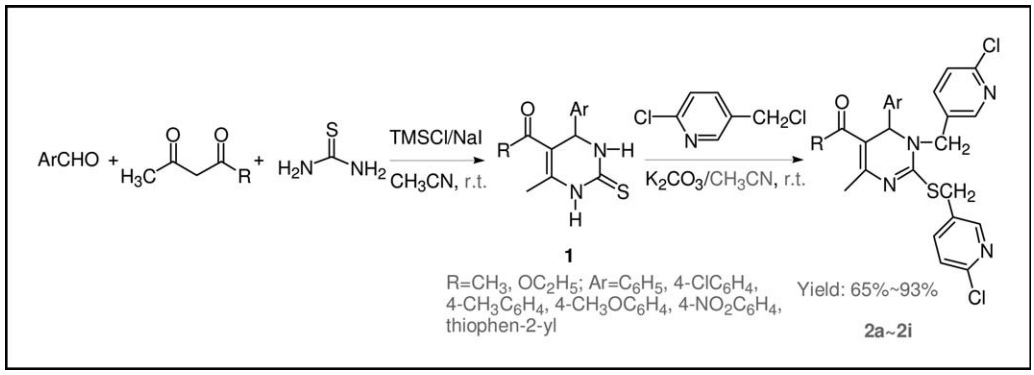
Xiao-Fei Zhu and De-Qing Shi*

Key Laboratory of Pesticide and Chemical Biology, Ministry of Education, College of Chemistry, Central China Normal University, Wuhan 430079, Hubei, People's Republic of China
*E-mail: chshidq@mail.ccnu.edu.cn

Received April 18, 2009
DOI 10.1002/jhet.390
Published online 4 March 2011 in Wiley Online Library (wileyonlinelibrary.com).



2-Chloro-5-(chloromethyl)-pyridine reacted with 3,4-dihydropyrimidin-2(1H)-ones **1** to afford 1-[6-aryl-1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-1,6-dihydropyrimidin-5-yl] carboxylates or ethanones **2** in good yields. The structure of the target compounds **2** was confirmed by IR, ^{1}H NMR, EI-MS, and elemental analyses, and compound **2a** was further characterized by single crystal X-ray diffraction. The preliminary bioassay indicated that some of the title compounds possess moderate insecticidal and fungicidal activities.

J. Heterocyclic Chem., **48**, 572 (2011).

INTRODUCTION

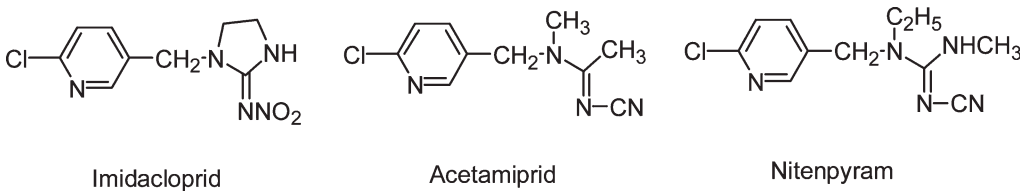
The latest class of chemical insecticides with outstanding economically impact on the agrochemical industry comprises the neonicotinoid insecticides, which act agonistically and show high selectivity to insect nicotinic acetylcholine receptor. A lot of new insecticides, such as imidacloprid, acetamiprid, and nitenpyram have been commercialized (Scheme 1) and widely used as neonicotinoid insecticides with relatively low human toxicity [1,2]. It was found that most of the biologically active neonicotinic compounds contain the aminomethylpyridine moiety [3,4]. Moreover, many compounds containing pyridyl are also known to possess a wide range of biological and pharmacological activities, as well as low toxicity toward mammals [5–8]. Recently, 3,4-dihydropyrimidin-2(1H)-ones (DHPMs) and their derivatives have attracted considerable interest because of their significant therapeutic and pharmacological properties, such as antiviral, antitumor, antibacterial, and antihypertensive effects [9–11]. There are some reports on the S-alkylation of DHPMs, and the alkylation reagents are usually benzyl and allyl halides [12,13]. However, there are few reports on the N, S-dialkylation of DHPMs in one pot reaction. As a continuation of our search for new biologically active compounds [14,15], we designed and synthesized a series of 1-[6-aryl-1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-1,6-dihydropyrimidin-5-yl]carboxylates or ethanones **2**, which have both the skeletons of DMHP and pyridine moieties.

