

Ali Mohammad Astaraki and Ayoob Bazgir*

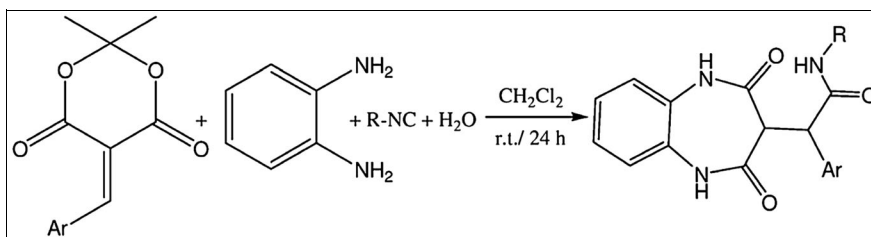
Department of Chemistry, Islamic Azad University, Doroud Branch, Doroud, Iran

*E-mail: a_bazgir@iau-doroud.ac.ir

Received April 12, 2011

DOI 10.1002/jhet.1041

View this article online at wileyonlinelibrary.com.



New tetrahydro-1H-1,5-benzodiazepin-2-phenylacetamides were synthesized in good yields by a four-component reaction of benzylidene Meldrum's acid, benzene-1,2-diamines, isocyanides, and water in CH_2Cl_2 at room temperature.

J. Heterocyclic Chem., **50**, 175 (2013).

INTRODUCTION

Benzodiazepine derivatives have been known to display a wide range of pharmacological activities as anticonvulsant, antianxiety, analgesic, sedative, antidepressive, hypnotic agents [1], as well as anti-inflammatory agents [2]. Among the 1,5-benzodiazepines, the 1,5-benzodiazepine-2-ones such as telenzepine [3], triflubazam [4], and clobazam [5] (Fig. 1), are clinically used as anxiolytic or antisecretory agents. Further, compound **1** have been investigated as cholecystokinin-B receptor antagonist [6] (Fig. 1). Two recently published patents indicate that 2,3,4,5-tetrahydro-1H-1,5-benzodiazepine derivatives carrying carboxamide substituents are potentially important as a therapeutic and prophylactic agent for diabetes, diabetic nephropathy, or glomerulosclerosis [7].

Multicomponent reactions (MCRs) have been frequently used by synthetic chemists as a facile means to generate molecular diversity from bifunctional substrates that react sequentially in an intramolecular fashion [8,9]. In recent years, isocyanide-based multicomponent condensation reactions (IMCRs) by virtue of their synthetic potential, their inherent atom efficiency, convergent nature, ease of implementation, and the generation of molecular diversity, have attracted much attention because of the advantages that they offer to the field of combinatorial chemistry [10,11]. Similarly, IMCRs have emerged as valuable tools for the preparation of structurally diverse chemical libraries of drug-like heterocyclic compounds [12–16]. In this context, benzodiazepine derivatives show interesting features that make them attractive for use in IMCRs [17–23].

Because of the biological activity of 2,3,4,5-tetrahydro-1H-1,5-benzodiazepine [7], and our interest in synthesis

of heterocyclic compounds [24–28], herein, we report an efficient isocyanide-based four-component method for the preparation of new tetrahydro-1H-1,5-benzodiazepin-2-phenylacetamides. These compounds have closely related ring systems such as triflubazam, clobazam, and 1,5-benzodiazepines, which have a broad spectrum of biological activities.

RESULTS AND DISCUSSION

We found that a mixture of benzylidene Meldrum's acid **1**, benzene-1,2-diamines **2**, isocyanides **3**, and water in CH_2Cl_2 at room temperature, afforded corresponding 2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl-2-phenylacetamides **4** in good yields for 24 h. The results are summarized in Table 1.

The good yield and purity of products and simplicity of the present procedure makes it an interesting, convenient, and acceptable one-pot method for the preparation of tetrahydro-1H-1,5-benzodiazepin-2-phenylacetamides. In addition, the workup of these very clean reactions involves only a filtration and simple washing step with EtOH.

Because of the importance of ferrocenyl heterocyclic compounds [29,30], we used ferrocenecarboxaldehyde **5** in the reaction. This made it possible to synthesize new ferrocenyl benzodiazepine **6** (Scheme 1).

