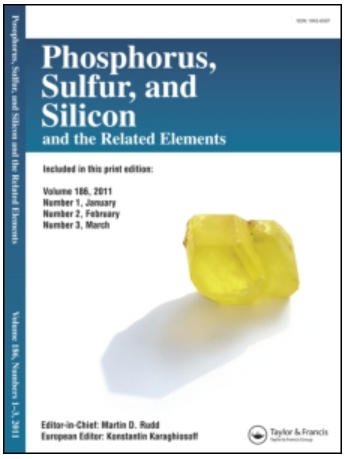

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Facile, Three-Component Synthesis of Dithiocarbamate Derivatives With Potent Antimicrobial Activity

M. S. Behalo[a]; A. A. Aly[a]
[a] Chemistry Department, Faculty of Science, Benha University, Benha, Egypt

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FACILE, THREE-COMPONENT SYNTHESIS OF DITHIOCARBAMATE DERIVATIVES WITH POTENT ANTIMICROBIAL ACTIVITY

M. S. Behalo and A. A. Aly
Chemistry Department, Faculty of Science, Benha University, Benha, Egypt

A one-pot three component synthesis of alkyl/aryl-dithiocarbamic acid-3-oxo-3-(phenoxathiin-2-yl)-1-phenyl/(4-chlorophenyl)propyl esters (3a–n) was achieved from the reaction of 3-phenyl/(4-chlorophenyl)-1-(phenoxathiin-2-yl)propenones (1a,b), amine, and carbon disulfide. The antimicrobial activities of some compounds were also screened against some selected bacteria and fungi.

Supplemental materials are available for this article. Go to the publisher's online edition of* Phosphorus, Sulfur, and Silicon and the Related Elements *to view the free supplemental file.

Keywords Antimicrobial activity; dithiocarbamates; phenoxathiin

INTRODUCTION

The chemistry of dithiocarbamates has attracted the interest of many researchers in the last several years. There are a few general approaches involving amines, carbon disulfide, and alkyl halide, epoxide or Michael acceptors to afford dithiocarbamates,[1–6] which have demonstrated a broad spectrum of applications including in the agrochemical, medicinal, and rubber industries.[7–10]

On the other hand, phenoxathiin derivatives were found to be active as potential antihypertensive,[11] antimicrobial,[12, 13] antitumor,[14] and anti-inflammatory agents[15] and have promising fluorescent properties.[16, 17] Several phenoxathiin pyridinium derivatives were prepared and have acted as effective antifungal agents against *Aspergillus* and *Candida*.[18]

In previous work, we reported three components synthesis of dithiocarbamates and heterocycles from azoalkene systems, carbon disulfide, and primary amine.[19] In our ongoing research program that aims at the synthesis of biologically active compounds,[20–22] we report here the one-pot synthesis of dithiocarbmates having bulky phenoxathiin moiety substituted at position-2 utilizing carbon disulfide, amine, and phenoxathiinylchalcones as Michael acceptors in order to enhance their biological and pharmacological activities.

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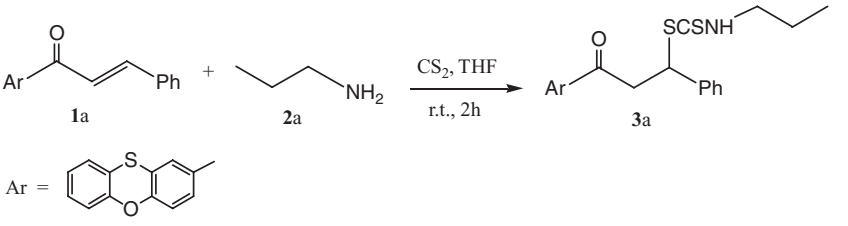
All strains were kindly supplied from Botany Department, Faculty of Science, Benha University, Benha, Egypt.