RESULTS AND DISCUSSION

DHPMs reacted with 2-chloro-5-(chloromethyl)-pyridine to afford the target products **2** in high yields and no mono S-alkylation product was detected even with excess (3∼4 equimolecular) DHPMs. It was found that the bases played a major role in the alkylation reaction, when triethyl amine was used, the yield of product **2** was very low (about 20%) under refluxing for 12 h; however, when anhydrous potassium carbonate was used, the reaction underwent very smoothly at room temperature and the yields were also good (Scheme 2).

All products were fully characterized by IR, ^{1}H NMR, mass spectra, and elemental analysis. All the spectral data were in accordance with the anticipated structures. In the ^{1}H NMR spectra of **2**, both of the two protons of CH_2N and CH_2S moieties displayed as two doublets, giving the chemical shifts δ in 4.3, 4.4 and 4.2, 4.7, respectively. The 6-position proton of 1,6-

Scheme 1



dihydropyrimidine exhibited as a singlet with chemical shift δ between 5.0 and 5.5. IR spectra of compounds **2** showed normal stretching absorption bands, indicating the existence of C=O (~1668 cm^{-1}), C=N (~1560 cm^{-1}). The EI mass spectra of compounds **2** revealed the existence of the molecular ion peaks and anticipant fragmentation peaks (*e.g.*, compound **2b**, molecular ion peak: 510), which were in good accordance with the given structures of products.

Moreover, to confirm their molecular structure absolutely, a single crystal of **2a** was obtained as colorless crystals from a dichloromethane and hexane (1:3 v/v). X-ray diffraction analysis indicates that the single crystal of **2a** is triclinic with space group P-1, cell parameters $a = 10.289$ (1), $b = 11.149$ (1), $c = 12.639$ (1) Å, $\alpha = 104.740$ (2), $\beta = 95.725$ (2), $\gamma = 116.332$ (2)°, $v = 1218.1$ (2) $Å^3$, $z = 2$, $Dc = 1.450$ g/cm^3, F (000) = 548, $\mu = 0.489$ mm^{-1}, and final $R = 0.0502$, $wR = 0.1236$ for 5262 reflections ($I > \sigma(I)$). Figures 1 and 2 shows the molecular structure of compound **2a** and packing of the molecules in the unit cell, respectively. Intermolecular C(5)—H(5)···O1^{i} and C(25)—H(25)···(O1)^{i} [symmetry code: (i) $-x, -y, -z$] hydrogen bonds link two molecules together, these pairs are linked into a three-dimensional network by C(17)—H(17)···Cl(3)^{ii} [symmetry code: (ii) $-x+1, -y, -z$] interactions (Fig. 2 and Table 1).

Compounds **2** were tested for insecticidal activity against aphides at the concentration of 250 mg/L according to a previously reported method [16]. The result is listed in Table 2, which indicated that some of the title compounds possess moderate insecticidal activity, for example, compound **2h** exhibited 71.4% death rate against aphides at this dosage.

