1,4- and 1,3-Dipolar Reactivity of α-Alkoxycarbonylcycloimmonium *N*-Aminides with Dipolarophiles: Synthesis of New Imidazo[2,1-*f*][1,2,4]triazinium Inner Salts

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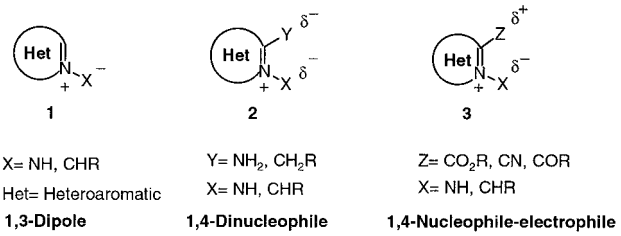
2-Alkoxycarbonylazolium *N*-aminides are interesting species, as they have the potential to act as efficient 1,4-dipole equivalents when they react with heterocumulenes, such as iso(thio)cyanates and carbodiimides. These reactions give heterobetaines containing the imidazo[2,1-*f*][1,2,4]-triazinium system, in a formal [4 + 2] cyclocondensation process. These *N*-aminides, however, can also behave as 1,3-dipoles when they react with isocyanates to afford a cycloadduct that, depending on the position of alkoxycarbonyl group, can undergo a reversion process or a ring expansion to the more stable heterobetaine system.

Introduction

Cycloimmonium *N*-ylides and *N*-aminides[1] **1** are well-established, versatile 1,3-dipoles, usually involved in 1,3-dipolar cycloaddition reactions.[2] 2-Alkyl- and 2-amino-substituted structures **2** have the potential to function as 1,4-dinucleophiles through deprotonation and are capable of reacting with 1,2-dicarbonyl compounds (Westphal reaction)[3]to afford a great variety of derivatives possessing a quaternary bridgehead nitrogen.[4]

However, with the exception of a few examples in the literature that describe the reactivity of 2-carbonylpyridinium *N*-aminides with nitriles, and the dimerization of 2-cyano-, 2-alkoxycarbonyl-, and 2-aroyl-*N*-aminoazinium salts,[5] relatively less attention has been focused on the possibility of using compounds **3** as 1,4-nucleophile−electrophiles (Chart 1).

Chart 1



With regard to the 1,4-nucleophilic−electrophilic character of **3**, we previously reported[6] some examples of 2-ethoxycarbonyl azinium (pyridinium, quinolinium, isoquinolinium) salts **4**, which reacted with isocyanates and isothiocyanates to afford new conjugated mesomeric betaines **5** in a formal [4 + 2] cyclocondensation process (Scheme 1).

As an extension of this preliminary work, we recently reported[7] the reactivity of **4** with different olefinic dipolarophiles. We found that *N*-aminides **4a** function as 1,3-dipoles when reacted with typical Michael acceptors to give the corresponding cycloadducts and, depending on the regioisomeric nature, one of the products undergoes a ring expansion leading to heterobetaines **6** (Scheme 1). By contrast, the same *N*-aminides **4a**,[7b] when allowed to react with acetylenic compounds, afford only the corresponding cycloadduct **7**. In this case the initial formation of a cycloadduct that is stabilized upon oxidation precludes the ring expansion process.

This interesting dual role found for azinium *N*-aminides **4a** prompted us to extend our work to include the behavior of of azolium *N*-aminides **9**, aiming to find an effective methodology applicable to the synthesis of

* To whom correspondence should be addressed. FAX: 34-1-91-8854660.

(1) The term "*N*-Aminides" has been used as defined by Ollis, W. D.; Stanforth, S. P. *Tetrahedron* **1985**, *41*, 2239−2329.

(2) (a) Padwa, A. In *1,3-Dipolar Cycloaddition Chemistry*; Taylor, E. C., Weissberger, A., Eds.; J. Wiley & Sons: New York, 1984; vol. 2, p 277. (b) Grashey, R.; Padwa, A. In *1,3-Dipolar Cycloaddition Chemistry*; Taylor, E. C., Weissberger, A., Eds.; J. Wiley & Sons: New York, 1984; vol. 1, p 733. (c) Rodina, L. L.; Kolberg, A.; Schilze, B. *Heterocycles* **1998**, *49*, 587−618.

(3) Westphal, O.; Jahn, K.; Heffe, W. E. *Arch. Pharm.* **1961**, *294*, 37−45.

(4) For recent contributions, see: (a) Matia, M. P.; Ezquerra, J.; Sanchez-Ferrando, F.; García Navio, J. L.; Vaquero, J. J.; Alvarez-Builla, J. *Tetrahedron* **1991**, *47*, 7329−7342. (b) Matia, M. P.; Ezquerra, J.; Sanchez-Ferrando, F.; Garcia-Navio J. L.; Vaquero, J. J.; Alvarez-Builla, J. *Tetrahedron Lett.* **1991**, *32*, 7575−7578. (c) Hajós, G.; Messmer, A.; Bátori, S.; Riedl, Z. *Bull. Soc. Chim. Belg.* **1992**, *101*, 597−607. (d) Hajós, G.; Riedl, Z.; Gács-Baitz, E.; Messmer, A. *Tetrahedron* **1992**, *48*, 8459−8464. (e) Matia, M. P.; García-Navio, J. L.; Vaquero, J. J.; Alvarez-Builla, J. *Liebigs Ann. Chem.* **1992**, 777−779. (f) Santiesteban, I.; Siro, J. G.; Vaquero, J. J.; García-Navio, J. L.; Alvarez-Builla, J.; Castaño. O. *J. Org. Chem.* **1995**, *60*, 5667−5672. (g) Diaz, A.; Matia, M. P.; García-Navio, J. L.; Vaquero, J. J.; Alvarez-Builla, J. *J. Org. Chem.* **1994**, *59*, 8294−8296. (h) Molina, A.; Vaquero, J. J.; García-Navio, J. L.; Alvarez-Builla, J.; Rodrigo, M. M.; Castaño, O.; de Andrés, J. L. *Bioorg., Med. Chem. Lett.* **1996**, 1453−1456. (i) Pastor, J.; Siro, J. G.; García-Navio, J. L.; Vaquero, J. J.; Rodrigo, M. M.; Ballesteros. M.; Alvarez-Builla, J. *Bioorg. Med. Chem. Lett.* **1995**, *6*, 3043−3048. (j) Pastor, J.; Siro, J.; García-Navio, J. L.; Alvarez-Builla, J.; Gago, F.; de Pascual-Teresa, B.; Pastor, M.; Rodrigo, M. *J. Org. Chem.* **1997**, *62*, 5476−5483. (k) Molina, A.; Vaquero J. J.; García-Navio, J. L.; Alvarez-Builla, J.; de Pascual-Teresa, B.; Gago, F.; Rodrigo, M. M. *J. Org. Chem.* **1999**, *64*, 3907−3915.

(5) (a) Bátori, S.; Juhász-Riedl, Zs.; Sandor, P.; Messmer, A. *J. Heterocycl. Chem.* **1986**, *23*, 375−380. (b) Bátori, S.; Messmer, A. *J. Heterocycl. Chem.* **1988**, *25*, 437−444. (c) Bátori, S.; Hajós, G.; Sándor, P.; Messmer, A. *J. Org. Chem.* **1989**, *54*, 3062−3068. (d) Bátori, S.; Messmer, A. *J. Heterocycl. Chem.* **1990**, *27*, 1673−1680.

(6) Cuadro, A. M.; Valenciano, J.; Vaquero, J. J.; García-Navio, J. L.; Alvarez-Builla, J. *Tetrahedron* **1993**, *49*, 3185−3192.

(7) (a)Valenciano, J.; Cuadro, A. M.; Vaquero, J. J.; Alvarez-Builla, J. *Tetrahedron Lett.* **1999**, *40*, 763−766. (b) Valenciano, J.; Cuadro, A. M.: Vaquero J. J.; Alvarez-Builla, J.; Palmeiro, R.; Castaño, O. *J. Org. Chem.* **1999**, *64*, 9001−9010.

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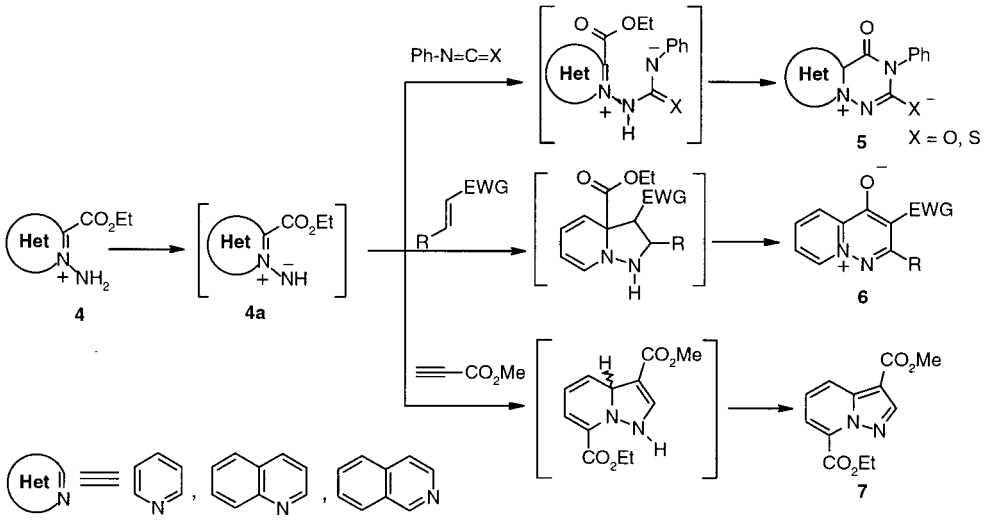
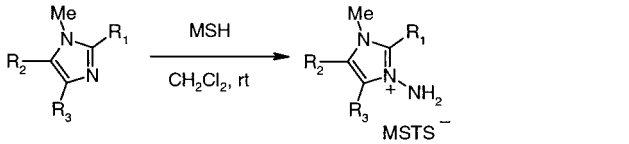
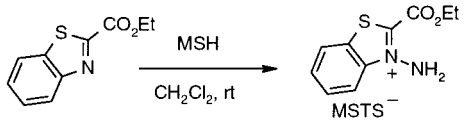
Scheme 1



