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Synthesis of unsaturated β-amino acid derivatives from carbamates of the Baylis–Hillman products

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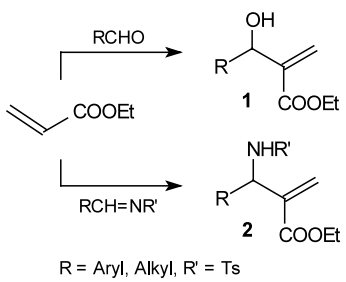
Abstract—By treatment with a catalytic amount of DBU in DCM, *N*-*p*-toluenesulphonyl carbamates **6a–c**, prepared starting from the corresponding Baylis–Hillman adducts, gave (*E*)-2-(*p*-toluenesulphonylaminomethyl)propenoates **3a–c**, exclusively. On the contrary, changing DABCO for DBU, 2-methylene-3-*p*-toluenesulfonylamino esters **4a–f** were obtained in good yield starting from *N*-*p*-toluenesulphonyl carbamates **6a–f**. In analogy, *N*-acyl carbamates **9a–f** were treated with DABCO in DCM to give the 2-methylene-3-acylamino esters **5a–f**. © 2002 Elsevier Science Ltd. All rights reserved.

The Baylis–Hillman reaction[1] is a very useful process whereby, via a base-catalyzed tandem Michael reaction-enolate addition, followed by elimination, 2-methylene-3-hydroxy alkanoates **1** are formed in a straightforward manner (Scheme 1).[2,3]

The aza version of the reaction, i.e. exchanging the aldehyde reactant for an aldimine and thus forming 2-methylene-3-aminocarbonyl compounds, **2**, was also reported (Scheme 1).[4] In addition, compounds **2** can be obtained by a simple substitution reaction on the adducts **1**, displacing the alcohol functionality with an amine.[5] However, a loss in selection generally results when regioisomers are formed by competing S_N2' reactions or Michael additions on the allylic substrates.[5,6]



Scheme 1.

As part of a program directed to prepare new, non-proteinogenic amino acids which can induce conformational restrictions in oligopeptides,[7–9] we devised to prepare amino acid derivatives starting from the products of the Baylis–Hillman reaction. We report herein a novel, convenient procedure for the preparation of both unsaturated β-amino acid derivatives, **3** and **4**,**5** proceeding with high regioselection (Scheme 2).

At first, *N*-tosyl carbamates **6a–c** were prepared, starting from the corresponding Baylis–Hillman adducts **1a–c** and tosyl isocyanate (Scheme 3). These compounds were treated in DCM at rt in the presence of a catalytic amount of DBU (0.2 equiv.), and the corresponding (*E*)-2-*p*-toluenesulphonylaminomethyl alkenoates **3a–c** were isolated in good yield,[10,11] whose configuration was determined following literature methods and NOE experiments.[12] The (*Z*)-isomer which might be present in trace amounts in the reaction mixtures was never isolated.

The (*E*)-selective formation of **3**, proceeding via a tandem S_N2'-decarboxylation sequence, can be easily explained by inspection of molecular models supported by molecular modeling since conformer **A** resulted to be the preferred one for the intermediate anion (Scheme 4).[13]

On the contrary, starting from **6a–f**, *N*-*p*-toluenesulphonylamino derivatives **4a–f** were formed exclusively in good yield when DABCO (0.2 equiv.) was changed for DBU (Scheme 5).[14,15]