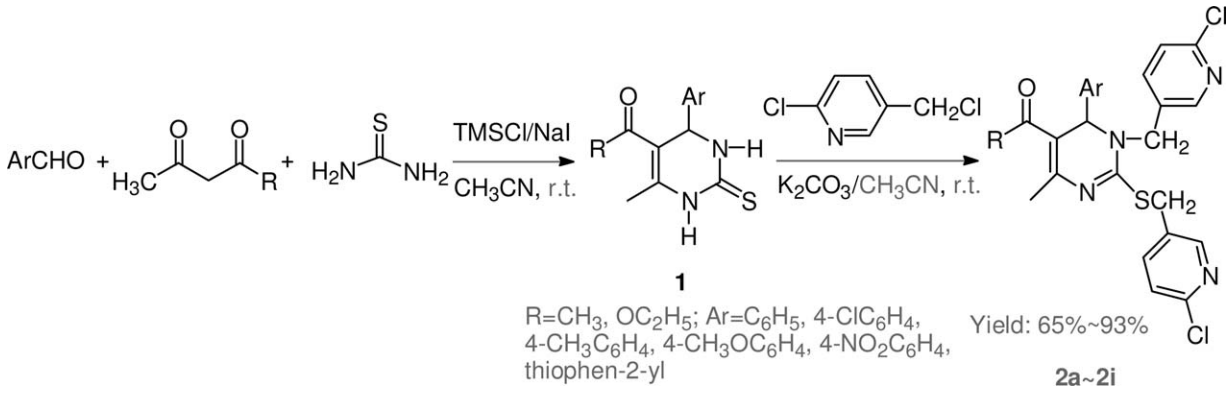
The fungicidal activities of the target compounds **2** were tested at a concentration of 50 mg/L. The six fungi used, *Fusarium oxysporium, Rhizoctonia solani*, *Botrytis cinereapers*, *Gibberella zeae*, *Dothiorella gregaria*, and *Colletotrichum gossypii*, belongs to the group of field fungi and were isolated from corresponding crops. The activity data were also listed in Table 2. The preliminary bioassay indicated that the title compounds **2** possess moderate to weak inhibitory activities against the above six fungi, for example, compound **2f** showed 78, 64, and 69% inhibitory activities against *Rhizoctonia solani, Gibberella zeae*, and *Dothiorella gregaria* fungi, respectively. Further structure-activity relationships are under investigation.

In conclusion, a series of 1-[6-aryl-1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-1,6-dihydropyrimidin-5-yl] carboxylates or ethanones 2 were synthesized *via* the alkylation reaction of DHPMs with 2-chloro-5-(chloromethyl)-pyridine. The results of the preliminary bioassays indicated that some of the title compounds possess moderate fungicidal and insecticidal activity.

EXPERIMENTAL

Melting points were determined with a WRS-1B digital melting point apparatus and are uncorrected. ^1H NMR spectra were recorded with a Varian Mercury PLUS400 (400 MHz)

Scheme 2



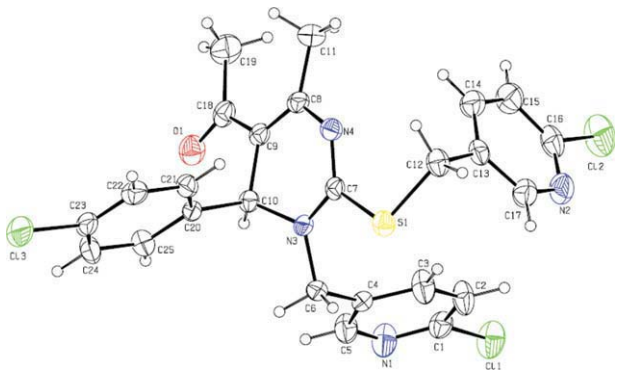


Figure 1. The structure of **2a**, showing displacement ellipsoids at the 50% probability level for non-H atoms. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

spectrometer with TMS as the internal reference and $CDCl_3$ as the solvent, while mass spectra were obtained with a Finnigan TRACEMS2000 spectrometer using the EI method. IR spectra were measured by a Nicolet NEXUS470 spectrometer. Elemental analyses were performed with an Elementar Vario ELIIICHNSO elemental analyzer. X-ray diffraction analysis was performed on a Bruker SMART 1000 CCD diffractometer. DHPMs were synthesized according to the reported method [17], all of the solvents and materials were reagent grade and purified as required.

