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# Silicon tetrachloride-induced regioselective reaction of N-bromosuccinimide with arylidene malononitrile and with α,β-unsaturated ketones

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## ABSTRACT

A mild method for the regioselective N-bromosuccinimide (NBS) addition to the olefinic double bond of benzalmalononitile derivatives using tetrachlorosilane (TCS) in acetonitrile as solvent at room temperature to produce 2-bromo-2-((2,5-dioxopyrrolidin-1-yl)(aryl)methyl) malononitrile, in case of presence of donating group on benzene ring, substitution of β-hydrogen by bromine accrue at the same conditions, also α,β-unsaturated ketones react with TCS/NBS in methylene chloride as a solvent and the corresponding (geminal or vicinal) dibromoketones produced. © 2015 Trade Science Inc. - INDIA

## KEYWORDS

Tetrachlorosilane;
N-bromosuccinimide;
Olefinic double bond;
Benzalmalononitile α;
β-unsaturatedketones;
Dibromoketones.

## INTRODUCTION

N-bromosuccinimide (NBS) is a versatile reagent used as brominating and oxidizing agent[1-7], wohl-Ziegler bromination, which is one of the most popular methods of obtaining α-brominated alkyl arenes, is usually performed with *N*-bromosuccinimide (NBS) in the presence of a radical initiator at high temperature in solvent $CCl_4$[8]. Recently *ortho* bromination of aromatic compounds occurs by NBS[9,10], also NBS used for side-chain bromination of aromatic compounds in the presence of differant catalyst,[11-13] and as a catalyst for hetero ring formation[14-16]. In conjunction with our interest in exploring the utility of *in situ* reagents based on tetrachlorosilane (TCS) in organic synthesis[17], Combination of tetrachlorosilane and NBS is used for bromination of methylene ketones[18] and side chain of aromatic compound[19] under miled conditions. Because of the importance of brominated arenens as versatile intermediates in the synthesis of a wide variety of biologically active compounds[20], in this work we used this combination for regioselective N-bromosuccinimide addition or bromination to the olefinic double bond of benzalmalononitile derivatives and bromination of α,β-unsaturated ketones.

## RESULTS AND DISCUSSION

We report herein the reaction of tetrachlorosilane (TCS,1.2ml,10 mmol) N-bromo succinimide (NBS)(0.98g, 10mmol) with benzalmalononitile derivatives(10mmol) in acetonitrile as a solvent, at room temperture, addition of (NBS) to the olefinic

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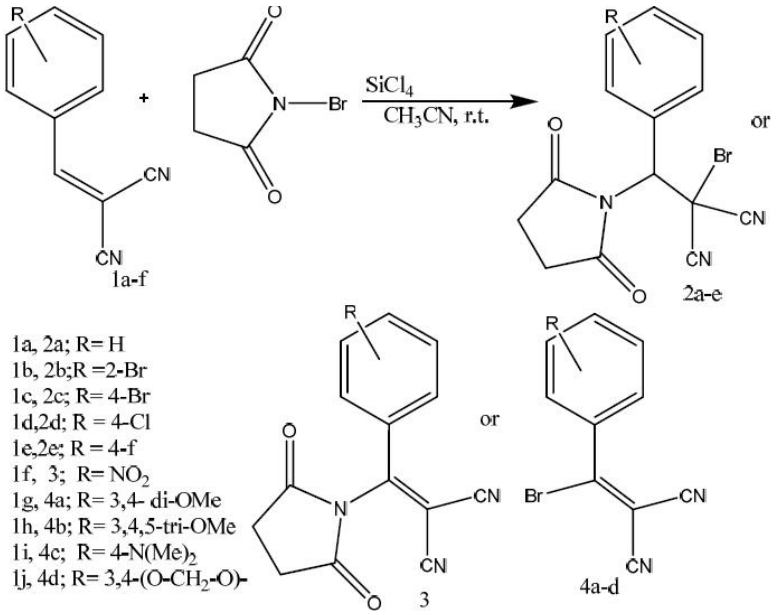



