Available online at www.sciencedirect.com

SCIENCE DIRECT®

Tetrahedron Letters 45 (2004) 6875–6877

Tetrahedron Letters

Indium(I) iodide promoted highly selective 1,2-addition of allyl and benzyl groups to α,β-unsaturated nitriles under sonication: a new synthesis of conjugated imines

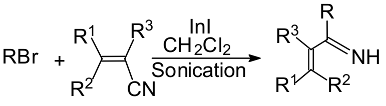
Brindaban C. Ranu* and Arijit Das

Department of Organic Chemistry, Indian Association for the Cultivation of Science, Jadavpur, Calcutta 700 032, India

Received 21 May 2004; revised 16 July 2004; accepted 22 July 2004
Available online 10 August 2004

Abstract—Allyl and benzyl bromides react with α,β-unsaturated nitriles in the presence of indium(I) iodide under sonication to produce the corresponding allylated and benzylated conjugated imines involving exclusive addition of the allyl/benzyl group to the C≡N moiety.

There has been increasing interest in the use of organoindium reagents in organic synthesis as they have made significant contributions towards carbon–carbon bond formation, novel rearrangements, and a variety of other useful transformations over the past few years.[1] The addition of organoindium reagents to nitriles is very interesting. Both allylindium sesquibromide and triallylindium reagents react with α,β-unsaturated nitriles to give 1,4-addition products, whereas similar reactions with α,β-unsaturated carbonyl compounds lead to the products of 1,2-addition.[2a,b] On the other hand, the reaction of allylindium reagents with nitriles possessing another electron withdrawing group at the α-position affords the corresponding allylated enamines.[2c] As part of our drive to explore new applications of organoindium reagents,[1e,3] we recently initiated an investigation on the use of indium(I) iodide for useful chemical transformations.[4] During this project we discovered another novel application of InI, which demonstrated that allyl and benzyl bromides react with α,β-unsaturated nitriles in the presence of indium(I) iodide to produce the corresponding allylated and benzylated conjugated imines involving 1,2-addition exclusively (Scheme 1).



R= allyl, benzyl; R^1, R^2, R^3 = H or alkyl

Scheme 1.

The experimental procedure is very simple.[5] Several allyl and benzyl bromides underwent reactions with a variety of substituted α,β-unsaturated nitriles to provide the corresponding imines through exclusive 1,2-addition.[5] The results are presented in Table 1. Substituted allyl bromides such as crotyl and cinnamyl bromides (entries 4–6) also participate in the reaction without any difficulty producing only the products of α-addition. The products were unequivocally identified as imines by their characteristic IR absorptions (~3300 and 1650 cm^{-1} due to =N—H and C=N, respectively) and ^1H NMR (δ 6.0–6.5 for NH) and ^{13}C NMR (δ 166–168 due to the quaternary C of C=N) spectral data. The mass spectrometric data (LC–MS) of a couple of representative compounds agree with the assigned structures. These spectral data are also consistent with the values reported for imines.[6] Interestingly, the ^1H and ^{13}C NMR spectra of these products did not indicate the presence of any tautomeric enamines.

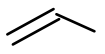
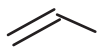
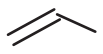
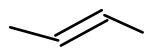
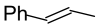
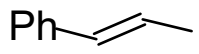
The reactions are, in general, very clean. Without sonication the reaction did not proceed at room temperature under stirring. Although heating the reaction mixtures under reflux leads to conversion, a longer period of time is required than for reaction under sonication.

Keywords: Indium(I) iodide; Conjugated nitrile; 1,2-Addition; Imine; Sonication.