Address correspondence to M. S. Behalo, Chemistry Department, Faculty of Science, Benha University, P. O. Box 13518, Benha, Egypt. E-mail: mohamedbehalo@hotmail.com

RESULTS AND DISCUSSION

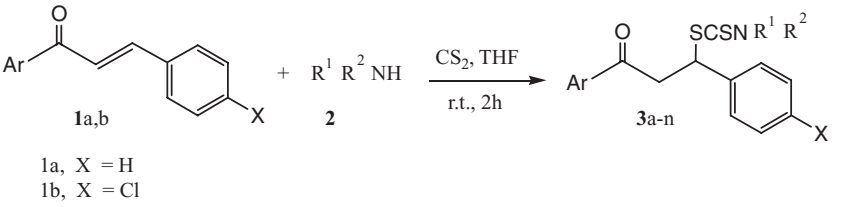
The starting chalcones, 3-phenyl/(4-chlorophenyl)-1-(phenoxathiin-2-yl)propenones (**1a**,**b**), were prepared by the reaction of 2-acetylphenoxathiin and aromatic aldehydes, namely benzaldehyde and 4-chlorobenzaldehyde.[23]

The reaction of 3-phenyl-1-(phenoxathiin-2-yl)propenone (**1a**) (1 mmol), carbon disulfide (3 mmole), and *n*-propylamine (**2a**) (1.5 mmol) in THF at room temperature afforded propyl-dithiocarbamic acid-3-oxo-3-(phenoxathiin-2-yl)-1-phenylpropyl ester (**3a**) in good yield (Scheme 1). The structure of compound **3a** was assigned on the basis of the elemental analysis and spectroscopic data (^{1}HNMR, ^{13}CNMR, MS, and IR).



Scheme 1

From these results, and in order to generalize this three-component synthesis, chalcones **1a**,**b** were allowed to react with different amines, *viz.* benzylamine, cyclohexylamine, 1-amino-2-acetaldahyde diethylacetal, diethylamine, and carbon disulide under the same reaction conditions. It was found that the reaction afforded the corresponding dithiocarbamate derivatives **3a–n** (Scheme 2). The spectral data and the elemental analysis of the products are all consistent with the assigned structures.

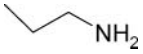
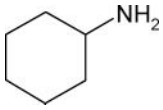
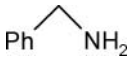
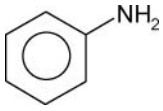
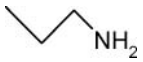
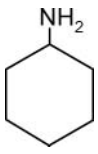
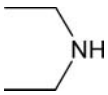
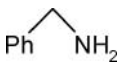
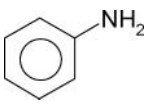


Scheme 2

The reaction was also carried out in different organic solvents such as ethanol, acetonitrile, dimethylformamide, diethyl ether, and finally solvent-free conditions. In these solvents, the reaction proceeded from low to high yield to give the corresponding dithiocarbamates (Table I).

On the other hand, aromatic amines such as aniline and *p*-toluidine did not participate well in the reaction due to isolation of low yield.

Table I Reaction of chalcones **1a**,**b** with carbon disulfide and amines

Entry	Chalcone 1	Amine, R^1R^2NH 2	Product 3	Yield% Mp °C
1	**1a**		a	85 182–184
2			b	91 177–179
3			c	88 196–198
4			d	68 206–208
5			e	83 212–214
6			f	45 194–196
7			g	49 202–204
8	**1b**		h	82 195–197
9			i	83 186–188
10			j	82 214–216
11			k	75 183–185
12			l	74 206–208
13			m	39 180–182
14			n	46 191–193

CONCLUSION

The objectives of the present study were to synthesize and investigate the biological activities of new phenoxathiin-containing compounds. This aim has been verified by an efficient three-component synthesis of dithiocarbamate derivatives **3a–n** at room temperature from the reaction of phenoxathiinylchalcones **1a**,**b**, carbon disulfide, and amines.