**Scheme 1 : Reaction of benzalmalononitrile with $SiCl_4$- NBS**

**TABLE 1**

| Entry | Substrate | Time/min | Product | Yield? | M.P.oc |
|---|---|---|---|---|---|
| 1 | 1a | 30 | 2a | 90 | 105-107 |
| 2 | 1b | 15 | 2b | 94 | 145-147 |
| 3 | 1c | 10 | 2c | 94 | 148-150 |
| 4 | 1d | 15 | 2d | 89 | 127-129 |
| 5 | 1e | 20 | 2e | 93 | 80-82 |
| 6 | 1f | 20 | 3 | 90 | 201-203 |
| 7 | 1g | 20 | 4a | 88 | 149-151 |
| 8 | 1h | 30 | 4b | 86 | 96 |
| 9 | 1i | 30 | 4c | 85 | 120 |
| 10 | 1j | 30 | 4d | 80 | 179-181 |

double bond of benzalmalono- nitrile derivatives is completed within (10 – 30) minuts, and the 2-bromo-2-((2,5-dioxopyrrolidin-1-yl)(aryl)methyl) malononitrile are produced in excellent yields as illustrated in scheme 1,and TABLE 1,(entry 1-5).

Presence of strong withdrawing group on benzene ring of benzalmalono-nitrile (e.g. 4-$NO_2$, entry 6) leads to dehydrobromination of the product and 2-((2,5-dioxopyrro- lidin-1-yl)(4-nitrophenyl) methylene)malononitrile (3) produced.

Identification of the products was carried out by their spectroscopic analysis, appearance of new characteristic IR signals at ≈ 1780,1710 $cm^{-1}$ for (2 C=O) for each product, also, each product exhibited new characteristic $^1$HNMR singlet for ($2CH_2$) at δ ≈ 2.8, in addition to the original signals at δ ≈ 5-6, 7-8, for H of CH and protons of aromatic respectively, $^{13}$CNMR showed new signals at δ ≈ 176 and 28 for 2(C=O) and 2($CH_2$), furthermore, the mass spectra displayed the *m/z* peaks refer to the isotopes of bromine for example compound 2a showed *m/z* at 334,332.

For generality we examined the reaction with a vast number of benzalmalononitrile possessing electron donating groups (entry 7-10), at the same conditions we found that substitution of the olefinic proton is occrue and the 2-(bromo(aryl)methylene) malononitrile (4a-d) were obtained Scheme 1, TABLE 1.

Spectroscopic analysis of product 4 showed no absorption band for carbonyl group in IR spectra,as well as no signal for the proton of olefinic CH

in $^1$HNMR, but isotopes of bromine presence in mass spectrum.

A plausible pathway of the reaction is depicted in Scheme 2. It is likely that siloxy imine A and bromonium chloride (which is a source of $Br^+$) are formed, Br+ is added to the olefinic double bond of benzalmalononitrile to produce a bridged brominium ione B. Addetion of A to B leads to the formation of the product 2. In case of more electron rich aromatic ring, Substitution of the proton of olefinic double bond accrue, and the aromatic ring not affected as reverse of reported[21].

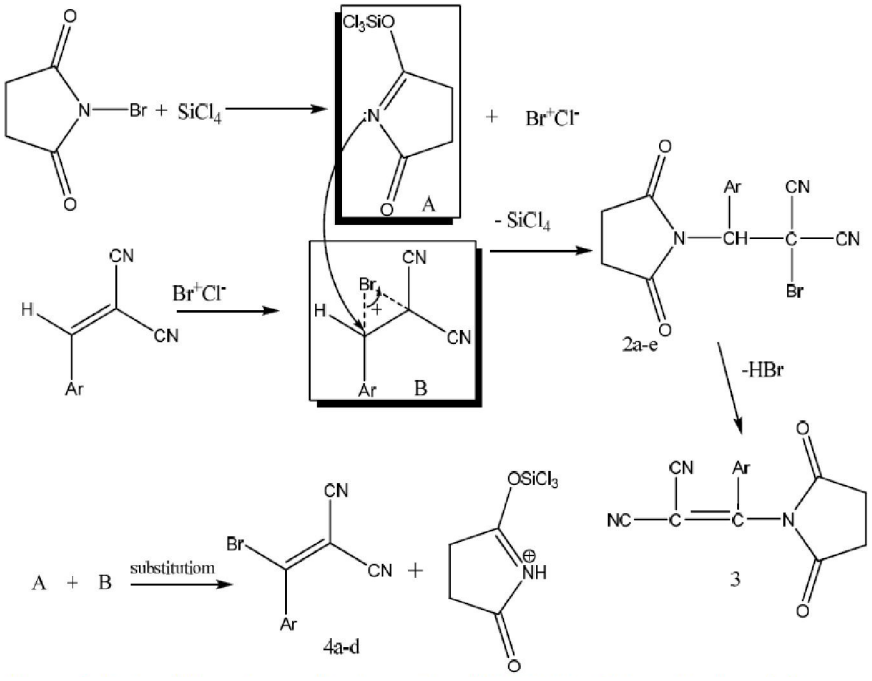
The reaction of benzalacetophenone derivatives (5a-c) with TCS-NBS reagent in$CH_2Cl_2$ as asolvent at ambient temperature produced 2,2-dibromo-1,3-diphenylpropan-1-one derivatives (6a-c) in very good yields as illustrated in scheme 3,and TABLE 2, (entry 1-3).

