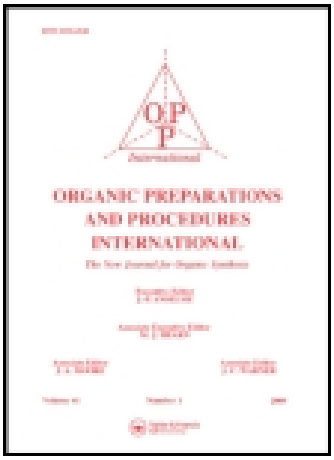


Organic Preparations and Procedures International: The New Journal for Organic Synthesis

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uopp20

An Efficient Multi-component Synthesis of 6-Amino-3-methyl-4-Aryl-2,4-dihydropyrano[2,3-c]Pyrazole-5-carbonitriles

G. Santhosh Kumar [a] , C. Kurumurthy [a] , B. Veeraswamy [a] , P. Sambasiva Rao [a] , P. Shanthan Rao [a] & B. Narsaiah [a]

[a] Fluoroorganic Division , Indian Institute of Chemical Technology , Tarnaka , Hyderabad , 500607 , India

Published online: 16 Aug 2013.

To cite this article: G. Santhosh Kumar , C. Kurumurthy , B. Veeraswamy , P. Sambasiva Rao , P. Shanthan Rao & B. Narsaiah (2013) An Efficient Multi-component Synthesis of 6-Amino-3-methyl-4-Aryl-2,4- dihydropyrano[2,3-c]Pyrazole-5-carbonitriles, Organic Preparations and Procedures International: The New Journal for Organic Synthesis, 45:5, 429-436, DOI: 10.1080/00304948.2013.816220

To link to this article: http://dx.doi.org/10.1080/00304948.2013.816220

Organic Preparations and Procedures International, 45:429–436, 2013

ISSN: 0030-4948 print / 1945-5453 online
DOI: 10.1080/00304948.2013.816220

OPPI BRIEF

An Efficient Multi-component Synthesis of 6-Amino-3-methyl-4-Aryl-2,4-dihydropyrano[2,3-c]Pyrazole-5-carbonitriles

G. Santhosh Kumar, C. Kurumurthy, B. Veeraswamy, P. Sambasiva Rao, P. Shanthan Rao, and B. Narsaiah

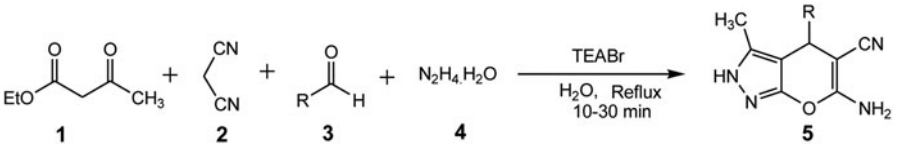
Fluoroorganic Division, Indian Institute of Chemical Technology, Tarnaka, Hyderabad-500607, India

Multi-component reactions are effective in building complex molecules in a single step in a minimum amount of time and with facile isolation procedures; they have high economy[1–7] and thus have become a powerful synthetic strategy in recent years.[8–10] The multi-component protocols are even more attractive when carried out in aqueous medium. Water offers several benefits, including control over exothermicity, and the isolation of products can be carried out by single phase separation technique. Pyranopyrazoles are a biologically important class of heterocyclic compounds and in particular dihydropyrano[2,3-c]pyrazoles play an essential role in promoting biological activity and represent an interesting template in medicinal chemistry. Heterocyclic compounds bearing the *4-H* pyran unit have received much attention in recent years as they constitute important precursors for promising drugs.[11–13] Pyrano[2,3-c]pyrazoles exhibit analgesic,[14] anti-cancer,[15] anti-microbial and anti-inflammatory[16] activity. Furthermore dihydropyrano[2,3-c]pyrazoles show molluscidal activity[17,18] and are used in a screening kit for Chk 1 kinase inhibitor activity.[19,20] They also find applications as pharmaceutical ingredients and bio-degradable agrochemicals.[21–29] Junek and Aigner[30] first reported the synthesis of pyrano[2,3-c]pyrazole derivatives from 3-methyl-1-phenylpyrazolin-5-one and tetracyanoethylene in the presence of triethylamine. Subsequently, a number of synthetic approaches such as the use of triethylamine,[31] piperazine,[32] piperidine,[33] *N*-methylmorpholine in ethanol,[34] microwave irradiation,[35,36] solvent-free conditions,[37–39] cyclodextrins (CDs),[40] different bases in water,[41] γ-alumina,[42] and L-proline[43] have been reported for the synthesis of 6-amino-4-alkyl/aryl-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitriles. Recently, tetraethylammonium bromide (TEABr) has emerged as mild, water-tolerant, eco-friendly and inexpensive catalyst. To the best of our knowledge, quaternary ammonium salts, more specifically TEABr, have not

