*Tetrahedron* Vol. 49, No. 1, pp. 135-140, 1993
Printed in Great Britain

0040-4020/93 $5.00+.00


# Reaction of Spironaphthalenones with Hydroxylamine: Part III. A Novel Mechanism for the Formation of Products and Trapping of an Intermediate.

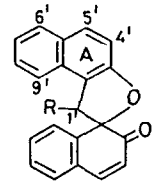
Tirumalai R.Kasturi*, Kaipenchery A.Kumar, Palle V.P.Pragnacharyulu and Gundi Sridevi

Department of Organic Chemistry
Indian Institute of Science
Bangalore - 560 012, India.

(*Received in UK 27 August* 1992)

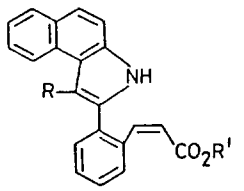
**Abstract** : A mechanism involving the intermediacy of nitrene 5, formed from the oxime of spironaphthalenone 1 by acid catalysed dehydration, has been proposed to explain the formation of pyrrolotropones / pyrrolo esters from spironaphthalenones. The initially formed nitrene rearranges to the isopyrrole 6, which either undergoes sigmatropic migration to the pyrrolotropone 2 or adds alcohol to form the pyrrolo ester depending on substitution at 1' position. The isopyrrole intermediate 6 has been trapped as a Diels-Alder adduct 8.

We have recently[1] provided evidences to show that the mechanism proposed by Dean et.al[2] for the conversion of spironaphthalenone 1a to pyrrolotropone 2 is not correct. Further, we have also reported[3] the



