THE REACTIONS OF CYCLOPROPENONES AND NITROSOARENES. PART I.

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The chemistry of cyclopropenones has been the subject of intensive investigation in the last few years and the results have been summarized in a recent review.[1] We undertook a study of the reaction of diphenylcyclopropenone (1) with substituted nitrosobenzenes (2) as a potential synthetic route to the unknown mesoionic anhydro-4-hydroxyisoxazolium hydroxides (3)[2] with the ultimate goal of preparing 1,3-bridged mesoionic systems by extending the reaction to compounds such as cycloheptenocyclopropenone.
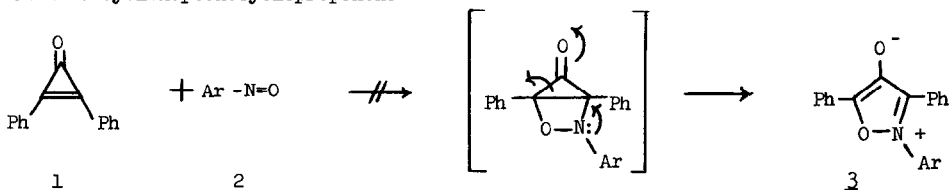
In fact, heating equimolar mixtures of 1 and nitrosoarenes 2(a-e) in refluxing chloroform for 4 days led to addition across the 1,2-bond with formation of 2-aryl-3,4-diphenylisoxazolin-5-ones 4(a-e) (Table 1).[3]
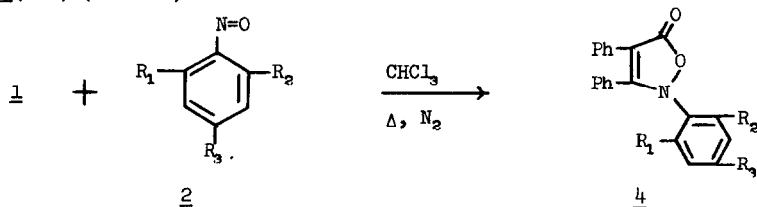

Steric interaction with the C-Ph center of 1 appears to be critical. The reaction with 2b is relatively sluggish and when the bulk of the aromatic substituent on nitrogen is further increased as in 2f and 2g, 5 molar equivalents of nitrosoarene must be added over a 10-day

period to obtain the indicated yields of the corresponding isoxazolinones.

Table 1

Cpd.	R_1	R_2	R_3	mp	ir(CHCl$_3$) cm^{-1}	uv(MeOH) nm (ϵ)	Yield
4a	H	H	H	202-203°	1741	312 (13,000)	32%
4b	CH$_3$	H	H	142-143°	1732	310 (10,000)	49%
4c	CO$_2$C$_2$H$_5$	H	H	112-114°	1730	312 (11,500)	28%
4d	CO$_2$C$_2$H$_5$	H	Cl	135-137°	1738	310 (7,500)	37%
4e	Cl	H	H	184-185°	1740	306 (12,500)	84%
4f	C$_2$H$_5$	H	H	oil	1742	310 (10,500)	23%
4g	Cl	Cl	H	176-177°	1745	306 (13,000)	20%

The infrared absorptions are consistent with those reported for other isoxazolin-5-ones[4] and eliminate the possibility of the isomeric isoxazolin-3-ones which absorb in the 1665-1685 cm^{-1} region[5]. Hydrogenation of 4b gave the expected[4] N-(1,2-diphenylethyl)-2-methylaniline (5), thus ruling out a structure of type 3 in which the phenyl groups are no longer attached to vicinal carbons.
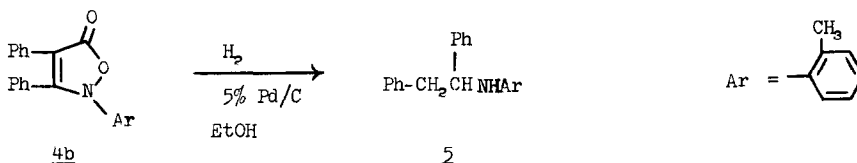

Compound 5 had the following physical and spectral characteristics: mp 93.5-94.5° C; nmr (CDCl$_3$) δ2.02 (3H, s, C$_6$H$_4$CH$_3$), 2.95 and 3.25 (2H, AB portion of ABX system, J$_{AB}$=14 Hz, J$_{AX}$=8 Hz, J$_{BX}$=6 Hz, -CH-CH$_2$-Ph), 4.60 (1H, doublet of doublets, J$_{AX}$=8 Hz, J$_{BX}$=6 Hz, HN-CH-CH$_2$-), 6.2-7.4 (14H, Ar-H); ir (CHCl$_3$) 3430 cm^{-1}; uv (MeOH) λ_{max}=244 nm (ϵ=14,000), 292 nm (ϵ=2,500).