Scheme 2



8a, $R_1 = CO_2Et$; $R_2, R_3 = H$ (92%)
8b, $R_1 = CO_2Et$; $R_2, R_3 = -(CH{=}CH)_2-$ (79%)
8c, $R_1 = Me$; $R_3 = CO_2Me$; $R_2 = H$ (93%)



8d (84%)

MSTS = Mesitylenesulfonate

new classes of heterobetaines. Furthermore, with regard to the reactivity of azolium *N*-aminides **9**, no examples has been reported in the literature, where the compounds **9** behave as formal 1,4-nucleophile−electrophiles. However, some examples describing their behaviors as 1,3-dipoles[1,2b,c] with acetylenic and olefinic dipolarophiles, and as 1,4-dinucleophiles with 1,2-dicarbonyl compounds, have been reported.[4e,i,j]

In this paper we report the first example of the 1,4-nucleophilic−electrophilic behavior of azolium *N*-aminides by reaction with heterocumulenes, leading to imidazo-[2,1-*f*][1,2,4]triazinium systems. Additionally, full details are given on the reactivity found for azolium *N*-aminides as 1,3- and/or 1,4-dipole equivalents, as well as a new route to guanidines bearing an imidazolium group.

Results and Discussion

Bearing our aims in mind, and taking into account the aforementioned behavior of azinium *N*- aminides **4a** with dipolarophiles, we initiated our study from 2-ethoxycarbonylazolium *N*-aminides **9**. The precursor salts **8** were obtained by direct amination of the corresponding alkoxycarbonylazoles (Scheme 2) using mesitylenesulfonylhydroxylamine (MSH) as the aminating agent.[8]

We found that azolium *N*-aminides **9a** and **9b**, readily generated from the corresponding salts **8** in the presence of *N*-ethyldiisopropylamine (Hünig's base), reacted with phenyl iso(thio)cyanates to afford the corresponding imidazo [2,1-*f*][1,2,4] triazinium inner salts **12a**−**d** in a formal [4 + 2] cyclocondensation process (Scheme 3). Similarly, treatment of the *N*-aminide **9d** with phenyl isocyanate gave the heterobetaine **12e** in moderate yield (35%). However, only tarry materials were obtained in the reaction of **8d** with phenyl isothiocyanate.

Although all our attempts to isolate intermediates **10** (see Scheme 4, **10a**) failed, the formation of the heterobetaines **12** can be envisaged via these dipolar intermediates, by analogy with the observed behavior of azinium *N*-aminides with heterocumulenes, where these intermediates have been detected and/or isolated in a number of cases.[6]

However, the isolation of carbamate **13** in 10−13% yield (Scheme 3), suggests prior formation of the less stable cycloadduct **11a** (Scheme 4), formed in a 1,3-dipolar cycloaddition fashion, and subsequent reaction with phenyl isocyanate. Compound **12a** also could be formed from **11a** by a concerted ring expansion process, as outlined in our recent report.[7b] The formation of **11a** could be explained by cyclization of **10a**, where the ester group at C-2 of the azolium ring enhances the electrophilicity at this position. Alternatively, direct formation of **12a** and **13** from open betaine **10a** cannot be discarded.

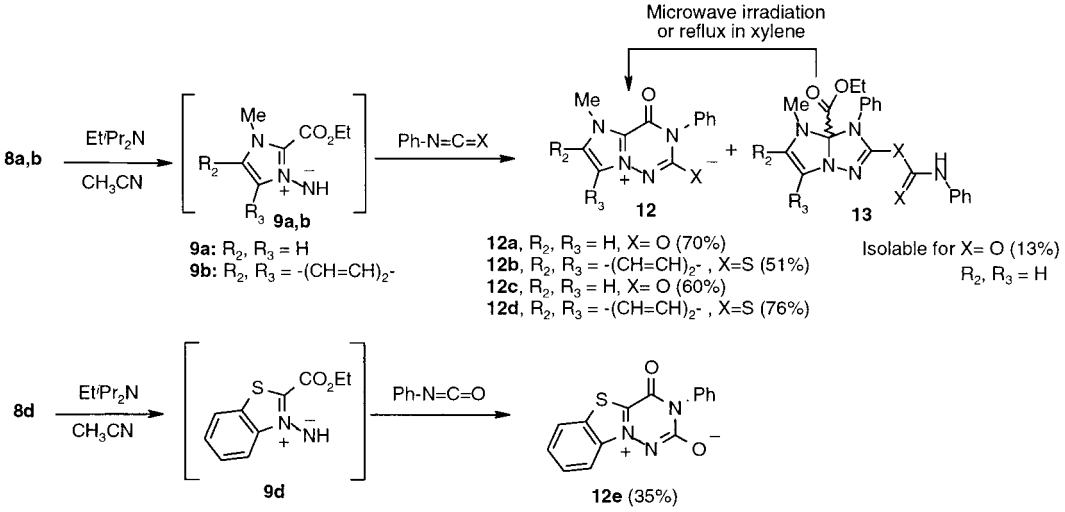
Conversion of **13** into **12a** (Scheme 3) was achieved by adsorbing **13** onto silica gel and then irradiating the adsorbed compound with microwaves[9] [5 min /470 W]. Thermal heating of **13** by refluxing in acetonitrile for 24 h yielded only the starting material, while refluxing in xylene produced traces of **12a** after 10 h.

All these results provide further support for the mechanism proposed in Scheme 4, involving an equilibrium between intermediates **10a** and **11a**, with **12a**, aromatic and with a (5,6)-fused bicyclic ring system, being the main reaction product.

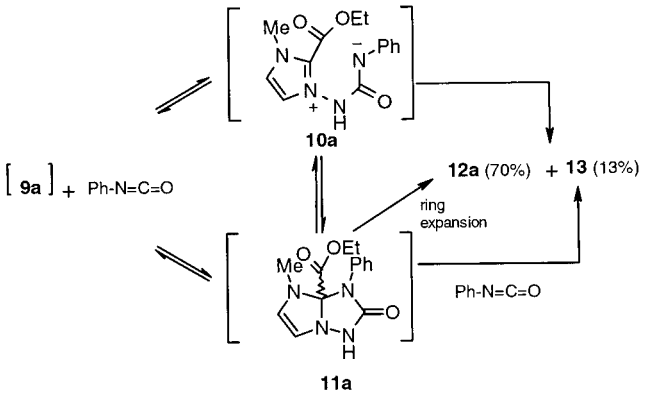
To explore the scope of the process, we also studied the reaction of 5-alkoxycarbonyl-azolium *N*-aminide **9c**

(8) Tamura, Y.; Minamikawa, J.; Ykeda, M. *Synthesis* **1977**, 1−17.
(9) Microwave irradiation was carried out with a Sanyo microwave oven (EM-S100, 800 W), calibrated by a standard procedure (Watkinds, K. W. *J. Chem. Ed.* **1983**, *60*, 1043−1044).

Scheme 3



Scheme 4



with phenyl isocyanate. This compound reacted to give only the carbamate **15** (80%), with no traces of the heterobetaine **16** detected. In this case, the methoxycarbonyl group at C-5 of the imidazolium ring would be less activated, so the cycloaddition at C-2 would be expected to be the predominant process. In addition, the initial cycloadduct **14**, in the presence of base, is stabilized further by acylation to **15** (Scheme 5). All our attempts to convert **15** into the heterobetaine **16** failed. The different behavior of **15** when compared with **13** can not only be explained by the differences of steric hindrance of the bridgehead methyl group when compared with the ethoxycarbonyl substituent in **13**, or by the different reactivity of the 5-ester group in **9c**. If ring expansion were produced through a zwiterionic intermediate, the heterobetaine **16** should have been detected. As only **14** was formed—isolated as **15**—the result supports a concerted ring expansion mechanism, according to our previous results.[7b]

The salts **8** were reacted with other heterocumulenes, such as benzoyl iso(thio)cyanates. Thus, the reaction of **8a** with benzoyl isocyanate was carried out at room temperature for 5 h, and the aminide **17a** was obtained as the major component (48%), along with traces of the heterobetaine **18a**. Furthermore, when **17a** was heated in CH_3CN or xylene with Hünig's base for up to 20 h, or under microwave irradiation (10 min, 470 W), it could not be converted into the heterobetaine **18a**, and in the latter case, extensive decomposition was observed. However, when **8a** was refluxed with benzoyl isocyanate for 24 h in a homogeneous system (Hünig's base/CH_3CN), the heterobetaine **18a** (14%) was obtained as minor, along with **17a** (42% yield) and traces of compound **19**. Analogous behavior was observed in the reaction of **8b** with benzoyl isocyanate at room temperature for 10 h, leading to **17b** (56%). However, after reflux in CH_3CN for 24 h, the heterobetaine **18b** was isolated in 20% yield, together with **17b** (30%). The low yield obtained in the cyclocondensation product could be related to the low nucleophilicity of the imide nitrogen in compounds **17**, as a result of the extensive delocalization of the negative charge (Scheme 6).

