Na_2SO_4. The yellow residue obtained after the removal of solvent was separated into four compounds on column (silica gel, benzene). (i) Spiro{naphthalen-1 (2*H*),2′ (1′*H*)-naphtho[1,2-b]furan}-2-one (**4a**, 178 mg) : m.p 123-5 °C; I.R. (nujol): 1675 cm^{-1}; ^1H NMR (90 MHz, $CDCl_3$): 3.39 (d, J = 15.5 Hz, 1H), 3.95 (d, J = 15.5 Hz, 1H), 6.22 (d, J = 10.8 Hz, 1H), 7.2-8.2 (m, 11 H). ^{13}C NMR (22.5 MHz, $CDCl_3$): 44.6, 89.1, 116.0, 120.2, 121.3, 121.8, 122.6, 123.6 (× 2), 125.6 (× 2), 126.0, 127.8, 128.7 (× 2), 129.4, 130.6, 134.3, 143.4, 145.1, 155.5, 197.5; MS: m/e 298, 281; Anal. Cald. for $C_{21}H_{14}O_2$ C, 84.56; H, 4.69 % ; Found : C, 84.50; H, 4.60 % . (ii) 5′-Bromo-spiro{naphthalen- 1 (2*H*),2′ (1′*H*)- naphtho[1,2-b]furan}-2-one (**4b**, 146 mg) : m.p 135-6 °C (chloroform-hexane); I.R. (nujol): 1672 cm^{-1}; ^1H NMR (90 MHz, CDCl3): 3.88 (d, J = 15.5 Hz, 1H), 3.90 (d, J = 16.2 Hz, 1H), 6.20 (d, J = 9.9 Hz, 1H), 7.2-8.2 (m, 10H); ^{13}C NMR (22.5 MHz, $CDCl_3$): 44.2, 89.2, 113.6, 117.3, 121.0, 122.2, 123.3, 125.4, 126.3 (× 2), 127.2 (× 2), 127.4, 128.8, 129.5, 130.6, 131.8, 142.7, 145.3, 155.4, 197.2; MS: m/e 376, 378 (M^+, M^+ + 2), 359, 361; Anal. Cald. for $C_{21}H_{13}BrO_2$: C, 66.8: H, 3.45 % ; Found : C, 66.57, H 3.38 % (iii) Spiro{naphthalene-2(1*H*),2′(2′*H*)-naphtho[2,1-b]furan}-1-one (**5a**, 84 mg) : m.p. 183-4 °C; I.R. (nujol): 1704 cm^{-1}; ^1H NMR (90 MHz, $CDCl_3$): 3.48 (d, J = 15.5 Hz, 1H), 3.9 (d, J = 15.5Hz, 1H), 6.42 (d, J = 9.4 Hz, 1H), 6.62 (d, J = 9.4 Hz, 1H), 7.2-8.1 (m, 10 H); ^{13}C NMR (100.6 MHz, $CDCl_3$): 39.8, 86.8, 112.2, 116.6, 122.6, 123.2, 126.6, 126.9, 127.7, 127.9, 128.7, 128.8, 129.6, 129.7, 130.8, 134.0, 135.2, 137.2, 145.3, 156.8, 196.8 ; MS: m/e 298, 281 ; Anal. Cald. for $C_{21}H_{14}O_2$.; C, 84.56; H, 4.69 % ; Found : C, 84.39; H, 4.59 % . (iv) 4-Bromo-spiro{naphthalen- 2 (1*H*),2′(2′*H*)-naphtho[2,1-b]furan}-1-one (**5b**, 26 mg) : m.p 192-3 °C (chloroform-hexane); I.R. (nujol): 1701 cm^{-1}; ^1H NMR (90 MHz, $CDCl_3$) : 3.6 (d, J = 16.2 Hz, 1H), 3.98 (d, J = 16.2 Hz, 1H), 6.96 (s, 1H), 7.2-8.2 (m, 10 H); MS: m/e 376, 378 (M^+, M^+ + 2), 359, 361. Anal. Cald. for $C_{21}H_{13}BrO_2$; C, 66.8; H, 3.45 % ; Found : C, 66.5 ; H, 3.45 %.

