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MECHANISMS OF THE REACTIONS OF SUBSTITUTED ISO-QUINOLINE AND QUINOLINE N-OXIDES WITH ARENESULFONYL CHLORIDES[1]

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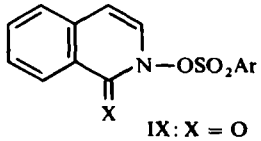
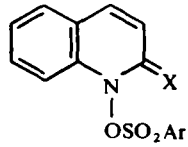
Abstract—The rearrangements of substituted iso-quinoline and quinoline N-oxides with arenesulfonyl chlorides have been carried out to clarify the mode of migration of the arenesulfonoxy group by means of both ^{18}O tracer and kinetic experiments. In the rearrangements of N-arenesulfonoxy-iso-carbostyril and carbostyril, the main migration route of the arenesulfonoxy group is *via* the solvent separated ion pair path with a minor portion passing through the oxygen-bridged ion pair process and the rate-determining step appears to be N—O bond cleavage. For 1-amino-iso-quinoline N-oxide the migration of tosyloxy group to 1-amino-4-tosyloxyiso-quinoline through the oxygen-bridged ion pair pathway is so fast that the presence of the anhydro base cannot be detected. Reaction of 2-aminoquinoline N-oxide to afford 2-amino-6-tosyloxyquinoline which involves migration to a distant position proceeds rapidly, apparently through the solvent separated ion pair path.

THE REACTIONS of pyridine, quinoline and iso-quinoline N-oxides having active Me or $phCH_2$ groups with Ac_2O[2] were suggested either to proceed *via* the anhydro base intermediates which result from the rate-determining proton-removal or to have rate-determining N—O bond cleavages after reversible proton-removals. "Anhydro bases", *i.e.*, neutral spieces are generally accepted as the key intermediates in these migration reactions. Previously the reaction between iso-quinoline N-oxide and arenesulfonyl chloride[3] to afford 4-arenesulfonoxy-iso-quinoline has been suggested to proceed *via* the oxygen-bridged ion pair pathway that involves a rate-determining N—O bond cleavage from the anhydro base analogue (XII) on the basis of ^{18}O tracer and kinetic experiments.

We have been interested in the reactions of N-hydroxy-iso-carbostyril (I),[4] N-hydroxycarbostyril (II),[5] 1-amino-iso-quinoline N-oxide (III) and 2-aminoquinoline N-oxide (IV)[6] with arenesulfonyl chlorides to afford 4-arenesulfonoxy-iso-carbostyril (V), 8-arenesulfonoxycarbostyril (VI), 4-arenesulfonoxy-1-amino-iso-quinoline (VII) and 6-arenesulfonoxy-2-aminoquinoline (VIII), respectively since careful examination of the mechanisms of these reactions would lead to a better understanding of the nature of α,γ-arenesulfonoxy migration in these hetero-aromatic systems. In these rearrangements, the structures of anhydro bases and their analogues are considered as shown below.



