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A Novel Carbonyl Ylide Rearrangement

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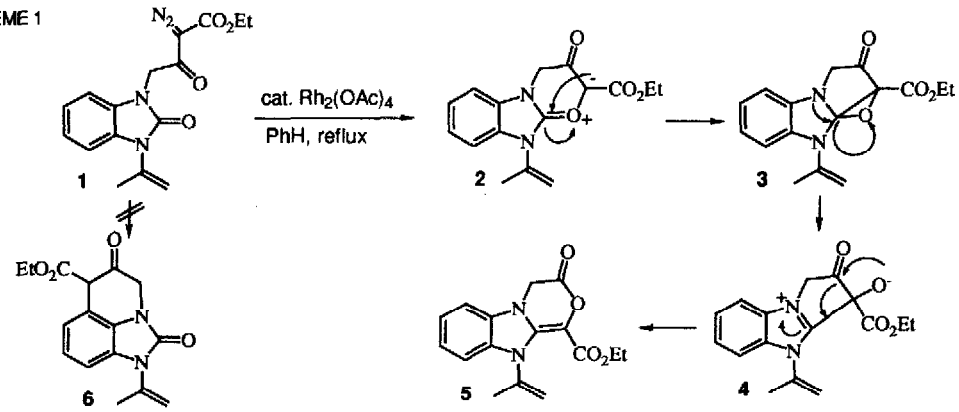
Abstract: *Decomposition of diazoketone 1 gave the novel carbonyl ylide rearrangement product 5. The structure of 5 was confirmed by X-ray analysis.*

The intramolecular generation of carbonyl ylides from diazoketones containing attached carbonyl functionalities is a topic of current interest.[1-4] Padwa and others have shown that carbonyl ylides are efficiently formed and trapped by dipolarophiles when the diazoketone is five to seven centers from the carbonyl group of ketones, esters, amides, and imides.[1,4] However, the fate of intermediate ylides in the absence of trapping agents has not been thoroughly studied. In the few examples reported to date, cyclic carbonyl ylides generated alone have dimerized,[4-6] reacted with solvent or oxygen,[4,6,7] undergone proton transfer,[3] or yielded complex mixtures of products.[8,9] We wish to report a novel carbonyl ylide rearrangement in the decomposition of a diazoketone containing an attached benzimidazolone ring system.

When diazoketone **1**[10] was refluxed in benzene with a catalytic amount of $Rh_2(OAc)_4$, an orange crystalline material was obtained. The compound was unstable to aqueous workup or chromatography on silica gel or neutral alumina and could only be isolated by crystallization from the crude reaction mixture. It was initially suspected that the product was either the stabilized carbonyl ylide **2**[9] or a dimer thereof.[4-6] However, X-ray single crystal structure analysis revealed that the structure was the rearrangement product **5**.[11]

It is proposed that formation of **5** occurred by way of the mechanism outlined in Scheme 1. Intramolecular trapping of the Rh-carbene complex by the benzimidazolone carbonyl generated the stabilized carbonyl ylide **2**. Collapse of **2** to the epoxide **3**[12] followed by ring opening gave the zwitterion **4**. Attack of the oxygen on the more electrophilic carbonyl (ketone vs. ester) and carbon bond migration then gave the product **5**[13]. It is interesting to note that none of the product from C-H insertion, **6**, was observed.

