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Heterocyclic Betaines. Imidazolium Benzimidazolate Inner Salts with a Vinylene and Oxoethylene Interannular Linkages

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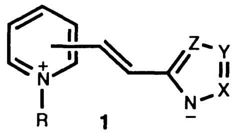
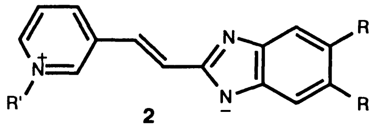
A novel ensemble of heterocyclic betaines is reported. The title compounds were synthesized by two methodologies according to the nature of the interannular linkage. Their highly dipolar structure is well shown by their physicochemical properties.

Both the fundamental and practical interest of extended π-systems have been a matter of extensive investigation.[1)] Recently, we have reported a novel ensemble of aza-analogs of (*E*)-stilbene **1** with a betaine character leading to a conjugated π-system which contains extremely π-deficient (pyridinio) and π-excessive (azolate) moieties (i.e. **2**).[2)] With regard to imidazolium quaternary salts, several examples of the imidazolium benzimidazolate inner salts **3**[3)] and their homologues **4**[4)] have been investigated.



1

(X, Y, Z: =CR-; =N-)



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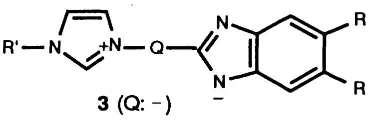
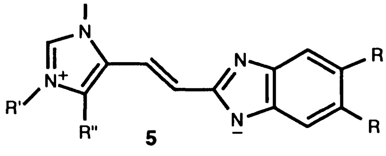


3 (Q: -)
4 (Q: CH_2)

Following our work in the search for unconventional extended π-systems, we describe the results concerning a new type of betaines **5** analogues of **2** and the 2-(3-alkyl-1-imidazolioacetyl)benzimidazolate inner salts **6** potential precursors of the 2-[2-(3-alkyl-1-imidazolio)vinyl]benzimidazolate inner salts **7** vinylogues of the *N*-ylides **3**.



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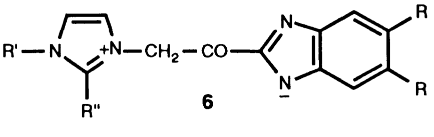

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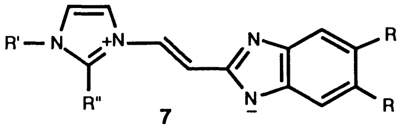
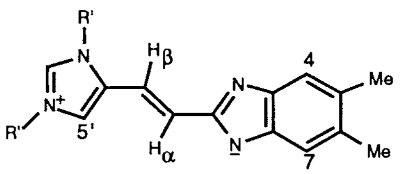
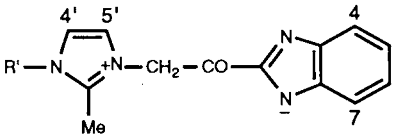


7

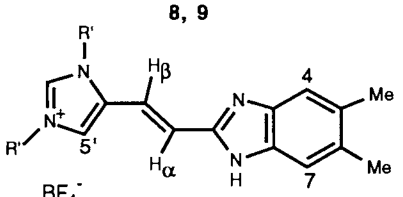
The first synthesis and characterization of examples of the title betaines **8-11** and their immediate precursors **12-15** has been achieved employing two methodologies which generated either compounds **8**, **9** or compounds **10**, **11**.



