Oxazepines and thiazepines 46.[1] Synthesis of tetracyclic 1,5-benzothiazepines by the reaction of α,β,γ,δ-unsaturated ketones with 2-aminothiophenol

Albert Lévai*[a] and József Jekő[b]

[a]Department of Organic Chemistry, University of Debrecen, P.O.Box 20, H-4010 Debrecen, Hungary
[b]Department of Chemistry, College of Nyíregyháza, Sóstói u. 31/b, H-4400 Nyíregyháza, Hungary
E-mail: alevai@puma.unideb.hu

Dedicated to Professor Dr. Kálmán Hideg on the occasion of his 75th birthday

Abstract

Hitherto unknown tetracyclic 1,5-benzothiazepines **9-16** have been synthesized by an acid-catalyzed reaction of exocyclic α,β,γ,δ-unsaturated ketones **1-8** and 2-aminothiophenol. Structures of all new compounds have been elucidated by microanalyses, ^{1}H-, ^{13}C-NMR, IR and mass spectroscopic measurements.

Keywords: 2-Aminothiophenol, 3-cinnamylidenechromanones, 3-cinnamylidene-1-thiochromanones, tetracyclic 1,5-benzothiazepines

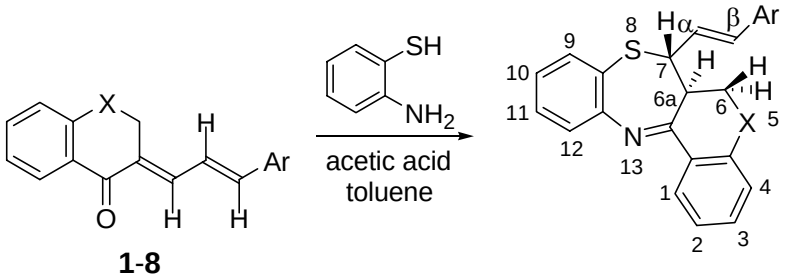
Introduction

The 1,5-benzothiazepines are important nitrogen- and sulfur-containing seven-membered heterocyclic compounds in drug research since they possess diverse bioactivities.[2-6] As a result, various procedures have been worked out for their synthesis and numerous derivatives have been published in the literature. Probably owing to their easy availability and bioactivities, a well known group comprises the 2,3-dihydro-1,5-benzothiazepines. The reaction of α,β-unsaturated ketones and 2-aminothiophenol is an especially convenient and versatile method for their preparation.[7-17] Reaction of exocyclic α,β-unsaturated ketones with 2-aminothiophenol afforded related tetracyclic 1,5-benzothiazepines.[18-27] However, for the synthesis of 1,5-benzothiazepines by the reaction of the related α,β,γ,δ-unsaturated ketones with 2-aminothiophenol only one example has been described in the literature.[28] We have synthesized 4-aryl-2,3-dihydro-2-styryl-1,5-benzothiazepines as sole products in this way. Reaction of exocyclic α,β,γ,δ-unsaturated

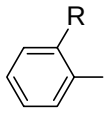
ketones and 2-aminothiophenol has not hitherto been published. For this reason, as a continuation of our study on the reaction of exocyclic α,β-unsaturated ketones with 2-aminothiophenol, in our present paper we report on the first synthesis of tetracylic 1,5-benzothiazepines by the reaction of exocyclic α,β,γ,δ-unsaturated ketones and 2-aminothiophenol under acid-catalyzed conditions.