When the reaction of **8a** was performed with benzoyl isothiocyanate, the heterobetaine **22a** was not observed, and only the aminide **21** was obtained (57% yield) instead. The formation of **21** is explained by the attack of the nitrogen of the *N*-aminide to the carbonyl group and subsequent loss of isothiocyanate. Under the same conditions, the salt **8b** gave the heterobetaine **22b** in 45% yield (Scheme 7).

In the reaction of azolium-*N*-aminides with carbodiimides, it was found that the corresponding heterobetaines, which are analogous to azinium-related derivatives previously described,[10] were obtained. The conjugated heterobetaines **24** were prepared quantitatively by reaction of 2-alkoxycarbonylazolium salts **8** with di-*p*-tolylcarbodiimide, followed by treatment with potassium carbonate in CH_3CN.

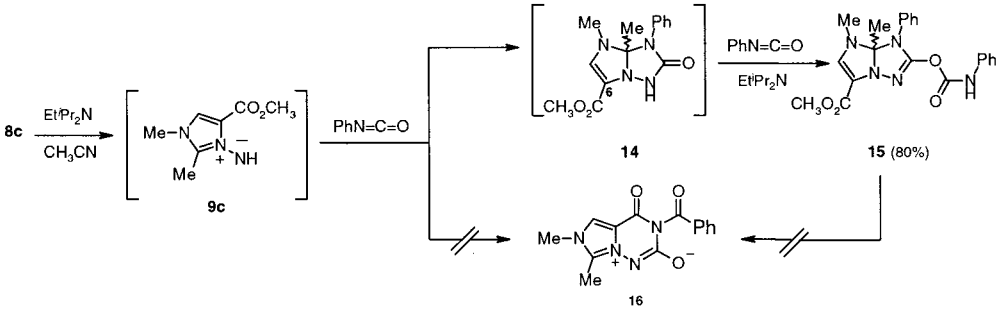
Aqueous treatment of **24a** yielded the imidazolium guanidine **25** by ring hydrolysis and subsequent decarboxylation (Scheme 8). This compound also was obtained directly by stirring **23a** in an aqueous potassium carbonate solution at room temperature. This result is of particular interest in terms of gaining access, under mild conditions, to imidazolium-substituted guanidines. Unfortunately, **24b** undergoes extensive decomposition under similar conditions.

Finally, to complete this study we decided to investigate the behavior of the salts **8** with olefinic dipolarophiles, expecting to observe a tandem 1,3-cycloaddition/ring expansion process.[7b]

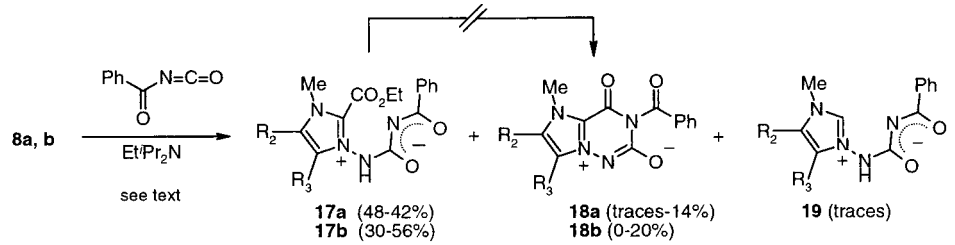
The reaction of **8a** with *N*-methylmaleimide (Scheme 9) in CH_2Cl_2, in the presence of Hünig's base, produced

(10) Valenciano, J.; Cuadro, A. M.; Vaquero, J. J.; Garca-Navio, J. L.; Alvarez-Builla, J.; Gomez-Sal, P.; Martin, A. *Tetrahedron* **1996**, *52*, 11349−11360.

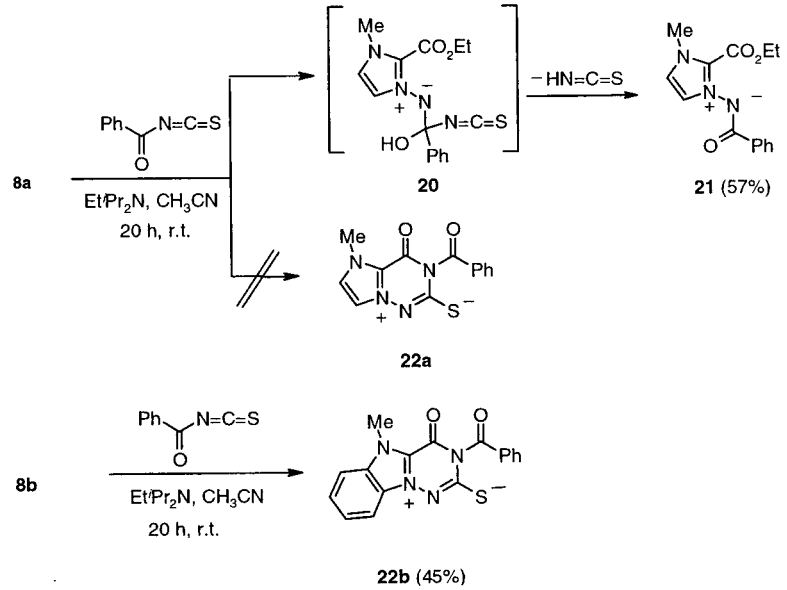
Scheme 5



Scheme 6



Scheme 7

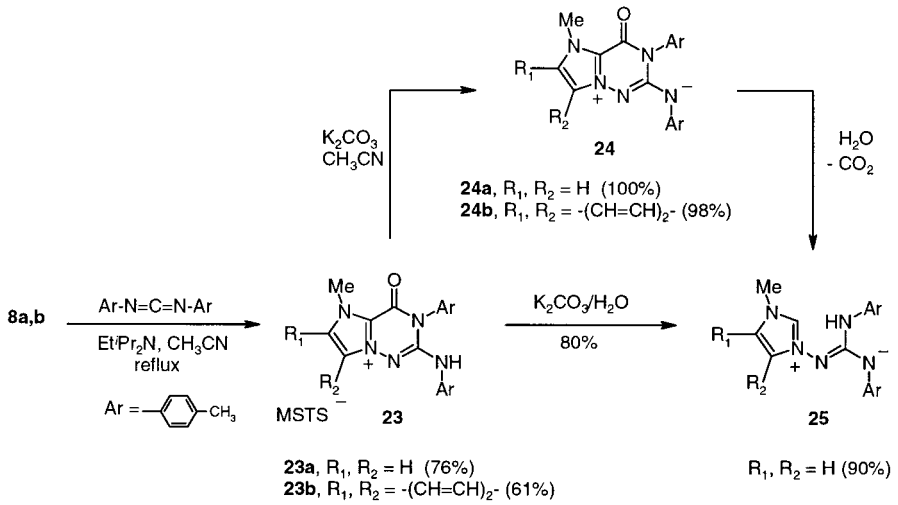


extensive decomposition, and the expected tandem process was not observed. Under similar conditions, the reaction of **8a** with acrylonitrile produced the dihydro derivative **28** as the only isolable product (23%), which resisted oxidation to the heterobetaine **29,** either by using 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) at room temperature, or by refluxing in CH_3CN for 20 h. The process was also tested with diethyl fumarate, allowing acces to the dihydro derivative **30** (11%) from a complex reaction mixture. A slightly better result was obtained in the presence of K_2CO_3 at room temperature to produce **30** (16%), together with the fully aromatized product **31** (7%).

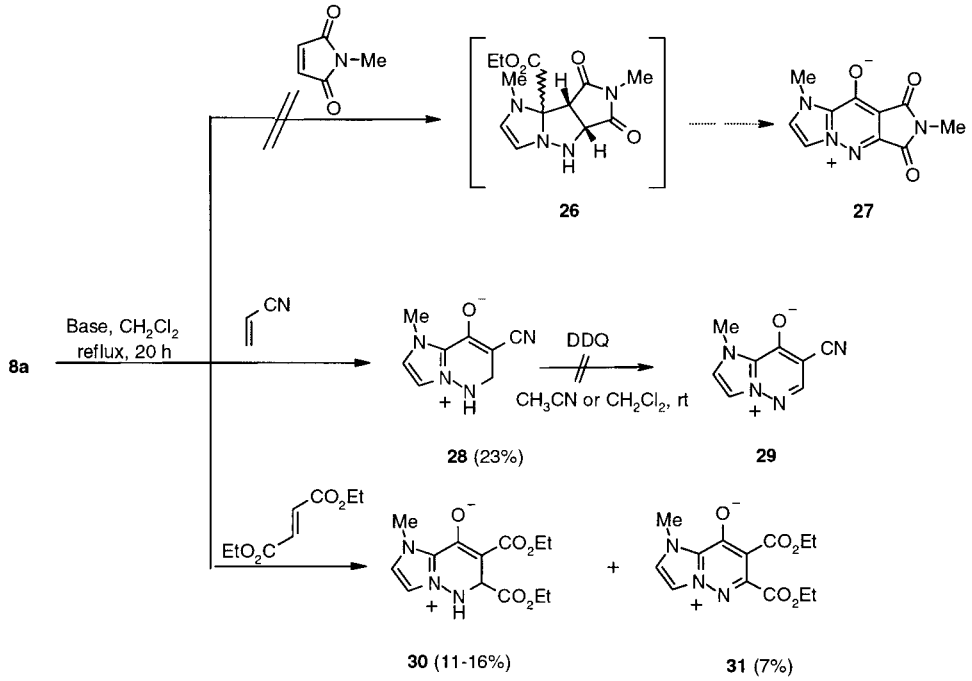
Similar experiments were performed on **8b** with *N*-methylmaleimide (Scheme 10), producing a mixture of *endo*/*exo*-cycloadducts **32** and **33** (7:1) in 78% yield after 20 h reflux. These cycloadducts were identified by the different shielding effect observed on the imide *N*-methyl group,[11] because no useful data were obtained neither from ring hydrogen shifts nor from coupling constants.[12] According to our previous results,[7b] we expected that refluxing the mixture would result in the formation of **34**. This heterobetaine, however, was not detected even when the cycloadducts were heated in CH_3CN for up to 20 h, in xylene or irradiating the adsorbed compound with microwaves [5 min/470 W]. The above results could be explained by invoking the aromaticity. The cycloadducts **32** and **33** have an aromaticity that is not clearly increased on evolution to **34**, and thus the change is not favored in the same way as for the monocyclic heterocycles (Scheme 1). Under the same conditions, when acrylonitrile was used as dipolarophile, extensive decomposition was observed, whereas with diethyl fumarate, in the presence of K_2CO_3, the heterobetaine **36** was