Preparation of 1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-aryl-1,6-dihydropyrimidin-5-yl]carboxylate or ethanone 2: General procedure. The mixture of DHPM **1** (2 mmol), 2-chloro-5-(chloromethyl)-pyridine (0.65 g, 4 mmol), K_2CO_3 (0.55 g, 5 mmol), and anhydrous CH_3CN (25 mL) was stirred at room temperature until the reaction was complete (monitored by TLC). After the solid was filtered off, the filtrate was concentrated and the residue was purified by flash column chromatography on silica gel using ethyl acetate/petroleum ether (3:4, V/V) as the eluent to give **2a**–**2i** as yellow crystals or yellow oil.

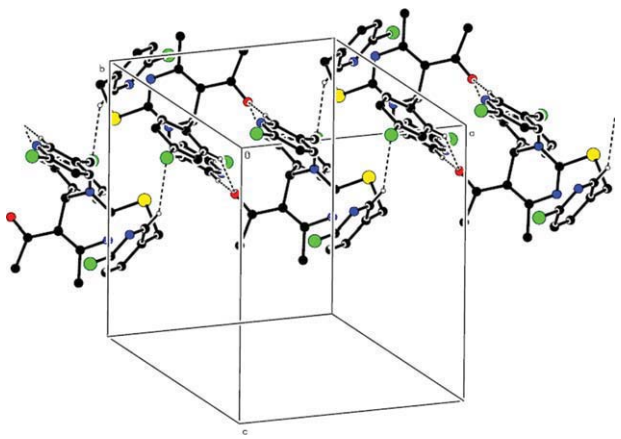


Figure 2. Part of the crystal packing of **2a**, showing molecules linked into pairs by C---H···O interactions (dashed lines). The pairs are linked further by C---H···Cl interactions (dashed lines). H atoms not involved in these interactions have been omitted. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Table 1

Hydrogen-bond geometry (Å, °).

D-H···A	D-H	H···A	D···A	D-H···A
C(5)—H(5)···O(1)^{i}	0.93	2.42	3.326 (3)	165
C(25)—H(25)···O(1)^{i}	0.93	2.55	3.348 (3)	144
C(17)—H(17)···Cl(3)^{ii}	0.93	2.80	3.564 (3)	140

Symmetry codes: (i) $-x, -y, -z$; (ii) $-x+1, -y, -z$

1-[6-(4-chlorophenyl)-1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-1,6-dihydropyrimidin-5-yl]ethanone (2a). Yellow crystals, yield: 88%, mp 104–106°C; IR: 3055 (ArH), 1619 (C=O), 1584, 1566 (C=N), 1488, 1460 cm^{-1}; ^1H NMR: δ 2.28 (s, 3H, CH_3), 2.42 (s, 3H, CH_3), 4.21 (d, J = 16 Hz, 1H, SCH_2), 4.30 (d, J = 14.4 Hz, 1H, NCH_2), 4.42 (d, J = 14.0 Hz, 1H, NCH_2), 4.73 (d, J = 16.4 Hz, 1H, SCH_2), 5.30 (s, 1H, CHAr), 7.12–7.32 (m, 4H, ArH), 7.41 (d, J = 7.6 Hz, 2H, PyH), 7.67 (d, J = 7. 6 Hz, 2H, PyH), 8.22 (s, 1H, PyH), 8.45 (s, 1H, PyH); ms (70 eV): m/z 530 (M^+, 56.0), 418 (94.2), 263 (100), 246 (31.9), 158 (29.4), 135 (96.4), 87 (99.6), 71 (99.3), 57 (93.5), 48 (97.2). *Anal*. Calcd. for $C_{25}H_{21}Cl_3N_4OS$: C, 56.45; H, 3.98; N, 10.53. Found: C, 56.64; H, 4.18; N, 10.39.