IX: X = O
X: X = NH
XI: X = CH_2
XII: X = H, Cl



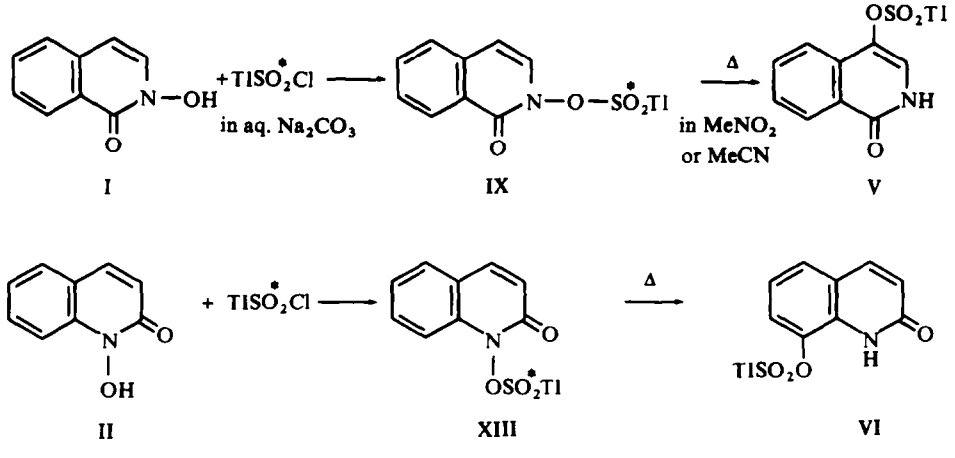
XIII: X = O
XIV: X = NH
XV: X = CH_2

Similar reactions[7] of 1-methyl-iso-quinoline and quinaldine N-oxides with arenesulfonyl chlorides, however, give chlorination products of the Me groups apparently through the formation of anhydro bases, XI and XV do not afford any arenesulfonoxy-migrated compound. Koenig and Wieczorek[8] found that treatment of 2-picoline N-oxide with trichloroacetyl chloride gave 2-pyridylmethyl chloride and CO_2 in high yield and proposed that 2-pyridylmethyl chloride results from the subsequent reaction between the expected trichloroacetate and chloride ion. In reactions of 1-methylisoquinoline and quinaldine N-oxides with arenesulfonyl chloride, however, side-chain chlorination is considered to take place directly from the anhydro bases XI and XV, since no methylene sulfonate esters could be isolated. Meanwhile, N-arenesulfonoxy-iso-carbostyril (IX) and N-arenesulfonoxy-carbostyril (XIII) are known to be quite stable and can be isolated, and hence can serve as a model for anhydro bases for studying the nature of the α,γ-migrations of arenesulfonoxy groups. Katritzky *et al.*[9] suggested that the reactions of 2- and 4-aminopyridine N-oxides with acylating agents afforded N-acylated products with the exception of O-acylation by BzCl, but the treatment of this O-benzoate compound with Na_2CO_3, gave the acyl-transfer compound, 2-benzoylaminopyridine N-oxide. They did not detect the benzoyloxy-migrated product.

In the reactions of III and IV with TsCl, stable O-acylated salts were nicely isolated and treatment of these salts with base *i.e.*, Et_3N, 2,6-lutidine or aniline, gave the tosyloxy migration products (VII and VIII) probably through the intermediate X and XIV, however, migration of the tosyloxy group from the anhydro base analogues (X or XIV) was so fast that the existence of anhydro base could not be detected. In order to disclose the mode of the migrations of arenesulfonoxy groups and the stabilities of these anhydro bases, ^{18}O tracer and kinetic experiments were carried out.

N-*Hydroxy-iso-carbostyril* (I) *and* N-*hydroxycarbostyril* (II)

Upon treatments of I and II with uniformly ^{18}O-labeled TsCl under usual Schötten–Baumann conditions, the respective N-tosyloxy derivatives IX and XIII were obtained in fairly good yields. These N-tosyloxy compounds were then heated in nitromethane or MeCN and the rearranged products, *i.e.*, 4-tosyloxy-iso-carbostyril (V) and 8-tosyloxy-carbostyril (VI) were obtained.



In order to improve the accuracy of the ^{18}O-tracer experiments, the carbonyl group in the products was converted into a chloro group; 1-chloro-4-tosyloxy-iso-quinoline and 2-chloro-8-tosyloxyquinoline thus obtained were hydrolyzed in EtOH containing KOH and 1-chloro-4-hydroxy-iso-quinoline and 2-chloro-8-hydroxyquinoline formed were subjected together with the tosylates to the routine ^{18}O-analysis[10] to determine the ^{18}O content of the etheral oxygen in the respective compounds. The ^{18}O analytical results of the starting materials, the tosylates and hydrolyzed products are shown in Tables 1 and 2. When the ^{18}O-labeled N-tosyloxy-iso-carbostyril (mean value 0·65% of excess atom % ^{18}O) was treated as usual in the presence of an equimolar amount of non-labeled tetra-n-butyl-ammonium tosylate (0·00), the rearrangement product obtained was found to contain 0·52% of excess ^{18}O.

TABLE 1 ^{18}O ANALYTICAL RESULTS OF THE REACTION OF N-TOSYLOXYISOCARBOSTYRIL

Compound/solvent. temp.	$MeNO_2$. 80–90°		MeCN. reflux	
	Excess atom % ^{18}O (calc.)			
N-Tosyloxyisocarbostyril (IX)	0·70	(0·72)	0·65	(0·67)
4-Tosyloxyisocarbostyril (V)	0·73	(0·72)	0·64	(0·67)
1-Chloro-4-tosyloxyisoquinoline	0·80*	(0·95)	0·85	(0·89)
1-Chloro-4-hydroxyisoquinoline	0·74		0·66	
p-Tosyl chloride	1·43		1·33	

* Contaminated with a small amount of original carbonyl compound.

