Heterocyclic Betaines. XXIII.[1] Access to Novel Dipolar Ethyleneimidazolium(pyridinium) 4-Nitrobenzimidazolate Inner Salts. Synthesis, Characterization and Reactivity Concerning a Type of β-Elimination Reaction

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The first synthesis of some imidazolium(pyridinium) 4-nitrobenzimidazolate betaines with an ethylene interannular spacer has been performed. Their chemical behavior concerning a type of β-elimination reaction has also been studied and contrasted to that of their pyridinium counterparts.

Key words (imidazolium)ethyl benzimidazolate betaine; 4-nitrobenzimidazole derivative; β-elimination reaction; 4-nitro-2-vinylbenzimidazole

Recently, we have reported[1] the synthesis and antitrichomonal activity of an ensemble of pyridinium(imidazolium) 4-nitrobenzimidazolate betaines **1** and **2** and their immediate precursors **3** and **4** with different interannular spacers, together with the 4-nitrobenzimidazolylpyridinium(azolium) salts **7** and **8**, precursors of the unknown betaines **5** and **6** with an ethylene spacer (Fig. 1). Among the compounds tested *in vitro* against *Trichomonas vaginalis*, 1-(4-nitro-2-benzimidazolyl)ethylpyridinium salt **7a** displayed some inhibitory activity. Compounds **7b**, **8a** and **8b** were also tested for antitrichomonal activity but none was active.[1] In this work, we prepared the corresponding new inner salts **5** and **6** (Fig. 1) and studied their chemical stability concerning β-elimination reactions.[2]

The 3-alkyl-1-[2-(4-nitro-1*H*-benzimidazol-2-yl)ethyl]-imidazolium salts **8a, b** were prepared through a two-step procedure (Chart 1). Thus, nucleophilic substitution on the β-chloroamide **9** with *N*-alkylimidazoles afforded the

