

## Evidence for Phthalimidonitrene as a Common Intermediate in Several Extrusion Reactions

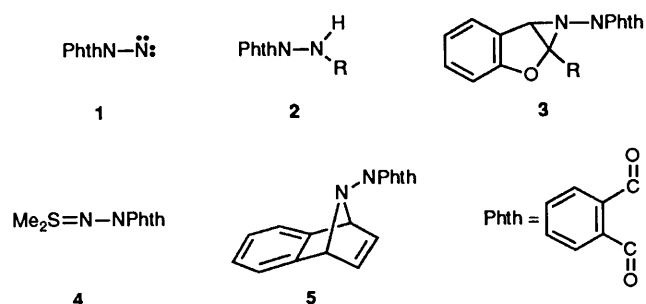
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A common intermediate, presumably phthalimidonitrene **1**, is generated in the thermolysis of the aziridinobenzofurans **3** (R = Ac, CO<sub>2</sub>Me, Bz, COBu<sup>t</sup> and CN) as well as the sulphimide **4**, and the azabenzonorbornadiene **5**. The transfer of **1** shown in Scheme 1 is zero order in 2-acetylbenzofuran providing further evidence against a concerted bimolecular mechanism **10** for 'nitrene' transfer.

Phthalimidonitrene **1** was proposed as an intermediate in the oxidation of *N*-aminophthalimide **2** (R = H) with lead tetraacetate, a process which when carried out in the presence of olefins gives aziridines in good yield.<sup>1</sup> Later the aziridine **3** (R = Ac),<sup>2</sup> the sulphimide **4**,<sup>3</sup> and the 7-azanorbornadiene **5**<sup>4</sup> emerged as putative precursors of **1**. On mild heating with olefins they also give the expected aziridines. Recent work has suggested that the *N*-acetoxyhydrazine **2** (R = OAc) and not phthalimidonitrene **1** is the aziridinating species in the oxidative route from **2** (R = H) using lead tetraacetate.<sup>5</sup> A common intermediate was not involved in the oxidation of **2** (R = H) and the thermolysis of **3** (R = Ac) as each of these processes showed a different selectivity in reaction with a mixture of styrene and methyl acrylate.<sup>5</sup> Aziridination involving **2** (R = OAc) may involve a process **6** (arrows) analogous to the Bartlett mechanism for epoxidation.<sup>6</sup> Consequently, the assign-



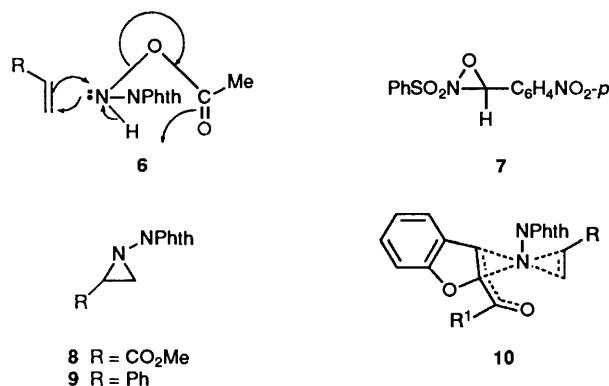
ment of phthalimidonitrene to the reactive intermediate generated from the other precursors **3**, **4** and **5** required further scrutiny.

Table 1

Entry	Putative nitrene precursor	Ratio of aziridines 8:9
1	3 (R = Ac)	1.83
2	3 (R = CO <sub>2</sub> Me)	1.80
3	3 (R = Bz)	1.80
4	3 (R = COBu')	1.84
5	3 (R = CN)	1.81
6	4	1.81
7	5	1.83

Aziridination with 3 (R = Ac) could involve a direct reaction of an olefin with 3 (R = Ac). There is precedent for such a one-step process in the oxygen-atom transfer from oxaziridines like 7 to olefins.<sup>7</sup> We now present evidence for the intervention of a common intermediate, presumably phthalimidonitrene 1 in the thermolysis of 4, 5 and a range of aziridinobenzofurans 3 (R = Ac, CO<sub>2</sub>Me, Bz, COBu' and CN).

