α-Methylene-β-trichloroacetylamino Alkanoates from Trichloroacetimidates of the Baylis–Hillman Adducts

Roberta Galeazzi, Gianluca Martelli, Mario Orena,* Samuele Rinaldi

Dipartimento di Scienze dei Materiali e della Terra, Università Politecnica delle Marche, Via Brecce Bianche, 60131 Ancona, Italy
Fax +39(071)2204714; E-mail: m.orena@univpm.it

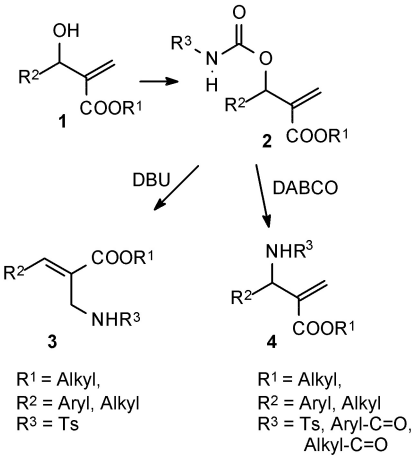
Received 11 June 2004

Abstract: The Baylis–Hillman adducts **1** were treated with a large amount of CCl_3CN in the presence of DBU without solvent to give in good yield the corresponding trichloroacetimidates **5** which by thermal [3.3]sigmatropic rearrangement were converted into the corresponding (*E*)-2-trichloroacetylaminomethyl-2-propenoates **6**, exclusively. On the contrary, when compounds **5** were treated with a catalytic amount of DABCO in dichloromethane, 2-methylene-3-trichloroacetylamino esters **7** were obtained in good yield. Both **5a** and **7a** underwent iodocyclization, to give a cyclic intermediate precursor of a polyfunctionalized sequence, and the differences in stereoselectivity were in agreement with computational results.

Key words: amino acids, amides, rearrangement, cyclization, stereoselectivity

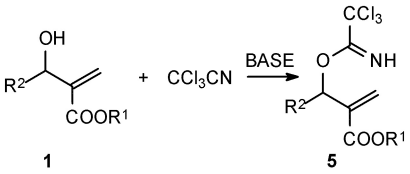
The Baylis–Hillman reaction is an important carbon–carbon bond forming reaction leading to 2-methylene-3-hydroxy alkanoates **1** starting from acrylates and aldehydes, via a base-catalyzed tandem Michael reaction-enolate addition, followed by elimination.[1–3]

Recently, we have shown that *p*-toluenesulfonyl and acyl carbamates of the Baylis–Hillman adducts **2** can be easily converted into the corresponding acylamino derivatives **3** or **4** simply by treating with DBU or DABCO in dichloromethane, respectively (Scheme 1).[4,5]



Scheme 1

Owing to the presence of the rigid α-methylene group, the corresponding non-proteinogenic amino acids can be useful for inducing conformational restrictions in a peptide structure.[6] Within this area, we envisaged that the trichloroacetimidates of the Baylis–Hillman adducts **5** could be useful for the preparation of 2-methylene-3-trichloroacetylamino alkanoates, the lability of the trichloroacetyl group making these compounds attractive for the introduction in oligopeptides. Thus, we targeted preparation of the trichloroacetimidates **5**, as we thought it could be easily achieved simply following literature methods (Scheme 2).



Scheme 2

However, when we treated the Baylis–Hillman adducts **1** with a catalytic amount of NaH in anhydrous THF, followed by addition of an equimolar amount of CCl_3CN,[7] the trichloroacetimidates **5** were isolated only in poor yield, the rest being starting material. Similar results were obtained by adding DBU to a solution of the adduct **1** and CCl_3CN in dichloromethane at temperatures ranging from –15 to 0 °C.[8] Changing MeCN for dichloromethane led to minor improvement, and maximum yield raised to 40% after silica gel chromatography. In this case a large excess of DBU or CCl_3CN and even prolonged reaction time did not affect the yield.[9] In addition, we observed that a reaction occurs between DBU and CCl_3CN in dichloromethane at 0 °C, leading to a strongly polar adduct **A** that remained unaffected by subsequent addition of **1**. The structure of **A** was tentatively assigned as internal salt, owing to the presence in the ^{13}C NMR spectrum of a peak at δ = 166.1, diagnostic for an iminic carbon (Figure 1).[10]

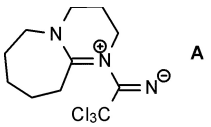
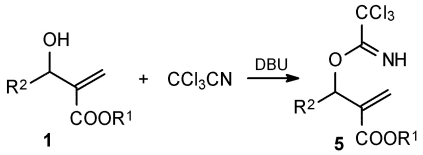


Figure 1 Structure of the adduct **A**

SYNTHESIS 2004, No. 15, pp 2560–2566
Advanced online publication: 22.09.2004
DOI: 10.1055/s-2004-831235; Art ID: P05804SS

Table 1 Preparation of Trichloroacetimidates **5** from the Baylis–Hillman Adducts



Run	5	R^1	R^2	DBU(%)	Temp (°C)	Yield (%)[a]
1	**a**	*t*-C_4H_9	C_6H_5	5	r.t.	94
2	**a**	*t*-C_4H_9	C_6H_5	5	0	96
3	**b**	C_2H_5	C_6H_5	5	0	95
4	**c**	CH_3	4-$O_2NC_6H_4$	5	r.t.	98
5	**c**	CH_3	4-$O_2NC_6H_4$	5	0	98
6	**d**	C_2H_5	4-$O_2NC_6H_4$	5	0	97
7	**e**	C_2H_5	4-ClC_6H_4	50	r.t.	97
8	**e**	C_2H_5	4-ClC_6H_4	5	0	96
9	**e**	C_2H_5	4-ClC_6H_4	5	–15	97
10	**f**	C_2H_5	2-naphthyl	5	0	95
11	**f**	C_2H_5	2-naphthyl	5	–15	96
12	**g**	CH_3	$(CH_3)_2CH$	30	0	87
13	**g**	CH_3	$(CH_3)_2CH$	30	–15	93
14	**h**	*t*-C_4H_9	CH_3	100	–15	83
15	**h**	*t*-C_4H_9	CH_3	50	–40 to –15	85
16	**i**	*t*-C_4H_9	H	5	r.t.	94
17	**i**	*t*-C_4H_9	H	5	0	96
18	**j**	CH_3	$(CH_3)_2CHCH_2$	50	r.t.	79
19	**j**	CH_3	$(CH_3)_2CHCH_2$	30	0	91
20	**j**	CH_3	$(CH_3)_2CHCH_2$	30	–15	97
21	**k**	C_2H_5	$(CH_3)_2CHCH_2$	30	–15	96

[a] Yields refer to pure isolated products.