BIOLOGICAL ACTIVITIES

Some of the newly synthesized target compounds were evaluated in vitro for their antibacterial activity against *Bacillus Subtilis* and *Rhadococcus equii* as Gram-positive bacteria and *Pseudomonas aeruginosa* and *Escherichia coli* as Gram-negative bacteria[24] (see the Supplemental Materials, available online).

EXPERIMENTAL

All reactions were monitored by thin layer chromatography (TLC) using Merck Platen Kieselgel 60 F 25G. Chromatographic purifications were performed on columns packed with Merck silica gel 60, and melting points are uncorrected. IR spectra in KBr were recorded using a Perkin-Elmer 298 spectrophotometer. Mass spectra were obtained using a Shimadzu GCMS-QP 1000 EX mass spectrometer. ^{1}H and ^{13}C NMR spectra were obtained using 400 MHz and 100 MHz, respectively, in the Institute of Organic Chemistry, Faculty of Science and Technology, University of Urbino, Italy.

General Procedure for the Synthesis of Dithiocarbmates 3a–n

To a stirred solution of amine **2** (1.5 mmol) in THF (20 mL), CS_2 (3 mmol) was added. The chalcone **1** (1 mmol) was added, and the reaction mixture was stirred at room temperature for 2 h. Excess carbon disulfide was removed, and the crude product was purified by column chromatography on silica gel and ethyl acetate/cyclohexane as eluent.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropylpropyldithiocarbamate (3a). ^{1}H NMR (DMSO-d_6), δ ppm = 1.07–1.11 (t, 3H, CH_3), 2.03 (m, 2H, CH_2), 3.32–3.37(t, 2H, CH_2N), 3.46–3.49(d, 2H, CH_2CO), 4.85–4.93(dd, 1H, CHS), 6.97–7.53(m, 12H, Ar-H), 12.60 (s, 1H, NH, exchangeable); ^{13}C NMR 14.0 (CH_3), 22.2 (CH_2), 39.9 (CHS), 47.6 (CH_2CO), 52.4 (CH_2N), 117.2, 117.4, 117.9, 125.0, 126.6, 126.7, 127.2, 128.2, 129.0, 130.1, 131.1, 135.2, 151.9, 156.9 (phenoxathiin and phenyl carbons), 191.1 (CO), 199.1 (CS); IR, 1680 (CO), 3187 (NH), 2923, 2854 (CH_2), 1218 (CS) cm^{-1}; MS: m/z: 465 (M^+); Anal. calcd. for $C_{25}H_{23}NO_2S_3$ (465.65): C, 64.49; H, 4.98; N, 3.01%. Found: C, 64.66; H, 5.12; N, 3.21%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropylcyclohexyldithiocarbamate (3b). ^{1}H NMR (DMSO-d_6), δ ppm = 1.53 (m, 6H, $3CH_2$), 2.14 (m, 4H, $2CH_2$), 3.82 (m, 1H, CHN), 4.19–4.28 (d, 2H, CH_2CO), 5.06 (dd, 1H, CHS), 6.78–8.05(m, 12H, Ar-H), 11.10 (s, 1H, NH, exchangeable); ^{13}C NMR 22.2, 28.9, 32.3 ($5CH_2$), 39.8 (CHS), 42.7 (CH_2CO), 52.3 (CHN), 117.6, 118.3, 125.2, 125.9, 126.4, 127.0, 127.6, 128.3, 129.3, 131.5, 133.5, 144.9, 151.0, 159.0 (phenoxathiin and phenyl carbons), 193.4 (CO), 196.2 (CS); IR, 1681 (CO), 3350 (NH), 2925, 2850 (CH_2), 1216 (CS) cm^{-1}; MS: m/z: 505 (M^+); Anal. calcd. for $C_{28}H_{27}NO_2S_3$ (505.71): C, 66.50; H, 5.38; N, 2.77%. Found: C, 66.82; H, 5.47; N, 2.68%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropyl diethyldithiocarbamate (3c). ^{1}H NMR (DMSO-d_6), δ ppm = 1.13–1.24 (2t, 6H, $2CH_3$), 3.66–3.69 (d, 2H, CH_2CO), 4.01–4.17 (2q, 4H, $2CH_2$), 5.82 (dd, 1H, CHS), 6.72–7.98 (m, 12H, Ar-H), 10.47 (s, 1H, NH, exchangeable); ^{13}C NMR 11.3 ($2CH_3$), 45.7 (CHS), 47.2 ($2CH_2$), 47.9 (CH_2CO), 117.9, 118.1, 118.8, 121.6, 122.4, 122.9, 125.1, 128.3, 128.5, 131.1, 134.2, 136.2, 154.8, 156.9 (phenoxathiin and phenyl carbons), 191.2 (CO), 195.2 (CS); IR, 1704 (CO), 3378 (NH), 2980, 2844 (CH_2), 1232 (CS) cm^{-1}; MS: m/z: 479 (M^+); Anal. calcd. for $C_{26}H_{25}NO_2S_3$ (479.68): C, 65.10; H, 5.25; N, 2.92%. Found: C, 65.27; H, 5.39; N, 2.88%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropyl (2,2-diethoxyethyl)dithiocarbamate (3d). ^{1}H NMR (DMSO-d_6), δ ppm = 1.24–135 (2t, 6H, $2CH_3$), 2.25–2.26 (d, 2H, CH_2N), 4.05 (d, 2H, CH_2CO), 4.07 (dd, 1H, CHS), 4.15–4.31 (2q, 4H, $2CH_2$), 5.06 (m, 1H, OCH), 7.20–7.95 (m, 12H, Ar-H), 8.75 (s, 1H, NH, exchangeable); ^{13}C NMR 14.2 ($2CH_3$), 42.2 (CHS), 48.1 (CH_2CO), 51.5 (CH_2NH), 53.5 ($2CH_2O$), 95.4 (CHO), 115.5, 116.3, 116.9, 119.6, 121.4, 122.5, 124.2, 126.5, 128.1, 130.7, 132.5, 138.2, 151.6, 155.4 (phenoxathiin and phenyl carbons), 193.4 (CO), 198.8 (CS); IR, 1688 (CO), 3345 (NH), 2935, 2820 (CH_2), 1315 (CS) cm^{-1}; MS: m/z: 539 (M^+); Anal. calcd. for $C_{28}H_{29}NO_4S_3$ (539.72): C, 62.31; H, 5.42; N, 2.60%. Found: C, 62.45; H, 5.53; N, 2.49%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropylbenzyldithiocarbamate (3e). ^{1}H NMR (DMSO-d_6), δ ppm = 3.72 (s, 2H, CH_2), 3.78–3.82 (d, 2H, CH_2CO), 4.69 (m, 1H, CH), 6.93–7.88 (m, 17H, Ar-H), 9.38 (s, 1H, NH, exchangeable); ^{13}C NMR 43.5 (CHS), 48.7 (CH_2 CO), 51.2 (CH_2NH), 115.9, 117.3, 118.4, 121.4, 121.9, 123.1, 123.7, 125.2, 127.4, 128.3, 130.3, 131.4, 131.8, 133..1, 133.5, 141.2, 153.7, 158.4 (phenoxathiin and phenyl carbons), 188.9 (CO), 197.2 (CS); IR, 1685 (CO), 3335 (NH), 2945, 2830 (CH_2), 1240 (CS) cm$^{-1;}$ MS: m/z: 513 (M^+); Anal. calcd. for $C_{29}H_{23}NO_2S_3$ (513.68): C, 67.81; H, 4.51; N, 2.73%. Found: C, 68.11; H, 4.72; N, 2.63%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropyl phenyldithiocarbamate (3f). ^{1}H NMR (CDCl3), δ ppm = 3.35–3.38 (d, 2H, CH_2), 4.67 (m, 1H, CH), 7.01–7.98 (m, 17H, Ar H), 10.22 (s, 1H, NH, exchangeable); IR, 1684 (CO), 2930, 2845 (CH_2), 1252 (CS) cm$^{-1;}$ Anal. calcd. for $C_{28}H_{21}NO_2S_3$ (499.67): C, 67.30; H, 4.24; N, 2.80%. Found: C, 67.13; H, 4.15; N, 2.72%.

