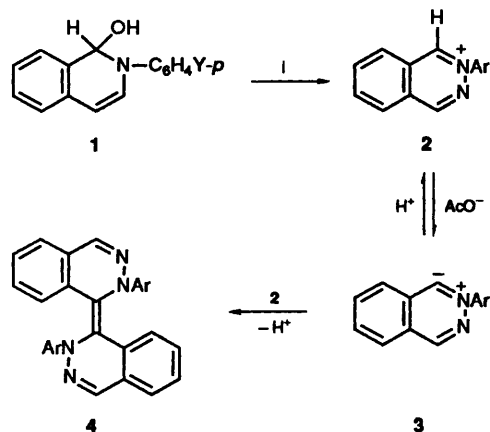


N-Arylphthalazinium Cations: Synthons for Biphthalazinylidenes via Endocyclic Phthalazinium Ylide Intermediates

Richard N. Butler* and Carmel S. Pyne
Chemistry Department, University College Galway, Ireland

Treatment of 2-aryl-1-hydroxy-1,2-dihydrophthalazines with HClO_4 in MeCN gave 2-*N*-arylphthalazinium cations as perchlorate salts. These, when heated with NaOAc in MeCN gave good yields of biphthalazinylidenes via an endocyclic 2-arylphthalazin-2-ium-1-ide intermediate. The presence of the ylide intermediate is supported by deuterium protium exchange at C-1 in the phthalazinium cation. At ambient temperature in water some nucleophiles added to the cations to give 1-substituted-2-aryl-1,2-dihydrophthalazines.

Recently we reported¹ the first biphthalazinylidenes **4** obtained by heating the 1-hydroxy-1,2-dihydrophthalazines **1** with acetic acid in acetonitrile. The ylidenes proved to be particularly interesting because of the pure *trans*-folded nature of the alkene moiety of the ylide linkage.¹ We proposed the mechanism outlined in Scheme 1 as the route to the ylidenes. This involved

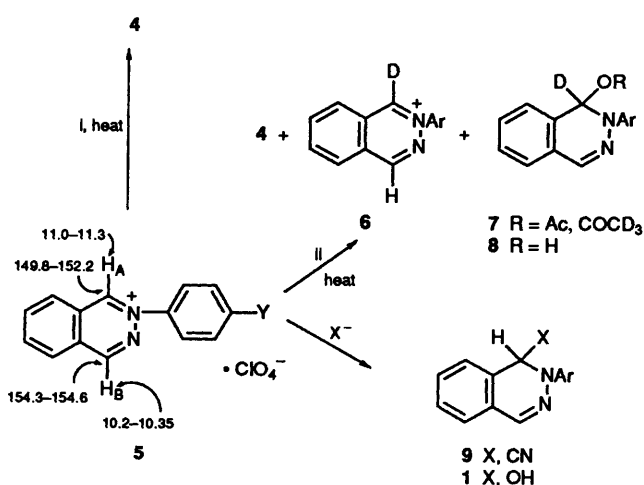


Scheme 1 Reagent: i, HOAc in MeCN

a phthalazinium cation **2** which was deprotonated to the reactive phthalazinium ylide intermediate **3** which reacted with the precursory cation **2** to give the ylide. The proposed mechanism was supported by reactions with the additives, such as sulfur, dimethyl acetylenedicarboxylate and *N*-phenylmaleimide. These gave new ylide products which were consistent with reactions between the additives and intermediates, such as **2** and **3**, but they were not conclusive. We present results herein which lend support for the proposed mechanism, because they establish the existence of the species **2** and **3** and show that together they can give rise to high yields of the ylidenes **4**.

Results and Discussion

The cations **2** should be stable since they have the 10π -naphthalene aromatic electronic structure. We isolated these cations in high yields as crystalline solid perchlorate salts **5** (Scheme 2) by treating compounds **1** with perchloric acid in acetonitrile followed by precipitation with ether (Table 1). The salts **5** were identified from microanalysis, 270 MHz proton and carbon-13 NMR spectra which proved their structure. All of the required signals were clearly identifiable and there was no serious overlap. In particular the C=N carbons with their protons H_A and H_B stood out in the proton and carbon spectra



Scheme 2 Reagents: i, NaOAc in MeCN; ii, NaOAc-DOAc in MeCN. Y = a MeO; b Me; c H; d Br; e NO_2 ; f Cl. Some key proton and carbon NMR shifts shown

