Journal of Sulfur Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gsrp20

The reaction of carbon disulfide with bromoacetophenone in the presence of primary amines: synthesis of 3-alkyl-4-phenyl-1,3-thiazole-2(3H)-thione derivatives

Javad Safaei-Ghomi [a], Fariba Salimi [a], Ali Ramazani [b], Fatemeh Zeinali Nasrabadi [b] & Yavar Ahmadi [c]

[a] Department of Organic Chemistry, Faculty of Chemistry, University of Kashan, 51167, Kashan, Iran

[b] Chemistry Department, Zanjan University, PO Box 45195-313, Zanjan, Iran

[c] Young Researchers Club, Zanjan Branch, Islamic Azad University, Zanjan, Iran

Published online: 28 Nov 2011.

To cite this article: Javad Safaei-Ghomi , Fariba Salimi , Ali Ramazani , Fatemeh Zeinali Nasrabadi & Yavar Ahmadi (2012) The reaction of carbon disulfide with bromoacetophenone in the presence of primary amines: synthesis of 3-alkyl-4-phenyl-1,3-thiazole-2(3H)-thione derivatives, Journal of Sulfur Chemistry, 33:1, 87-92, DOI: 10.1080/17415993.2011.635794

To link to this article: http://dx.doi.org/10.1080/17415993.2011.635794

Journal of Sulfur Chemistry
Vol. 33, No. 1, February 2012, 87–92

Taylor & Francis
Taylor & Francis Group

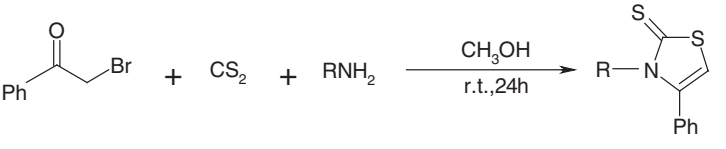
The reaction of carbon disulfide with bromoacetophenone in the presence of primary amines: synthesis of 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives

Javad Safaei-Ghomi[a], Fariba Salimi[a], Ali Ramazani[b]*, Fatemeh Zeinali Nasrabadi[b] and Yavar Ahmadi[c]

[a]*Department of Organic Chemistry, Faculty of Chemistry, University of Kashan, 51167 Kashan, Iran;* [b]*Chemistry Department, Zanjan University, PO Box 45195-313, Zanjan, Iran;* [c]*Young Researchers Club, Zanjan Branch, Islamic Azad University, Zanjan, Iran*

(*Received 10 October 2011; final version received 24 October 2011*)

A three-component reaction between a primary amine, carbon disulfide, and bromoacetophenone that affords novel 3-alkyl-4-phenyl-1,3-thiazole-2(3H)-thione derivatives is reported. The reaction sequence consists of an initial nucleophilic addition of primary amines to carbon disulfide, followed by the nucleophilic attack of carbamodithioic acid so obtained to the bromoacetophenone, and then ring closure by intramolecular attack of nitrogen to the carbonyl carbon to afford the products. This cascade reaction sequence represents a rapid and unprecedented route to the described molecules that have biological specifications.



Keywords: carbon disulfide; bromoacetophenone; primary amines; thiazole; nucleophilic addition

1. Introduction

In recent years, multicomponent reactions (MCRs) have become important tools in modern primary synthetic chemistry because these reactions increase the efficiency by combining several operational steps without any isolation of intermediates or changes of the conditions (*1–10*). So, this principle is very efficient in terms of time as well as resources (*11*). Among the known MCRs, the most valuable reactions are those based on isocyanides. Isocyanide-based MCRs (abbreviated to IMCRs by Ugi and Dömling) (*11–14*) due to their synthetic potential, their inherent atom efficiency, convergent nature, ease of implementation, and molecular diversity have attracted much

*Corresponding author. Email: aliramazani@gmail.com

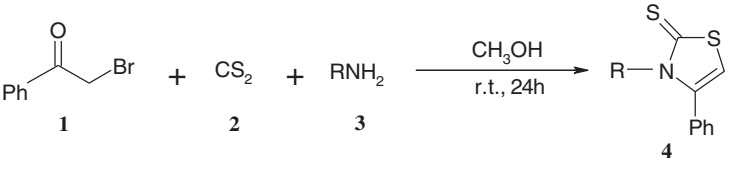
ISSN 1741-5993 print/ISSN 1741-6000 online

http://dx.doi.org/10.1080/17415993.2011.635794
http://www.tandfonline.com

attention. Therefore, because of these advantages they offer, they are a valuable tool in the field of combinatorial chemistry (*12–14*).