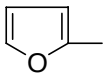
Results and Discussion

Studying the synthesis of the related 4-aryl-2,3-dihydro-2-styryl-1,5-benzothiazepines[28] we have investigated various conditions for the reaction of α,β,γ,δ-unsaturated ketones (*E*,*E*-cinnamylideneacetophenones) with 2-aminothiophenol to afford 1,5-benzothiazepines. Slightly acidic reaction conditions proved to be the most convenient for this purpose.[28]



1-8 **9-16**

Ar: **1**-**6**, **9**-**14** = 

Ar: **7**, **8**, **15**, **16** = 

1,**9:** X = O, R = H
2,**10:** X = O, R = MeO
3,**11:** X = O, R = NO_2
4,**12:** X = S, R = H
5,**13:** X = S, R = MeO
6,**14:** X = S, R = NO_2

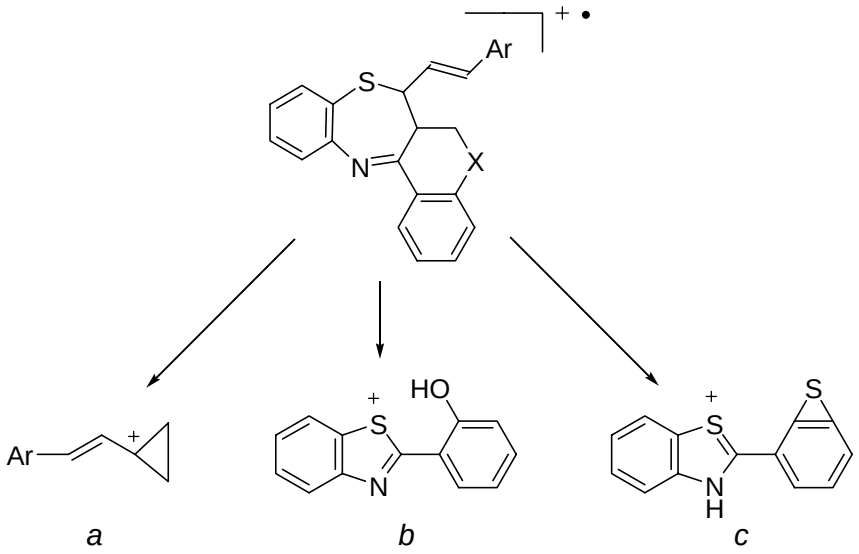
Scheme 1

Utilizing this experience, exocyclic α,β,γ,δ-unsaturated ketones **1-8** were allowed to react with 2-aminothiophenol in a mixture of boiling toluene and acetic acid and tetracyclic 1,5-benzothiazepines **9-16** (Scheme 1) were obtained in relatively good or medium yields (59-71%, *cf*. Experimental Section). Neither the yield nor the course of the reaction were influenced by the presence of an electron donor or an electron acceptor *o*-substituent in the starting material. Replacement of the styryl group by a 2-(furan-2-yl)ethenyl one slightly enhaced the yield of the formation of 1,5-benzothiazepines **15** and **16**.

Structures of all new compounds have been elucidated by microanalyses, IR, ^{1}H-, ^{13}C-NMR and mass spectroscopic measurements. Elemental analyses unambiguously proved the elemental composition of all new compounds which was confirmed by their mass spectra. In their IR

spectra a characteristic C=N band was assigned aroud 1600 cm^{-1} referring to the presence of a C=N double bond in the seven-membered heterocycle. ^{1}H-NMR chemical shifts, multiplicity and coupling constant values (*cf*. Experimental Section) of protons attached to the C-6, C-6a and C-7 carbon atoms unequivocally prove the tetracyclic 6a,7-dihydro-1,5-benzothiazepine structure. Coupling constant values of 11-12 Hz indicate that the 6a-H and 7-H protons are *trans*-oriented as in the case of all the related tetracyclic 6a,7-dihydro-1,5-benzothiazepines.[18-20,22,25] This similarity also indicates a stereoselective formation of one diastereomer compounds **9-16** depicted in Scheme 1. ^{13}C-NMR chemical shift values of the aliphatic carbon atoms C-6 (*ca.* 66 ppm for the benzopyrano derivatives **9-11** and **15** and *approx.* 29 ppm for the 1-benzothiopyrano compounds **12-14** and **16**), C-6a (40-42 ppm) and C-7 (58-59 ppm) corroborate the tetracyclic 6a,7-dihydro-1,5-benzothiazepine structure deduced from the ^{1}H-NMR spectroscopic data. These ^{13}C-NMR chemical shift values are in harmony with those values of the related tetracyclic 6a,7-dihydro-1,5-benzothiazepines.[18-20]

