Available online at www.sciencedirect.com
ScienceDirect
Tetrahedron 64 (2008) 1378–1382
Tetrahedron
www.elsevier.com/locate/tet

Three-component reaction of 2-alkynylbenzaldehyde, amine, and nucleophile using Lewis acid-surfactant combined catalyst in water

Yang Ye [a], Qiuping Ding [a,c], Jie Wu [a,b,*]

[a] Department of Chemistry, Fudan University, 220 Handan Road, Shanghai 200433, China
[b] State Key Laboratory of Organometallic Chemistry, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, 354 Fenglin Road, Shanghai 200032, China
[c] Analytical Centre for Physics and Chemistry, Jiangxi Normal University, 437 West Beijing Road, Nanchang 330027, China

Received 26 September 2007; received in revised form 14 November 2007; accepted 16 November 2007
Available online 21 November 2007

Abstract

Lewis acid-surfactant combined catalyst (LASC) catalyzed three-component reactions of 2-alkynylbenzaldehyde, amines, and nucleophiles (alkyne, nitromethane, or diethyl phosphate) in water under ultrasonic conditions afforded the corresponding 1,2-dihydroisoquinoline derivatives in good yields.

Keywords: Lewis acid-surfactant combined catalyst; Water; Ultrasonic; 1,2-Dihydroisoquinoline

1. Introduction

Lewis acid catalysis has received continuous attention in organic synthesis.[1] Recently, 'Lewis acid-surfactant combined catalyst (LASC)', shows high efficiency in various organic transformations as a new type of catalyst. These reactions are promoted in water without organic cosolvents.[2] Proposed by Kobayashi,[3] this kind of catalyst acts both as a Lewis acid to activate the substrate molecules and as a surfactant to form emulsions in water. High efficiency of LASC in reactions, as well as the environmentally benign processes promoted us to explore the possibility to develop scaffold construction of natural product-like compounds.

Availability of practical route for generation of small molecules based natural products is of utmost urgency and importance in the biomedical research.[4] Realizing such a critical need, we have focused on the development of methodologies for facile synthesis of natural product-like molecules.[5] As a privileged fragment, 1,2-dihydroisoquinoline is a subunit in many natural products with remarkable biological activities.[6] The prominence of 1,2-dihydroisoquinoline in natural products and biologically active molecules has promoted considerable efforts toward their synthesis.[7,8] For instance, Yamamoto and Takemoto described recently the synthesis of functionalized 1,2-dihydroisoquinoline skeletons through the direct addition of various carbon pronucleophiles to *ortho*-alkynylaryl aldimines catalyzed by Lewis acid.[7a–c] Based on these results, we conceived that this kind of reaction may be performed in water via combination of 2-alkynylbenzaldehyde, amine, and nucleophile under suitable conditions instead of *ortho*-alkynylaryl aldimine. This three-component one-pot procedure in water will provide a new, rapid, and environmentally benign route to prepare 1,2-dihydroisoquinoline derivatives. Thus, we started to investigate the possibility of this reaction.

2. Results and discussion

Initial studies were performed by treatment of 2-alkynylbenzaldehyde **1**, aniline **2a**, and phenylacetylene **3a** in water in the presence of a catalytic amount of various Lewis

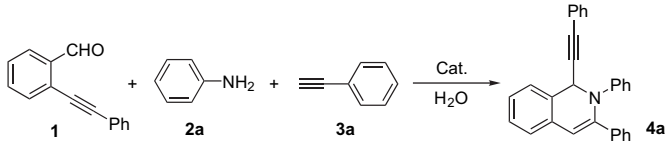
* Corresponding author. Tel.: +86 2155664619; fax: +86 2165102412.
E-mail address: jie_wu@fudan.edu.cn (J. Wu).