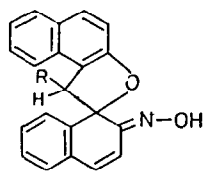
1

a) R = H
b) R = 4-$OCH_3$Ph
c) R = 4-$NO_2$Ph



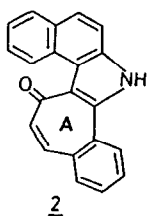
3

a) R = 4-$OCH_3$Ph ; R' = Et
b) R = 4-$NO_2$Ph ; R' = Et

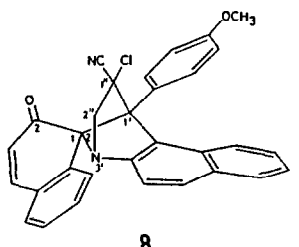


4

a) R = 4-$OCH_3$Ph
b) R = 4-$NO_2$Ph



2

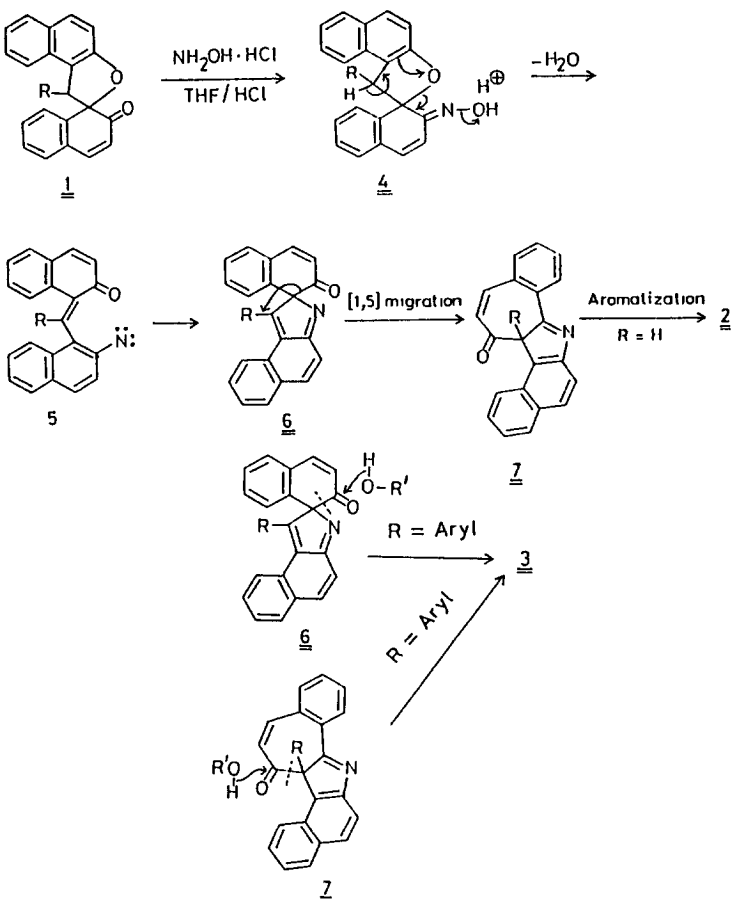


8

Scheme 1

formation of pyrrolo esters 3 (Scheme 1) in the reaction of 1'-aryl substituted spironaphthalenones with hydroxylamine hydrochloride. By using suitable substrates in the reaction, we have shown[1] that the ring A of spironaphthalenone 1 is converted to the tropone ring in 2 and similarly, the ring A of 1'-aryl substituted spironaphthalenone is cleaved[3] to form the $\alpha$ , $\beta$ -unsaturated ester moiety in 3. In order to explain the formation of these products a mechanism invoking a common intermediate is postulated and discussed further in this paper.

The first step in the proposed mechanism is obviously the formation[4] of the oxime 4 from the spironaphthalenone 1. This oxime then undergoes an acid catalysed dehydration to give the nitrene intermediate 5 , which on intramolecular insertion reaction gives the isopyrrole compound 6 . A [1,5] sigmatropic migration of the acyl group in 6 leads to the dihydrotropone intermediate 7 which readily undergoes aromatisation to the pyrrolotropone 2.




Scheme 2

The formation of pyrrolo esters 3 from 1'– aryl substituted spironaphthlenones 1 can also be presumed to follow a similar pathway to give the dihydrotropone 7. As aromatisation of 7 is not feasible, addition of alcohol to 7 followed by a facile bond cleavage would result in the formation of 3 (Scheme 2). Alternatively, this ester 3 could arise by the addition of alcohol to 6 itself.

Nitrenes have been postulated as intermediates[5] in the acid catalysed rearrangement of oximes (Beckmann rearrangement ), and the addition and insertion of nitrenes to suitably oriented groups have also been documented in literature[6]. In the conversion of biphenyl azide to carbazole[7], isopyrrole like intermediates have been postulated. Intramolecular insertion of nitrenes derived from azides to give spiro intermediates are reported[8-10]. Also sigmatropic migration of C-S group[8] or acyl groups[9-11] in such spiro intermediates have been invoked to explain the formation of products. The present postulation of a nitrene intermediate 6 and its insertion followed by acyl migration to give 7 (Scheme 2) has undoubtedly many analogies.

It was not possible to isolate any intermediate in the reaction of spironaphthalenone with hydroxylamine hydrochloride even after stopping the reaction after a very short interval. It is strange that even the oxime could not be isolated. Attempts were then made to trap the isopyrrole intermediate 6 by using suitable dienophiles. No adducts could be isolated when the reaction was carried out in presence of maleic anhydride, diethyl maleate, N-phenymaleimide or dimethyl acetylenedicarboxylate. However, when the reaction of spironaphthalenone **1b** was carried out with hydroxylamine hydrochloride in ethanol in presence of acrylonitrile, we obtained after work up, a white solid ($M^+$ 419, analysing for $C_{28}H_{21}NO_3$ ) in 20% yield in addition to a small amount of pyrrolo ester **3a**[3]. This compound showed no carbonyl absorptions in its IR spectrum. The compound exhibited in its $^1H$ NMR a methoxy signal at $\delta$ 3.62 and a singlet at $\delta$ 5.38 integrating for one proton. Based on the spectral data, this compound was shown to be the oxime **4a**(Scheme 1). This was the first time that an oxime was isolated in these reactions[12]. When the oxime **4a** in THF was refluxed with ethanol containing a trace of acid, we obtained after work up the corresponding ethyl ester[3] **3a** in nearly quantitative yield. This experiment was repeated using **4b** prepared from spironaphthalenone **1c**. In this case also, the pyrrolo ester **3b** was obtained in about 80 % yield.These experiments undoubtedly proved that the formation of the oxime is the first step in this rearrangement reaction and further confirmed our earlier observation[1] that one mole of $NH_2OH.HCl$ is enough to take the reaction to completion.