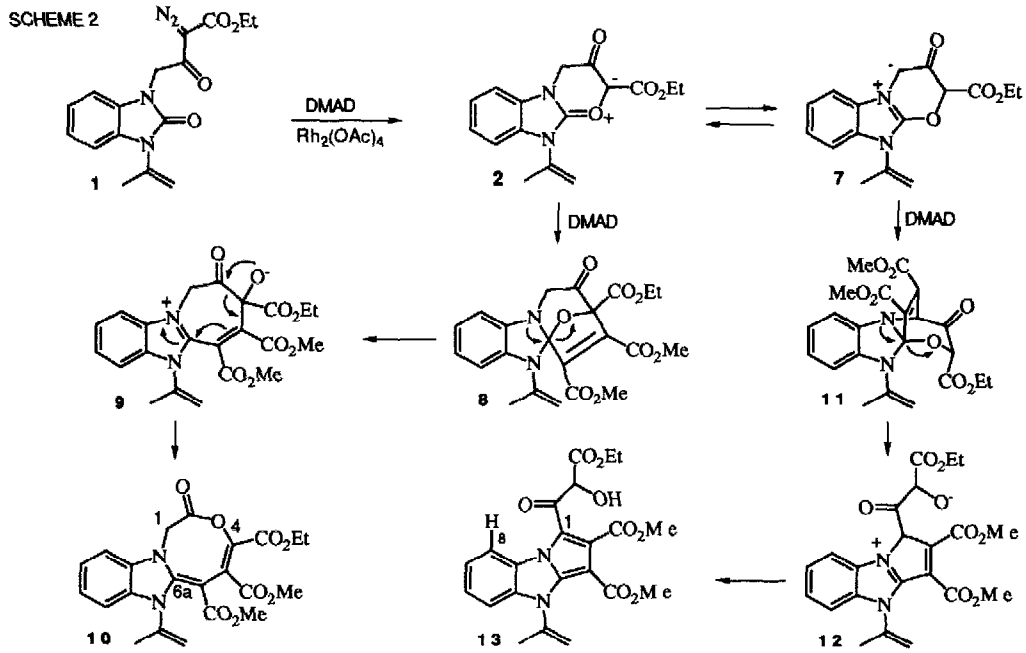
SCHEME 1



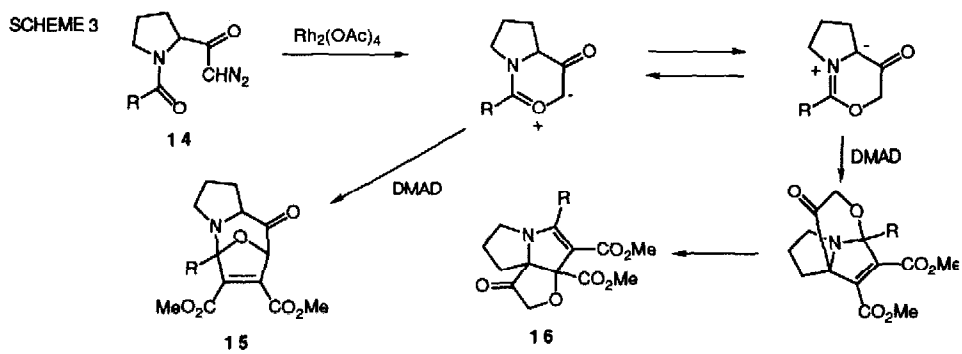
In attempts to demonstrate the intermediacy of the carbonyl ylide **2** by trapping with the dipolarophile dimethyl acetylenedicarboxylate (DMAD), two unusual addition/rearrangement products were obtained. Decomposition of diazoketone **1** (refluxing benzene; 1 mole percent $Rh_2(OAc)_4$) in the presence of DMAD gave the new heterocyclic ring system **10** and the pyrrolobenzimidazole **13** in 33% and 24% yield respectively (Scheme 2). Under these conditions none of the rearrangement product **5** was observed.

Formation of the unexpected products **10** and **13** resulted from the trapping of two isomeric ylides. Trapping of the expected carbonyl ylide **2** with DMAD gave the [3+2] cycloaddition product **8**, which under the reaction conditions fragmented to zwitterion **9**. Carbon to oxygen acyl migration then generated the eight membered dienol lactone **10**. Rearrangement of **9** to **10** can be seen as a vinylogous rearrangement of **4** to **5** (Scheme I) and underscores the thermodynamic driving force for this type of transformation. The structure of **10** was assigned based on the ^1H and ^{13}C NMR and IR.[14] Characteristic features which differentiate **10** from **8** are the ^{13}C shifts of the quaternary olefinic carbons C-6a (152.8 ppm) and C-4 (139.2 ppm), and the multiplicity of the methylene of the ethyl ester. The 400 MHz ^1H NMR showed a simple quartet indicating non-diastereotopic protons. It is expected that the corresponding methylene protons of **8** would be a doublet of quartets since they are diastereotopic. In addition, the IR absorption for the C-2 carbonyl (1772 cm^{-1}) was indicative of an enol lactone.

Formation of pyrrolobenzimidazole **13** required isomerization of carbonyl ylide **2** to azomethine ylide **7**. Condensation of **7** with DMAD gave the [3+2] cycloaddition product **11**. Fragmentation to zwitterion **12** followed by proton transfer afforded pyrrolobenzimidazole **13**. Key features of the ^1H and ^{13}C NMR and IR which allowed for the structural assignment of **13** were the absence of the methylene attached to the benzimidazole nitrogen, the presence of a methine coupled to an exchangeable proton, and an O-H stretching absorption in the IR (3475 cm^{-1}).[15] The methylene of the ethyl ester was a multiplet indicating diastereotopic protons and thus, a nearby asymmetric center. An unusual feature of the ^1H NMR was a doublet at 8.85 ppm ($CDCl_3$). This is a characteristic feature of 1-acyl pyrrolobenzimidazoles because the C-8 proton is shifted downfield by the anisotropic effect of the C-1 carbonyl.[16]



An analogous isomerization of a carbonyl ylide to an azomethine ylide has been reported by Padwa.[17] Decomposition of diazoketone **14** in the presence of DMAD at 25 °C gave the [3+2] cycloaddition products **15** and **16** which arose from trapping of the carbonyl and the azomethine ylides, respectively (Scheme 3).



