Heteroatom Chemistry
Volume 19, Number 6, 2008

A Convenient Synthesis of Novel 7-Phosphonylbenzyl-2-Substituted Pyrazolo[4,3-*e*]-1,2,4-Triazolo[1,5-*c*]-Pyrimidine Derivatives

Lin-Xia Xiao, Ke Li, Liu Meng, and De-Qing Shi

Key Laboratory of Pesticide & Chemical Biology of Ministry of Education, College of Chemistry, Central China Normal University, Wuhan 430079, People's Republic of China

Received 22 October 2007; revised 28 February 2008

ABSTRACT: *A series of pyrazolo[4,3-e]-1,2,4-triazolo-[1,5-c]pyrimidine derivatives, bearing phosphonylbenzyl chain in position 7, were conveniently synthesized in an attempt to obtain potent and selective antagonists for the A_{2A} adenosine receptor or potent pesticide lead compounds. Diethyl[(5-amino-4-cyano-3-methylsulfanyl-pyrazol-1-yl)-benzyl]phosphonate (***3***), which was prepared by the cyclization of diethyl 1-hydrazinobenzylphosphonate (***1***) with 2-[bis(methylthio)methylene]malononitrile (***2***), reacted with triethyl orthoformate to afford diethyl[(4-cyano-5-ethoxymethyleneamino-3-methylsulfanyl-pyrazol-1-yl)-benzyl]phosphonate (***4***), which reacted with various acyl hydrazines in refluxing 2-methoxyethanol to give the target compounds* **5a–h** *in good yields. Their structures were confirmed by IR, ^{1}H NMR, ^{13}C NMR, MS, and elemental analysis. The crystal structure of* **5e** *was determined by single crystal X-ray diffraction* © 2008 Wiley Periodicals, Inc. Heteroatom Chem 19:634–638, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/hc.20478

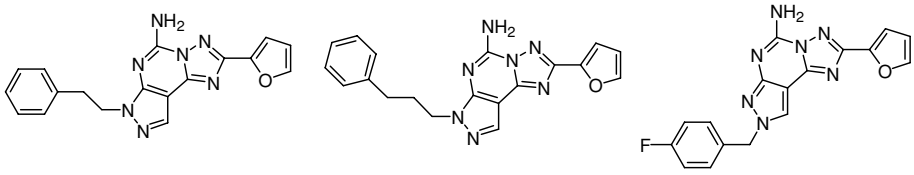
Correspondence to: De-Qing Shi; e-mail: chshidq@mail.ccnu.edu.cn.

Contract grant sponsor: Natural Science Foundation of China.
Contract grant number: 20302002.
Contract grant sponsor: Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry.
Contract grant number: [2007] 1108.

INTRODUCTION

Adenosine modulates a wide range of physiological functions by interacting with specific cell surface receptors that have been classified as A_1, A_{2A}, A_{2B}, and A_3 adenosine receptor subtypes [1,2]. Efforts made in medicinal chemistry over the last two decades have led to the discovery of a series of adenosine analogs that possess specific agonist properties at A_1, A_{2A}, $A_{2B,}$ or A_3 receptors [3,4]. As for adenosine receptor antagonists, a large number of xanthine derivatives have been synthesized in an attempt to improve both receptor subtype affinity and selectivity of the natural compounds caffeine and theophylline [3]. Recently, pyrazolo[4,3-*e*]-1,2,4-triazolo-[1,5-*c*]pyrimidine derivatives, such as SCH 58261, SCH 63390, and 8FB-PTP, have been found to be potent adenosine A_{2A} antagonists [5,6]. However, they are unselective, while being potent at A_1 receptor as well. In recent years, it is found that 1-amino phosphonates act as the phosphorus analogues of natural amino acids and have received an increasing attention in medicinal chemistry and pesticide science [7,8] due to their wide biological activities such as enzyme inhibition [9], antibiotics [10], and haptens of catalytic antibodies [11], antifungal agents, herbicides, plant regulators, and plant virucides [12]. To find potent and selective antagonists for the A_{2A} adenosine receptor or potent pesticide lead compounds, herein we report a convenient synthesis of pyrazolo[4,3-*e*]-1,2,

4-triazolo-[1,5-*c*]pyrimidine derivatives, bearing a phosphonylbenzyl chain in position 7.



