This article was downloaded by: ["University at Buffalo Libraries"] On: 11 October 2014, At: 09:39 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



# Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry

Publication details, including instructions for authors and subscription information: <u>http://www.tandfonline.com/loi/lsyc20</u>

A Convenient Synthesis of Novel N'-tert-Butyl-N'-Substituted Benzoyl-N-(Substituted Phenyl)aminocarbonylhydrazines and Their Derivatives

Qingmin Wang <sup>a</sup> & Runqiu Huang <sup>a</sup>

<sup>a</sup> State Key Laboratory of Elemento-Organic Chemistry, Research Institute of Elemento-Organic Chemistry, Nankai University, Tianjin, 300071, P.R. China Published online: 18 Oct 2011.

To cite this article: Qingmin Wang & Runqiu Huang (2004) A Convenient Synthesis of Novel N'-tert-Butyl-N'-Substituted Benzoyl-N-(Substituted Phenyl)aminocarbonylhydrazines and Their Derivatives, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 34:2, 255-264, DOI: <u>10.1081/</u> <u>SCC-120027261</u>

To link to this article: http://dx.doi.org/10.1081/SCC-120027261

# 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 & Conditions of access and use can be found at <a href="http://www.tandfonline.com/page/terms-and-conditions">http://www.tandfonline.com/page/terms-and-conditions</a>

SYNTHETIC COMMUNICATIONS<sup>®</sup> Vol. 34, No. 2, pp. 255–264, 2004

# A Convenient Synthesis of Novel N'-tert-Butyl-N'-Substituted Benzoyl-N-(Substituted Phenyl)aminocarbonylhydrazines and Their Derivatives

## Qingmin Wang and Runqiu Huang\*

State Key Laboratory of Elemento-Organic Chemistry, Research Institute of Elemento-Organic Chemistry, Nankai University, Tianjin, P.R. China

#### ABSTRACT

*N-tert*-butyl-*N*-substituted benzoylhydrazines were prepared in two convenient procedures with good yields, subsequent reaction with substituted phenylisocyanates in 1,2-dichloroethane provided a series of novel N'-tert-butyl-N'-substituted benzoyl-N-(substituted phenyl)amino-carbonylhydrazines. Further treatment with oxalyl chloride gave their derivatives in good yields. The title compounds exhibit moderate larvicidal activities and anticancer activities.

*Key Words: N'-tert*-Butyl-*N'*-substituted benzoylhydrazine; Phenylisocyanate; Benzoylphenylurea; Insect growth regulators.

255

DOI: 10.1081/SCC-120027261 Copyright © 2004 by Marcel Dekker, Inc. 0039-7911 (Print); 1532-2432 (Online) www.dekker.com

<sup>\*</sup>Correspondence: Runqiu Huang, State Key Laboratory of Elemento-Organic Chemistry, Research Institute of Elemento-Organic Chemistry, Nankai University, Tianjin 300071, P.R. China; Fax: 0086-022-23503438; E-mail: wang98h@263.net.

In contrast to traditional pesticides, benzoylphenylurea (BPU) and its derivatives mainly control the growth and development process of insects by interfering with chitin biosynthesis and breeding, and the activities of BPUs are attributed to the structures of the urea linkage.<sup>[1,2]</sup> Moreover, *N-tert*-butyl-*N,N'*-diacylhydrazines (TBDH) as a new class of insect growth regulators (IGR) have been found to mimic the action of 20-hydroxyecdysone to activate the ecdysone receptor, leading to lethal premature molting.<sup>[3–7]</sup> Relationships between the structure and biological activity of the *N-tert*-butyl-*N,N'*-dibenzoylhydrazine larvicides have been extensively investigated. The results indicated that the molecular hydrophobicity is favorable to insecticidal activity and *N-tert*-butyl-*N*-benzoylhydrazine is the biologically active unit.<sup>[8–12]</sup>

In the course of our studies on diacylhydrazine as novel IGRs,<sup>[13–15]</sup> we combined the bioactive units of TBDH and BPU to design and synthesize novel *N-tert*-buty1-*N'*-substituted benzoyl-*N*-(substituted phenyl)aminocarbonylhydrazines and their derivatives in order to find a new lead compound with unusual biological properties and a different spectrum of activities.