Organic compounds containing five-membered aromatic heterocyclic rings form a wide range of compounds in the nature and often play an important role in diverse biochemical processes. Consequently, aromatic heterocycles such as thiophenes, benzothiophene derivatives, and their reduced forms are important structural fragments in many pharmaceutical and chemical compounds. Thiophenes and thiazole compounds have been found to indicate nematocidal, insecticidal, antibacterial, antifungal, antiviral, and antioxidant activity (*15–17*). Tetrahydrothiophene is an important building block of a large quantity of compounds that are very interesting from the point of view of biological activity. Its derivatives have exhibited antisecretory and antiulcer activities (*18*). In particular, it is found in structures of nucleoside analogs and certain compounds where the sulfur atom is in the ring, such as sulfimides, salicinol, and kotalanol, which are excellent glycosidase inhibitors (*19–21*).

As part of our ongoing program to develop efficient and robust methods for the preparation of heterocyclic compounds (*22–31*), we sought to develop a easy preparation of 3-alkyl-4-phenyl-1,3-thiazole-2(3H)-thione derivatives **4a**–**i**. Herein, we express a new one-pot three-component reaction, which starting from readily available carbon disulfide, bromoacetophenone **3**, and primary amine, affords **4a**–**i** (Scheme 1).



4a: R = 4-methylbenzyl, **4b**: R = benzyl, **4c**: R = 4-fluorobenzyl**, 4d**: R = 4-methoxybenzyl, **4e**: R = 2-methoxybenzyl, **4f**: R = Furan-2-ylmethyl, **4g**: R = naphthyl, **4h**: R = 3, 4-dichlorobenzyl, **4i**: R = 2-methoxy ethyl

Scheme 1. Three-component synthesis of 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives **4** (see Section 4).