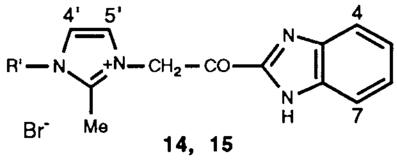
8, 9



10, 11



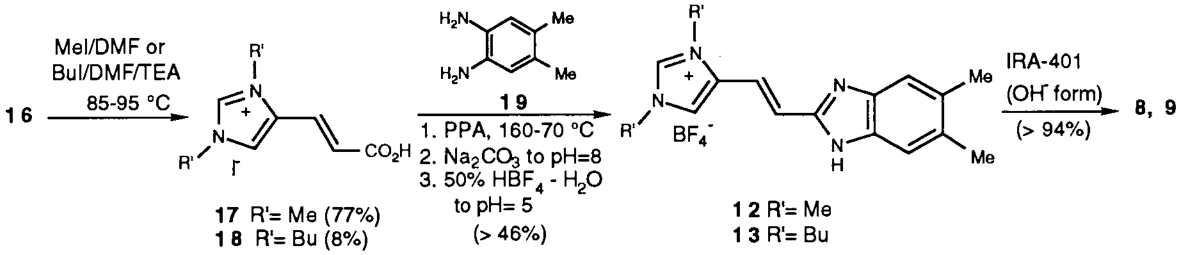
12, 13



14, 15

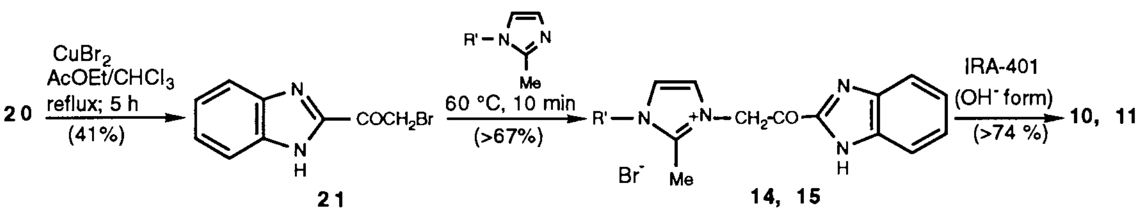
	R'
8, 12, 10, 14	Me
9, 13, 11, 15	Bu

The (*E*)-2-[2-(1,3-dialkyl-4-imidazolio)vinyl]benzimidazolate inner salts **8, 9** were prepared by a three-step procedure (Scheme 1). Firstly, (*E*)-3-(4-imidazolyl)acrylic acid **16** reacted with an excess of alkyl iodide to give the carboxyvinylimidazolium quaternary salts **17** and **18**.[5] Secondly, the 1,3-dialkyl-4-[2-(1*H*-benzimidazol-2-yl)vinyl]imidazolium salts **12, 13** were obtained by reaction of compounds **17, 18** and 4,5-dimethyl-1,2-phenylenediamine **19** using polyphosphoric acid as cyclodehydrating agent.[6] Transformation of compounds **12, 13** into the betaines **8, 9** was carried out using an anion-exchange resin (OH$^-$ form).[7]



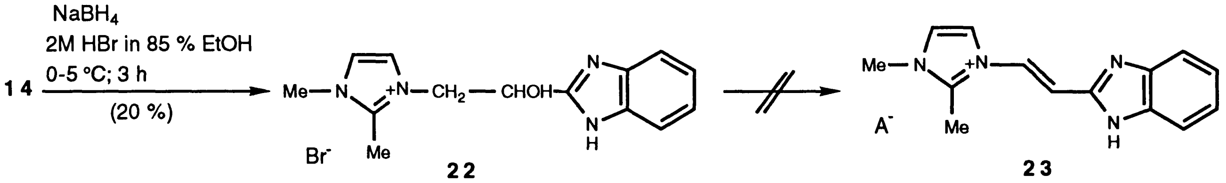
Scheme 1.

Betaines **10** and **11** were obtained as outlined in Scheme 2. The starting material, 2-acetyl-1*H*-benzimidazole **20** was brominated in the α-position[8] to give compound **21**. Then, reaction of the α-bromo-ketone **21** with an 1-alkylimidazole gave the 1-alkyl-3-(benzimidazolyloxoethyl)imidazolium salts **14, 15**, which were transformed[7] into their corresponding inner salts **10, 11**.



Scheme 2.

The unknown (*E*)-1-alkyl-3-[2-(1*H*-benzimidazol-2-yl)vinyl]imidazolium salts, e.g. **23**, the immediate precursors of the above-mentioned betaines **7**, *a priori* could be prepared according to a procedure published by Mc Farland *et al.*[9] for synthesis of 1-(2-arylvinyl)pyridinium salts.[10] This approach was attempted with 1-[2-(1*H*-benzimidazol-2-yl)oxoethyl]-3-methylimidazolium bromide **14** (Scheme 3). Different $NaBH_4$ reduction conditions of **14** were assayed,[9,11,12] and the best result is described in Scheme 3. Once synthesis of the intermediate alcohol **22** was achieved, its direct dehydration to the benzimidazolylvinylimidazolium salt **23** with several reagents[13] was tried. Neither the unreacted intermediate alcohol **22** nor the dehydrated compound **23** was observed, and these were therefore not further studied.[17]



Scheme 3.