A weak but distinct molecular ion was detected in the EI 70 eV mass spectra of the tetracyclic benzothiazepines **9-16**. In the course of their fragmentation, these benzothiazepine molecules are split into two major fragment ions, *viz.* ions *a*, *b* or *c* (Scheme 2). Fragment ion *a* was detected in each spectra which correspond to the base peak in the case of benzopyrano derivatives **9-11** and **15**. Fragment ion *b* appears at *m/z* 227 in the mass spectra of compounds **9-11** and **15**. However, in the mass spectra of the benzothiopyrano derivatives **12-14** and **16** the base peak is the fragment ion *c* at *m/z* 242. This fragmentation pattern unequivocally proves the structures of tetracyclic benzothiazepines **9-16** elucidated by other spectrsocopic methods.



Scheme 2

It is well known that the formation of 1,5-benzothiazepines by the reaction of α,β-unsaturated ketones and 2-aminothiophenol is a two-step process.[27] The first step is the Michael

addition of the mercapto group to the β-carbon atom of the unsaturated ketone. The second step is the ring closure of the Michael adduct to form the seven-membered heterocycle. In some cases, the Michael adduct can be isolated and then converted into the appropriate 1,5-benzothiazepine on an acid-catalyzed cyclization.[27] In our previous studies on the preparation of tetracylic 1,5-benzothiazepines by the reaction of exocyclic α,β-unsaturated ketones with 2-aminothiophenol[18] we isolated Michael adducts and determined their stereochemistry. As expected, owing to the formation of two centres of chirality, these adducts proved to be diastereomeric mixtures. However, an acid-catalyzed ring closure of these mixtures afforded only one diastereomer of the appropriate tetracyclic 1,5-bernzothiazepines stereochemistry of which was equal to that of one of the two diastereomers of the Michael adducts. It means that the „stereochemically unfavoured" distereomer gave tetracyclic 1,5-benzothiazepine on an acid-catalyzed epimerization followed by cyclization.

Although in our present study on the reaction of α,β,γ,δ-unsaturated ketones and 2-aminothiophenol no Michael adduct could be isolated, a similar reaction mechanism can be supposed resulting in high stereoselectivity. On the basis of our previous[18] and present experimental results, it can be concluded that the acid-catalyzed reaction of these two groups of unsaturated ketones with 2-aminothiophenol leads to the formation of the thermodynamically more stable diastereomer of tetracyclic 1,5-benzothiazepines as sole isolable products.

In conclusion, we have conducted the first, stereoselective synthesis of hitherto unknown tetracyclic 6a,7-dihydro-7-styryl-1,5-benzothiazepines by an acid-catalyzed reaction of exocyclic α,β,γ,δ-unsaturated ketones and 2-aminothiophenol. Our experimental results also prove that the site of the Michael addition of the thiol group is the β-carbon atom of the starting α,β,γ,δ-unsaturated ketones as in the cases of the reaction of such unsaturated ketones with dinucleophiles.[28-31]

Experimental Section

General Procedures. Melting points were determined on a Kofler hot-stage apparatus and are uncorrected. ^{1}H- and ^{13}C-NMR spectra were measured with Bruker WP 200 SY and Bruker Avance DRX 500 spectrometers at 200/50 and 500/125 MHz in $CDCl_3$ (internal standard TMS, δ = 0.0 ppm). The IR spectra were obtained in KBr discs with a Perkin-Elmer 16 PC instrument. Mass spectra were recorded on a VG Trio-2 apparatus. Elemantal analyses (C, H, N) were measured in-house with a Carlo Erba 1106 EA instrument. Thin layer chromatography (TLC) was performed on Kieselgel 60 F_{254} (Merck) layer and the column chromatography on Kieselgel 60 columns using toluene:ethyl acetate (4:1 v/v) as eluent.

