JOC*Note*

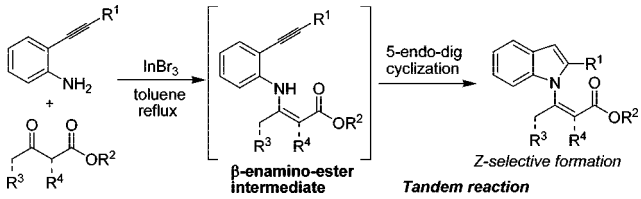
Tandem β-Enamino Ester Formation and Cyclization with *o*-Alkynyl Anilines Catalyzed by $InBr_3$: Efficient Synthesis of β-(*N*-Indolyl)-α,β-unsaturated Esters

Kenichi Murai, Shoko Hayashi, Nobuhiro Takaichi, Yasuyuki Kita,† and Hiromichi Fujioka*

Graduate School of Pharmaceutical Sciences, Osaka University, 1-6 Yamada-oka, Suita, Osaka, 565-0871 Japan

fujioka@phs.osaka-u.ac.jp

Received November 01, 2008

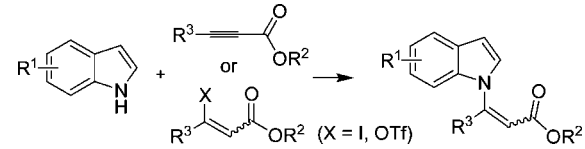


A tandem reaction providing β-(*N*-indolyl)-α,β-unsaturated esters from β-keto esters and *o*-alkynyl anilines was developed. *Z*-Alkenes were selectively formed due to the stability of the β-enamino ester as an intermediate of the reaction. This reaction includes the intermolecular β-enamino ester formation and intramolecular cyclization catalyzed by $InBr_3$.

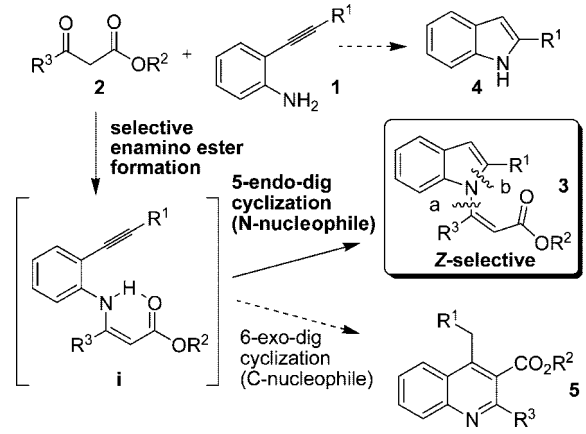
The development of novel tandem reactions is important because they can easily provide complex molecules, simplify the procedures, and reduce the waste.[1] They generally include several catalytic cycles. When several functional groups were activated by a catalyst, it was necessary not only to promote each step but also to activate each functional group in order.[2] During the course of our research for efficient methods for heterocyclic compounds using β-enamino esters,[3] we examined the reaction of β-enamino esters prepared from β-keto esters and *o*-alkynyl anilines and found that $InBr_3$ promotes two reactions, intermolecular amination and subsequent intramolecular cyclization, at once and activates the formation of the β-enamino esters faster than the intramolecular cyclization. We now report a tandem reaction to provide diverse *Z*-β-(*N*-indolyl)-α,β-unsaturated esters.

Indoles are some of the most important heterocycles because they are found in various biologically active compounds, and

SCHEME 1. Previous Methods



SCHEME 2. Strategy



numerous methods for the syntheses of functionalized indoles have been developed.[4] However, there are only a few methods to synthesize β-(*N*-indolyl)-α,β-unsaturated esters.[5,6] Although Michael addition to alkynoates or the transition metal-catalyzed coupling reaction with alkenyl iodide or triflate were reported to be syntheses of these compounds (Scheme 1), they had limitations with the synthesis of diverse substituted alkenes: α-positions of the products from alkynoates or alkenyl iodide were limited to being a proton[7] and *Z* alkenes were difficult to obtain from *Z*-vinyl triflate because of steric hindrances. Since their synthetic utilities are potentially interesting,[5] to develop an efficient synthetic method for them having diverse substitutents is desirable.