Received March 8, 2013.
Address correspondence to B. Narsaiah, Fluoroorganic Division, Indian Institute of Chemical Technology, Tarnaka, Hyderabad -500607, India. E-mail: narsaiahbanda84@gmail.com

been used as catalysts for the synthesis of pyrano[2,3-c]pyrazoles, and we decided to investigate the application of TEABr as a catalyst for the synthesis of a series of pyrazole-fused pyran derivatives *via* multi-component reactions.

Initial reactions of ethyl acetoacetate (**1**, 2.0 mmol), 98% hydrazine hydrate (**2**, 2.5 mmol), benzaldehyde (**3a**, 2.0 mmol), and malononitrile (**4**, 2.0 mmol) (*Scheme 1*) conducted in water without catalyst, led to no reaction.



Scheme 1

The same reaction was performed in water using TEABr. The product 2,4-dihydropyrano[2,3-c]pyrazole (**5a**) was formed in 90% yield in water using TEABr as catalyst presumably *via* initial formation of the pyrazolinone ring followed by condensation with benzylidenemalononitrile (generated *in situ* from benzaldehyde and malononitrile). The use of other catalysts such as 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), tetrabutylammonium bromide (TBABr) and neat grinding of the components gave marginally low

Table 1
Preparation of 6-Amino-3-methyl-4-aryl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitriles (**5a–5p**)

Cmpd	R	Time (min)	Yield (%)	mp (°C)	lit. mp (°C)
5a	C_6H_5	15	90	244–245	244–245[42]
5b	4-$CH_3C_6H_4$	10	88	208–209	206–207[42]
5c	4-$CH_3OC_6H_4$	20	82	211–213	210–212[42]
5d	4-BrC_6H_4	10	88	178–180	179–180[42]
5e	4-ClC_6H_5	10	90	234–236	234–235[42]
5f	3-FC_6H_4	10	89	181–184	—
5g	4-CNC_6H_4	15	91	196–198	196–198[39]
5h	4-$NO_2C_6H_4$	25	80	192–194	193–195[42]
5i	3-$NO_2C_6H_4$	30	76	250–252	251–253[42]
5j	2,4-$F_2C_6H_3$	15	85	178–179	176–178[44]
5k	3-$CF_3C_6H_4$	20	84	188–190	—
5l	2,5-$(CH_3)_2C_6H_3$	25	88	202–204	—
5m	2-Furyl	30	78	175–177	175–177[40]
5n	2-Thienyl	30	75	189–190	190–191[40]
5o	Styryl	30	70	180–182	—
5p	*n*-Propyl	15	68	162–164	—

yields. The scope of present protocol was extended to variously substituted aldehydes and 2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile derivatives were obtained in high yields.

In summary, we have devised a simple, rapid, green method *via* a four-component reaction for the synthesis of 6-amino-4-alkyl/aryl-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitriles by using TEABr (10 mol%) as a catalyst and water as the solvent.

Experimental Section

IR spectra were recorded as KBr pellets on a Perkin-Elmer FT-IR 240-C spectrophotometer using KBr optics. ^{1}H NMR spectra were obtained on an Avance 300 MHz spectrometer in $CDCl_3$, DMSO-d_6 and $(D_3C)_2CO$ using TMS as an internal standard. Chemical ionization mass spectra were acquired on VG-7070 H instrument at 70 ev. All reactions were monitored by thin layer chromatography (TLC) on pre-coated silica gel 60 F_{254} (mesh) using *n*-hexane-ethyl acetate. Spots were visualized with UV light. Merck silica gel (100–200 mesh) was used for column chromatography.