1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-(4-tolyl)-1,6-dihydropyrimidin-5-yl]ethanone (2b). Yellow crystals, yield: 85%, mp 125–127°C; IR: 3047(ArH), 1621(C=O), 1586, 1565(C=N), 1491, 1459 cm^{-1}; ^1H NMR: δ 2.24 (s, 3H, CH_3), 2.31 (s, 3H, CH_3), 2.40 (s, 3H, CH_3), 4.22 (d, J = 14.4 Hz, 1H, SCH_2), 4.31(d, J = 10.8 Hz, 1H, NCH_2), 4.43 (d, J = 10.8 Hz, 1H, NCH_2), 4.70 (d, J = 12 Hz, 1H, SCH_2), 5.25 (s, H, CHAr), 7.08–7.31 (m, 4H, ArH), 7.42 (s, 2H, PyH), 7.67 (d, J = 6.8 Hz, 2H, PyH), 8.22 (s, 1H, PyH), 8.44 (s, 1H, PyH); ms (70 eV): m/z 510 (M^+, 84.2), 417 (91.4), 350 (99.8), 260 (60.3), 228 (17.6), 136 (73.3), 113 (92.2), 87 (100), 71 (98.4), 57 (95.1), 48 (98.1). *Anal*. Calcd. for $C_{26}H_{24}Cl_2N_4OS$: C, 61.06; H, 4.73; N, 10.95. Found: C, 61.20; H, 4.60; N, 10.87.

1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-phenyl-1,6-dihydropyrimidin-5-yl]ethanone (2c). Yellow oil, yield: 90%; ^1H NMR: δ 2.23 (s, 3H, CH_3), 2.41(s, 3H, CH_3), 4.23 (d, J = 12.4 Hz, 1H, SCH_2), 4.35 (d, J = 10.4 Hz, 1H, NCH_2), 4.44 (d, J = 10.8 Hz, 1H, 1NCH_2), 4.71 (d, J = 12.4 Hz, 1H, SCH_2), 5.31 (s, H, CHAr), 7.18–7.31 (m, 5H, ArH), 7.42 (d, J = 7.6 Hz, 2H, PyH), 7.67 (d, J = 8.4 Hz, 2H, PyH), 8.23 (s, 1H, PyH), 8.45 (s, 1H, PyH); ms (70 eV): m/z 485 (M^+, 5.0), 232 (40.2), 132 (80.6), 77 (100), 63 (30.3). *Anal*. Calcd. for $C_{25}H_{22}Cl_2N_4OS$: C, 60.36; H, 4.46; N, 11.26. Found: C, 60.49; H, 4.51; N, 11.39.

1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-6-(4-methoxyphenyl)-4-methyl-1,6-dihydropyrimidin-5-yl]ethanone (2d). Yellow crystals, yield: 92%, mp 97–99°C; IR: 3050 (ArH), 1622 (C=O), 1584, 1566 (C=N), 1488, 1460 cm^{-1}; ^1H NMR: δ 2.24 (s, 3H, CH_3), 2.41 (s, 3H, CH_3), 3.78 (s, 3H, CH_3), 4.29 (d, J = 12.4 Hz, 1H, SCH_2), 4.31 (d, J = 11.4 Hz, 1H, NCH_2), 4.43 (d, J = 10.8 Hz, 1H, NCH_2), 4.71 (d, J = 12 Hz, 1H, SCH_2), 5.22 (s, 1H, CHAr), 6.78–7.31 (m, 4H, ArH), 7.42 (s, 2H, PyH), 7.70 (s, 2H, PyH), 8.23 (s, 1H, PyH), 8.45 (s, 1H, PyH). *Anal*. Calcd. for

Table 2

The insecticidal and fungicidal activities of compounds of **2a–2i** (inhibitory rate %).

