Formation of Phosphorylated 3*H*-Pyrroles from *Nef*–Isocyanide–*Perkow* Adducts and Tosylmethyl Isocyanide

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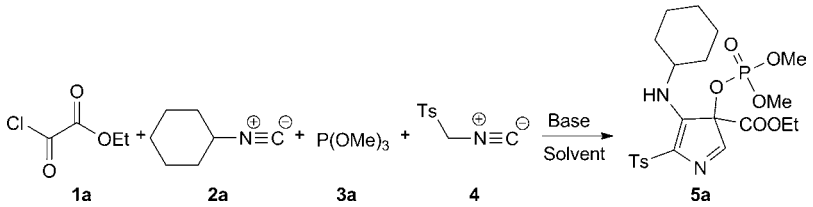
Imidoyl chlorides, generated from isocyanides and acyl chlorides, react with trialkyl phosphites, in a *Perkow*-type reaction, to afford 3-(alkylimino)-2-[(dialkyloxyphosphoryl)oxy]acrylates, which undergo a smooth reaction with tosylmethyl isocyanide (TsMIC) to furnish 4-(alkylamino)-3-[(dialkyloxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylates in moderate-to-good yields.

Introduction. – Sequential one-pot transformations offer significant advantages over conventional linear-step syntheses, by reducing time and saving energy, thus resulting in both economic and environmental benefits [1–4]. Multicomponent synthesis has been established as a valuable tool to the pharmaceutical industry for construction of low-molecular-weight compound libraries through combinatorial strategies and parallel synthesis [5–7]. Although (*p*-toluenesulfonyl)methyl isocyanide (=1-[(isocyanomethyl)sulfonyl]-4-methylbenzene; TsMIC) is a versatile and widely applicable reagent that constitutes a functionalized building block [8] bearing an active CH_2 group apart from its inherent advantage of possessing also an isocyanide functionality, which can serve as a handle for further manipulation, the possibility of its use in multicomponent reactions has not been widely appreciated. TsMIC has most commonly been used in heterocyclic ring construction [9][10], in particular, of oxazole and pyrrole moieties, but comparatively rarely in multicomponent reactions [11][12]. Since the reaction between imines and TsMIC in basic media is a trusted method for the synthesis of 1,5-disubstituted imidazoles [13], we speculated that formation of functionalized 3*H*-pyrroles *via* cyclizations of *Nef*–isocyanide–*Perkow* products and TsMIC would be possible, *via* a sequential one-pot transformation.

As part of our interest in the development of new routes in heterocyclic synthesis [14–18], we studied the reaction between ketenimines and TsMIC in basic solution. This reaction provided new 4-(alkylamino)-3-[(dialkyloxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylates.

Results and Discussion. – Initially, we studied the reaction of ethyl 2-chloro-2-oxoacetate (**1a**), cyclohexyl isocyanide (**2a**), $P(OMe)_3$ (**3a**), and TsMIC (**4**) in the presence of common bases at room temperature in different solvent systems, and the results are compiled in *Table 1*. The desired product **5a** could be obtained in 23–53% yield using THF, CH_2Cl_2, acetone, EtOH, and MeCN as solvent, but MeCN afforded the highest yield (*Table 1*, *Entry 2*). Common bases such as Et_3N, DBU (=1,8-

Table 1. *Reaction of Ethyl 2-Chloro-2-oxoacetate* (**1a**), *Cyclohexyl Isocyanide* (**2a**), *Trimethyl Phosphite* (**3a**), *and TsMIC in the Presence of a Base*[a])



1a **2a** **3a** **4** **5a**

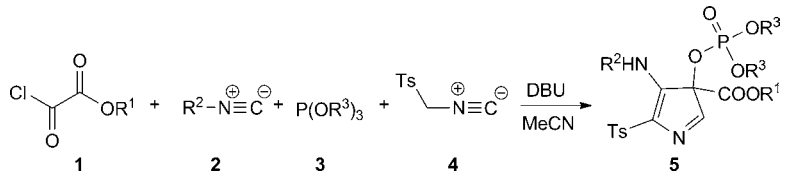
Entry	Solvent	Base	Time [h][b])	Yield [%][c]) of **5a**
1	MeCN	Et_3N	7	35
2	MeCN	DBU	4	53
3	MeCN	KOH	7	23
4	MeCN	K_2CO_3	7	25
5	MeCN	$NaHCO_3$	7	38
6	THF	DBU	7	24
7	EtOH	DBU	7	38
8	CH_2Cl_2	DBU	7	27
9	Acetone	DBU	7	32