Typical Procedure: A mixture of the aromatic aldehyde (2 mmol), malononitrile (0.13 g, 2 mmol), ethyl acetoacetate (0.26 g, 2 mmol) 98% hydrazine hydrate (0.12 g, 2.5 mmol) and TEABr (10 mol%) was placed in 5 ml of water as a solvent in a round bottom flask. The mixture was stirred and heated at reflux for 10–30 min. After completion of the reaction, the content was allowed to cool to room temperature, and the precipitated solid product was collected through filtration, washed with water followed by chloroform (2 × 10 ml) and dried to afford products **5** as colorless solids. Compounds **5c**, **5d**, **5h**, **5i**, **5n** were purified by column chromatography using *n*-hexane and ethyl acetate in 1:3 ratio and other products were isolated in pure form without purification.

6-Amino-3-methyl-4-phenyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5a).

IR (cm^{-1}): 3420 ($-NH_2$), 3400 ($-NH_2$), 2198 ($-CN$); ^{1}H NMR $(CD_3)_2CO$, 300 MHz: δ 1.89 (s, 3H, CH_3), 4.55 (s, 1H, $-CH=$), 6.25 (br, s, 2H, NH_2), 7.17–7.44 (m, 5H, Ar-H); MS (ESI): m/z [$(M+H)^+$]: 253 [$(M+Na)^+$]: 275.

Anal. Calcd for $C_{14}H_{12}N_4O$: C, 66.65; H, 4.79; N, 22.21. Found: C, 66.32; H, 4.82; N, 22.11.

6-Amino-4-(4-methoxyphenyl)-3-methyl-2,4-dihydro pyrano[2,3-c]pyrazole-5 carbonitrile (5b).

IR (cm^{-1}): 3426 ($-NH_2$), 3409 ($-NH_2$), 2199 ($-CN$); ^{1}H NMR (DMSO-d_6, 300 MHz): δ 1.85 (s, 3H, CH_3), 3.79 (s, 3H, CH_3), 4.50 (s, 1H, $-CH=$), 6.15 (br, s, 2H, NH_2), 6.82 (d, $J = 8.68$ Hz, 2H, Ar-H), 7.09 (d, $J = 8.68$ Hz, 2H, Ar-H).

MS (ESI): m/z [$(M+H)^+$]: 283 [$(M+Na)^+$]: 305.

Anal. Calcd for $C_{15}H_{14}N_4O_2$: C, 63.82; H, 5.00; N, 19.85. Found: C, 63.62; H, 5.10; N, 19.82.

6-Amino-4-(4-bromophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5c).

IR (cm^{-1}): 3425 ($-NH_2$), 3400 ($-NH_2$), 2200 ($-CN$); ^1H NMR ($(CD_3)_2CO$, 300 MHz): δ 1.84 (s, 3H, CH_3), 4.56 (s, 1H, $-CH=$), 6.02 (br, s, 2H, NH_2), 7.11 (d, $J = 7.96$ Hz, 2H, Ar-H), 7.43 (d, $J = 7.96$ Hz, 2H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 331.

Anal. Calcd for $C_{15}H_{14}N_4O_2$: C, 50.77; H, 3.35; N, 16.92. Found: C, 50.48; H, 3.48; N, 16.79.

6-Amino-4-(4-chlorophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5d).

IR (cm^{-1}): (cm^{-1}): 3421 ($-NH_2$), 3398 ($-NH_2$), 2198 ($-CN$); ^1H NMR ($(CD_3)_2CO$, 300 MHz): δ 1.83 (s, 3H, CH_3), 4.55 (s, 1H, $-CH=$), 6.07 (br, s, 2H, NH_2), 7.13 (d, $J = 7.38$ Hz, 2H, Ar-H), 7.83 (d, $J = 7.38$ Hz, 2H, Ar-H)

MS (ESI): m/z $[(M+H)^+]$: 287.