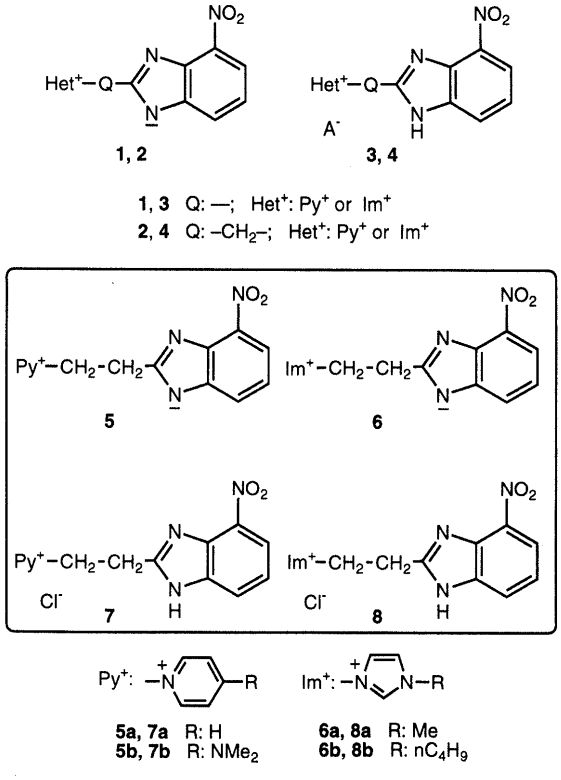

Fig. 1

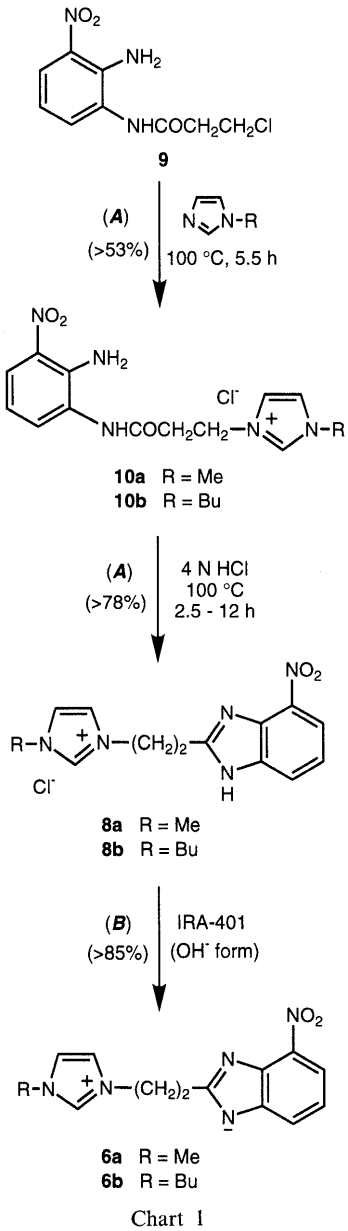

Chart 1

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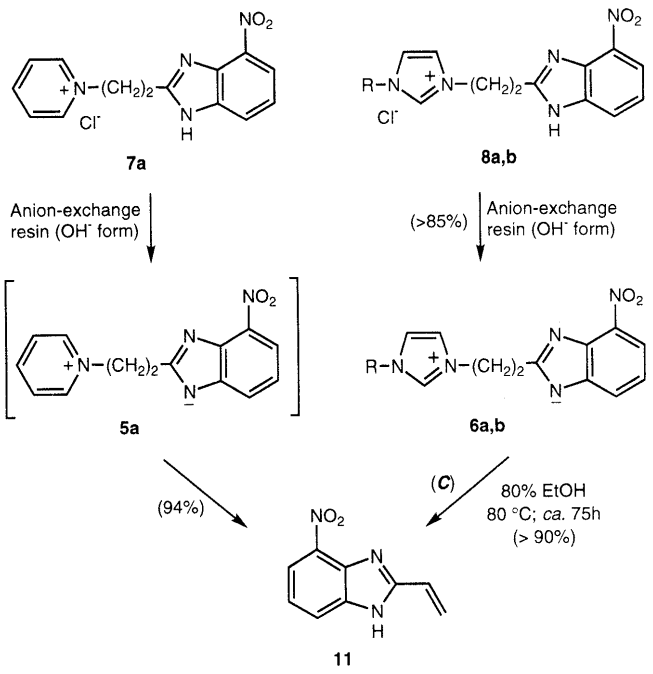

Chart 2

Table 1. Reaction Conditions for the Formation of 4-Nitro-2-vinyl-1*H*-benzimidazole **11**

Starting material	Product	Method[a]	Time (h)	Yield[b] (%)
6a	**11**	C	40	95
6b	**11**	C	25	90
5b	**11**	C	20	95

a) See Charts 2 and 3 and Experimental. *b*) Yields were not optimized.

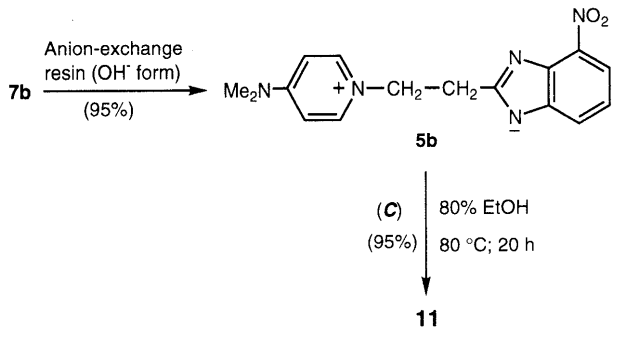

Chart 3

intermediate salts **10a, b**, and the benzimidazole nucleus was generated by using a Phillip's synthesis[3] to give the target salts **8a, b**. Then, they were transformed into the corresponding inner salts **6a, b** using a strong anion-exchange resin (OH^- form).[4a]

The propensity of the above-mentioned pyridinium and imidazolium salts **7a** and **8a, b**—through the betaines **5** and **6**—to undergo a type of β-elimination was then examined (Chart 2). As for several benzimidazolylethylpyridinium salts,[3a] *e.g.* **7a**, a type of β-elimination has been observed, and they are transformed at room temperature into the corresponding 2-vinylbenzimidazoles, *e.g.* **11**,[5] using an anion-exchange resin (hydroxide form). In contrast, deprotonation of the benzimidazolylethylimidazolium salts **8a, b**[4b] afforded the fairly stable ethyleneimidazolium benzimidazolate betaines **6a, b**, which were transformed into the 4-nitro-2-vinylbenzimidazole **11** under neutral and mild conditions (80% ethanol at 80°C) in remarkably good yield (Chart 2 and Table 1).