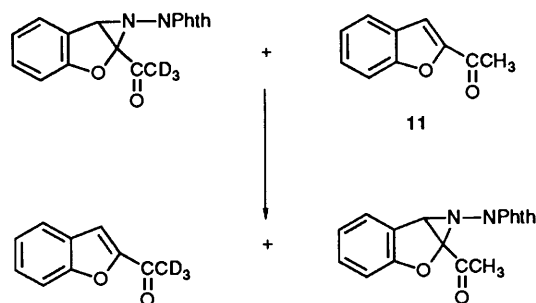
To apply the test for a common intermediate<sup>8</sup> the precursors 3 were prepared from the corresponding benzofurans, *N*-aminophthalimide 2 (R = H) and lead tetraacetate as previously described for 3 (R = H).<sup>9</sup> The precursors 3 were allowed to react with a 1:1 mixture of methyl acrylate and styrene in benzene at 80 °C, and the ratio of the aziridines 8 and 9 determined using 400 MHz <sup>1</sup>H NMR spectroscopy. For



the precursors 3 both the steric bulk and the electron accepting ability\* of the groups R is varied widely. Moreover, the electronic characters of the sulphimide 4 and the azanorbornadiene 5 would be expected to be quite different from that of the precursors 3. Bearing in mind the differing electronic character of the styrene and methyl acrylate used as traps, the constancy of the product ratio (Table 1) rules out transition states of the type 10 involving a direct transfer from precursor to olefin trap.

A mechanism for aziridination involving reversible dissociation of 3 (R = Ac) to nitrene 1 and 2-acetylbenzofuran 11 and trapping of the nitrene 1 by added olefin is also supported by kinetic measurements on the nitrene transfer shown in Scheme 1. A direct transfer *via* a transition state of the type 10 should be first order in dienophile. On the other hand, dissociation to free phthalimidonitrene and subsequent addition to 2-acetylbenzofuran should be zero order in dienophile. Initial rate constants for the disappearance of the methyl resonance of 2-acetylbenzofuran 11 (Scheme 1) were unchanged as the initial concentration of 11 was varied by a factor of 4.

We have confirmed that oxidation of 2 (R = H) by lead



Scheme 1

tetraacetate at 80 °C provides an intermediate(s) that shows a reduced preference for methyl acrylate (ratio 8:9 = 1.28). It is striking that in CH<sub>2</sub>Cl<sub>2</sub> at 0–5 °C this ratio changes to 3.19 in favour of the styrene adduct 9 whilst in acetonitrile at 0–5 °C the styrene adduct is slightly less favoured (ratio 9:8 = 1.19). Dissociation of 3 (R = Ac) in CH<sub>2</sub>Cl<sub>2</sub> at 80 °C also shows a similar solvent effect the styrene adduct being now slightly preferred (ratio 9:8 = 1.075). It appears, therefore, that phthalimidonitrene 1 and *N*-acetoxyhydrazine 2 (R = OAc) both have an independent existence and both can function as aziridinating agents with distinct but not dissimilar reactivities.

## Experimental

**Thermolysis of Aziridinobenzofurans 3, the Sulphimide 4 and the 7-Azanorbornadiene 5.**—The precursor 3 (*ca.* 100 mg), styrene (10 mol equiv.), methyl acrylate (10 mol equiv.) (both freshly distilled), and benzene (*ca.* 4 cm<sup>3</sup>) were boiled under reflux in an argon atmosphere (5 h). After removal of solvent and olefins at 100 °C under a water pump vacuum the product in CDCl<sub>3</sub> was analysed by 400 MHz NMR spectroscopy. The ratios given in Table 1 were derived by comparing integrals for OMe in the two invertomers of 8 ( $\delta$  3.84 and 3.71) with the methine resonance of 9 ( $\delta$  3.60). These signals were selected as showing least interference from impurities in the range of precursors studied. Thermolysis of 4 was performed in the same way but the slower thermolysis of 5 was conducted in a sealed tube in a bath heated at 80 ± 1 °C over 96 h as loss of methyl acrylate over the extended reaction time was significant under reflux conditions.

**Kinetic Measurements.**—The deuterium labelled aziridine 3 (R = COCD<sub>3</sub>) (25 mg) and 2-acetylbenzofuran (12.3 mg) were heated at 80 °C in [<sup>2</sup>H<sub>6</sub>]benzene (1.2, 0.6 and 0.3 cm<sup>3</sup> in separate experiments) and the disappearance of the methyl group of 2-acetylbenzofuran followed by 300 MHz <sup>1</sup>H NMR spectroscopy to give the initial rate constants: 2.15 × 10<sup>-4</sup>, 1.83 × 10<sup>-4</sup> and 2.25 × 10<sup>-4</sup> s<sup>-1</sup> respectively.

## Acknowledgements

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\* The aziridinobenzofuran 3 (R = H) lacking a conjugating electron withdrawing group does not function as an aziridinating agent.<sup>2</sup>

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