(Fig. 1) and the related signals were identified by selective proton decoupling during the carbon-13 NMR spectral measurements. When the salts **5** were heated with one mol of sodium acetate under anhydrous conditions in acetonitrile the ylidenes **4** were readily obtained in yields which were comparable and, in most cases, better than the yields obtained by heating compounds **1** with acetic acid.¹ This reaction with the salts **5** provided a cleaner and better route to the ylidenes and side reactions which were encountered with acetic acid did not interfere. For example, the *p*- NO_2 derivative **4e** (Ar = *p*- $\text{NO}_2\text{C}_6\text{H}_4$ -) could not be made previously because of complicated equilibria involving the acyclic aldehyde form of compound **1e** which gave quite different chemistry on treatment with acid.² However, compound **4e** was obtained readily by heating compound **5e** with NaOAc in acetonitrile (Table 1). When deuterioacetic acid was introduced into the reactions of **5** with NaOAc in acetonitrile and the starting material **5** recovered before the full yield of ylide **4** built up, significant deuterium exchange at H_A in the cation was observed using proton and carbon-13 NMR spectra (Fig. 1). This exchange at H_A occurred only in presence of NaOAc and on heating. It was most effectively seen with 2 mol of $\text{CD}_3\text{CO}_2\text{D}$ present. The salts **6** recovered from these reactions showed small amounts of contamination ($\leq 10\%$) from compounds **7** and **8** due to addition of acetic acid and this could not be avoided. Indeed treatment of the cations **5** with the nucleophiles such as OH^- or CN^- at ambient temperatures in aqueous solutions gave high

Table 1 Phthalazinium salts and ylidenes

Compound	M.p. ^a /°C	Yield (%)	Microanalyses (%), Found (required)			Compound	M.p. ^a /°C	Yield ^c (%)
			C	H	N			
5a	224–225	98.5	53.7 (53.5)	3.9 (3.9)	8.2 (8.3)	4a	232–233	48 (58) ^d
5b	170–171	91	56.1 (56.2)	4.2 (4.1)	8.7 (8.7)	4b	256–257	82.5 (60)
5c	213–214	80	55.0 (54.8)	3.5 (3.6)	9.05 (9.1)	4c	230–231	71 (48)
5d	209–210	88	43.5 (43.6)	2.9 (2.6)	7.3 (7.25)	4d	245–246	87 (49)
5e	252–253	98.4	47.5 (47.8)	2.6 (2.85)	11.7 (11.95)	4e	282–283	60 —
5f	180–181	91.2	49.7 (49.3)	3.0 (2.9)	8.2 (8.2)	4f	252–253	83 (48)

^a From acetone–Et₂O. ^b Ref. 1. ^c Balance was recovered 5. ^d Parentheses contain yields from treating compounds 1 with HOAc in MeCN (Ref. 1).

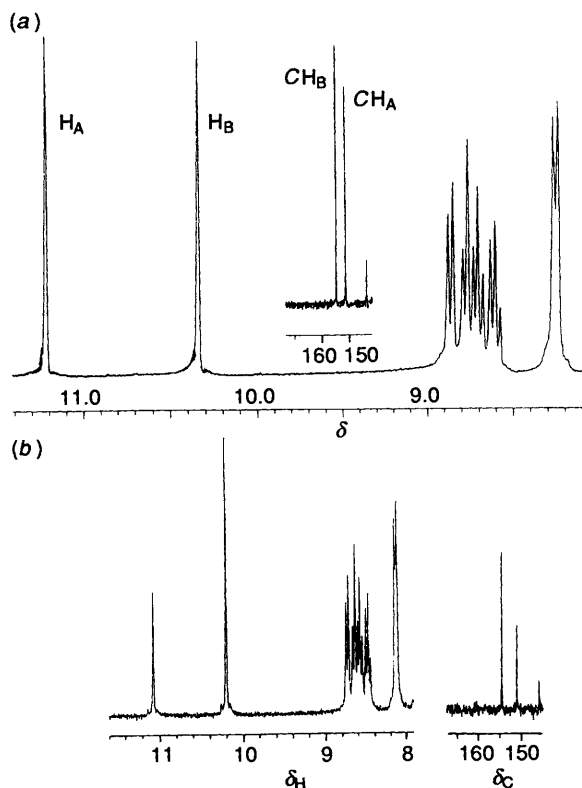


Fig. 1 (a) Lower aromatic region of the proton and carbon-13 (inset) NMR spectra of 5c in (CD₃)₂SO; (b) The same regions for a sample of 5c recovered from being heated with NaOAc and DOAc in MeCN during which a 40% yield of 4c was formed

yields of the products 1 and 9 from simple addition of the nucleophile in a reaction that can be synthetically useful.