N-tert-Butyl-N-substituted benzoylhydrazines are important intermediates in synthesis of N-tert-butyl-N,N'-dibenzoylhydrazine derivatives and three synthesis methods of such compound have been published as exemplified below. (1) N-tert-Butylhydrazine was reacted with di-tert-butyldicarbonate to afford *N-tert*-butyloxycarbonyl-N'-tert-butylhydrazine, then condensation with benzoylchloride and deprotection using hydrochloric acid yielded N-tert-butyl-N-benzoylhydrazine in 38% yield;<sup>[16]</sup> (2) N-tertbutylhydrazine was reacted with N-(9-fluorenylmethylcarbonyl)succinimide to afford N-tert-butyl-N-(9-fluorenylmethylcarbonyl)hydrazine, then acylation and deprotection using piperidine provided N-tert-butyl-N-substituted benzoylhydrazine;<sup>[8]</sup> and (3) *N-tert*-butyl-N'-acetonehydrazine prepared from N-tert-butylhydrazine and acetone was condensation with substituted benzoylchloride, then deprotection using hydrochloric acid afforded N-tertbutyl-N-substituted benzoylhydrazine.<sup>[17]</sup> However, all of these methods have some respective problems. In the methods (1) and (3), the yields are low (<50%). The method (2) is not economically profitable, because an expensive N-(9-fluorenylmethycarbonyl)succinimide is used. Herein we report the syntheses of N-tert-butyl-N-substituted benzoylhydrazines by two novel procedures as shown in Schs. 1 and 2.

**Method 1.** Benzyl alcohol was treated with triphosgene [bis(trichloromethyl)carbonate] to obtain benzyl chloroformate in good yield. This convenient synthesis of benzyl chloroformate avoids the use of phosgene gas and the complicated experimental set-up associated with it. Benzyl chloroformate was condensed with *tert*-butylhydrazine hydrochloride to give *N-tert*butyl-*N*'-benzyloxycarbonylhydrazine (1), and subsequent acylation with

ORDER		REPRINTS
-------	--	----------



Scheme 1.





Downloaded by ["University at Buffalo Libraries"] at 09:39 11 October 2014

substituted benzoyl chlorides yielded the *N-tert*-butyl-*N'*-benzyloxycarbonyl-*N*-substituted benzoylhydrazines (**2**). Further deprotection using 5% Pd-C as a catalyst provided *N-tert*-butyl-*N*-substituted benzoylhydrazines (**3**) in good yields as shown in Scheme 1 and Table 1. This highly efficient method for the synthesis of *N-tert*-butyl-*N*-substituted benzoylhydrazines enjoys a number of advantages in that the reaction is carried out under mild conditions in good

		Isolate	d yield (%)
Entry	Xn	$1 \rightarrow 2a{-}e$	2a - e  ightarrow 3a - e
a	Н	90	96
b	3,5-Me <sub>2</sub>	83	92
c	2-F	86	96
d	2-Cl	91	90
е	2.4-Cl <sub>2</sub>	87	82

*Table 1. N-tert*-butyl-*N*-substituted benzoylhydrazine yield using 5% Pd-C catalyst.



ORDER		REPRINTS
-------	--	----------

		Isola	ted yield (%)
Entry	Xn	$4 \rightarrow 5a,5f{-}g$	5a, 5f-g $\rightarrow$ 3a, 3f-g
a	Н	81	76
f	3-Me	77	73
g	4-OMe	81	78

*Table 2. N-tert*-butyl-*N*-substituted benzoylhydrazine yield using sodium hydroxide.

258

yields, the starting materials are cheap a easily prepared, the experimental procedure is very simple and this method may be applicable to large scale production.

**Method 2.** Phenyl chloroformate was treated with *tert*-butylhydrazine hydrochloride to obtain *N-tert*-butyl-*N'*-phenyloxycarbonylhydrazine (**4**), and subsequent acylation with substituted benzoyl chloride yielded the *N-tert*-butyl-*N'*-phenyloxycarbonyl-*N*-substituted benzoylhydrazines (**5**). Further deprotection using sodium hydroxide provided *N-tert*-butyl-*N'*-substituted benzoylhydrazines (**3**) as shown in Scheme 2 and Table 2. As a consequence of its practical simplicity and high efficiency, this new method has already been applied to the preparation of *N-tert*-butyl-*N*-substituted benzoylhydrazines in our laboratory.