In conclusion,this work demonstrates a novel rearrangement pathway for the carbonyl ylide derived from benzimidazolone **1**. Although the generality of the reaction has not been investigated, it is expected that structurally similar carbonyl ylides might follow this rearrangement cascade in the absence of trapping agents. In addition, the synthesis of oxazocine **10** demonstrates the potential of carbonyl ylide chemistry for constructing new and complex heterocyclic ring systems. Furthermore, pyrrolobenzimidazole **13** offers additional support for the isomerization of carbonyl ylides to azomethine ylides.

References and Notes

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9. For an example of a stable cyclic carbonyl ylide see Hamaguchi, M.; Ibata, T.; *Tetrahedron Lett.*, **1974**, *51*,4475-4476.
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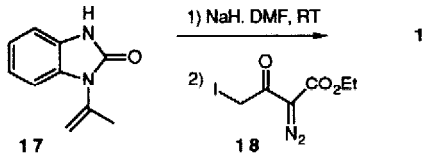
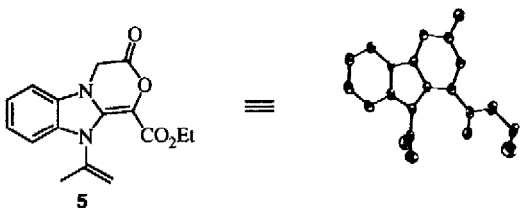


11. Compound **5** was obtained in 41% yield by ^{1}H NMR of the crude reaction mixture with methyl 4-nitrobenzoate added as an internal standard.Spectral data for **5.** ^{1}H NMR (400 MHz, $CDCl_3$, ppm): 1.32 (t, 3H, J=7Hz), 2.01 (s, 3H), 4.26 (q, 2H, J=7Hz), 4.55 (s, 2H), 5.22 (s, 1H), 5.41 (s, 1H), 7.05 (m, 1H), 7.19 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, ppm): 161, 160.5, 142, 140, 135, 131, 123.5 (CH), 123 (CH), 113 (CH_2), 110 (CH), 108 (CH), 105, 59 (CH_2), 44 (CH_2), 19 (CH_3), 15 (CH_3). IR ($CHCl_3$, cm^{-1}): 1761, 1672.



12. For an example of an equilibrium between a carbonyl ylide and an epoxide, see Ullman, E. F.; Milks, J. E.; *J. Am. Chem. Soc.*, **1964**, *86*, 3814-3819.
13. For an analogous rearrangement of a thiirane, see Fang, F. G.; Maier, M. E.; Danishefsky, S. J.; *J. Org. Chem.*, **1990**, *55*, 831-838.
14. Spectral data for **10.** ^{1}H NMR (400 MHz, $CDCl_3$, ppm): 1.30 (t, 3H, J=7Hz); 2.15 (s, 3H); 3.74 (s, 3H), 3.87 (s, 3H), 4.28 (s, 2H), 4.29 (q, 2H, J=7Hz), 5.28 (s, 1H), 5.43 (s, 1H), 7.13-7.17(m,2H), 7.23-7.27 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$, ppm): 187.72, 166.91, 162.52,160.12, 152.89, 139.20, 137.25, 134.20, 130.21, 124.33 (CH), 122.21 (CH), 120.70, 116.84 (CH_2), 110.78 (CH), 108.51 (CH), 85.23, 61.83 (CH_2), 55.67 (CH_3), 52.7(CH_3), 50.74 (CH_2), 20.86 (CH_3), 13.95 (CH_3). IR ($CHCl_3$, cm^{-1}): 1773, 1723, 1658.
15. Spectral data for **13.** ^{1}H NMR (400 MHz, $CDCl_3$, ppm): 1.27 (t, 3H, J=7Hz); 2.18 (s, 3H), 3.84 (s, 3H),4.02 (s, 3H), 4.16 (d, 1H, J=7.5Hz, exchanged with D_2O), 4.20-4.32 (m, 2H), 5.36 (d, 1H, J=7.5Hz), 5.61(s, 1H), 7.26-7.46 (m, 3H), 8.85 (d, 1H, J=8.4Hz). ^{13}C NMR (100MHz,$CDCl_3$, ppm): 181.78,169.27,165.96,162.04, 140.83, 139.43, 136.54, 132.00, 126.64, 126.75, 125.49 (CH), 122.34 (CH),117.79 (CH), 116.94, 116.35 (CH), 110.38 (CH), 73.19 (CH), 65.86 (CH_2), 53.28 (CH_3), 51.34 (CH_3), 21.71 (CH_3), 14.04 (CH_3). IR (KBr, cm^{-1}): 3475, 1742, 1722, 1709.
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