The presence of electron donating substituents in the nitrosoarene altered the course of the reaction. Treatment of 1 with o-nitrosoanisole (6) under the usual conditions gave the novel iminonitrone 7, mp 195-197° C, as the sole adduct in 30% yield (based on nitrosoarene).
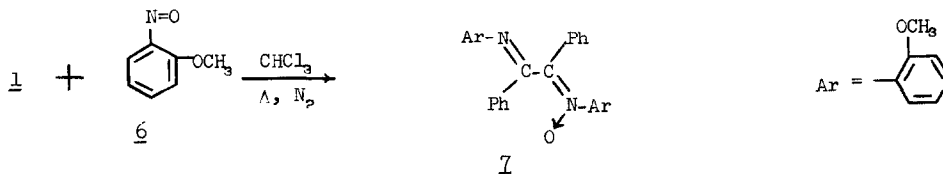
The nmr (CDCl$_3$) spectrum of $\underline{7}$ showed nonequivalent methoxyls as singlets at δ3.30 and 3.55, the ir (CHCl$_3$) exhibited bands at 1610 (C=C), 1592 and 1581 cm^{-1} (C=N), and the uv (MeOH) spectrum had a maximum at 267 nm (ϵ=20,000). While these data are consistent with the proposed structure, they do not exclude a diazetine N-oxide or more extensively rearranged structures which are frequently encountered in nitrosoarene reactions. Accordingly, the structure of $\underline{7}$ was unequivocally established by an X-ray crystallographic examination[6] of its monobromo derivative $\underline{8}$, mp 208-210°C.
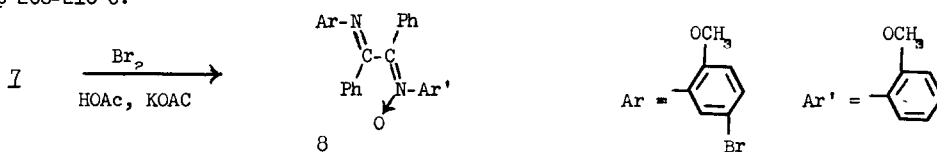
The spectral data for $\underline{8}$ are in complete agreement with its formulation as a simple bromo-substitution product.[7]

The reaction of $\underline{1}$ with p-(N,N-dimethyl)nitrosoaniline ($\underline{9}$) proceeded at room temperature over a 24 hr period to give an analogous iminonitrone ($\underline{10}$), mp 196-198°C and 5-(N,N-dimethyl-amino)-2,3-diphenylindole ($\underline{11}$), mp 165-167°C, in 20 and 21% yields, respectively.
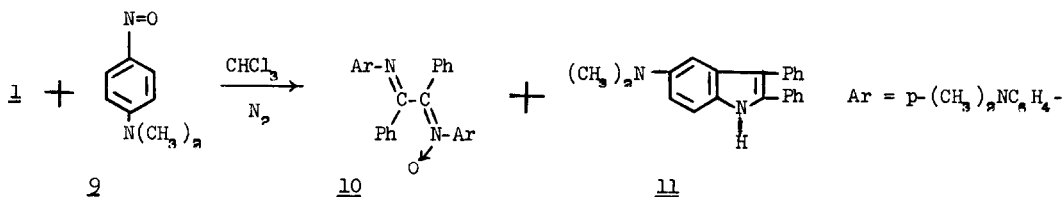
Iminonitrone $\underline{10}$ was obtained as a mixture of isomers whose spectral characteristics closely resemble $\underline{7}$: nmr (DMSO-d$_6$) δ3.80 and 3.85 [singlets totalling 6H, -CN(O)C$_6$H$_4$N(CH$_3$)$_2$], 3.93 (6H, s, CNC$_6$H$_4$N(CH$_3$)$_2$], 6.1-8.4 (18H, Ar-H); ir (CHCl$_3$) 1615, 1588, 1370 cm^{-1}; uv (MeOH) λ_{max}=259 nm (ϵ=32,000), 386 nm (ϵ=15,000). The lability of the nitrone double bond is ascribed to extensive delocalization of the electron pair of the dimethylamino substituent on the iminophenyl ring.