(11) Tamura, Y.; Miki, Y.; Ikeda, M. *J. Chem. Soc., Perkin Trans. 1* **1976**, 1702−1705.
(12) Huisgen, R.; Temme, R. *Eur. J. Org. Chem.* **1998**, 387−401.

Scheme 8



Scheme 9



isolated in low yield (19%), together with byproducts corresponding to a double addition of the dipolarophile.

In summary, we have shown that azolium *N*-aminides **9** bearing an ester group can behave as ambivalent substrates when reacted with heterocumulenes, yielding imidazo [2,1-*f*]-[1,2,4] triazinium inner salts. The reaction can be explained in terms either of intermediates such as the open betaine **10a** or the cycloadduct **11a**, with *N*-aminides behaving as 1,4-nucleophile−electrophiles in a formal cyclocondensation process or, alternatively, behaving as 1,3-dipoles leading to cycloadducts that, depending on the position of the alkoxycarbonyl group, can undergo a thermal reversion process or a ring expansion to the more stable heterobetaine system. Furthermore, an efficient and simple method for the preparation of imidazolium-substituted guanidines has been developed using this methodology.

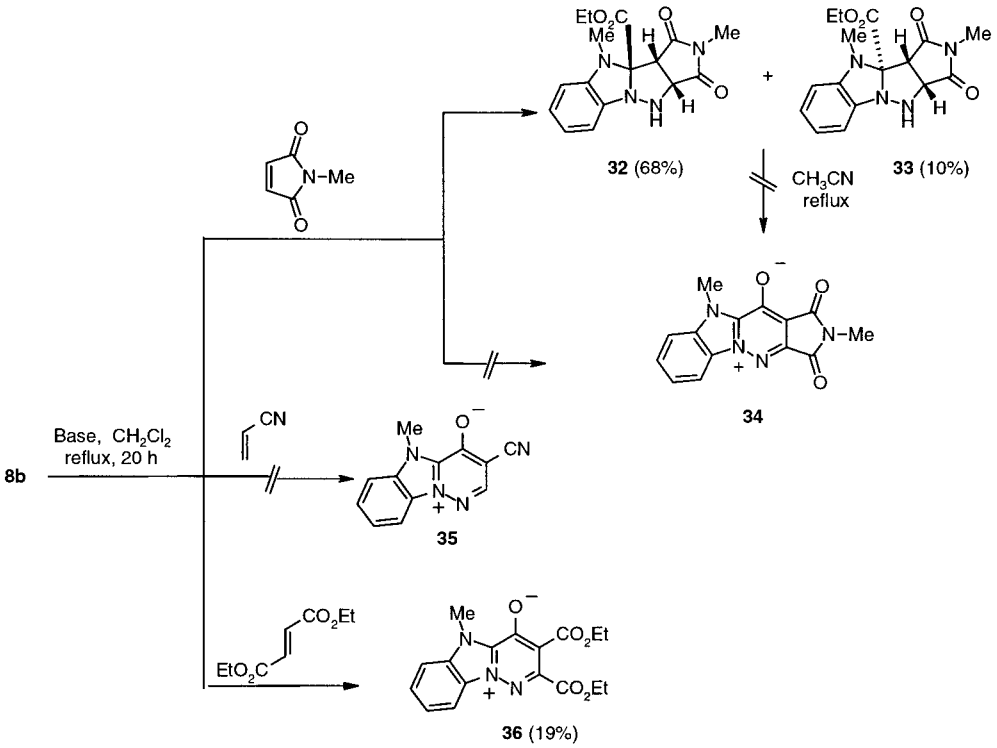
Experimental Section

General. Melting points are uncorrected. Infrared spectra were recorded on KBr pellets and bands are reported in cm^{-1}. The ^1H and ^{13}C NMR spectra were collected at 200, 300, 500 MHz and 50, 75, 125 MHz, respectively. Chemical shifts are reported as δ values (ppm). The low-resolution mass spectra (MS) were obtained as CI (CH_4), FAB (*m*-NBA), or ESI (Na), and high-resolution mass spectra (HRMS) were recorded with *m*-NBA at 35 keV (Cs iodide). Column chromatography was performed on silica gel 60 (230−400 mesh). 2-Ethoxycarbonyl-1-methylbenzimidazole[13,14] and 2-ethoxycarbonyl-1-methylimidazole[15] were obtained according to previously described methods. 1,2-Dimethyl-4-methoxycarbonylimidazole was obtained from *N*-phenyl-1,2-dimethylimidazole-4-carboxamide,[16] after hydrolysis and esterification, using known procedures.

Synthesis of Azolium Salts 8. General Procedure. To a stirred solution of the alkoxycarbonylazole (2 mmol) in 5 mL of CH_2Cl_2 was added a solution of MSH (0.650 g, 3 mmol) in 5 mL of CH_2Cl_2. The mixture was stirred at room temperature for 2 h, and the solvent was evaporated. The resulting residue

(13) Dürckheimer, W. *Liebigs Ann. Chem*. **1972**, *756*, 45−154.
(14) Sabri, S. S.; El-Abadelah, M. M.; Yasin, H. A. *J. Heterocycl. Chem*. **1987**, *24*, 165−169.
(15) Regel, E.; Büchel, K. H. *Liebigs Ann. Chem*. **1977**, 145−158.
(16) Papadopoulos, E. *J. Org. Chem*. **1977**, *24*, 3925−3929.

Scheme 10



was triturated with EtOAc or Et_2O and crystallized from EtOAc/EtOH.

1-Amino-2-ethoxycarbonyl-3-methylimidazolium Mesitylenesulfonate (8a). From 2-ethoxycarbonyl-1-methylimidazole (0.310 g, 2 mmol) and following the general procedure, the resulting residue was triturated with EtOAc. The precipitate was isolated by filtration and washed with EtOAc to afford 0.68 g (92%) of **8a** as a white solid: mp 133−134 °C (EtOAc/EtOH); IR (KBr) 3290, 1736, 1198, 1152 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 8.12 (s, 1H), 7.85 (s, 1H), 6.78 (s, 2H), 4.44 (q, 2H, $J = 7.0$ Hz), 4.06 (s, 3H), 2.59 (s, 6H), 2.21 (s, 3H), 1.39 (t, 3H, $J = 7.0$ Hz); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 154.3, 140.0, 138.2, 136.8, 130.5, 126.9, 125.3, 123.1, 64.3, 39.1, 22.9, 20.7, 13.8; MS (ESI^+) *m/z* 170 (M^+). Anal. Calcd for $C_{16}H_{23}N_3O_5S$: C, 52.02; H, 6.27; N, 11.37. Found: C, 52.29; H, 6.32; N, 11.65,

1-Amino-2-ethoxycarbonyl-3-methylbenzimidazolium Mesitylenesulfonate (8b). Following the general procedure, from 2-ethoxycarbonyl-1-methylbenzimidazole (0.400 g, 2 mmol), the resulting residue was triturated with Et_2O. The precipitate was isolated by filtration and washed with Et_2O to afford 0.65 g (79%) of **8b** as a white solid: mp 174−175 °C (EtOAc/EtOH); IR (KBr) 3245, 1734, 1174 cm^{-1}; ^1H NMR (CD_3OD, 200 MHz) δ 8.04−8.80 (m, 2H), 7.82−7.78 (m, 2H), 6.81 (s, 2H), 4.7 (q, 2H, $J = 7.2$ Hz), 4.30 (s, 3H), 2.56 (s, 6H), 2.21 (s, 3H), 1.53 (t, 3H, $J = 7.2$ Hz); ^{13}C NMR (DMSO-d_6, 125 MHz) δ 153.6, 142.0, 135.7, 135.6, 135.3, 130.5, 129.5, 128.0, 127.7, 113.4, 113.2, 63.9, 33.7, 22.1, 19.7, 13.1; MS (ESI^+) *m/z* 220 (M^+). Anal. Calcd for $C_{20}H_{25}N_3O_5S$: C, 57.26; H, 6.01; N, 10.02. Found: C, 57.09; H, 5.98; N, 9.85.