SCH 58261 SCH 63390 8FB PTP

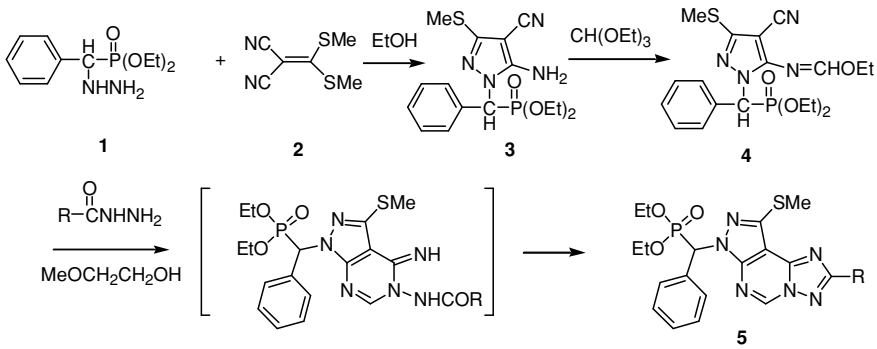
RESULTS AND DISCUSSION

The synthesis of diethyl 1-hydrazinobenzylphosphonate (**1**) has been reported by several methods [13]. It was synthesized by a modified procedure of Yuan's report [13a]. For converting benzaldehyde to diethyl 1-hydroxybenzyl phosphonate, an excess of catalyst (KF, four times) was used, which caused difficulty in stirring and incomplete reactivity. Instead, we used 1 equiv of catalyst (Et_3N) in CH_2Cl_2 to avoid these shortcomings and obtained it in a better yield (85%). **1** can be obtained in a better yield by the reaction of diethyl 1-hydroxybenzyl phosphonate with mesyl chloride, followed by the nucleophilic substitution with hydrazine in a one-pot reaction.

Cyclization of **1** with 2-[bis(methylthio)-methylene]malononitrile (**2**) in mild conditions gave diethyl[(5-amino-4-cyano-3-methylsulfanyl-pyrazol-1-yl)-benzyl]phosphonate (**3**), which can be easily converted to diethyl[(4-cyano-5-ethoxymethyleneamino-3-methylsulfanyl-pyrazol-1-yl)-benzyl]-phosphonate (**4**) by refluxing triethyl orthoformate. **4** reacted with various acyl hydrazines to yield the corresponding tricyclic target compounds **5a–h** conveniently in refluxing 2-methoxyethanol in one step (Scheme 1), without the isolation of 5-acylamino-4-imino-4,5-dihydropyrazolo[3,4-*d*]pyrimidine intermediates, contrary to the report by Baraldi et al. [14]. In Baraldi's report, analogous imidates reacted with acyl hydrazine in refluxing 2-methoxyethanol to provide 5-acylamino-4-imino-4,5-dihydropyrazolo[3,4-*d*]pyrimidines. Whereas the ring closure of these imidates to the corresponding pyrazolo[4,3-*e*]-1,2,4-triazolo-[1,5-*c*] pyrimidines thermally needed a higher boiling point solvent (260°C) like diphenyl ether.

To confirm the structure of the regioisomer of the cyclization and investigate its regioselectivity, a single crystal of the compound **5e** was obtained as colorless crystals from the mixture of petroleum ether and acetone (6:1 v/v) and its molecular structure was determined by X-ray diffraction (Fig. 1) [15].