We have not established an exact mechanism for the formation of products **4**; however, a reasonable possibility is shown in Scheme 2. The formation of product **4** can be rationalized by initial formation of 1,5-benzodiazepine **7** via condensation of **1** and **2**. Intermediate **8** was produced by Michael-type addition reaction of an isocyanide **3** to **7**, followed by nucleophilic attack of a H_2O molecule on the nitrilium moiety to produce compound **9**. Finally, tautomerization

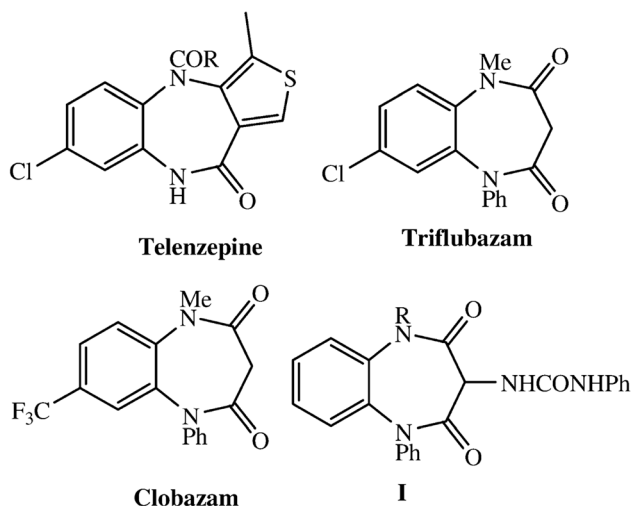


Figure 1. Important biologically active 1,5-benzodiazepines.

of **9** produces the tetrahydro-1*H*-1,5-benzodiazepin-2-phenylacetamides **4** (Scheme 2) [23]. Compounds **4** and **6** are stable solids whose structures were established by IR, ^1H NMR spectroscopy, and elemental analysis.

In conclusion, we have described an efficient four-component method for the synthesis of new tetrahydro-1,5-benzodiazepin-2-phenylacetamides using readily available starting materials. The products are of potential synthetic and pharmacological interest. Prominent among the advantages of this new method are operational simplicity, good yields, and easy work-up procedures employed.

EXPERIMENTAL

Melting points were measured on an Electrothermal 9100 apparatus. Mass spectra were recorded on a FINNIGAN-MAT

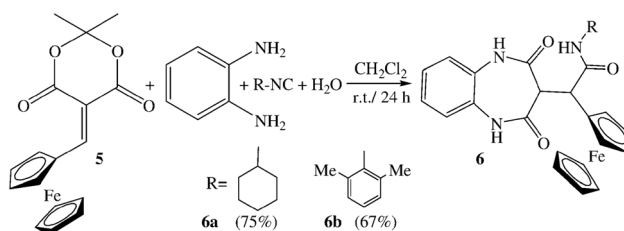
Table 1

Synthesis of 1,5-benzodiazepin **4**.

Product 4	Ar	R'	Yield (%) ^a
a	C ₆ H ₅	Cyclohexyl	82
b	4-Cl-C ₆ H ₄	Cyclohexyl	80
c	2-Cl-C ₆ H ₄	Cyclohexyl	76
d	4-Me-C ₆ H ₄	Cyclohexyl	79
e	4-Br-C ₆ H ₄	Cyclohexyl	77
f	3-Br-C ₆ H ₄	Cyclohexyl	73
g	3-NO ₂ -C ₆ H ₄	Cyclohexyl	81
h	3-MeO-C ₆ H ₄	Cyclohexyl	82
i	C ₆ H ₅	2,6-(Me) ₂ C ₆ H ₃	77
j	4-Cl-C ₆ H ₄	2,6-(Me) ₂ C ₆ H ₃	74
k	3-MeO-C ₆ H ₄	2,6-(Me) ₂ C ₆ H ₃	79

^aIsolated yields.

Scheme 1



8430 mass spectrometer operating at an ionization potential of 70 eV. ^1H NMR spectra were recorded on a BRUKER DRX-300 AVANCE spectrometer at 300.13. IR spectra were recorded using a Shimadzu IR-470 apparatus. Elemental analyses were performed using a Heracus CHN-O-Rapid analyzer.

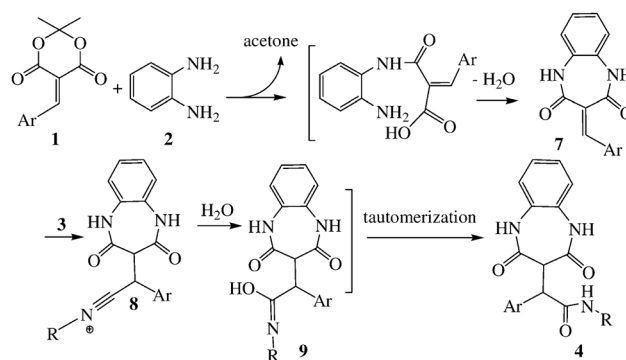
Because of the very low solubility of products **4** and **6**, we were unable to obtain the ^{13}C -NMR spectrum.