Our approach for β-(*N*-indolyl)-α,β-unsaturated esters **3** is illustrated in Scheme 2. Contrary to the reported methods, we postulated making two C−N bonds (bonds **a** and **b** of compound **3**) at once by tandem reaction. Thus bond **a** would be made by amination of β-keto esters **2** with *o*-alkynyl anilines **1**, and bond **b** would be made by 5-*endo-dig* intramolecular hydroamination of β-enamino ester **i**.[8] This approach was attractive on several points for making bond **a**: the formation of β-enamino ester

† Present address: College of Pharmaceutical Sciences, Ritsumeikan University, 1-1-1 Nojihigashi, Kusatsu, Shiga, 525-8577 Japan.

(1) For reviews about tandem reactions, see: (a) Chapman, C. J.; Frost, C. G. *Synthesis* **2007**, 1–21. (b) Wasilke, J.-C.; Obrey, S. J.; Baker, R. T.; Bazan, G. C. *Chem. Rev.* **2005**, *105*, 1001–1020.

(2) For a review, see: (a) Yamamoto, Y. *J. Org. Chem.* **2007**, *72*, 7817–7831.

(3) (a) Fujioka, H.; Murai, K.; Kubo, O.; Ohba, Y.; Kita, Y. *Org. Lett.* **2007**, *9*, 1687–1690. (b) Murai, K.; Nakatani, R.; Kita, Y.; Fujioka, H. *Tetrahedron* **2008**, *64*, 11034–11040.

(4) For a review, see: Humphrey, G. R.; Kuethe, J. T. *Chem. Rev.* **2006**, *106*, 2875–2911, and references cited therein.

(5) (a) Raboisson, P.; Manthey, C. L.; Chaikin, M.; Lattanze, J.; Crysler, C.; Leonard, K.; Pan, W.; Tomczuk, B. E.; Marugán, J. J. *Eur. J. Med. Chem.* **2006**, *41*, 847–861. (b) Leonard, K.; Pan, W.; Anaclerio, B.; Gushue, J. M.; Guo, Z.; DesJarlais, R. L.; Chaikin, M. A.; Lattanze, J.; Crysler, C.; Manthey, C. L.; Tomczuk, B. E.; Marugan, J. J. *Bioorg. Med. Chem. Lett.* **2005**, *15*, 2679–2684. (c) Rainka, M. P.; Aye, Y.; Buchwald, S. L. *Proc. Natl. Acad. Sci. U.S.A.* **2004**, *101*, 5821–5823.

(6) Movassaghi, M.; Ondrus, A. E. *J. Org. Chem.* **2005**, *70*, 8638–8641.

(7) β-Iodo-α,β-unsaturated esters were generally prepared from alkynoates. For examples, see: (a) Maguire, R. J.; Munt, S. P.; Thomas, E. J. *J. Chem. Soc., Perkin Trans. 1* **1998**, 2853–2863. (b) Dieter, R. K.; Lu, K. *J. Org. Chem.* **2002**, *67*, 847–855.

(8) For a gold-catalyzed tandem double hydroamination of *o*-alkynyl aniline with terminal alkynes providing *N*-vinyl indoles, see: Zhang, Y.; Donahue, J. P.; Li, C. J. *Org. Lett.* **2007**, *9*, 627–630.

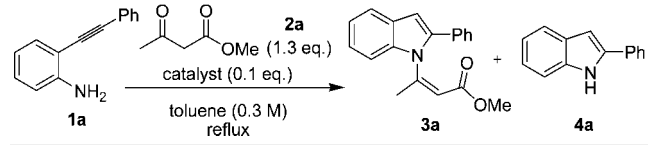
10.1021/jo802435b CCC: $40.75 © 2009 American Chemical Society
Published on Web 12/29/2008

seemed to be relatively easier than previous methods and diverse β-ketoesters were available. In addition, the theoretical coproduct of this process was only water. Furthermore, due to the stability of hydrogen bonding of the β-enamino ester, the geometries of alkenes were expected to be *Z*.

