Pergamon

Tetrahedron Letters 39 (1998) 8605–8608

TETRAHEDRON
LETTERS

Organometallic Reactions in Aqueous Media. Indium-mediated Allylation of Sulfonimines

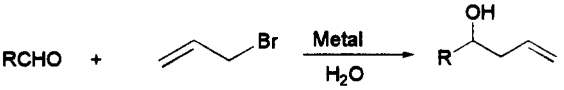
Tak Hang Chan and Wenshuo Lu*

Department of Chemistry, McGill University,
Montreal, Quebec, Canada H3A 2K6

Received 5 August 1998; revised 9 September 1998; accepted 10 September 1998

Abstract: Barbier-type allylation of sulfonimines with indium and allyl bromide to give homoallylic sulfonamides can be performed smoothly in organic solvents and in aqueous media. The regio- and the stereoselectivity of the reaction have been examined.

Recently, we and others have reported on the metal-mediated allylation of carbonyl compounds in aqueous media to give the corresponding homoallylic alcohols (scheme 1).[1] The development of such organometallic-type reactions in aqueous media is of interest because they offer the possibility of environmentally benign reaction conditions by reducing the burden of organic solvent disposal.[2] The metals used in scheme 1 include zinc,[3] tin,[4] bismith[5] and indium.[6]

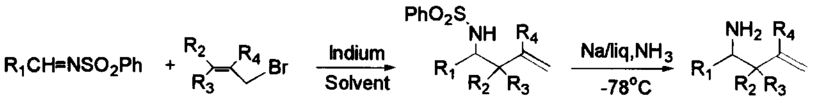


Scheme 1

Indium is considered the metal of choice because the allylation can proceed in water without the need of activation and the amount of side products due to reduction or coupling of the carbonyl compound is minimal. However, the allylation reaction has been limited to the carbonyl compounds. The application of such allylation reaction to aldimines to give the corresponding homoallylic amines has not been extensively reported.[7,8] This is attributed to the fact that aldimines are generally less electrophilic than the corresponding carbonyl compounds.[9,10] Furthermore, in aqueous media, many imines are hydrolysed to the corresponding carbonyl compounds before allylation occurs thus giving the corresponding homoallylic alcohols instead.[11]

PII: S0040-4039(98)01926-1

Finally, it has been reported that indium mediated the homocoupling of imines in aqueous media to give the corresponding 1,2-diamines.[12] We report here our study on the allylation of sulfonimines with indium and allyl bromide in aqueous media. N-Sulfur bonded aldimines are versatile intermediates in organic synthesis.[13] In comparison to aldimines, sulfonimine are more electrophilic on the one hand, and yet more stable to hydrolysis in the aqueous media on the other hand. It offers the additional advantage in synthesis in that the sulfonyl group can be readily removed from the product homoallylic sulfonamides to give the corresponding primary amines (scheme 2).



1a R_1=Ph
1b R_1=*p*-Cl-Ph
1c R_1=*p*-CH_3O-Ph
1d R_1=Ph-CH=CH

2a R_2=R_3=R_4=H
2b R_2=CH_3, R_3=R_4=H
2c R_2=R_3=CH_3, R_4=H
2d R_2=R_3=H, R_4=CH_3
2e R_2=R_3=H, R_4=COOMe
2f 3-bromocyclohexene

3a~i

4

Scheme 2

In a typical experiment, the sulfonimine[14] (0.5 mmol) and allyl bromide (1.5 mmol) were stirred in aqueous or organic solvent (4 ml). Indium powder (1.5 mmol) was added and the mixture was stirred overnight. The reaction was quenched by 1N HCl (2 ml) and extracted with ether (2 x 15 ml). The combined organic phase was dried and evaporated to give the crude product which was purified by chromatography on silica gel (eluent: 15% ethyl acetate and 85% hexane) to afford the sulfonamide product (Table 1).

Table 1 Indium-mediated allylation reaction with sulfonimines

Entry	Sulfonimine	Allylbromide	Solvent	Product	Yield (%)^a	MP (°C)
1	1a	2a	THF	3a	99^b	80~81
			Dioxane		99^b	
			DMF		99^b	
			H_2O		95	
2	1b	2a	H_2O	3b	50^b	108~110
			H_2O:THF=3:1		95	
3	1c	2a	H_2O	3c	80^b	71~73
			H_2O:THF=4:1		95	
4	1a	2b	H_2O	3d^c	92	128~130
5	1a	2c	H_2O:THF=1:1	3e	55	118~120
6	1a	2d	H_2O:THF=3:1	3f	95	72~74
7	1a	2e	H_2O:THF=1:1	3g	30	liquid
8	1a	2f	H_2O:THF=1:1	3h^c	50	120~122
9	1d	2a	H_2O:THF=1:1	3i^d	90	Liquid

^{a} Isolated yield. ^{b} Yields were determined by ^{1}H NMR spectra. ^{c} Only γ-adducts were obtained. ^{d} Only 1,2-adduct was obtained.