Table 2. Physical Data for **5b**, **6a, b** and **8a, b**

Compd. No.	Method[a]	Yield[b] (%)	Time (h)	mp (°C)[c] (Recryst. solvent)	Molecular formula[d]
8a	A	78	12	205 (Acetonitrile)	$C_{13}H_{14}ClN_5O_2$
8b	A	89	2.5	180 (Dry ethanol)	$C_{16}H_{20}ClN_5O_2 \cdot 2H_2O$
6a	B	85	[e]	162—4 (80% Ethanol)	$C_{13}H_{13}N_5O_2 \cdot H_2O$
6b	B	90	[e]	190 (80% Ethanol)	$C_{16}H_{19}N_5O_2 \cdot H_2O$
5b[f]	B	95	[e]	99 (80% Ethanol)	$C_{16}H_{17}N_5O_2 \cdot 2H_2O$

a) See Chart 1 and Experimental. *b*) Yields were not optimized. *c*) Uncorrected, measured with a CTP-MP hot-plate melting point apparatus. *d*) Satisfactory analytical data (±0.4% for C, H, N) were obtained for new compounds. *e*) See Experimental. *f*) See Chart 3.

With regard to the 1-(ethylpyridinium) chloride **7b**,[3a,6] the 4-dimethylamino substituent on the quaternary moiety restricted its nucleofugal ability, and it was possible to isolate the unknown inner salt **5b** and subsequently to transform it into the 4-nitro-2-vinylbenzimidazole **11** in high yield (Chart 3).[7]

Physical data for the new compounds described in this work (**5b**, **6a, b** and **8a, b**) are listed in Table 2, and all gave satisfactory elemental analyses (see Experimental). The structures of the new inner salts **5b**, **6a, b** and their immediate precursors **7b**, **8a, b** were unambiguously characterized on the basis of their spectroscopic data.

The IR spectra of compounds **7b**, **8a, b** showed absorptions in the range of 3500—3400 cm^{-1} (ν_{NH}) and 2800—2500 cm^{-1} (hydrochlorides). These bands were absent for the inner salts **5b**, **6a, b**. The ^1H and ^{13}C chemical shifts of **5b**, **6a, b** confirmed the dipolar structure, as they resembled those of other types of heterocyclic betaines.[1] The ^1H and ^{13}C chemical shifts of the betaines **5b**, **6a, b** and their precursors **7b**, **8a, b** are shown in Tables 3 and 4; individual assignments were made by using the appropriate NMR experiments[8] (*vide infra*).

The ^1H- and the ^{13}C-NMR parameters[8e] accord well with the nature of the π-excessive and π-deficient heteroaromatic rings and with data for related systems within dipolar molecules **1**. The chemical shifts of the CH protons in the benzimidazolate moiety move to lower frequencies (see $\Delta\delta$ in Table 3) with respect to their precursors **7b**, **8a, b**, reflecting the high electron density on the azolate ring, and they are consistent with the ^1H-NMR chemical shifts of anionic species in the azole series.[1] Moreover, the δ_C values of carbon atoms (see Table 4) were in agreement with data reported for a variety of benzimidazolate anions and also the less frequently reported nitrobenzimidazolate species.[1] With regard to the quaternary imidazolium rings, both the ^1H- and the ^{13}C-NMR chemical shifts accord with the data previously

Table 3. ^{1}H-NMR Data[8] for Pyridinio or (Imidazolioethyl)benzimidazolate Inner Salts **5b**, **6a**, **b** and the Corresponding (Benzimidazolylethyl)-pyridinium or Imidazolium Salts **7b**, **8a**, **b**[a]

Compd. No.	H-2,6	H-4	H-3,5	$-CH_2-N^+$	$-CH_2-$	H-5′	H-6′	H-7′	R
5b	8.38	—	6.92	4.69	3.30	7.60	6.79	7.62	3.11
7b[b]	8.37	—	7.02	4.74	3.61	8.16	7.45	8.08	3.15
$\Delta\delta$[c]	+0.01	—	−0.1	−0.05	−0.31	−0.56	−0.66	−0.46	−0.04