	Insecticidal activity (250 mg/L)	Fungicidal activity (50 mg/L)					
Compd.	*Aphides*	*Fusarium oxysporium*	*Rhizoctonia solani*	*Botrytis cinereapers*	*Gibberella zeae*	*Dothiorella gregaria*	*Colletotrichum gossypii*
2a	20.5	13	19	27	12	14	14
2b	52.0	39	44	41	24	16	37
2c	18.4	29	64	29	18	28	53
2d	28.5	26	31	12	42	39	15
2e	6.7	32	38	26	58	12	26
2f	40.6	26	78	44	64	69	26
2g	36.0	14	34	12	17	32	48
2h	71.4	35	38	26	35	11	26
2i	65.8	45	56	32	48	38	54

$C_{26}H_{24}Cl_2N_4O_2S$: C, 59.20; H, 4.59; N, 10.62. Found: C, 59.36; H, 4.63; N, 10.61.

1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-(thiophen-2-yl)-1,6-dihydropyrimidin-5-yl]ethanone (2e). Yellow oil, yield: 77%; IR: 3050 (ArH), 1625 (C=O), 1580, 1570 (C=N), 1505, 1464 cm^{-1}; ^1H NMR: δ 2.29 (s, 3H, CH_3), 2.41(s, 3H, CH_3), 4.37(d, J = 12.8 Hz, 1H, SCH_2), 4.38 (d, J = 10.8 Hz, 1H, NCH_2), 4.43 (d, J = 10.4 Hz, 1H, NCH_2), 4.79 (d, J = 12 Hz, 1H, SCH_2), 5.30 (s, H, CHAr), 5.60–5.66 (m, 1H, Thiophene-H), 6.83 (d, J = 15 Hz, 2H, Thiophene-H), 7.17 (d, J = 4.8 Hz, 1H, PyH), 7.28 (d, J = 6.0 Hz, 1H, PyH), 7.44 (d, J = 8.0 Hz, 1H, PyH), 7.67 (d, J = 6.4 Hz, 1H, PyH), 8.25 (s, 1H, PyH), 8.42 (s, 1H, PyH). *Anal*. Calcd. for $C_{23}H_{20}Cl_2N_4OS_2$: C, 54.87; H, 4.00, N, 11.13. Found: C, 54.78; H, 4.12; N, 11.07.

1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-(4-nitrophenyl)-1,6-dihydropyrimidin-5-yl]ethanone (2f). Yellow crystals, yield 65%, mp 171–173°C; ^1H NMR: δ 2.34 (s, 3H, CH_3), 2.44 (s, 3H, CH_3), 4.21 (d, J = 15.6 Hz, 1H, SCH_2), 4.35 (d, J = 10.8 Hz, 1H, NCH_2), 4.58 (d, J = 11.4 Hz, 1H, NCH_2), 4.79 (d, J = 16 Hz, 1H, SCH_2), 5.50 (s, H, CHAr), 7.26–7.38 (m, 4H, ArH), 7.41 (d, J = 8.0 Hz, 2H, PyH), 7.69 (d, J = 8.0 Hz, 2H, PyH), 8.22 (s, 1H, PyH), 8.47 (s, 1H, PyH). *Anal*. Calcd. for $C_{25}H_{21}Cl_2N_5O_3S$: C, 55.36; H, 3.90; N, 12.91. Found: C, 55.18; H, 3.82; N, 12.77.