Although each individual reaction of the β-enamino ester formation[9] and catalytic intramolecular hydroamination of *o*-alkynyl aniline derivatives[10] was well documented, there were no reports of what caused the two reactions at once. In addition, to the best of our knowledge, no intramolecular cyclization reaction of β-enamino esters prepared from *o*-alkynyl aniline to give indole derivatives has been reported yet. For the success of our aim, the chemoselectivity (β-keto esters vs alkynes) of the catalyst was very important. When the affinity of the catalyst to alkynes was much stronger than that to β-keto esters, intramolecular hydroamination of **1** would predominantly occur to afford indole **4** and the desired tandem reaction would fail.[11] Therefore, to achieve this tandem reaction, it was very important to find a catalyst that promotes both intermolecular amination of the β-keto esters **2** and subsequent intramolecular cyclization of β-enamino ester **i** in order. On the other hand, from the viewpoint of reactivity of β-enamino esters, their α-carbons were also nucleophilic.[12,13] Then two reaction pathways from **i**, 5-*endo-dig* cyclization giving indole derivatives **3** and 6-*exo-dig* cyclization giving quinoline derivatives **5**, were possible. Therefore, the mode of cyclization of **i** was also of interest.

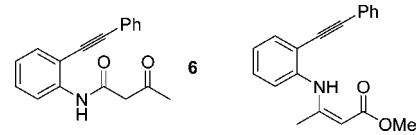
We first screened the catalysts using the *o*-alkynyl aniline **1a** and β-keto ester **2a** (Table 1). When $NaAuCl_4 \cdot 2H_2O$ was used, the desired product **3a** was obtained in only 34% yield, and 2-Ph indole **4a**, which was the cyclized product of **1a**, was the predominant produced (entry 1). Other metals such as $Cu(OAc)_2$, $AgBF_4$, and $Yb(OTf)_3$ were found to be ineffective (entries 2−4). The reaction with $Cu(OAc)_2$ produced the β-keto amide **6**. The reactions with $AgBF_4$ or $Yb(OTf)_3$ produced the β-enamino ester **7** but did not allow the sequential intramolecular cyclization. On the other hand, $InBr_3$ was found to be an efficient catalyst in this tandem reaction, which resulted in a good yield and selectivity (entry 5).[14] Although $InCl_3$ was also efficient and a high selectivity was observed, the yields were slightly low because of the side production of **6** (entry 6). Reaction with $In(OTf)_3$ resulted in low yield (entry 7). To our surprise, 6-*exo-dig* cyclization of enamino ester to affrod quinoline derivative **5** was not observed in this reaction. As a result of the further optimization, it was found that the reaction carried out with the β-keto ester (1.3 equiv) and $InBr_3$ (0.05 equiv) in refluxing toluene (0.3 M) gave the best result (entry 8).[15]

TABLE 1. Optimization[a]



entry	catalyst	time	yield (**3a**, **4a**) (%)[b]
1	$NaAuCl_4 \cdot 2H_2O$	20 min	85 (34, 51)
2	$Cu(OAc)_2$	6 h	N.D.[c]
3	$AgBF_4$	3.5 h	N.D.[d]
4	$Yb(OTf)_3$	5.5 h	N.D.[e]
5	$InBr_3$	30 min	91 (82, 9)
6	$InCl_3$	30 min	83 (78, 5)
7	$In(OTf)_3$	2.7 h	24 (23, 1)
8[f]	$InBr_3$	30 min	99 (91, 8)

[a] Reaction was carried out with 0.4 mmol of **1a**. [b] Ratio was determined by ^{1}H NMR analysis. [c] Main product was amide **6**. [d] Main product was enamino ester **7**. [e] Main products were amide **6** and enamino ester **7**. [f] 0.05 equiv of $InBr_3$ was used.