Compd. No.	H-2	H-4	H-5	$-CH_2-N^+$	$-CH_2-$	H-5′	H-6′	H-7′	R
6a	9.26	7.63	7.82	4.67	3.35	7.59	6.80	7.59	3.80
8a	9.37	7.66	7.84	4.79	3.66	8.21	7.49	8.10	3.86
$\Delta\delta$[c]	−0.11	−0.03	−0.02	−0.12	−0.31	−0.62	−0.69	−0.51	−0.06
6b	9.24	7.65	7.84	4.66	3.29	7.62	6.82	7.56	4.07[d]
8b	9.30	7.78	7.86	4.76	3.65	8.18	7.47	8.06	4.12[d]
$\Delta\delta$[c]	−0.06	−0.13	−0.02	−0.10	−0.36	−0.56	−0.65	−0.50	−0.05

a) In DMSO-d_6. *b*) See reference 3*a*. *c*) $\Delta\delta$: observed chemical shift difference between betaines and the corresponding salts. *d*) Only δ for the α-protons to nitrogen are listed.

Table 4. ^{13}C-NMR Data[8] for Pyridinio or (Imidazolioethyl)benzimidazolate Inner Salts **5b**, **6a**, **b** and the Corresponding (Benzimidazolylethyl)-pyridinium or Imidazolium Salts **7b**, **8a**, **b**[a]

Compd. No.	C-2,6	C-4	C-3,5	$-CH_2-N^+-$	$-CH_2-$	C-2′	C-3a′	C-4′	C-5′	C-6′	C-7′	C-7a′	R
5b	142.85	156.3	107.6	55.9	32.9	163.9	151.2	149.9	115.2	116.1	122.7	135.2	39.9
7b[b]	144.0	159.2	110.9	57.2	31.0	155.4	127.9	136.8	125.1	125.3	128.7	137.4	42.5

Compd. No.	C-2	C-4	C-5	$-CH_2-N^+-$	$-CH_2-$	C-2′	C-3a′	C-4′	C-5′	C-6′	C-7′	C-7a′	R
6a	137.0	122.5	123.2	48.8	32.8	165.4	[c]	135.5	114.6	115.1	122.2	[c]	35.8
8a	137.1	123.8	124.2	47.0	28.6	154.7	[c]	139.1	121.0	123.2	127.3	[c]	36.0
$\Delta\delta$[d]	−0.1	−1.3	−1.0	+1.8	+4.2	+10.7	—	−3.6	−6.4	−8.1	−5.1	—	−0.2
6b	137.2	122.3	123.1	48.5	32.5	165.6	144.2	135.4	114.6	115.1	122.2	152.2	48.6[e]
8b	137.2	123.9	124.3	46.8	28.4	154.8	[c]	139.0	120.9	123.1	127.2	[c]	48.8[e]
$\Delta\delta$[d]	0.0	−0.6	−1.2	+1.7	+4.1	+10.8	—	−3.6	−6.3	−8.0	−5.0	—	−0.2

a) In DMSO-d_6. *b*) In D_2O. *c*) No signal observed. *d*) $\Delta\delta$: observed chemical shift difference between betaines and the corresponding salts. *e*) Only δ for the α-protons to nitrogen are listed.

reported for betaines of imidazolium azolate.[1] Concerning the chemical shift values for the ethylene interannular spacer,[9] the parameters for the α-CH_2 are much more affected than those for the β-CH_2 counterpart (see Tables 3 and 4); thus, for betaines **5b**, **6a**, **b** the chemical shifts of the α-CH protons move upfield (*ca.* 0.33 ppm), and the same methylenic carbon atoms show a shift downfield (*ca.* 4.2 ppm). Unambiguous assignments for compounds **5**—**8** were made by using bidimensional HMQC[8c] and HMBC[8c] spectroscopic techniques with the selected compound pair **6b** and **8b** (Fig. 2).