Ethyl 1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-(4-tolyl)-1,6-dihydropyrimidin-5-yl]carboxylate (2g.) Yellow crystals, yield 89%, mp 128–129°C; IR: 3053 (ArH), 1660 (C=O), 1599, 1586, 1564 (C=N), 1501, 1460 cm^{-1}; ^1H NMR: δ 1.14 (t, J = 7.6 Hz, 3H, CH_3), 2.32 (s, 3H, CH_3), 2.39 (s, 3H, CH_3), 3.96–4.01 (m, 2H, OCH_2), 4.20 (d, J = 16.4 Hz, 1H, SCH_2), 4.30 (d, J = 10.0 Hz, 1H, NCH_2), 4.41 (d, J = 10.4 Hz, 1H, NCH_2), 4.68 (d, J = 16.0 Hz, 1H, SCH_2), 5.07(s, H, CHAr), 7.06–7.11 (m, 4H, ArH), 7.27 (d, J = 10.4 Hz, 2H, PyH), 7.45 (d, J = 7.2 Hz, 1H, PyH), 7.68 (d, J = 8 Hz, 1H, PyH), 8.22 (s, 1H, PyH), 8.44 (s, 1H, PyH). *Anal*. Calcd. for $C_{27}H_{26}Cl_2N_4O_2S$: C, 59.89; H, 4.84; N, 10.35. Found: C, 60.02; H, 4.89; N, 10.30.

Ethyl 1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-4-methyl-6-phenyl-1,6-dihydropyrimidin-5-yl] carboxylate (2h). Yellow crystals, yield 91%, mp 68–70°C; IR: 3054 (ArH), 1668 (C=O), 1606, 1564 (C=N), 1504, 1459 cm^{-1}; ^1H NMR: δ 1.14 (t, J = 8.0 Hz, 3H, CH_3), 2.41 (s, 3H, CH_3), 3.96–4.02 (m, 2H, OCH_2), 4.09 (d, J = 14 Hz, 1H, SCH_2), 4.27 (d, J = 10.4 Hz, 1H, NCH_2), 4.44 (d, J = 10.8 Hz, 1H, NCH_2), 4.70 (d, J = 14.4 Hz, 1H, SCH_2), 5.12 (s, 1H, CHAr), 7.19–7.28 (m, 7H, ArH, PyH), 7.44 (d, J = 10 Hz, 1H, PyH), 7.69 (d, J = 8 Hz, 1H, PyH), 8.23 (s, 1H, PyH), 8.44 (s, 1H, PyH); ms (70 eV): m/z 526 (M^+, 12.6), 448(15.3), 323 (11.3), 273 (11.6), 158 (8.3), 125 (100), 89 (20.5), 77 (14.6), 63 (20.0). *Anal*. Calcd. for $C_{26}H_{24}Cl_2N_4O_2S$: C, 59.20; H, 4.59; N, 10.62. Found: C, 59.32; H, 4.47; N, 10.71.

Ethyl 1-[1-(6-chloropyridin-3-yl-methyl)-2-(6-chloropyridin-3-yl-methylthio)-6-(4-methoxyphenyl)-4-methyl-1,6-dihydropyrimidin-5-yl]carboxylate (2i). Yellow crystals, yield 93%, mp 112–114°C; ^1H NMR: δ 1.14 (t, J = 7.6 Hz, 3H, CH_3), 2.40 (s, 3H, CH_3), 3.77 (s, 3H, CH_3), 3.96–4.02 (m, 2H, OCH_2), 4.09 (d, J = 16 Hz, 1H, SCH_2), 4.30 (d, J = 10.4 Hz, 1H, NCH_2), 4.41 (d, J = 10.8 Hz, 1H, NCH_2), 4.67 (d, J = 16.4 Hz, 1H, SCH_2), 5.05 (s, H, CHAr), 6.79–7.30 (m, 6H, ArH, PyH), 7.44 (d, J = 8 Hz, 1H, PyH), 7.68 (d, J = 6.8 Hz, 1H, PyH), 8.23 (s, 1H, PyH), 8.44 (s, 1H, PyH); ms (70 eV): m/z 556 (M^+, 100), 526 (11.4), 511 (24.6), 483 (43.9). *Anal*. Calcd. for $C_{27}H_{26}Cl_2N_4O_3S$: C, 58.17; H, 4.70; N, 10.05. Found: C, 58.14; H, 4.57; N, 10.19.