To confirm the reaction pathway, the reaction of **4a** and **2a** with $InBr_3$ in refluxing toluene was carried out. However, **3a** was not obtained even after 16 h. This fact excluded the tandem cyclization/enamino ester formation pathway. Meanwhile, the reaction of **7** with $InBr_3$ afforded **3a** in 92% yield. Therefore, this tandem reaction was considered to proceed through the following sequence: (1) the activation of the β-keto esters, (2)

(9) For recent examples, see: (a) Arcadi, A.; Bianchi, G.; Giuseppe, S. D.; Marinelli, F. *Green Chem.* **2003**, *5*, 64–67. (b) Brandt, C. A.; Da Silva, A. C. M. P.; Pancote, C. G.; Brito, C. L.; Da Silveira, M. A. B. *Synthesis* **2004**, 1557–1559. (c) Stefane, B.; Polanc, S. *Synlett* **2004**, 698–702. (d) Gao, Y.-H.; Zhang, Q.-H.; Xu, J.-X. *Synth. Commun.* **2004**, *34*, 909–916. (e) Bartoli, G.; Bosco, M.; Locatelli, M.; Marcantoni, E.; Melchiorre, P.; Sambri, L. *Synlett* **2004**, 239–242. (f) Varala, R.; Nuvula, S.; Adapa, S. R. *Aust. J. Chem.* **2006**, *59*, 921924 (g) For $InBr_3$-catalyzed formation of β-enamino esters, see: (h) Zhang, Z.-H.; Yin, L.; Wang, Y.-M. *Adv. Synth. Catal.* **2006**, *348*, 184–190, and references cited therein.

(10) For selected reviews and papers, see: (a) Cacchi, S.; Fabrizi, G. *Chem. Rev.* **2005**, *105*, 2873–2920. (b) Takeda, A.; Kamijo, S.; Yamamoto, Y. *J. Am. Chem. Soc.* **2000**, *122*, 5662–5663. (c) Hiroya, K.; Itoh, S.; Sakamoto, T. *J. Org. Chem.* **2004**, *69*, 1126–1136. (d) Ohno, H.; Ohta, Y.; Oishi, S.; Fujii, N. *Angew. Chem., Int. Ed.* **2007**, *46*, 2295–2298. (e) Alfonsi, M; Arcadi, A.; Aschi, M.; Bianchi, G.; Marinelli, F. *J. Org. Chem.* **2005**, *70*, 2265–2273. (f) Li, X.; Chianese, A. R.; Vogel, T.; Crabtree, R. H. *Org. Lett.* **2005**, *7*, 5437–5440. (g) Trost, B. M.; McClory, A. *Angew. Chem., Int. Ed.* **2007**, *46*, 2074–2077. (h) Shimada, T.; Nakamura, I.; Yamamoto, Y. *J. Am. Chem. Soc.* **2004**, *126*, 10546–10547. (i) McDonald, F. E.; Chatterjee, A. K. *Tetrahedron Lett.* **1997**, *38*, 7687–7690. (j) Kurisaki, T.; Naniwa, T.; Yamamoto, H.; Imagawa, H.; Nishizawa, M. *Tetrahedron Lett.* **2007**, *48*, 1871–1874. (k) Kusama, H.; Takaya, J.; Iwasawa, N. *J. Am. Chem. Soc.* **2002**, *124*, 11592–11593. (l) Rodriguez, A. L.; Koradin, C.; Dohle, W.; Knochel, P. *Angew. Chem., Int. Ed.* **2000**, *39*, 2488–2490. (m) Koradin, C.; Dohle, W.; Rodriguez, A. L.; Schmid, B.; Knochel, P. *Tetrahedron* **2003**, *59*, 1571–1587. (n) McLaughlin, M.; Palucki, M.; Davies, I. W. *Org. Lett.* **2006**, *8*, 3307–3310. (o) Yin, Y.; Ma, W.; Chai, Z.; Zhao, G. *J. Org. Chem.* **2007**, *72*, 5731–5736. For $InBr_3$-catalyzed cyclization of *o*-alkynyl anilines, see: (p) Sakai, N.; Annaka, K.; Fujit, A.; Sato, A.; Konakahara, T. *J. Org. Chem.* **2008**, *73*, 4160–4165. (q) Sakai, N.; Annaka, K.; Konakahara, T. *Tetrahedron Lett.* **2006**, *47*, 631–634. (r) Sakai, N.; Annaka, K.; Konakahara, T. *Org. Lett.* **2004**, *6*, 1527–1530. (s) Sakai, N.; Annaka, K.; Konakahara, T. *J. Org. Chem.* **2006**, *71*, 3653–3655.