1-Amino-5-methoxycarbonyl-2,3-dimethylimidazolium Mesitylenesulfonate (8c). Following the general procedure, from 1,2-dimethyl-4-methoxycarbonylimidazole (0.300 g, 2 mmol) and stirring the mixture for 30 min, the resulting residue was triturated with Et_2O. The precipitate was isolated by filtration and washed with Et_2O to afford 0.68 g (93%) of **8c** as a white solid: mp 168−170 °C (EtOAc/EtOH); IR (KBr) 3291, 1744, 1180 cm^{-1}; ^1H NMR (DMSO-d_6, 200 MHz) δ 8.37 (s, 1H), 6.71 (s, 2H), 6.59 (s, 2H), 3.87 (s, 3H), 3.76 (s, 3H), 2.57 (s, 3H), 2.46 (s, 6H), 2.15 (s, 3H); ^{13}C NMR (DMSO-d_6, 125 MHz) δ 157.3, 147.9, 142.3, 135.7, 135.4, 129.3, 126.2, 121.5, 52.1, 34.8, 22.2, 19.7, 8.6; MS (ESI^+) *m/z* 156 (M^+). Anal. Calcd for $C_{16}H_{23}N_3O_5S$: C, 52.02; H, 6.27; N, 11.37. Found: C, 51.79; H, 6.12; N, 11.09.

3-Amino-2-ethoxycarbonylbenzothiazolium Mesitylenesulfonate (8d). Following the general procedure, from 2-ethoxycarbonylbenzothiazole (0.210 g, 1 mmol) and stirring the mixture for 30 min, the resulting residue was triturated with Et_2O. The precipitate was isolated by filtration and washed with Et_2O to afford 0.35 g (84%) of **8d** as a pale yellow solid: mp 154−155 °C (AcOEt/EtOH); IR (KBr) 3300, 1726, 1169 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 8.64−8.60 (m, 1H), 8.10−8.02 (m, 1H), 7.90−7.78 (m, 2H), 6.68 (s, 2H), 4.62 (c, 2H, $J = 7.2$ Hz), 2.44 (s, 6H), 2.19 (s, 3H), 1.50 (t, 3H, $J = 7.2$ Hz); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 156.8, 142.9, 140.0, 139.9, 138.0, 136.9, 131.7, 130.8, 130.4, 128.3, 123.3, 119.8, 65.8, 22.8, 20.7, 13.9; MS (ESI^+) *m/z* 223 (M^+). Anal. Calcd for $C_{19}H_{22}N_2O_5S_2$ C, 54.01; H 5.25; N 6.63. Found: C, 53.77; H 5.18; N 6.45.

Reaction of Azolium Salts 5 with Iso(thio)cyanates. Synthesis of Heterobetaines 12. General Procedure. To a solution of the azolium salt **8** (0.12 mmol) and the heterocumulene (0.18 mmol) in 5 mL of dry CH_3CN was added dropwise 0.083 mL (0.24 mmol) of *N*-ethyldiisopropylamine. The mixture was stirred at room temperature for 20 h, and the corresponding heterobetaine was purified by crystallization or column chromatography.

5-Methyl-4-oxo-3-phenyl-4,5-dihydro-3*H*-imidazo[2,1-*f*][1,2,4]-8-triazinium-2-olate (12a) and 4-Methyl-3-phenyl-2-phenylcarbamoyloxy-3*H*,4*H*-imidazo[1,2-*b*][1,2,4]-triazole-3a-carboxylic Acid Ethyl Ester (13). Following the general procedure, from 0.050 g (0.14 mmol) of **8a** and phenyl isocyanate (19 μL, 0.18 mmol), the solvent was removed and the residue was purified by column chromatography on silica gel (acetone and acetone/MeOH, 7:3). The carbamate **13** (0.072 mg, 13%) was eluted first and isolated as a white solid. The heterobetaine **12a** (0.023 g, 70%) was obtained as white solid.

13: mp 157−158 °C; IR (KBr) 1731, 1689, 1328 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 12.23 (s, 1H), 7.53 (dd, 2H, $J = 8.0$, 1.8 Hz), 7.40 (ddd, 2H, $J = 7.2$, 8.0, 1.8 Hz), 7.32 (dd, 2H, $J = 7.9$, 1.4 Hz), 7.29 (ddd, 1H, $J = 7.2$, 1.8 Hz), 7.22 (dd, 2H, $J = 7.9$, 7.3, 1.4 Hz), 7.19 (d, 1H, $J = 1.8$ Hz), 7.01 (d, 1H, $J = 1.8$ Hz), 6.97 (ddd, 1H, $J = 7.3$, 1.4 Hz), 4.46 (q, 2H), 1.43 (t, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 164.3, 154.6, 154.3, 139.9, 139.2, 131.2, 129.6, 128.65, 127.1, 124. 6, 122.51, 121.8, 119. 5, 119.4, 63.5, 38.1, 14.1; MS (FAB, *m*-NBA) (*m/z*) (relative intensity) 408 (M^+, 65), 196 (100); HRMS Calcd for $C_{21}H_{21}N_5O_4$: 408.1672. Found: 408.1675.

12a: mp 294−295 °C; IR (KBr) 1698, 1613 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 7.91 (d, 1H, J = 1.8 Hz), 7.81 (d, J = 1.8 Hz), 7.50−7.32 (m, 3H), 7.24−7.16 (m, 2H), 4.01 (s, 3H); ^{13}C NMR (DMSO-d_6, 50 MHz) δ 153.7, 152.0, 135.9, 128.8, 128.6, 127.8, 125.6, 125.3, 116.6, 36.1; MS (*m*/*z*) 242 (M^+, 100). Anal. Calcd for $C_{12}H_{10}N_4O_2$: C, 59.50; H, 4.16; N, 23.13. Found: C, 59.17; H, 4.01; N, 22.89.

Microwave-Induced Transformation of 13 in 12a. Compound **13** (0.05 g, 12 mmol) was supported on silica gel (60, 230−400 mesh, 100 mg) in an open vial (10 mL). The mixture was placed in a conventional microwave and irradiated for 5 min at 470 W. After the mixture was cooled to room temperature, it was washed with acetone. The solvent was evaporated to give 0.029 g (98%) of **12a** as white solid.

5-Methyl-4-oxo-3-phenyl-4,5-dihydro-3*H*-imidazo[2,1-*f*][1,2,4]-8-triazinium-2-thiolate (12b). From the salt **8a** (0.100 g, 0.27 mmol) and phenyl isothiocyanate (48 μL, 0.40 mmol), following the general procedure, the resulting precipitate was filtered off to yield **12b** (0.035 g, 50%) as a pale yellow solid: mp 210−211 °C (CH_3CN); IR (KBr) 1691, 1470, 1405, 1178 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 8.0−7.99 (m, 2H), 7.42−7.39 (m, 3H), 7.13−7.10 (m, 2H), 4.03 (s, 3H); ^{13}C NMR (DMSO-d_6, 125 MHz) δ 173.5, 149.7, 138.2, 128.5, 128.1, 127.2, 126.9, 125.3, 115.7, 35.8; MS (*m*/*z*) 258 (M^+, 16), 226 (72), 109 (100). Anal. Calcd for $C_{12}H_{10}N_4OS$: C, 55.80; H, 3.90; N, 21.70. Found: C, 55.57; H, 3.79; N, 21.65.

5-Methyl-4-oxo-3-phenyl-4,5-dihydro-3*H*-benzo[4,5]-imidazo[2,1-*f*][1,2,4]triazinium-2-olate (12c). Following the general procedure, from 0.050 g (0.12 mmol) of **8b** and phenyl isocyanate (19 μL, 0.18 mmol), the solvent was removed and the residue was purified by column chromatography (EtOAc/acetone, 6:4) to yield 0.021 g (60%) of **12c** as a pale yellow solid: mp 279−280 °C; IR (KBr) 1690, 1640 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 8.11−8.03 (m, 2H), 7.80−7.74 (m, 1H), 7.68−7.65 (m, 1H), 7.51−7.40 (m, 3H), 7.26−7.23 (m, 2H), 4.24 (s, 3H); ^{13}C NMR (DMSO-d_6, 50 MHz) δ 153.5, 153.0, 135.9, 131.7, 128.8, 128.7, 128.6, 127.9, 126.9, 125.7, 114.2, 112.9, 32.2; MS (*m*/*z*) 292 (M^+, 100), 144 (94), 118 (87). Anal. Calcd for $C_{16}H_{12}N_4O_2$: C, 65.75; H, 4.14; N, 19.17. Found: C, 65.59; H, 4.03; N, 19.05.

5-Methyl-4-oxo-3-phenyl-4,5-dihydro-3*H*-[1,2,4]triazino-[1,6-*a*]-10-benzimidazolium-2-thiolate (12d). The general procedure was applied to **8b** (0.050 g, 0.12 mmol) and phenyl isothiocyanate (22 μL, 0.18 mmol). After removing the solvent, the residue was purified by column chromatography (EtOAc/acetone, 9:1) to yield 0.028 g of **12d** (76%) as a yellow solid: mp 219−220 °C (CH_3CN); IR (KBr) 1680, 1184 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 8.21−8.06 (m, 2H), 7.83−7.73 (m, 2H), 7.48−7.36 (m, 3H), 7.20−7.15 (m, 2H), 4.26 (s, 3H); ^{13}C NMR (DMSO-d_6, 50 MHz) δ 173.5, 151.2, 138.8, 131.5, 131.4, 129.2, 128.8, 128.7, 127.9, 126.7, 126.1, 114.7, 113.2, 32.5; MS (ESI^+) *m*/*z* 308 $(M + H)^+$. Anal. Calcd for $C_{16}H_{12}N_4OS$: C, 62.32; H, 3.92; N, 18.17. Found: C, 62.62; H, 4.13; N, 18.36.