General method for the synthesis of benzothiazepines 9-16

A mixture of exocyclic α,β,γ,δ-unsaturated ketone (**1-8**, 5.0 mmoles), 2-aminothiophenol (6.0 mmoles), acetic acid (5 mL) and toluene (50 mL) was heated at reflux for 5 h, then the solvent

was evaporated under reduced pressure. The benzothiazepines (**9-16**, Scheme 1) obtained were purified by column chromatography as indicated above.

6a,7-Dihydro-7-styryl-6*H*-benzopyrano[3,4-c][1,5]benzothiazepine (**9**)**.** Isolated as white needles in 67% yield, mp 174-175 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.60 (1H, m, 6a-H), 4.20 (1H, dd, J = 9.4, 12.2 Hz, 6-H), 4.41 (1H, dd, J = 5.9, 12.2 Hz, 6-H), 4.62 (1H, t, J = 11.2, 7-H), 6.16 (1H, dd, J = 13.1, 15.0 Hz, α-H), 6.52 (1H, d, J = 15.0 Hz, β-H), 7.01-8.30 (m, 13 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 42.0, 58.7, 65.7, 106.4, 117.6, 120.1, 121.4, 122.8, 124.9, 125.2, 126.6, 128.3, 128.6, 130.0, 131.1, 133.3, 135.5, 136.1, 151.7, 158.0, 162.9; IR (cm^{-1}): 1601, 1578, 1452, 1320, 1262, 1210, 1129, 1061, 968, 813, 754, 691; MS (m/z): 369 (M^+, 6), 338 (4), 227 (8), 143 (100); Anal. Calcd. for $C_{24}H_{19}NOS$: C, 78.03; H, 5.18; N, 3.79. Found: C, 78.12; H, 5.23; N, 3.82.

6a,7-Dihydro-7-(2-methoxystyryl)-6*H*-benzopyrano[3,4-c][1,5]benzothiazepine (**10**)**.** Isolated as pale yellow needles in 66% yield, mp 154-155 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.42 (1H, m, 6a-H), 3.74 (3H, s, MeO), 3.87 (1H, dd, J = 11.7, 14.8 Hz, 6-H), 4.28 (1H, dd, J = 8.7, 14.8 Hz, 6-H), 4.51 (1H, dd, J = 8.1, 11.3 Hz, 7-H), 6.26 (1H, dd, J = 9.4, 15.7 Hz, α-H), 6.83 (1H, d, J = 15.7, β-H), 6.89-8.36 (m, 12 arom, H); ^{13}C-NMR (δ, $CDCl_3$): 42.2, 55.4, 59.2, 66.8, 110.8, 117.5, 120.4, 121.9, 122.9, 124.8, 125.0, 125.8, 126.7, 128.9, 133.2, 135.5, 145.0, 151.6, 156.9, 158.0, 165.0; IR (cm^{-1}): 1600, 1576, 1464, 1320, 1245, 1212, 1129, 1029, 975, 814, 752; MS (m/z): 399 (M^+, 8), 278 (7), 227 (13), 173 (100); Anal. Calcd. for $C_{25}H_{21}NO_2S$: C, 75.17; H, 5.30; N, 3.50. Found: C, 75.07; H, 5.36; N, 3.45.

6a,7-Dihydro-7-(2-nitrostyryl)-6*H*-benzopyrano[3,4-c][1,5]benzothiazepine (**11**)**.** Isolated as yellow plates in 61% yield, mp 122-123 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.73 (1H, m, 6a-H), 4.16 (1H, dd, J = 11.3, 14.5 Hz, 6-H), 4.33 (1H, dd, J = 8.4, 14.5 Hz, 6-H), 4.57 (1H, dd, J = 9.5, 11.7 Hz, 7-H), 6.18 (1H, dd, J = 9.5, 15.3 Hz, α-H), 7.01 (1H, d, J = 15.3 Hz, β-H), 7.06-8.32 (m, 12 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 41.8, 57.7, 66.6, 117.7, 119.9, 121.9, 122.3, 124.8, 125.0, 126.6. 128.8, 130.1, 132.1, 133.0, 133.4, 135.4, 151.7, 158.0, 162.8; IR (cm^{-1}): 1602, 1578, 1522, 1479, 1452, 1344, 1320, 1262, 1211, 1129, 962, 864, 749; MS (m/z): 414 (M^+, 1), 227 (52), 198 (17), 156 (100); Anal. Calcd. for $C_{24}H_{18}N_2O_3S$: C, 69.56; H, 4.38; N, 6.76. Found: C, 69.66; H, 4.44; N, 6.72.