The reactions of the *N-tert*-butyl-*N*-substituted benzoylhydrazines (3) with substituted phenylisocyanates in 1,2-dichloroethane provided *N'-tert*-butyl-*N'*-substituted benzoyl-*N*-(substituted phenyl)aminocarbonylhydrazines (6) as shown in Sch. 3 and Tables 3–5. The structures of the title compounds 6 were confirmed by <sup>1</sup>H NMR and IR and mass spectra and elemental analysis. For example, for **6f**, 3343 cm<sup>-1</sup> (s) corresponds to an N–H stretching absorption band,  $1720 \text{ cm}^{-1}$  (s) and  $1621 \text{ cm}^{-1}$  (s) to C==O stretching absorption bands,  $1392 \text{ cm}^{-1}$  (s) and  $1360 \text{ cm}^{-1}$  (s) to the C–H absorption bands in the Bu<sup>t</sup> group. The EI-MS of the title compound **6f** gives the molecular ion peaks (373.20, M<sup>+</sup>) and those of the main fragments.

Treatment of the N'-tert-butyl-N'-substituted benzoyl-N-(substituted phenyl)aminocarbonylhydrazines (6) with oxalyl chloride gave the colorless



Scheme 3.

ORDER		REPRINTS
-------	--	----------

		Table 3.	Experimenta	l and microanal	ytical data for 6a-	- <b>m</b> and <b>7m</b> .	
Entry	Xn	Yn	Yield (%)	MP (°C)	Elemental C	Analysis (%) H	Found (calcd.) N
6a	Η	Η	75	259-260	69.49(69.43)	6.72(6.80)	13.58(13.49)
6b	Н	4-F	81	251 - 253	65.41(65.64)	6.11(6.12)	12.73(12.76)
6c	Н	4-OMe	87	205 - 207	66.47(66.84)	6.67(6.79)	12.32(12.31)
6d	Н	r	87	212 - 214	57.04(56.85)	5.04(5.04)	10.86(11.05)
6e	Н	3,4-Cl2	57	239 - 240	70.68(70.77)	7.36(7.42)	12.20(12.38)
6f	3,5-Me2	2,6-Me2	87	256-257	64.35(64.25)	6.44(6.47)	11.17(11.24)
6g	2-F	4-CI	69	218 - 219	59.49(59.42)	5.26(5.26)	11.44(11.55)
6h	2-CI	4-CI	80	245 - 246	56.75(56.85)	4.93(5.04)	10.95(11.05)
6i	2-CI	4-C1	79	226 - 227	62.61(62.52)	5.75(5.83)	12.02(12.15)
6j	2,4-C12	Н	71	174 - 175	56.99(56.85)	5.31(5.04)	11.05(11.05)
6k	3,5-Me2	Н	80	237 - 238	66.99(67.21)	6.50(6.77)	12.04(11.76)
61	2-F	4-F	84	233 - 235	62.25(62.24)	5.46(5.51)	12.20(12.10)
6m	Н	4-F	75	243 - 245	62.49(62.52)	5.77(5.83)	11.98(12.15)
7m	Н	4-CI	71	124 - 126	59.86(60.08)	4.37(4.54)	10.74(10.51)