Anal. Calcd for $C_{14}H_{11}ClN_4O$: C, 58.65; H, 3.87; N, 19.54. Found: C, 58.48; H, 3.99; N, 19.42.

6-Amino-3-methyl-4-(4-nitrophenyl)-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5e).

IR (cm^{-1}): 3424 ($-NH_2$), 3405 ($-NH_2$), 2199 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.84 (s, 3H, CH_3), 4.54 (s, 1H, $-CH=$), 6.05 (br, s, 2H, NH_2), 7.49 (d, $J = 8.18$ Hz, 2H, Ar-H), 7.95 (d, $J = 7.18$ Hz, 2H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 298.

Anal. Calcd for $C_{14}H_{11}N_5O_3$: C, 56.56; H, 3.73; N, 23.56. Found: C, 56.35; H, 3.63; N, 23.62.

6-Amino-4-(3-fluorophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5f).

IR (cm^{-1}): 3418 ($-NH_2$), 3398 ($-NH_2$), 2201 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.83 (s, 3H, CH_3), 4.55(s, 1H, $-CH=$), 6.07 (br, s, 2H, NH_2), 7.05–7.12 (m, 3H, Ar-H), 8.52 (s, 1H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 271.

Anal. Calcd for $C_{14}H_{11}FN_4O$: C, 62.22; H, 4.10; N, 20.73. Found: C, 62.56; H, 4.25; N, 20.61.

6-Amino-4-(4-cyanophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5g).

IR (cm^{-1}): 3424 ($-NH_2$), 3399 ($-NH_2$), 2198 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.83 (s, 3H, CH_3), 4.54(s, 1H, $-CH=$), 6.07 (br, s, 2H, NH_2), 7.32 (d, $J = 8.12$ Hz, 2H, Ar-H), 7.54 (d, $J = 8.12$ Hz, 2H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 278.

Anal. Calcd for $C_{15}H_{11}N_5O$: C, 64.97; H, 4.00; N, 25.26. Found: C, 64.65; H, 3.86; N, 25.13.

6-Amino-3-methyl-4-(p-tolyl)-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5h).

IR (cm^{-1}): 3422 ($-NH_2$), 3398 ($-NH_2$), 2199 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.84 (s, 3H, CH_3), 2.32 (s, 3H, CH_3), 4.53 (s, 1H, $-CH=$), 5.66 (br, s, 2H, NH_2), 6.85 (d, $J = 8.68$ Hz, 2H, Ar-H), 7.10 (d, $J = 8.68$ Hz, 2H, Ar-H).

MS (ESI): m/z [$(M+H)^+$]: 267 [$(M+Na)^+$]: 299.

Anal. Calcd for $C_{15}H_{14}N_4O_2$: C, 67.65; H, 5.30; N, 21.04. Found: C, 67.79; H, 5.21; N, 21.25.

6-Amino-3-methyl-4-(3-nitrophenyl)-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5i).

IR (cm^{-1}): 3419 ($-NH_2$), 3399 ($-NH_2$), 2200 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.84 (s, 3H, CH_3), 4.56(s, 1H, $-CH=$), 6.07 (br, s, 2H, NH_2), 7.05–7.12 (m, 3H, Ar-H), 8.52 (s, 1H, Ar-H).

MS (ESI): m/z [$(M+H)^+$]: 298.

Anal. Calcd for $C_{14}H_{11}N_5O_3$: C, 56.56; H, 3.73; N, 23.56. Found: C, 56.38; H, 3.65; N, 23.78.

6-Amino-4-(2,4-difluorophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5j).

IR (cm^{-1}): 3422 ($-NH_2$), 3401 ($-NH_2$), 2198 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.89 (s, 3H, CH_3), 4.94 (s, 1H, $-CH=$), 5.78 (br, s, 2H, NH_2), 6.77–6.89 (m, 2H, Ar-H), 7.10–7.18 (m, 1H, Ar-H).