In electron impact mass spectrometry,[10] compounds **5**—**8** exhibit a common, characteristic behavior. In all cases, the fragmentation pattern shows that the base peak does not correspond to the molecular ion, but to a fragment resulting from a β-elimination type reaction of molecules **5**—**8**, *i.e.*, to 4-nitro-2-vinylbenzimidazole **11**; the other peak appearing with high relative abundance belongs to the nucleofuge moiety, *i.e.* and 1-alkylimidazole. This fragmentation pattern is consistent with the major features of the chemical reactivity of compounds **5**—**8**.

Summing up, the propensity of the new betaines **5** and **6** to undergo a type of β-elimination reaction under mild and neutral conditions indicates that the dipolar character within the substrate acts as the driving force. Whatever the 1,2-elimination mechanism may be, the formation of

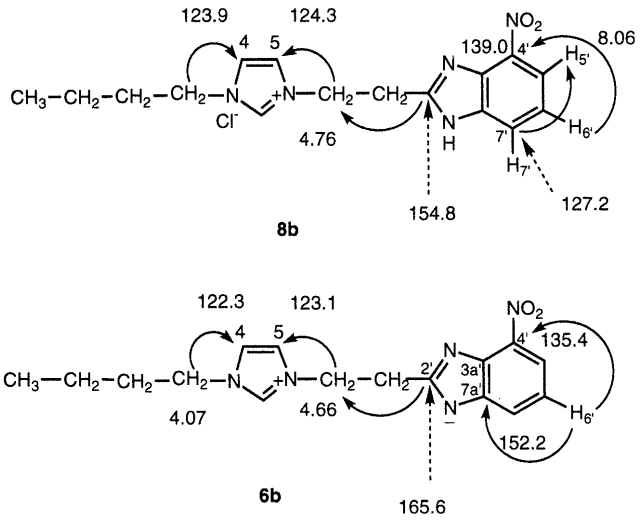

Fig. 2. Heteronuclear Multiple Bond Correlation (HMBC) Spectra of Compounds **6b** and **8b**

Chemical shifts (δ) are given in ppm. Dotted arrows indicate reference values, from which heterocorrelations (indicated by solid arrows) were established.

4-nitro-2-vinylbenzimidazole **11** can be rationalized by taking into account that the negative part of the dipole is a basic benzimidazolate moiety and the cationic charged moiety modulates β-elimination depending on the nature of the nucleofuge in the relative order pyridine > 4-dimethylaminopyridine > 1-alkylimidazole.

Experimental

General Methods Melting point: CTP-MP 300 hot-plate apparatus with ASTM 2C thermometer (see Table 2). IR (KBr disks): Perkin Elmer 1430 spectrophotometer. ^{1}H-NMR: Varian Gemini 200 and Varian Unity 300 spectrometers (200 and 300 MHz). ^{13}C-NMR: Bruker AM-100 and Varian Gemini 200 spectrometers (25.1 and 50.3 MHz). HMQC and HMBC[8c]: Varian VXR-500 spectrometer (500 MHz). NMR spectra were determined in dimethylsulfoxide-d_6 (DMSO-d_6),[8d] and chemical shifts are expressed in parts per million (δ) relative to tetramethylsilane (TMS) or to the central peak of DMSO-d_6. EIMS: Hewlett-Packard HP-5988A and Finnegan TSQ-70. TLC: Merck precoated Silica gel 60F_{254} plates; detection under UV light. For method B, a column (0.5-in. diameter) was packed with anion-exchange resin IRA-401 (OH^- form),[1,9b] up to a height of 5 in. When a rotary evaporator was used, the bath temperature was 25°C. In general, the compounds were dried overnight at 25°C in a vacuum oven. Microanalyses were performed on a Carlo Erba 1106 analyzer.

Materials *N*-Butyl- and *N*-methylimidazole are commercially available. *N*-(2-Amino-3-nitrophenyl)-3-chloropropionamide (**9**),[3a] and 4-(*N*,*N*-dimethylamino)-1-[2-(4(7)-nitro-1*H*-benzimidazol-2-yl)ethyl]pyridinium chloride (**7b**)[3a] were prepared as described in the literature.