ORDER		REPRINTS
-------	--	----------

Entry	$\delta$ (ppm) (DMSO-d <sub>6</sub> )
6a	1.46(s, 9H, Bu <sup>t</sup> ), 6.84–7.50(m, 10H, Ph), 8.39(s, 1H, NH), 8.54(s, 1H, NH).
6b	1.45(s, 9H, Bu <sup>t</sup> ), 6.97-7.72(m, 9H, Ph), 8.44(s, 1H, NH), 8.56(s, 1H, NH).
6c	1.45(s, 9H, Bu <sup>t</sup> ), 3.66(s, 3H, OMe), 6.74–7.44(m, 9H, Ph), 8.17(s, 1H, NH), 8.44(s, 1H, NH).
6d	1.45(s, 9H, Bu <sup>t</sup> ), 7.13-7.63(m, 8H, Ph), 8.77(s, 1H, NH), 8.86(s, 1H, NH).
6e	1.46(s, 9H, Bu <sup>t</sup> ), 1.83(s, 6H, Me), 6.96-7.39(m, 8H, Ph), 8.66(br., 1H, NH).
6f	1.44(s, 9H, Bu <sup>t</sup> ), 2.20(s, 6H, Me), 6.94–7.27(m, 7H, Ph), 8.52(s, 1H, NH), 8.56(s, 1H, NH).
6g	1.52(s, 9H, Bu <sup>t</sup> ), 7.00-7.64(m, 8H, Ph), 8.34(s, 1H, NH), 8.56(s, 1H, NH).
6h	1.52(s, 9H, Bu <sup>t</sup> ), 7.04–7.52(m, 8H, Ph), 8.32(s, 1H, NH), 8.42(s, 1H, NH).
6i	1.52(s, 9H, Bu <sup>t</sup> ), 6.80-7.52(m, 9H, Ph), 8.20(s, 1H, NH), 8.40(s, 1H, NH).
6j	1.46(s, 9H, Bu <sup>t</sup> ), 6.86–7.94(m, 8H, Ph), 8.34(s, 1H, NH), 8.61(s, 1H, NH).
6k	1.52(s, 9H, Bu <sup>t</sup> ), 2.26(s, 6H, Me), 6.56-7.44(m, 7H, Ph), 8.22(s, 1H, NH),
	8.40(s, 1H, NH).
6l	1.50(s, 9H, Bu <sup>t</sup> ), 6.72–7.60(m, 8H, Ph), 8.20(s, 1H, NH), 8.48(s, 1H, NH).
6m 7m	1.45(s, 9H, Bu <sup>t</sup> ), 7.16–7.42(m, 9H, Ph), 8.36(s, 1H, NH), 8.6 1(s, 1H, NH). 1.59(s, 9H, Bu <sup>t</sup> ), 7.01–7.38(m, 9H, Ph).

*Table 4.* <sup>1</sup>H NMR data for 6a-m and 7m.

260

Table 5. IR data for 6a-m and 7m.

Entry	$IR (cm^{-1}) (KBr)$
6f	3343, 3114, 2964, 1720, 1621, 1594, 1533, 1490, 1392, 1360, 1223, 1190, 1090, 852, 822, 757, 691, 618.
6m	3371, 3255, 2995, 1691, 1626, 1590, 1532, 1501, 1395, 1366, 1218, 1197, 824, 706, 699, 604.
7m	3092, 2975, 1790, 1753, 1695, 1492, 1392, 1311, 1190, 804, 741, 699.

crystalline products (7) in good yields (>70%) as shown in Sch. 4. The structures of the title compounds 7 were confirmed by <sup>1</sup>H NMR and IR and mass spectra and elemental analysis. For example, for **7m**, 1790 cm<sup>-1</sup> (s),  $1753 \text{ cm}^{-1}$  (S) and  $1695 \text{ cm}^{-1}$  (s) to C=O stretching absorption bands,



Scheme 4.

Marcel Dekker, Inc. 270 Madison Avenue, New York, New York 10016



 $1392 \text{ cm}^{-1}$  (s) and  $1311 \text{ cm}^{-1}$  (s) to the C–H absorption bands in the Bu<sup>t</sup> group. The EI-MS of the title compound **7m** gives the molecular ion peaks (399.15, M<sup>+</sup>) and those of the main fragments.

The larvicidal activities of the title compounds (6) and (7) and *N*-tertbutyl-*N*,*N*'-dibenzoylhydrazine (**RH5849**) were evaluated using previously reported procedure.<sup>[7,16,18,19]</sup> The larvicidal activities show that the title compounds (6) and (7) exhibit moderate larvicidal activities. For example, at 1000 ppm, the percent mortality of compounds **6f**, **6k** and **RH5849** is 75.0%, 82.5% and 100%, respectively. Toxicity assays indicated that the title compounds (**6**) and (**7**) can induce a premature, abnormal and lethal larval molt. The symptoms of toxicity included discoloration, weight loss, cessation of feeding, and developmentally premature, lethal molting at higher rates.