6a,7-Dihydro-7-styryl-6*H*-[1]benzothiopyrano[3,4-c][1,5]benzothiazepine (**12**)**.** Isolated as pale yellow needles in 59% yield, mp 186-187 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.80 (1H, m, 6a-H), 3.06 (1H, dd, J = 9.8, 13.4 Hz, 6-H), 3.37 (1H, dd, J = 7.6, 13.4 Hz, 6-H), 4.81 (1H, t, J = 11.6 Hz, 7-H), 6.27 (1H, t, J = 15.8 Hz, α-H), 6.53 (1H, d, J = 15.8 Hz, β-H), 7.10-8.56 (m, 13 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 29.2, 40.5, 58.9, 118.1, 122.1, 123.4, 124.8, 125.3, 126.6, 127.9, 128.2, 128.6, 129.9, 130.7, 131.0, 132.6, 135.3, 136.2, 137.3, 145.0, 151.6, 154.5; IR (cm^{-1}): 1600, 1575, 1448, 1315, 1188, 1157, 1072, 961, 888, 757, 731, 690; MS (m/z): 385 (M^+, 4), 338 (6), 294 (4), 242 (100); Anal. Calcd. for $C_{24}H_{19}NS_2$: C, 74.79; H, 4.97; N, 3.63. Found: C, 74.86; H, 4.92; N, 3.69.

6a,7-Dihydro-7-(2-methoxystyryl)-6*H*-[1]benzothiopyrano[3,4-c][1,5]benzothiazepine (**13**)**.** Isolated as yellow needles in 61% yield, mp 178-179 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.78 (1H, m, 6a-

H), 3.12 (1H, dd, J = 8.9, 14.0 Hz, 6-H), 3.41 (1H, dd, J = 7.1, 14.0 Hz, 6-H), 3.84 (3H, s, MeO), 4.84 (t, J = 12.1 Hz, 7-H), 6.22 (1H, dd, J = 9.8, 15.8 Hz, α-H), 6.80 (1H, d, J = 15.8 Hz, β-H), 6.93-8.60 (m, 12 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 29.3, 40.7, 55.4, 59.5, 110.9, 120.5, 123.5, 124.7, 125.2, 126.8, 127.7, 128.8, 129.9, 130.9, 135.2, 137.3, 151.5, 156.9, 164.5; IR (cm^{-1}): 1598, 1576, 1488, 1462, 1315, 1291, 1115, 1033, 967, 886, 751; MS (m/z): 415 (M^+, 2), 368 (4), 294 (5), 242 (100); Anal. Calcd. for $C_{25}H_{21}NOS_2$: C, 72.28; H, 5.09; N, 3.37. Found: C, 72.20; H, 5.15; N, 3.4l.

6a,7-Dihydro-7-(2-nitrostyryl)-6*H*-[1]benzothiopyrano[3,4-c][1,5]benzothiazepine (14). Isdolated as yellow plates in 63% yield, mp 181-182 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.84 (1H, m, 6a-H), 3.08 (1H, dd, J = 9.1, 14.3 Hz, 6-H), 3.36 (1H, dd, J = 7.4, 14.3 Hz, 6-H), 4.92 (1H, dd, J = 9.8, 11.3 Hz, 7-H), 6.17 (1H, dd, J = 9.7, 15.6 Hz, α-H), 7.01 (1H, d, J = 15.6 Hz, β-H), 7.10-8.62 (m, 12 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 29.1, 40.4, 58.0, 122.9, 124.6, 124.8, 125.2, 126.3, 127.8, 129.0, 130.0, 131.1, 132.9, 133.1, 135.0, 137.4, 147.6, 151.6, 164.4; IR (cm^{-1}): 1602, 1577, 1518, 1345, 1313, 963, 759, 690; MS (m/z): 430 (M^+, 1), 383 (8), 242 (100), 156 (14); Anal. Calcd. for $C_{24}H_{18}N_2O_2S_2$: C, 66.97; H, 4.21; N, 6.50. Found: C, 67.0.7; H, 4.24; N, 6.57.

