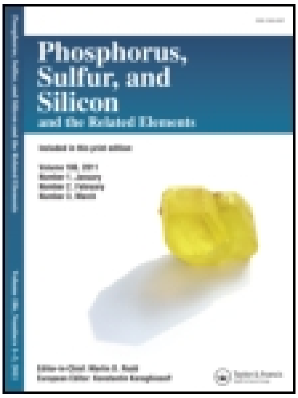
This article was downloaded by: [University of Stellenbosch]
On: 17 August 2013, At: 15:08
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gpss20

The Reaction of Thioacids with α-Haloketones in Water: an Environmentally Green Synthesis of Thioester Derivatives

Ali Ramazani [a] & Fatemeh Zeinali Nasrabadi [b]

[a] Department of Chemistry, Zanjan Branch , Islamic Azad University , Zanjan , Iran

[b] Department of Chemistry , University of Zanjan , Zanjan , Iran

Accepted author version posted online: 01 Nov 2012.Published online: 16 Aug 2013.

To cite this article: Ali Ramazani & Fatemeh Zeinali Nasrabadi (2013) The Reaction of Thioacids with α-Haloketones in Water: an Environmentally Green Synthesis of Thioester Derivatives, Phosphorus, Sulfur, and Silicon and the Related Elements, 188:9, 1214-1219, DOI: 10.1080/10426507.2012.740704

To link to this article: http://dx.doi.org/10.1080/10426507.2012.740704

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

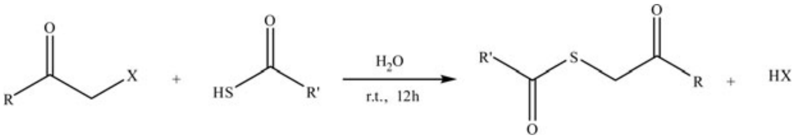
This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms &

Phosphorus, Sulfur, and Silicon, 188:1214–1219, 2013
Copyright © Taylor & Francis Group, LLC
ISSN: 1042-6507 print / 1563-5325 online
DOI: 10.1080/10426507.2012.740704

THE REACTION OF THIOACIDS WITH α-HALOKETONES IN WATER: AN ENVIRONMENTALLY GREEN SYNTHESIS OF THIOESTER DERIVATIVES

Ali Ramazani[1] and Fatemeh Zeinali Nasrabadi[2]
[1]*Department of Chemistry, Zanjan Branch, Islamic Azad University, Zanjan, Iran*
[2]*Department of Chemistry, University of Zanjan, Zanjan, Iran*

GRAPHICAL ABSTRACT



Abstract *The reaction between a thioacid and an* α*-haloketone in water affords thioester derivatives in high yields. The reaction proceeded smoothly and cleanly under mild conditions and no side reactions were observed.*

[Supplementary materials are available for this article. Go to the publisher's online edition of Phosphorus, Sulfer, and Silicon and the Related Elements *for the following free supplemental files:* Additional figures.*]*

Keywords Thioacid; α-haloketone; thioester; water; green chemistry

INTRODUCTION

α-haloketones are significant organic reagents, which have been used in the synthesis of an enormous number of both aliphatic and heterocyclic compounds. α-haloketones were obtained and described at the end of the eighteenth century.[1] They have increasingly attracted attention as a building block for the preparation of compounds of various classes because of their high reactivity and selective transformations with different reagents. The reactivity of α-haloketones toward nucleophiles was described by Tchoubar in 1955.[2]

During the past few decades, a great deal of effort has been made to develop methodologies that form carbon−sulfur bonds in the synthesis of molecules with various biological applications. Thioacids have little reactivity because of their low nucleophilic characteristic. However, the thioesters obtained from thioacids as nucleophiles are synthetically much valuable due to their widespread application in pharmaceutical chemistry and also they serve as key intermediates in the synthesis of various bioactive molecules. Meanwhile, thioesters are used as coupling partners in organometallic reactions, building blocks for the synthesis of heterocyclic compounds, and acyl transfer reactions.[3–15] Also, thioesters are

Received 24 June 2012; accepted 14 October 2012.