The structures of the new betaines **8-11** and their precursors **12-15** have been unambiguously characterized on the basis of their spectroscopic data and all gave satisfactory elemental analysis.

For the title betaines **8-11**, the high degree of charge separation could be reflected in their ^1H and ^{13}C NMR data together with their experimental dipole moment values.[18] Table 1 summarizes the selected spectral data of the representative compounds **8**, **10**, **12**, and **14**; individual assignments have been made using the appropriate NMR techniques.

Table 1. Selected ^1H and ^{13}C NMR data of the representative compounds[20] **8**, **10**, **12**, and **14**

Compd	H-5'	H-α	H-β	H-4,7	C-α	C-β	C-2
8[a]	7.66	7.15	7.23	7.35	129.6	113.5	157.1
12[a]	8.10	7.28	7.50	7.43	123.9	117.3	149.9
Δδ[b]	-0.44	-0.13	-0.27	-0.08	+5.7	-3.8	+7.2
12[c]	8.22	7.22	7.45	7.35	123.2	116.2	149.1
		C$\underline{H_2}$	H-4	H-7	$\underline{C}O$[d]	$\underline{C}H_2$	
10[c]	7.65	5.40	7.24[e]	7.13[e]	149.4	50.7	163.1
14[c]	7.68	5.60	7.49[e]	7.35[e]	154.1	49.4	154.2
Δδ[b]	-0.03	-0.20	-0.25	-0.22	-4.7	+1.3	+8.9

a) In CD_3OD. $J_{H\alpha,H\beta} \approx 15.5$ Hz. b) Δδ: Observed chemical shifts difference between betaines **8**, **10** and their corresponding benzimidazolylimidazolium salts **12**, **14**. c) In DMSO-d_6. d) IR (KBr disks): betaine **10** ν_{CO} 1547 cm^{-1} and compound **14** ν_{CO} 1654 cm^{-1}. e) Signals can be interchanged.

With regard to the π-excessive and π-deficient heteroaromatic rings, both the ^1H and the ^{13}C NMR chemical shifts were in agreement with data for related heterocyclic betaines **1-4** and their derivatives.[2-4] Inspection of the ^1H and ^{13}C NMR parameters for betaines **8**, **10** and their corresponding benzimidazolylimidazolium salts **12**, **14** shows that the values of interannular linkage chemical shifts and the δC values of the C-2 in the benzimidazole ring are the most affected, along with the δ H-5' for compound pair **8** and **12** (see: Δδ in Table 1).

The dipolar character of the heterocyclic betaines **5** and **6** should have a dominant influence upon their chemistry and practical applications, which merit further studies, especially the novel extended π-systems **5** and their derivatives.

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5) *N*-Alkylation of urocanic acid gave the desired compounds **17** and **18** together with their corresponding monoalkylated products. Compounds **17** and **18** were isolated after several recrystallizations.
6) E.Alcalde, I.Dinarés, L.Pérez-García, and T.Roca, *Synthesis*, **1992**, 395.
7) The method of choice of this transformation was the use of a strong anion-exchange Amberlite IRA-401 (OH^- form) and also applied to other betaines or compounds with a betaine character.2-4)
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10) 1-(2-Arylvinyl)pyridinium salts were obtained by a four-step procedure from their corresponding arylacetophenones.9)
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17) Only products of decomposition were detected by ^{1}H NMR and TLC, probably due to the instability of either compound **22** or **23** under the reaction conditions. Notwithstanding, the imidazolium quaternary moiety has proved to be stable in other analogous compounds.3,4)
18) Concerning to the experimental dipole moment data of the aza-analogues of (*E*)-stilbene **1** with a dipolar character and the inner salts **2**2) together with the methyleneimidazolium azolate inner salts **4**,4) it was pointed out that the perturbing effect of self-association was not completely eliminated, with consequent decrease in the measured values. A similar situation holds for the present study, and it was not possible to measure coherent experimental dipole moment for betaine **8**.19)
19) J.-P.Fayet, Personal communication.
20) ^{1}H and ^{13}C NMR spectra were recorded on Varian Gemini 200, Varian Unity 300 and Varian VXR-500 spectrometers.

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