Preparation of 2-[2-(3-Alkyl-1-imidazolium)ethyl]benzimidazolate Inner Salts 6a, b and 2-[2-(4-Dimethylamino-1-pyridinium)ethyl]-4(7)-nitrobenzimidazolate 5b (Table 2). Method A A stirred solution of compound **9** (2.0 g, 8.2 mmol) in anhydrous *N*-methylimidazole or *N*-butylimidazole (25.0 mmol) under an atmosphere of nitrogen was heated in a bath at 100°C for 5.5 h. The solution was cooled, acetone (30 ml) was added and the mixture was triturated to give an orange solid, which was collected by filtration, washed in acetone (2 × 5 ml), and dried. Recrystallization from ethanol or acetonitrile afforded 2.0 g (75%) of **10a** or 1.6 g (53%) of **10b**. Compound **10a**: mp 236°C. *Anal.* Calcd for $C_{13}H_{16}ClN_5O_3$: C, 47.93; H, 4.95; H, 21.49. Found: C, 47.95; H, 4.93; N, 21.39. ^{1}H-NMR (DMSO-d_6, 200 MHz) δ: 3.10 (t, J = 6.6 Hz, 2H, CH_2), 3.45 (s, 3H, CH_3), 4.45 (t, J = 6.6 Hz, 2H, CH_2N^+), 6.60 (dd, J = 7.4, 8.7 Hz, 1H, H-5′), 7.10 (br, 2H, NH_2), 7.43 (d, J = 7.4 Hz, 1H, H-6′), 7.76 (s, 1H, H-4), 7.80 (s, 1H, H-5), 7.87 (d, J = 8.7 Hz, 1H, H-4′), 9.28 (s, 1H, H-2), 10.20 (br, 1H, NHCO). ^{13}C-NMR (DMSO-d_6, 50.3 MHz) δ: 35.0 (CH_3), 35.4 (CH_2), 51.3 (CH_2N^+), 113.1 (C-4′), 124.8 (C-5′), 125.2 (C-4, 5), 126.3 (C-1′), 131.4 (C-2′), 133.1 (C-6′), 138.1 (C-2), 140.5 (C-3′), 167.2 (CO). Compound **10b**: mp 190°C. *Anal.* Calcd for $C_{16}H_{22}ClN_5O_3$: C, 52.24; H, 6.03; N, 19.04. Found: C, 52.45; H, 6.05; N, 19.11. ^{1}H-NMR (DMSO-d_6, 200 MHz) δ: 0.85 (t, 3H, CH_3), 1.21 (m, 2H, Me-C$\underline{H}_2$), 1.74 (m, 2H, Et-C$\underline{H}_2$), 3.12 (t, J = 5.6 Hz, 2H, CH_2), 4.16 (t, J = 6.7 Hz, 2H, Pr-C$\underline{H}_2$), 4.48 (t, J = 5.6 Hz, 2H, CH_2N^+), 6.63 (dd, J = 7.5, 8.7 Hz, 1H, H-5′), 7.27 (br, 2H, NH_2), 7.45 (d, J = 7.5 Hz, 1H, H-6′), 7.79 (s, 1H, H-4), 7.83 (s, 1H, H-5), 7.88 (d, J = 8.7 Hz, 1H, H-4′), 9.31 (s, 1H, H-2), 10.03 (br, 1H, NHCO). ^{13}C-NMR (DMSO-d_6, 50.3 MHz) δ: 13.6 (CH_3), 19.1 (Me-$\underline{C}H_2$), 31.9 (Et-$\underline{C}H_2$), 35.9 (CH_2), 49.2 (Pr-$\underline{C}H_2$), 52.4 (CH_2N^+), 114.2 (C-4′), 123.9 (C-5′), 125.3 (C-4), 125.9 (C-1′), 126.1 (C-5), 130.6 (C-2′), 132.4 (C-6′), 137.9 (C-2), 139.8 (C-3′), 169.3 (CO).

A suspension of compound **10a** (3.4 g, 10.0 mmol) or **10b** (0.6 g, 1.6 mmol) in 4 N HCl (30.0 ml, 120.0 mmol or 4.9 ml, 19.6 mmol, respectively) was heated in a bath at 100°C for the time specified in Table 2. The resulting solution was concentrated to dryness, and acetone (15 ml) was then added. The precipitate was collected by filtration, washed in acetone (2 × 3 ml), and dried. Recrystallization afforded **8a** or **8b** (Table 2).