Address correspondence to Ali Ramazani, Department of Chemistry, Zanjan Branch, Islamic Azad University, Zanjan 49195-467, Iran. E-mail: aliramazani@gmail.com

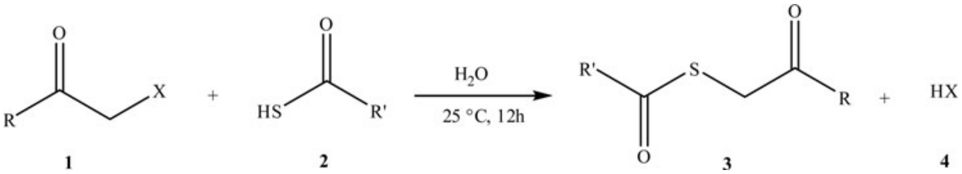
Table 1 Synthesis of thioester derivatives **3** in H_2O (see Scheme 1)

Entry	3	R	R′	X	Yield (%)[a]
1	**3a**	4-Methoxyphenyl	Ph	Br	94
2	**3b**	Methyl	Ph	Cl	92
3	**3c**	Chloromethyl	Ph	Cl	87
4	**3d**	Phenyl	Ph	Cl	87
5	**3d**	Phenyl	Ph	Br	90
6	**3e**	Phenyl	CH_3	Br	90
7	**3e**	Phenyl	CH_3	Cl	88
8	**3f**	4-Methoxyphenyl	CH_3	Br	91

[a]Yield of isolated **3**.

multipurpose intermediates in natural products synthesis, which have multifarious applications in synthetic chemistry as precursors to aldehydes, ketones, acids, esters, lactones, amides, lactams, and heterocycles.[16,17]

Recently, we have established a one-pot method for the preparation of organic compounds including heterocyclic and nonheterocyclic compounds.[18–24] As part of our ongoing program to develop efficient and robust methods for the synthesis of heteroatom-containing compounds,[25–32] we wish to report the preparation of a new class of thioester derivatives **3a–f** by condensation reaction of thioacid **2** and α-haloketone **1** in water with excellent yields (Scheme 1).



Scheme 1 Synthesis of thioester derivatives **3** (See Experimental and Table 1).

RESULTS AND DISCUSSION

We examined the reaction of thioacid with α-haloketone in water at r.t. (25°C) and we obtained the corresponding thioester derivatives **3** (Scheme 1 and Table 1).

We also used methanol, dichloromethane, and acetonitrile as solvent instead of water in this reaction; however, an increase of reaction times and a decrease of yields of **3** were observed. Also, this reaction has been performed in solvent-free conditions, the first time in the solid phase (silica gel powder) and the second time as neat conditions. Under both the conditions, an increase in reaction times and a decrease in yields of **3** was seen (Table 2).

Also, 2-chloro-2-phenylacetophenone, 2-bromo-4′-phenylacetophenone, 2-chloro-3′,4′-dihydroxyacetophenone, 3-chloro-2-butanone, and 1,4-dibromo-2,3-butanedione were used in the reaction; however, no corresponding products **3** were observed, and they were recovered without any reaction at the end of the reaction. So, these α-haloketones are not suitable as starting materials in this reaction. However, the reactions proceeded efficiently with α-haloketones, shown in Table 1.

Among the compounds we reported, compounds **3d** and **3e** are available commercially. Also, we compared spectral data of compound **3d** with the compound reported in

Table 2 Synthesis of thioester **3b** under various conditions

Entry	Solvent	Temp.	Time (h)	Yield (%)[a]
1	H_2O	r.t.	12	92
2	CH_3CN	r.t.	24	50
3	CH_3OH	r.t.	24	50
4	CH_2Cl_2	r.t.	24	50
5	Silica gel powder (0.1 g)	r.t.	24	30
6	Neat	r.t.	24	30

[a]Yield of isolated **3**.

previous literatures.[33] In comparison with other reported methods in previous literatures, the important advantage of the reported method in this paper is the use of water as it is easily available, cheap, nontoxic, and environmentally green solvent at ambient temperature, without using any kind of reagent.

In summary, the reported method offers a mild, simple, and efficient route for the preparation of thioester derivatives **3**. 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.

EXPERIMENTAL

General

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 TLC and NMR, which indicated that there is no side product. Melting points were measured on an Electrothermal 9100 apparatus and were uncorrected. IR spectra were measured on a Jasco 6300 FTIR spectrometer. ^1H and ^{13}C NMR spectra were measured ($CDCl_3$) with a BRUKER DRX-250 AVANCE spectrometer at 250.0 MHz 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 layer chromatography (PLC) plates were prepared from Merck silica gel (F_{254}) powder.