3-Phenyl-4-oxo-3,4-dihydro[1,2,4]triazino[6,1-*b*]-10-benzothiazolium-2-olate (12e). The general procedure was applied to **8d** (0.200 g, 0.47 mmol) and phenyl isocyanate (0.061 mL, 0.57 mmol), and the resulting precipitate was isolated by filtration to give 0.049 g of **12e** (35%) as a white solid: mp 297−298 °C (CH_3CN); IR (KBr) 1697, 1630 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 8.41 (dd, 1H, J = 8.2, 1.3 Hz), 7.92−7.84 (m, 1H), 7.80−7.64 (m, 2H), 7.52−7.40 (m, 5H); ^{13}C NMR (DMSO-d_6, 50 MHz) δ 168.0, 157.3, 132.7, 131.8, 129.2, 129.0, 128.9, 128.5, 128.1, 127.6, 126.6, 121.9, 119.8; MS (ESI^+) *m*/*z* 613 $(2M + Na)^+$. Anal. Calcd for $C_{15}H_9N_3O_2S$: C, 61.01; H, 3.07; N, 10.86. Found: C, 60.89; H, 3.00; N, 10.78.

Reaction of the Salt 5c with Phenyl Isocyanate. Synthesis of Triazolone 15. To a suspension of **8c** (0.050 g, 0.14 mmol) and phenyl isocyanate (22 μL, 0.20 mmol) in dry CH_3CN was added 47 μL (0.28 mmol) of *N*-ethyldiisopropylamine. The reaction mixture was stirred for 20 h at room temperature, the solvent was evaporated, and the residue was chromatographed on silica gel (EtOAc/acetone, 1:1) to give 0.022 g (80%) of **15** as a colorless oil, which solidified upon standing at room temperature: mp 171−172 °C; IR (KBr) 1768, 1722, 1617 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 10.40 (s, 1H), 7.62−7.24 (m, 9H), 7.16−7.06 (m, 1H), 6.04 (s, 1H), 3.70 (s, 3H), 3.19 (s, 3H), 2.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 168.6, 154.6, 150.5, 137.3, 135.0, 129.3, 129.1, 129.0, 127.6, 126.3, 124.5, 124.2, 121.6, 120.0, 53.3, 32.7, 14.8; MS (*m*/*z*) 407 (M^+, 3), 288 (6), 196 (100). Anal. Calcd for $C_{21}H_{21}N_5O_4$: C, 61.21; H, 5.20; N, 17.19. Found: C, 61.11; H, 5.12; N, 16.87.

Reaction of the Salts 5 with Benzoyl Iso(thio)cyanate. General Procedure. To a solution of the azolium salt **8** and a heterocumulene in 10 mL of dry CH_3CN was added dropwise 2 equiv of *N*-ethyldiisopropylamine. The mixture was refluxed for 20 h or stirred at room temperature over 5−20 h as indicated. The corresponding heterobetaine was purified by crystallization or column chromatography.

2-Ethoxycarbonyl-3-methylimidazolium *N*-(*N*′-Benzoylaminocarbonyl)aminide (17a). Following the general procedure, from **8a** (0.200 g, 0.54 mmol) and benzoyl isocyanate (0.12 g, 0.40 mmol) in dry acetonitrile (10 mL), the reaction mixture was stirred for 5 h and the resulting precipitate was isolated by filtration. The aminide **17a** (0.082 g, 48%) was obtained as a white solid: mp 169−170 °C (CH_3CN); IR (KBr) 1692, 1642, 1238 cm^{-1}; ^1H NMR (DMSO-d_6, 200 MHz) δ 9.51 (s, 1H), 7.86−7.70 (m, 3H), 7.56 (d, 1H, J = 1.8 Hz), 7.50−7.30 (m, 3H), 4.30 (q, 2H, J = 7.1 Hz), 3.92 (s, 3H), 1.26 (t, 3H, J = 7.1 Hz);^{13}C NMR (DMSO-d_6, 125 MHz) δ 169.0, 161.7, 136.1, 133.4, 130.1, 129.8, 128.9, 128.5, 124.0, 121.7, 58.5, 36.7, 18.5; MS (ESI^+) *m*/*z* 317 $(M + H)^+$. Anal. Calcd for $C_{15}H_{16}N_4O_4$: C, 56.96; H, 5.10; N, 17.71. Found: C, 57.27; H, 5.16; N, 17.90.

2-Ethoxycarbonyl-3-methylbenzimidazolium *N*-(*N*′-Benzoylaminocarbonyl)aminide (17b). From 0.100 g (0.24 mmol) of **8b** and benzoyl isocyanate (0.053 g, 0.36 mmol) in dry acetonitrile (10 mL), the reaction mixture was stirred for 10 h at room temperature and the resulting precipitate was isolated by filtration. The aminide **17b** (0.049 g, 56%) was obtained as a yellow solid: mp 215−216 °C (CH_2Cl_2); IR (KBr) 1734, 1694, 1637 cm^{-1}; ^1H NMR (CD_3OD, 200 MHz) δ 7.94−7.82 (m, 4H), 7.67−7.49 (m, 5H), 4.26−4.07 (m, 5H), 1.26 (t, 3H); ^{13}C NMR (CD_3OD, 50 MHz) δ 168.7, 162.2, 144.0, 136.0, 133.1, 132.8, 131.9, 129.5, 128.7, 127.4, 126.7, 114.9, 113.3, 64.9, 33.2, 14.6; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 367 $(M + H^+, 100)$, 246 (52); HRMS Calcd for $C_{19}H_{19}N_4O_4$: 367.1406. Found: 367.0014.

3-Benzoyl-5-methyl-4-oxo-4,5-dihydro-3*H*-imidazo[2,1-*f*][1,2,4]-8-triazinium-2-olate (18a). The general procedure was applied to **8a** (0.100 g, 0.27 mmol) and benzoyl isocyanate (0.060 g, 0.40 mmol). After refluxing the reaction mixture for 20 h, the solvent was removed and the residue was chromatographed on silica gel (acetone/MeOH, 8:2) to give 0.010 g (14%) of **18a** as a white solid: mp 234−235 °C; IR (KBr) 1615, 1570 cm^{-1}; ^1H NMR (CD_3OD, 200 MHz) δ 8.25−8.15 (m, 2H), 8.00 (d, 1H, J = 2.0 Hz), 7.81 (d, 1H, J = 2.0 Hz), 7.50−7.35 (m, 3H), 4.30 (s, 3H); ^{13}C NMR (CD_3OD, 125 MHz) δ 163.0, 160.7, 136.6, 131.8, 130.5, 129.3, 128.9, 125.9, 118.3, 37.2; MS (*m*/*z*) (relative intensity) 255 (M^+ − Me, CO), 227 (100). Anal. Calcd for $C_{13}H_{10}N_4O_3$: C, 57.78; H, 3.73; N, 20.73. Found: C, 57.47; H, 3.56; N, 20.50.

3-Benzoyl-5-methyl-4-oxo-4,5-dihydro-3*H*-[1,2,4]triazino-[1,6-*a*]-10-benzimidazolium-2-olate (18b). From **8b** (0.100 g, 0.24 mmol) and benzoyl isocyanate (0.053 g, 0.36 mmol), reflux of the mixture for 20 h and purification of the crude product by chromatography with EtOAc/MeOH (8:2) gave 0.014 g (20%) of **18b** as an oil; IR (NaCl) 1614, 1393 cm^{-1}; ^1H NMR (CD_3OD, 300 MHz) δ 8.37−8.33 (m, 3H), 8.00 (d, 1H, J = 8.4 Hz), 7.85 (t, 1H, J = 7.3 Hz), 7.75(t, 1H, J = 7.3 Hz), 7.49−7.46 (m, 3H), 4.53 (s, 3H);^{13}C NMR (CD_3OD, 75 MHz) δ 162.1, 161.2, 158.6, 147.1, 136.7, 133.1, 131.8, 130.5, 129.4, 129.3, 129.0, 127.3, 115.1, 114.0, 33.2; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 277 (M^+- Me, CO, 100), 154 (23). Anal. Calcd for $C_{17}H_{12}N_4O_3$: C, 63.75; H, 3.78; N, 17.49. Found: C,-63.92; H,3.76; N,17.10.

3-Methylimidazolium *N*-(*N*′-Benzoylaminocarbonyl)-aminide (19): ^1H NMR (DMSO-d_6, 500 MHz) δ 9.48 (s, 1H), 9.26 (s, 1H), 7.81 (d, 2H, J = 7.3 Hz), 7.49−7.33 (m, 5H), 3.80; MS (ESI^+) *m*/*z* 245 $(M + H)^+$.