In conclusion, we have developed an efficient and selective synthesis of pyrazolo[4,3-*e*]-1,2,4-triazolo-[1,5-*c*]pyrimidine derivatives, bearing phosphonylbenzyl chain in position 7, via the directed ring closure of functionalized imidates with various acyl hydrazines. Owing to the easily accessible and versatile starting materials and straightforward product isolation, we think that this method has potential in the synthesis



R= methyl; *n*-propyl; phenyl; phenoxymethyl; 4-chlorophenoxymethyl; 2,4-dichlorophenoxymethyl;

4-tert-butylphenoxymethyl; 3-trifluoromethylphenoxymethyl

SCHEME 1

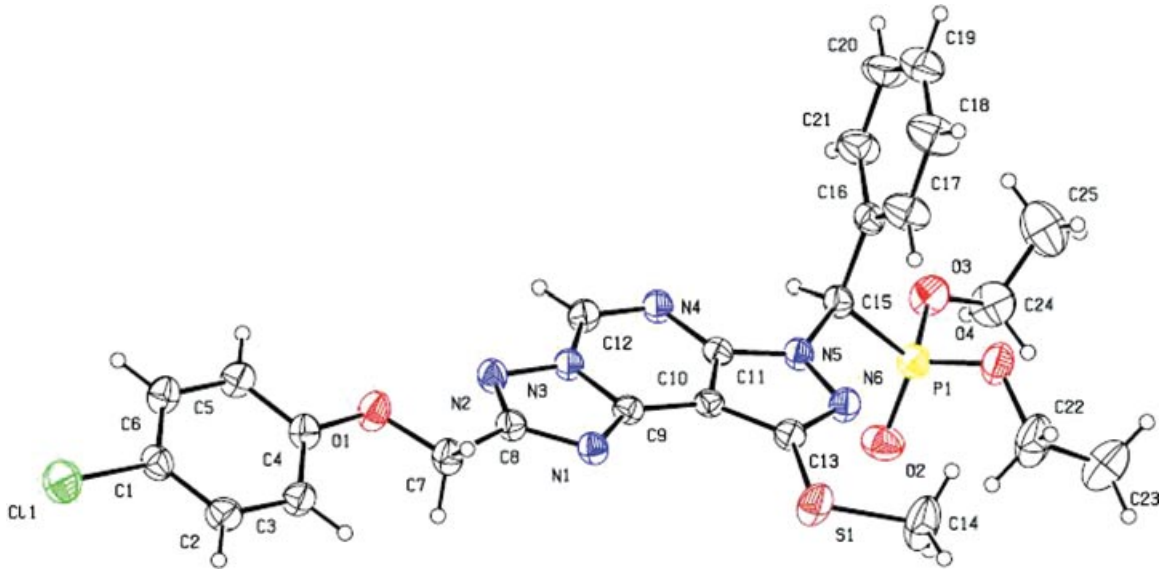


FIGURE 1 X-ray crystal structure of compound **5e**.

of phosphonyl-substituted pyrazolo[4,3-*e*]-1,2,4-triazolo-[1,5-*c*]pyrimidine derivatives with biological and pharmaceutical activities.

EXPERIMENTAL

Melting points were determined with a WRS-1B digital melting point apparatus and were uncorrected. ^{1}H and ^{13}C NMR spectra were recorded with a Varian mercury-plus 400 spectrometer with TMS as the internal reference and $CDCl_3$ as the solvent, whereas mass spectra were obtained with a Finnigan TRACEMS 2000 spectrometer using the EI method. IR spectra were measured by a Nicolet NEXUS470 spectrometer. Elemental analyses were performed with an Elementar Vario ELIIICHNSO elementary analyzer. X-ray diffraction analysis was performed on a Bruker Smart 1000 CCD diffractometer. All of the solvents and materials were of high-reagent grade and were purified as required. Diethyl 1-hydrazinobenzylphosphonate (**1**), 2-[bis(methylthio)methylene]malononitrile (**2**), and acyl hydrazines were prepared according to the methods described in [13a], [16], and [17], respectively.

*Preparation of Diethyl[(5-amino-4-cyano-3-methylsulfanyl-pyrazol-1-yl)-benzyl]phosphonate (**3**) [18]*

A mixture of **1** (6.27 g, 24.3 mmol), **2** (3.89 g, 22.9 mmol), and ethanol (30 mL) was refluxed for 5 h. The reaction mixture was cooled to room temperature, concentrated in vacuo, and the residues were recrystallized from ethyl acetate and petroleum (1:1, v/v) to give white crystals (5.58 g, 64% yield). mp 161–163°C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.19–1.27 (m, 6H, $2CH_3$), 2.53 (s, 3H, SCH_3), 4.01–4.16 (m, 4H, $2CH_2$), 5.54 (s, 2H, NH_2), 5.75 (d, $J = 24$ Hz, 1H, PCH), 7.27–7.52 (m, 5H, Ar-H). Anal. Calcd for $C_{16}H_{21}N_4O_3PS$: C 50.52, H 5.56, N 14.73; Found: C 50.69, H 5.48, N 14.89.