The oximes, thus prepared, could serve as suitable substrates for carrying out trapping experiments with different dienophiles. Initial experiments with acrylonitrile and diethyl maleate were unsuccessful but when the oxime **4a** was refluxed with excess of 2-chloroacrylonitrile in THF containing a trace of acid, we obtained after careful chromatography and preparative TLC, a yellow compound in very small yield showing IR absorptions at 2180 ( C≡N ) and 1680cm$^{-1}$(unsaturated C=O ). This compound exhibited in its $^{1}$H NMR signals at $\delta$ 3.6 corresponding to methoxy group and a singlet at $\delta$ 1.1 integrating for two protons. Based on these spectral data , the compound was tentatively assigned the structure **8**. The structure of this compound was further confirmed by its mass spectrum which showed an ion at m/e 401 (relative intensity 60% ) corresponding to the retro Diels-Alder fragmentation of compound **8**. The structure of this compound was also further substantiated by its $^{13}$C NMR which showed signals at $\delta$ 56.10 ( $CH_2$), 116.99 ( C≡N ) and $\delta$ 198.76 (unsaturated C=O ). Isolation of the adduct **8** unambiguously proved the postulated intermediacy of isopyrrole **6** in the rearrangement. Thus, the common intermediate **7** can explain the formation of pyrrolotropones or pyrrolo esters depending on the substitution at 1'-position of spironaphthalenones.

Utility of this novel rearrangement in the synthesis of a variety of compounds of possible biological interest is being studied at present.

## EXPERIMENTAL SECTION

All m.ps reported are uncorrected. IR (cm$^{-1}$) spectra were recorded on a Hitachi model 270-50 double wavelength /double beam spectrometer. NMR spectra were recorded on a Jeol FX-90Q(90 MHz) or a Bruker-400(100.62 MHz, $^{13}$C ) instrument using TMS as an internal standard. Mass spectra were recorded on a Jeol MS-DX 303 spectrometer operating at 70 ev and fitted with a builtin-inlet system.

**Oxime of 1'-(4-methoxyphenyl)-spiro[naphthalene-1(2H),2'(1'H)-naphtho[2,1-b] furan]-2-one** ( **4a** ): A solution of $NH_2OH.HCl$ (0.53 gm ) in ethanol (10 ml) was added to a solution of spironaphthalenone **1b** (1 gm) in THF (5 ml) containing acrylonitrile (1 ml). Five drops of conc.HCl was added and the mixture refluxed with stirring for 48 hrs. The reaction mixture was then concentrated and the resulting solid filtered and recrystallised from $CHCl_3$ to give **4a** in 20% yield; m.p. 212°C; IR (nujol) 1630 cm$^{-1}$; $^{1}$H NMR (90 MHz, $CDCl_3$ ) 3.62 (s,3H,$OCH_3$ ), 5.38 (s,1H,benzylic CH), 6.4-7.9 ( m,17H, ArH); MS: m/e 419 ( $M^+$, 25),402 (90) and 283 (100%); Anal. Calcd. for $C_{28}H_{21}NO_3$: C, 80.19; H, 5.01; N, 3.34. Found. C, 80.43; H, 4.46; N, 3.43%.

The filtrate, after purification, gave ester **3a**(50 mg) identified by spectral data[3].

**Oxime of 1'-(4-nitrophenyl)-spiro{naphthalene-1 (2H),2'(1'H)-naphtho[2,1-b] furan }-2-one (4b)**: Reaction of spironaphthalenone **1c** (1 gm) with $NH_2OH.HCl$ (0.52 gm) in THF/ethanol containing acrylonitrile (1 ml) and 5 drops of conc. HCl, followed by workup as mentioned above resulted in **4b** in about 20% yield: m.p. 228°C; IR (nujol) 1632 $cm^{-1}$; $^1H$ NMR (90 MHz, $CDCl_3$ ) 5.43 (s,1H, benzylic CH ), 6.78 (d,J=10 Hz, 1H,∝-styrene), 6.9-8.0 (m, 16H, ArH); MS: m/e (424 $M^+$, 20 ), 417 (60), 282 (100%); Anal. Calcd for $C_{27}H_{18}N_2O_4$: C, 74.65; H,4.14 ; N, 6.45. Found: C, 75.07; H,4.45 ; N, 6.68%.

The filtrate, after purification, gave ester **3b**(35 mg) identified by spectral data[3].

**Reaction of Oxime 4a /4b with ethanol**: A solution of oxime **4a** (100 mg) in THF (3 ml) was refluxed with ethanol containing a drop of conc. HCl for 24 hrs. Solvent removal followed by column chromatography ( silica gel, $CHCl_3$) resulted in the ethyl ester **3a**[3] in quantitative yield. Similarly reaction of oxime **4b** with ethanol resulted in the corresponding ester **3b**[3] in 80 % yield.