2-Ethoxycarbonyl-3-methylimidazolium *N*-(*N*′-Benzoyl)-aminide (21). Following the general procedure, from 0.100 g (0.27 mmol) of **8a** and benzoyl isothiocyanate (54 μL, 0.40 mmol), the solvent was removed and the residue purified by column chromatography (MeOH/acetone, 9:1). The aminide **21** (0.042 g, 57%) was obtained as a white solid: mp 147−148 °C; IR (KBr) 1724, 1600 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.10−8.00 (m, 2H), 7.43−7.40 (m, 1H), 7.38−7.26 (m, 3H), 7.12−7.04 (m, 1H), 4.33 (q, 2H, J = 7.2 Hz), 4.00 (s, 3H), 1.17 (t, 3H, J = 7.2 Hz); MS (*m*/*z*) 274 (M^+ + 1, 57). Anal. Calcd for $C_{14}H_{15}N_3O_4$: C, 61.53; H, 5.53; N, 17.56. Found: C, 61.27; H, 5.36; N, 17.42.

3-Benzoyl-5-methyl-4-oxo-4,5-dihydro-3*H*-[1,2,4]triazino-[1,6-*a*]-10-benzimidazolium-2-thiolate(22b). Following the general procedure, to **8b** (0.100 g, 0.24 mmol) and benzoyl isothiocyanate (50 μL, 0.37 mmol), in dry CH_3CN (10 mL), was added *N*-ethyldiisopropylamine (46 μL, 0.48 mmol). The reaction mixture was refluxed or stirred at room temperature for 20 h. The solvent was removed and the residue triturated with EtOAc. The heterobetaine **22b** (0.04 g, 45%) was obtained as a white solid: mp 214−215 °C; IR (KBr) 1622, 1593, 1560 cm^{-1}; ^1H NMR (CD_3OD, 300 MHz) δ 8.13−8.10 (m, 2H), 7.92−7.83 (m, 2H), 7.71−7.61 (m, 2H), 7.51−7.43 (m, 3H), 4.16 (s, 3H); ^{13}C NMR (CD_3OD, 75 MHz) δ 174.2, 140.5, 138.3,133.7, 133.0, 132.1, 131.8, 131.4, 129.0, 127.5, 126.9, 115.0, 113.3, 33.3; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 293 (M^+ − Me, CO, 10), 252 (100), 154 (37). Anal. Calcd for $C_{17}H_{12}N_4O_2S$: C, 60.70; H, 3.60; N, 16.66. Found: C, 61.07; H, 3.36; N, 16.42.

Reaction of the Azolium Salts 5 with Carbodiimides. General Procedure. To a solution of **8** (0.55 mmol) and di-*p*-tolylcarbodiimide (0.14 g, 0.61 mmol) in dry CH_3CN (10 mL, 0.19 mL) was added *N*-ethyldiisopropylamine (1.1 mmol). The reaction mixture was refluxed for 20 h, the solvent was evaporated, and the residue was triturated with Et_2O and EtOAc. The resulting precipitate was filtered off and crystallized (EtOAc/EtOH).

5-Methyl-4-oxo-3-*p*-tolyl-2-*p*-tolylamino-4,5-dihydro-3*H*-imidazo[2,1-*f*][1,2,4]-8-triazinium Mesitylenesulfonate (23a). The general procedure was applied to **8a** (0.200 g, 0.55 mmol) to give 0.22 g of **23a** (76%) as a pale yellow solid: mp 217−218 °C (EtOAc/EtOH); IR (KBr) 1717, 1557 cm^{-1}; ^1H NMR (DMSO-d_6, 300 MHz) δ 8.22 (d, 1H, J = 2.2 Hz), 8.19−8.16 (m, 2H), 7.44 (d, 2H, J = 8.4 Hz), 7.35 (d, 2H, J = 8.4 Hz), 7.20−7.12 (m, 4H), 6.72 (s, 2H), 4.11 (s, 3H), 2.47 (s, 6H), 2.41 (s, 3H), 2.27 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (DMSO-d_6, 50 MHz) δ 150.8, 149.9, 142.9, 140.1, 136.1, 135.8, 135.0, 134.5, 130.9, 129.8, 129.1, 128.7, 126.6, 126.3, 125.2, 118.3, 36.6, 22.7, 21.0, 20.5, 20.3; MS (ESI^+) *m*/*z* 346 (M^+). Anal. Calcd for $C_{29}H_{31}N_5O_4S$: C, 63.83; H, 5.73; N, 12.83. Found: C, 64.19; H, 5.77; N, 12.95.

Synthesis of the Heterobetaine 24a. A mixture of 0.050 g (0.1 mmol) of **23a** and 0.100 g of anhydrous K_2CO_3 (0.8 mmol) in dry CH_3CN (5 mL) was stirred for 18 h at room temperature. The K_2CO_3 was removed by filtration, and the liquid was concentrated to yield 0.029 g (100%) of **24a** as an orange solid: mp 123−124 °C; IR (KBr) 1685, 1555 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 7.33−7.15 (m, 5H), 7.05−6.80 (m, 5H), 4.00 (s, 3H), 2.38 (s, 3H), 2.25 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 152.0, 151.0, 147.6, 137.8, 136.8, 133.4, 130.4, 130.0, 128.9, 128.1, 123.8, 123.0, 116.3, 36.5, 21.3, 20.8; MS (ESI^+) *m*/*z* 346 ($M + H)^+$. Anal. Calcd for $C_{20}H_{19}N_5O$: C, 69.55; H, 5.54; N, 19.99. Found: C, 69.30; H, 5.57; N, 20.32.

5-Methyl-4-oxo-3-*p*-tolyl-2-*p*-tolylamino-4,5-dihydro-3*H*-benzo[4,5]imidazo[2,1-*f*][1,2,4]triazinium Mesitylenesulfonate (23b). Following the general procedure, from **8b** (0.23 g, 0.55 mmol), gave 0.20 g (61%) of **23b** as a pale yellow solid: mp 259−260 °C (EtOAc/EtOH); IR (KBr) 1722, 1540 cm^{-1}; ^1H NMR (DMSO-d_6, 200 MHz) δ 8.37 (bs, 1H, −NH), 8.22 (d, 1H, J = 8.6 Hz), 8.04−7.70 (m, 3H), 7.54−7.10 (m, 8H), 6.71 (s, 2H), 4.37 (s, 3H), 2.46 (s, 6H), 2.43 (s, 3H), 2.30 (s, 3H), 2.14 (s, 3H); ^1H NMR (CD_3OD, 300 MHz) δ 8.07 (d, 1H, J = 8.4 Hz), 8.01 (d, 1H, J = 8.8 Hz), 7.94−7.84 (m, 1H), 7.82−7.74 (m, 1H), 7.53 (d, 2H, J = 8.4 Hz), 7.45 (d, 2H, J = 8.4 Hz), 7.32 (d, 2H, J = 8.4 Hz), 7.22 (d, 2H, J = 8.4 Hz), 6.83 (s, 2H), 4.45 (s, 3H), 2.58 (s, 6H), 2.50 (s, 3H), 2.36 (s, 3H), 2.22 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 150.5, 149.3, 141.8, 140.5, 137.2, 136.8, 135.7, 133.2, 132.0, 131.8, 130.0, 129.9, 129.7, 129.5, 128.8, 128.4, 127.6, 127.2, 123.2, 114.3, 112.6, 33.3, 22.7, 21.4, 21.0, 20.7; MS (ESI^+) *m*/*z* 396 (M^+). Anal. Calcd for $C_{33}H_{33}N_5O_4S$: C, 66.53; H, 5.58; N, 11.76. Found: C, 66.91; H, 5.67; N, 11.95.

Synthesis of the Heterobetaine 24b. A mixture of 0.020 g (0.034 mmol) of **23b** and 0.040 g of anhydrous K_2CO_3 (0.27 mmol) in dry CH_3CN (5 mL) was stirred for 24 h at room temperature. The K_2CO_3 was removed by filtration and the liquid was concentrated. The resulting residue was triturated and washed with dry Et_2O to yield 0.013 g (98%) of **24b** as a dark red solid: mp 263−264 °C; IR (KBr) 1686, 1545 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.06 (d, 1H, J = 8.3 Hz), 7.66 (ddd, 1H, J = 7.8, 7.0, 1.2 Hz), 7.56−7.44 (m, 2H), 7.35−7.21 (m, 4H), 7.15−6.95 (m, 4H), 4.27 (s, 3H), 2.39 (s, 3H), 2.26 (s, 3H); ^{13}C NMR ($CDCl_3$, 50 MHz) 152.9, 150.3, 146.9, 137.8, 133.6, 132.1, 130.3, 130.0, 129.6, 129.5, 128.6, 128.0, 127.5, 125.1, 123.5, 115.9, 111.0, 32.2, 21.3, 20.9; MS (*m*/*z*) 395 (M^+, 52). Anal. Calcd for $C_{24}H_{21}N_5O$: C, 72.89; H, 5.35; N, 17.71. Found: C, 72.76; H, 5.18; N, 17.96.

3-Methylimidazolium *N*-[*N*′-(*N*″,*N*‴-di-*p*-tolylcarbamimidoyl)]aminide (25). Method A. Theheterobetaine **24a** (0.029 g, 0.1 mmol) was triturated with H_2O for 5 min to give 0.026 g (90%) of **25** as a white solid.