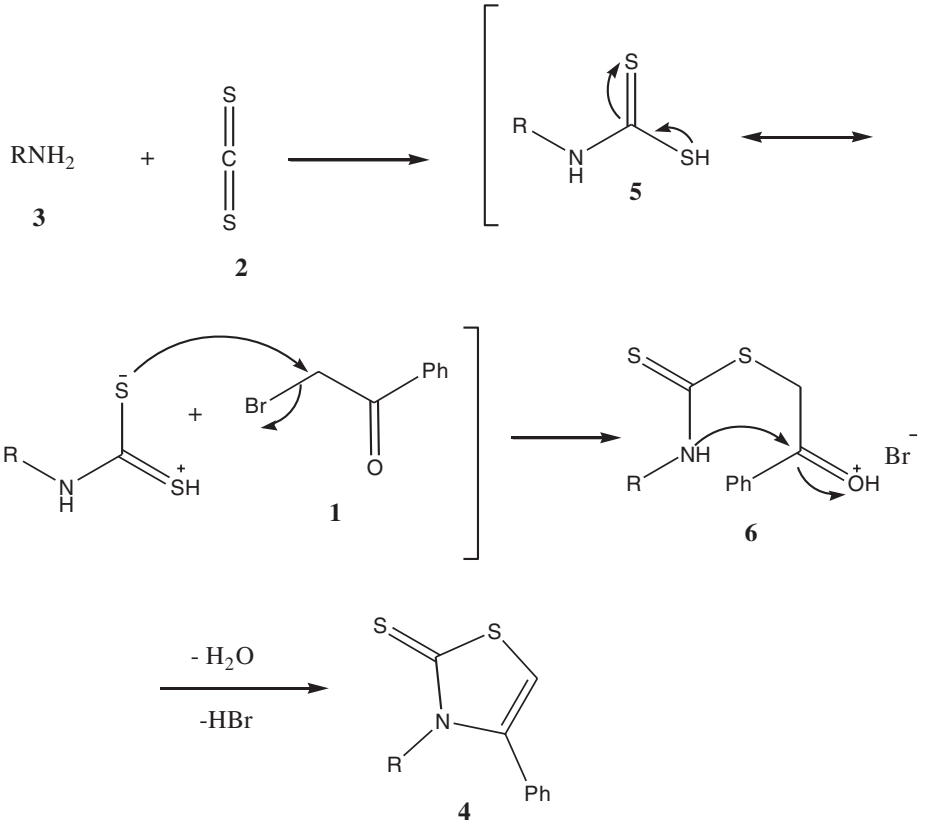
2. Results and discussion

We examined the reaction of primary amines with carbon disulfide in the presence of bromoacetophenone in dry CH_3OH at room temperature (25°C) and we obtained the corresponding 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives **4** in excellent yields. The reaction proceeds smoothly and cleanly under mild and neutral conditions, and no side products were observed. The compounds **4** were stable when stored at room temperature for several months. We have also used chloroacetophenone instead of bromoacetophenone **1** in this reaction, but no corresponding products **4** were observed and unreacted chloroacetophenone was recovered.

The structures of the products were deduced from their ^{1}H NMR, ^{13}C NMR, IR, and mass spectra. The mass spectra of these compounds displayed molecular ion peaks at the appropriate *m*/*z* values. The ^{1}H NMR spectrum of **4a** consisted of a singlet for CH_3 at δ 2.28, a singlet for CH_2 at δ 4.48, a singlet for CH at δ 6.00, two doublets for four aromatic protons at δ 6.83 and 7.01, and a multiplet at δ 7.16–7.41 for five aromatic protons. The ^{1}H decoupled ^{13}C NMR spectrum of **4a** showed 12 distinct resonances, partial assignment of these resonances is given in Section 4. The ^{1}H and ^{13}C NMR spectra of compounds **4b**–**i** were similar to those of **4a**, except for the aromatic moiety, which exhibited characteristic signals with appropriate chemical shifts.

A possible mechanism for the present reaction is shown in Scheme 2, which envisages a tandem sequence. On the basis of established chemistry of trivalent nitrogen nucleophiles, the successful

nucleophilic attack by amines on a carbon atom is facilitated when the latter is conjugated with a carbonyl group, or when it is a part of an otherwise activated unsaturated bond. First, the nucleophilic addition of the primary amine **3** to carbon disulfide **2** generates the nucleophilic carbamodithioic acid **5** (*32*). The next step involves nucleophilic attack of carbamodithioic acid **5** at the methylene carbon of bromoacetophenone **1**, leading to intermediate **6**, and then ring closure by intramolecular attack of nitrogen at the carbonyl carbon to afford the 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives **4**.



Scheme 2. Proposed mechanism for the formation of 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives **4a–i**.

3. Conclusions

The reported method offers a mild, simple, and efficient route for the preparation of 3-alkyl-4-phenyl-1,3-thiazole-2(3*H*)-thione derivatives **4**. Its ease of work-up, high yields, and fairly mild reaction conditions make it a useful addition to modern synthetic methodologies. Other aspects of this process are under investigation.

4. Experimental

Starting materials and solvents were obtained from Merck (Germany) and Fluka (Switzerland) and were used without further purification. The methods used to follow the reactions are thin-layer

chromatography (TLC) and NMR, which indicated that there is no side product. Melting points were measured on an Electrothermal 9100 apparatus and are uncorrected. IR spectra were measured on a Jasco 6300 FTIR spectrometer. ^{1}H and ^{13}C NMR spectra were measured ($CDCl_3$) with a BRUKER DRX-250 AVANCE spectrometer at 250.0 and 62.5 MHz, respectively. Elemental analyses were performed using a Heraeus CHN-O-Rapid analyzer. Mass spectra were recorded on a FINNIGAN-MAT 8430 mass spectrometer operating at an ionization potential of 70 eV. Preparative TLC was prepared from Merck silica gel (F_{254}) powder.

4.1. *General procedure for the preparation of 4a–i*

The solution of primary amine (1.0 mmol) and carbon disulfide (1.0 mmol) in CH_3OH (7 ml) was stirred for 1 h and then bromoacetophenone **3** (1.0 mmol) was added, and the mixture was stirred for 24 h. The solvent was removed under reduced pressure and the viscous residue was purified by preparative TLC (silica gel; petroleum ether–ethyl acetate (10:2)). The solvent was removed under reduced pressure and the products were obtained. The characterization data of the compounds are given below.