3-Oxo-3-(phenoxathiin-2-yl)-1-phenylpropyl p-tolyldithiocarbamate (3g). ^{1}H NMR (DMSO-d_6), δ ppm = 2.25 (s, 3H, CH_3), 4.12 (d, 2H, CH_2), 4.87 (m, 1H, CH), 6.92–7.50 (m, 12H, Ar-H), 10.98 (s, 1H, NH, exchangeable); ^{13}C NMR 23.2 (CH_3), 48.3 (CHS), 51.2 (CH_2 C O), 115.2, 118.2, 118.7, 120.1, 121.4, 121.4, 123.6, 125.7, 128.4, 128.5, 129.1, 131.3, 133.5, 133.8, 135.6, 144.6, 152.4, 154.8 (phenoxathiin and phenyl carbons), 192.5 (CO), 196.3 (CS); IR, 1690 (CO), 3364 (NH), 2930, 2825 (CH_2), 1282 (CS) cm^{-1}; MS: m/z: 513 (M^+); Anal. calcd. for $C_{29}H_{23}NO_2S_3$ (513.68): C, 67.81; H, 4.51; N, 2.73%. Found: C, 68.05; H, 4.75; N, 2.67%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propylpropyldithiocarbamate (3h). ^{1}H NMR (DMSO-d6), δ ppm = 1.12–1.15 (t, 3H, CH_3), 2.06 (m, 2H, CH_2), 3.25–3.28 (t, 2H, CH_2N), 3.41–3.45 (d, 2H, CH_2CO), 5.12–5.18 (dd, 1H, CH), 7.07–7.98 (m, 11H, Ar-H), 11.35 (s, 1H, NH, exchangeable); IR, 1695 (CO), 3325 (NH), 2933, 2840 146 (CH_2), 1310 (CS) cm^{-1}; Anal. calcd. for $C_{25}H_{22}NO_2S_3Cl$ (500.10): C, 60.04; H, 4.43; N, 2.80%. Found: C, 59.82; H, 4.30; N, 2.86%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propylcyclohexyldithiocarbamate (3i). ^{1}H NMR (DMSO-d_6), δ ppm = 1.80 (m, 6H, $3CH_2$), 2.44 (m, 4H, $2CH_2$), 3.07–3.09 (d, 2H, CH_2CO), 3.78 (m, 1H, CHN), 5.38–5.48 (dd, 1H, CHS),