General Procedure for the Preparation of 3a–f

A mixture of α-haloketone (1.0 mmol; 0.23 g [R = 4-methoxyphenyl, X = Br], 0.08 mL [R = CH_3, X = Cl], 0.12 g [R = Chloromethyl, X = Cl], 0.15 g [R = phenyl, X = Cl], and 0.2 g [R = phenyl, X = Br]), and thioacid (1.0 mmol; 0.12 mL [R′ = Ph]), 0.07 mL [R′ = CH_3]) in H_2O (5 mL) was stirred at r.t. (25 °C) for 12 h. The solvent was removed under reduced pressure, and the viscous residue was purified by preparative layer chromatography (PLC) (silica gel [F_{254}] powder; petroleum ether–ethyl acetate [3:1]). The characterization data of the compounds are given as follows.

2-(4-Methoxyphenyl)-2-oxoethyl 1-benzenecarbothioate (3a). White powder, mp 72–74 °C, ^1H NMR ($CDCl_3$, 250 MHz): δ_H (ppm) 3.86 (s, 3H, OCH_3), 4.54 (s, 2H, CH_2), 6.95 (d, 2H, $^3J_{HH} = 8.7$ Hz, CH arom), 7.42–8.05 (m, 7H, CH arom). ^{13}C NMR ($CDCl_3$, 62.5 MHz): δ_C (ppm) 36.3 (CH_2), 55.6 (OCH_3), 114.0, 127.4, 128.7, 132.0, 133.7

(9CH), 136.0, 136.3, 164.0 (3C), 190.6 (S–C = O), 191.92 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 3001, 2921, 1700, 1659, 1599, 1447, 1262, 1205, 1169, 916, 822, 775, 688. Ms m/z (%) 286 (16), 167 (40), 149 (56), 135 (100), 105 (96), 77 (94), 69 (64), 57 (44). Anal. calcd. for $C_{16}H_{14}O_3S$ (286): C, 67.11; H, 4.93. Found: C, 67.18; H, 4.86.

2-Oxopropyl 1-benzenecarbothioate (3b). Yellow oil, ^{1}H NMR (CDCl$_3$, 250 MHz): δ_H (ppm) 2.34 (s, 3H, CH$_3$), 3.93 (s, 2H, CH$_2$), 7.43–7.99 (m, 5H, CH arom). ^{13}C NMR (CDCl$_3$, 62.5 MHz): δ_C (ppm) 28.9 (CH$_3$), 39.5 (CH$_2$), 127.4, 128.8, 133.9 (5CH), 136.1 (C), 190.4 (S–C=O), 202.04 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 3061, 2926, 1720, 1680, 1581, 1448, 1208, 1161, 913, 773, 688. Anal. calcd. for $C_{10}H_{10}O_2S$ (194): C, 61.83; H, 5.19; Found: C, 61.89; H, 5.13.

3-Chloro-2-oxopropyl 1-benzenecarbothioate (3c). White powder, mp 58–60 °C, ^{1}H NMR (CDCl$_3$, 250 MHz): δ_H (ppm) 4.05 (s, 2H, CH$_2$), 4.36 (s, 2H, CH$_2$), 7.47–8.09 (m, 5H, CH arom). ^{13}C NMR (CDCl$_3$, 62.5 MHz): δ_C (ppm) 36.3, 47.8 (2CH$_2$), 127.5, 128.8, 134.2 (5CH), 135.7 (C), 190.4 (S–C=O), 196.67 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 3075, 2962, 1735, 1681, 1649, 1447, 1204, 1042, 910, 774, 690. Anal. calcd. for $C_{10}H_9ClO_2S$ (228): C, 52.52; H, 3.97. Found: C, 52.46; H, 3.91.

2-Ooxo-2-phenylethyl 1-benzenecarbothioate (3d). White powder, mp 59–61 °C, ^{1}H NMR (CDCl$_3$, 250 MHz): δ_H (ppm) 4.59 (s, 2H, CH$_2$), 7.43–8.07 (m, 10H, CH arom). ^{13}C NMR (CDCl$_3$, 62.5 MHz): δ_C (ppm) 36.6 (CH$_2$), 127.5, 128.6, 128.72, 128.8, 133.8, 133.9 (10CH), 135.6, 136.3 (2C), 190.4 (S–C=O), 193.40 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 3050, 2918, 1700, 1656, 1577, 1445, 1285, 1207, 1195, 917, 775, 689. Anal. calcd. for $C_{15}H_{12}O_2S$ (256): C, 70.29; H, 4.72. Found: C, 70.22; H, 4.65.