MS (ESI): m/z [$(M+H)^+$]: 271.

Anal. Calcd for $C_{14}H_{10}F_2N_4O$: C, 58.33; H, 3.50; N, 19.44. Found: C, 58.10; H, 3.42; N, 19.68.

6-Amino-3-methyl-4-(3-(trifluoromethyl)phenyl)-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5k).

IR (cm^{-1}): 3420 ($-NH_2$), 3402 ($-NH_2$), 2199 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.87 (s, 3H, CH_3), 4.58(s, 1H, $-CH=$), 6.07 (br, s, 2H, NH_2), 7.05–7.12 (m, 3H, Ar-H), 8.52 (s, 1H, Ar-H).

MS (ESI): m/z [$(M+H)^+$]: 321.

Anal. Calcd for $C_{15}H_{11}F_3N_4O$: C, 56.25; H, 3.46; N, 17.49. Found: C, 56.01; H, 3.39; N, 17.40.

6-Amino-4-(2,5-dimethylphenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5l).

IR (cm^{-1}): 3421 ($-NH_2$), 3400 ($-NH_2$), 2200 ($-CN$); ^1H NMR (DMSO-d_6, 300 MHz): δ 1.76 (s, 3H, CH_3), 2.23 (s, 3H, CH_3), 2.30 (s, 3H, CH_3), 4.81 (s, 1H, $-CH=$), 5.93 (br, s, 2H, NH_2), 6.82 (s, 1H, Ar-H), 6.90 (d, $J = 7.55$ Hz, 1H, Ar-H), 6.98 (d, $J = 7.84$ Hz, 1H, Ar-H). MS (ESI): m/z [$(M+H)^+$]: 281.

Anal. Calcd for $C_{16}H_{16}N_4O$: C, 68.55; H, 5.75; N, 19.99. Found: C, 68.25; H, 5.62; N, 20.10.

6-Amino-4-(2-furyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5m).

IR (cm^{-1}): 3422 (−NH_2), 3405 (−NH_2), 2199 (−CN); ^{1}H NMR ($(CD_3)_2CO$, 300 MHz): δ 1.87 (s, 3H, CH_3), 4.57 (s, 1H, −CH=), 6.65 (br, s, 2H, NH_2), 6.11–6.27 (m, 1H, Ar-H), 7.20 (d, 2H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 243.

Anal. Calcd for $C_{14}H_{12}N_4O$: C, 59.50; H, 4.16; N, 23.13. Found: C, 59.21; H, 4.08; N, 23.02.

6-Amino-3-methyl-4-(2-thienyl)-2,4-dihydropyrano [2,3-c]pyrazole-5-carbonitrile (5n).

IR (cm^{-1}): 3422 (−NH_2), 3405 (−NH_2), 2199 (−CN); ^{1}H NMR ($(CD_3)_2CO$, 300 MHz): δ 1.87 (s, 3H, CH_3), 4.57 (s, 1H, −CH=), 6.65 (br, s, 2H, NH_2), 6.11–6.27 (m, 1H, Ar-H), 7.20 (d, 2H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 259.

Anal. Calcd for $C_{12}H_{10}N_4OS$: C, 55.80; H, 3.90; N, 21.69. Found: C, 55.53; H, 3.82; N, 21.81.

6-Amino-2,4-dihydro-3-methyl-4-styryl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5o).

IR (cm^{-1}): 3415 (−NH_2), 3400 (−NH_2), 2199 (−CN); ^{1}H NMR (DMSO-d_6, 300 MHz): δ 2.01 (s, 3H, CH_3), 4.68 (s, 1H, −CH=), 6.58 (br, s, 2H, NH_2), 6.27–7.20 (m, 7H, Ar-H).

MS (ESI): m/z $[(M+H)^+]$: 279.

Anal. Calcd for $C_{16}H_{14}N_4O$: C, 69.05; H, 5.07; N, 20.13. Found: C, 69.31; H, 5.12; N, 20.14.

6-Amino-3-methyl-4-(n-propyl)-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile (5p).