7.08–8.01 (m, 12H, Ar-H), 11.55 (s, 1H, NH, exchangeable); ^{13}C NMR 22.0, 29.2, 31.8 (5CH2), 39.92 (CHS), 44.2 (CH_2C O), 50.17 (CHN), 118.2, 118.5, 123.8, 125.6, 126.6, 127.2, 127.7, 128.8, 130.5, 131.6, 132.8, 142.8, 152.2, 157.9 (phenoxathiin and phenyl carbons), 188.7, (CO), 193.84 (CS); IR, 1680 (CO), 3400 (NH), 2920, 2850 (CH_2), 1250(CS); MS: m/z: 540 (M^+); Anal. calcd. for $C_{28}H_{26}NO_2S_3Cl$ (540.16): C, 62.26; H, 4.85; N, 2.59%. Found: C, 62.45; H, 4.97; N, 2.66%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propyl diethyldithiocarbamate (3j). ^{1}H NMR (DMSO-*d*6), δ ppm = 1.09–1.14 (2t, 6H, $2CH_3$), 3.45–3.49 (d, 2H, CH_2 CO), 4.22–4.29 (2q, 4H, $2CH_2$), 4.91 (1H, CHS), 6.94–8.01 (m, 11H, Ar H), 9.58 (s, 1H, NH, exchangeable); IR,1687(CO), 2930, 2835 (CH_2), 1245(CS); Anal. calcd. for $C_{26}H_{24}NO_2S_3Cl$ (514.12): C, 60.74; H, 4.71; N, 2.72%. Found: C, 60.94; H, 4.88; N, 2.78%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propyl(2,2-diethoxyethyl) dithiocarbamate (3k). ^{1}H NMR (CDCl3), δ ppm = 1.15–1.28 (2t, 6H, $2CH_3$), 2.18–2.22 (d, 2H, CH_2N), 3.84–3.88 (d, 2H, CH_2CO), 4.12 (t, 1H, CHS), 4.14–4.27 (2q, 4H, 2CH2), 5.11–5.16 (m, 1H, OCH), 6.92–8.06 (m, 11H, Ar-H), 9.84 (s, 1H, NH, exchangeable); IR, 1692 (CO), 3270 (NH), 2936, 2845 (CH_2), 1260 (CS) cm $^{-1}$;Anal. calcd. for $C_{28}H_{28}NO_4S_3Cl$ (574.17): C, 58.52; H, 4.91; N, 2.44%. Found: C, 58.42; H, 4.80; N, 2.48%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propylbenzyldithiocarbamate (3l). ^{1}H NMR (DMSO-d_6), δ ppm = 3.46 (s, 2H, CH_2), 3.85–3.89 (d, 2H, CH_2CO), 5.33 (m, 1H, CH), 6.77–7.92 (m, 16H, Ar-H), 9.85 (s, 1H, NH, exchangeable); IR, 1700 (CO), 2938, 2840 (CH_2), 1270 (CS) cm $^{-1}$; Anal. calcd. for $C_{29}H_{22}NO_2S_3Cl$ (548.14): C, 63.55; H, 4.05; N, 2.56%. Found: C, 63.72; H, 4.13; N, 2.63%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propylphenyldithiocarbamate (3m). ^{1}H NMR (DMSO-*d*6), δ ppm = 3.23–3.27 (d, 2H, CH_2), 4.85 (m, 1H, CH), 6.97–8.01 (m, 16H, Ar-H), 9.23 (s, 1H, NH, exchangeable); IR, 1680 (CO), 2945, 2825 (CH2), 1312 (CS); Anal. calcd. for $C_{28}H_{20}NO_2S_3Cl$ (534.11): C, 62.97; H, 3.77; N, 2.62%. Found: C, 63.11; H, 3.85; N, 2.68%.

1-(4-Chlorophenyl)-3-oxo-3-(phenoxathiin-2-yl)propylp-tolyldithiocarbamate (3n). ^{1}H NMR (DMSO-*d*6), δ ppm = 2.38 (s, 3H, CH_3), 4.32–4.36 (d, 2H, CH_2), 5.16 (m, 1H, CH), 6.79–7.95 (m, 15H, Ar-H), 9.87 (s, 1H, NH, exchangeable); IR, 1705 (CO), 3385 (NH), 2925, 2838 (CH_2), 1310 (CS) cm^{-1}; Anal. calcd. for $C_{29}H_{22}NO_2S_3Cl$ (548.14): C, 63.55; H, 4.05; N, 2.56%. Found: C, 63.68; H, 4.12; N, 2.62%.