4.1.1. *3-(4-Methylbenzyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4a)*

Colorless viscous oil; yield 90%; IR (KBr) (υ_{max}, cm^{-1}): 3100, 3000, 1650, 1600, 1475, 1200. ^{1}H NMR (250 MHz, $CDCl_3$): δ 2.28 (s, 3H, CH_3), 4.84 (s, 2H, CH_2), 6.00 (s, 1H, CH of alkene), 6.83 (d, 2H, $J = 7.5$ Hz, CH arom), 7.01 (d, 2H, $J = 7.5$ Hz, CH arom), 7.16–7.41 (m, 5H, CH arom). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ 21.06 (CH_3), 47.00 (CH_2), 98.81 (CH of alkene), 127.12, 128.57, 129.15, 129.27 (9CH), 131.52, 133.47, 136.85 (3C), 152.39 (C of alkene), 194.17 (C9S). MS (EI, 70 eV): *m/z*(%) = 297 (2), 281 (60), 149 (10), 105 (100), 77 (24). Anal. Calcd. for $C_{17}H_{15}NS_2$ (297): C, 68.65; H, 5.08; N, 4.71. Found: C, 68.60; H, 5.13; N, 4.76 %.

4.1.2. *3-Benzyl-4-phenyl-1,3-thiazole-2(3H)-thione (4b)*

Colorless viscous oil; yield 89%; IR (KBr) (υ_{max}, cm^{-1}): 3100, 3000, 1600, 1475, 1200. ^{1}H NMR (250 MHz, $CDCl_3$): δ 4.87 (s, 2H, CH_2), 6.02 (s, 1H, CH of alkene), 6.94–7.34 (m,10H, CH arom). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ 47.22 (CH_2), 98.88 (CH of alkene), 127.09, 127.45, 128.50, 128.58, 129.09, 129.31(10CH), 131.44, 136.47, 137.80 (3C), 153.39 (C of alkene), 179.17 (C9S). MS (EI, 70 eV): *m/z*(%) = 283 (4), 267(70), 181(7), 91 (100), 77 (4), 65 (10), 45 (4). Anal. Calcd. for $C_{16}H_{13}NS_2$ (283): C, 67.81; H, 4.62; N, 4.94. Found: C, 67.87; H, 4.67; N, 4.88 %.

4.1.3. *3-(4-Fluorobenzyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4c)*

Colorless viscous oil; yield 86%; IR (KBr) (υ_{max}, cm^{-1}): 3150, 3000, 1625, 1600, 1475, 1300, 1100. ^{1}H NMR (250 MHz, $CDCl_3$): δ 4.84 (s, 2H, CH_2), 6.00 (s, 1H, CH of alkene), 6.88 (d, 2H, $J = 6.8$ Hz, CH arom), 7.01–7.57 (m, 5H, CH arom), 7.96 (d, 2H, $J = 7.5$ Hz, CH arom).^{13}C NMR (62.5 MHz, $CDCl_3$): δ 46.48 (CH_2), 99.05 (CH of alkene), 115.56 (d, 2CH, $^2J = 22.0$, CH arom), 128.62, 128.72, 133.54 (5CH), 129.04 (d, 2CH, $^3J = 6.3$, CH arom), 135.40, 137.52 (2C), 153.25 (C of alkene), 159.5 (d, C, $^1J = 440.3$, CH arom), 194.17 (C=S). Anal. Calcd. for $C_{16}H_{12}FNS_2$ (301): C, 63.76; H, 4.01; N, 4.54. Found: C, 63.81; H, 4.06; N, 4.59 %.

4.1.4. *3-(4-Methoxybenzyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4d)*

Colorless viscous oil; yield 80%; IR (KBr) (υ_{max}, cm^{-1}): 3150, 3000, 1650, 1600, 1470, 1200, 1100. ^{1}H NMR (250 MHz, $CDCl_3$): δ 3.75 (s, 3H, OCH_3), 4.82 (s, 2H, CH_2), 5.99 (s, 1H, CH of alkene), 6.72 (d, 2H, $J = 7.8$ Hz, CH arom), 6.84–7.61 (m, 5H, CH arom), 7.97 (d, 2H, $J = 6.8$ Hz, CH arom). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ 46.67 (CH_2), 55.20 (OCH_3), 98.50 (CH of alkene), 113.83, 128.62, 128.72, 129.16, 133.54 (9CH), 133.54, 135.40 (2C), 153.15 (C of alkene), 159.32 (C), 194.17 (C9S). Anal. Calcd. for $C_{17}H_{15}NOS_2$ (313): C, 65.14; H, 4.82; N, 4.47. Found: C, 65.09; H, 4.87; N, 4.52 %.