(11) For a tandem reaction with *o*-alkynyl anilines and 1,3-dicarbonyl compounds with a gold catalyst providing 3-alkenyl indoles through intramolecular hydroamination and sequential alkenylation, see: Arcadi, A.; Alfonsi, M.; Bianchi, G.; D'Anniballe, G.; Marinelli, F. *Adv. Synth. Catal.* **2006**, *348*, 331–338.

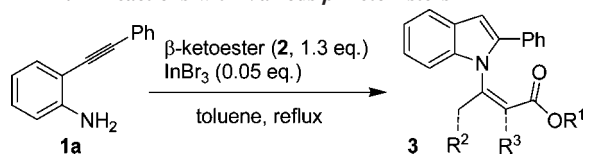
(12) For reviews, see: (a) Stanovnik, B.; Svete, J. *Chem. Rev.* **2004**, *104*, 2433–2480. (b) Elassar, A.-Z. A.; El-Khair, A. A. *Tetrahedron* **2003**, *59*, 8463–8480.

(13) For reactions of β-enamino esters having alkynes, see: (a) Cacchi, S.; Fabrizi, G.; Filisti, E. *Org. Lett.* **2008**, *10*, 2629–2632. (b) Arcadi, A.; Giuseppe, S. D.; Marinelli, F.; Rossi, E. *Tetrahedron: Asymmetry* **2001**, *12*, 2715–2720. (c) Robinson, R. S.; Dovey, M. C.; Gravestock, D. *Tetrahedron Lett.* **2004**, *45*, 6787–6789. (d) Arcadi, A.; Giuseppe, D. G.; Marinelli, F.; Rossi, E. *Adv. Synth. Catal.* **2001**, *343*, 443–446.

(14) For selected reviews and papers about indium-catalyzed reactions, see: (a) Augé, J.; Lubin-Germain, N.; Uziel, J. *Synthesis* **2007**, 1739–1764. (b) Loh, T.-P.; Chua, G.-L. *Chem. Commun.* **2006**, 2739–2749. (c) Takahashi, K.; Midori, M.; Kawano, K.; Ishihara, J.; Hatakeyama, S. *Angew. Chem., Int. Ed.* **2008**, *47*, 6244–6246. (d) Kawata, A.; Takata, K.; Kuninobu, Y.; Takai, K. *Angew. Chem., Int. Ed.* **2007**, *46*, 7793–7795. (e) Obika, S.; Kono, H.; Yasui, Y.; Yanada, R.; Takemoto, Y. *J. Org. Chem.* **2007**, *72*, 4462–4468. (f) Endo, K.; Hatakeyama, T.; Nakamura, M.; Nakamura, E. *J. Am. Chem. Soc.* **2007**, *129*, 5264–5271. (g) Takita, R.; Fukuta, Y.; Tsuji, R.; Ohshima, T.; Shibasaki, M. *Org. Lett.* **2005**, *7*, 1363–1366. (h) Nakamura, M.; Endo, K.; Nakamura, E. *J. Am. Chem. Soc.* **2003**, *125*, 13002–13003. (i) Yasuda, M.; Onishi, Y.; Ueba, M.; Miyai, T.; Baba, A. *J. Org. Chem.* **2001**, *66*, 7741–7744, and references cited therein.

(15) One reviewer suggested that the reaction of β-keto ester (1.0 equiv) and slight excess of *o*-alkynyl aniline (1.3 equiv) should be carried out. The reaction of **2a** (1.0 equiv) and **1a** (1.3 equiv) with $InBr_3$ (0.05 equiv) yielded **3a** (75%) and **4a** (21%) (yields were based on **1a**).