0040-4020/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tet.2007.11.055

acid-surfactant combined catalysts (LASC) (10 mol %), and the results are shown in Table 1. To our delight, we found that the desired product **4a** could be afforded in 39% yield when $AgC_{12}H_{25}SO_3$ (10 mol %) was utilized as the catalyst (Table 1, entry 1). However, when other metals were employed in the reaction, inferior results were observed (Table 1, entries 2–13). For example, only trace amount of product **4a** was detected in the presence of $Yb(C_{12}H_{25}OSO_3)_3$ (10 mol %) (Table 1, entry 9). Further studies revealed that the yield could be dramatically improved under ultrasonic conditions [Table 1, entry 14: 80% yield, $AgC_{12}H_{25}SO_3$ (10 mol %)]. Using AgOTf instead of $AgC_{12}H_{25}SO_3$ afforded **4a** in 32% yield (Table 1, entry 20). Meanwhile, trace amount of product was detected when only $C_{12}H_{25}SO_3Na$ (10 mol %) was utilized (Table 1, entry 21). We also found that the reaction proceeded smoothly to generate the corresponding product **4a** in 89% yield in the presence of combination of $C_{12}H_{25}SO_3Na$ (10 mol %) and $CuSO_4$ (10 mol %) (Table 1, entry 17). Similar result (87% yield) was observed when the amount of catalyst was decreased to 5 mol % (Table 1, entry 18). However, prolonged reaction time was necessary to complete the reaction. Again, surfactant is crucial for this reaction, since only trace amount of product **4a** was generated when $CuSO_4$ (10 mol %) was employed without $C_{12}H_{25}SO_3Na$ (10 mol %) (Table 1, entry 19).

To demonstrate the generality of this method, we next investigated the scope of substrates under optimized conditions [$C_{12}H_{25}SO_3Na$ (10 mol %), $CuSO_4$ (10 mol %), ultrasonic], and the results are summarized in Table 2. 2-Alkynylbenzaldehyde **1** reacted with various aromatic amines and phenylacetylene to afford the corresponding products **4a–f** in good to excellent yields, catalyzed by $C_{12}H_{25}SO_3Na/CuSO_4$ under ultrasonic conditions (Table 2, entries 1–6). Aromatic amines with electron-donating or electron-withdrawing group attached to the aromatic ring were all good partners in this transformation. For example, *p*-toluidine **2c** reacted with 2-alkynylbenzaldehyde **1** and phenylacetylene **3a** leading to the corresponding product **4c** in 77% yield (Table 2, entry 3), and almost quantitative yield (98%) of product **4e** was obtained when 4-chlorobenzeneamine **2e** was utilized in the reaction (Table 2, entry 5). However, aliphatic amines were not suitable in this reaction.

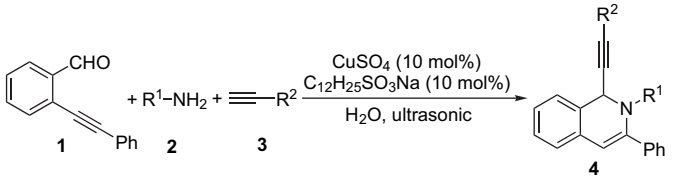
Table 1
Conditions screening for Lewis acid-catalyzed reaction of 2-alkynylbenzaldehyde **1**, aniline **2a**, and phenylacetylene **3a** in water

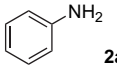
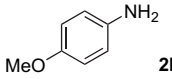
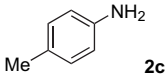
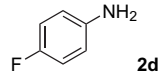
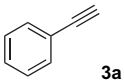
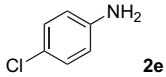
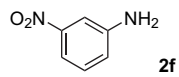
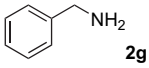
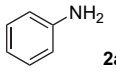
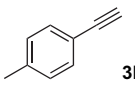
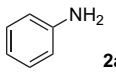
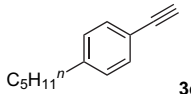
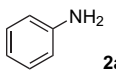
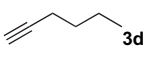
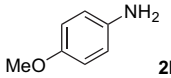
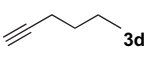


Entry	Conditions	Yield (%)[a]
1	$Ag(C_{12}H_{25}SO_3)$ (10 mol %), 50–60 °C	39
2	$Y(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	17
3	$Fe(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	16
4	$Dy(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	30
5	$Gd(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	7
6	$Sm(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	7
7	$Yb(C_{12}H_{25}SO_3)_3$ (10 mol %), 70–80 °C	12
8	$Gd(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
9	$Yb(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
10	$Y(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
11	$Fe(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
12	$Dy(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
13	$Sm(C_{12}H_{25}OSO_3)_3$ (10 mol %), 70–80 °C	Trace
14	$AgC_{12}H_{25}SO_3$ (10 mol %), ultrasonic	80
15	$C_{12}H_{25}SO_3Na$ (10 mol %)/AgOTf (10 mol %), ultrasonic	65
16	$C_{12}H_{25}SO_3Na$ (10 mol %)/CuI (10 mol %), ultrasonic	76
17	$C_{12}H_{25}SO_3Na$ (10 mol %)/$CuSO_4$ (10 mol %), ultrasonic	89
18	$C_{12}H_{25}SO_3Na$ (5 mol %)/$CuSO_4$ (5 mol %), ultrasonic	87
19	$CuSO_4$ (10 mol %), ultrasonic	Trace
20	AgOTf (10 mol %), ultrasonic	32
21	$C_{12}H_{25}SO_3Na$ (10 mol %), ultrasonic	Trace

[a] Isolated yield based on 2-alkynylbenzaldehyde **1**.