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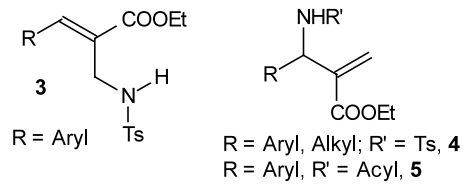
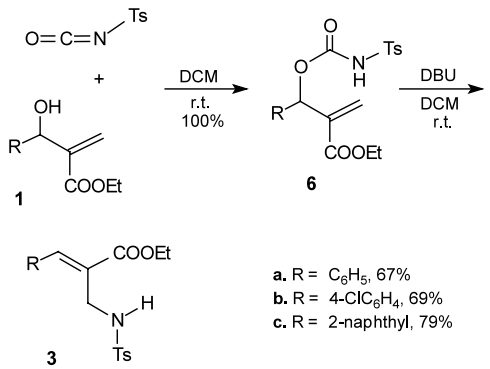
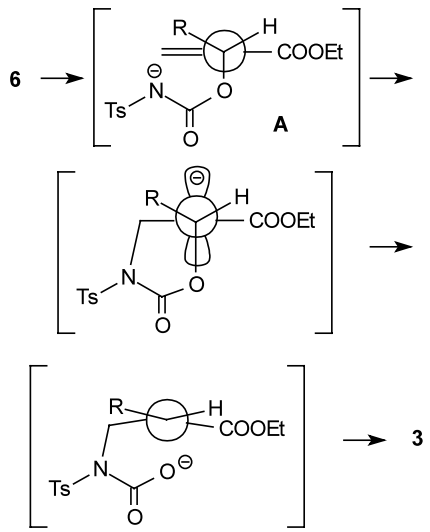


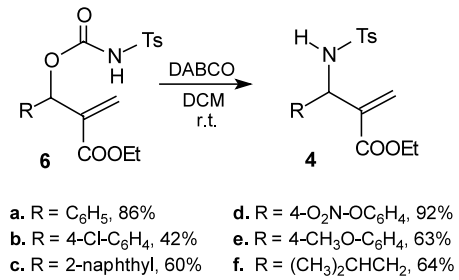
Scheme 2.



Scheme 3.



Scheme 4.



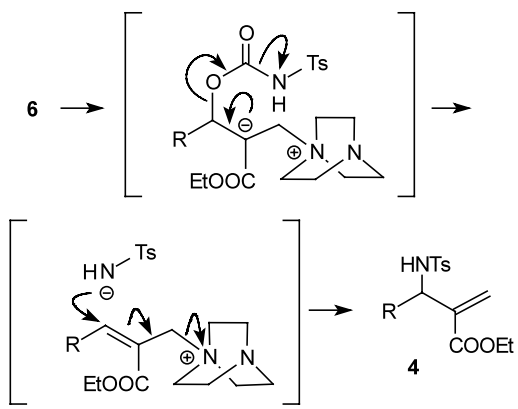
Scheme 5.

The observed results are due to a reaction mechanism proceeding via a tandem S_N2'–S_N2' sequence involving the initial formation of a quaternary ammonium ion, followed by elimination of the *N*-*p*-toluenesulphonylcarbamate anion. Then, after loss of carbon dioxide, the anion of *p*-toluenesulphonylamide attacks the intermediate cation to give the observed products **4** (Scheme 6).

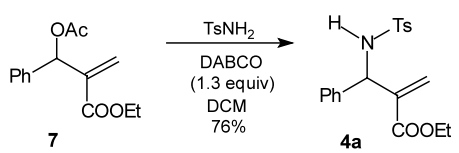
Therefore, the reaction mechanism was easily proven by treating the acetate **7** and *p*-toluenesulphonylamide in DCM at rt in the presence of an excess of DABCO, in order to generate both the intermediate cation and the amide anion. In fact, under these conditions, the acetate **7** was converted into the tosylamino derivative **4a** in good yield, thus confirming the proposed mechanism (Scheme 7).

The results observed on changing DABCO for DBU can be ascribed to the higher basicity of DBU with respect to DABCO.[16] In fact, when DBU is employed, the anion formation at the nitrogen is favored with respect to the nucleophilic attack on the conjugate double bond by DBU, so that the nucleophile is the carbamidic nitrogen. On the contrary, DABCO acts as the nucleophile, exclusively, leading to compounds **4**,**5** via a tandem S_N2'–S_N2' process, and competing formation of products **3**, arising from the anion at the carbamidic nitrogen, was never observed.