2-Ooxo-2-phenylethyl Ethanethioate (3e). Yellow oil, ^{1}H NMR (CDCl$_3$, 250 MHz): δ_H (ppm) 2.41 (s, 3H, CH$_3$), 4.41 (s, 2H, CH$_2$), 7.46–8.01 (m, 5H, CH arom). ^{13}C NMR (CDCl$_3$, 62.5 MHz): δ_C (ppm) 30.3 (CH$_3$), 36.7 (CH$_2$), 128.5, 128.8, 133.7 (5CH), 135.5 (C), 193.2 (S–C=O), 194.2 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 2920, 2851, 1685, 1596, 1448, 1201, 1131, 990, 747, 688. Anal. calcd. for $C_{10}H_{10}O_2S$ (194): C, 61.83; H, 5.19. Found: C, 61.89; H, 5.25.

2-(4-Methoxyphenyl)-2-oxoethyl Ethanethioate (3f). Yellow oil, ^{1}H NMR (CDCl$_3$, 250 MHz): δ_H (ppm) 2.39 (s, 3H, CH$_3$), 3.87 (s, 3H, OCH$_3$), 4.35 (s, 2H, CH$_2$), 6.94 (d, 2H, $^3J_{HH} = 8.7$ Hz, CH arom), 7.97 (d, 2H, $^3J_{HH} = 8.7$ Hz, CH arom). ^{13}C NMR (CDCl$_3$, 62.5 MHz): δ_C (ppm) 30.3 (CH$_3$), 36.3 (CH$_2$), 55.5 (OCH$_3$), 113.9, 130.9 (4CH), 128.5, 164.0 (2C), 191.8 (S–C=O), 194.4 (C=O). IR (KBr) (υ_{max}, cm^{-1}): 2919, 2849, 1682, 1599, 1500, 1420, 1206, 1170, 989, 827. Anal. Calcd. for $C_{11}H_{12}O_3S$ (224): C, 58.91; H, 5.39. Found: C, 58.84; H, 5.46.

REFERENCES

1. Moiseev, I. K.; Makarova, N. V.; Zemtsova, M. N. *Russ. J. Org. Chem.* **2003,** 39, 1685-1701.
2. Tchoubar, B. *Bull. Soc. Chim. Fr.* **1955,** 22, 1363-1383.
3. Mariola, Z. B.; Rafal, K.; Jacek, S. *Tetrahedron* **2005,** 61, 5235-5240.
4. Fan, R. H.; Hou, X. L. *J. Org. Chem.* **2003,** 68, 726-730.
5. Li, H.; Wang, J.; Zu, L.; Wang, W. *Tetrahedron Lett.* **2006,** 47, 2585-2589.
6. Fanjul, S.; Hulme, A. N.; White, J. W. *Org. Lett.* **2006,** 8, 4219-4222.
7. Haslam, E. *Tetrahedron* **1980,** 36, 2409-2433.
8. Chakor, N.; Dallavalle, S.; Musso, L.; Moretti, M. *Tetrahedron Lett.* **2008,** 49, 5056-5058.
9. Tius, M. A.; Astrab, D. P. *Tetrahedron Lett.* **1989,** 30, 2333-2336.
10. Morita, A.; Kuwahara, S. *Org. Lett.* **2004,** 8, 1613-1616.