The generality of the reagent was examined through applying the reaction to various mono and bis chalcones, ex. 2-benzal-1-tetralone(7a-c) give the corresponding α,β-vicinal dibromoketone (8a-c), scheme 4, TABLE 2(entry4-6).

Also, on treating of 2,6-dibenzalcyclohexanone and 2,5-dibenzalcyclopentanone with TCS-NBS reagent, 6-benzylidene-2-bromo-2-(bromo(phenyl) methyl)cyclohexanone and 5-benzylidene-2-bromo-2-(bromo(phenyl)methyl)cyclopentanone produced respectively,scheme 5, TABLE 2 (entry7-10)

We found that TCS-NBS reagent exercising an unique regioselectivity at the olefinic double bond bromination of α,β-unsaturated ketones, in case of presence of α-hydrogen, 2,2-dibromoketone produced (because of elimination of HBr from 2,3-dibromoketone and α-bromoα,β-unsaturated ketone produced and then addition of HBr again under the reaction conditions), and in case of absence of α-hydrogen 2,3-dibromoketone produced. The structure of the products was assigned based on their spectral analyses as well as by matching their melting points with reported literature[22,23]. For example all compounds showed carbonyl stretching absorption in the IR spectra at ν = 1686-1710cm$^{-1}$ which indicate the saturation of double bond. The $^1$HNMR spectra of products 6a-c revealed the presence of singlet for $CH_2$ at δ = 5.55. Furthermore mass analyses of all compounds displayed peaks corresponding to the molecular ions and showed the isotopes of bromine.

In conclusion, we have presented herein a new convenient route to the synthesis of 2-bromo-2-((2,5-dioxopyrrolidin-1-yl)(phenyl)methyl)malononitrile and 2-(bromo(aryl) methylene)malononitrile with the cheap and readily available




**Scheme 2 : A plausible mechanism for the reaction of TCS-NBS with benzalmalononitrile**

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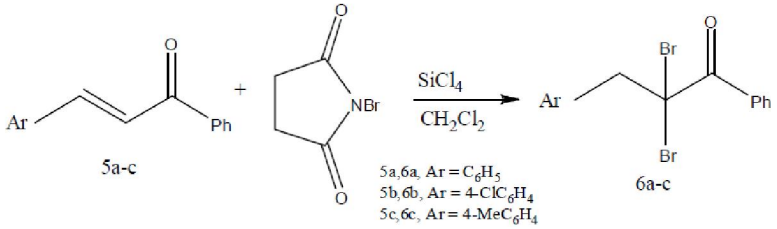
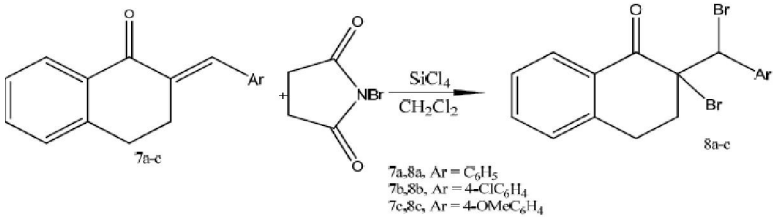
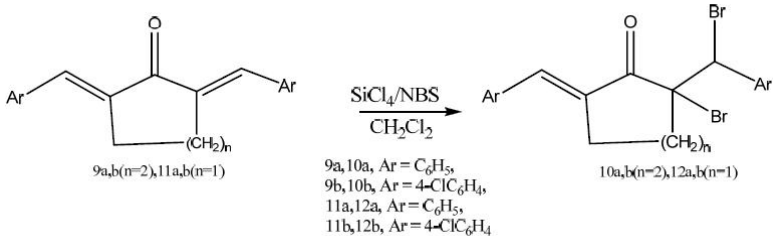