* Corresponding author. Tel.: +91 33 24734971; fax: +91 33 24732805; e-mail: ocbcr@iacs.res.in

0040-4039/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2004.07.098

Table 1. Synthesis of conjugated imines

Entry	R	R^1	R^2	R^3	Time (h)	Yield (%)[a]
1		H	H	CH_3	8.20	73
2		Ph	H	H	11.30	74
3				H	10	73
4				H	11.10	71[b]
5		H	H	H	12	70[b]
6		H	H	CH_3	12.20	71[b]
7	$PhCH_2$	H	H	H	8	84
8	$PhCH_2$	H	H	CH_3	8.30	82
9	$PhCH_2$	Ph	H	H	11.10	73
10	$PhCH_2$			H	10	80
11	$PhCHCH_3$			H	11	80

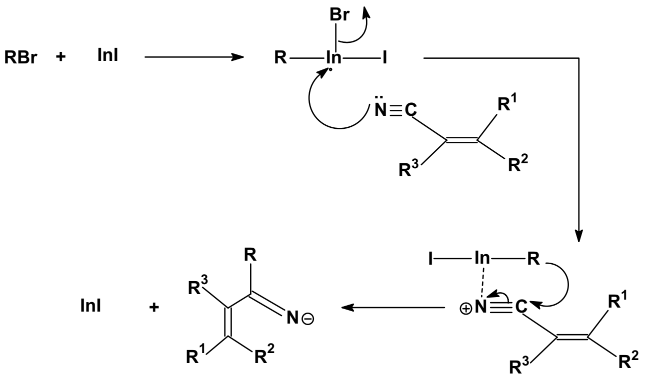
[a] Yields refer to those of pure isolated products characterized by spectroscopic data (IR, ^1H and ^{13}C NMR).

[b] Only the α-addition product was obtained.

Usually, the reaction proceeds efficiently with 20 mol% of InI, however, with a smaller amount (5–10 mol%) the reaction takes a relatively long period of time to go to completion. Although other solvents such as THF, acetonitrile may be used, the best results in terms of yield were obtained using methylene chloride.

The exact mechanism for this 1,2-addition is not clearly understood at this moment, however, it may be speculated that the reaction goes via the following path (Scheme 2).

In conclusion, the present procedure using indium(I) iodide provides an easy access to allylated and benzylated conjugated imines, which are of synthetic utility in organic reactions.[7] Moreover, the exclusive 1,2-addition of allyl and benzyl groups to α,β-unsaturated nitriles promoted by InI is of significance in the context of the typical 1,4-addition promoted by triallylindium,[2b] allylindium sesquibromide[2a] and other organometallic reagents.[2d] Nevertheless, this reaction demonstrates the potential of indium(I) iodide[8] and presents great promise for more useful applications.



Scheme 2.

Acknowledgements

We are pleased to acknowledge the financial support from CSIR, New Delhi [Grant No. 01(1739)/02] for this investigation. A.D. is also thankful to CSIR for his fellowship.