TABLE 2. ^{18}O ANALYTICAL RESULTS OF THE REACTION OF N-TOSYLOXYCARBOSTYRIL

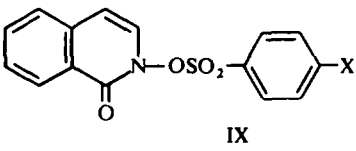
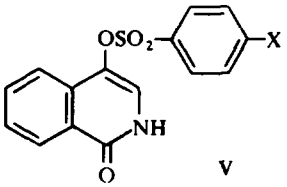
Compound/solvent.temp.	$MeNO_2$ 80–90°
	Excess atom % ^{18}O (calc)
N-Tosyloxycarbostyril (XIII)	0·71 (0·72)
8-Tosyloxycarbostyril (VI)	0·69 (0·72)
2-Chloro-8-tosyloxyquinoline	0·90 (0·95)
2-Chloro-8-hydroxyquinoline	0·73
p-Tosyl chloride	1·43

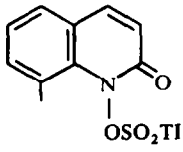
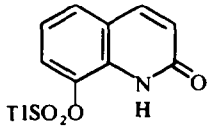
Inspection of these ^{18}O analytical results seems to suggest that the main route of the migration of the tosyloxy group is *via* the solvent separated ion pair path with a minor portion passing through the oxygen-bridged ion pair process in both reactions of IX and XIII.

N-(*p*-Substituted benzenesulfonoxy)-iso-carbostyril (IX) and N-tosyloxycarbostyril (XIII) were synthesized similarly and the rate constants of migration were determined photometrically following the change of the respective UV absorption peak.

A few pertinent physical properties, such as m.ps and maximum absorption of UV of both N-arenesulfonoxy derivatives IX and XIII and rearranged products V and VI are summarized in Table 3.

TABLE 3. PHYSICAL PROPERTIES OF IX, XIII, V AND VI

		m.p.	IR	SO_2 cm^{-1}	λ_{max}	(mμ)ε
 IX	X = MeO	129·5–130·5°	1198	1380	331	4390
	Me	206·5–207°	1200	1392	322	4100
	H	110 –111°	1195	1394	301	4210
	Cl	217 –218°	1200	1398	335·5	4200
	NO_2	105·5–106°	1196	1410	345	4540
 V	X = MeO	185 –186·5°	1190	1372		
	Me	207 –208·5°	1182	1375		
	H	196 –197°	1192	1375		
	Cl	227 –228·5°	1190	1360		

	m.p.	λ_{max}(mμ)	ε	IR	SO_2
 XIII	142–143°	327	4700	1168	1344
 VI	209–210°	332	3550	1170.1185. 1370	

The kinetic measurements were performed by following the UV absorption peak of the remaining unreacted N-oxide (λ_{max}327 mμ ε = 7000 in 5% KOH—MeOH(30)—H_2O(70)) after quenching the mixture. Good first order kinetic behaviour was observed for each compound, and the rate constants for migration are shown in Table 4.