**Scheme 3 : Reaction of benzalacetophenone with $SiCl_4$- NBS**




**Scheme 4 : Reaction of benzalα- tetralone with $SiCl_4$- NBS**




**Scheme 5 : Reaction of bis chalcones with $SiCl_4$- NBS**

Tetrachlorosilane/N-bromosuccinimide reagent in acetonitrile, application of this reagent to α,β-unsaturated ketones in methylenechloride leads to formation of geminal dibromoketones - in presence of α-hydrogen – and formation of vicinal dibromoketones – in abcence of α-hydrogen. However, the good yields can be obtained, great operational simplicity at ambient temperature, applicability of this protocol for various substrates, high yields, short reaction times, and easy work-up are some advantages of this approach.. Exploring this protocol for preparation of biologically important pyrrolidinone derivatives is on-going project in our laboratory

## EXPERIMENTAL

### General

Melting points were determined using a Buchi melting point M 565 apparatus and are uncorrected. The IR spectra were recorded with Mattson FTIR spectrometer 5000. Absorption maxima were measured in $cm^{-1}$. The NMR spectra were recorded with Bruker 300 MHz spectrometer instrument in $CDCl_3$. The chemical shifts (δ) were measured in ppm. Mass spectra were recorded on a Agilent LC-MS spectrometer (pump quarter nary 1200 Series, quadrupole MSD 6110). LC column into multimode (ESI+APCI) ion source of MSD. Column chromatography was performed on silica gel (100-200 or 200-300 mesh) using petroleum ether and ethyl acetate as eluent. Thin layer chromatography (TLC) was performed on Merck silica gel GF254 plates and visualized by UV-light (254 nm). Tetrachlorosilane was used as obtained from commercial sources and used without further purification.

### General procedure for the reaction of benzal malononitrile derivatives with $SiCl_4$- NBS

To a mixture of benzalmalononitrile derivative (5 mmol) and NBS (.98g,10mmol) in $CH_3CN$ (20 ml), $SiCl_4$ (1.2ml,10 mmol) was added and the reaction mixture was stirred at room temperature. On completion (the reaction was monitored by TLC), the mixture was quenched with cold water, extracted with $CH_2Cl_2$, dried over anhydrous MgSO4 and the

**TABLE 2 : Reaction α,β-unsaturatedketones with $SiCl_4$-NBS combination**

| Entry | Substrate | Time/min | Product | Yield? | M.P.oc | Lit Mp oc. |
|---|---|---|---|---|---|---|
| 1 | 5a | 20 | 6a | 85 | 123-125 | |
| 2 | 5b | 15 | 6b | 80 | 150-152 | |
| 3 | 5c | 20 | 6c | 95 | 160-161 | |
| 4 | 7a | 15 | 8a | 85 | 149-150 | 149-150[22] |
| 5 | 7b | 20 | 8b | 85 | 158-160 | |
| 6 | 7c | 20 | 8c | 91 | 164-166 | |
| 7 | 9a | 30 | 10a | 90 | 125-126 | 122-124[23] |
| 8 | 9b | 35 | 10b | 95 | 129-130 | 128-130[23] |
| 9 | 11a | 35 | 12a | 94 | 99-101 | |
| 10 | 11b | 35 | 12b | 95 | 180-182 | |

solvent was vaporized under vacuum and the residue was chromatographed using the eluent system petroleum ether-ethyl acetate(6:1) to give pure 2a-f, 3, and (10:1) for 4a-d.

Spectral data of some examples are listed below:

2-bromo-2-((2,5-dioxopyrrolidin-1-yl)(phenyl)methyl)malononitrile(2a):IR (KBr): ν = 2944 (CH), 1777,1710 (2C=O), 1388, 1354, 779,714, 645 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =7.78-7.70(m, 2H, Ar-H) 7.50-7.39(m,3H, Ar-H), 5.75(s, 1H, CH), 2.87(s, 4H, $2CH_2$). $^{13}$CNMR δ = 176.30(2C=O), 131.34, 130.87, 130.33, 129.68(Ar-C), 111.62, 111.35 (2CN), 62.94(CH), 28.39($2CH_2$), 27.85(C). MS(*m/z*,%) = 334, 332($M^+$,3.62, 3.65), 253($M^+$-Br), 225($M^+$-Br-CN), 188 ($C_{11}H_{10}NO_2$,100), 106($PhCH_2NH_2$, 38.12).

2-((2,5-dioxopyrro-lidin-1-yl)(4-nitrophenyl) methylene)malononitrile (3): IR (KBr): ν= 2948,2926 (CH), 2242(CN), 1730 (2C=O), 1606, 1524,1350 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =8.40-8.36 (d, 2H, Ar-H) 7.78-7.74(d,3H, Ar-H), 3.05(s, 4H, $2CH_2$). MS(*m/z*,%) = 296($M^+$,15.72).