6a,7-Dihydro-7-[2-(furan-2-yl)ethenyl]-6*H*-benzopyrano[3,4-c][1,5]benzothiazepine (15). Isolated as white needles in 71% yield, mp 169-170 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.73 (1H, m, 6a-H), 4.12 (1H, dd, J = 8.8, 15.7 Hz, 6-H), 4.20 (1H, J = 5.6, 15.7 Hz, 6-H), 4.48 (1H, dd, J = 7.4, 12.1 Hz, 7-H), 6.20 (1H, dd, J = 7.4, 15.1 Hz, α-H), 7.02 (1H, d, J = 15.1 Hz, β-H), 7.20-8.32 (m, 11 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 40.6, 58.5, 66.4, 109.1, 111.4, 117.5, 119.2, 120.0, 121.9, 122.6, 124.8, 125.0, 126.7, 129.9, 133.2, 135.5, 142.2, 151.5, 157.9, 162.6; IR (cm^{-1}): 1602, 1577, 1464, 1377, 1321, 1262, 1212, 1151, 1129, 1014, 958, 927, 814, 774, 752, 687; MS (m/z): 359 (M^+, 9), 227 (11), 212 (12), 133 (100); Anal. Calcd. for $C_{22}H_{17}NO_2S$: C, 73.52; H, 4.77; N, 3.89. Found: C, 73.44; H, 4.71; N, 3.92.

6a,7-Dihydro-7-[2-(furan-2-yl)ethenyl]-6*H*-[1]benzothiopyrano[3,4-c][1,5]benzo- thiazepine (16). Isolated as yellow needles in 68% yield, mp 179-180 °C; ^{1}H-NMR (δ, $CDCl_3$): 2.72 (1H, m, 6a-H), 3.02 (1H, dd, J = 9.7, 13.8 Hz, 6-H), 3.37 (1H, dd, J = 5.4, 13.8 Hz, 6-H), 4.80 (1H, t, J = 11.4 Hz, 7-H), 6.16 (1H, dd, J = 7.6, 14.9 Hz, α-H), 7.03 (1H, d, J = 14.9 Hz, β-H), 7.09-8.63 (m, 11 arom. H); ^{13}C-NMR (δ, $CDCl_3$): 29.2, 40.5, 58.7, 109.0, 111.4, 118.8, 123.2, 124.7, 125.2, 126.8, 127.6, 128.7, 129.8, 130.9, 135.2, 137.1, 142.1, 144.8, 151.4, 164.3; IR (cm^{-1}): 1601, 1576, 1487, 1462, 1316, 1291, 1257, 1191, 1157, 1013, 957, 928, 884, 784, 756, 735, 593; MS (m/z): 375 (M^+, 1), 328 (3), 242 (100), 133 (35); Anal. Calcd. for $C_{22}H_{17}NOS_2$: C, 70.39; H, 4.57, N, 3.73. Found: C, 70.46; H, 4.51; N, 3.67.

Acknowledgements

The present study was sponsored by the Hungarian National Research Fund (Grant No. OTKA T049468) for which our gratitude is expressed. Technical assistance of Mrs. M. Nagy is highly appreciated.