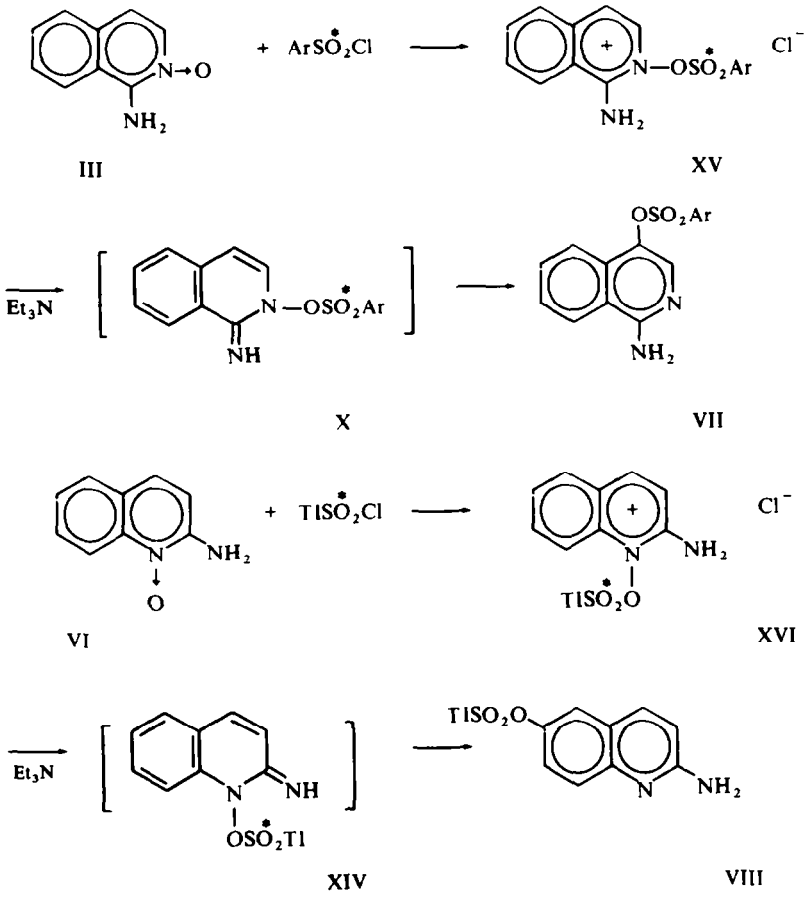
Activation parameters are Ea = 28·0 Kcal/mole, $\Delta S^{\ddagger}$ = +13·4 e.u. for N-tosyloxy-iso-carbostyril and Ea = 27·1 Kcal/mole, $\Delta S^{\ddagger}$ = +9·5 e.u. for N-tosyloxycarbostyril. The Hammett ρ value (ρ_σ = +1·6) and these activation parameters seem to suggest the rate-determining step to be the N—O bond cleavage similar to the S_N1 process in solvolytic reactions[11] and the reaction[3] of isoquinoline N-oxide with arenesulfonyl chloride in which ρ was found to be 1·9.

TABLE 4. MIGRATION-RATE CONSTANTS

p-Substituent	$k_1 \times 10^5$ sec^{-1}	
MeO of IX	4·33	
Me of IX	6·93	
H of IX	11·6	
Cl of IX	30·9	Temp.: 60·0°
NO_2 of IX	154	(N—OSO_2Ar) = 7 × 10^{-4} mole/l
Me of XIII	4·08	Solvent: MeCN

1-Amino-iso-quinoline N-*oxide* (III) *and 2-aminoquinoline* N-*oxide* (IV)

1-amino-iso-quinoline (III) and 2-aminoquinoline N-oxides (IV) were treated similarly with uniformly ^{18}O-labeled TsCl and BsCl and 1-amino-N-arenesulfonoxy-iso-quinolinium chloride (XV) and 2-amino-N-tosyloxyquinolinium chloride (XVI) were obtained quantitatively. The rearrangement reaction of these salts (XV and XVI) were carried out in MeCN containing Et_3N and rearranged products VII and VIII were identified from IR. UV and NMR.



The ^{18}O distributions of the products are shown in Table 5 and 6.

While the reaction of 2-aminoquinoline N-oxide (IV) with TsCl which involves the migration of TsO group to a distant position proceeds through the solvent separated ion pair path, the rearrangements in the reaction of 1-amino-iso-quinoline N-oxide (III) with TsCl proceed apparently *via* the oxygen-bridged ion pair pathway as in the case of iso-quinoline N-oxide. However, with BsCl, the solvent separated ion pair process appears to be contributing to this rearrangement though in minor extent.

The difference in the modes of migrations between I and III are believed to be due either to the stability of the anhydro base or the difference in rate-determining steps

TABLE 5. ^{18}O ANALYTICAL RESULTS. REACTIONS OF 1-AMINO-ISO-QUINOLINE N-OXIDE AND ARENESULFONYL-CHLORIDE IN MeCN

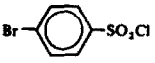
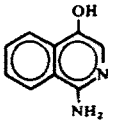
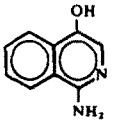
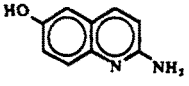
Compound	excess atom % ^{18}O	Compound	excess atom % ^{18}O
$TlSO_2Cl$	1·39		1·20
XV	0·82 (0·89)	XV	0·71 (0·80)
VII	0·90 (0·89)	VII	0·77 (0·80)
	0·01		0·06

TABLE 6. ^{18}O ANALYTICAL RESULTS, REACTIONS OF 2-AMINO-QUINOLINE N-OXIDE AND TOSYL CHLORIDE IN MeCN

Compound	excess atom % ^{18}O
$TlSO_2Cl$	1·29
XVI	0·70
VIII	0·86 (0·86)
	0·78

for the two compounds or both In the case of the amino derivatives III and IV, stable N-tosyloxy salts XV and XVI can be isolated nicely, however, the anhydro base analogues (X and XIV) cannot be detected even under the UV conditions.