Reaction of 4a with hydroxylamine hydrochloride

To a solution of 150 mg of **4a** in 0.7 ml THF was added 80 mg of $NH_2OH.HCl$ in 1.5 ml EtOH and stirred well. To this was then added a drop of conc. HCl and stirred overnight. The solvent was removed *in vacuo* and the residue taken up in EtOAc. The organic layer was washed with water, 5 % $NaHCO_3$ solution and water and dried over an. $NaSO_4$. After removal of solvent, the residue was purified over PTLC to give 14*H*-benzo[4,5]cyclohepta[1,2-b]naphtho[1,2-d]indole-14- one (**11a**) as a yellow solid which was recrystallised from EtOAc-hexane, (51 mg) . m.p > 360 °C; I.R. (nujol): 3320- 3310 and 1620 cm^{-1} ; ^1H NMR (400 MHz, Acetone-d_6) : 7.55- 7.66 (m, 3H), 7.77 (dt, J = 6.7, 1.4 Hz, 1H), 7.85-95 (m, 3H), 7.97 (m, 2H), 8.02 (d, J = 8.7 Hz, 1H), 8.12 (d, J = 7.2 Hz, 1H), 8.8 (m, 1H), 9.6 (d, J = 8.5 Hz, 1H),

11.9 (s, D_2O exchangeable, 1H, NH); ^{13}C NMR (100.6 MHz, Acetone-d_6) : 111.7, 118.9, 120.4, 120.8, 123.5, 124.5, 126.5 (× 2), 127.8, 128.1, 128.2, 129.7, 129.8, 130.05, 130.07, 131.1, 132.6, 134.6, 138.2, 139.3, 184.8; MS: m/e 295, 267 (M^+ - 28); HRMS cald. for $C_{21}H_{13}NO$ 295.0997. Found 295.0975 .

Reaction of 4b with hydroxylamine hydrochloride

To a solution of 110 mg of **4b** in 0.6 ml THF was added 70 mg of $NH_2OH.HCl$ in EtOH (1 ml) and stirred well. To this was added a drop of conc. HCl and stirred overnight. The workup as above followed by the purification on PTLC gave 9-bromo-14*H*-benzo[4,5]cyclohepta[1,2-b]naphtho[1,2-d]indole- 14-one (**11b**) as a yellow solid which was crystallised from EtOAc-hexane (31 mg). m.p. > 360 °C; I.R. (nujol): 1625 cm^{-1}; ^1H NMR (400 MHz, Acetone-d_6) 7.65 (ddd, J = 8.0, 6.9, 1.1 Hz, 1H), 7.76 (ddd, J = 8.4, 6.9, 1.3 Hz, 1H), 7.91-7.98 (m, 3H), 8.03 (d, J = 8.7 Hz, 1H), 8.1 (d, J = 7.9 Hz, 1H), 8.42 (s, 1H), 8.52 (dd, J = 6.9, 1.8 Hz, 1H), 8.8 (dd, J = 7.2, 1.2 Hz, 1H), 9.32 (d, J = 8.5 Hz, 1H), 12.1 (s, D_2O exchangeable, 1H, NH); MS: m/e 373, 375 (M^+, M^+ + 2), 345, 347 (M^+ - 28); HRMS cald. for $C_{21}H_{12}BrNO$ 373.0102 (^{79}Br). Found 373.0097.

Reaction of 5a with hydroxylamine hydrochloride

To a solution of **5a** (70 mg) in THF (0.5 ml) was added $NH_2OH.HCl$ (60 mg) in EtOH (1 ml). To this was then added a drop of conc. HCl and stirred overnight. The workup as above followed by PTLC gave 3- (2-hydroxy-1-naphthyl)- naphth[1,2-c]isoxazole (**12a**, 48 mg). m.p. 221-2 °C (EtOAc- hexane); I.R. (nujol): 3330 cm^{-1}; ^1H NMR (400 MHz, Acetone-d_6) : 7.72 (d, J = 9.2 Hz, 1H), 7.82 (d, J = 9.2 Hz, 1H), 7.85-7.97 (m, 3H), 8.03 (d, J = 8.3 Hz, 1H), 8.13-8.2 (m, 2H), 8.34 (d, J = 7.9 Hz, 1H), 8.39 (d, J = 8.0 Hz, 1H), 8.51 (d, J = 8.9 Hz, 1H), 9.0 (d, J = 7.2 Hz, 1H), 9.93 (s, D_2O exchangeable, 1H); MS: m/e 311, 283, 254 ; HRMS cald. for $C_{21}H_{13}NO_2$ 311.0946. Found 311.0954.