11. Lengar, A.; Kappe, C. O. *Org. Lett.* **2004,** 6, 771-774.
12. Ibarra, A. C.; Mendoza, M.; Orellana, G.; Quiroga, M. L. *Synthesis* **1989**, 560-562.
13. Sviridov, A. F.; Ermolenko, M. S.; Yashunsky, D. V.; Kochetkov, N. K. *Tetrahedron Lett.* **1983,** 24, 4355-4358.
14. Dubs, P.; Stuessi, R. *Synthesis* **1976**, 696-697.
15. Zali Boeini, H.; Eshghi Kashan, M. *Green Chem.* **2009,** 11, 1987-1991.
16. Paz, M. M.; Corrca, J. F.; Cabcza, M. I.; Sardina, F. J. *Tetrahedron Lett.* **1996,** 37, 9259-9262.
17. Yang, W. I.; Zhao, C.; Romo, D. *Tetrahedron* **1997,** 53, 16471-16488.
18. (a) Ramazani, A.; Mahyari, A. *Helv. Chim. Acta* **2010,** 93, 2203-2209. (b) Ramazani, A.; Ahmadi, Y.; Tarasi, R. *Heteroat. Chem.* **2011,** 1, 79-84. (c) Ramazani, A.; Ahmadi, Y.; Rouhani, M.; Shajari, N.; Souldozi, A. *Heteroat. Chem.* **2010,** 21, 368-372. (d) Ramazani, A.; Ahmadi, Y.; Mashhadi Malekzadeh, A.; Rezaei, A. *Heteroat. Chem.* **2010,** 22, 692-698. (e) Ramazani, A.; Salmanpour, S.; Souldozi, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2010,** 185, 97-102. (f) Ramazani, A.; Rouhani, M.; Rezaei, A.; Shajari, N.; Souldozi, A. *Helv. Chim. Acta* **2011,** 94, 282-288. (g) Ghomi, J. S.; Salimi, F.; Ahmadi, Y.; Ramazani, A.; Nasrabadi, F. Z. *Chemija.* **2012,** 23, 43-47. (h) Souldozi, A.; Ramazani, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2009,** 184, 3191-3198. (i) Ahankar, H.; Ramazani, A.; Amini, I.; Ahmadi, Y.; Souldozi, A. *Heteroat. Chem.* **2011,** 22, 612-616. (j) Ramazani, A.; Souldozi, A. *Arkivoc* **2008,** xvi, 235-242. (k) Ramazani, A.; Ahmadi, Y.; Mahyari, A. *Synth. Commun.* **2011,** 41, 2273-2282.
19. Ramazani, A.; Bodaghi, A. *Tetrahedron Lett.* **2000,** 41, 567-568.
20. Pakravan, P.; Ramazani, A.; Noshiranzadeh, N.; Sedrpoushan, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2007,** 182, 545-549.
21. (a) Ramazani, A.; Rahimifard, M.; Souldozi, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2007,** 182, 1-5. (b) Ramazani, A.; Rahimifard, M.; Noshiranzadeh, N.; Souldozi, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2007,** 182, 413-417. (c) Shajari, N.; Ramazani, A.; Ahmadi, Y. *Bull. Chem. Soc. Ethiop.* **2011,** 25, 1-6. (d) Ramazani, A.; Farshadi, A.; Mahyari, A.; Ślepokura, K.; Lis, T.; Rouhani, M. *J. Chem. Crystallogr.* **2011,** 41, 1376-1385. (e) Ramazani, A.; Kazemizadeh, A. R.; Marandi, F. *Phosphorus, Sulfur Silicon Relat. Elem.* **2005,** 180, 1541-1544. (f) Ramazani, A.; Noshiranzadeh, N.; Ghamkhari, A.; Ślepokura, K.; Lis, T. *Helv. Chim. Acta* **2008,** 91, 2252-2261. (g) Ramazani, A.; Rezaei, A.; Mahyari, A. T.; Rouhani, M.; Khoobi, M. *Helv. Chim. Acta* **2010,** 93, 2033-2036. (h) Noshiranzadeh, N.; Ramazani, A.; Tofangchi Mahyari, A.; Ślepokura, K.; Lis, T. *Z. Naturforsch.* **2008,** 63b, 65-70. (i) Tofangchi Mahyari, A.; Shajari, N.; Kazemizadeh, A. R.; Ślepokura, K.; Lis, T.; Ramazani, A. *Z. Naturforsch.* **2007,** 62b, 829-834. (j) Kazemizadeh, A. R.; Ramazani, A. *J. Braz. Chem. Soc.* **2009,** 20, 309-312. (k) Noshiranzadeh, N.; Ramazani, A. *Synth. Commun.* **2007,** 37, 3181-3189. (l) Ramazani, A.; Kardan, M.; Noshiranzadeh, N. *Synth. Commun.* **2008,** 38, 383-390.
22. (a) Valizadeh Holagh, M.; Maharramov, A. M.; Allahverdiyev, M. A.; Ramazani, A.; Ahmadi, Y.; Souldozi, A. *Turk. J. Chem* **2012,** 36, 179-188. (b) Ramazani, A.; Karimi, Z.; Souldozi, A.; Ahmadi, Y. *Turk. J. Chem* **2012,** 36, 81-91. (c) Noshiranzadeh, N.; Ramazani, A.; Ślepokura, K.; Lis, T. *Synth. Commun.* **2008,** 38, 1560-1568. (d) Ramazani, A.; Noshiranzadeh, N. *Synth. Commun.* **2009,** 39, 1204-1214. (e) Ramazani, A.; Shajari, N.; Tofangchi Mahyari, A.; Khoobi, M.; Ahmadi, Y.; Souldozi, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2010,** 185, 2496-2502. (f) Souldozi, A.; Ramazani, A.; Noshiranzadeh, N. *Phosphorus, Sulfur Silicon Relat. Elem.* **2006,** 181, 587-589. (g) Souldozi, A.; Ramazani, A.; Noshiranzadeh, N. *Phosphorus, Sulfur Silicon Relat. Elem.* **2006,** 181, 1271-1275. (h) Ramazani, A.; Amini, I.; Massoudi, A. *Phosphorus, Sulfur Silicon Relat. Elem.* **2006,** 181, 2373-2376. (i) Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur Silicon Relat. Elem.* **2003,** 178, 2189-2192. (j) Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur Silicon Relat. Elem.* **2003,** 178, 1329-1332. (k) Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur Silicon Relat. Elem.* **2003,** 178, 1325-1328. (l) Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur Silicon Relat. Elem.* **2003,** 178, 2663-2666. (m) Ramazani, A.; Rahimifard, M. *Phosphorus, Sulfur Silicon Relat. Elem.* **2006,** 181, 2675-2678.