Their physical properties are summarized in Table 7. Upon addition of an equimolar amount of base, *e.g.* Et_3N, 2,6-lutidine or aniline, to the diluted MeCN solution of the salt (XV or XVI), the UV absorption changes immediately to that of the rearranged product peak (VII or VIII) as shown in Fig. 1 and 2.

TABLE 7. PHYSICAL PROPERTIES OF XV, XVI, VII AND VIII

Compounds	m.p.	λ_{max}(mμ)	ε
XV	230–231·5° (decomp.) gradually	335	6800
XVI	over 230° (decomp.)	333	6400
VII	177·5–179°	311	8100
VIII	203·5–204°	337	5600

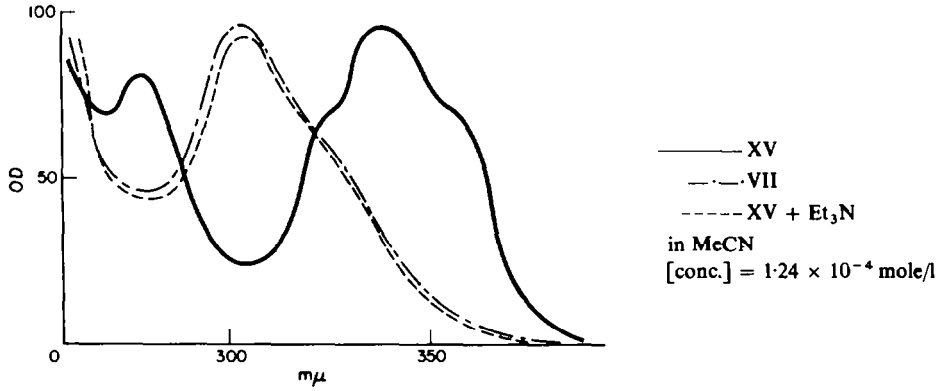


FIG 1. UV Absorption Spectra

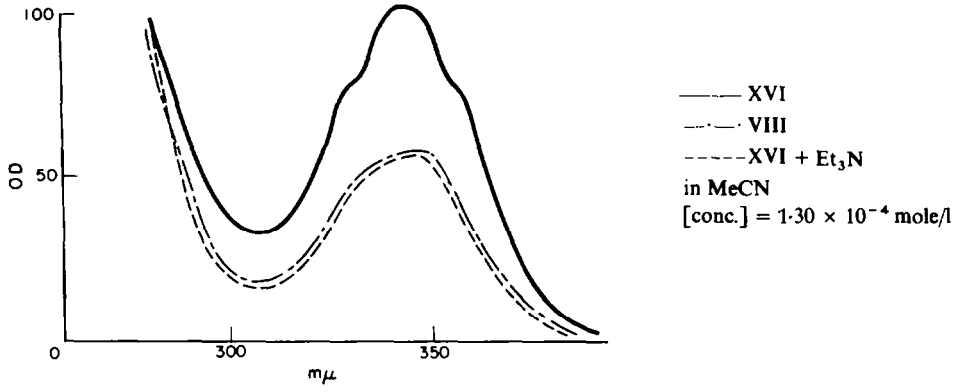


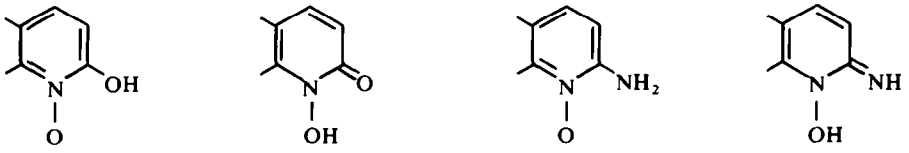
FIG 2. UV Absorption Spectra

In the absence of base the rearrangement reaction does not proceed at all. If the base concentration is not sufficient to complete the reaction, only a partially rearranged peak is observed. These remarkably rapid reactions could be caused by the facile proton-transfer from the amino cation (XV or XVI) to the bases, and the migration of TsO group from the anhydro base (X or XIV) to the product through the oxygen-bridged ion pair pathway is also so fast that the presence of the anhydro base cannot be detected.