TABLE 2. Reactions with Various *β*-Keto Esters[a,b]



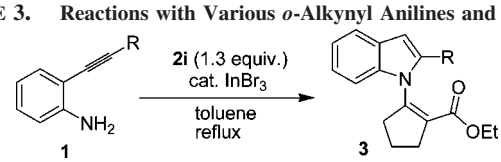
Entry	β-Ketoester (**2**)	Product (**3**)	Time	Yield (%)
1	**2a** (R = Me)	**3a** (R = Me)	30 min	95
2	**2b** (R = Bn)	**3b** (R = Bn)	30 min	88
3	**2c** (R = *i*Pr)	**3c** (R = *i*Pr)	30 min	81
4	**2d** (R = *t*Bu)	**3d** (R = *t*Bu)	30 min	54
5	**2e** (R = Allyl)	**3e** (R = Allyl)	30 min	72
6	**2f**	**3f**	45 min	71
7	**2g**	**3g**	1 h	73
8	**2h**	**3h**	40 min	81
9	**2i**	**3i**	20 min	91
10[c]			30 min	94

[a] Reaction was carried out with 0.4 mmol of **1a** unless otherwise noted. [b] Starting materials were completely consumed in every entry (judged by TLC). [c] 3.8 mmol of **1a** was used.

formation of *β*-enamino esters, and (3) intramolecular cyclization promoted by activation of the acetylene.

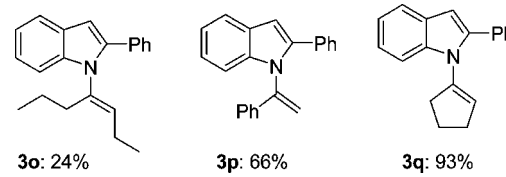
Under the optimized reaction conditions, the generality of the reaction with various *β*-keto esters was examined (Table 2). The reactions with methyl, benzyl, and isopropyl acetoacetate (**2a**−**c**), which each gave good results (entries 1−3). The reaction with *tert*-butyl acetoacetate **2d** decreased the yield (entry 4) probably due to the acid-sensitive *tert*-butyl ester, while the allyl acetoacetate **2e** resulted in a moderate yield (entry 5). Various *β*-keto esters having substitutions on their α and/or *γ* positions were next examined. The use of methyl propionylacetate **2f** resulted in a 71% yield (entry 6). The use of ethyl 2-methyl acetoacetate **2g** also gave a moderate result (entry 7). *β*-Keto esters having a lactone ring, α-acetylbutyrolactone **2h**, and a cyclic ketone, ethyl 2-oxocyclopentanecarboxylate **2i**, both resulted in good yields (entries 8 and 9). The reaction with 3.8 mmol of **1a** also proceeded without any problems and the gram amount of **3i** was obtained in 94% yield (entry 10). As shown

TABLE 3. Reactions with Various *o*-Alkynyl Anilines and 2i[a,b]



entry	R	time	yield (%)
1[c]	*p*-Cl-C_6H_4 (**1b**)	20 min	**3j**, 94
2[c]	*p*-MeO-C_6H_4 (**1c**)	1 h	**3k**, 84
3[d]	*n*-Bu (**1d**)	24 h	***3l***, 67
4[d]	cyclohexyl (**1e**)	24 h	**3m**, 70
5[c]	cyclohexenyl (**1f**)	1 h	**3n**, 67

[a] Reaction was carried out with 0.4 mmol of **1a**. [b] Starting materials were completely consumed in every entry (judged by TLC). [c] 0.05 equiv of $InBr_3$ was used. [d] 0.15 equiv of $InBr_3$ was used.



3o: 24% **3p**: 66% **3q**: 93%

FIGURE 1. Products from simple ketones.

as these results, the developed reaction readily provided α-substituted α,*β*-unsaturated esters that were difficult to obtain with the reported methods. Furthermore, as we expected, the geometries of the products were completely controlled and every product was the *Z*-alkene.[16]

We next examined the reactions with various *o*-alkynyl anilines and *β*-keto ester **2i** (Table 3). Substituent effects on the para position of the phenyl group were first examined and it was found that both the electron-withdrawing Cl group and the electron-donating MeO group were applicable (entries 1 and 2). The substrates having an *n*-butyl and cyclohexyl gave moderate yields (entries 3 and 4), though 0.15 equiv of $InBr_3$ and a long reaction time were necessary. Furthermore, a substrate having a cyclohexenyl group, whose olefin could be transformed into various functional groups, was tolerant (67%, entry 5).[17]