We have found that the title compounds (**6**) possess anticancer activities in vitro. The anticancer activity was assayed by the MTT or SRB methods.<sup>[20–23]</sup> For example, at 1000  $\mu$ M, the inhibition rate of compound **6c** to P388 and A-549 is 29.8% and 29.2%, respectively. The inhibition rate of compound **6b** to HL-60 and BEL-7402 is 33.3% and 21.6%, respectively.

### **EXPERIMENTAL**

Downloaded by ["University at Buffalo Libraries"] at 09:39 11 October 2014

All the melting points were determined with Thomas-Hoover melting point apparatus, the thermometer was not standardized. IR spectra were recorded with a Shimadzu-435. <sup>1</sup>H NMR spectra were recorded with Bruker AC-P200 using tetramethylsilane as an internal standard. Mass spectra were recorded with HP5988A spectrometer using the EI method. Elemental analysis was carried out with a Yanaco CHN Corder MT-3 elemental analyzer.

*N-tert*-Butyl-*N*-substituted benzoylhydrazines 3a-e. To a solution of *N-tert*-butyl-*N*-benzyloxycarbonyl-*N*-substituted benzoylhydrazine 2a-e (41.40 mmol) in methanol (100 mL) was added 5% Pd-C. Hydrogen gas was then admitted to the solution. The reaction was monitored by TLC and stopped after complete consumption of 2a-e. The solid was filtered off and the filtrate was concentrated under vacuum to obtain a white powder.

**3a**. m.p. 127–129°C. (literature m.p.:  $124-125^{\circ}$ C)<sup>[16]</sup> <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$  1.48 (s, 9H, Bu<sup>t</sup>), 3.90 (s, 2H, NH<sub>2</sub>), 7.28–7.56 (m, 5H, Ph).

**3b.** m.p. 128–130°C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$  1.48 (s, 9H, Bu<sup>t</sup>), 2.34 (s, 6H, Me), 4.08 (s, 2H, NH<sub>2</sub>), 7.00–7.20 (m, 3H, Ph).

**3c.** m.p. 106–107°C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$  1.52 (s, 9H, Bu<sup>t</sup>), 4.06 (s, 2H, NH<sub>2</sub>), 6.96–7.60 (m, 4H, Ph).

**3d**. m.p. 59–61°C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$  1.52 (s, 9H, Bu<sup>t</sup>), 4.00 (s, 2H, NH<sub>2</sub>), 7.20–7.60 (m, 4H, Ph).



ORDER		REPRINTS
-------	--	----------

**3e**. m.p. 103–105°C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$  1.50 (s, 9H, Bu<sup>t</sup>), 3.88 (s, 2H, NH<sub>2</sub>), 7.20–7.50 (m, 3H, Ph).

#### N-tert-Butyl-N-Substituted Benzoylhydrazines 3a, 3f-g

*N-tert*-Butyl-*N'*-phenyloxycarbonyl-*N*-substituted benzoylhydrazine (8.00 mmol) was dissolved in lukewarm ethanol (40 mL). While the reaction mixture was stirred, a 15% aqueous solution of sodium hydroxide (50 mL) was added. Following the addition, the mixture was stirred at 60°C for 1 hr, then cooled, and extracted three times with 100 mL of chloroform. The extraction solvent was dried over anhydrous magnesium sulfate and filtered. The solvent was removed by distillation to give a white solid. The solid was then recrystallized from isopropanol and petroleum ether to obtain a colorless crystalline solid.

**3a.** m.p.  $127-129^{\circ}$ C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$ : 1.48 (s, 9H, Bu<sup>t</sup>), 3.90 (s, 2H, NH<sub>2</sub>), 7.28–7.56 (m, 5H, Ph). IR (KBr): 3276.0 (NH<sub>2</sub>), 1620.5 (C=O), 1573.1, 1529.5, 1508.8 (Ph), 1375.6, 1350.0 (Bu<sup>t</sup>), 719.6, 696.7 (Ph) cm<sup>-1</sup>.

