

## THE REARRANGEMENT OF HYDROPEROXYINDOLENINES

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Summary. Examination of a series of substituted 3-(hydroxyperoxy)indolenines favours a mechanism for base catalysed decomposition of the dioxetan rather than Criegee type.

It has recently been suggested<sup>1</sup> that the decomposition of 3-(hydroperoxy)-5-methoxy-3-methyl-2-phenylindolenine(1) follows the route shown (scheme 1) rather than that of the alternative dioxetan decomposition (scheme 2). It is of interest to determine whether the suggestion is generally applicable, and we have examined a series of substituted indolyl peroxides<sup>2</sup> with the conclusion that at least under our conditions, rearrangement follows the dioxetan path. We have previously demonstrated that both oxygen atoms in the product come from the peroxide, and that the reaction is weakly chemiluminescent<sup>3</sup>.

The two mechanisms under discussion are represented in schemes 1 and 2. The group migration or ring expansion of peroxides is usually considered to be the result of protonation of the distal oxygen atom, or as in the case of the Criegee rearrangement (considered a useful analogy by the previous authors), the formation of the acyl peroxide<sup>4</sup>. It is thus surprising to find this mechanism operative in a base catalysed reaction, since the necessary electron deficiency is unlikely to be created in this way. For example the closely related 3-(hydroperoxy)-2,3-diphenylindene does not rearrange in base<sup>5</sup>, reduction only being observed<sup>5</sup>. Addition to the CC double bond to form a transient dioxetan is of course much less likely than in the case of the polar CN double bond.

It is almost certain that the transition state (2) develops charge at atoms other than the initially charged oxygen and the extremes (within the representation (2)) of nucleophilic attack or migration to electrophilic oxygen are posed to aid discussion. Thus it may be argued that the transition state (2) implies some negative charge at C-2 of the indolenine. This requires that a peroxide

anion be capable of displacement of an unactivated C-C bond. Since this is without precedent, and contrary to the properties of related peroxide rearrangements, we consider it an unlikely alternative in the present case. A further consideration is the ease with which dioxetan formation is accomplished in base. The internal attack of peroxide is so effective as to exclude competition with external nucleophiles such as alkoxide ion in the case of  $\alpha$ -bromohydroperoxides<sup>6</sup>. The transition state (2) on the other hand is obviously strained, and lacks a suitable leaving group.

The rearrangement of peroxides is clearly a consequence of the cleavage of the weak O-O bond and substitution of the migrating group shows that the rate is increased by electron donation, in accord with migration to an electron deficient centre<sup>7</sup>. We have investigated a series of substituted 3-hydroperoxyindolenines (3) with the results shown in the table. The overall rate of reaction was obtained by observing the decay of light emission from the reaction, and the rates of formation of (4) and (5) derived by measuring the amounts of (4) and (5) produced in each case by parallel pseudo first order reactions.

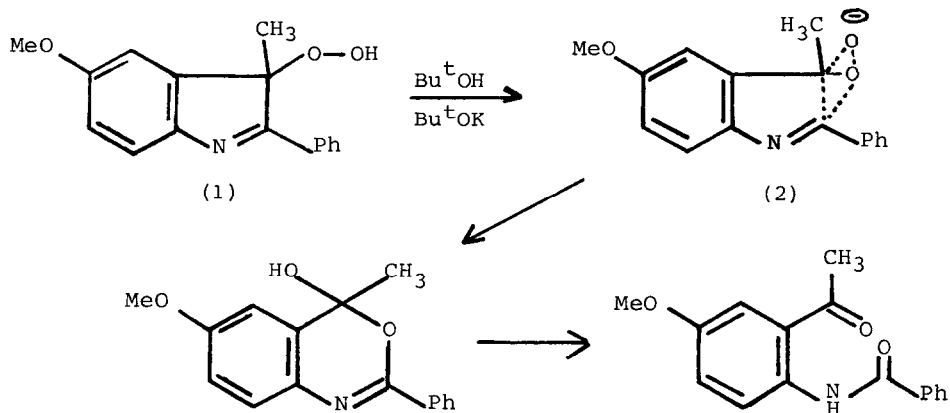
The reaction, run in basic DMSO with varying amounts of water is neatly first order in peroxide (to greater than seven half lives). The value of  $H_-$  of the solution was varied from 19.58 to 16.07 by addition of water. At the higher value the formation of amide (4) is almost quantitative, dropping to below 10% of the total at the lower value. The rate of reduction of the peroxide on the other hand is almost independent of base strength, and thus alcohol formation predominates at low  $H_-$  values