DISCUSSION

The IR spectrum[12] of 2-hydroxyquinoline N-oxide has been interpreted as that of the oxo form (structure II) and a similar view has been expressed for that of 1-hydroxy-iso-quinoline N-oxide (I).[13] When these α-hydroxy N-oxides having the oxo tautomeric forms are reacted with acylating agents, N-acyloxy compounds are generally obtained.[14]

Physical data show that the amino substituted N-oxides exist predominantly in the amino tautomeric form (III and IV) and the amino N-oxides generally react with alkylating agents at the N-oxide oxygen atom.[16] Jones and Katritzky showed that 2- and 4-amino- and 2- and 4-methylaminopyridine N-oxides undergo acetylation and benzoxylation to yield products acylated at the amino nitrogen atom. However, in the case of 2-aminopyridine N-oxide, a labile O-benzoate, which readily rearranges to the N-benzoyl derivatives, can be isolated. A similar observation was found in the reaction of 1-amino-iso-quinoline N-oxide with benzoyl chloride. 1-Amino-N-benzoyloxy iso-quinolinium chloride, precipitated upon treatment of

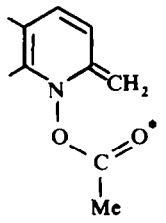


III with benzoyl chloride in MeCN, was treated with Et_3N, and then the N-benzoyl derivative, formed by the benzoyl-transfer from oxygen to nitrogen, was obtained without any formation of the nuclear rearranged products of benzoyloxy group.

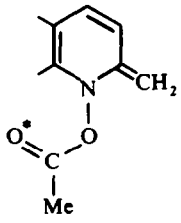
Differences of the tautomeric oxo forms and amino forms in the starting N-oxides (I. II. III and IV) seem to be caused mainly by differences in stabilities of the anhydro base analogues (IX. X. XIII and XIV).

On the other hand, among the ion pair species formed by the cleavage of N—O bonds of the anhydro base analogues, 1-imino-iso-quinolinium and 2-iminoquinolinium cations would be more stable than 1-oxo-iso-quinolinium and 2-oxoquinolinium cations respectively because of the difference of electron-negativities of nitrogen and oxygen atoms. However, the experimental data from both ^{18}O tracer and kinetic experiments indicate that the migration of the TsO group, (which proceeds through the oxygen-bridged ion pair pathway similar to the reaction of iso-quinoline N-oxide with arenesulfonyl chlorides) in the reaction of 1-amino-iso-quinoline N-oxide with TsCl is so fast that the presence of the anhydro base analogue (X) cannot be detected. This means that the proton-transfer from the amino cation (XV or XVI) to base is an important step but not considered to be the rate-determining step, while the heterolytic N—O bond cleavage of the anhydro base analogues (X or XIV) should be the rate-determining step. The migration of the TsO group through the oxygen-bridge ion pair pathway in the reaction of III is presumed to proceed *via* the unstable anhydro base intermediate which would be just as unstable as 1-methylene-N-arene-sulfonoxy-iso-quinoline (XI) and 1-imino-N-arenesulfonoxy-iso-quinoline (X). Because of the instability of the anhydro base analogue (X), a facile N—O bond cleavage should occur without much activation energy and the recombination to form the product (VII) is also considered to be so fast that there would not be enough time for the sulfonoxy group to equilibrate and hence the oxygen atom that is relatively closer to the carbon atom of 4-position would have a better chance of combining to become the etheral oxygen (XVII).

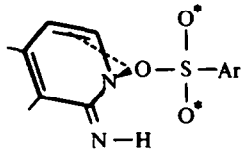
In our previous work[17] concerning the uneven distributions of ^{18}O in the resulting esters formed in the reactions of 2-picoline, 2,6-lutidine and quinaldine N-oxides with Ac_2O, the ^{18}O distribution patterns were explained in terms of the conformational stabilities of the intermediates (anhydro bases XVIII or XIX).