References and notes

1. (a) Cintas, P. *Synlett* **1995**, 1087; (b) Li, C.-J. *Tetrahedron* **1996**, *52*, 5643; (c) Li, C.-J.; Chan, T. H. *Tetrahedron* **1999**, *55*, 11149; (d) Chauhan, K. K.; Frost, C. G. *J. Chem. Soc., Perkin Trans. 1* **2000**, 3015; (e) Ranu, B. C. *Eur. J. Org. Chem.* **2000**, 2347; (f) Podlech, J.; Maier, T. C. *Synthesis* **2003**, 633.
2. (a) Wang, L.; Sun, X.; Zhang, Y. *Synth. Commun.* **1998**, *28*, 3263; (b) Araki, S.; Horie, T.; Kato, M.; Hirashita, T.; Yamamura, H.; Kawai, M. *Tetrahedron Lett.* **1999**, *40*, 2331; (c) Fujiwara, N.; Yamamoto, Y. *Tetrahedron Lett.* **1998**, *39*, 4729; (d) Fleming, F. F.; Wang, Q. *Chem. Rev.* **2003**, *103*, 2035.
3. (a) Ranu, B. C.; Hajra, A.; Jana, U. *J. Org. Chem.* **2000**, *65*, 6270; (b) Ranu, B. C.; Hajra, A.; Jana, U. *Tetrahedron Lett.* **2000**, *41*, 531; (c) Ranu, B. C.; Samanta, S.; Hajra, A. *Synlett* **2002**, 987; (d) Ranu, B. C.; Das, A.; Samanta, S. *Synlett* **2002**, 727; (e) Ranu, B. C.; Dey, S. S.; Hajra, A. *Tetrahedron* **2002**, *58*, 2529; (f) Ranu, B. C.; Hajra, A.; Dey, S. S.; Jana, U. *Tetrahedron* **2003**, *59*, 813; (g) Ranu, B. C.; Samanta, S. *J. Org. Chem.* **2003**, *68*, 7130; (h) Ranu, B. C.; Das, A.; Hajra, A. *Synthesis* **2003**, 1012; (i) Ranu, B. C.; Samanta, S. *Tetrahedron* **2003**, *59*, 7901.
4. (a) Ranu, B. C.; Mandal, T.; Samanta, S. *Org. Lett.* **2003**, *5*, 1439; (b) Ranu, B. C.; Mandal, T. *Synlett* **2004**, 1239.
5. *Representative experimental procedure* (*entry* **7**): A mixture of acrylonitrile (53 mg, 1 mmol) and benzyl bromide (171 mg, 1 mmol) in dry methylene chloride (3 mL) was sonicated in an ultrasonic bath (Eyela, Japan) in the presence of indium(I) iodide (50 mg, 20 mol%) for 8 h (TLC). The reaction mixture was quenched with a few drops of H_2O and extracted with diethyl ether (3 × 10 mL). The organic extract was washed with brine, dried (Na_2SO_4) and evaporated to leave the crude product, which was purified by column chromatography over silica gel (hexane/ether 3:1) to give the pure product (122 mg, 84%) as a white solid, mp 51 °C; IR (KBr) 3286, 3066, 1652, 1539, 1242 cm^{-1}; ^1H NMR δ 4.42 (AB q, $J_1 = 21.8$, $J_2 = 5.8$ Hz, 2H), 5.58 (dd, $J_1 = 2.0$, $J_2 = 9.8$ Hz, 1H), 6.09–6.28 (m, 2H), 6.64 (br s, NH), 7.22–7.31 (m, 5H); ^{13}C NMR δ 43.8, 127.0, 127.8, 128.1 (2C), 129.1 (2C), 131.1, 138.5, 166.1; LC–MS: molecular ion 145.020. Anal. Calcd for $C_{10}H_{11}N$: C, 82.71; H, 7.63. Found: C, 82.55; H, 7.71. This procedure is followed for all the reactions listed in Table 1. All the compounds were satisfactorily characterized from their spectroscopic data (IR, ^1H NMR and ^{13}C NMR) and elemental analysis.
6. (a) Weingarten, H.; Chupp, J. P.; White, W. A. *J. Org. Chem.* **1967**, *32*, 3246; (b) Ahlbrecht, H. *Tetrahedron Lett.* **1968**, *9*, 4421; (c) Ahlbrecht, H.; Rauchschwalbe, G. *Tetrahedron Lett.* **1971**, *12*, 4897.
7. (a) Jutz, C.; Lobesing, G.; Trinkul, M.-H. *Synthesis* **1977**, 326; (b) Serckx-Poncin, B.; Hezbain-Frisque, A. M.; Ghosez, L. *Tetrahedron Lett.* **1982**, *23*, 3261; (c) Boger,

D. L.; Kasper, A. M. *J. Am. Chem. Soc.* **1989**, *111*, 1517; (d) Potts, K. T.; Bhattacharjee, D.; Walsh, E. B. *Chem. Commun.* **1984**, 114.

8. (a) Ohno, H.; Hamaguchi, H.; Tanaka, T. *Org. Lett.* **2000**, *2*, 2161; (b) de Rego Barros, O. S.; Lang, E. S.; de Oliveira, C. A. F.; Peppe, C.; Zeni, G. *Tetrahedron Lett.* **2002**, *43*, 7921; (c) de Rego Barros, O. S.; Lang, E. S.; Peppe, C.; Zeni, G. *Synlett* **2003**, 1725; (d) Miyabe, H.; Yamaoka, Y.; Naito, T.; Takemoto, Y. *J. Org. Chem.* **2004**, *69*, 1415.