*Preparation of Diethyl[(4-cyano-5-ethoxymethyleneamino-3-methylsulfanyl-pyrazol-1-yl)-benzyl]phosphonate (**4**)*

Compound **3** (2.28 g, 6 mmol) was dissolved in triethyl orthoformate (4 mL), and the mixture was refluxed for 2 h; after cooling, the solvent was removed under a reduced pressure, and the residues were purified on silica gel (EtOAc-light petroleum, 1:5, v/v) to afford **4** as a white solid (2.48 g, 95%). mp 64–66°C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.18–1.27 (m, 6H, $2CH_3$), 1.40 (t, $J = 7$ Hz, 3H, CH_3), 2.62 (s, 3H, SCH_3), 4.01–4.20 (m, 4H, $2CH_2$), 4.39 (t, $J = 6.6$ Hz, 2H, CH_2), 5.90 (d, $J = 22.8$ Hz, 1H, PCH), 7.33–7.55 (m, 5H, Ar-H), 8.39 (s, 1H, =CH). Anal. Calcd for $C_{19}H_{25}N_4O_4PS$: C 52.28, H 5.77, N 12.84; Found: C 52.41, H 5.54, N 12.72.

*Preparation of Diethyl{[9-(methylsulfanyl)-2-substituted-7H-pyrazolo-[4,3-e]-1,2,4-triazolo-[1,5-c]-pyrimidin-7-yl]-benzyl}phosphonate (**5a–h**): General Procedure*

A solution of **4** (0.65 g, 1.5 mmol) and acyl hydrazine (such as acetyl hydrazine, benzoyl hydrazine, and

substituted phenoxy acetyl hydrazine) (1 mmol) in methoxyethanol (20 mL) was refluxed for 3–5 h. After cooling, the solvent was removed under reduced pressure, and the residues were purified on silica gel (acetone and light petroleum, 1:6–7, v/v) to afford the corresponding target compounds **5a–h.**

*Diethyl[(2-methyl-9-methylsulfanyl-pyrazolo [4,3-e]-1,2,4-triazolo[1,5-c]pyrimidin-7-yl)-benzyl]phosphonate (***5a***)*

Colorless crystals, yield, 75%, mp 95–96°C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.17–1.27 (m, 6H, $2CH_3$), 2.64 (s, 3H, CH_3), 2.83 (s, 3H, SCH_3), 4.04–4.22 (m, 4H, $2CH_2$), 6.43 (d, $J = 23$ Hz, 1H, PCH), 7.27–7.72 (m, 5H, Ar-H), 8.97 (s, 1H, N=CH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 166.1, 148.2, 147.9, 142.1, 138.7, 133.2, 129.0, 128.7, 128.5, 101.4, 63.8, 63.4, 63.3, 59.4, 57.8, 16.3, 14.7. Anal. Calcd for $C_{19}H_{23}N_6O_3PS$: C 51.11, H 5.19, N 18.82; Found: C 50.99, H 5.27, N 18.97.

*Diethyl[(9-methylsulfanyl-2-propyl-pyrazolo[4,3-e]-1,2,4-triazolo[1,5-c]pyrimidin-7-yl)-benzyl]-phosphonate (***5b***)*

Colorless oil, yield, 69%. ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.02 (t, $J = 6.8$ Hz, 3H, CH_3), 1.17–1.27 (m, 6H, $2CH_3$), 1.90 (q, $J = 7.5$ Hz, 2H, CH_2), 2.82 (s, 3H, SCH_3), 2.93 (t, $J = 7.6$ Hz, 2H, CH_2), 4.02–4.22 (m, 4H, $2CH_2$), 6.43 (d, $J = 23$ Hz, 1H, PCH), 7.27–7.71 (m, 5H, Ar-H), 8.99 (s, 1H, N=CH); MS (70 eV) *m/z* (%): 476 (5.14), 474 (M^+, 12.4), 337 (100), 291 (5.9), 262 (19.3), 109 (16.4), 91 (8.9), 81 (12.5). Anal. Calcd for $C_{21}H_{27}N_6O_3PS$: C 53.15, H 5.74, N 17.71; Found C: 53.23, H 5.81, N 17.50.