2-(bromo(3,4-di-methoxyphenyl)methylene) malononitrile (4a): IR (KBr): ν = 2955 (CH), 2222 (CN), 1596, 1568 1392, 1332, 1016, 865 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =8.1(d, 1H, Ar-H) 7.8(d,1H, Ar-H),7.15(s,1H, Ar-H) 4.00(s, 3H, OMe), 3.95(s, 3H, OMe). MS(*m/z*,%) = 294, 292($M^+$,100, 84.36), 214($M^+$-Br, 9.73), 188($M^+$-Br-CN,1.22).

**General procedure for the reaction of α,β-unsaturated ketones derivatives with $SiCl_4$- NBS**

To a mixture of α,β-unsaturated ketones derivative (5 mmol) and NBS (.98g,10mmol) in $CH_2Cl_2$ (15 ml), $SiCl_4$ (1.2ml,10 mmol) was added and the reaction mixture was stirred at room temperature. On completion (the reaction was monitored by TLC), the mixture was quenched with cold water, extracted with $CH_3Cl$, dried over anhydrous MgSO4 and the solvent was vaporized under vacuum and the residue was chromatographed using the eluent system petroleum ether-ethyl acetate(4:1) to give pure product.

Spectral data of some examples are listed below:

2,2-dibromo-1-phenyl-3-p-tolylpropan-1-one (6c): IR (KBr): ν = 3028,2996 ($CH,CH_2$), 1685 (C=O), 1594, 779,714, 645 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =8.10-8.05(d, 2H, Ar-H) 7.70-7.60(m,1H, Ar-H), 7.55-7.45(t, 2H, Ar-H), 7.25-7.20 (d, 2H, Ar-H), 5.55(s, 2H, $CH_2$), 2.35(s, 3H, $CH_3$). $^{13}$CNMR δ = 187.30(C=O), 136.34, 13.87, 133.33, 128.68(Ar-C), 78.94($CBr_2$), 45.39($CH_2$), 21.85($CH_3$). MS(*m/z*,%) =

2-bromo-2-(bromo(4-methoxyphenyl)methyl)-3,4-dihydronaphthalen-1(2H)-one(8c): IR (KBr): ν = 3034,2835($CH,CH_2$), 1695 (C=O), 1598 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =8.29-8.19(d, 2H, Ar-H) 7.60-7.28(m,5H, Ar-H), 6.98-6.88 (d, 2H, Ar-H), 6.10 (s, 1H, CH-Br), 3.85(s, 3H, $OCH_3$), 3.28-3.10 (m, 1H, CH), 3.07-2.90(m, 2H, $CH_2$), 2.41-2.30(m, 1H, CH). MS(*m/z*,%) = 424,422($M^+$) 263($M^+$-2Br).

6-benzylidene-2-bromo-2-(bromo(phenyl)

methyl)cyclohexanone(10a): IR (KBr): ν = 3034,2950(CH,$CH_2$), 1685 (C=O), 1600, 1445. 1150, 830, 700, 520 $cm^{-1}$. $^1$HNMR (300MHz, $CDCl_3$): δ =7.8 (s, 1H, =CH) 7.60-7.52(m,2H, Ar-H), 7.50-7.30 (m, 8H, Ar-H), 6.05 (s, 1H, CH-Br), 3.20-3.07(m, 1H, CH), 2.95-2.80 (m, 1H, CH), 2.70-2.55(m, H, CH), 2.25-2.10(m, 1H, CH), 2.00-1.80 (m, 2H, $CH_2$). MS(*m/z*,%) = 434,432($M^+$),273($M^+$-2Br).