IR (cm^{-1}): 3420 (−NH_2), 3390 (−NH_2), 2200 (−CN); ^{1}H NMR (DMSO-d_6, 300 MHz): δ 0.99(t, 3H, CH_3),1.31–1.36 (m, 4H,−CH_2−CH_2-), 1.80 (s, 3H, CH_3), 3.56 (s, 1H, −CH=), 6.55 (br, s, 2H, NH_2).

MS (ESI): m/z $[(M+H)^+]$: 219.

Anal. Calcd for $C_{11}H_{14}N_4O$: C, 60.53; H, 6.47; N, 25.67. Found: C, 60.31; H, 6.82; N, 25.53.

Acknowledgments

The authors are thankful to the Director, IICT for his constant encouragement and authors G. S. Kumar, C. K. Murthy, B. V. Swamy and P. S. Rao are grateful to CSIR for providing financial assistance in the form of Senior Research Fellowship.

References

1. J. Zhu and H. Bienayme, *in Multicomponent Reactions*; J. Zhu, H. Bienayme Eds.; Wiley-VCH Verlag GmbH & Co: KGaA, *Chem. Soc. Rev.*, **36**, 484 (2007).
2. I. Ugi, *Pure Appl. Chem.*, **73**, 187 (2001).
3. D. Tejedor and F. Garcia-Tellado, Heterocyclic Libraries See; F. Lie'by-Muller, C. Simon, T. Constantieux and J. Rodriguez, QSAR *Comb.Sci*, **25**, 432 (2006).
4. C. Simon, T. Constantieux and J. Rodriguez, *Eur. J. Org. Chem.*, 4957 (**2004**).
5. N. M. Evdokimov, A. S. Kireev, A. A. Yakovenko, M. Y. Antipin, I. V. Magedov and A. Kornienko, *J. Org. Chem.*, **72**, 3443 (2007).
6. L. Weber, *Drug Discovery Today*, **7**, 143 (2002).
7. C. Hulme and V. Gore, *Curr. Med. Chem.*, **10**, 51 (2001).
8. P. Eilbracht, L. Barfacker, C. Buss, C. Hollmann, B. E. Kitsos-Rzychon, C. L. Kranemann, T. Rische, R. Roggenbuck and A. Schmidt, *Chem. Revs.*, **99**, 3329 (1999).
9. A. Domling and I. Ugi, *Angew. Chem., Int. Ed.*, **39**, 3168 (2009).
10. C. O. Kappe, *Acc. Chem. Res.*, **33**, 879 (2000).
11. M. N. Elinson, A. S. Dorofeev, S. K. Feducovich, S. V. Gorbunov, R. F. Nasybullin, N. O. Stepanov and G. I. Nikishin, *Tetrahedron Lett.*, **47**, 7629 (2006).
12. W. Sun, L. J. Cama, E. T. Birzin, S. Warrier, L. Locco, R. Mosely, M. L. Hammond and S. P. Rohrer, *Bioorg. Med. Chem. Lett.*, **16**, 1468 (2006).
13. J. P. Gesson, N. Fonteneau, M. Mondon, S. Charbit, H. Ficheux and F. Schutze, *US Patent, 6, 965039 B2, 2005*; *Chem. Abs.*, **142**:19772u (2005).
14. S. C. Kuo, L. J. Huang and H. Nakamura, *J. Med. Chem.*, **27**, 539 (1984).
15. J. L. Wang, D. Liu, Z. J. Zheng, S. Shan, X. Han, S. M. Srinivasula, C. M. Croce, E. S. Alnemri and Z. Huang, *Proc. Natl. Acad. Sci. USA*, **97**, 7124 (2000).
16. M. E. A. Zaki, H. A. Soliman, O. A. Hiekal and A. E. Z. Rashad, *Naturforsch. C.*, **61**, 1 (2006).
17. F. M. Abdelrazek, P. Metz, N. H. Metwally and S. F. El-Mahrouky, *Arch. Pharm.*, **339**, 456 (2006).
18. F. M. Abdelrazek, P. Metz, O. Kataeva, A. Jaeger and S. F. ElMahrouky, *Arch. Pharm.*, **340**, 543 (2007).
19. N. Foloppe, L. M. Fisher, R. Howes, A. Potter, A. G. S. Robertson and A. E. Surgenor, *Bioorg. Med. Chem.*, **14**, 4792 (2006).
20. A. Kimata, H. Nakagawa, R. Ohyama, T. Fukuuchi, S. Ohta, T. Suzuki and N. Miyata, *J. Med. Chem.*, **50**, 5053 (2007).
21. H. Junek and H. Aigner, *Chem. Ber.*, **106**, 914 (1973).
22. V. Y. Sosnovskikh, M. A. Barabanov, B. I. Usachev, R. A. Irgashev and V. S. Moshkin, *Russ. Chem. Bull. Int. Ed.*, **54**, 2846 (2005).
23. S. A. El-Assiery, G. H. Sayed and A. Fouda, *Acta Pharm.*, **54**, 143 (2004).
24. J. A. M. Guard and P. J. Steel, *ARKIVOC*, **vii**, 32 (2001).
25. H. Wamhoff, E. Kroth and K. Strauch, *Synthesis*, 1129 (**1993**).