Typical procedure for the preparation of tetrahydro-1*H*-1,5-benzodiazepin-2-phenylacetamides (4**).** A mixture of benzylidene Meldrum's acid (1 mmol), benzene-1,2-diamines (1 mmol), isocyanides (1 mmol) and H₂O (0.5 mL) in CH₂Cl₂ (4 mL) was stirred for 24 h at room temperature. After completion of the reaction (TLC; ethyl acetate/*n*-hexane, 1/1), the reaction mixture was filtered and the precipitate washed with EtOH (5 mL) to afford the pure product.

***N*-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1*H*-1,5-benzodiazepin-3-yl)-2-phenylacetamide (**4a**).** White powder (82%); mp >260°C. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3331, 3283, 3065, 1700, 1649, 1606. ^1H NMR (300 MHz, DMSO-*d*₆): δ_{H} 0.99–1.74 (10H, m, 5CH₂ of cyclohexyl), 3.35 (1H, bs, CH-N, overlap with solvent), 3.74 (1H, d, *J* = 10.4 Hz, CH), 4.33 (1H, d, *J* = 10.4 Hz, CH), 7.11–7.39 (9H, m, Ar-H), 8.03 (1H, bs, NH-cyclohexyl), 10.29 (1H, s, NH), 10.49 (1H, s, NH). MS (EI, 70 eV) *m/z*: 391 (M⁺). Anal. Calcd for C₂₃H₂₅N₃O₃: C, 70.57; H, 6.44; N, 10.73. Found: C, 70.48; H, 6.38; N, 10.65.

2-(4-Chlorophenyl)-*N*-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1*H*-1,5-benzodiazepin-3-yl) acetamide (4b**).** White powder (80%); mp >260°C. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3319, 3216, 3074, 1699, 1646, 1602. ^1H NMR (300 MHz, DMSO-*d*₆): δ_{H} 0.98–1.65 (10H, m, 5CH₂ of cyclohexyl), 3.36 (1H, bs, CH-N, overlap with solvent), 3.71 (1H, d, *J* = 11.3 Hz, CH), 4.35 (1H, d, *J* = 11.3 Hz, CH), 7.10–7.42 (8H, m, Ar-H), 8.08 (1H, d, *J* = 7.1 Hz, NH-cyclohexyl), 10.34 (1H, s, NH), 10.53 (1H, s, NH). MS

Scheme 2



(EI, 70 eV) m/z : 425 (M^+). Anal. Calcd for $C_{23}H_{24}ClN_3O_3$: C, 64.86; H, 5.68; N, 9.87. Found: C, 64.74; H, 5.59; N, 9.96.

2-(2-Chlorophenyl)-N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl) acetamide (4c). White powder (76%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3346, 3265, 3080, 1701, 1651, 1605. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.08–1.69 (10H, m, 5CH_2 of cyclohexyl), 3.47 (1H, bs, CH-N, overlap with solvent), 3.95 (1H, d, $J = 11.2$ Hz, CH), 4.72 (1H, d, $J = 11.2$ Hz, CH), 7.14–7.37 (8H, m, Ar-H), 7.57 (1H, d, $J = 8.1$ Hz, NH-cyclohexyl), 10.31 (1H, s, NH), 10.62 (1H, s, NH). MS (EI, 70 eV) m/z : 425 (M^+). Anal. Calcd for $C_{23}H_{24}ClN_3O_3$: C, 64.86; H, 5.68; N, 9.87. Found: C, 64.94; H, 5.48; N, 9.80.

N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)-2-(4-methylphenyl) acetamide (4d). White powder (79%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3324, 3214, 3075, 1699, 1647, 1603. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 0.94–1.65 (10H, m, 5CH_2 of cyclohexyl), 2.20 (3H, s, CH_3), 3.36 (1H, bs, CH-N, overlap with solvent), 3.69 (1H, d, $J = 11.3$ Hz, CH), 4.28 (1H, d, $J = 11.2$ Hz, CH), 6.97–7.27 (8H, m, Ar-H), 7.99 (1H, d, $J = 7.8$ Hz, NH-cyclohexyl), 10.26 (1H, s, NH), 10.48 (1H, s, NH). MS (EI, 70 eV) m/z : 405 (M^+). Anal. Calcd for $C_{24}H_{27}N_3O_3$: C, 71.09; H, 6.71; N, 10.36. Found: C, 70.99; H, 6.79; N, 10.45.