*Diethyl[(9-methylsulfanyl-2-phenyl-pyrazolo[4, 3-e]-1,2,4-triazolo[1,5-c]pyrimidin-7-yl)-benzyl phosphonate (***5c***)*

White crystals, yield, 88%, mp 111–113°C.^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.15–1.27 (m, 6H, $2CH_3$), 2.87 (s, 3H, SCH_3), 4.03–4.25 (m, 4H, $2CH_2$), 6.46 (d, $J = 23$ Hz, 1H, PCH), 7.27–7.75 (m, 10H, Ar-H), 9.07 (s, 1H, N=CH); MS (70 eV) *m/z* (%): 508 (M^+, 6), 371 (42), 261 (2), 109 (100). Anal. Calcd for $C_{24}H_{25}N_6O_3PS$: C 56.68, H 4.96, N 16.53; Found: C 56.40, H 5.03, N 16.75.

*Diethyl[(9-methylsulfanyl-2-phenoxymethyl-pyrazolo[4,3-e]-1,2,4-triazolo[1,5-c]pyrimidin-7-yl)-benzyl]phosphonate (***5d***)*

White crystals, yield, 86%, mp 130.3–131.8°C. IR (KBr, cm^{-1}) ν: 2982, 1497, 1245, 1027, 761, 694, 565; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.17–1.27 (m, 6H, $2CH_3$), 2.83 (s, 3H, SCH_3), 4.04–4.22 (m, 4H, $2CH_2$), 5.41 (s, 2H, OCH_2), 6.44 (d, $J = 23$ Hz, 1H, PCH), 7.05–7.73 (m, 10H, Ar-H), 9.07 (s, 1H, N=CH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 164.6, 158.0, 148.3, 147.7, 142.2, 139.0, 132.9, 129.3, 128.9, 128.6, 128.4, 121.3, 114.6, 101.5, 63.6, 63.4, 63.2, 59.3, 57.8, 16.2, 14.6. Anal. Calcd for $C_{25}H_{27}N_6O_4PS$: C 55.75, H 5.05, N 15.60; Found: C 55.93, H 5.11, N 15.74.

*Diethyl{[2-(4-chlorophenoxy)methyl-9-methylsulfanyl-pyrazolo[4,3-e]-1,2,4-triazolo[1, 5-c]pyrimidin-7-yl]-benzyl}phosphonate (***5e***)*

White crystals, yield, 91%, mp 159.1–160.0°C. IR (KBr, cm^{-1}) ν: 2983, 1493, 1248, 1050, 826, 563 ^{1}H NMR ($CDCl_3$, 400 MHz): δ: 1.18–1.27 (m, 6H, $2CH_3$), 2.82 (s, 3H, SCH_3), 4.00–4.24 (m, 4H, $2CH_2$), 5.38 (s, 2H, OCH_2), 6.44 (d, $J = 23$ Hz, 1H, PCH), 6.96–7.73 (m, 9H, Ar-H), 9.06 (s, 1H, N=CH); MS (70 eV) *m/z* (%): 575 (6.5), 573.5 (10.5), 572 (M^+, 24.6), 438 (14.3), 437.5 (25.7), 436.5 (74.0), 435 (100), 434 (69.9), 433 (36.5), 432.5 (16.9), 309 (9.2), 307 (12.1), 262 (12.7), 129 (5.0), 128 (5.9), 91 (5.4). Anal. Calcd for $C_{25}H_{26}ClN_6O_4PS$: C 52.40, H 4.57, N 14.67; Found: C 52.57, H 4.41, N 14.42.