Table 2
Reaction of 2-alkynylbenzaldehyde **1**, amine **2**, and alkyne **3** in water catalyzed by Lewis acid-surfactant combined catalyst (LASC)

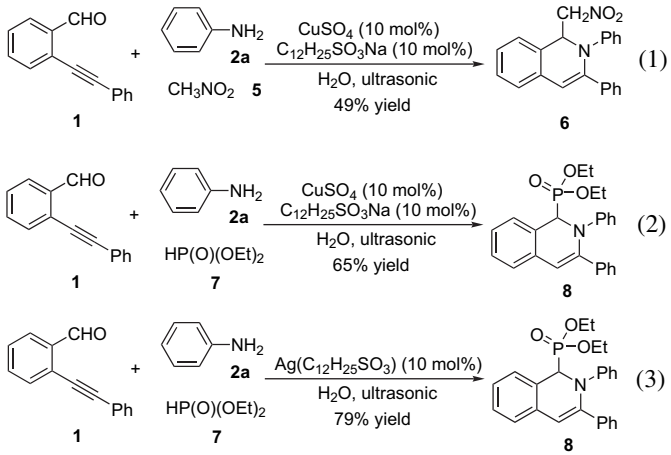


Entry	Amine **2**	Alkyne **3**	Product	Yield (%)[a]
1	 **2a**		**4a**	89
2	 **2b**		**4b**	63
3	 **2c**		**4c**	77
4	 **2d**	 **3a**	**4d**	84
5	 **2e**		**4e**	98
6	 **2f**		**4f**	88
7	 **2g**		**4g**	Trace
8	 **2a**	 **3b**	**4h**	86
9	 **2a**	 **3c**	**4i**	66
10	 **2a**	 **3d**	**4j**	37
11	 **2b**	 **3d**	**4k**	36

[a] Isolated yield based on 2-alkynylbenzaldehyde **1**.

Only trace amount of product **4g** was obtained when benzyl amine **2g** was employed in the reaction with 2-alkynylbenzaldehyde **1** and phenylacetylene **3a** (Table 2, entry 7). Other substituted phenylacetylenes **3b** and **3c** were also effective in this kind of reaction and good yields of products **4h** and **4i** were observed (Table 2, entries 8 and 9). However, only low yield of product **4j** or **4k** was obtained when 1-hexyne **3d** was used in the reaction (Table 2, entries 10 and 11).

Other nucleophiles instead of acetylene, such as nitromethane and diethylphosphite, were also tested in this kind of transformation. As outlined in Scheme 1, reaction of 2-alkynylbenzaldehyde **1**, aniline **2a**, and nitromethane **5** in water catalyzed by $C_{12}H_{25}SO_3Na/CuSO_4$ (10 mol %) under ultrasonic conditions afforded the desired product **6** in 49% yield (Scheme 1, Eq. 1). When diethylphosphite **7** was employed under the same conditions, the corresponding product **8** was generated in 65% yield (Scheme 1, Eq. 2). Silver catalyst was also effective in this reaction and 79% yield of compound **8** was obtained (Scheme 1, Eq. 3).



Scheme 1.

3. Conclusion

In summary, we have described that Lewis acid-surfactant combined catalyst shows efficiency in the three-component reaction of 2-alkynylbenzaldehydes, amines, and nucleophiles in water. This method offers a mild and efficient route for the synthesis of 1,2-dihydroisoquinoline derivatives. The advantages of this method include good yields, environmentally benign, and experimentally operational ease.