2-(4-Bromophenyl)-N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)acetamide (4e). White powder (77%); mp $>270^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3315, 3214, 3071, 1699, 1647, 1603. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 0.99–1.66 (10H, m, 5CH_2 of cyclohexyl), 3.33 (1H, bs, CH-N, overlap with solvent), 3.73 (1H, d, $J = 8.8$ Hz, CH), 4.35 (1H, d, $J = 8.8$ Hz, CH), 6.95–7.49 (8H, m, Ar-H), 8.03 (1H, bs, NH-cyclohexyl), 10.28 (1H, s, NH), 10.47 (1H, s, NH). MS (EI, 70 eV) m/z : 471 (M^+), 469 (M^+). Anal. Calcd for $C_{23}H_{24}BrN_3O_3$: C, 58.73; H, 5.14; N, 8.93. Found: C, 58.81; H, 5.21; N, 8.82.

2-(3-Bromophenyl)-N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl) acetamide (4f). White powder (73%); mp $>270^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3317, 3185, 3069, 1700, 1648, 1601. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.14–1.65 (10H, m, 5CH_2 of cyclohexyl), 3.38 (1H, bs, CH-N, overlap with solvent), 3.71 (1H, d, $J = 9.6$ Hz, CH), 4.32 (1H, d, $J = 9.6$ Hz, CH), 7.20–7.48 (8H, m, Ar-H), 8.10 (1H, bs, NH-cyclohexyl), 10.37 (1H, s, NH), 10.55 (1H, s, NH). MS (EI, 70 eV) m/z : 471 (M^+), 469 (M^+). Anal. Calcd for $C_{23}H_{24}BrN_3O_3$: C, 58.73; H, 5.14; N, 8.93. Found: C, 58.60; H, 5.07; N, 8.81.

N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)-2-(3-nitrophenyl) acetamide (4g). White powder (81%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3316, 3216, 3069 (NH), 1700, 1646, 1605. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 0.94–1.76 (10H, m, 5CH_2 of cyclohexyl), 3.36 (1H, bs, CH-N, overlap with solvent), 3.79 (1H, d, $J = 11.3$ Hz, CH), 4.52 (1H, d, $J = 11.3$ Hz, CH), 7.08–8.21 (7H, m, Ar-H), 8.05 (1H, d, $J = 8$ Hz, NH-cyclohexyl), 8.18–8.21 (2H, m, Ar-H), 10.38 (1H, s, NH), 10.60 (1H, s, NH). MS (EI, 70 eV) m/z : 436 (M^+). Anal. Calcd for $C_{23}H_{24}N_4O_5$: C, 63.29; H, 5.54; N, 12.84. Found: C, 63.36; H, 5.62; N, 12.75.

N-cyclohexyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)-2-(3-methoxyphenyl) acetamide (4h). White powder (82%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3361, 3260, 3060, 1690, 1677, 1605. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.15–1.65 (10H, m, 5CH_2 of cyclohexyl), 3.38 (1H, bs, CH-N, overlap with solvent), 3.67 (4H, bs, OCH_3 and CH), 4.29 (1H, bs, CH), 6.77–7.21 (8H, m, Ar-H), 8.03 (1H, bs, NH-cyclohexyl), 10.30 (1H, s, NH), 10.49 (1H, s, NH). MS (EI, 70 eV) m/z : 421

(M^+). Anal. Calcd for $C_{24}H_{27}N_3O_4$: C, 68.39; H, 6.46; N, 9.97. Found: C, 68.28; H, 6.38; N, 10.09.

N-(2,6-dimethylphenyl)-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)-2-phenylacetamide (4i). White powder (77%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3450, 3256, 3064, 1702, 1656, 1601. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.88 (6H, s, 2CH_3), 3.84 (1H, d, $J = 10.8$ Hz, CH), 4.64 (1H, d, $J = 10.8$ Hz, CH), 6.96–7.55 (12H, m, Ar-H), 9.40 (1H, s, NH), 10.16 (1H, s, NH), 10.63 (1H, s, NH). MS (EI, 70 eV) m/z : 413 (M^+). Anal. Calcd for $C_{25}H_{23}N_3O_3$: C, 72.62; H, 5.61; N, 10.16. Found: C, 72.79; H, 5.55; N, 10.23.