[a]) General conditions: **1** (1 mmol), **2a** (1 mmol), **3a** (1 mmol), TsMIC (**4**; 1 mmol), and base (1 mmol). [b]) Reaction time for consumption of all starting materials. [c]) Yields of isolated product.

diazabicyclo[5.4.0]undec-7-ene), K_2CO_3, $NaHCO_3$, and KOH can catalyze this reaction with low-to-moderate yields (*Table 1*, *Entries 1–9*). However, DBU turned out to be the optimal catalyst (*Table 1*, *Entry 2*).

With the suitable reaction conditions in hand, we next explored the protocol with different alkyl 2-chloro-2-oxoacetates **1**, isocyanides **2**, trialkyl phosphites **3**, and TsMIC (**4**) in the presence of DBU in MeCN. As shown in *Table 2*, the reaction

Table 2. *Synthesis of Functionalized 3-[(Dialkyloxyphosphoryl)oxy]-3*H*-pyrrole-3-carboxylates* **5**



1 **2** **3** **4** **5**

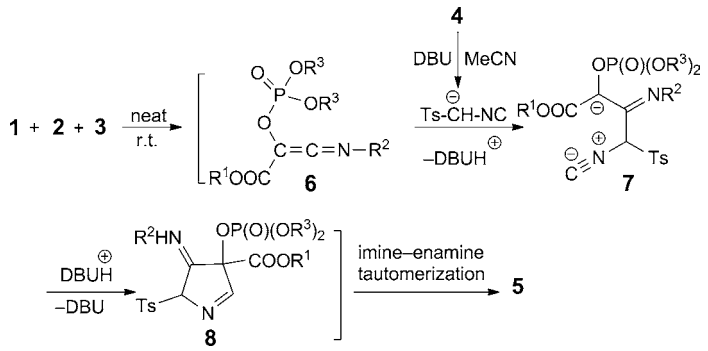
Entry	R^1	R^2	R^3	Yield [%]
1	Et	Cyclohexyl	Me	**5a** (53)
2	Me	^{t}Bu	Me	**5b** (57)
3	Me	^{t}Bu	Et	**5c** (48)
4	Et	^{t}Bu	Me	**5d** (45)
5	Et	Cyclohexyl	Et	**5e** (59)
6	Me	Cyclohexyl	Et	**5f** (55)
7	Me	Cyclohexyl	Me	**5g** (60)

afforded the corresponding 4-(alkylamino)-3-[(dialkyloxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylates **5** in 45–60% yields.

The structures of compounds **5a**–**5g** were deduced from their IR, and ^{1}H- and ^{13}C-NMR data. For example, the ^{1}H-NMR spectrum of **5a**, exhibited two *singlet*s for Me (2.32 ppm) and HC=N (7.57 ppm), two *doublet*s for MeO (3.67, (^3J(H,P) = 14.1) and 3.75 ppm (^3J(H,P) = 14.1)), along with characteristic signals for the rest of H-atoms. The ^{1}H-decoupled ^{13}C-NMR spectrum of **5a** showed 20 distinct resonances in agreement with the proposed structure. The ^{1}H- and ^{13}C-NMR spectra of compounds **5b**–**5g** are similar to those of **5a**, except for the substituents on the pyrrole ring, which show characteristic signals in the appropriate regions of the spectra.

Although the detailed mechanism of this reaction remains to be clarified, a plausible mechanism for the formation of compounds **5** is proposed in the *Scheme*. The addition of isocyanides to acyl chlorides (*Nef*–isocyanide reaction) leads to imidoyl chlorides, which can later react with trialkyl phosphites to afford ketenimine intermediates **6** in a *Perkow*-type reaction [19]. It is conceivable that formation of intermediate **7** takes place through a nucleophilic attack of the base-activated TsMIC at **6**. Intramolecular 5-*endo-dig* ring formation of **7** affords intermediate **8**, which is converted to **5** by imine–enamine tautomerization.