4.1.5. *3-(2-Methoxybenzyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4e)*

Colorless viscous oil; yield 80%; IR (KBr) (υ_{max}, cm^{-1}): 3150, 3000, 1650, 1600, 1470, 1200, 1100. ^{1}H NMR (250 MHz, $CDCl_3$): δ 3.62 (s, 3H, OCH_3), 4.90 (s, 2H, CH_2), 6.03 (s, 1H, CH of alkene), 6.71–7.98 (m, 9H, CH arom).^{13}C NMR (62.5 MHz, $CDCl_3$): δ 42.73 (CH_2), 55.09 (OCH_3), 98.67 (CH of alkene), 110.00, 120.52, 128.36, 128.44, 128.63, 128.73, 129.01, 133.55 (9CH), 127.13, 135.40 (2C), 156.39 (C of alkene and C arom), 194.17 (C9S). Anal. Calcd. for $C_{17}H_{15}NOS_2$ (313): C, 65.14; H, 4.82; N, 4.47. Found: C, 65.09; H, 4.87; N, 4.52 %.

4.1.6. *3-(2-Furyl methyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4f)*

Colorless viscous oil; yield 86%; IR (KBr) (υ_{max}, cm^{-1}): 3100, 3000, 1650, 1600, 1475, 1200. ^{1}H NMR (250 MHz, $CDCl_3$): δ 4.82 (s, 2H, CH_2), 6.11(s, 1H, CH of furan), 6.23 (s, CH of furan), 6.45 (s, CH of alkene), 7.26–8.08 (m, 6H, CH arom and CH of furan). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ_C 44.22 (CH_2), 108.67 (CH of alkene), 109.64, 110.45, 126.20, 128.78, 129.61, 142.10 (8CH), 144.53, 147.90 (2C); 155.53 (C of alkene), 192.17 (C9S). Anal. Calcd. for $C_{14}H_{11}NOS_2$ (273): C, 61.51; H, 4.06; N, 5.12. Found: C, 61.57; H, 4.12; N, 5.18 %.

4.1.7. *3-(2-Naphthyl methyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4g)*

Colorless viscous oil; yield 86%; IR (KBr) (υ_{max}, cm^{-1}): 3100, 3000, 1650, 1600, 1475, 1200. ^{1}H NMR (250 MHz, $CDCl_3$): δ 3.98 (s, 2H, CH_2), 6.10 (s, 1H, CH of alkene), 6.94–7.98 (m, 12H, CH arom). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ 45.39 (CH_2), 99.09 (CH of alkene), 123.73, 125.31, 125.80, 126.31, 128.01, 128.63, 128.73, 133.56 (12CH), 122.51, 129.27, 131.53, 135.04 (4C), 172.49 (C of alkene), 194.17 (C9S). Anal. Calcd. for $C_{20}H_{15}NS_2$ (333): C, 72.03; H, 4.53; N, 4.20. Found: C, 72.08; H, 4.48; N, 4.25 %.

4.1.8. *3-(3,4-Dichlorobenzyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4h)*

Colorless viscous oil; yield 86%; IR (KBr) (υ_{max}, cm^{-1}): 3150, 3000, 1625, 1600, 1475, 1300, 1100. ^{1}H NMR (250 MHz, $CDCl_3$): δ 4.81 (s, 2H, CH_2), 6.04 (CH of alkene), 6.78–7.98 (m, 8H, CH arom). ^{13}C NMR (62.5 MHz, $CDCl_3$): δ 46.08 (CH_2), 99.28 (CH of alkene), 126.71, 128.63, 128.73, 129.39, 129.64, 133.56 (8CH), 130.52, 135.39, 136.63, 137.23 (4C), 172.72 (C of alkene), 194.17 (C9S). Anal. Calcd. for $C_{16}H_{11}Cl_2NS_2$ (350): C, 54.55; H, 3.15; N, 3.98. Found: C, 54.49; H, 3.10; N, 3.93 %.