The reaction constant  $\rho$  determined by a least squares method from the usual Hammett plot was +2.23 for formation of (4) and zero or slightly positive for formation of the alcohol (5). The alcohol is thus the result of reduction of the peroxide (presumably by DMSO) and not of the dioxetan, a conclusion opposite to that obtained using 3,5-di-tert-butylcatechol as reductant<sup>1</sup>.

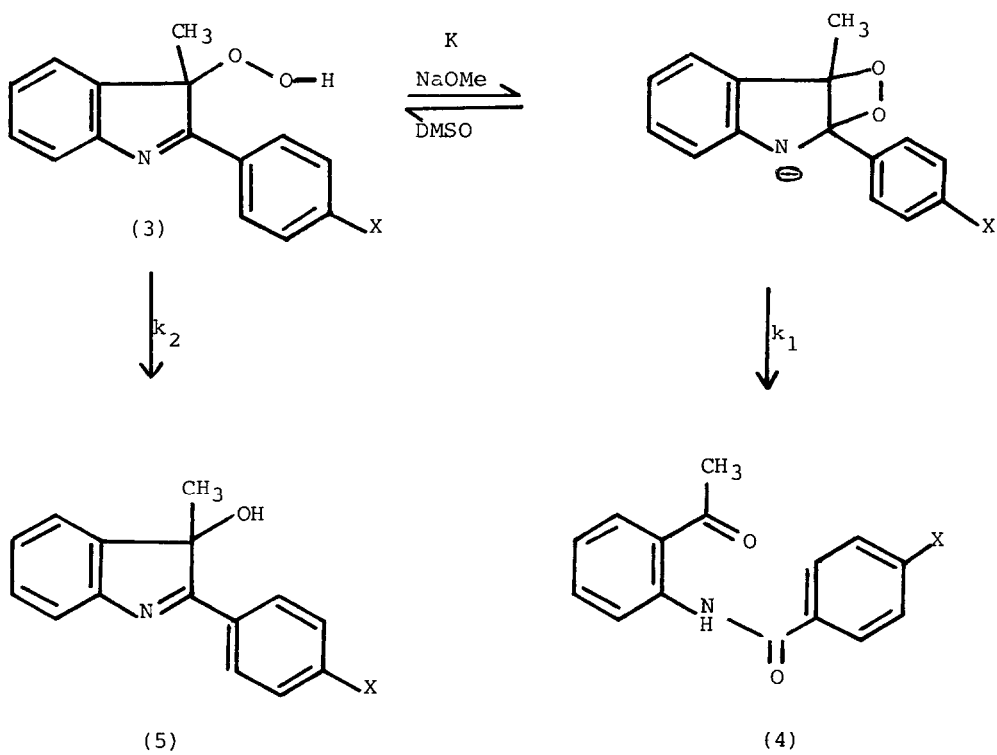
Since the  $\rho$  value for other migrating peroxide rearrangements is strongly negative<sup>7</sup>, and the presently obtained value is very similar to that of nucleophilic attack on unsaturated polar bonds (+2.46 for hydrolysis of methyl benzoates, +1.66 for the attack of peroxide anion on benzonitriles), then nucleophilic addition with formation of a dioxetan is indicated as the rate determining step for cleavage.

It has been pointed out<sup>1</sup> that a cleavage reaction of this sort is of some importance in a variety of biochemical pathways, and further work will be needed to distinguish between these possibilities and others in the context of enzymic reactions.

## SCHEME 1



## SCHEME 2



T A B L E

(3), X	$k_1 (s^{-1})$	$k_2 (s^{-1})$
NMe <sub>2</sub>	0.005	0.09
OMe	0.04	0.09
H	0.15	0.14
F	0.17	0.12
Cl	0.39	0.15
Br	0.40	0.13

Peroxide  $5 \times 10^{-4}$  M, NaOMe 0.013M in DMSO: water = 85:15 at 30°C

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