4. Experimental section

4.1. General

All reactions were performed in test tubes under nitrogen atmosphere. Flash column chromatography was performed using silica gel (60 Å pore size, 32–63 μm, standard grade, Sorbent Technologies). Analytical thin layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Solvents and other commercial reagents were used as received. 2-Alkynylbenzaldehyde **1** was synthesized via Sonogashira coupling according to the literature report.[8e]

4.2. General procedure for synthesis of compound *4*

A mixture of 2-alkynylbenzaldehyde **1** (0.5 mmol), amine **2** (0.5 mmol, 1.0 equiv), alkyne **3** (0.6 mmol, 1.2 equiv), $CuSO_4$ (10 mol %), and $C_{12}H_{25}SO_3Na$ (5 mol %) in water (3.0 mL) was stirred under ultrasonic conditions. After completion of the reaction as indicated by TLC, the reaction mixture was filtered and the filtrate was extracted with EtOAc (2×10 mL). Evaporation of the organic solvent followed by purification of the residue on silica gel afforded pure 1,2-dihydroisoquinolin-1-ylphosphonate **4**.

4.2.1. 2,3-Diphenyl-1-(2-phenylethynyl)-1,2-dihydroisoquinoline (*4a*)[7a]

Yield 89%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.03 (s, 1H), 6.48 (s, 1H), 6.83 (t, J=7.3 Hz, 1H), 6.98 (d, J=7.4 Hz, 2H), 7.09 (t, J=7.4 Hz, 2H), 7.17–7.26 (m, 10H), 7.33–7.35 (m, 2H), 7.50 (d, J=7.8 Hz, 2H); *m/z*: 383 (M^+).

4.2.2. 2-(4-Methoxyphenyl)-3-phenyl-1-(2-phenylethynyl)-1,2-dihydroisoquinoline (*4b*)

Yield 63%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.65 (s, 3H), 5.92 (s, 1H), 6.44 (s, 1H), 6.64 (d, J=9.2 Hz, 2H), 6.95 (d, J=8.7 Hz, 2H), 7.16–7.26 (m, 10H), 7.34–7.36 (m, 2H), 7.50 (d, J=8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 56.7, 84.3, 88.9, 109.7, 113.8, 123.0, 123.8, 124.3, 125.3, 126.4, 127.7, 127.8, 127.9, 128.0, 128.1, 128.8, 131.8, 132.1, 137.8, 139.6, 141.6, 155.0; *m/z*: 413 (M^+). HRMS calcd for $C_{30}H_{23}NO$: 413.1780, found: 413.1792.

4.2.3. 3-Phenyl-1-(2-phenylethynyl)-2-p-tolyl-1,2-dihydroisoquinoline (*4c*)

Yield 77%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.17 (s, 1H), 5.99 (s, 1H), 6.46 (s, 1H), 6.90 (s, 4H), 7.16–7.26 (m, 10H), 7.34–7.36 (m, 2H), 7.50 (dd, J=1.8, 8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.6, 56.3, 84.2, 88.8, 110.5, 122.0, 123.0, 124.5, 125.3, 126.4, 127.7, 127.9, 128.1, 128.2, 129.1, 129.2, 131.4, 131.8, 132.0, 137.9, 141.2, 143.5; *m/z*: 397 (M^+). HRMS calcd for $C_{30}H_{23}N$: 397.1830, found: 397.1845.

4.2.4. 2-(4-Fluorophenyl)-3-phenyl-1-(2-phenylethynyl)-1,2-dihydroisoquinoline (*4d*)

Yield 84%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.93 (s, 1H), 6.48 (s, 1H), 6.79 (t, J=8.7 Hz, 2H), 6.93–6.96 (m, 2H), 7.18–7.26 (m, 10H), 7.34–7.36 (m, 2H), 7.48 (dd, J=1.8, 8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 56.4, 84.5, 88.4, 110.7, 115.2 ($^2J_{CF}$=21.9 Hz), 122.8, 123.5, 123.6, 124.6, 125.3, 126.7, 127.9, 128.0, 128.1, 128.2, 128.3, 129.1, 131.8, 137.4, 141.1, 142.1, 158.2 ($^1J_{CF}$=241.2 Hz); *m/z*: 401 (M^+). HRMS calcd for $C_{29}H_{20}FN$: 401.1580, found: 401.1598.