4.1.9. *3-(2-Methoxyethyl)-4-phenyl-1,3-thiazole-2(3H)-thione (4i)*

Colorless viscous oil; yield 86%; IR (KBr) (υ_{max}, cm^{-1}): 3100, 3000, 1650, 1600, 1475, 1200, 1100. ^{1}H NMR (250 MHz, $CDCl_3$): δ 3.16 (t, 2H, NCH_2), 3.35 (s, 3H, OCH_3), 3.63 (t, 2H, OCH_2), 6.07 (s, 1H, CH of alkene), 7.41–7.98 (m, 5H, CH arom).^{13}C NMR (62.5 MHz, $CDCl_3$): δ 46.40 (NCH_2), 58.88 (OCH_3), 68.79 (OCH_2), 105.68 (CH of alkene), 126.12, 128.73, 128.94 (5CH), 133.56 (C), 163.72 (C of alkene), 194.17 (C9S). Anal. Calcd. for $C_{12}H_{13}NOS_2$ (251): C, 57.34; H, 5.21; N, 5.57. Found: C, 57.29; H, 5.26; N, 5.62 %.

References

(1) Zhu, J.; Bienayme, H., Eds.; *Multicomponent Reactions*; Wiley: Weinheim, 2005.
(2) Henkel, B.; Sax, M.; Dömling, A. *Tetrahedron Lett*. **2003,** *44,* 3679–3682.
(3) Waller, R.W.; Diorazio, L.J.; Taylor, B.A.; Motherwell, W.B.; Sheppard, T.D. *Tetrahedron* **2010,** *66,* 6496–6507.
(4) Yavari, I.; Hossaini, Z.; Sabbaghan, M. Mol. Divers **2006,** *10,* 479–482.
(5) Chunduru, V.S.R.; Rao, V.R. *J. Sulfur Chem*. **2010,** *31,* 545–550.
(6) Yavari, I.; Bayat, M.J.; Sirouspour, M.; Souri, S. *Tetrahedron* **2010,** *66,* 7995–7999.
(7) Bayat, M.; Imanieh, H.; Zabarjad Shiraz, N.; Shah Qavidel, M. *Monatsh. Chem*. **2010,** *141,* 333–338.
(8) Ramazani, A.; Nasrabadi, F.Z.; Ahmadi, Y. *Helv. Chim. Acta* **2011,** *94,* 1024–1029.
(9) Ramazani, A.; Shajari, N.; Mahyari, A.; Ahmadi, Y. *Mol. Divers* **2011,** *15,* 521–527.
(10) Ramazani, A.; Mahyari, T.A.; Rouhani, M.; Rezaei, A. *Tetrahedron Lett*. **2009,** *50,* 5625–5627.
(11) Domling, A. *Chem. Rev.* **2006,** *106,* 17–89.
(12) Dömling, A.; Ugi, I. *Angew. Chem. Int. Ed. Engl*. **2000,** *39,* 3168–3210.
(13) Ugi, I.; Werner, B.; Dömling, A. *Molecules* **2003,** *8,* 53–66.
(14) Dömling, A.; Herdtweck, E.; Heck, S. *Tetrahedron Lett*. **2006,** *47,* 1745–1747.
(15) (a) Pessoa-Mahana, H.; Johann, K.C.; Nadia, R.H.; Recabarren-Gajardo, G.; Claudio, S. B.; Araya-Matsurana, R.; Pessoa-Mahana, C.D. *Heterocycles* **2008,** *75,* 1913–1929; (b) Blagg, J.; Mowbray, C.; Pryde, D.C.; Salmon, G.; Schmid, E.; Fairman, D.; Beaumont, K. *Bioorg. Med. Chem. Lett*. **2008,** *18,* 5601–5604.
(16) (a) Simoni, D.; Romagnoli, R.; Baruchello, R.; Rondanin, R.; Grisolia, G.; Eleopra, M.; Rizzi, M.; Tolomeo, M.; Giannini, G.; Alloatti, D.; Castorina, M.; Marcellini, M.; Pisano, C. *J. Med. Chem*. **2008,** *51,* 6211–6215; (b) Radwan, M.A.A.; Shehab, M.A.; El-Shenawy, S.M. *Monatsh. Chem*. **2009,** *140,* 445–450.