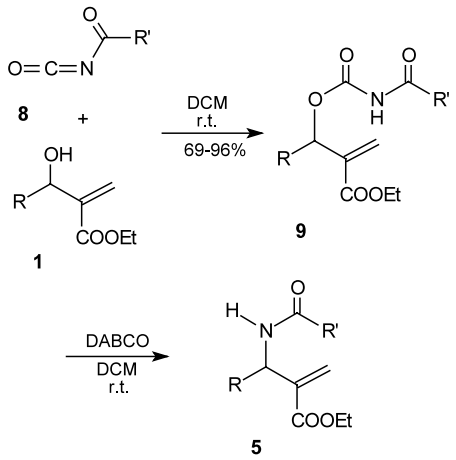
However, as a further development of this approach, we devised to prepare amides of carboxylic acids which can easily afford the corresponding free amino group. In fact we considered as starting materials the *N*-acyl carbamates **9**, which can be easily synthesized simply by treating the appropriate *N*-acyl isocyanates **8** with the products **1** obtained from the Baylis–Hillmann reaction. Thus, a number of *N*-acyl isocyanates were prepared following literature methods,[17] and directly reacted without isolation, to give the corresponding *N*-acyl carbamates **9** in very good yield. The subsequent reaction of *N*-acyl carbamates **9**, carried out in DCM in the presence of a catalytic amount of DABCO (0.15



Scheme 6.



Scheme 7.



a. R = R' = C_6H_5, 93%
b. R = 4-CH_3O-C_6H_4, R' = C_6H_5, 53%
c. R = C_6H_5, R' = CCl_3, 98%
d. R = 4-$CH_3OC_6H_4$, R' = CCl_3, 63%
e. R = C_6H_5, R' = *t*-C_4H_9, 62%
f. R = C_6H_5, R' = $OCH_2C_6H_5$, 42%

Scheme 8.

equiv.), gave the corresponding amides **5a–e** in good yield. It is worth mentioning that by using this method, starting from the *N*-benzyloxycarbonyl carbamate **9f**, the corresponding *N*-Cbz derivative **5f** was also prepared in moderate yield (Scheme 8).[18,19]

In conclusion, starting from either *N*-*p*-toluenesulphonyl **6** or *N*-acyl carbamates **9**, both prepared starting from the Baylis–Hillman products **1**, a convenient approach to either β-amino acid derivatives **3** and **4**,**5** was realized simply on changing DABCO for DBU. The corresponding amino acids will be incorporated in oligopeptides, with the aim to induce conformational restrictions. Moreover work is currently underway in order to prepare **4** and **5** in the enantiomerically pure form, which can afford bioactive α-hydroxy-β-amino acids.