Scheme



In summary, imidoyl chlorides react with trialkyl phosphites, in a *Perkow*-type reaction, to afford intermediate 3-(alkylimino)-2-[(dialkyloxyphosphoryl)oxy]acrylates, which undergo a smooth reaction with TsMIC to afford 4-(alkylamino)-3-[(dialkyloxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylates in moderate-to-good yields. The mild and simple reaction conditions renders this transformation suitable for synthesis of functionalized 3-[(dialkyloxyphosphoryl)oxy]-3*H*-pyrrole-3-carboxylates.

Experimental Part

General. All chemicals were obtained commercially and used without further purification. M.p.: *Electrothermal-9100* apparatus. IR Spectra: *Shimadzu-IR-460* spectrometer; $\tilde{\nu}$ in cm^{-1}. ^{1}H- and ^{13}C-NMR Spectra: *Bruker DRX-500 Avance* instrument at 500.1 and 125.7 MHz, resp.; δ in ppm, J in Hz. MS:

Finnigan-MAT-8430 spectrometer; at 70 eV; in *m/z* (rel. %). Elemental analyses: *Vario EL III CHNOS* elemental analyzer.

General Procedure for the Synthesis of Compound **7**. A mixture of **1** (1 mmol) and **2** (1 mmol) was stirred at r.t. for 10 min. Then, **3** (1 mmol) was added. After stirring the mixture for 5 min, a soln. of TsMIC (1.0 mmol) and DBU (1.0 mmol) in MeCN (5 ml) was added in one portion. After 4 h, the solvent was removed under reduced pressure, and the residue was purified by SiO_2 (*Merck* 230–240 mesh) column chromatography (hexane/AcOEt 2:1).

*Ethyl 4-(Cyclohexylamino)-3-[(dimethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5a**). Pale-yellow oil. Yield: 0.27 g (53%). IR (KBr): 3484 (NH), 1755 (C=O), 1284 (SO_2), 1040 (C–O). ^{1}H-NMR: 1.18 (*t*, ^3J = 7.1, Me); 1.20–2.02 (*m*, 5 CH_2); 2.32 (*s*, Me); 3.78–3.93 (*m*, CH); 3.67 (*d*, ^3J(H,P) = 14.1, Me); 3.75 (*d*, ^3J(H,P) = 14.1, Me); 7.00 (*d*, ^3J = 7.0, NH); 7.24 (*d*, ^3J = 8.1, 2 CH); 7.57 (*s*, HC=N); 7.92 (*d*, ^3J = 8.1, 2 CH). ^{13}C-NMR: 13.8 (Me); 21.4 (Me); 24.7; 25.5; 25.6; 34.3; 34.8 (5 CH_2); 54.6 (*d*, ^2J(C,P) = 5.7, Me); 54.7 (*d*, ^2J(C,P) = 5.7, Me); 56.6 (CH); 62.7 (CH_2); 66.7 (*d*, ^2J(C,P) = 5.0, COP); 127.2 (C); 128.1 (2 CH); 129.5 (2 CH); 137.1 (CH); 138.0 (C); 138.9 (C); 144.2 (C); 166.9 (*d*, ^3J(C,P) = 5.5, C=O). EI-MS: 514 (5, M^+), 508 (11), 469 (32), 368 (12), 256 (25), 236 (24), 213 (19), 185 (15), 136 (55), 111 (39), 97 (56), 81 (73), 60 (57). Anal. calc. for $C_{22}H_{31}N_2O_8PS$ (514.15): C 51.35, H 6.07, N 5.44; found: C 51.03, H 5.98, N 5.38.

*Methyl 4-[(*tert*-Butyl)amino]-3-[(dimethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5b**). Pale-yellow oil. Yield: 0.27 g (57%). IR (KBr): 3427 (NH), 1755 (C=O), 1270 (SO_2), 1043 (C–O). ^{1}H-NMR: 1.34 (*s*, ^{t}Bu); 2.33 (*s*, Me); 3.57 (*d*, ^3J(H,P) = 14.3, Me); 3.63 (*s*, Me); 3.71 (*d*, ^3J(H,P) = 14.3, Me); 7.26 (*d*, ^3J = 8.2, 2 CH); 7.66 (*s*, HC=N); 7.80 (*s*, NH); 7.92 (*d*, ^3J = 8.2, 2 CH). ^{13}C-NMR: 21.6 (Me); 30.7 (*Me*$_3$C); 51.6 (Me$_3$*C*); 54.4 (*d*, ^2J(C,P) = 3.0, Me); 53.4 (COO*Me*); 55.2 (*d*, ^2J(C,P) = 3.0, Me); 66.6 (*d*, ^2J(C,P) = 4.1, COP); 127.7 (C); 128.3 (2 CH); 129.0 (2 CH); 137.9 (CH); 139.6 (C); 140.1 (C); 144.1 (C); 166.5 (*d*, ^3J(C,P) = 5.4, C=O). EI-MS: 474 (4, M^+), 460 (5), 410 (7), 386 (9), 359 (11), 310 (10), 277 (16), 251 (17), 236 (43), 216 (49), 187 (91), 172 (100), 158 (38), 139 (63), 111 (36), 91 (82), 71 (56), 57 (89). Anal. calc. for $C_{19}H_{27}N_2O_8PS$ (474.12): C 48.10, H 5.74, N 5.90; found: C 48.25, H 5.68, N, 5.84.