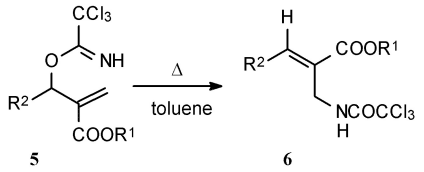
As a matter of fact, the preparation of trichloroacetimidates **5** required appropriate reaction conditions under which DBU can deprotonate the adduct **1** before forming irreversibly the addition product **A**. Thus, all reactions were carried out without solvent by using a 5:1 ratio of CCl_3CN/adduct **1** for 1 hour at temperatures ranging from –40 °C to room temperature, in order to optimize the preparation of compounds **5**, as summarized in Table 1.[11,12]

With the trichloroacetimidates **5** in hand, we carried out the preparation of both unsaturated β-amino acid derivatives **6** and **7**, analogs of **3** and **4**, respectively, in which $R^3 = CCl_3$. At first, compounds **5** were heated in toluene at reflux and the expected thermal [3.3]sigmatropic rearrangement occurred,[7] to give the corresponding 2-trichloroacetylaminomethyl alkenoates **6** in high yields (Table 2). The rearrangement proceeded with total stereoselectivity, and a single product was invariably observed in the reaction mixture, whose configuration was assigned as *E* on the basis of NOE experiments and literature methods.[13] The presence of the *Z*-isomer, which might be present in trace amounts in the reaction mixtures, could never be evidenced.

As a further development aimed to extend the usefulness of trichloroacetimidates **5**, these compounds were treated with a catalytic amount of DABCO in dichloromethane at room temperature, to give in good yield the corresponding trichloroacetylamino derivatives **7** (Table 3).

The formation of compounds **7** deserves some comments. In fact the reaction mechanism probably proceeds via a tandem S_N2'-S_N2' sequence involving the initial formation

Table 2 Preparation of 2-Trichloroacetylaminomethyl Alkenoates **6** from Trichloroacetimidates **5** by Thermal Rearrangement

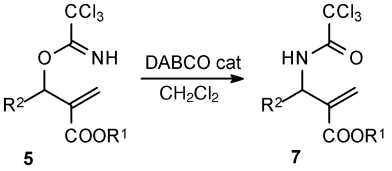


5 6

Run	6	R^1	R^2	Yield (%)[a]
1	**a**	*t*-C_4H_9	C_6H_5	93
2	**b**	*t*-C_4H_9	CH_3	89
3	**c**	C_2H_5	4-ClC_6H_4	94
4	**d**	C_2H_5	2-naphthyl	92
5	**e**	CH_3	$(CH_3)_2CH$	94

[a] Yields refer to pure isolated products.

Table 3 Preparation of Trichloroacetamides **7** Starting from Trichloroacetimidates **5**



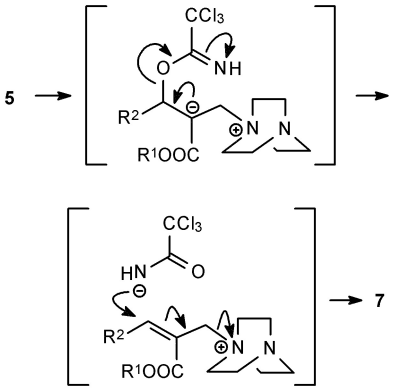
5 7

Run	7	R^1	R^2	Yield (%)[a]
1	**a**	*t*-C_4H_9	C_6H_5	86
2	**b**	C_2H_5	$(CH_3)_2CHCH_2$	69
3	**c**	C_2H_5	4-ClC_6H_4	74
4	**d**	C_2H_5	2-naphthyl	82
5	**e**	*t*-C_4H_9	CH_3	74
6	**f**	C_2H_5	C_6H_5	83

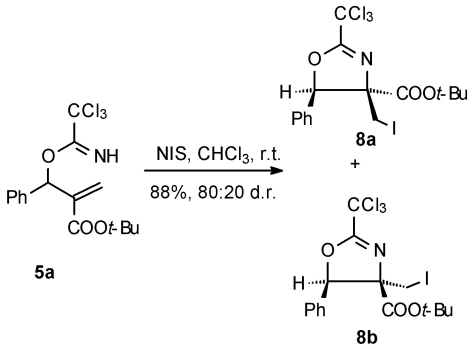
[a] Yields refer to pure isolated products.

of a quaternary ammonium ion, followed by elimination of the trichloroacetamide anion. This anion eventually attacks the intermediate cation to give the observed products **7**, in analogy with behavior already observed for *N*-acyl carbamates **2** (Scheme 3).[14]

Both trichloroacetimidates **5** and trichloroacetamides **7**, arising from the Baylis–Hillman adducts, can be converted into cyclic intermediates which are useful precursors of polyfunctional compounds. In fact, when the trichloroacetimidate **5a** was treated with NIS in $CHCl_3$,[15] the diastereomeric 4,5-dihydro-1,3-oxazoles **8a** and **8b** were obtained in good yield and 80:20 dr, the *cis*-isomer being the major component of the reaction mixture. The diastereomers were separated by silica gel chromatography and configurations were assigned by means of ^{1}H NMR spectral data and subsequently confirmed by NOE experiments (Scheme 4).

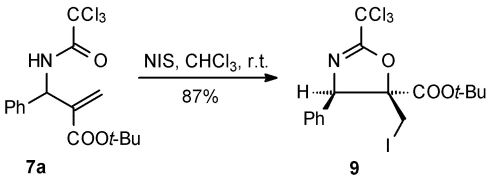


Scheme 3 Reaction pathways leading to **7**.



Scheme 4

On the contrary, when the iodocyclization reaction was carried out under the same conditions but starting from the trichloroacetamide **7a**, the *cis*-4,5-dihydro-1,3-oxazole **9** was exclusively obtained in good yield and its configuration was assigned by means of ^{1}H NMR spectral data and NOE experiments (Scheme 5).