Acknowledgements

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References

1. (a) Drewes, S. E.; Roos, G. H. P. *Tetrahedron* **1988**, *44*, 4653–4670; (b) Basavaiah, D.; Rao, P. D.; Hyma, R. S. *Tetrahedron* **1996**, *52*, 8001–8062; (c) Ciganek, E. *Org. React*. **1997**, *51*, 201–350.
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*, 34174q).
3. (a) Brzezinski, L. J.; Rafel, S.; Lehahy, J. W. *J. Am. Chem. Soc*. **1997**, *119*, 4317–4318; (b) Aggarwal, V. K.; Mereu, A.; Tarver, G. J.; McCague, R. *J. Org. Chem*. **1998**, *63*, 7183–7189; (c) Kataoka, T.; Iwama, T.; Tsujiyama, S.; Iwamura, T.; Watanabe, S. *Tetrahedron* **1998**, *54*, 11813–11824; (d) Shi, M.; Jiang, J.-K.; Feng, Y.-S. *Org. Lett*. **2000**, *2*, 2397–2399; (e) Yang, K.-S.; Chen, K. *Org. Lett*. **2000**, *2*, 729–731.
4. (a) Perlmutter, P.; Teo, C. C. *Tetrahedron Lett*. **1984**, *25*, 5951–5952; (b) Bertenshaw, S.; Kahn, M. *Tetrahedron Lett*. **1989**, *30*, 2731–2732; (c) Cyrener, J.; Burger, K. *Monatsh. Chem*. **1994**, *125*, 1279–1285; (d) Kundig, E. P.; Xu, L. H.; Schnell, B. *Synlett* **1994**, 413–414; (e) Campi, E. M.; Holmes, A.; Perlmutter, P.; Teo, C. C. *Aust. J. Chem*. **1995**, *48*, 1535–1540; (f) Richter, H.; Jung, G. *Tetrahedron Lett*. **1998**, *39*, 2729–2730.
5. (a) Brown, J. M.; James, A. P.; Prior, L. M. *Tetrahedron Lett*. **1987**, *28*, 2179–2180; (b) Takagi, M.; Yamamoto, K. *Chem. Lett*. **1989**, 2123–2124; (c) Drewes, S. E.; Horn, M. M.; Ramesar, N. *Synth. Commun*. **2000**, *30*, 1045–1049.
6. (a) Kulkarni, B. A.; Ganesan, A. *J. Comb. Chem*. **1999**, *1*, 373–378; (b) Kundu, M. K.; Bhat, S. V. *Synth. Commun*. **1999**, *29*, 93–99; (c) Nayak, S. K.; Thijs, L.; Zwanenburg, B. *Tetrahedron Lett*. **1999**, *40*, 981–984.
7. (a) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1996**, *52*, 1069–1084; (b) Galeazzi, R.; Geremia, S.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1996**, *7*, 79–88; (c) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1997**, *8*, 133–137; (d) Galeazzi, R.; Geremia, S.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **1996**, *7*, 3573–3584.
8. (a) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1999**, *55*, 261–270; (b) Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron* **1999**, *55*, 4029–4042; (c) Fava, C.; Galeazzi, R.; Gonzalez-Rosende, M. E.; Orena, M. *Tetrahedron Lett*. **2000**, *41*, 8577–8580; (d) Fava, C.; Galeazzi, R.; Mobbili, G.; Orena, M. *Tetrahedron: Asymmetry* **2001**, *12*, 2731–2741.
9. (a) Jordá-Gregori, J. M.; González-Rosende, M. E.; Sepùlveda-Arques, J.; Galeazzi, R.; Orena, M. *Tetrahedron: Asymmetry* **1999**, *10*, 1135–1143; (b) Jordà-Gregori, J. M.; Gonzalez-Rosende, M. E.; Cava-Montesinos, P.; Sepùlveda-Arques, J.; Galeazzi, R.; Orena, M. *Tetrahedron: Asymmetry* **2000**, *11*, 3769–3777.
10. General procedure for preparation of compounds **3**: To a solution containing the *N*-*p*-toluenesulphonyl carbamates **6a–c** (5 mmol) in DCM (20 ml), DBU (0.15 g; 1 mmol) was added and the mixture was stirred for 12 h at rt. Then the mixture was diluted with ethyl acetate (150 ml) and the organic layer 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:ethyl acetate 80:20 as eluant), to give pure isolated **3a–c**.
11. Selected data for compounds **3a–c**. Compound **3a**: ^{1}H NMR (200 MHz, $CDCl_3$): 1.30 (t, 3H, $J=7.0$), 2.43 (s, 3H), 3.95 (d, 2H, $J=6.4$), 4.21 (q, 1H, $J=7.0$), 5.21 (t, 1H, $J=6.4$), 7.27 (d, 2 ArH, $J=8.3$), 7.40 (m, 5 ArH), 7.68 (d, 2 ArH, $J=8.3$), 7.74 (s, 1H). ^{13}C NMR (50 MHz, $CDCl_3$): 14.6, 22.0, 41.1, 61.8, 126.9, 127.2, 127.7, 128.2, 129.0, 129.2, 130.0, 130.1, 134.4, 137.0, 143.7, 143.9, 167.7. Compound **3b**: ^{1}H NMR (200 MHz, $CDCl_3$): 1.27 (t, 3H, $J=7.1$), 2.43 (s, 3H), 3.87 (d, 2H, $J=6.6$), 4.19 (q,