The exchange results (Fig. 1) suggest that the endocyclic ylide 3 is present in anhydrous hot solutions of the cation 5 and sodium acetate and that such solutions containing the species 5 and 3 give good yields of the ylidenes 4. As far as we are aware,³ this is the first report of an endocyclic phthalazinium ylide intermediate. Deuterium–hydrogen exchange has been reported³ for substituted amino-pyridazines and pyridazinones and an endocyclic pyridinium ylide is involved in the ready deuterium–hydrogen exchange which occurs at C-2 and C-6 of the pyridinium system.^{4,5} There are reports of endocyclic quinolinium⁶ and azolium ylides^{7,8} and recently 1,3-di-(1-

† The name 'ylide' is widely used (ref. 5 and references therein) for nitrogen heterocyclic systems containing the moiety $\overset{\ominus}{\text{N}}=\overset{\oplus}{\text{C}}$. These systems can also be referred to as ylidenes if a non-octet carbene form $\overset{\ominus}{\text{N}}-\overset{\oplus}{\text{C}}$ is drawn. Herein they are referred to as ylides and drawn in the octet form.

adamantyl)imidazolium-2-ylidene† has been described as the first 'bottleable' carbene.⁹

Experimental

M.p.s were measured on an Electrothermal apparatus. IR spectra were measured for Nujol mulls with a Perkin-Elmer 983 G spectrophotometer. NMR spectra were measured on a JEOL JNM-GX-270 instrument with tetramethylsilane as internal reference and deuteriochloroform or hexadeuteriodimethyl sulfoxide as a solvent. The substrates 1 were prepared as previously described.¹

N-Arylphthalazinium Salts 5.—Typically, a solution of compound 1c (0.5 g, 2.2 mmol) in acetonitrile (10 cm³) was treated with an equimolar quantity of aqueous perchloric acid (73%, BDH), (0.184 cm³, 2.2 mmol) and the mixture was stirred for 5 min and treated with diethyl ether causing precipitation of 5c, m.p. 213–214 °C (from acetone–diethyl ether) (80%); $\delta_{\text{H}}[(\text{CD}_3)_2\text{SO}]$ 7.86–7.93 (m, 3 H, N-Ph, *meta* and *para* protons), 8.19–8.30 (m, 2 H, phthalazine 6-H, 7-H), 8.65–8.99 (m, 4 H, phthalazine 5-H, 8-H, N-Ph, *ortho* Hs), 10.33 (s, 1 H, H_B) and 11.18 (s, 1 H, H_A); δ_{C} 143.3, 123.9, 130.1 and 127.5 (N-Ph, C-1', C-2', C-3', C-4', resp.), 128.2 (C-4a), 131.2, (C-8a), 136.4, 128.35, 131.6 and 139.7 (phthalazine C-5, C-6, C-7, C-8, resp.), 151.08 (C-1, *i.e.* CH_A, Fig. 1) and 154.6 (C-4, *i.e.* CH_B, Fig. 1).

Bipthalazinylidenes 4.—Typically a solution of 5c (0.25 g, 0.825 mmol) in dry acetonitrile (10 cm³) was treated with anhydrous sodium acetate (70 mg, 0.825 mmol) and the mixture was stirred under reflux for 3 h. On cooling compound 4c (71%) separated. Treatment of the acetonitrile mother liquor with diethyl ether resulted in recovery of 5c and no other compounds were encountered. For substrate 5e the mixture was stirred under reflux for 3 h and cooled to give the previously unattainable red coloured derivative 4e, (60%) as a mixture with compound 1e (37%). The ylide 4e was removed in chloroform in which 1e is insoluble; 4e, m.p. 282–283 °C (from MeCN) (Found: C, 66.7; H, 3.5; N, 16.5. C₂₈H₁₈N₆O₄ requires C, 66.9; H, 3.6; N, 16.7%).

When aqueous solutions of NaOH were treated with equimolar quantities of compounds 5 and the mixtures stirred at ambient temperatures for 30 min, the compounds 1 (<90%) separated and were recrystallised from MeCN. Similar treatment of aqueous solutions of 5 (0.98 mmol, 10 cm³) with aqueous KCN (0.98 mmol, 10 cm³) gave compounds 9; *e.g.* 9c, m.p. 154–155 °C (EtOH) (94%) (Found: C, 76.8; H, 4.6; N, 18.0. C₁₅H₁₁N₃ requires C, 77.25; H, 4.7; N, 18.05%); $\delta_{\text{H}}[(\text{CD}_3)_2\text{SO}]$ 7.2 (s, 1 H, 1-CH), 7.24–7.26 (m) and 7.54–7.74 (m, 9 H, Ar) and 8.20 (s, 1 H, 4CH); δ_{C} (with multiplicity for off-resonance decoupling), 45.3 (d, C-1), 115.8 (d, NPh–C-2'), 123.9(s), 126.25 (s, C-4a, C-8a), 116.4 (s, CN), 122.7, 125.8, 129.3, 130.4 and 131.8 (all ds, ArCHs), 139.5 (d, C-4) and 145.0 (s, N-Ph, C-1').

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