7a 9

Scheme 5

The presence of a single significant conformer for compound **7a** can account for the observed stereoselectivity. In fact the lower stereoselectivity observed in the cyclization of **5a** could be tentatively ascribed to the presence of a number of significant conformations within 1.0 Kcal/mol, as determined by molecular mechanics calculations.[13]

In conclusion, the trichloroacetimidates **5**, prepared starting from the Baylis–Hillman adducts **1**, were useful intermediates for accessing both β-amino acid derivatives **6** and **7**. Work is currently underway towards the synthesis of **7** in the enantiomerically pure form, with the aim to in-

duce conformational restrictions in oligopeptides and to prepare polyfunctionalized sequences present in bioactive compounds.

^{1}H and ^{13}C NMR spectra were recorded on Varian Gemini 200 in $CDCl_3$: chemical shifts are quoted in ppm and *J* values are given in Hz. IR spectra were recorded on an FT-IR spectrophotometer Nicolet XS. Mass spectra were recorded on a Hewlett-Packard 5989B mass spectrometer. Column chromatography was performed using silica gel 60 (230–400 mesh).

Trichloroacetimidates 5; General Procedure

To a solution of the Baylis–Hillman adduct **1** in CCl_3CN (5 equiv), was added DBU (see Table 1 for amounts and temperature) directly (1 μL/sec) under vigorous stirring. After 1 h the mixture was directly purified by silica gel chromatography (cyclohexane–EtOAc, 95:5) to give trichloroacetimidates **5** as colorless oils (Table 1).

***tert*-Butyl 2-Methylene-3-phenyl-3-trichloroacetiminoxypropanoate (5a)**

IR ($CHCl_3$): 3340, 1695, 1660 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.42 (s, 9 H), 5.83 (s, 1 H), 6.36 (s, 1 H), 6.78 (s, 1 H), 7.29–7.52 (m, 5 H, ArH), 8.42 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 28.4, 78.1, 82.0, 126.2, 128.1, 128.8, 137.9, 141.4, 161.3, 164.7.

EIMS: *m*/*z* = 379 (MH^+), 321, 278, 261, 219, 160, 117.

Anal. Calcd for $C_{16}H_{18}Cl_3NO_3$: C, 50.75; H, 4.79; N, 3.70. Found: C. 50.69; H, 4.75; N, 3.73.

Ethyl 2-Methylene-3-phenyl-3-trichloroacetiminoxypropanoate (5b)

IR ($CHCl_3$): 3342, 1697, 1661 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.26 (t, 3 H, *J* = 7.1 Hz), 4.12–4.28 (m, 2 H), 5.96 (s, 1 H), 6.93 (s, 1 H), 6.80 (s, 1 H), 7.29–7.55 (m, 5 H, ArH), 8.43 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 61.6, 77.9, 126.6, 128.1, 128.9, 129.0, 137.8, 140.2, 161.2, 165.6.

EIMS: *m*/*z* = 351 (MH^+), 321, 233, 190, 160.

Anal. Calcd for $C_{14}H_{14}Cl_3NO_3$: C, 47.96; H, 4.02; N, 3.99. Found: C, 47.92; H, 3.98; N, 4.03.

Methyl 2-Methylene-3-(4-nitrophenyl)-3-trichloroacetiminoxypropanoate (5c)

IR ($CHCl_3$): 3340, 1698, 1664 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 3.76 (s, 3 H), 6.11 (s, 1 H), 6.49 (s, 1 H), 6.84 (s, 1 H), 7.66 (d, 2 H, ArH, *J* = 8.9 Hz), 8.22 (d, 2 H, ArH, *J* = 8.9 Hz), 8.50 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 52.2, 76.1, 90.8, 123.6, 126.9, 128.3, 138.3, 144.5, 147.8, 160.4, 165.0.

EIMS: *m*/*z* = 382 (MH^+), 366, 264, 221, 122.

Anal. Calcd for $C_{13}H_{11}Cl_3N_2O_5$: C, 40.92; H, 2.91; N, 7.34. Found: C, 40.87; H, 2.94; N, 7.28.

Ethyl 2-Methylene-3-(4-nitrophenyl)-3-trichloroacetiminoxypropanoate (5d)

IR ($CHCl_3$): 3340, 1694, 1660 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.26 (t, 3 H, *J* = 7.1 Hz), 4.12–4.28 (m, 2 H), 6.08 (s, 1 H), 6.49 (s, 1 H), 6.85 (s, 1 H), 7.67 (d, 2 H, ArH, *J* = 8.7 Hz), 8.22 (d, 2 H, ArH, *J* = 8.7 Hz), 8.51 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 61.9, 76.7, 124.1, 127.3, 128.9, 139.0, 145.1, 148.3, 160.9, 165.0.

EIMS: *m*/*z* = 396 (MH^+), 366, 278, 235, 160, 122.

Anal. Calcd for $C_{14}H_{13}Cl_3N_2O_5$: C, 42.50; H, 3.31; N, 7,08. Found: C, 42.44; H, 3.26; N, 7.04.

Ethyl 3-(4-Chlorophenyl)-2-methylene-3-trichloroacetiminoxypropanoate (5e)

IR ($CHCl_3$): 3341, 1719, 1669 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.26 (t, 3 H, *J* = 7.3 Hz), 4.11–4.27 (m, 2 H), 5.99 (s, 1 H), 6.44 (s, 1 H), 6.75 (s, 1 H), 7.33 (d, 2 H, ArH, *J* = 8.6 Hz), 7.42 (d, 2 H, ArH, *J* = 8.6 Hz), 8.44 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 61.6, 77.1, 126.4, 129.0, 129.3, 129.6, 132.1, 134.8, 136.4, 139.8, 160.9, 165.2.

EIMS: *m*/*z* = 386 (MH^+), 356, 268, 225, 157, 114.

Anal. Calcd for $C_{14}H_{13}Cl_4NO_3$: C, 43.67; H, 3.40; N, 3.64. Found: C, 43.61; H, 3.43; N, 3.59.