2H, $J=7.1$), 5.32 (t, 1H, $J=6.6$), 7.27 (d, 2 ArH, $J=8.3$), 7.35 (m, 4 ArH), 7.67 (s, 1H), 7.68 (d, 2 ArH, $J=8.3$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.7, 22.0, 41.0, 62.0, 127.6, 127.7, 128.5, 129.5, 130.2, 131.3, 132.9, 136.0, 136.8, 142.3, 144.1, 167.4. Compound **3c**: ^1H NMR (200 MHz, $CDCl_3$): 1.30 (t, 3H, $J=7.2$), 2.34 (s, 3H), 4.03 (d, 2H, $J=6.2$), 4.25 (q, 2H, $J=7.2$), 5.32 (t, 1H, NH, $J=6.2$), 7.12–8.08 (m, 11 ArH+1 H). ^{13}C NMR (50 MHz, $CDCl_3$): 14.7, 22.0, 41.3, 61.9, 127.1, 127.3, 127.7, 128.0, 128.1, 128.5, 128.8, 128.9, 129.3, 129.9, 130.1, 130.4, 131.9, 133.6, 133.9, 136.9, 143.8, 143.9, 167.8.

12. A similar behavior was observed when alkyl carbamates of the Baylis–Hillman adducts were treated with CsF in the presence of a quaternary ammonium salt: Foucaud, A.; El Guemmout, F. *Bull. Soc. Chim. Fr.* **1989**, 403–408.
13. (a) Bucholz, R.; Hoffmann, H. M. R. *Helv. Chim. Acta* **1991**, *74*, 1213–1220; (b) Kim, H. S.; Kim, T. Y.; Chung, Y. M.; Lee, H. J.; Kim, J. N. *Tetrahedron Lett.* **2000**, *41*, 2613–2616.
14. General procedure for preparation of compounds **4**: To a solution containing the *N*-*p*-toluenesulphonyl carbamates **6a**–**f** (5 mmol) in DCM (20 ml), DABCO (0.11 g; 1 mmol) was added and the mixture was stirred for 12 h at rt. Then the mixture was diluted with ethyl acetate (150 ml) and the organic layer 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:ethyl acetate 80:20 as eluant), to give pure isolated **4a**–**f**.
15. Selected data for compounds **4a**–**f**. Compound **4a**: ^1H NMR (200 MHz, $CDCl_3$): 1.15 (t, 3H, $J=7.0$), 2.40 (s, 3H), 4.04 (q, 2H, $J=7.0$), 5.30 (d, 1H, $J=8.8$), 5.69 (d, 1H, NH, $J=8.8$), 5.82 (s, 1H), 6.23 (s, 1H), 7.14–7.33 (m, 7 ArH), 7.68 (d, 2 ArH, $J=8.4$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 22.0, 59.5, 61.5, 126.9, 127.0, 127.7, 128.0, 128.1, 128.7, 128.9, 129.0, 129.9, 130.0, 130.1, 138.1, 139.2, 139.3, 143.8, 165.8. Compound **4b**: ^1H NMR (200 MHz, $CDCl_3$): 1.11 (t, 3H, $J=7.2$), 2.37 (s, 3H), 4.01 (q, 2H, $J=7.2$), 5.29 (d, 1H, $J=9.2$), 5.78 (s, 1H), 6.17 (d, 1H, NH, $J=9.2$), 6.18 (s, 1H), 7.04–7.20 (m, 6 ArH), 7.62 (d, 2 ArH, $J=8.3$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 21.9, 58.5, 61.5, 127.6, 128.0, 128.7, 128.9, 129.9, 133.8, 138.0, 139.2, 143.9, 165.6. Compound **4c**: ^1H NMR (200 MHz, $CDCl_3$): 1.11 (t, 3H, $J=7.2$), 2.30 (s, 3H), 4.02 (q, 2H, $J=7.2$), 5.53 (d, 1H, $J=9.1$), 5.90 (s, 1H), 6.14 (d, 1H, NH, $J=9.1$), 6.29 (s, 1H), 7.11 (d, 2 ArH, $J=8.4$), 7.22–7.28 (m, 1 ArH), 7.37–7.48 (m, 2 ArH), 7.54–7.58 (m, 1 ArH), 7.61–7.71 (m, 5 ArH). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 21.9, 59.5, 61.5, 125.1, 126.2, 126.6, 126.7, 127.7, 128.0, 128.5, 128.8, 129.9, 133.2, 133.5, 136.5, 138.1, 139.4, 143.8, 165.8. Compound **4d**: ^1H NMR (200 MHz, $CDCl_3$): 1.10 (t, 3H, $J=7.1$), 2.33 (s, 3H), 4.00 (q, 2H, $J=7.1$), 5.38 (d, 1H, $J=9.5$), 5.81 (s, 1H), 6.20 (s, 1H), 6.36 (d, 1H, NH, $J=9.5$), 7.18 (d, 2 ArH, $J=8.3$), 7.35 (d, 2 ArH, $J=8.7$), 7.63 (d, 2 ArH, $J=8.3$), 8.01 (d, 2 ArH, $J=8.7$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.3, 21.9, 58.8, 61.8, 123.9, 124.2, 127.6, 128.1, 129.1, 130.1, 130.2, 130.7, 137.8, 138.4, 144.2, 146.8, 147.6, 165.3. Compound **4e**: ^1H NMR (200 MHz, $CDCl_3$): 1.15 (t, 3H, $J=7.1$), 2.40 (s, 3H), 3.74 (s, 3H), 4.05 (q, 2H, $J=7.1$), 5.25 (d, 1H, $J=8.7$), 5.66 (d, 1H, NH, $J=8.7$), 5.80 (s, 1H), 6.19 (s, 1H), 6.74 (d, 2 ArH, $J=8.8$), 7.04 (d, 2 ArH, $J=8.8$), 7.23 (d, 2 ArH, $J=8.3$), 7.67 (d, 2 ArH, $J=8.8$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 22.0, 55.7, 58.8, 61.4, 114.3, 127.4, 127.7, 128.3, 129.9, 131.3, 138.1, 139.6, 143.7, 159.5, 165.9. Compound **4f**: ^1H NMR (200 MHz, $CDCl_3$): 0.83 (d, 3H, $J=6.4$), 0.85 (d, 3H, $J=6.4$), 1.22 (t, 3H, $J=7.1$), 1.31–1.67 (m, 3H), 2.40 (s, 3H), 4.05 (q, 2H, $J=7.1$), 4.05–4.19 (m, 1H), 5.38 (d, 1H, NH, $J=8.9$), 5.48 (s, 1H), 5.91 (s, 1H), 7.23 (d, 2 ArH, $J=8.4$), 7.65 (d, 2 ArH, $J=8.4$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.5, 21.9, 22.2, 22.9, 44.9, 55.3, 61.2, 127.1, 127.5, 127.7, 129.8, 138.5, 139.8, 143.5, 165.9.
16. (a) Benoit, R. L.; Lefebvre, D.; Frechette, M. *Can. J. Chem.* **1987**, *65*, 996–1001; (b) Leffek, K. T.; Pruszynski, P.; Thanapaalasingham, K. *Can. J. Chem.* **1989**, *67*, 590–595; (c) Yadav, V. K.; Kapoor, K. K. *Tetrahedron* **1995**, *51*, 8573–8584; (d) Aggarwal, V. K.; Mereu, A. *J. Chem. Soc., Chem. Comm.* **1999**, 2311–2312; (e) Kaljurand, I.; Rodima, T.; Leito, I.; Koppel, I. A.; Schwesinger, R. *J. Org. Chem.* **2000**, *65*, 6202–6208.
17. (a) Speziale, A. J.; Smith, L. R. *J. Org. Chem.* **1962**, *27*, 3742–3743; (b) Speziale, A. J.; Smith, L. R. *J. Org. Chem.* **1963**, *28*, 1805–1811.