(17) (a) Fakar, I.M.I.; Radwan, M.A.A.; El-Batran, S.; Abd El-Salam, O.M.E.; El-Shenawy, S.M. *Eur. J. Med. Chem*. **2009,** *44,* 1718–1725; (b) Abreu, R.M.V.; Ferreira, I.C.F.R.; Queiroz, M.J.R.P. *Eur. J. Med. Chem*. **2009,** *44,* 1952–1958.
(18) Aloup, J.C.; Bouchaudon, J.; Farge, D.; James, C.; Deregnaucourt, J.; Hardy-Houis, M. *J. Med. Chem*. **1987,** *30,* 24–29.
(19) (a) Selwood, D.V.; Carter, K.; Young, R.J.; Jandu, K.S. *Bioorg. Med. Chem. Lett*. **1996,** *8,* 991–994; (b) Tber, B.; Fahmi, N.D.; Ronco, G.; Villa, P.; Ewing, D.F.; Mackenzie, G. *Carbohydr. Res*. **1995,** *267,* 2203–2216.
(20) Yuasa, H.; Kajimoto, T.; Wong, C.H. *Tetrahedron Lett*. **1994,** *35,* 8243–8246.
(21) (a) Yoshikawa, M.; Murakami, T.; Shimada, H.; Matsuda, H.; Yamahara, J.; Tanabe, G.; Muraoka, O. *Tetrahedron Lett*. **1997,** *38,* 8367–8370; (b) Yoshikawa, M.; Murakami, T.; Yashiro, K.; Matsuda, H. *Chem. Pharm. Bull*. **1998,** *46,* 1339–1340.
(22) (a) Souldozi, A.; Ramazani, A.; Bouslimani, N.; Welter, R. *Tetrahedron Lett.* **2007,** *48,* 2617–2620; (b) Souldozi, A.; Ramazani, A. *Tetrahedron Lett*. **2007,** *48,* 1549–1551; (c) Souldozi, A.; Ramazani, A. *Phosphorus, Sulfur, Silicon* **2009,** *184,* 3191–3198.
(23) (a) Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur, Silicon* **2009,** *184,* 2344–2350; (b) Ramazani, A.; Souldozi, A. *Arkivoc*, **2008,** *xvi,* 235–242; (c) Ramazani, A.; Salmanpour, S.; Souldozi, A. *Phosphorus, Sulfur, Silicon* **2010,** *185,* 97–102.
(24) Ramazani, A.; Rezaei, A. *Org. Lett.* **2010,** *12,* 2852–2855.
(25) Souldozi, A.; Ślepokura, K.; Lis, T.; Ramazani, A. *Z. Naturforsch*. **2007,** *62b,* 835–840.
(26) Ramazani, A.; Morsali, A.; Ganjeie, B.; Kazemizadeh, A.R.; Ahmadi, E.; Kempe, R.; Hertle, I. *Z. Naturforsch.* **2005,** *60b,* 569–571.
(27) Ramazani, A.; Noshiranzadeh, N.; Ghamkhari, A.; Slepokura, K.; Lis, T. *Helv. Chim. Acta* **2008,** *91,* 2252–2261.
(28) Ramazani, A.; Rezaei, A.; Mahyari, A.T.; Rouhani, M.; Khoobi, M. *Helv. Chim. Acta*. **2010,** *93,* 2033–2036.
(29) Ramazani, A.; Mahyari, A. *Helv. Chim. Acta*. **2010,** *93,* 2203–2209.
(30) Ramazani, A.; Nasrabadi, F.Z.; Mashhadi Malekzadeh, A.; Ahmadi, Y. *Monatsh. Chem.* **2011,** *142,* 625–630.
(31) Ramazani, A.; Ahmadi, Y.; Zeinali Nasrabadi, F. *Z. Naturforsch.* **2011,** *66b,* 184–190.
(32) Khalilzadeh, M.A.; Hossaini, Z.; Baradarani, M.M.; Hasannia, A. *Tetrahedron* **2010,** *66,* 8464–8467.