*Methyl 4-[(*tert*-Butyl)amino]-3-[(diethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5c**). Pale-yellow oil. Yield: 0.25 g (48%). IR (KBr): 3305 (NH), 1758 (C=O), 1272 (SO_2), 1035 (C–O). ^{1}H-NMR: 1.15–1.18 (*m*, 2 Me); 1.33 (*s*, ^{t}Bu); 2.36 (*s*, Me); 3.84 (*s*, COO*Me*); 4.12–4.20 (*m*, 2 CH_2); 7.08 (*s*, NH); 7.27 (*d*, ^3J = 8.0, 2 CH); 7.70 (*s*, HC=N); 7.88 (*d*, ^3J = 8.0, 2 CH). ^{13}C-NMR: 16.0 (*d*, ^3J(C,P) = 6.0, Me); 16.4 (*d*, ^3J(C,P) = 6.0, Me); 21.6 (Me); 28.5 (*Me*$_3$C); 51.9 (Me$_3$*C*); 53.2 (CO_2Me); 65.7 (*d*, ^2J(C,P) = 5.9, COP); 64.8 (*d*, ^2J(C,P) = 2.9, CH_2); 64.9 (*d*, ^2J(C,P) = 2.9, CH_2); 122.8 (C); 127.9 (2 CH); 129.7 (2 CH); 137.6 (CH); 138.8 (C); 143.0 (C); 144.2 (C); 166.0 (*d*, ^3J(C,P) = 4.1, C=O). EI-MS: 502 (4, M^+), 492 (5), 362 (8), 355 (10), 270 (15), 253 (23), 226 (96), 199 (63), 171 (19), 155 (42), 138 (71), 99 (72), 58 (51). Anal. calc. for $C_{21}H_{31}N_2O_8PS$ (502.15): C 50.19, H 6.22, N 5.57; found: C 50.57, H 6.17, N 5.49.

*Ethyl 4-[(*tert*-Butyl)amino]-3-[(dimethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5d**). Pale-yellow oil. Yield: 0.20 g (45%). IR (KBr): 3417 (NH), 1753 (C=O), 1278 (SO_2), 1044 (C–O). ^{1}H-NMR: 1.20 (*t*, ^3J = 7.0, Me); 1.31 (*s*, ^{t}Bu); 2.32 (*s*, Me); 3.21–3.36 (*m*, CH_2); 3.51 (*d*, ^3J(H,P) = 14.0, Me); 3.68 (*d*, ^3J(H,P) = 14.0, Me); 7.28 (*d*, ^3J = 8.3, 2 CH); 7.60 (*s*, NH); 7.71 (*s*, HC=N); 8.31 (*d*, ^3J = 8.3, 2 CH). ^{13}C-NMR: 14.6 (Me); 21.6 (Me); 28.5 (*Me*$_3$C); 51.4 (Me$_3$*C*); 52.5 (*d*, ^2J(C,P) = 3.1, Me); 55.1 (*d*, ^2J(C,P) = 3.1, Me); 58.1 (CH_2); 65.1 (*d*, ^2J(C,P) = 5.8, COP); 127.6 (C); 128.2 (2 CH); 129.4 (2 CH); 137.6 (CH); 138.2 (C); 138.5 (C); 142.9 (C); 165.3 (*d*, ^3J(C,P) = 6.1, C=O). EI-MS: 488 (3, M^+), 473 (10), 415 (9), 401 (13), 343 (11), 319 (14), 265 (93), 249 (42), 172 (46), 139 (64), 123 (42), 91 (100), 65 (57), 51 (17). Anal. calc. for $C_{20}H_{29}N_2O_8PS$ (488.13): C 49.17, H 5.98, N 5.73; found: C 49.59, H 5.91, N 5.68.