XVIII

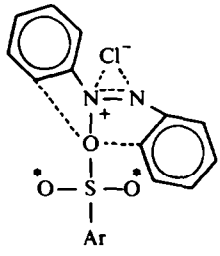


XIX

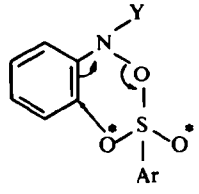


XVII

In addition to these hetero-aromatic systems, acyloxy derivatives of aromatic tertiary amines undergo interesting molecular rearrangements. We proposed on the basis of ^{14}C and ^{18}O tracer experiments that in the reactions[18] of azoxybenzene with *p*-bromo- and *p*-nitro-benzenesulfonyl chlorides the main route of migration of the sulfonoxy groups is the sliding shift (XIX) of the azoxy-oxygen atom to the Ph ring attached to the azo side.



XIX



XX

Tisue *et al.*[19] found that in the rearrangement of N-benzoylphenylhydroxylamine with *p*-nitrobenzenesulfonyl chloride the oxygen atom migrating to the aniline ring comes exclusively from the sulfonyl group of the sulfonyl chloride, and then suggested the concerted cyclic mechanism XX. These two reactions are quite different in the modes of migration of sulfonoxy groups, but these five- or six-membered cyclic transition states have configurational closeness between the bond-forming oxygens and its carbons at the migrating position. Therefore, the recombination after the facile N—O bond cleavage would be so fast that no scramble of ^{18}O was observed.

However, the migrations of carboxy groups in the reactions[20] of phenylhydroxylamines with acyl chlorides proceed through a solvent separated ion pair process, due mainly to the fact that the N—O bond in carboxy derivatives would be stronger than that in the sulfonated derivatives and require much more activation energy to cleave it.

Since the anhydro base analogues IX, XIII are quite stable, they rearrange only upon heating. On the basis of the Hammett ρ value and the magnitude of the activation parameters the rearrangement reactions of IX and XIII are considered to proceed *via* the rate-determining N—O bond cleavage, similar to the S_Ni process in solvolytic reactions. Additional evidence to support the rate-determining N—O bond cleavage

may be found in that when N-benzoyloxy-iso-carbostyril[4] was heated alone to 180°, some decomposition occurred, but only the starting material could be recovered, while a similar result was obtained with N-benzoyloxycarbostyril.[5] When N-(*p*-nitro-benzoyloxy)-iso-carbostyril having a good leaving group was heated in refluxing MeCN or $MeNO_2$, no rearranged product was detected and the IR spectrum and m.p. of the isolated mixture showed only those of the recovered starting material. The N—O linkage in IX should be stronger than that in X because of the larger electronnegativity of the oxygen atom than the nitrogen atom, therefore, the cleavage of the N—O bond of IX to form the isocarbostyril cation and arenesulfonate anion would require more activation energy than that of X and hence migration of the arenesulfonoxy group would proceed *via* the solvent ion pair process.

EXPERIMENTAL

The preparations of N-hydroxy-iso-carbostyril (I), N-hydroxycarbostyril (II), 1-amino-iso-quinoline N-oxide (III) and 2-aminoquinoline N-oxide (IV) were carried out according to the literature.[21] *p*-Toluenesulfonyl and *p*-bromobenzenesulfonyl chlorides, ^{18}O-labeled, were prepared similarly according to the method reported in the previous paper.[10]

^{18}O Analyses were done as usual.[10] and the ^{18}O analytical results of these esters and hydrolyzed compounds are listed in Table 1, 2, 5 and 6.

The kinetic measurements of the rearrangement reaction of IX and XIII were performed as reported,[3] namely following the UV absorption peak of the N-oxide (λ_{max} 327 mμ of IX and λ_{max} 322 mμ of XIII) after quenching the mixture. A good first order behaviour was observed in each case, and a typical run is shown in Fig. 3.

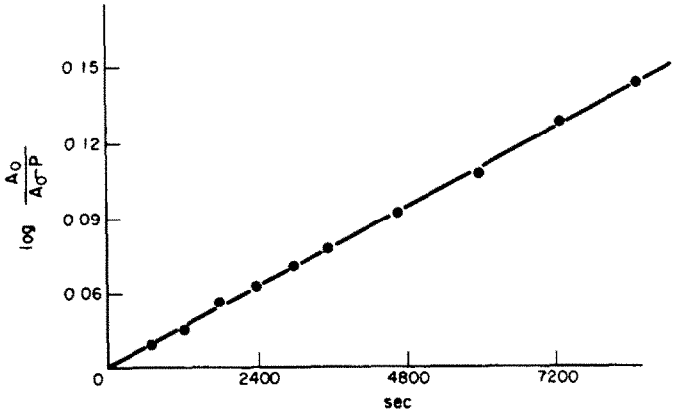


FIG 3. Example of Kinetics of IX

Syntheses of N-(p-*substituted benzenesulfonoxy*)-*iso-carbostyrils* (IX) *and* N-*tosyloxycarbostyril* (XIII). IX or XIII was synthesized upon treatment of I or II with *p*-sub. benzenesulfonyl chloride under usual Schötten-Baumann conditions and the physical properties are shown in Table 3.