*Diethyl{[2-(2,4-dichlorophenoxy)methyl-9-methylsulfanyl-pyrazolo[4,3-e]-1,2,4-triazolo[1, 5-c]pyrimidin-7-yl]-benzyl}phosphonate (***5f***)*

White crystals, yield, 92%, mp 109.6–111.3°C. IR (KBr, cm^{-1}) ν: 2968, 1511, 1250, 1019, 830, 805, 565; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.18–1.27 (m, 6H, $2CH_3$), 2.83 (s, 3H, SCH_3), 4.05–4.22 (m, 4H, $2CH_2$), 5.46 (s, 2H, OCH_2), 6.48 (d, $J = 23$ Hz, 1H, PCH), 7.01–7.71 (m, 8H, Ar-H), 9.06 (s, 1H, N=CH); MS (70 eV) *m/z* (%): 609 (10.3), 608 (31.2), 607 (14.6), 606 (M^+, 42), 571 (11.4), 473 (16.1), 472 (20.3), 471 (74.5), 470 (29.2), 469 (100), 308 (17.4), 261 (8.8), 163 (23.0), 161 (37.3), 135 (20.0), 133 (32.7), 116 (14.3), 109 (36.2), 105 (14.0), 91 (40.6), 81 (41.2), 77 (35.1). Anal. Calcd for $C_{25}H_{25}Cl_2N_6O_4PS$: C 49.43, H 4.15, N 13.83; Found: C 49.29, H 4.07, N 13.60.

*Diethyl{[2-(4-t-butylphenoxy)methyl-9-methylsulfanyl-pyrazolo[4,3-e]-1,2,4-triazolo[1, 5-c]pyrimidin-7-yl]-benzyl}phosphonate (***5g***)*

White crystals, yield, 84%, mp 121–122°C. IR (KBr, cm^{-1}) ν: 2960, 1514, 1251, 1017, 829, 697, 569; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 1.17–1.31 (m, 15H, CH_3), 2.83 (s, 3H, SCH_3), 4.06–4.22 (m, 4H, $2CH_2$), 5.40 (s, 2H, OCH_2), 6.44 (d, $J = 23$ Hz, 1H, PCH), 6.98–7.73 (m, 9H, Ar-H), 9.08 (s, 1H, N=CH); ^{13}C NMR

($CDCl_3$, 100 MHz) δ: 165.0, 155.8, 148.4, 147.9, 144.1, 142.3, 139.0, 133.0, 129.0, 128.7, 128.5, 126.2, 114.2, 101.6, 63.9, 63.7, 63.3, 59.4, 57.9, 34.0, 31.4, 16.3, 14.7. Anal. Calcd for $C_{29}H_{35}N_6O_4PS$: C 58.57, H 5.93, N 14.13; Found: C 58.69, H 6.08, N 14.00.

*Diethyl{[9-methylsulfanyl-2-(3-trifluoromethylphenoxy)methyl-pyrazolo[4,3-e]-1,2,4-triazolo[1,5-c]pyrimidin-7-yl]-benzyl} phosphonate (**5h**)*

Colorless oil, yield, 85%. ^1H NMR ($CDCl_3$, 400 MHz) δ: 1.18–1.27 (m, 6H, $2CH_3$), 2.83 (s, 3H, SCH_3), 4.05–4.22 (m, 4H, $2CH_2$), 5.44 (s, 2H, OCH_2), 6.44 (d, $J = 23$ Hz, 1H, PCH), 7.21–7.72 (m, 9H, Ar-H), 9.07 (s, 1H, N=CH); MS (70 eV) *m/z* (%): 608 (10.6), 606 (M^+, 23.0), 469 (100), 449 (4.6), 308 (6.0), 261 (6.1), 161 (9.7), 133 (11.9), 109 (21.3), 91 (17.5). Anal. Calcd for $C_{26}H_{26}F_3N_6O_4PS$: C 51.48, H 4.32, N 13.86; Found: C 51.51, H 4.17, N 13.63.

REFERENCES

[1] Fredholm, B. B.; Abbracchio, M. P.; Burnstock, G.; Daly, J. W.; Harden, T. K.; Jacobson, K. A.; Leff, P.; Williams, M. Pharmcol Rev 1994, 46, 143.