Ethyl 2-Methylene-3-(2-naphthyl)-3-trichloroacetiminoxypropanoate (5f)

IR ($CHCl_3$): 3339, 1719, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.24 (t, 3 H, *J* = 7.2 Hz), 4.10–4.29 (m, 2 H), 6.03 (s, 1 H), 6.47 (s, 1 H), 6.97 (s, 1 H), 7.46–7.59 (m, 3 H, ArH), 7.82–7.95 (m, 4 H, ArH), 8.45 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 61.7, 78.1, 125.6, 126.7, 126.8, 127.0, 127.7, 128.3, 128.8, 133.6, 133.8, 135.1, 140.1, 161.3, 165.6.

EIMS: *m*/*z* = 401 (MH^+), 371, 284, 240, 113.

Anal. Calcd for $C_{18}H_{16}Cl_3NO_3$: C, 53.96; H, 4.02; N, 3.50. Found: C, 53.91; H, 3.98; N, 3.97.

Methyl 4-Methyl-2-methylene-3-trichloroacetiminoxypentanoate (5g)

IR ($CHCl_3$): 3344, 1693, 1663 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.99 (d, 3 H, *J* = 7.1 Hz), 1.03 (d, 3 H, *J* = 7.1 Hz), 2.04–2.20 (m, 1 H), 3.80 (s, 3 H), 5.55 (d, 1 H, *J* = 4.8 Hz), 5.88 (s, 1 H), 6.35 (s, 1 H), 8.30 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 16.6, 18.9, 32.2, 51.9, 80.4, 91.6, 125.4, 138.4, 161.2, 165.9.

EIMS: *m*/*z* = 303 (MH^+), 287, 170, 142.

Anal. Calcd for $C_{10}H_{14}Cl_3NO_3$: C, 39.69; H, 4.66; N, 4.63. Found: C, 39.65; H. 4.71; N, 4.58.

***tert*-Butyl 2-Methylene-3-trichloroacetiminoxybutanoate (5h)**

IR ($CHCl_3$): 3341, 1694, 1660 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.51 (s, 9 H), 1.51 (d, 3 H, *J* = 6.4 Hz), 5.81 (q, 1 H, *J* = 6.4 Hz), 5.89 (s, 1 H), 6.23 (s, 1 H), 8.36 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 20.0, 28.5, 73.5, 81.8, 124.2, 142.5, 161.7, 165.0.

EIMS: *m*/*z* = 317 (MH^+), 259, 215, 199, 156.

Anal. Calcd for $C_{11}H_{16}Cl_3NO_3$: C, 41.73; H, 5.09; N, 4.42. Found: C, 41.68; H, 5.11; N, 4.38.

***tert*-Butyl 2-Methylene-3-trichloroacetiminoxypropanoate (5i)**

IR ($CHCl_3$): 3342, 1694, 1661 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.50 (s, 9 H), 5.00 (s, 1 H), 5.89 (s, 1 H), 6.33 (s, 1 H), 8.38 (br s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 28.0, 67.1, 81.4, 126.2, 136.2, 162.2, 164.1.

EIMS: *m*/*z* = 303 (MH^+), 245, 201, 185, 142.

Anal. Calcd for $C_{10}H_{14}Cl_3NO_3$: C, 39.69; H, 4.66; N, 4.63. Found: C, 39.64; H, 4.70; N, 4.59.

Methyl 5-Methyl-2-methylene-3-trichloroacetiminoxyhexanoate (5j)
IR ($CHCl_3$): 3344, 1690, 1663 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 0.95 (d, 3 H, *J* = 6.5 Hz), 0.97 (d, 3 H, *J* = 6.5 Hz), 3.80 (s, 3 H), 5.77 (dd, 1 H, *J* = 2.8, 9.2 Hz), 5.93 (s, 1 H), 6.30 (s, 1 H), 8.33 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 21.4, 23.3, 24.9, 44.3, 51.9, 75.1, 124.2, 140.2, 161.2, 165.7.

EIMS: *m*/*z* = 317 (MH^+), 301, 257, 199, 156, 99.

Anal. Calcd for $C_{11}H_{16}Cl_3NO_3$: C, 41.73; H, 5.09; N, 4.42. Found: C, 41.69; H, 5.05; N, 4.46.

Ethyl 5-Methyl-2-methylene-3-trichloroacetiminoxyhexanoate (5k)
IR ($CHCl_3$): 3342, 1692, 1663 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 0.96 (d, 3 H, *J* = 6.5 Hz), 0.98 (d, 3 H, *J* = 6.5 Hz), 1.33 (t, 3 H, *J* = 7.2 Hz), 1.52–1.68 (m, 1 H), 1.70–1.95 (m, 2 H), 4.25 (q, 2 H, *J* = 7.2 Hz, 50%), 4.26 (q, 2 H, *J* = 7.2 Hz, 50%), 5.78 (dd, 1 H, *J* = 3.3, 9.5 Hz), 5.91 (s, 1 H), 6.28 (s, 1 H), 8.33 (s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 22.0, 23.9, 25.4, 44.8, 61.3, 75.6, 124.4, 141.0, 161.6, 165.7.

EIMS: *m*/*z* = 331 (MH^+), 301, 213, 170, 113.

Anal. Calcd for $C_{12}H_{18}Cl_3NO_3$: C, 43.59; H, 5.49; N, 4.24. Found: C, 43.55; H, 5.45; N, 4.28.

Trichloroacetamides 6; General Procedure
A solution containing the trichloroacetimidates **5** (5 mmol) in toluene (20 mL) was refluxed for 3 h under argon. The solvent was then removed under reduced pressure and the residue was purified by silica gel chromatography (cyclohexane–EtOAc, 80:20), to give trichloroacetamides **6** as colorless oils (Table 2).

***tert*-Butyl (*E*)-3-Phenyl-2-trichloroacetylaminomethylpropenoate (6a)**
IR ($CHCl_3$): 3344, 1719, 1668 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.57 (s, 9 H), 4.40 (d, 2 H, *J* = 5.9 Hz), 7.28–7.54 (m, 5 H, ArH + NH), 7.79 (s, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 28.1, 38.7, 82.2, 128.7, 129.2, 134.0, 142.6, 161.3, 166.5.

EIMS: *m*/*z* = 379 (MH^+), 321, 261, 233, 188, 111.

