Template Effect in Intramolecular Hydrogen Abstraction by Acyl Nitroxides: Preferential 1,6- and 1,7-Hydrogen Shifts

By Corrado Berti and M. John Perkins*

(*Department of Chemistry, Chelsea College, Manresa Road, London* SW3 6LX)

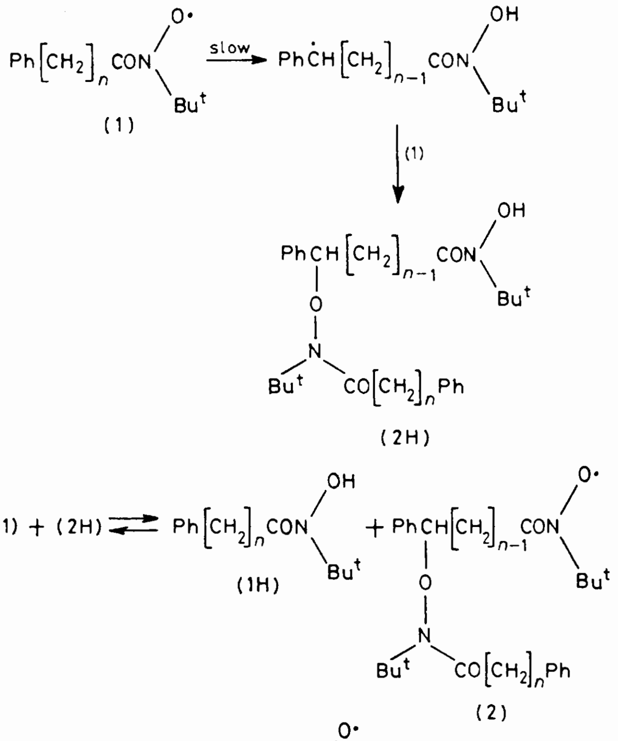
Summary In the series of ω-phenylalkanoyl t-butyl nitroxides (**1**), $n = 1$—5, intramolecular hydrogen transfer to oxygen from the benzylic position occurs most readily when $n = 3$ or 4.

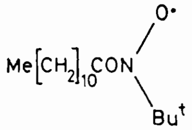
It is well known in free-radical chemistry that 1,5-hydrogen atom transfer is particularly easy.[1] We have been investigating the reactions of highly persistent (isolable)[2] acyl t-alkyl nitroxides, which are appreciably more reactive than dialkyl nitroxides,[3] and have now examined intramolecular benzylic hydrogen abstraction in the series of radicals (**1**) with $n = 1$—5. These nitroxides are readily obtained by oxidation[2] of the corresponding hydroxamic acids (**1H**). With the exception of (**1**; $n = 1$), each decays in boiling benzene to give one major product (**2H**)† (*ca.* 60—70%) arising from abstraction of benzylic hydrogen. The reactions are first order in nitroxide, and, when the rate data (measured in chlorobenzene by the e.s.r. method) are compared with those for the intermolecular reaction of (**3**) with ethylbenzene, it is clear that intramolecular hydrogen abstraction is involved (see Table). The nitroxide (**1**; $n = 1$) decays very slowly by a different route.

TABLE

Radical	k (109 °C) /s^{-1} × 10^3	E^{a} /kJ mol^{-1}	log A
(**1**; $n=2$)	0·46	17·8 ± 1·3	6·84 ± 0·75
(**1**; $n=3$)	1·27	17·3 ± 1·3	6·99 ± 0·8
(**1**; $n=4$)	1·18	16·35 ± 1·2	6·43 ± 0·7
(**1**; $n=5$)	0·030	—	—
(**3**) in PhEt–PhCl	—	18·2 ± 1·0	7·42 ± 0·6

The principal feature of the kinetic results is that the fastest reactions occur when $n = 3$ or 4, *i.e.*, in those instances requiring 1,6- and 1,7-hydrogen shifts, respectively. The effective concentration of phenethyl group in the reaction of (**1**; $n = 4$) at 109 °C is *ca.* 1·3 M, which compares with *ca.* 7·5 M in pure ethylbenzene.





(3)

The relative rates of these intramolecular reactions may be explained if it is assumed (i) that the carbonyl nitroxide unit is coplanar and has the oxygen atoms *anti*-related,‡ and (ii) that hydrogen is transferred to a p-orbital lobe on

---

† The 'dimers' (**2H**) were normally obtained as chromatographically homogeneous gums characterised by broad one-proton singlets at *ca.* δ 8·5(OH) and *ca.* δ 5·0(benzylic methine). However (**2H**; $n = 2$) was also obtained as an analytically pure solid.

‡ As found in the crystal for 3,5-dinitrobenzoyl t-butyl nitroxide, (S. A. Hussain, M. J. Perkins, and T. J. King, unpublished observations).

nitroxide oxygen in a direction roughly perpendicular to the plane of the –CON(O•)– unit. Molecular models then show that for (**1**; $n = 4$) the methylene chain can bridge the –CON(O•)– 'template' in a strain-free fully staggered conformation, whilst for $n = 3$, and particularly for $n = 2$, the transition state is reached only with the introduction of torsional or angle strain.

Although the relative reactivities accord with this picture, the balance between entropy and enthalpy effects, which might have been expected to appear in the activation parameters, barely shows above the error limits of the experiments. However, further support for the interpretation has been adduced from what, at first, seemed a complicating feature of the reactions: since the 'dimeric' hydroxamic acids (**2H**) rapidly exchange hydroxy hydrogen with (**1**), the products include (**1H**), and the kinetics are slightly perturbed, as the reaction proceeds, by formation and decay of (**2**). When a pure sample of (**2H**; $n = 2$) is oxidised, it gives the radical (**2**; $n = 2$), which decays roughly twice as fast as does (**1**; $n = 2$) under comparable conditions; this seems a reasonable consequence of the presence of the benzylic substituent. In contrast, (**2**; $n = 4$) prepared similarly, is essentially stable under the normal conditions for the kinetic experiments; reference to models suggests that the favourable transition-state geometry is no longer accessible because of interference of the ω-acylaminyloxy (or ω-phenyl) substituent with the t-butyl group.

The results reported here, and their interpretation, have important consequences for the design of more complex structures in which intramolecular hydrogen abstraction by acyl nitroxide might be utilised.

We thank the S.R.C. for support and Drs. T. C. Jenkins and B. Terem for preliminary work.

(*Received*, 28*th September* 1979; *Com.* 1036.)

---

[1] *E.g.* J. W. Wilt in 'Free Radicals,' ed. J. K. Kochi, Wiley, New York, **1971**, vol. 1, p. 333.

[2] P. F. Alewood, S. A. Hussain, T. C. Jenkins, M. J. Perkins, A. H. Sharma, N. P. Y. Siew, and P. Ward, *J.C.S. Perkin I*, **1978**, 1066.

[3] T. C. Jenkins, M. J. Perkins, and S. A. Hussain, *Tetrahedron Letters*, **1977**, 3199; *J.C.S. Perkin I*, in the press; C. Berti and M. J. Perkins, *Angew. Chem.*, in the press.