*Ethyl 4-(Cyclohexylamino)-3-[(diethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5e**). Pale-yellow oil. Yield: 0.32 g (59%). IR (KBr): 3484 (NH), 1756 (C=O), 1283 (SO_2), 1041 (C–O). ^{1}H-NMR: 1.15–1.31 (*m*, 3 Me); 1.21–1.98 (*m*, 5 CH_2); 2.35 (*s*, Me); 3.76–3.85 (*m*, CH); 4.00–4.25 (*m*, 3 CH_2); 7.01 (*d*, ^3J = 6.8, NH); 7.25 (*d*, ^3J = 8.2, 2 CH); 7.57 (*s*, HC=N); 7.94 (*d*, ^3J = 8.2, 2 CH). ^{13}C-NMR: 14.0 (Me); 15.9 (*d*, ^3J(C,P) = 6.9, Me); 16.1 (*d*, ^3J(C,P) = 6.9, Me); 21.5 (Me); 24.8, 25.6, 25.6, 34.4, 34.8 (5 CH_2); 56.6 (CH); 53.6 (CH_2); 64.4 (*d*, ^2J(C,P) = 5.6, CH_2); 64.5 (*d*, ^2J(C,P) = 5.6,

CH_2); 66.0 (*d*, ^2J(C,P) = 4.3, COP); 127.5 (C); 128.1 (2 CH); 129.5 (2 CH); 137.1 (CH); 138.1 (C); 138.8 (C); 144.1 (C); 167.2 (*d*, ^3J(C,P) = 5.6, C=O). EI-MS: 542 (5, M^+), 387 (100), 368 (8), 352 (10), 317 (22), 271 (25), 243 (18), 150 (16), 133 (17), 110 (10), 83 (19), 57 (5). Anal. calc. for $C_{24}H_{35}N_2O_8PS$ (542.18): C 53.13, H 6.50, N 5.16; found: C 53.51, H 6.44, N 5.23.

*Methyl 4-(Cyclohexylamino)-3-[(diethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5f**). Pale-yellow oil. Yield: 0.29 g (55%). IR (KBr): 3479 (NH), 1755 (C=O), 1284 (SO_2), 1040 (C–O). ^{1}H-NMR: 1.27–1.37 (*m*, 2 Me); 1.23–2.00 (*m*, 5 CH_2); 2.34 (*s*, Me); 3.69–3.77 (*m*, CH); 4.05 (*s*, COOMe); 4.10–4.21 (*m*, 2 CH_2); 7.02 (*d*, ^3J = 6.9, NH); 7.24 (*d*, ^3J = 8.1, 2 CH); 7.55 (*s*, HC=N); 7.93 (*d*, ^3J = 8.1, 2 CH). ^{13}C-NMR: 16.6 (*d*, ^3J(C,P) = 6.7, Me); 16.9 (*d*, ^3J(C,P) = 6.7, Me); 22.6 (Me); 25.6, 25.6, 32.6, 34.5, 34.7 (5 CH_2); 53.6 (Me); 56.7 (CH); 64.4 (*d*, ^2J(C,P) = 5.6, CH_2); 64.6 (*d*, ^2J(C,P) = 5.6, CH_2); 64.9 (*d*, ^2J(C,P) = 5.7, COP); 127.4 (C); 127.5 (2 CH); 129.8 (2 CH); 137.0 (CH); 138.0 (C); 138.2 (C); 144.2 (C); 167.6 (*d*, ^3J(C,P) = 5.7, C=O). EI-MS: 528 (6, M^+), 483 (7), 469 (43), 373 (100), 315 (8), 293 (32), 251 (27), 155 (28), 127 (16), 99 (32), 83 (31), 56 (29). Anal. calc. for $C_{23}H_{33}N_2O_8PS$ (528.17): C 52.26, H 6.29, N 5.30; found: C 52.54, H 6.22, N 5.23.