2-(4-Chlorophenyl)-N-(2,6-dimethylphenyl)-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)acetamide (4j). White powder (73%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3450, 3300, 3290, 1699, 1662, 1600. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.94 (6H, s, 2CH_3), 3.81 (1H, d, $J = 12.9$ Hz, CH), 4.65 (1H, d, $J = 12.9$ Hz, CH), 6.97–7.54 (11H, m, Ar-H), 9.65 (1H, s, NH), 10.39 (1H, s, NH), 10.67 (1H, s, NH). MS (EI, 70 eV) m/z : 447 (M^+). Anal. Calcd for $C_{25}H_{22}ClN_3O_3$: C, 67.04; H, 4.95; N, 9.38. Found: C, 67.14; H, 4.87; N, 9.31.

2-(3-Methoxyphenyl)-N-(2,6-dimethylphenyl)-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)acetamide (4k). White powder (79%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3291, 3228, 3078, 1700, 1656. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.92 (6H, s, 2CH_3), 3.77 (3H, s, OCH_3), 3.85 (1H, d, $J = 11.2$ Hz, CH), 4.62 (1H, d, $J = 11.2$ Hz, CH), 6.76–7.20 (11H, m, Ar-H), 9.40 (1H, s, NH), 10.17 (1H, s, NH), 10.42 (1H, s, NH). MS (EI, 70 eV) m/z : 443 (M^+). Anal. Calcd for $C_{26}H_{25}N_3O_4$: C, 70.41; H, 5.68; N, 9.47. Found: C, 70.30; H, 5.61; N, 9.55.

N-cyclohexyl-2-ferrocenyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)acetamide (6a). Light yellow (75%); mp $>260^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3460, 3300, 3074, 1700, 1655, 1603. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 1.19–1.83 (10H, m, 5CH_2 of cyclohexyl), 3.56 (1H, bs, CH-N), 3.94–4.18 (11H, m, CH_{fer} and 2CH), 7.08–7.18 (4H, m, Ar-H), 8.10 (1H, d, $J = 7.6$ Hz, NH), 10.38 (1H, s, NH), 10.40 (1H, s, NH). MS (EI, 70 eV) m/z : 499 (M^+). Anal. Calcd for $C_{27}H_{29}FeN_3O_3$: C, 64.94; H, 5.85; N, 8.41. Found: C, 64.81; H, 5.76; N, 8.49.

N-(2,6-dimethylphenyl)-2-ferrocenyl-2-(2,4-dioxo-2,3,4,5-tetrahydro-1H-1,5-benzodiazepin-3-yl)acetamide (6b). White powder (67%); mp $228\text{--}235^\circ\text{C}$. ir (KBr) ($\nu_{\text{max}}/\text{cm}^{-1}$): 3450, 3300, 3261, 1680, 1662, 1600. ^1H NMR (300 MHz, DMSO- d_6): δ_{H} 2.19 (6H, s, 2CH_3), 4.22–4.80 (11H, m, CH_{fer} and 2CH), 6.53–7.31 (7H, m, Ar-H), 9.09 (1H, s, NH), 9.20 (1H, s, NH), 9.65 (1H, s, NH). MS (EI, 70 eV) m/z : 521 (M^+). Anal. Calcd for $C_{29}H_{27}FeN_3O_3$: C, 66.80; H, 5.22; N, 8.06. Found: C, 66.89; H, 5.28; N, 7.99.

Acknowledgments. We gratefully acknowledge the financial support from the Research Council of Islamic Azad University, Doroud Branch.

REFERENCES AND NOTES

- [1] (a) Schutz, H. *Benzodiazepines*; Springer: Heidelberg, 1982; (b) Landquist, J. K. In *Comprehensive Heterocyclic Chemistry*; Katritzky, A. R., Rees, C. W., Eds.; Pergamon: Oxford, 1984; Vol.1, p 166.
- [2] De Baun, J. R.; Pallos, F. M.; Baker, D. R. U.S. Pat. 3,978,227, 1976; Chem Abstr 1977, 86, 5498d.
- [3] Eltze, M.; Gonne, S.; Riedel, R.; Schlotke, B.; Schudt, C.; Simon, W. A. *Eur J Pharmacol* 1985, 112, 211.