Indole $\underline{11}$ exhibited the expected spectral characteristics and, when treated with methyl iodide, gave a quaternary salt ($\underline{12}$), mp 227-229°C, with physical and spectral properties identical to those of an authentic sample prepared from 2,3-diphenyl-5-nitroindole[8] by reduction with dodecacarbonyltriiron and subsequent exhaustive methylation.

Mechanistically, cycloadditions involving heteroatom attack at C-1 and C-2 of cyclopropenones are well known.[1,9] Nucleophilic additions initiated by both nitrogen and oxygen have been described for nitrosoarenes.[10] The present results can best be interpreted in terms of oxygen initiated attack at C-1 of diphenylcyclopropenone as outlined in Scheme 1. The presence of

powerful electron donating substituents in the nitrosoarene can reasonably be expected to accel

erate the rate of attack by oxygen and to stabilize the intermediate i to the extent that inter

molecular reactions intervene (path b) or cyclization occurs at the ortho position of the now

more electrophilic phenyl ring (path c) in preference to nucleophilic ring closure at nitrogen

(path a). The driving force for decomposition of iib and iiib is cleavage of very weak

nitrogen-oxygen bonds, while rearomatization causes the rearrangement of iic.

Further experiments are in progress to provide additional insight into the scope and

mechanistic details of these reactions.

Scheme 1

References and Notes
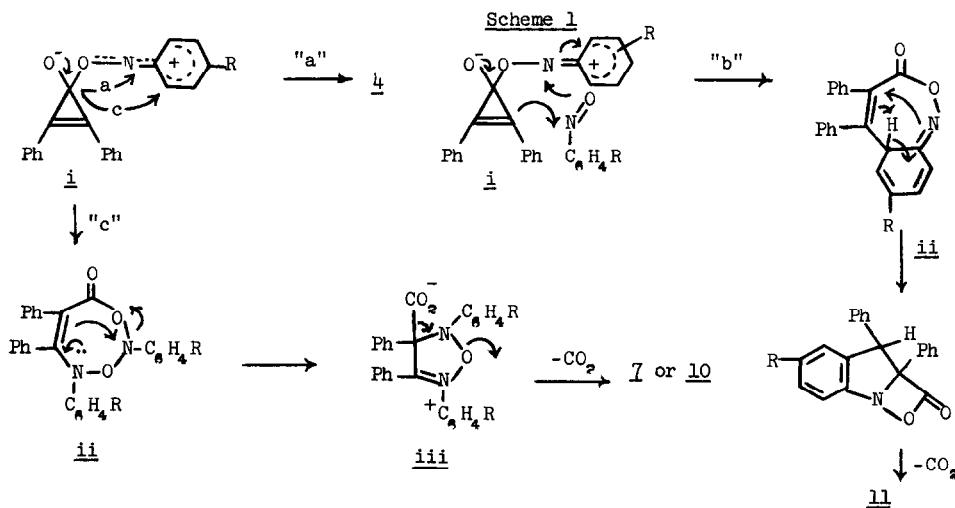
1. K. T. Potts and J. S. Baum, Chem. Reviews, 74, 189 (1974).

2. (a) M. J. Nye and W. P. Tang, Tetrahedron, 28, 455 (1972); (b) G. Boyd and T. Norris, JCS Perkin I, 1028 (1974).

3. Satisfactory elemental analyses have been obtained for all compounds reported here.

4. F. De Sarlo, L. Fabbrini and G. Renzi, Tetrahedron, 22, 2989 (1966).

5. N. Nakamura, Y. Kishida and N. Ishida, Chem. Pharm. Bull. (Tokyo), 19, 1389 (1971).

6. This study was carried out by Professor J. Brown, Dr. Roy Bible and Patricia Green.

7. nmr (DMSO-d_6) δ3.34 (3H, s, -OCH$_3$), 3.62 (3H, s, -OCH$_3$); ir (KBr) 1610, 1580, and 1550 cm^{-1}; uv (MeOH) λ_{max}=270 nm (ϵ=21,000); ms m/e=516, 514 (M$^+$), 485, 483, 469, 467, 379, 377, 210 (base). Compound 7: ms m/e=436 (M$^+$), 405, 299, 210 (base).

8. R. C. G. Fennell and S. G. P. Plant, J. Chem. Soc., 135, 2872 (1932).

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