Method B A solution of the (4-nitrobenzimidazolylethyl)imidazolium chlorides **8a**, **8b** (*ca.* 0.3 mmol) in 80% ethanol (30 ml) was passed through a column packed with anion-exchange Amberlite resin IRA-401, with a flow rate of *ca.* 1.7 mg/min (*ca.* 1 ml/min; total time *ca.* 30 min). The neutral eluates were evaporated to dryness of 25°C to afford the (imidazolioethyl)nitrobenzimidazolate inner salts **6a**, **6b** as solids, which were then recrystallized in the cold (Table 2).

Following the same procedure, the (pyridinioethyl)nitrobenzimidazolate inner salt **5b** was also obtained (Table 2).

Table 5. Elemental Analyses of Pyridinio or (Imidazolioethyl)benzimidazolate Inner Salts **5b**, **6a**, **b** and the (Benzimidazolylethyl)pyridinium or Imidazolium Salts **8a**, **b**

Compd. No.	Molecular formula	Calcd (%)			Found (%)		
		C	H	N	C	H	N
5b	$C_{16}H_{17}N_5O_2 \cdot 2H_2O$	55.31	6.10	20.17	55.52	5.94	19.82
6a	$C_{13}H_{13}N_5O_2 \cdot H_2O$	53.96	5.23	24.22	53.87	5.17	24.51
6b	$C_{16}H_{19}N_5O_2 \cdot H_2O$	57.93	6.39	21.13	57.59	6.41	20.88
8a	$C_{13}H_{14}ClN_5O_2$	50.74	4.59	22.76	50.54	4.60	22.73
8b	$C_{16}H_{20}ClN_5O_2 \cdot 2H_2O$	49.85	6.28	18.11	49.63	6.50	17.95

Following the same procedure, but starting from the (4-nitrobenzimidazolylethyl)pyridinium chloride **7a**, 4-nitro-2-vinyl-1*H*-benzimidazole **11** was obtained (94%), mp 163°C (lit.[5,7b]). *Anal.* Calcd for $C_9H_7N_3O_2 \cdot H_2O$: C, 55.82; H, 3.80; N, 21.72. Found: C, 55.56; H, 3.65; N, 21.71. ^{1}H-NMR (DMSO-d_6, 200 MHz) δ: 5.79 (dd, J = 1.6, 11.1 Hz, 1H), 6.56 (dd, J = 1.6, 17.6 Hz, 1H), 6.97 (dd, J = 11.1, 17.6 Hz, 1H), 7.40 (dd, J = 6.5, 7.5 Hz, 1H, H-6), 8.08 (d, J = 6.5 Hz, 1H, H-5), 8.10 (d, J = 7.50 Hz, 1H, H-7), 15.71 (br, 1H). ^{13}C-NMR (DMSO-d_6, 50.3 MHz) δ: 119.1 (C-7), 122.0 (CH=), 124.2 (CH_2=), 126.0 (C-6), 127.0 (C-5), 154.2 (C-2).

Formation of 4-Nitro-2-vinyl-1*H*-benzimidazole 11. Method C A solution of (imidazolioethyl)benzimidazolate inner salts **6a**, **b** or (pyridinioethyl)nitrobenzimidazolate **5b** (*ca.* 0.08 mmol) in 80% ethanol (30 ml) was heated in a bath at 80°C for the time specified in Table 1. The cooled solution was evaporated to dryness. The solid obtained was then washed in diethyl ether (2 × 2 ml) and dried to yield the 4-nitro-2-vinylbenzimidazole **11** (Table 1).