Methylation of 12a

To a solution of 20 mg of **12a** in an. acetone, was added 1 gm fused K_2CO_3 and 20 mg MeI. The reaction mixture was refluxed for 2 hr. The K_2CO_3 was filtered off and washed thoroughly with acetone. The filtrate was concentrated *in vacuo* and the residue filtered through an alumina column to give the methylated compound, **12c** (19 mg). m.p. 101-2 °C; ^1H NMR (400 MHz, $CDCl_3$) : 3.9 (s, 3H, OMe), 7.12 (d, J = 9.2 Hz, 1H), 7.23 (d, J = 9.2 Hz, 1H), 7.43 (m, 3H), 7.64 (m, 3H), 7.75 (d, J = 6.7 Hz, 1H), 7.88 (d, J = 7.6 Hz, 1H), 8.06 (d, J = 9.1 Hz, 1H), 8.63 (d, J = 6.6 Hz, 1H). ^{13}C NMR (100.6 MHz, $CDCl_3$) : 56.6, 111.7, 113.1, 122.7, 124.2, 124.3, 124.5, 126.3, 127.7, 127.8, 128.2, 128.5, 129.0, 129.6, 132.9, 133.3, 134.1, 156.3, 161.8, 164.0 ; MS: m/e 325.

Reaction of 5b with hydroxylamine Hydrochloride

To a solution of **5b** (30 mg) in 0.2 ml THF was added $NH_2OH.HCl$ (20 mg) in EtOH (0.4 ml) and stirred well. To this was added a drop of conc. HCl and stirred overnight. The usual work up followed by purification on PTLC gave 5- bromo-3- (2-hydroxy-1-naphthyl)-naphth[1,2-c]isoxazole (**12b**) as a yellow compound which was crystallised from EtOAc- hexane (12 mg). m.p. 245-6 °C; I.R. (nujol): 3325 cm^{-1} ; ^1H NMR (400 MHz, Acetone-d_6) : 7.57 (ddd, J = 7.9, 6.8, 1.1 Hz, 1H), 7.61 (d, J = 8.9 Hz, 1H), 7.66 (ddd, J = 8.4, 6.8, 1.3 Hz, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.9 (s, 1H), 7.98 (ddd, J = 7.6, 7.4, 1.2 Hz, 1H), 8.04 (ddd, J = 8.2, 7.3, 1.4 Hz, 1H), 8.1 (d, J = 7.6, 1H), 8.22 (d, J = 9.0 Hz, 1H), 8.76 (dd, J = 7.8, 1.2 Hz, 1H), 9.85 (s, D_2O exchangeable, 1H, OH), MS: m/e 389, 391 (M^+, M^+ + 2), 361, 363, 332, 334, 310 : HRMS cald. for $C_{21}H_{12}BrNO_2$ 389.0052 (for ^{79} Br). Found 389.0073 .

Crystal Structure Determination

Crystal structure of compound 9b

Crystal data: Mol. formula $C_{18}H_{13}NO_2$, M = 275.31, Monoclinic, Space group $P2_1/a$ (#14), a = 7.411 (3) A°, b = 19.079 (6) A°, c = 10.105 (4) A°, b = 100.78° (4), V = 1403.7 (9) A°, Z = 4, d_{cal} = 1.303 g/cm^3, MoKa radiation, lamda = 0.71069 A°. 2766 reflections were collected on a Rigaku ACF5R diffractometer of which 2502 were unique (R_{int} = 0.035). The structure was solved by direct method using SHELX 86[10]. The non-hydrogen atoms were refined anisotropically. The final R and R_w values are 0.0454 and 0.0515 respectively. A perspective view of the molecule drawn with PLUTO[11], is shown in

Fig.1.

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