**3f.** m.p. 98–100°C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$ : 1.45 (s, 9H, Bu<sup>t</sup>), 2.36 (s, 3H, Me), 3.78 (br., 2H, NH<sub>2</sub>), 7.28 (m, 4H, Ph). Anal. Calcd. for C<sub>12</sub>H<sub>18</sub>N<sub>2</sub>O (%): C, 69.87; H, 8.79; N, 13.58. Found: C, 69.85; H, 8.88; N, 13.56.

**3g.** m.p.  $151-152^{\circ}$ C. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz)  $\delta$ : 1.45 (s, 9H, Bu<sup>t</sup>), 3.80 (s, 3H, OMe), 4.00 (br., 2H, NH<sub>2</sub>), 6.85, 7.48 (dd, 4H, <sup>3</sup>*J*<sub>HH</sub> = 8.4 Hz, Ph). Anal. Calcd. for C<sub>12</sub>H<sub>18</sub>N<sub>2</sub>O (%): C, 64.84; H, 8.16; N, 12.60. Found: C, 64.42; H, 8.42; N, 12.78.

## General Procedure for the Preparation of N'-tert-Butyl-N'-Substituted Benzoyl-N-(Substituted Phenyl)aminocarbonylhydrazines (6a-m)

To a stirred solution of the *N*-tert-butyl-*N*-substituted benzoylhydrazine (3) (2.17 mmol) in 1,2-dichloroethane (10 mL) was added dropwise a solution of a substituted phenylisocyanate (2.17 mmol) in 1,2-dichloroethane (5 mL) at room temperature. After the addition, the resulting mixture was stirred at reflux temperature. The reaction was monitored by TLC and stoped after complete consumption of **3**. The reaction mixture was diluted with petroleum ether (60–90°C) and filtered to afford a white solid. The crude solid was recrystallized from dimethylformamide to obtain an analytical sample of **6a**–**m**. The preparative and spectral data of **6a–m** are listed in Tables 3–5.

ORDER		REPRINTS
-------	--	----------

#### General Procedure for the Preparation of the Compounds (7)

*N'-tert*-butyl-*N'*-substituted benzoyl-*N*-(substituted phenyl)aminocarbonylhydrazine (6) (3.27 mmol) and oxalyl chloride (0.50 g) were dissolved in 25 mL of 1,2-dichloroethane and boiled for 24 hr. The solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel using a mixture of petroleum ether ( $60-90^{\circ}$ C) and ethyl acetate as the eluent. Finally, the colourless crystalline (7) was obtained. The preparative and spectral data of **7m** are listed in Tables 3–5.

### ACKNOWLEDGMENTS

We gratefully acknowledge support of this work by the National Natural Science Foundation of China (20202005) and the Research Fund for the Doctoral Program of Higher Education (20010055006) and the Foundation for the author of National Excellent Doctoral Dissertation of P.R. China (200255).

#### REFERENCES

- 1. Norman, J.; Meola, S. Antimicrob. Agents Chemother. 1983, 32, 313.
- 2. Mayer, R.; Netter, K.; Leising, H.; Schatshabel, D. Toxicology **1984**, *30*, 1.
- 3. Wing, K.D. Science 1988, 241, 467.