Rearrangement reaction of N-*tosyloxy-iso-carbostyril sulfonyl-*^{18}O. The solution of N-tosyloxy-iso-carbostyril sulfonyl-^{18}O (1·6 g) was heated under refluxing MeCN or $MeNO_2$ (30 ml) for 3 hr and then evaporation of solvent left 4-tosyloxy-iso-carbostyril. Recrystallization of this slightly impure compound from acetone afforded material (V), m.p. 206–208°. (lit.[4] 204–206°).

Chlorination of 4-*tosyloxy-iso-carbostyril* (V). 1·0 g of V was heated with PCl_5 (4·0 g) and 5 drops $POCl_3$ at 140–150° overnight. The mixture was poured into ice-water, neutralized (Na_2CO_3) and extracted with $CHCl_3$. After removal of solvent, recrystallization of the residue from EtOH gave 1-*chloro*-4-*tosyloxy-iso-quinoline* (0·8 g), m.p. 95–97°.

Hydrolysis of 1-*chloro-4-tosyloxy-iso-quinoline.* Hydrolysis of this ester (500 mg) was carried out under reflux in 15 ml of 95% aq. EtOH containing KOH (2·0 g) for about 10 hr. The solution was neutralized with bubbling CO_2 and ether extracted. Removal of the solvent from the extract, and recrystallization from AcOH—H_2O afforded 1-*chloro-4-hydroxy-iso-quinoline* (200 mg), m.p. 192–193° (lit.[4] 192–192·5°).

Rearrangement reaction of N-*tosyloxycarbostyril sulfonyl-*^{18}O (XIII). The procedures for rearrangement, chlorination and hydrolysis of N-tosyloxycarbostyril are the same as above. Rearranged products: VI, m.p. 210–211°), 1-chloro-8-tosyloxy-quinoline (m.p. 133–135°) and 1-chloro-8-hydroxyquinoline (m.p. 62–64°) were obtained.

Treatment of 1-*amino-iso-quinoline* N-*oxide* (III) with *tosyl chloride-*^{18}O. Treatment of III (600 mg) with uniformly ^{18}O-labelled TsCl (800 mg) in MeCN (30 ml) gave a colourless solid. Filtration and recrystallization from EtOH afforded 1-*amino*-N-*tosyloxy-iso-quinolinium chloride* (XV, 1·2 g), m.p. 230–231·5° (decomp). The compound was identified by IR, UV, NMR and elementary analysis. (Calcd. for $C_{16}H_{15}N_2O_3SCl$: C, 54·78; H, 4·28; N, 7·99. Found: C, 54·84; H, 4·39; N, 7·98%).

Rearrangement of 1-*amino*-N-*tosyloxy-iso-quinolinium chloride* (XV) *with* Et_3N. On addition of Et_3N (1·5 ml) in MeCN (20 ml) to 800 mg of XV, the latter disappeared immediately at room temp and the solution was refluxed for 2 hr. After evaporation of solvent, the residue was poured into water and extracted with $CHCl_3$. Removal of solvent from the extract and recrystallization from EtOH gave 1-*amino-4-tosyloxy-iso-quinoline* (VII, 600 mg), m.p. 177·5–179°, identified by NMR, UV, and IR.

Hydrolysis of 1-*amino-4-tosyloxy-iso-quinoline* (VII). Hydrolysis of VII was carried out similar to 1-chloro-4-tosyloxy-iso-quinoline and 1-amino-4-hydroxy-iso-quinoline, m.p. 194–195·5° was obtained.

Rearrangement reaction of 2-*aminoquinoline* N-oxide (IV) *with tosyl chloride-*^{18}O. 2-Aminoquinoline N-oxide (IV) was also treated with TsCl-^{18}O and the rearranged product (VIII, m.p. 204–205°) obtained together with hydrolyzed compound, 2-amino-6-hydroxyquinoline, m.p. 211–213°.

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