Lastly, to compare the reactivity between the *β*-keto esters and simple ketones, 4-heptanone and *o*-alkynyl aniline **1a** were subjected to the optimized reaction conditions. Although the tandem reaction occurred, the yield of the desired **3o** was only 24% and the major product was indole **4a** (see Table 1). Therefore, the 1,3-dicarbonyl structures were considered to be important for good yield probably due to the high affinity to $InBr_3$ or to stabilize the enamine structures of the intermediates or the products. In addition, interestingly, **3o** (Figure 1) was formed *E*-selectively. This result showed a good contrast to the result with *β*-keto esters, which prefered *Z*-selectivity due to the intramolecular hydrogen bonding of *β*-enamino esters. On the other hand, the reaction with acetophenone produced the desired compound **3p** in 66% yield. Furthermore, the reaction with cyclopentanone produced compound **3q** in high yield (93%). These results showed that the developed tandem reaction could be expanded to *N*-vinyl indole syntheses[18] by using

(16) Determined by NOE analysis.

(17) Unfortunately, the reaction with *o*-ethynyl aniline afforded complex mixtures including an enamino ester bearing a teminal alkyne such as **7** and a quinoline delivative by the dimerization of *o*-ethynyl aniline (for the dimerization of *o*-ethynyl aniline, see ref 10s).

(18) Only a few methods for the synthesis of *N*-vinyl indoles were reported. References are ceited in ref 8.

various ketones in place of β-keto esters, though further optimizations would be necessary.

In conclusion, we have developed a novel tandem reaction providing diverse *Z*-β-(*N*-indolyl)-α,β-unsaturated esters from readily available β-keto esters and *o*-alkynyl anilines. This approach is very effective and the generality is high and can provide α-substituted anilines, which were difficult to prepare with the previous methods. The finding that $InBr_3$ promotes two reactions of intermolecular amination and subsequent intramolecular cyclization at once and activates formation of the β-enamino esters faster than the intramolecular cyclization is very interesting. In addition, this is the first example of the reaction of *o*-alkynyl anilines having β-enamino ester structures and it was found that 5-*endo-dig* cyclization proceeded rather than 6-*exo-dig* cyclization. Further investigations for *N*-vinyl indoles, clarification of the difference between β-keto esters and simple ketones, and synthesis of biologically active compounds are underway.

Experimental Section

Representative Procedure for the Tandem Reaction. Compound 3a. $InBr_3$ (7.3 mg, 0.021 mmol) was added to a solution of *o*-alkynyl aniline **1a** (80.0 mg, 0.414 mmol) and β-keto ester **2a** (58 μL, 0.538 mmol) in toluene (1.38 mL) at rt under N_2. The reaction mixture was heated under reflux. After 30 min, the reaction mixture was cooled to rt, quenched with water, and extracted with AcOEt. The organic phase was washed with sat. NaCl aq, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by SiO_2 column chromatography (two purifications: first eluent, hexane/AcOEt = 10/1; second eluent, benzene/hexane = 1/1) to afford **3a**. Colorless oil; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.63−7.56 (m, 3H), 7.44−7.32 (m, 3H), 7.20−7.11 (m, 3H), 6.74 (s, 1H), 6.17 (s, 1H), 3.49 (s, 3H), 1.89 ppm (d, J = 0.9 Hz, 3H); ^{13}C NMR (75.5 MHz, $CDCl_3$) δ 164.5, 148.2, 139.6, 137.1, 132.9, 128.8, 128.6, 127.88, 127.85, 122.5, 120.7 (2C), 118.1, 110.2, 104.6, 51.5, 24.0 ppm; IR (KBr) 3059, 2949, 1732, 1661, 1454, 1213 cm^{-1}; HRMS (FAB) calcd for $C_{19}H_{17}NO_2Na$ $[M + Na]^+$ 314.1157, found 314.1157. Anal. Calcd for $C_{19}H_{17}NO_2$: C, 78.33; H, 5.88; N, 4.81. Found: C, 78.29; H, 6.01; N, 4.77.

Acknowledgment. We are grateful to Dr. Kotoku, N. for his help with NMR measurement. This work was financially supported by a Grant-in-Aid for Scientific Research (A) and (B) and a Grant-in-Aid for Exploratory Research from Japan Society for the Promotion of Science.

Supporting Information Available: Experimental details and detailed spectroscopic data of all new compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

JO802435B