- [4] Nicholson, A. N.; Stone, B. M.; Clarke, C. H. *Br J Clin Pharmacol* 1977, 4, 567.
- [5] Kruse, H. *Drug Dev Res* 1982, 2, 145.
- [6] Ursini, A.; Capelli, A. M.; Carr, R. A. E.; Cassara, P.; Corsi, M.; Curcuruto, O.; Curotto, G.; Cin, M. D.; Davalli, S.; Donati, D.; Feriani, A.; Finch, H.; Finizia, G.; Gaviraghi, G.; Marien, M.; Pentassuglia, G.; Polinelli, S.; Ratti, E.; Reggiani, A.; Tarzia, G.; Tedesco, G.; Tranquillini, M. E.; Trist, D. G.; Van Amsterdam, F. T. M. *J Med Chem* 2000, 43, 3596.
- [7] (a) Ohtake, Y.; Fukaya, Y. E. E. Pat. 1,820,799 A1, 2007; (b) Finch, H.; Shah, P.; Carr, R. A. E. U.S. Pat. 5,585,376, 1996.
- [8] Dömling, A.; Ugi, I. *Angew Chem Int Ed Engl* 2000, 39, 3168.
- [9] Dömling, A. *Chem Rev* 2006, 106, 17.
- [10] Ugi, I.; Werner, B.; Dömling, A. *Molecules* 2003, 8, 53.
- [11] Hulme, C.; Gore, V. *Curr Med Chem* 2003, 10, 51.
- [12] Shaabani, A.; Maleki, A.; Mofakham, H.; Khavasi, H. R. *J Comb Chem* 2008, 10, 323.
- [13] Fujiwara, S.-I.; Asanuma, Y. Shin-Ike, T.; Kambe, N. *J Org Chem* 2007, 72, 8087.
- [14] Yavari, I.; Esnaashari, M. *Synthesis* 2005, 1049.
- [15] Nair, V.; Vinod, A. U.; Abhilash, N.; Menon, R. S.; Santhi, V.; Varma, R. L.; Viji, S.; Mathew, S.; Srinivas, R. *Tetrahedron* 2003, 59, 10279.
- [16] Teimouri, M. B.; Mansouri, F. *J Comb Chem* 2008, 10, 507.
- [17] Xu, Z.; Dietrich, J.; Shaw, Hulme C. *Tetrahedron Lett* 2010, 51, 4566.
- [18] Sañudo, M.; García-Valverde, M.; Marcaccini, S.; Delgado, J. J.; Rojo, J.; Torroba, T. *J Org Chem* 2009, 74, 2189.
- [19] De Silva, R. A.; Santra, S.; Andreana, P. R. *Org Lett* 2008, 10, 4541.
- [20] Zohreh, N.; Alizadeh, A.; Bijanzadeh, H. R.; Zhu, L.-G. *J Comb Chem* 2010, 12, 497.
- [21] Shaabani, A.; Maleki, A.; Hajishaabanha, F.; Mofakham, H.; Seyyedhamzeh, M.; Mahyari, M.; Weng Ng, S. *J Comb Chem* 2010, 12, 186.
- [22] Shaabani, A.; Maleki, A.; Mofakham, H. *J Comb Chem* 2008, 10, 595.
- [23] Shaabani, A.; Rezayan, A. H.; Keshipour, S.; Sarvary, A.; Weng Ng, S. *Org Lett* 2009, 11, 3342.
- [24] Ghahremanzadeh, R.; Sayyafi, M.; Ahadi, S.; Bazgir, A. *J Comb Chem* 2009, 11, 393.
- [25] Jadidi, K.; Ghahremanzadeh, R.; Bazgir, A. *J Comb Chem* 2009, 11, 341.
- [26] Ghahremanzadeh, R.; Imani Shakibaei, G.; Ahadi, S.; Bazgir, A. *J Comb Chem* 2010, 12, 191.
- [27] Ahadi, S.; Ghahremanzadeh, R.; Mirzaei, P.; Bazgir, A. *Tetrahedron* 2009, 65, 9316.
- [28] Akbarzadeh, R.; Mirzaei, P.; Bazgir, A. *J Organomet Chem* 2010, 695, 2320.
- [29] Kelly, P. N.; Prêtre, A.; Devoy, S.; O'Rielly, I.; Devery, R.; Goel, A.; Gallagher, J. F.; Lough, A. J.; Kenny, P. T. M. *J Organomet Chem* 2007, 692, 1327.
- [30] Anderson, C. E.; Donde, Y.; Yariv, D.; Christopher, J.; Overman, L. E. *J Org Chem* 2005, 70, 648.