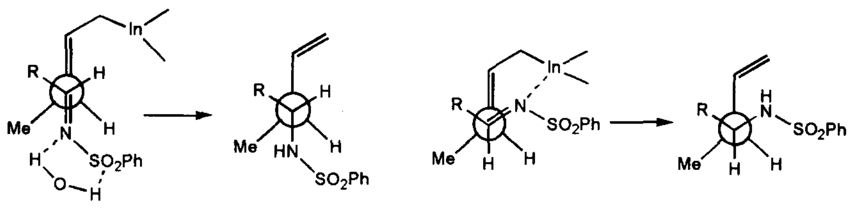
As one can see from the results in Table 1, the allylation reaction can be performed in either organic solvent or in aqueous media. Various substituted arylimines could be used to give the products in good yields. In all cases, the reaction can proceed in water alone, however, in some cases, due to the low solubility of the sulfonimine in water, addition of THF to the solvent can lead to improved yields. The optimum medium for this allylation reaction seems to be a 1:1 mxiture of THF and water. When crotyl- or γ, γ-dimethylallyl- bromide was used, the reaction proceeded with high regioselectivity.[15] When α,β-unsaturated sulfonimine was employed, only 1,2-allylation product was obtained and no 1,4-allylation was observed.

Table 2 Reaction of sulfonimine (1a) with crotyl bromide (2b) in different solvents

Entry	Solvent (H_2O:THF)	Yield%(3d)[a]	*Syn:anti*
1	100:0	98	39:61
2	95:5	98	66:44
3	90:10	98	67:33
4	70:30	98	78:22
5	50:50	98	79:21
6	40:60	98	78:22
7	30:70	98	77:23
8	0:100	98	68:32

[a] Yields were determined by ^{1}H NMR spectra.

The stereochemistry of the allylation of benzaldehyde sulfonimine (**1a**) with crotyl bromide (**2b**) was carefully studied and showed interesting results. The reaction exhibits moderate *anti* stereoselectivity in pure water; whereas when the reaction was performed in THF, the stereoselectivity of the reaction was reverse and moderate *syn* selectivity was obtained. (Table 2).[16] For comparison, the reaction of crotyl bromide with benzaldehyde in water is *anti*-selective.[15a] In order to explain the change in stereoselectivity observed for the change in solvents, we postulate that the allylindium species can allylate the sulfonimine either through an anti-periplanar transition state **5a** or a synclinal transition state **5b**. For carbonyl compounds, the reaction proceeds preferentially through the synclinal transition state due to the coordination of the carbonyl oxygen with the indium metal even in aqueous media.[15a] For sulfonimine, the coordination of nitrogen with indium is weaker, and the synclinal transition state **5b** is preferred in THF but not in water. Since the sulfonimine is known to have the anti-stereochemistry, transition state **5b** gives rise to *syn*-**3d**. In aqueous media, due to coordination of water with the sulfonimine function, the anti-periplanar transition state **5a** is preferred, giving rise to *anti*-**3d** (scheme 3).



5a **anti-3d** **5b** **syn-3d**

Scheme 3

References:

[1] For reviews, see (a) Chan, T. H.; Li, C. J.; Lee, M. C.; Wei, Z. Y. *Can. J. Chem.* **1994**, *72*, 1181. (b) Lubineau, A.; Auge, J.; Queneau, Y. *Synthesis* **1994**, 741. (c) Li, C. J. *Tetrahedron* **1996**, *52*, 5643.

[2] Li, C. J.; Chan, T. H. *Organic Reactions in Aqueous Media*, John Wiley & Sons, New York, 1997.

[3] (a) Einhorn, C.; Luche, J. L. *J. Organometallic Chem.* **1987**,*322*, 177. (b) Wilson, S. R.; Giazzarpmo. M. E. *J. Org. Chem.* **1989**, *54*, 3087.