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## REFERENCES

**[1]** N.Zhang, R.Yang, D.Zhang-Negrerie, Y.Du, K.Zhao; Homocoupling and J.Org.Chem., **78**, 8705-8711**(2013)**.
**[2]** K.Jeyakumar, D.K Chand; Molybdenum(VI) Dichloride Dioxide Catalyzed Synthesis, 306-310 **(2009)**.
**[3]** P.Pawluc, G.Heczycho, J.Szudkowska, M.Kubicki, B.Marciniec; Org.Lett., **11**, 3390-3393 **(2009)**.
**[4]** S.Haira, B.Maji, S.Bar, Samarium; Org Lett., **9**, 2783-2786 **(2007)**.
**[5]** X.Huang, W.J.Fu; Synthesis, 1016-1020 **(2006)**.
**[6]** L.X.Shao, M.Shi; Synlett, 1269-1271 **(2006)**.
**[7]** M.Narender, M.S.Reddy, K.R.Rao; Synthesis, 1741-1743 **(2004)**.
**[8]** C.Djerassi; Chem.Rev., **43**, 271-317 **(1948)**.
**[9]** N.Schrder; J.Wencel-Delord, F.Glorius, J.am.Chem.Soc., **134**, 8298-8301 **(2012)**.
**[10]** F.B.Du, X.Jiang, P.Sun; J.Org.Chem., **78**, 2786-2791, **(2013)**.
**[11]** D.Cantillo, O.De Frutos, J.A.Rincon, C.Mateos, C.O.Kappe; J.Org.Chem., **79**, 223"229 **(2014)**.
**[12]** D.Šterk, M.Jukič, Z.Časar; Org.Process Res.Dev., **17**, 145"151 **(2013)**.
**[13]** Y.Zhang, K.Shibatomi, H.Yamamoto; Synlett, 2837–2842 **(2005)**.
**[14]** L.Zhou, J C.Zhou, K.Tan, J.Chen, Y.Y.Yeung; Org.Lett., **13**, 2448-2451 **(2011)**.
**[15]** Q.Yan, J.Luo, D.Zhang-Negrerie, H.Li, X.Qi, K.Zhao; J.Org.Chem., **76**, 8690-8697 **(2011)**.
**[16]** M.Narender, M.S.Reddy, V.P.Kumar, B.Srinivas, R.Sridhar, Y.V.D.Nageswar, K.R.Rao; Synthesis, 3469-3472 **(2007)**.
**[17]** a) H.A.Soliman, T.A.Salama; Organic Chemistry An Indian Journal, **10**, 63-68 **(2014)**; (b) H.A.Soliman, T.A.Salama; Chin.Chem.Lett., http://dx.doi.org/10.1016/j.cclet.2013.03.021, 24 **(2013)**; (c) H.A.Soliman, T.K.Khatab; Egypt.J.Chem.in press (d) T.A.Salama, M.A.Ismail, A.M.Khalil, et al., Arkivoc, ix; 242-253 **(2012)**; (e) T.A.Salama, A.S.El-Ahl, S.S.Elmorsy, et al.; Tetrahedron Lett., **50**, 5933-5936 **(2009)**; (f) T.A.Salama, S.S.Elmorsy, A.M.Khalil; Tetrahedron Lett., **48**, 4395-4398 **(2007)**; (g) T.A.Salama, S.S.Elmorsy, A.M.Khalil, et al.; Synth.Commun., **37**,1313-1319 **(2007)**; (h) T.A.Salama, A.S.El-Ahl, A.M.Khalil, et al.; Monatsh.Chem., **134**, 1241-1252 **(2003)**; (i) S.S.Elmorsy; A.S.El-Ahl, H.A.Soliman, F.A.Amer; Tetrahedron Lett., **37**, 2297-2298 **(1996)**; (j) A.S.El-Ahl, S.S.Elmorsy, H.A.Soliman et al.; Tetrahedron Lett., **36**, 7337-7340 **(1995)**; (k) S.S.Elmorsy, A.S.El-Ahl, H.A.Soliman, F.A.Amer; Tetrahedron Letters, **36**, 2639-2640 **(1995)**.
**[18]** S.S.Elmorsy, D.S.Badawy, T.K.Khatab; Phosphorus, Sulfur Silicon and Relat.Elem., **181**, 2005-2012 **(2006)**.
**[19]** T.A.Salama, Z.Novak; Tetrahedron Lett., **52**, 4026-4029 **(2011)**.
**[20]** V.V.Vashchenko, V.V.Kravests; L.A.Kutulya Mandeleev Commun., **5**, 159 **(1995)**; C.A.,**124**, 8323g **(1996)**.
**[21]** (a) K.Rajesh, M.Somasundaram, R.Saiganesh, K.K.Balasubramanian; J.Org.Chem., **72**, 5867-5869 **(2007)**; (b) ] N.C.Ganguly; P.De, S.Dutta, Synthesis, 1103-1108 **(2005)**.
**[22]** A.Hassner, N.H.Cromwell, S.J.Davis; J.Am.Chem.Soc., **79**, 230 **(1957)**.
**[23]** A.M.Islam, A.A.Khalaf; Indian J.Chem., **7**, 546 **(1969)**.