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References and Notes

1) Part XXII: Alcalde E., Pérez-García L., Dinarés I., Frigola J., *Chem. Pharm. Bull.*, **43**, 493 (1995), and references quoted therein.
2) *a*) Among the different types of 1,2-elimination reactions,[2b,c] Bunting *et al.* have reported a detailed kinetic and mechanistic study of *N*-(2-cyanoethyl)pyridinium cations.[2d] Of particular interest in relation to the present study are the results with several *N*-(2-substituted-ethyl)pyridinium cations, and the imidazolium analogues with the same activating group. They have shown that for leaving groups of similar basicity, pyridine is a better nucleofuge than 1-methylimidazole[2e]; *b*) March J., "Advanced Organic Chemistry," 4th ed., John Wiley and Sons, Inc., New York, 1992, Chapter 17; *c*) Katritzky A. R., Brycki B. E., *Chem. Soc. Rev.*, **19**, 83 (1990); *d*) Bunting J. W., Toth A., Heo C. K. M., Moors R. G., *J. Am. Chem. Soc.*, **112**, 8878 (1990); *e*) Bunting J. W., Kanter J. P., *ibid.*, **113**, 6950 (1991).
3) *a*) Alcalde E., Pérez-García L., Dinarés I., Frigola J., *J. Org. Chem.*, **56**, 6516 (1991), and references quoted therein; *b*) Alcalde E., Gisbert M., Pérez-García L., *Chem. Lett.*, **1992**, 2357.
4) *a*) An appropriate protocol was used for the preparation of several azinium(azolium) azolate betaines and also applied to other homologues and analogous inner salts[1]; *b*) The imidazolium quaternary moiety has been proved to be stable in 3-alkyl-1-(1*H*-benzimidazol-2-yl)imidazolium salts with different interannular linkers.[1]
5) An improved protocol raised to 94% the yield of 4-nitro-2-vinylbenzimidazole **11** from **7a**; the previously reported value was *ca.* 34%.[3a]
6) *a*) Due to the instability of simple inner salts of type **5**, it was

only possible to detect formation of these species from 4-nitrobenzimidazole derivatives by ^{1}H-NMR in D_2O–NH_4OH[6b]; *b*) The ^{1}H-NMR spectrum of the 1-[2-(1*H*-4(7)-nitrobenzimidazole-2-yl)ethyl]pyridinium chloride **7a**[3a] in D_2O with addition of 3 eq of NH_4OH concentrated solution (*ca.* 30%) showed an appreciable shift upfield for all the proton signals. The chemical shift differences were further increased by registering the ^{1}H-NMR spectrum in D_2O immediately after the above-mentioned chloride had been treated with an anion-exchange resin (OH^- form).[1] Thus, ^{1}H-NMR allowed the detection of the corresponding betaine along with the elimination product **11**. Unfortunately, the instability of the betaine precluded its isolation. Moreover, this compound was transformed into the 4-nitro-2-vinylbenzimidazole **11** after 3 d in solution.

7) *a*) The transformation of **7b** into **11** had not been thoroughly studied,[3a] due to the moderate reactivity exhibited by **7b** regarding β-elimination type processes; *b*) Although compound **11** has been previously obtained, it has not been isolated in analytically pure form.[3a]

8) *a*) Unambiguous assignments have been made by DEPT,[8b] heteronuclear multiple-quantum coherence (HMQC),[8c] and HMBC[8c] techniques; *b*) Breitmeier E., Voelter W., "Carbon-13 NMR Spectroscopy," VHC, Weinheim, 1987, p. 80; *c*) Summers M. F., Marzilli L. G., Bax A., *J. Am. Chem. Soc.*, **108**, 4285 (1986); *d*) DMSO-d_6 was previously dried with an activated molecular sieve (3 Å) to reduce the presence of water in the solvent; *e*) Although the ^{1}H-NMR spectra were also recorded in CD_3OD for compounds **8a, b** and $Na^+CD_3O^-/CD_3OD$ for the inner salts **6a, b**, DMSO-d_6 was the solvent of choice to observe the dipolar nature of compounds **6a, b**.

9) *a*) For consistency with previous work on heterocyclic betaines,[9b] for compounds **5**—**8** we quoted as α-CH_2 the methylene group directly attached to the azole/azolate moiety, and as β-CH_2 the methylene group directly linked to the quaternary moiety; *b*) Alcalde E., Dinarés I., Pons J.-M., Roca T., *J. Org. Chem.*, **59**, 639 (1994), and references quoted therein.

10) *a*) Katritzky *et al.*[2c,10b] have investigated the fragmentation pathways for collisionally activated dissociation (CAD) of *N*-alkylpyridinium cations to pyridinium cations and olefins in the gas phase, by laser desorption (LD) FTICR mass spectrometry; *b*) Katritzky A. R., Watson C. H., Dega-Szafran Z., Eyler J. R., *J. Am. Chem. Soc.*, **112**, 2479 (1990).