REFERENCES

1. C. M. Buess, *J. Am. Chem. Soc.*, **77,** 6613 (1955).
2. R. N. Salvatore, S. Sahaba, and K. W. Junga, *Tetrahedron Lett.*, **42,** 2055 (2001).
3. A. Ziyaei-Halimjani and M. R. Saidi, *J. Sulfur Chem.*, **26,** 149 (2005).
4. F. Busque, P. D. March, M. Fegueredo, J. Font, and L. Gonzales, *Eur. J. Org. Chem.*, 1492 (2004).
5. N. Azizi, F. Aryanasab, L. Torkiyan, A. Ziyaei, and M. R. Saidi, *J. Org. Chem.*, **71,** 3634 (2006).
6. N. Azizi, B. Pourhasan, F. Aryanasab, and M. R. Saidi, *Synlett*, 1239 (2007).
7. C. Rafin, E. Veignie, M. Sancholle, D. Postal, C. Len, P. Villa, and G. Ronco, *J. Agric. Food Chem.*, **48,** 5283 (2001).
8. P. J. Nieuwenhizen, A. W. Ehlers, J. G. Haasnoot, S. R. Janse, J. Reedijk, and E. J. Baerends, *J. Am. Chem. Soc.*, **121,** 163 (1999).

9. L. Ronconi, C. Marzano, P. Zanello, M. Corsini, G. Miolo, C. Macca, A. Trevisan, and D. Fregona, *J. Med. Chem.*, **49,** 1648 (2006).
10. M. R. Wood, D. J. Duncalf, S. P. Rannard, and S. Perrier, *Org. Lett.*, **8,** 553 (2006).
11. J. J. Tegeler, H. H. Ong, and J. A. Profitt, *J. Heterocyclic Chem.*, **20,** 867 (1983).
12. Y. M. Al-Hiari and B. A. Sweileh, *Asian J. Chem.*, **18**(3), 2285 (2006).
13. O. Maior, D. Gavriliu, and S. Stoia, *South. Braz. J. Chem.*, **3,** 79 (1995).
14. G. W. Rewcastle, G. J. Atwell, B. D. Palmer, P. D. Boyd, B. C. Baguley, and W. A. Denny, *J. Med. Chem.*, **34**(2), 491 (1991).
15. Y. Girard, P. Hamel, and D. Delorme, US Patent 5036067 (1990); *Chem. Abstr.*, **115,** 232258 (1991).
16. S. Ionescua, D. Gavriliu, O. Maior, and M. Hillebrand, *J. Photochem. Photobiol. A*, **124,** 67 (1999).
17. T. Constantinescu, A. Mischie, O. Maior, F. Badea, M. Vasilescu, M. T. Caproiu, R. Socoteanu, and D. Nourescu, *Rev. Roum. Chim.*, **45,** 1009 (2000).
18. C. T. Supuran, A. Scozzafava, F. Briganti, G. Loloiu, and O. Maior, *J. Enzyme Inhib.*, **31**(4), 291 (1998); *Chem. Abstr.*, **130**, 49076 (1999).
19. O. A. Attanasi, L. D. Crescentini, G. Favi, P. Filippone, G. Giorgi, F. Mantellini, G. Moscatelli, and M. S. Behalo, *Org. Lett.*, **11**(11), 2265 (2009).
20. Y. A. Issac, I. G. El-Karim, S. G. Donia, and M. S. Behalo, *Sulf. Lett.*, **25**(4), 183 (2002).
21. Y. A. Issac, I. G. El-Karim, M. S. Behalo, A. A. Aly, and S. G. Donia, *Olaj, Szappan, Kozmetika*, **57**(4), 128 (2008).
22. M. S. Behalo, *Phosphorus, Sulfur, and Silicon*, **184**(1), 206 (2009).
23. E. Lescot, N. P. Buu-Hoi, and N. D. Xuong, *J. Chem. Soc.*, 2408 (1956).
24. C. Leifert, S. Chidbouree, S. Hampson, S. Workman, D. Sigee, H. A. S. Epton, and A. Harbour, *J. Appl. Bact.*, **78,** 97 (1995).