[4] (a) Nokami, J.; Otera, J.; Sudo, T.; Okawara, R. *Organometallics* **1983**, *2*, 191. (b) Nokami, J.; Wakabayashi, S.; Okawara, R. *Chem. Lett.* **1984**, 869. (c) Uneyama, K.; Kamaki, N.; Moriya, A.; Torii, S. *J. Org. Chem.* **1985**, *50*, 5396. (d) Wu, S. H.; Huang, B. Z.; Zhu, T. M.; Yiao, D. Z.; Chu, Y. L. *Acta Chim. Sinica* **1990**, *48*, 372. (e) Einhorn, C.; Luche, J. L. *J. Organomet. Chem.* **1987**, *322*, 177

[5] (a) Wada, M.; Ohki, H.; Akiba, K. Y. *Bull. Chem. Soc. Jpn.* **1990**, *63*, 1738. (b) Katritzky, A. R.; Shobana, N.; Harris, P. A. *Organometallics* **1992**, *11*, 1381.

[6] (a) Li, C. J.; Chan, T. H. *Tetrahedron Lett.* **1991**, *32*, 7017. (b) Paquette, L. A.; Bennett, G. D.; Isaac, M. B.; Chhatriwalla, A. *J. Org. Chem.* **1998**, *63*, 1836 and references therein

[7] In organic solvents, allyllithium, magnesium and zinc can only allylate non-enolizable imines. (a) Katzenellenbogen, J. A.; Lenox, R. S. *J. Org. Chem.* **1973**, *38*, 326. (b) Emling, B. L.; Horvath, R. J.; Saraceno, A.J.; Ellermeyer, E. F.; Haile, L.; Hudac, L. D. *J. Org. Chem.* **1959**, *24*, 657. (c) Mauze, B.; Miginiac, L. *Bull. Chem. Soc. Fr.* **1973**, 1832 and 1838.

[8] For a recent review of allylation reaction using allylic metals, see Yamamoto, Y.; Asao, N. *Chem. Rev.* **1993**, *93*, 2207.

[9] Volkmann, R. A.: in *Comprehensive Organic Synthesis*, Trost, B. M.; Fleming, I. Eds.; Pergamon Press, Oxford, **1991**, *vol.1*, 355.

[10] Enhanced electrophilicity can be achieved by using phosphinoylimines or silylimines.or by Lewis acid activation. (a) Guijarro, D.; Pinho, P.; Anderson, P. G. *J. Org. Chem.* **1998**, *63*, 2530. (b) Gyenes, F.; Bergmann, K. E.; Welch, J. T. *J. Org. Chem.* **1998**, *63*, 2824. (c) Kobayashi, S.; Nagayama, S. *J. Am. Chem. Soc.* **1997**, *119*, 10049.

[11] We found, for example, benzaldehyde N-benzylimine reacted with allylic bromide and indium in water to give the homoallylic alcohol instead of the amine. See however, (a) Waldmann, H. *Synlett.* **1990**, 627. (b) Hanessian, S.; Yang, R.-Y. *Tetrahedron Lett.* **1996**, *37*, 5273.

[12] Lalyanam, N.; Rao, G. V. *Tetrahedron Lett.* **1993**, *34*, 1647.

[13] For review, see Davis, F. A.; Zhou, P.; Chen, B. C. *Chem. Soc. Rev.* **1998**, *27*, 13.

[14] Prepared according to literature procedures. (a) Davis, F. A.; Lamendola, J.; Nadir, U.; Kluger, E. W.; Sedergran, T. C.; Panunto, T. W.; Billmers, R.; Jenkins, R. Jr.; Turchi, I. J.; Watson, W. H.; Chen, J. S.; Kimura, M. J. *J. Org. Chem.* **1980**, *102*, 2000. (b) Boger, D. L.; Corbett, W. L.; Curran, T. T.; Kasper, A. M. *J. Am. Chem. Soc.* **1991**, *113*, 1713.

[15] The regioselectivity is the same as those previously observed for other indium mediated allylation reactions. (a) Isaac, M. B.; Chan, T. H. *Tetrahedron Lett.* **1995**, *36*, 9857. (b) Bryan, V. J.; Chan, T. H. *Tetrahedron Lett.* **1997**, *38*, 6493.

[16] The stereochemistry was determined by removal of the sulfonyl group with sodium in liquid ammonia to give the corresponding primary amines, the ^{1}H nmr of which can be compared with literature data. Hoffmann, R. W.; Endesfelder, A. *Liebigs Ann. Chem.* **1987**, 215.