18. General procedure for preparation of compounds **5**: To a solution containing the *N*-acyl carbamates (**9**) (5 mmol) in DCM (20 ml), DABCO (0.11 g; 1 mmol) was added and the mixture was stirred for 12 h at rt. Then the mixture was diluted with ethyl acetate (150 ml) and the organic layer 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 purified by silica gel chromatography (cyclohexane:ethyl acetate 80:20 as eluant), to give pure isolated **5**.
19. Selected data for compounds **5a**–**f**. Compound **5a**: ^1H NMR (200 MHz, $CDCl_3$): 1.22 (t, 3H, $J=7.2$), 4.16 (q, 2H, $J=7.2$), 6.00 (s, 1H), 6.24 (d, 1H, $J=8.8$), 6.41 (s, 1H), 7.21–7.57 (m, 9H, 8 ArH+NH), 7.81–7.89 (m, 2 ArH). ^{13}C NMR (50 MHz, $CDCl_3$): 14.5, 55.8, 61.6, 126.9, 127.6, 128.1, 129.1, 132.2, 134.7, 139.7, 140.2, 166.6, 166.8. Compound **5b**: ^1H NMR (200 MHz, $CDCl_3$): 1.24 (t, 3H, $J=7.1$), 3.78 (s, 3H), 4.17 (q, 2H, $J=7.1$), 5.97 (s, 1H), 6.17 (d, 1H, $J=8.8$), 6.38 (s, 1H), 6.86 (d, 2 ArH, $J=8.8$), 7.26 (d, 2 ArH, $J=8.8$), 7.33–7.59 (m, 4H, 3 ArH+NH), 7.80–7.85 (m, 2 ArH). ^{13}C NMR (50 MHz, $CDCl_3$): 14.5, 55.3, 55.7, 61.5, 114.5, 127.4, 127.5, 128.2, 129.1, 132.1, 132.3, 134.7, 139.9, 159.5, 166.7. Compound **5c**: ^1H NMR (200 MHz, $CDCl_3$): 1.24 (t, 3H, $J=7.2$), 4.18 (q, 2H, $J=7.2$), 5.92 (d, 1H, $J=8.9$), 6.00 (s, 1H), 6.44 (s, 1H), 7.21–7.41 (m, 5 ArH), 8.14 (d, 1H, NH, $J=8.9$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 57.3, 61.8, 126.7, 127.2, 128.5, 128.7, 129.0, 129.3, 138.4, 138.6, 161.5, 166.1. Compound **5d**: ^1H NMR (200 MHz, $CDCl_3$): 1.24 (t, 3H, $J=7.1$), 3.79 (s, 3H), 4.17 (q, 2H, $J=7.1$), 5.86 (d, 1H, $J=8.8$), 5.96 (s, 1H), 6.41 (s, 1H), 6.88 (d, 2 ArH, $J=8.8$), 7.21 (d, 2 ArH, $J=8.8$), 8.06 (d, 1H, NH, $J=8.8$). ^{13}C NMR (50 MHz, $CDCl_3$): 14.5, 55.7, 56.9, 61.8, 114.7, 128.0, 128.4, 130.6, 138.6, 159.8, 161.4, 166.2. Compound **5e**: ^1H NMR (200 MHz, $CDCl_3$): 1.22 (t, 3H, $J=7.2$), 1.25 (s, 9H), 4.13 (q, 2H, $J=7.2$), 5.90 (s, 1H), 5.99 (d, 1H, $J=8.3$), 6.35 (s, 1H), 6.93 (d, 1H, NH, $J=8.3$), 7.21–7.42 (m, 5 ArH). ^{13}C NMR (50 MHz, $CDCl_3$): 14.4, 27.9, 39.2, 55.2, 61.4, 126.7, 128.4, 129.0, 129.1, 139.9, 140.3, 166.4, 177.9. Compound **5f**: ^1H NMR (200 MHz, $CDCl_3$): 1.18 (t, 3H, $J=7.1$), 4.12 (q, 2H, $J=7.1$), 5.15 (s, 2H), 5.78 (d, 1H, $J=8.8$), 5.83 (d, 1H, NH, $J=8.8$), 6.39 (s, 1H), 7.25–7.43 (m, 10 ArH). ^{13}C NMR (50 MHz, $CDCl_3$): 14.5, 57.2, 61.4, 67.5, 126.7, 127.8, 127.9, 128.8, 129.0, 139.8, 140.4, 166.5, 177.9.