Anal. Calcd for $C_{16}H_{18}Cl_3N_3O_3$: C, 50.75; H, 4.79; N, 3.70. Found: C, 50.70; H, 4.83; N, 3.74.

***tert*-Butyl (*E*)-2-Trichloroacetylaminomethylbut-2-enoate (6b)**
IR ($CHCl_3$): 3347, 1721, 1670 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.50 (s, 9 H), 1.98 (d, 3 H, *J* = 7.3 Hz), 4.17 (d, 2 H, *J* = 6.1 Hz), 5.97 (q, 1 H, *J* = 7.3 Hz), 7.36 (br s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.3, 28.0, 37.1, 81.2, 129.1, 141.3, 161.3, 166.0.

EIMS: *m*/*z* = 317 (MH^+), 259, 199, 171, 57.

Anal. Calcd for $C_{11}H_{16}Cl_3NO_3$: C, 41.73; H, 5.09; N, 4.42. Found: C, 41.67; H, 5.04; N, 4.47.

Ethyl (*E*)-3-(4-Chlorophenyl)-2-trichloroacetylaminomethylpropenoate (6c)
IR ($CHCl_3$): 3343, 1717, 1667 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.38 (t, 3 H, *J* = 7.1 Hz), 4.36 (q, 2 H, *J* = 7.1 Hz), 4.41 (d, 2 H, *J* = 6.1 Hz), 7.35–7.51 (m, 4 H, ArH + NH), 7.82 (s, 1 H).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.1, 38.4, 61.5, 127.0, 129.0, 130.6, 132.2, 135.4, 141.7, 161.3, 167.0.

EIMS: *m*/*z* = 386 (MH^+), 356, 268, 240, 195, 111, 84.

Anal. Calcd for $C_{14}H_{13}Cl_4NO_3$: C, 43.67; H, 3.40; N, 3.64. Found: C, 43.67; H, 3.40; N, 3.64. Found: C, 43.61; H, 3.44; N, 3.68.

Ethyl (*E*)-3-(2-Naphthyl)-2-trichloroacetylaminomethylpropenoate (6d)
IR ($CHCl_3$): 3345, 1717, 1668 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.42 (t, 3 H, *J* = 7.2 Hz), 4.37 (q, 2 H, *J* = 7.2 Hz), 4.56 (d, 2 H, *J* = 5.9 Hz), 7.15–8.06 (m, 8 H, 7 H, ArH + NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.9, 39.3, 62.1, 123.2, 126.8, 127.0, 128.2, 128.8, 129.1, 129.2, 130.0, 131.7, 133.6, 134.0, 144.0, 162.0, 168.1, 192.4.

EIMS: *m*/*z* = 401 (MH^+), 371, 283, 255, 212, 127.

Anal. Calcd for $C_{18}H_{16}Cl_3NO_3$: C, 53.96; H, 4.02; N, 3.50. Found: C, 53.90; H, 3,97; N, 3.53.

Methyl (*E*)-4-Methyl-2-trichloroacetylaminomethylpentenoate (6e)
IR ($CHCl_3$): 3347, 1721, 1670 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.01 (d, 6 H, *J* = 6.6 Hz), 2.82–3.01 (m, 1 H), 3.74 (s, 3 H), 4.16 (d, 2 H, *J* = 6.2 Hz), 6.72 (d, 1 H, *J* = 10.5 Hz), 7.41 (br s, 1 H, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 22.1, 28.1, 37.4, 51.9, 92.5, 124.4, 154.0, 161.2, 167.7.

EIMS: *m*/*z* = 317 (MH^+), 301, 198, 170, 132, 97.

Anal. Calcd for $C_{11}H_{16}Cl_3NO_3$: C, 41.73; H, 5.09; N, 4.42. Found: C, 41.67; H, 5.13; N, 4.37.

Trichloroacetamides 7; General Procedure
To a solution containing the trichloroacetimidates **5** (5 mmol) in CH_2Cl_2 (20 mL), was added DABCO (0.11 g, 1 mmol) and the mixture was stirred for 6 h at r.t. It was then diluted with EtOAc (150 mL) and the organic layer was washed with 1 M HCl (30 mL) and brine (100 mL). After drying (Na_2SO_4), the solvents were removed under reduced pressure and the residue was purified by silica gel chromatography (cyclohexane–EtOAc, 80:20), to give pure trichloroacetamides **7** as colorless oils (Table 3).

***tert*-Butyl 2-Methylene-3-phenyl-3-trichloroacetylaminopropanoate (7a)**
IR ($CHCl_3$): 3344, 1719, 1666 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 1.36 (s, 9 H), 5.89 (s, 1 H), 5.90 (d, 1 H, *J* = 8.8 Hz), 6.37 (s, 1 H), 7.18–7.43 (m, 5 H, ArH), 8.00 (d, 1 H, NH, *J* = 8.8 Hz).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 28.4, 57.4, 82.9, 93.2, 126.5, 128.4, 128.6, 129.3, 138.9, 139.6, 161.6, 165.2.

EIMS: *m*/*z* = 379 (MH^+), 321, 261, 233, 190, 113.

Anal. Calcd for $C_{16}H_{18}Cl_3NO_3$: C, 50.75; H, 4.79; N, 3.70. Found: C, 50.71; H, 4,74; N, 3.75.

Ethyl 5-Methyl-2-methylene-3-trichloroacetylaminohexanoate (7b)
IR ($CHCl_3$): 3347, 1717, 1667 cm^{-1}.

^1H NMR (200 MHz, $CDCl_3$): δ = 0.94 (d, 3 H, *J* = 6.1 Hz), 0.96 (d, 3 H, *J* = 6.1 Hz), 1.33 (t, 3 H, *J* = 7.1 Hz), 1.45–1.82 (m, 3 H), 4.26

(q, 2 H, *J* = 7.1 Hz), 4.75 (dt, 1 H, *J* = 6.5, 8.9 Hz), 5.83 (s, 1 H), 6.26 (s, 1 H), 7.71 (d, 1 H, NH, *J* = 8.9 Hz).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.5, 22.7, 22.8, 25.4, 43.6, 53.3, 61.5, 93.2, 127.8, 139.0, 161.2, 166.2.

EIMS: *m*/*z* = 331 (MH^+), 301, 273, 258, 216, 164, 115.