[2] Baraldi, P. G.; Cacciari, B.; Spalluto, G.; Borioni, A.; Viziano, M.; Dionisotti, S.; Ongini, E. Curr Med Chem 1995, 2, 707.

[3] Van Galen, P. J. M.; Stiles, G. L.; Michaels, G.; Jacobson, K. A. Med Res Rev 1992, 12, 423.

[4] Kim, H. O.; Ji, X.; Melman, N.; Olah, M. E.; Stiles, G. L.; Jacobson, K. A. J Med Chem 1994, 37, 3373.

[5] Gatta, F.; Del Giudice, M. R.; Borioni, A.; Borea, P. A.; Dionisotti, S.; Ongini, E. Eur J Med Chem 1993, 28, 569.

[6] Dionisotti, S.; Conti, A.; Sandoli, D.; Zocchi, C.; Gatta, F.; Ongini, E. Br J Pharmacol 1994, 112, 659.

[7] Kafarski, P.; Lejczak, B. In Aminophosphonic and Aminophosphinic Acids; Kukhar, V. P.; Hudson, H. R. (Eds.); Wiley: New York, 2000; Ch. 12, p. 407.

[8] Palacios, F.; Alonoso, C.; de los Santos, J. M. Chem Rev 2005, 105, 899.

[9] Logusch, E. W.; Walker, D. M.; McDonald, J. F.; Leo, G. C.; Grang, J. E. J Org Chem 1988, 53, 4069.

[10] Atherton, F. R.; Hassal, C. H.; Lambert, R. W. J Med Chem 1986, 29, 29.

[11] Smith III, A. B.; Taylor, C. M.; Venkovic, S. J.; Hirchmann, R. Tetrahedron Lett 1994, 37, 6854.

[12] (a) Takematsu, K.; Konnai, M.; Tachibana, K.; Tsuruoka, T.; Inouye, S.; Watanabe, T. US Patent 4 265 654, 1981; (b) Ling, Y. X.; Zhang, K. S.; Qiu, D. W. Chem J Chinese Universities 1996, 17(8), 1247; (c) Borloo, M.; Jiao, X. Y.; Wojtowicz, H.; Rajan, R.; Verbruggen, C.; Augustyus, K.; Hacmers, A. Synthesis 1995, 1074; (d) Dai, Q.; Chen, R. Y. Heteroatom Chem 1997, 8(3), 203; (e) Wang, Q. M.; Li, Z. G.; Huang, R. Q.; Cheng, J. R. Heteroatom Chem 2001, 12(2), 68.

[13] (a) Yuan, C. Y.; Li, C. Z. Synthesis 1996, 507; (b) Yuan, C. Y. Phosphorus, Sulfur and Silicon and Relat Elem. 1995, 106, 115; (c) Diel, P.; Maier, L. Phosphorus, Sulfur and Silicon and Relat Elem. 1988, 36, 85; (d) Rachon, J.; Wasielewski, C. Rocz Chem 1976, 50, 477.

[14] (a) Baraldi, P. G.; Cacciari, B.; Spalluto, G.; Des las Infantasy Villatoro, M. J. P.; Zocchi, C.; Dionisotti, S.; Ongini, E. J Med Chem 1996, 391164; (b) Baraldi, P. G.; Cacciari, B.; Spalluto, G.; Bergonzoni, M.; Dionisotti, S.; Ongini, E.; Verani, K.; Borea, P. A. J Med Chem 1998, 41, 2126; (c) Gatta, F.; Del Giudice, M. R.; Borioni, A.; Borea, P. A.; Dionisotti, S.; Ongini, E. Eur J Med Chem 1993, 28, 569.

[15] Xiao, L. X.; Shi, D. Q. Acta Cryst E 2007, 63, o3613.

[16] Wang, X. J.; Huang, Z. T. Acta Chim Sinica 1989, 47, 890.

[17] Chen, W. J.; Liao, D. H. Huaxue Shijie 2006, 5, 285.

[18] Li, Z. G.; Sun, H. K.; Wang, Q. M.; Huang, R. Q. Heteroatom Chem 2003, 14(4), 384.