**1'-(4-Methoxyphenyl)-1',3'-(1''-chloro-1''-cyanoethano)-spiro{naphthalene-1(2H),2'(1'H)-naphtho[2,1-b]pyrrol}-2-one (8)** : A mixture of oxime **4a** (900 mg) in THF (20 ml) containing 2-chloroacrylonitrile (13 ml) and 6 drops of conc. HCl was refluxed for 48 hrs with stirring. Solvent removal followed by purification of the residue by column chromatography ( silica gel, $CHCl_3$:hexane ) and preparative TLC ( silica gel, $CHCl_3$:hexane ) resulted in compound **8** in 1% yield; m.p. 210°C (d): IR (nujol) 1680 $cm^{-1}$; $^1H$ NMR ( 90 MHz, $CDCl_3$ ); 1.22 (s,2H,$CH_2$), 3.78 (s,3H,$OCH_3$), 6.66-7.90 (m, 16H,ArH); $^{13}C$ NMR (100.62 MHz, $CDCl_3$ ); 55.15, 56.10, 64.08, 96.1, 111.98, 113.11, 113.68, 116.99, 122.98, 123.08, 123.22, 124.97, 126.97, 126.82, 127.64, 128.20, 128.42, 128.67, 128.82, 128.99, 129.99, 130.10, 130.37, 130.79, 130.94, 131.21, 139.06, 145.82, 158.96, 158.65, 198.70; MS: m/e 401 (50 ) 373 (15), 83 (100 %);Anal. Calcd. for $C_{31}H_{21}ClN_2O_2$: C, 76.29; H, 4.30; N, 5.76. Found C, 76.10; H, 4.23; N, 6.16%.

**ACKNOWLEDGMENTS**

We thank Dr. A.Sarkar, NCL, Pune and Dr. K.A.Reddy, REC, Warangal for the analyses reported herein.Thanks are due to SIF, Bangalore for the NMR spectra. We also thank Prof. S.K.Paknikar, University of Goa, Panjim and

Prof. G.S.R. Subba Rao and Dr. A. Srikrishna of our Department for helpful discussions. Financial assistance from Council of Scientific and Industrial Research and Indian National Science Academy, New Delhi is gratefully acknowledged.

**REFERENCES and NOTES**

1. Kasturi,T.R.; Jayaram,S.K.; Pragnacharyulu,P.V.P.; Sattegiri,J.A.; Reddy,G.M.; Ajay Kumar,K. Tetrahedron ( Part I of the series).
2. Dean,F.M.; Fletcher,C.; Locksley,H.D. J.Chem.Soc. **1964**,5096.
3. Kasturi,T.R.; Ajay Kumar,K.; Pragnacharyulu,P.V.P. Tetrahedron (Part II of the Series).
4. The oxime could not be made by the direct reaction of the spironaphthalenone with $NH_2OH$ in ethanol.
5. McCarty,C.J.; in The chemistry of Carbon-Nitrogen double bonds; Patai, S.Ed; Inter science publishers(New York).;pp 408-439.
6. Hobson,J.D.; Malpass,J.R. J.Chem.Soc.,Chem.Commun. **1966**,141.
7. Sundberg,R.J.; Heintzelman,R.W. J.Org.Chem. **1974**, 39,2546.
8. Cadogan,J.I.G.; Kulic,S.; Todd,M.J. J.Chem.Soc.,Chem.Commun. **1968**,736.
9. Kwok,R.; Pranc,P. J.Org.Chem. **1968**, 33,2880.
10. a) Wentrup,C.; in Advances in Heterocyclic Chemistry; Vol 28; Katritzky,A.R.;Boulton,A.J. Ed; Academic Press (New York); pp 231-361.
    b) Zimmer,H.; Downs,B. J.Heterocycl.Chem. **1978**,15,703.
11. a) Murray,A.W.; in Organic Reaction Mechanisms; Knipe,A.C.;Watts,W.E. Ed; John Wiley & Sons (New York).; pp 545-588.
    b) Ranganathan. S.; Panda,C.S. Heterocycles. **1977**,7,529.
12. Other 1'-aryl substituted spironaphthalenones also gave corresponding oximes on refluxion with $NH_2OH.HCl$ in ethanol in presence of acrylonitrile.