Anal. Calcd for $C_{12}H_{18}Cl_3NO_3$: C, 43.59; H, 5.49; N, 4.24. Found: C, 43,54; H, 5.53; N, 4.20.

Ethyl 3-(4-Chlorophenyl)-2-methylene-3-trichloroacetylaminopropanoate (7c)

IR ($CHCl_3$): 3346, 1718, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.26 (t, 3 H, *J* = 7.2 Hz), 4.19 (q, 2 H, *J* = 7.2 Hz), 5.88 (d, 1 H, *J* = 8.9 Hz), 6.01 (s, 1 H), 6.45 (s, 1 H), 7.23 (d, 2 H, ArH, *J* = 8.8 Hz), 7.34 (d, 2 H, ArH, *J* = 8.8 Hz), 8.18 (d, 1 H, NH, *J* = 8.9 Hz).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.5, 56.9, 62.0, 93.1, 128.1, 129.3, 129.4, 129.7, 132.1, 134.3, 137.3, 138.0, 161.6, 166.0.

EIMS: *m*/*z* = 386 (MH^+), 356, 268, 240, 163, 148, 98.

Anal. Calcd for $C_{14}H_{13}Cl_4NO_3$: C, 43.67; H, 3.40; N, 3.64. Found: C, 43.62; H, 3.44; N, 3.59.

Ethyl 2-Methylene-3-(2-naphthyl)-3-trichloroacetylaminopropanoate (7d)

IR ($CHCl_3$): 3345, 1717, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.23 (t, 3 H, *J* = 7.1 Hz), 4.17 (q, 2 H, *J* = 7.1 Hz), 6.07 (s, 1 H), 6.09 (d, 1 H, *J* = 8.7 Hz), 6.50 (s, 1 H), 7.39–7.55 (m, 3 H, ArH), 7.71–7.92 (m, 4 H, ArH), 8.24 (d, 1 H, *J* = 8.7 Hz, NH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 57.6, 62.0, 93.4, 124.8, 125.7, 126.9, 127.3, 128.2, 128.6, 129.2, 129.3, 133.4, 133.7, 136.1, 138.4, 161.7, 166.3.

EIMS: *m*/*z* = 401 (MH^+), 371, 283, 255, 240, 141, 99.

Anal. Calcd for $C_{18}H_{16}Cl_3NO_3$: C, 53.96; H, 4.02; N, 3.50. Found: C, 53.91; H, 3.97; N, 3.54.

***t*-Butyl 2-Methylene-3-trichloroacetylaminopropanoate (7e)**

IR ($CHCl_3$): 3343, 1721, 1667 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.43 (d, 3 H, *J* = 6.9 Hz), 1.51 (s, 9 H), 4.79 (dq, 1 H, *J* = 6.9, 8.8 Hz), 5.73 (s, 1 H), 6.14 (s, 1 H), 7.71 (d, 1 H, NH, *J* = 8.8 Hz).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 20.4, 28.0, 50.2, 82.1, 91.2, 125.5, 140.5, 160.7, 165.0.

EIMS: *m*/*z* = 303 (MH^+), 245, 185, 157, 142, 57.

Anal. Calcd for $C_{10}H_{14}Cl_3NO_3$: C, 39.69; H, 4.66; N, 4.63. Found: C, 39.65; H, 4.70; N, 4.59.

Ethyl 2-Methylene-3-phenyl-3-trichloroacetylaminopropanoate (7f)

IR ($CHCl_3$): 3345, 1718, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.24 (t, 3 H, *J* = 7.1 Hz), 4.18 (q, 2 H, *J* = 7.1 Hz), 5.92 (d, 1 H, *J* = 8.8 Hz), 6.00 (s, 1 H, Hz), 6.44 (s, 1 H), 7.24–7.44 (m, 5 H, ArH), 8.15 (d, 1 H, NH, *J* = 8.8 Hz).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.5, 57.4, 61.9, 93.4 126.7, 127.2, 128.5, 128.8, 129.0, 129.3, 138.4, 138.6, 161.5, 166.1.

EIMS: *m*/*z* = 351 (MH^+), 321, 252, 233, 205, 190, 112.

Anal. Calcd for $C_{14}H_{14}Cl_3NO_3$: C, 47.96; H, 4.02; N, 3.99. Found: C, 47.89; H, 3.98; N, 4.05.

(±)-(4*S,5*R**)-4-*tert*-Butoxycarbonyl-4-iodomethyl-5-phenyl-2-trichloromethyl-4,5-dihydro-1,3-oxazole (8a) and its (±)-(4*R**,5*S**)-Isomer (8b)**

To a solution containing the trichloroacetimidate **5a** (1.89 g, 5 mmol) in $CHCl_3$ (50 mL), was added NIS (1.25 g, 5.5 mmol) and the mixture was stirred at r.t. for 24 h. Then a sat. aq solution of $Na_2S_2O_4$ (50 mL) was added and the mixture was extracted with CH_2Cl_2 (2 × 100 mL). After drying (Na_2SO_4), the solvents were removed under reduced pressure. The residue was purified by silica gel chromatography (cyclohexane–EtOAc, 95:5) to give **8a** and **8b** as colorless oils in 80:20 dr and 88% overall yield.

8a

IR ($CHCl_3$): 1741, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.59 (s, 9 H), 3.02 (ABq, 2 H, *J* = 10.7 Hz), 6.11 (s, 1 H), 7.31–7.43 (m, 5 H, ArH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 4.7, 27.9, 80.7, 84.1, 88.4, 126.7, 128.7, 129.3, 129.4, 132.9, 168.5.

EIMS: *m*/*z* = 505 (MH^+), 447, 403, 387, 377, 363, 260, 183, 141, 105, 77.

Anal. Calcd for $C_{16}H_{17}Cl_3INO_3$: C, 38.09; H, 3.40; N, 2.78. Found: C, 38.04; H, 3.44; N, 2.82.

8b

IR ($CHCl_3$): 1739, 1668 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.51 (s, 9 H), 3.82 (ABq, 2 H, *J* = 11.3 Hz), 5.81 (s, 1 H), 7.31–7.43 (m, 5 H, ArH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.9, 27.6, 81.9, 84.1, 92.0, 127.0, 128.9, 129.0, 129.7, 135.3, 164.6.