*4.2.5. 2-(4-Chlorophenyl)-3-phenyl-1-(2-phenylethynyl)-1,2-dihydroisoquinoline (**4e**)*

Yield 98%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.95 (s, 1H), 6.50 (s, 1H), 6.90 (d, J=8.8 Hz, 2H), 7.05 (d, J=8.8 Hz, 2H), 7.19–7.27 (m, 10H), 7.33–7.35 (m, 2H), 7.48 (dd, J=1.8, 8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 56.0, 84.6, 88.1, 111.5, 122.7, 122.9, 124.7, 125.3, 126.8, 127.0, 127.8, 128.0, 128.1, 128.2, 128.4, 128.5, 129.4, 131.6, 131.8, 137.5, 140.7, 144.4; *m/z*: 417 (M^+). HRMS calcd for $C_{29}H_{20}ClN$: 417.1284, found: 417.1290.

*4.2.6. 2-(3-Nitrophenyl)-3-phenyl-1-(2-phenylethynyl)-1,2-dihydroisoquinoline (**4f**)*

Yield 88%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.04 (s, 1H), 6.61 (s, 1H), 7.16–7.38 (m, 14H), 7.49 (dd, J=1.8, 8.3 Hz, 2H), 7.66 (dt, J=1.8, 7.8 Hz, 1H), 7.89 (t, J=1.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6, 85.1, 87.1, 113.3, 115.4, 116.2, 122.4, 125.1, 125.3, 127.1, 127.3, 127.7, 128.1, 128.2, 128.3, 128.4, 128.5, 128.6, 129.1, 131.3, 131.8, 136.7, 139.7, 146.5, 148.6; *m/z*: 428 (M^+). HRMS calcd for $C_{29}H_{20}N_2O_2$: 428.1525, found: 428.1543.

*4.2.7. 2,3-Diphenyl-1-(2-p-tolylethynyl)-1,2-dihydroisoquinoline (**4h**)*

Yield 86%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.28 (s, 3H), 6.02 (s, 1H), 6.47 (s, 1H), 6.83 (t, J=7.4 Hz, 1H), 6.98–7.03 (m, 4H), 7.09 (t, J=7.4 Hz, 2H), 7.17–7.27 (m, 9H), 7.49 (dd, J=1.9, 8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.4, 56.0, 84.4, 87.8, 111.0, 119.8, 121.8, 121.9, 124.5, 125.3, 126.5, 127.7, 127.8, 127.9, 128.2, 128.5, 128.8, 129.6, 131.7, 131.8, 137.8, 138.2, 140.9, 145.8; *m/z*: 397 (M^+). HRMS calcd for $C_{30}H_{23}N$: 397.1830, found: 397.1852.

*4.2.8. 1-(2-(4-Pentylphenyl)ethynyl)-2,3-diphenyl-1,2-dihydroisoquinoline (**4i**)*

Yield 66%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.85 (t, J=6.9 Hz, 3H), 1.22–1.30 (m, 6H), 2.53 (t, J=7.8 Hz, 2H), 6.02 (s, 1H), 6.47 (s, 1H), 6.83 (t, J=6.8 Hz, 1H), 6.98 (d, J=7.8 Hz, 2H), 7.03 (d, J=7.8 Hz, 2H), 7.05–7.29 (m, 11H), 7.49 (d, J=6.8 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 22.5, 31.0, 31.5, 35.8, 56.1, 87.9, 111.1, 121.9, 122.0, 124.7, 125.4, 126.7, 127.8, 127.9, 128.3, 128.6, 131.8, 138.1, 140.8, 137.8, 138.2, 140.9 146.1; *m/z*: 453 (M^+). HRMS calcd for $C_{34}H_{31}N$: 453.2457, found: 453.2468.

*4.2.9. 1-(Hex-1-ynyl)-2,3-diphenyl-1,2-dihydroisoquinoline (**4j**)*

Yield 37%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.83 (t, J=7.4 Hz, 3H), 1.24–1.43 (m, 4H), 2.15 (t, J=7.8 Hz, 2H), 5.78 (s, 1H), 6.43 (s, 1H), 6.82 (t, J=7.4 Hz, 1H), 6.93 (d, J=7.3 Hz, 2H), 7.07 (d, J=7.3 Hz, 2H), 7.09–7.25 (m, 8H), 7.45 (dd, J=1.5, 8.3 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.5, 21.8, 29.7, 30.8, 55.5, 79.5, 85.0, 110.7, 121.6, 124.5, 125.0, 126.4, 127.6, 127.7, 127.8, 128.1, 128.4, 130.3, 131.6, 137.8, 140.3, 145.9; *m/z*: 363 (M^+). HRMS calcd for $C_{27}H_{25}N$: 363.1987, found: 363.1956.