FUNGICIDAL ACTIVITY TESTING

The fungicidal activity measurement method was adapted from the one described by Molina et al. [18]. The synthesized target compounds were dissolved in 0.5–1.0 mL of DMF and diluted with distilled water to the concentration of 500 mg/L. The solutions (1 mL) were mixed rapidly with thawed potato glucose agar culture medium (9 mL) under 50°C. The mixtures were poured into Petri dishes. After the dished were cooled, the solidified plates were incubated with 4 mm mycelium disk, inverted, and incubated at 28°C for 48 h. Distilled water was used as the blank control. Three replicates of each test were carried out. The mycelial elongation radius (mm) of fungi settlements was measured after 48 h of culture. The growth inhibitory rates were calculated with the following equation: $I = [(C-T)/C] \times$

100%, where, I is the growth inhibitory rate (%), C and T are the mycelial elongation radius (mm) of fungus settlements and that of treatment group, respectively. The results are listed in Table 2.

Acknowledgments. The authors are grateful to the Natural Science Foundation of China (Grant No. 20872046), and the Natural Science Foundation of Hubei Province (Grant No. 2008CDB086) for the financial support.

REFERENCES AND NOTES

[1] (a) Shiokawa, K.; Tsubo, S.; Kagabu, S.; Moriya, K. E.P. Pat. 192060, 1986; (b) Rudolf, E.; Ludwig, P. D.E. Pat. 2918775, 1980.

[2] Yamamoto, I.; Yabita, G.; Tomizawa, M.; Hissasomi, A. J Pest Sci 1994, 19, 335.

[3] Yamamoto, I. Nicotinoid Insecticides and the Nicotinic Acetylcholine Receptor; Yamamoto, I., Casida, J. E., Eds.; Springer: Tokyo, 1999; pp 3–27.

[4] Nakaya, N. M.; Ebihara, K.; Matsuno, H.; Kodaka, K. Pest Manag Sci 2003, 59, 1016.

[5] Liu, M. C.; Lin, T. S.; Cory, J. G.; Cory, A. H.; Sartorelli, A. C. J Med Chem 1996, 39, 2586.

[6] Finkelstein, B. L.; Martz, M. A.; Strock, C. J Pestic Sci 1997, 50, 319.

[7] Li, G. Y.; Qian, X. H.; Cui, J. N.; Huang, Q. C.; Zhang, R.; Guan, H. J Agric Food chem 2006, 54, 125.

[8] Jo, Y. W.; Im, W. B.; Rhee, J. K.; Shim, M. J.; Kim, W. B.; Choi, E. C. Bioorg Med Chem 2004, 12, 5909.

[9] Kappe, C. O. Tetrahedron 1993, 49, 6937.

[10] Kappe, C. O. Acc Chem Res 2000, 33, 879.

[11] Kappe, C. O. Eur J Med Chem 2000, 35, 1043.

[12] Ghorab, M. M.; Abdel-Gawad, S. M.; El-Gaby, M. S. A. Farmaco 2000, 55, 249.

[13] Rana, K.; Kaur, B.; Kumar, B. Indian J Chem B 2004, 43, 1553.

[14] Xiao, L. X.; Li, K.; Meng, L.; Shi, D. Q. Heteroatom Chem 2008, 19, 634.

[15] Shi, D. Q.; Zhu, X. F.; Song, Y. Z. Spectrochim Acta A 2008, 71, 1011.

[16] Kiriyama, K.; Kagabu, S.; Nishimura, K. J Pestic Sci 2004, 29, 43.

[17] Sabitha, G.; Reddy, G. S. K. K.; Reddy, C. S.; Yadav, J. S. Synlet 2003, 858.

[18] Molina-Torres, J.; Salazar-Cabrera, C. J.; Armenta-Salinas, C.; Ramirez-Chavez, E. J Agric Food Chem 2004, 52, 4700.