References

1. For part 45, see: Lévai, A.; Jekő, J.; Gondos, T.; Simon, A.; Tóth, G. *J. Heterocycl. Chem.* **2007**, *44*, 1453.
2. Nagao, T.; Sato, S.; Nakijama, H.; Kiyomoto, A. *Japan J. Pharmacol.* **1972**, *22*, 1.
3. Yamada, K.; Shimamura, T.; Nakajima, H. *Japan J. Pharmacol.* **1973**, *23*, 321.
4. Slade, L.; Stanton, J. L.; Ben-David, D.; Mazzenga, G. *J. Med. Chem.* **1986**, *28*, 1517.
5. Asano, T.; Okumura, T.; Hirano, K.; Adachi, T.; Sugiura, M. *Chem. Pharm. Bull.* **1986**, *34*, 4328.
6. Murata, S.; Kikkawa, K.; Yabana, H.; Nagao, T. *Arzneim. Forsch.* **1988**, *38*, 521.
7. Ried, W.; Marx, W. *Chem. Ber.* **1957**, *90*, 2683.
8. Stephens, W. D.; Field, L. *J. Org. Chem.* **1959**, *24*, 1576.
9. Hideg-Hankovszky, O.; Hideg, K. *Acta Chim. Acad. Sci. Hung.* **1971**, *68*, 403.
10. Lévai, A.; Bognár. R. *Acta Chim. Acad. Sci. Hung.* **1976**, *88*, 293.
11. Lévai, A.; Bognár, R. *Acta Chim. Acad. Sci. Hung.* **1977**, *92*, 415.
12. Lévai, A. *Pharmazie* **1979**, *34*, 439.
13. Lévai, A.; Bognár, R.; Kajtár, J. *Acta Chim. Acad. Sci. Hung.* **1980**, *103*, 27.
14. Gupta, A. K.; Singh, V. K.; Pant, U. C. *Indian J. Chem.* **1983**, *22B*, 1057.
15. Pant, U. C.; Gaur, B. S.; Chugh, M. *Indian J. Chem.* **1988**, *27B*, 189.
16. Prakash, O.; Kumar, A.; Sadana, A.; Prakash, R.; Singh, S. P.; Claramunt, R. M.; Sanz, D.; Alkorta, I.; Elguero, J. *Tetrahedron* **2005**, *61*, 6642.
17. Khatik, G. L.; Kumar, R.; Chakraborti, A. K. *Synthesis* **2007**, 541.
18. Tóth, G.; Szöllősy, Á.; Lévai, A.; Duddeck, H. *Org. Magn. Reson.* **1982**, *20*, 133.
19. Lévai, A. *Sci. Pharm.* **1996**, *64*, 523.
20. Lévai, A. *Heterocycl. Commun.* **1997**, *3*, 211.
21. Görlitzer, K.; Wichers, M.; Jones, P. G. *Pharmazie* **2001**, *56*, 303.
22. Lévai, A. *Heterocycl. Commun.* **2002**, *8*, 227.
23. Görlitzer, K.; Wichers, M. *Pharmazie* **2003**, *58*, 177.
24. Dandia, A.; Sati, M.; Arya, K.; Loupy, A. *Heterocycles*, **2003**, *60*, 563.
25. Sathunuru, R.; Koh, B.; Zhang, H.; Biehl, E. *Heterocycles,* **2005**, *65*, 2493.
26. Dandia, A.; Singh, R.; Khaturia, S. *Bioorg. Med. Chem.* **2006**, *14*, 1303.
27. Lévai, A. *J. Heterocycl. Chem.* **2000**, *37*, 199.
28. Lévai, A. *J. Heterocycl. Chem.* **2004**, *41*, 399.
29. Lévai, A.; Patonay, T.; Silva, A. M. S.; Pinto, D. C. G.A.; Cavaleiro, J. A. S. *J. Heterocycl. Chem.* **2002**, *39*, 751.
30. Lévai, A.; Jekő, J. *J. Heterocycl. Chem.* **2006**, *43*, 1303.
31. Tóth, G.; Simon, A.; Jenei, A.; Jekő, J.; Lévai, A. *Magn. Reson. Chem.* **2008**, *46,* 1025.