Method B. A solution of **23a** (0.050 g, 0.1 mmol) and 0.100 g of K_2CO_3 (0.8 mmol) in H_2O (5 mL) was stirred for 2 h at room temperature. The resulting precipitate was collected to give 0.023 g of **25** (80%): mp 113−114 °C (CH_3CN); IR (KBr) 1566, 1505 cm^{-1}; ^1H NMR (DMSO-d_6, 200 MHz) δ 9.16 (bs, 1H), 7.51 (bs, 1H), 7.37 (bs, 1H), 7.06−6.86 (m, 8H), 3.67 (s, 3H), 2.17 (s, 6H); ^1H NMR (CD_3OD, 500 MHz) δ 7.45 (d, 1H, J = 2.0 Hz), 7.33 (d, 1H, J = 2.0 Hz), 7.29 (d, 2H, J = 8.5 Hz), 7.17−7.12 (m, 4H), 7.06 (d, 2H, J = 8.0 Hz), 3.83 (s, 3H), 2.32 (s, 6H); ^{13}C NMR (CD_3OD, 125 MHz) δ 159.0, 137.3, 136.4, 136.3, 135.0, 130.9, 130.3, 124.2, 123.6, 123.3, 123.2, 123.1, 36.2, 20.8; MS (*m*/*z*) 319 (M^+, 16), 213 (82), 107 (100). Anal. Calcd for $C_{19}H_{21}N_5$: C, 71.45; H, 6.63; N, 21.93. Found: C, 71.57; H, 6.79; N, 22.04.

Synthesis of 3-Cyano-4-hydroxi-1,2-dihydro-5-methyl-3*H*-imidazo[1,2-b]-8-pyridazinium Innert Salt (28). To a solution of **8a** (0.100 g, 0.27 mmol) in dry CH_2Cl_2 (10 mL) were added acrylonitrile (20 μL, 0.30 mmol) and *N*-ethyldiisopropylamine (0.09 mL, 0.54 mmol). After refluxing the mixture for 20 h, the precipitate was filtered off and crystallized to yield 0.01 g (23%) of **28** as a yellow solid: mp 218−219 °C (CH_3CN); IR (KBr) 2174, 1647, 1586 cm^{-1}; ^1H NMR (CD_3OD, 200 MHz) δ 7.50 (d, 1H, J = 2.1 Hz), 7.42 (d, 1H, J = 2.1 Hz), 4.16 (s, 3H), 3.95 (s, 2H); ^{13}C NMR (CD_3OD, 50 MHz) δ160.8,139.8, 123.0, 121.3, 115.0, 74.8, 47.6, 37.3; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 177 (M + H^+, 100). Anal. Calcd for $C_8H_8N_4O$: C, 54.54; H, 4.58; N, 31.80. Found: C, 54.86; H, 5.00; N, 31.43.

Synthesis of 2,3-Diethoxycarbonyl-4-hydroxi-1,2-dihydro-5-methyl-3*H*-imidazo[1,2-*b*]-8-pyridazimium Innert Salt (30) and 2,3-Diethoxycarbonyl-4-hydroxi-5-methyl-3*H*-imidazo[1,2-*b*]-8-pyridazimium Innert Salt (31). To a suspension of **8a** (0.100 g, 0.27 mmol) and anhydrous K_2CO_3 (0.075 g, 0.54 mmol) in dry CH_2Cl_2 (10 mL) was added diethyl fumarate, and the mixture was stirred for 20 h at room temperature. The precipitate was separated by filtration and the filtrate concentrated and purified by column chromatography on silica gel (EtOAc). The heterobetaine **31** (0.005 g, 7%) was eluted first and was obtained as a yellow oil that solidified upon standing. The dihydro derivative **30** (0.013 g, 16%) was obtained as a pale yellow solid.

30: mp 189−190 °C; IR (KBr) 1729, 1648, 1190 cm^{-1}; ^1H NMR (CD_3OD, 300 MHz) δ 7.46 (d, 1H, J = 2.0 Hz), 7.40 (d, 1H, J = 2.0 Hz)), 5.02 (s 1H), 4.19−4.10 (m, 5H), 4.0 (q, 2H) 1.28 (t, 3H), 1.15 (t, 3H); ^{13}C NMR (CD_3OD, 75 MHz) δ 173.1, 168.6, 159.1, 138.4, 135.0, 123.4, 120.6, 62.2, 60.2, 59.3, 37.4, 15.0, 14.3. MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 296 (M + H^+, 100), 252(90), 222(39); HRMS Calcd for $C_{13}H_{18}N_3O_5$: 296.1246. Found: 296.1233.

31: mp 101−102 °C; IR (NaCl) 1738, 1713, 1580, 1150 cm^{-1}; ^1H NMR (CD_3OD, 300 MHz) δ 7.97 (d, 1H, J = 2.1 Hz), 7.80 (d, 1H, J = 2.1 Hz), 4.37−4.26 (m, 7H), 1.38−1.28 (m, 6H); ^{13}C NMR (CD_3OD, 50 MHz) δ166.7, 166.1, 162.7, 153.8, 138.2, 131.7, 126.8, 118.5, 63.5, 62.1, 37.5, 14.5, 14.3; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 294 ($M + H^+$, 40), 248 (22), 154 ((28); HRMS Calcd for $C_{13}H_{15}N_3O_5$: 294.1089. Found: 294.1094.

Synthesis of Cycloadducts 32 and 33. To a solution of **8b** (0.42 g, 1 mmol) in dry CH_2Cl_2 (10 mL) were added *N*-methylmaleimide (0.12 g, 1.1 mmol) and *N*-ethyldiisopropylamine (0.35 mL, 2 mmol). After refluxing the mixture for 20 h, the solvent was removed, and the residue was purified by column chromatography on silica gel (hexane/EtOAc, 1:1). The cycloadduct **33** (0.033 g, 10%) was eluted first and was obtained as a colorless oil that solidified on standing. The adduct **32** (0.22 g, 68%) was obtained as a pale yellow solid.

(rel-3aα**)-2**β**,3**β**-(*N*-Methylcarboxamido)-3a-ethoxycarbonyl-(**±**)-1,2,3,3a-tetrahydro-4*H*-pyrazole[5,1-*a*]benzimidazole (33)**. IR (KBr) 1709, 1225 cm^{-1}**.** ^1H NMR ($CDCl_3$, 200 MHz) δ 7.01−6.89 (m, 2H), 6.83−6.70 (m, 1H), 6.56−6.48 (m, 1H), 4.95 (d, 1H, J = 8.5 Hz, −NH), 4.38−4.10 (m, 3H), 3.58 (d, 1H, J = 9.1 Hz), 3.07 (s, 3H), 3.00 (s, 3H), 1.29 (t, 3H, J = 7.1 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 174.0, 173.9, 168.9, 138.9, 137.3, 124.3, 120.0, 113.5, 107.4, 98.9, 63.8, 62.8, 54.1, 32.7, 25.3, 14.0. MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 331 ($M + H^+$, 35), 257 (100), 154 (50).

(rel-3aβ**)-2**β**,3**β**-(*N*-Methylcarboxamido)-3a-ethoxycarbonyl-(**±**)-1,2,3,3a-tetrahydro-4*H*-pyrazole[5,1-*a*]benzimidazole (32)**. mp 93−94 °C (d); IR (KBr) 1685, 1627, 1039 $cm^{-1}$$^1H$ NMR ($CDCl_3$, 300 MHz) δ 6.87 (d, 1H, J = 7.3 Hz), 6.84−6.77 (m, 1H), 6.60 (dd, 1H, J = 8.0, 7.3 Hz), 6.29 (d, 1H, J = 7.3 Hz), 4.79 (d, 1H, J = 6.6 Hz, −NH), 4.48 (dd, 1H, J = 8.2, 6.6 Hz), 4.47−4.22 (m, 2H), 4.01 (d, 1H, J = 8.2 Hz), 3.11 (s, 3H), 2.45 (s, 3H), 1.35 (t, 3H, J = 7.3 Hz); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 175.3, 173.4, 168.9, 138.3, 137.0, 124.1, 118.6, 112.4, 104.4, 98.9, 65.1, 62.9, 53.6, 31.2, 24.6, 14.1. MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 331 ($M + H^+$, 31), 257 (100), 133 (97). Anal. Calcd for $C_{16}H_{18}N_4O_4$: C, 58.17; H, 5.49; N, 16.96. Found: C, 57.97; H, 5.10; N, 17.28.

Synthesis of 2,3-Diethoxycarbonyl-4-hydroxy-5-methylpyridazino[1,6-*a*]-10-benzimidazolium Innert Salt (36). To a solution of **8b** (0.100 g, 0.24 mmol) in dry CH_2Cl_2 (10 mL) were added diethyl fumarate (45 μL, 0.26 mmol) and anhydrous K_2CO_3 (0.066 g, 0.48 mmol). After refluxing the mixture for 20 h, the resulting precipitate was filtered off, and the liquid was purified by column chromatography on silica gel (hexane/EtOAc, 1:1). The heterobetaine **36** (0.0075 g, 19%) was obtained as a colorless oil. IR (NaCl) 1739, 1674, 1080 cm^{-1}. ^1H NMR ($CDCl_3$, 200 MHz) δ 8.46 (d, 1H, J = 8.1 Hz), 7.55−7.50 (m, 1H), 7.42−7.35 (m, 2H), 4.53−4.41 (m, 4H), 3.70 (s, 3H) 1.45−1.38 (m. 6H); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 161.9, 160.4, 153.2, 141.9, 130.2, 128.7, 127.9, 124.2, 119.9, 117.0, 115.4, 109.2, 62.4, 62.0, 29.0, 14.2; MS (FAB, *m*-NBA) (*m*/*z*) (relative intensity) 344 ($M + H^+$, 63), 298 (46); HRMS Calcd for $C_{17}H_{18}N_3O_5$: 344.1246. Found: 344.1235.

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