*Methyl 4-(Cyclohexylamino)-3-[(dimethoxyphosphoryl)oxy]-5-[(4-methylphenyl)sulfonyl]-3*H*-pyrrole-3-carboxylate* (**5g**). Pale-yellow oil. Yield: 0.30 g (60%). IR (KBr): 3436 (NH), 1751 (C=O), 1280 (SO_2), 1030 (C–O). ^{1}H-NMR: 1.19–1.86 (*m*, 5 CH_2); 2.37 (*s*, Me); 3.47 (*d*, ^3J(H,P) = 13.8, Me); 3.76 (*d*, ^3J(H,P) = 13.8, Me); 3.85 (*s*, COOMe); 3.86–3.93 (*m*, CH); 7.05 (*d*, ^3J = 8.7, NH); 7.28 (*d*, ^3J = 8.2, 2 CH); 7.59 (*s*, HC=N); 7.96 (*d*, ^3J = 8.2, 2 CH). ^{13}C-NMR: 21.6 (Me); 24.8, 25.6, 25.6, 34.4, 34.8 (5 CH_2); 53.2 (CH); 54.7 (*d*, ^2J(C,P) = 5.6, Me); 54.8 (*d*, ^2J(C,P) = 5.7, Me); 56.7 (Me); 66.3 (*d*, ^2J(C,P) = 4.2, COP); 127.2 (C); 128.2 (2 CH); 129.6 (2 CH); 137.1 (CH); 137.9 (C); 139.0 (C); 144.3 (C); 167.6 (*d*, ^3J(C,P) = 5.6, C=O). EI-MS: 500 (7, M^+), 469 (23), 387 (27), 373 (72), 345 (69), 293 (21), 242 (78), 198 (100), 166 (91), 127 (46), 110 (47), 84 (51), 58 (36). Anal. calc. for $C_{21}H_{29}N_2O_8PS$ (500.14): C 50.39, H 5.84, N, 5.60; found: C 50.02, H 5.76, N 5.65.

REFERENCES

[1] A. Dömling, I. Ugi, *Angew. Chem., Int. Ed.* **2000**, *39*, 3168.
[2] F. Sha, X. Huang, *Angew. Chem., Int. Ed*. **2009**, *48*, 3458.
[3] M. Boominathan, M. Nagaraj, S. Muthusubramanian, R. V. Krishnakumar, *Tetrahedron* **2011**, *67*, 6057.
[4] S. Balalaie, M. Bararjanian, S. Hosseinzadeh, F. Rominger, H. R. Bijanzadeh, E. Wolf, *Tetrahedron* **2011**, *67*, 7294.
[5] H. Bienaymé, C. Hulme, G. Oddon, P. Schmitt, *Chem.–Eur. J.* **2000**, *6*, 3321.
[6] G. Sathishkannan, K. Srinivasan, *Org. Lett*. **2011**, *13*, 6002.
[7] S.-i. Matsuoka, Y. Tochigi, K. Takagi, M. Suzuki, *Tetrahedron* **2012**, *68*, 9836.
[8] F. De Moliner, C. Hulme, *Org. Lett*. **2012**, *14*, 1354.
[9] D. Van Leusen, A. M. Van Leusen, *Org. React.* **2001**, *57*, 417.
[10] G. A. Molander, W. Febo-Ayala, L. Jean-Gérard, *Org. Lett*. **2009**, *11*, 3830.
[11] S. E. Denmark, Y. Fan, *J. Org. Chem.* **2005**, *70*, 9667.
[12] P. R. Krishna, G. Dayaker, P. V. N. Reddy, *Tetrahedron Lett.* **2006**, *47*, 5977.
[13] J. Sisko, A. J. Kassick, M. Mellinger, J. J. Filan, A. Allen, M. A. Olsen, *J. Org. Chem*. **2000**, *65*, 1516.
[14] I. Yavari, R. Pashazadeh, R. Hosseinpour, *Helv. Chim. Acta* **2012**, *95*, 169.
[15] I. Yavari, R. Hosseinpour, R. Pashazadeh, *Synlett* **2012**, *23*, 1662.
[16] I. Yavari, R. Hosseinpour, R. Pashazadeh, S. Skoulika, *Synlett* **2012**, *23*, 2103.
[17] I. Yavari, R. Hosseinpour, R. Pashazadeh, E. Ghanbari, S. Skoulika, *Tetrahedron* **2013**, *69*, 2462.
[18] I. Yavari, R. Pashazadeh, R. Hosseinpour, E. Ghanbari, *Helv. Chim. Acta* **2013**, *96*, 2191.
[19] D. Coffinier, L. El Kaim, L. Grimaud, *Org. Lett.* **2009**, *11*, 1825.

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