*4.2.10. 1-(Hex-1-ynyl)-2-(4-methoxyphenyl)-3-phenyl-1,2-dihydroisoquinoline (**4k**)*

Yield 36%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.83 (t, J=6.8 Hz, 3H), 1.26–1.43 (m, 4H), 2.15 (t, J=7.8 Hz, 2H), 3.66 (s, 3H), 5.68 (s, 1H), 6.38 (s, 1H), 6.63 (d, J=8.8 Hz, 2H), 6.89 (d, J=8.8 Hz, 2H), 7.09 (d, J=7.8 Hz, 2H), 7.13–7.25 (m, 6H), 7.46 (dd, J=2.0, 8.5 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.6, 21.8, 30.8, 55.3, 56.2, 79.7, 85.0, 109.4, 113.7, 123.6, 124.2, 125.0, 126.2, 127.6, 127.9, 128.1, 129.6, 131.9, 137.9, 139.7, 141.5, 145.8, 154.8; *m/z*: 393 (M^+). HRMS calcd for $C_{28}H_{27}NO$: 393.2093, found: 393.2098.

*4.2.11. Synthesis of compound **6***

A mixture of 2-alkynylbenzaldehyde **1** (0.5 mmol), aniline **2a** (0.5 mmol, 1.0 equiv), nitromethane **5** (0.6 mmol, 1.2 equiv), $CuSO_4$ (10 mol %), and $C_{12}H_{25}SO_3Na$ (5 mol %) in water (3.0 mL) was stirred under ultrasonic conditions. After completion of the reaction as indicated by TLC, the reaction mixture was filtered and the filtrate was extracted with EtOAc (2×10 mL). Evaporation of the organic solvent followed by purification of the residue on silica gel afforded the corresponding 2-(4-methoxyphenyl)-1-(nitromethyl)-3-phenyl-1,2-dihydroisoquinoline (**6**).[7a] Yield 49%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.35 (dd, J=3.9, 11.7 Hz, 1H), 4.79 (t, J=11.2 Hz, 1H), 5.74 (dd, J=3.9, 11.2 Hz, 1H), 6.77 (s, 1H), 6.85–6.91 (m, 3H), 7.05–7.12 (m, 3H), 7.19–7.29 (m, 4H), 7.32 (d, J=3.9 Hz, 2H), 7.53 (d, J=7.8 Hz, 2H).

*4.2.12. Synthesis of compound **8***

A mixture of 2-alkynylbenzaldehyde **1** (0.5 mmol), aniline **2a** (0.5 mmol, 1.0 equiv), diethylphosphite **7** (0.6 mmol, 1.2 equiv), $CuSO_4$ (10 mol %), and $C_{12}H_{25}SO_3Na$ (5 mol %) in water (3.0 mL) was stirred under ultrasonic conditions. After completion of the reaction as indicated by TLC, the reaction mixture was filtered and the filtrate was extracted with EtOAc (2×10 mL). Evaporation of the organic solvent followed by purification of the residue on silica gel afforded the diethyl 2,3-diphenyl-1,2-dihydroisoquinolin-1-ylphosphonate (**8**)[5d] as yellow liquid in 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.20–1.25 (m 6H), 3.90–4.10 (m, 4H), 5.45 (d, J=18.6 Hz, 1H), 6.50 (s, 1H), 6.85–6.87 (m, 1H), 7.07–7.25 (m, 11H), 7.58 (d, J=6.8 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.4, 62.5, 62.7, 64.2, 112.2, 122.3, 122.6, 124.3, 125.6, 126.5, 127.2, 127.6, 127.9, 128.2, 128.5, 133.0, 137.3, 142.0, 147.6. ^{31}P NMR (161 MHz, $CDCl_3$) δ 21.33. IR (cm^{-1}) ν_{max} 1025 (P–O), 1052 (P–O), 1251 (P=O). MS (ESI) *m/z* 420.20 (M^++1). HRMS calcd for $C_{25}H_{26}NO_3P$: 419.1650, found: 419.1654.

Acknowledgements

We thank Dr. Renhua Fan for his invaluable advice during the course of this research. Financial support from National Natural Science Foundation of China (20772018), Program for New Century Excellent Talents in University (NCET-07-0208), and Shanghai Pujiang Program is gratefully acknowledged.