EIMS: *m*/*z* = 505 (MH^+), 447, 403, 387, 377, 363, 260, 183, 141, 105, 77.

Anal. Calcd for $C_{16}H_{17}Cl_3INO_3$: C, 38.09; H, 3.40; N, 2.78. Found: C, 38.15; H, 3.36; N, 2.75.

(±)-(4*R,5*S**)-5-*tert*-Butoxycarbonyl-5-iodomethyl-4-phenyl-2-trichloromethyl-4,5-dihydro-1,3-oxazole (9)**

To a solution containing the trichloroacetamide **7a** (1.89 g, 5 mmol) in $CHCl_3$ (50 mL), was added NIS (1.25 g, 5.5 mmol) and the mixture was stirred at r.t. for 48 h. Then an aq sat. solution of $Na_2S_2O_4$ (50 mL) was added and the mixture was extracted with CH_2Cl_2 (2 × 100 mL). After drying (Na_2SO_4), the solvents were removed under reduced pressure. The residue was purified by silica gel chromatography (cyclohexane–EtOAc, 95:5) to give **9** in 87% yield as a colorless oil.

IR ($CHCl_3$): 1738, 1665 cm^{-1}.

^{1}H NMR (200 MHz, $CDCl_3$): δ = 1.61 (s, 9 H), 2.95 (ABq, 2 H, *J* = 11.1 Hz), 5.53 (s, 1 H), 7.15–7.26 (m, 2 H, ArH), 7.31–7.43 (m, 3 H, ArH).

^{13}C NMR (50 MHz, $CDCl_3$): δ = 3.9, 28.5, 76.1, 85.2, 92.5, 127.9, 129.4, 129.7, 134.0, 162.5, 169.0.

EIMS: *m*/*z* = 505 (MH^+), 447, 403, 387, 377, 363, 272, 260, 183, 155, 141, 77.

Anal. Calcd for $C_{16}H_{17}Cl_3INO_3$: C, 38.09; H, 3.40; N, 2.78. Found: C, 38.03; H, 3.44; N, 2.83.

Acknowledgment

We gratefully acknowledge financial support from M.I.U.R. (Rome, Italy) within the framework PRIN 2002.

References

(1) (a) Drewes, S. E.; Roos, G. H. P. *Tetrahedron* **1988**, *44*, 4653. (b) Basavaiah, D.; Rao, P. D.; Hyma, R. S. *Tetrahedron* **1996**, *52*, 8001. (c) Ciganek, E. *Org. React.* **1997**, *51*, 201. (d) Basavaiah, D.; Rao, A. J.; Satyanarayana, J. *Chem. Rev.* **2003**, *103*, 811.

(2) (a) Morita, K.; Suzuki, Z.; Hirose, H. *Bull. Chem. Soc. Jpn.* **1968**, *41*, 2815. (b) Baylis, A. B.; Hillman, M. E. D. German Patent 2155113, **1972**; *Chem. Abstr*. **1972**, *77*, 34174.

(3) (a) Brzezinski, L. J.; Rafel, S.; Lehavy, J. W. *J. Am. Chem. Soc.* **1997**, *119*, 4317. (b) Aggarwal, V. K.; Mereu, A.; Tarver, G. J.; McCague, R. *J. Org. Chem.* **1998**, *63*, 7183. (c) Kataoka, T.; Iwama, T.; Tsujiyama, S.; Iwamura, T.; Watanabe, S. *Tetrahedron* **1998**, *54*, 11813. (d) Shi, M.; Jiang, J.-K.; Feng, Y.-S. *Org. Lett.* **2000**, *2*, 2397. (e) Yang, K.-S.; Chen, K. *Org. Lett.* **2000**, *2*, 729.

(4) Ciclosi, M.; Fava, C.; Galeazzi, R.; Orena, M.; Sepulveda-Arques, J. *Tetrahedron Lett.* **2002**, *58*, 2199.

(5) For synthesis of similar compounds, see: (a) Perlmutter, P.; Teo, C. C. *Tetrahedron Lett.* **1984**, *25*, 5951. (b) Bertenshaw, S.; Kahn, M. *Tetrahedron Lett.* **1989**, *30*, 2731. (c) Cyrener, J.; Burger, K. *Monatsh. Chem.* **1994**, *125*, 1279. (d) Kündig, E. P.; Xu, L. H.; Schnell, B. *Synlett* **1994**, 413. (e) Campi, E. M.; Holmes, A.; Perlmutter, P.; Teo, C. C. *Aust. J. Chem.* **1995**, *48*, 1535. (f) Richter, H.; Jung, G. *Tetrahedron Lett.* **1998**, *39*, 2729. (g) Bucholz, R.; Hoffmann, H. M. R. *Helv. Chim. Acta* **1991**, *74*, 1213. (h) Kim, H. S.; Kim, T. Y.; Chung, Y. M.; Lee, H. J.; Kim, J. N. *Tetrahedron Lett.* **2000**, *41*, 2613. (i) Rajesh, S.; Banerji, B.; Iqbal, J. *J. Org. Chem.* **2002**, *67*, 7852.

(6) (a) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1996**, *52*, 1069. (b) Galeazzi, R.; Geremia, S.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1996**, *7*, 79. (c) Galeazzi, R.; Geremia, S.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1996**, *7*, 3573. (d) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1997**, *8*, 133. (e) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1999**, *55*, 261. (f) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1999**, *55*, 4029. (g) Galeazzi, R.; Martelli, G.; Mobbili, G.; Orena, M.; Rinaldi, S. *Tetrahedron: Asymmetry* **2003**, *14*, 3353. (h) Fava, C.; Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **2003**, *14*, 3697.

(7) (a) Overman, L. E. *J. Am. Chem. Soc.* **1974**, *96*, 597. (b) Overman, L. E. *J. Am. Chem. Soc.* **1976**, *98*, 2901. (c) Mehmandust, M.; Petit, Y.; Larcheveque, M. *Tetrahedron Lett.* **1992**, *33*, 4313. (d) Martin, C.; Bortolussi, M.; Bloch, R. *Tetrahedron Lett.* **1999**, *40*, 3735.

(8) Nishikawa, T.; Asai, M.; Ohyabu, N.; Isobe, M. *J. Org. Chem.* **1998**, *63*, 188.