Downloaded by ["University at Buffalo Libraries"] at 09:39 11 October 2014

- 4. Wing, K.D.; Slawecki, R.A.; Carlson, G.R. Science 1988, 241, 470.
- Aller, H.E.; Ramsay, J.R. Brighton crop protection conference. Pests and Diseases 1988, 2, 511–518.
- Hsu, A.C.T. Synthesis and Chemistry of Agrochemicals II; Baker, B.R., Fenyes, J.G., Moberg, W.K., Eds.; ACS Symp. Ser. No. 443, American Chemical Society: Washington, DC, 1991; 478–490.
- 7. Dhadialla, T.S.; Jansson, R.K. Pestic. Sci. 1999, 55, 343.
- Nakagawa, Y.; Smagghe, G.; Kugimiya, S.; Hattori, K.; Ueno, T.; Tirry, L.; Fujita, T. Pestic Sci. 1999, 55, 909.
- Nakagawa, Y.; Shimizu, B.; Oikawa, N.; Akamatsu, M.; Nishimura, K.; Kurihara, N.; Ueno, T.; Fujita, T. *Classical Three-Dimensional QSAR in Agrochemistry*, ACS Symposium Series 606, American Chemical Society: Washington, DC, 1995; 288.
- 10. Wang, Q.M.; Bi, F.C.; Li, Z.G.; Huang, R.Q. Sym. of Agrochemicals X Chinese Chemical Society, Hangzhou, 2000; 194.
- 11. Wang, Q.M.; Li, Z.G.; Huang, R.Q.; Chen, J.R. *Proceeding of CCS Congress 2000*, China Chemical Society: Beijing, 2000; 357.

Marcel Dekker, Inc.

ORDER	REPRINTS
	μ

- 12. Huang, R.Q.; Wang, Q.M. J. Organometal. Chem. 2001, 637–639, 94–98.
- 13. Wang, Q.M.; Huang, R.Q. Tetrahedron Lett. 2001, 42, 8881-8883.
- 14. Wang, Q.M.; Huang, R.Q.; Bi, F.C.; Li, Z.G. J. Chem. Research (S) 2001, 342–343.
- 15. Wang, Q.M.; Huang, R.Q. Appl. Organometal. Chem. 2002, 16, 593–596.
- 16. Murphy, R.A.; Hsu, A.C.T. US 5,117,057, 1993.
- 17. Smith, P.A.S.; Clegg, J.M.; Lakritz, J. J. Org. Chem. 1958, 23, 1595.
- 18. Wing, K.D. US 5,424,333, 1995; Chem. Abstr. 1995, 122, 313108e.
- Kelly, M.J. Eur. Pat. Appl. EP 638,545, 1995; Chem. Abstr. 1995, 122, 239332j.
- 20. Ma, Y.Q.; Li, J.S. Main Group Metal Chem. 2001, 24 (4), 235.
- 21. Li, J.S.; Ma, Y.Q.; Cui, J.R.; Wang, R.Q. Appl. Organometal Chem. 2001, *15*, 639.
- 22. Denizot, F.; Long, R. J. Immunol. Methods 1986, 89, 271.
- Skehan, P.; Storeng, R.; Scudiero, D.; Monks, A.; Mcmahon, J.; Vistica, D.; Warren, J.T.; Bokesch, H.; Kenney, S.; Boyd, M. J. Natl. Cancer Inst. 1990, 24, 1107.

Received in Japan May 12, 2003



# **Request Permission or Order Reprints Instantly!**

Interested in copying and sharing this article? In most cases, U.S. Copyright Law requires that you get permission from the article's rightsholder before using copyrighted content.

All information and materials found in this article, including but not limited to text, trademarks, patents, logos, graphics and images (the "Materials"), are the copyrighted works and other forms of intellectual property of Marcel Dekker, Inc., or its licensors. All rights not expressly granted are reserved.

Get permission to lawfully reproduce and distribute the Materials or order reprints quickly and painlessly. Simply click on the "Request Permission/ Order Reprints" link below and follow the instructions. Visit the <u>U.S. Copyright Office</u> for information on Fair Use limitations of U.S. copyright law. Please refer to The Association of American Publishers' (AAP) website for guidelines on <u>Fair Use in the Classroom</u>.

The Materials are for your personal use only and cannot be reformatted, reposted, resold or distributed by electronic means or otherwise without permission from Marcel Dekker, Inc. Marcel Dekker, Inc. grants you the limited right to display the Materials only on your personal computer or personal wireless device, and to copy and download single copies of such Materials provided that any copyright, trademark or other notice appearing on such Materials is also retained by, displayed, copied or downloaded as part of the Materials and is not removed or obscured, and provided you do not edit, modify, alter or enhance the Materials. Please refer to our <u>Website</u> User Agreement for more details.

# **Request Permission/Order Reprints**

Reprints of this article can also be ordered at http://www.dekker.com/servlet/product/DOI/101081SCC120027261