26. G. Tacconi, G. Gatti, G. Desimoni and V. Messori, *J. prakt. Chem.*, **322**, 831 (1980).

27. L. G. Sharanina, V. P. Marshtupa and Y. A. Sharanin, *Khim. Geterosikl. Soedin.*, **10**, 1420 (1980); *Chem. Abs.,* **94**:47212b (1981).

28. Y. A. Sharanin, L. G. Sharanina and V. V. Puzanova, *Zh. Org. Khim.*, **19**, 2609 (1983).

29. L. A. Rodinovskaya, A. V. Gromova, A. M. Shestopalov and V. N. Nesterov, *Russ. Chem. Bull., Int. Ed.*, **52**, 2207 (2003).

30. H. Junek and H. Aigner, *Chem. Ber.*, **106**, 914 (1973).

31. Y. A. Sharanin, L. G. Sharanina and V. V. Puzanova, *J. Org. Chem. USSR (Engl.Transl.)*, **19**, 221 (1983).

32. Y. Peng, G. Song and R. Dou, *Green Chem.*, **8**, 573 (2006).

33. G. Vasuki and K. Kumaravel, *Tetrahedron Lett.*, **49**, 5636 (2008).

34. F. Lehmann, M. Holm and S. Laufer, *J. Comb. Chem.*, **10**, 364 (2008).

35. J. F. Zhou, S. J. Tu, H. Q. Zhu and S. J. Zhi, *Synth. Commun.*, **32**, 3363 (2002).

36. R. M. Shaker, A. F. Mahmoud and F. F. Abdel-Latif, *J. Chin. Chem. Soc.*, **52**, 563 (2005); *Chem. Abs.*, **144**:311934f (2006).

37. S. B. Guo, S. X. Wang and J. T. Li, *Synth. Commun.*, **37**, 2111 (2007).

38. Z. Ren, W. Cao, W. Tong and Z. Jin, *Synth. Commun.*, **35**, 2509 (2005).

39. A. S. Nagarajan and B. S. R. Reddy, *Synlett*, 2002 (**2009**).

40. K. Kanagaraj and K. Pitchumani. *Tetrahedron Lett.*, **51**, 3312 (2010).

41. G. Vasuki and K. Kumaravel. *Tetrahedron Lett.*, **49**, 5636 (2008).

42. H. Mecadon, Md. Rumum Rohman, M. Rajbangshi and B. Myrboh, *Tetrahedron Lett.*, **52**, 2523 (2011).

43. H. Mecadon, Md. Rumum Rohman, I. Kharbangar, B. M. Laloo, I. Kharkongor, M. Rajbangshi and B. Myrboh, *Tetrahedron Lett.*, **52**, 3228 (2011).

44. H. V. Chavan, S. B. Babar, R. U. Hoval and B. P. Bandgar, *Bull Korean Chem. Soc.*, **32**, 3963 (2011). DOI-dx.doi.org/10.5012/bkcs.2011.32.11.3963.