References and notes

1. *Lewis Acids in Organic Synthesis*; Yamamoto, H., Ed.; Wiley-VCH: Weinheim, 2000.
2. (a) Otto, S.; Engberts, J. B. F. N.; Kwak, J. C. T. *J. Am. Chem. Soc.* **1998**, *120*, 9517; (b) Manabe, K.; Kobayashi, S. *Chem. Commun.* **2000**, 669; (c) Mori, Y.; Kakumoto, K.; Manabe, K.; Kobayashi, S. *Tetrahedron Lett.* **2000**, *41*, 3107; (d) Manabe, K.; Aoyama, N.; Kobayashi, S. *Adv. Synth. Catal.* **2001**, *343*, 174.
3. Kobayashi, S.; Manabe, K. *Acc. Chem. Res.* **2002**, *35*, 209.
4. (a) Schreiber, S. L. *Science* **2000**, *287*, 1964; (b) Schreiber, S. L. *Chem. Eng. News* **2003**, *81*, 51.
5. For selected examples, see: (a) Zhang, L.; Meng, T.; Fan, R.; Wu, J. *J. Org. Chem.* **2007**, *72*, 7279; (b) Ding, Q.; Ye, Y.; Fan, R.; Wu, J. *J. Org. Chem.* **2007**, *72*, 5439; (c) Wang, Z.; Fan, R.; Wu, J. *Adv. Synth. Catal.* **2007**, *349*, 1943; (d) Sun, W.; Ding, Q.; Sun, X.; Fan, R.; Wu, J. *J. Comb. Chem.* **2007**, *9*, 690; (e) Wang, Z.; Wang, B.; Wu, J. *J. Comb. Chem.* **2007**, *9*, 811.
6. Bentley, K. W. *The Isoquinoline Alkaloids*; Harwood Academic: Amsterdam, 1998; Vol 1.
7. (a) Obika, S.; Kono, H.; Yasui, Y.; Yanada, R.; Takemoto, Y. *J. Org. Chem.* **2007**, *72*, 4462 and references cited therein; (b) Asao, N.; Yudha, S. S.; Nogami, T.; Yamamoto, Y. *Angew. Chem., Int. Ed.* **2005**, *44*, 5526; (c) Yanada, R.; Obika, S.; Kono, H.; Takemoto, Y. *Angew. Chem., Int. Ed.* **2006**, *45*, 3822; (d) Asao, N.; Iso, K.; Yudha, S. S. *Org. Lett.* **2006**, *8*, 4149; (e) Mori, S.; Uerdingen, M.; Krause, N.; Morokuma, K. *Angew. Chem., Int. Ed.* **2005**, *44*, 4715; (f) Asao, N.; Chan, C. S.; Takahashi, K.; Yamamoto, Y. *Tetrahedron* **2005**, *61*, 11322; (g) Ohtaka, M.; Nakamura, H.; Yamamoto, Y. *Tetrahedron Lett.* **2004**, *45*, 7339; (h) Witulski, B.; Alayrac, C.; Tevzadze-Saeftel, L. *Angew. Chem., Int. Ed.* **2003**, *42*, 4257; (i) Yavari, I.; Ghazanfarpour-Darjani, M.; Sabbaghan, M.; Hossaini, Z. *Tetrahedron Lett.* **2007**, *48*, 3749; (j) Shaabani, A.; Soleimani, E.; Khavasi, H. R. *Tetrahedron Lett.* **2007**, *48*, 4743; (k) Wang, G.-W.; Li, J.-X. *Org. Biomol. Chem.* **2006**, *4*, 4063; (l) Diaz, J. L.; Miguel, M.; Lavilla, R. *J. Org. Chem.* **2004**, *69*, 3550.
8. (a) Huang, Q.; Larock, R. C. *J. Org. Chem.* **2003**, *68*, 980; (b) Dai, G.; Larock, R. C. *J. Org. Chem.* **2003**, *68*, 920; (c) Dai, G.; Larock, R. C. *J. Org. Chem.* **2002**, *67*, 7042; (d) Huang, Q.; Hunter, J. A.; Larock, R. C. *J. Org. Chem.* **2002**, *67*, 3437; (e) Roesch, K. R.; Larock, R. C. *J. Org. Chem.* **2002**, *67*, 86; (f) Roesch, K. R.; Zhang, H.; Larock, R. C. *J. Org. Chem.* **2001**, *66*, 8042; (g) Roesch, K. R.; Larock, R. C. *Org. Lett.* **1999**, *1*, 553.