(9) (a) Kang, S. H.; Kim, G. T.; Yoo, Y. S. *Tetrahedron Lett.* **1997**, *38*, 603. (b) Kang, S. H.; Kim, J. S.; Youn, J.-H. *Tetrahedron Lett.* **1998**, *39*, 9047.

(10) (a) An adduct of DBU with alkyl bromides has been already reported: Oediger, H.; Kabbe, H.; Moller, F.; Either, K. *Chem. Ber.* **1966**, *99*, 2012. (b) Spectral data for the adduct **A**: ^{1}H NMR ($CDCl_3$, 200 MHz): δ = 1.42–1.76 (m, 6 H), 1.78–1.92 (m, 2 H), 2.56–2.71 (m, 2 H), 3.15–3.39 (m, 6 H). ^{13}C NMR ($CDCl_3$, 50 MHz): δ = 19.5, 24.0, 26.8, 28.9, 32.0, 37.8, 48.7, 54.4, 77.2, 166.1.

(11) (a) The reactivity of the Baylis–Hillman adducts agrees with the relative acidity of the hydroxy functionality obtained from calculations. All the geometries were optimized at DFT level of theory. *Ab initio* DFT calculations were carried out using the GAUSSIAN 98 program package. For DFT calculations the hybrid functional B3LYP, which contains gradient corrections for both exchange and correlation was chosen. The molecular electrostatic potential and the frontier molecular orbital were calculated for all the compounds showing no remarkable differences. The stability of both the reactants and the conjugate bases was calculated referring to the isodesmic reactions and the correlated pK_a values and the geometry of both reactants and products were fully optimized at B3LYP/6-31G* theory level: **1c**, ΔE 14.08 kcal/mol; **1d**, ΔE 13.51 kcal/mol; **1b**, ΔE 5.09 kcal/mol; **1e**, ΔE 4.59 kcal/mol; **1a**, ΔE 0.0 kcal/mol; **1g**, ΔE –3.98 kcal/mol; **1i**, ΔE –5.46 kcal/mol; **1h**, ΔE –5.76 kcal/mol; **1k**, ΔE –5.51 kcal/mol; **1j**, ΔE –5.71 kcal/mol. For leading references, see: (b) Weiner, S. J.; Kollman, P. A.; Nguyen, D. T.; Case, D. A. *J. Comput. Chem.* **1986**, *7*, 230. (c) Chang, G.; Guida, W. C.; Still, W. C. *J. Am. Chem. Soc.* **1989**, *111*, 4379. (d) Mohamadi, H.; Richards, N. G. J.; Guida, W. C.; Liskamo, R.; Lipton, M.; Caulfield, C.; Chang, G.; Hendrickson, T.; Still, W. C. *J. Comput. Chem.* **1990**, *11*, 440. (e) Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Zakrzewski, V. G.; Montgomery, J. A. Jr.; Stratmann, R. E.; Burant, J. C.; Dapprich, S.; Millan, J. M.; Daniels, A. D.; Kudin, K. N.; Strain, M. C.; Farkas, O.; Tomasi, J.; Barone, V.; Cossi, M.; Cammi, R.; Mennucci, B.; Pomelli, C.; Adamo, C.; Clifford, S.; Ochterski, J.; Patersson, G. A.; Ayala, P. Y.; Cui, Q.; Morokuma, K.; Malik, D. K.; Rabuck, A. D.; Raghavachari, K.; Foresman, J. B.; Cioslowski, J.; Ortiz, J. V.; Baboul, A. G.; Stefanov, B. B.; Liu, G.; Liashenko, A.; Piskorz, P.; Komaromi, I.; Gomperts, R.; Martin, R. L.; Fox, D. J.; Keith, T.; Al-Laham, M. A.; Peng, C. Y.; Nanayakkara, A.; Challacombe, M.; Gill, P. M. W.; Johnson, B.; Chen, W.; Wong, M. W.; Andres, J. L.; Gonzales, C.; Head-Gordon, M.; Replogle, E. S.; Pople, J. *Gaussian 98 Revision A.9*; Gaussian Inc.: Pittsburgh, **1998**. (f) Lee, C.; Yang, W.; Parr, R. G. *Phys. Rev. B: Condens. Matter Mater. Phys.* **1988**, *37*, 785. (g) Becke, A. D. *Phys. Rev. A: At., Mol., Opt. Phys.* **1988**, *38*, 3098. (h) Mihelich, B.; Savin, A.; Stoll, H.; Preuss, H. *Chem. Phys. Lett.* **1989**, *157*, 200. (i) Becke, A. D. *J. Chem. Phys.* **1993**, *98*, 5648.

(12) It is worth mentioning that molecular mechanics calculations carried out for all compounds **5** indicate the presence of a number of conformers within a short energy range. Rotameric mixtures are evidenced by the ^{1}H NMR spectra of the ethyl derivatives **5b**,**d**,**f**,**k**, where a multiplet or a double quartet collapsing at 50 °C into a quartet takes place for the ethyl quartet.

(13) Foucaud, A.; El Guemmout, F. *Bull. Soc. Chim. Fr.* **1989**, 403.

(14) A concerted four-centers mechanism cannot be excluded, and investigation is currently underway. For a similar reaction recently reported in the literature, see: Mamaghani, M.; Badrian, A. *Tetrahedron Lett.* **2004**, *45*, 1547.

(15) (a) Cardillo, G.; Orena, M. *Tetrahedron* **1990**, *46*, 3321. (b) Orena, M. *Amination Reactions Promoted by Electrophiles*, In *Houben-Weyl, Methods of Organic Chemistry, Stereoselective Synthesis*, Vol. E 2le; Helmchen, G.; Hofmann, R. W.; Mulzer, J.; Schauman, E., Eds.; Thieme: Stuttgart, **1995**, 5291–5355. (c) Jordá-Gregori, J. M.; González-Rosende, M. E.; Sepùlveda-Arques, J.; Galeazzi, R.; Orena, M. *Tetrahedron: Asymmetry* **1999**, *10*, 1135. (d) Jordà-Gregori, J. M.; Gonzalez-Rosende, M. E.; Cava-Montesinos, P.; Sepùlveda-Arques, J.; Galeazzi, R.; Orena, M. *Tetrahedron: Asymmetry* **2000**, *11*, 3769.