23. Ramazani, A.; Shajari, N.; Gouranlou, F. *Phosphorus Sulfur Silicon Relat. Elem.* **2001,** 174, 223-227.
24. Ramazani, A.; Amini, I.; Massoudi, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2006,** 181, 2225-2229.
25. (a) Ramazani, A.; Zeinali Nasrabadi, F.; Ahmadi, Y. *Helv. Chim. Acta* **2011**, 94, 1024-1029. (b) Khoobi, M.; Ramazani, A.; Foroumad, A.; Emami, S.; Jafarpour, F.; Mahyari, A.; Slepokura, K.; Lis, T.; Shafiee, A. *Helv. Chim. Acta* **2012**, 95, 660-671. (c) Ganjali, M. R.; Aghabalazadeh, S.; Khoobi, M.; Ramazani, A.; Foroumadi, A.; Shafiee, A.; Norozi, P. *Int. J. Electrochem. Sci.* **2011**, 6, 52-62. (d) Khoobi, M.; Emami, S.; Dehghan, G.; Foroumadi, A.; Ramazani, A.; Shafiee, A. *Arch. Pharm.* **2011**, 344, 588-594. (e) Khoobi, M.; Mamani, L.; Rezazadeh, F.; Zareie, Z.; Foroumad, A.; Ramazani, A.; Shafiee, A. *J. Mol. Cat. A.* **2012**, 359, 74-80. (f) Ramazani, A.; Zeinali Nasrabadi, F.; Abdian, B.; Rouhani, M. *Bull. Korean Chem. Soc.* **2012**, 33, 453-458. (g) Zeinali Nasrabadi, F.; Ramazani, A.; Ahmadi, Y. *Mol. Divers.* **2011**, 15, 791-798. (h) Ramazani, A.; Tofangchi Mahyari, A.; Rouhani, M.; Rezaei, A. *Tetrahedron Lett.* **2009**, 50, 5625-5627. (i) Zareie, Z.; Khoobi, M.; Ramazani, A.; Foroumad, A.; Souldozi, A.; Slepokura, K.; Lis, T.; Shafiee, A. *Tetrahedron* **2012**, 68, 6721-6726. (j) Ramazani, A.; Kazemizadeh, A. R. *Curr. Org. Chem.* **2011**, 15, 3986-4020. (k) Kazemizadeh, A. R.; Ramazani, A. *Curr. Org. Chem.* **2012**, 16, 418-450. (l) Khoobi, M.; Ramazani, A.; Foroumadi, A.; Hamadi, H.; Hojjati, Z.; Shafiee, A. *J. Iran. Chem. Soc.* **2011**, 8, 1036-1042. (m) Khoobi, M.; Foroumadi, A.; Emami, S.; Safavi, M.; Dehghan, Gh.; Alizadeh, B. H.; Ramazani, A.; Ardestani, S. K.; Shafiee, A. *Chem. Biol. Drug Des.* **2011**, 78, 580-586. (n) Ramazani, A.; Souldozi, A.; Morsali, A.; Jalilian, A. R. Z. *Kristallogr. NCS* **2004**, 219, 247-248. (o) Moosavi, R.; Abbasi, A. R.; Yousefi, M.; Ramazani, A.; Morsali, A. *Ultrason. Sonochem.* **2012**, 19, 1221-1226. (p) Ramazani, A.; Abdian, B.; Zeinali Nasrabadi, F.; Shajari, N.; Ranjdoost, Z. *Bull. Korean Chem. Soc.* **2012**, 33, 3701-3705. (q) Ramazani, A.; Ahmadi, Y.; Zeinali Nasrabadi, F. Z. *Naturforsch.* **2011**, 66b, 184-190. (r) Ramazani, A.; Kalhor, R.; Rezaei, A.; Karimi, Z. *Heteroat. Chem.* **2012**, 23, 315-321. (s) Yavari, I.; Ramazani, A.; Yahya-Zadeh, A. *Synth. Commun.* **1996**, 26, 4495-4499. (t) Yavari, I.; Ramazani, A. *Phosphorus Sulfur Silicon Relat. Elem.* **1997**, 130, 73-77. (u) Ramazani, A.; Dastanra, K.; Zeinali Nasrabadi, F.; Karimi, Z.; Rouhani, M.; Hosseini, M. *Turk. J. Chem.* **2012**, 36, 467-476. (v) Ramazani, A.; Azizian, A.; Bandpey, M.; Noshiranzadeh, N. *Phosphorus Sulfur Silicon Relat. Elem.* **2006**, 181, 2731-2734. (w) Ramazani, A.; Souldozi, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2004**, 179, 529-534. (x) Ramazani, A.; Mahyari, A.; Farshadi, A.; Rouhani, M. *Helv. Chim. Acta* **2011**, 94, 1831-1837. (y) Massoudi, A.; Amini, I.; Ramazani, A.; Nasrabadi, F. Z.; Ahmadi, Y. *Bull. Korean Chem. Soc.* **2012**, 33, 39-42. (z) Ramazani, A.; Rezaei, A; Ahmadi, Y. *Phosphorus Sulfur Silicon Relat. Elem.* **2012**, 187, 22-31.
26. Ramazani, A.; Shajari, N.; Mahyari, A.; Ahmadi, Y. *Mol. Divers.* **2011,** 15, 521-527.
27. Ramazani, A.; Karimi, Z.; Souldozi, A.; Ahmadi, Y. *Turk. J. Chem.* **2012,** 36, 81-91.
28. (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) Ramazani, A.; Souldozi, A. *Phosphorus Sulfur Silicon Relat. Elem.* **2009,** 184, 2344-2350. (d) Shajari, N.; Ramazani, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2010,** 185, 1850-1857. (e) Kazemizadeh, A. R.; Ramazani, A. *Arkivoc.* **2008,** xv, 159-165. (f) Heshmati-Gonbari, M.; Ramazani, A.; Souldozi, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2009,** 184, 309-314. (g) Ramazani, A.; Bodaghi, A. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2004,** 179, 1615-1620.
29. Ramazani, A.; Rezaei, A. *Org. Lett.* **2010,** 12, 2852-2855.
30. Souldozi, A.; Ślepokura, K.; Lis, T.; Ramazani, A. *Z. Naturforsch.* **2007,** 62b, 835-840.
31. Ramazani, A.; Zeinali Nasrabadi, F.; Karimi, Z.; Rouhani, M. *Bull. Korean Chem. Soc.* **2011,** 32, 2700-2704.
32. Ramazani, A.; Zeinali Nasrabadi, F.; Mashhadi Malekzadeh, A.; Ahmadi, Y. *Monatsh. Chem.* **2011,** 142, 625-630.
33. Rao, S. A.; Chou, T.; Schipor, I.; Knochel, P. *Tetrahedron* **1992,** 48, 2025-2043.