COMMUNICATION

ChemComm
www.rsc.org/chemcomm

A facile reaction of imines with telluronium allylide. Highly stereoselective synthesis of vinylaziridines†

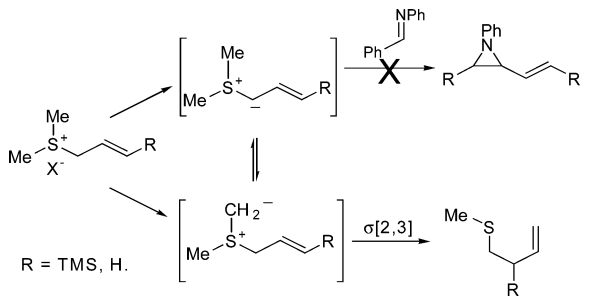
Wei-Wei Liao, Xian-Ming Deng and Yong Tang*

State Key Laboratory of Organometallic Chemistry, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, 354 Fenglin Lu, Shanghai 200032, P. R. China. E-mail: tangy@mail.sioc.ac.cn; Fax: (+86) 21-64166128

Received (in Cambridge, UK) 12th January 2004, Accepted 26th April 2004
First published as an Advance Article on the web 1st June 2004

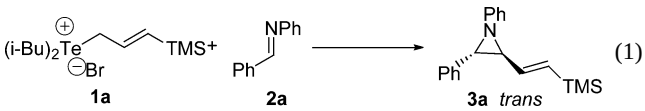
The reaction of telluronium allylides with alkylimines, generated *in situ* from α-amidoalkyl sulfones, affords *cis*-alkylvinylarizidines with good stereoselectivity in good yields. However, the same ylides react with *N*-aryl imines to provide *trans*-vinylaziridines.

Vinylaziridines have proven to be very useful building blocks in organic synthesis[1] and are important subunits in a number of biologically active compounds.[2] The development of synthetic protocols for direct preparation of vinylazirdines from readily available materials is specially attractive. Carbene[3] or nitrene[3i,4] approaches are generally recognized as the most efficient methods for the preparation of aziridines, but generally they are less effective for vinyl-type aziridines due to the difficulty associated with the regioselectivity control. Ylide aziridination provides a facile way as it involves the regioselective construction of vinylaziridine unit with a concomitant formation of a carbon–carbon bond. Of the synthetic methods *via* ylide routes, the reaction between allylic ylide and imines proved to be one of the most convenient methods. Dai and Hou found that sulfur allylides could react with *N*-tosyl arylimines under phase-transfer conditions to give aziridines.[5] Later on, they described that the stereoselectivity of the reaction of *N*-diphenylphosphinoyl arylimines with allylic sulfur ylides could be controlled by the choice of both reaction conditions and ylides.[6] Aggarwal *et al*. reported that silylated sulfur allylide could react with N-SES phenylimine to afford *trans*-phenylvinylarizidine.[7] Unlike the arylimines activated by tosyl or diphenylphosphinoyl, *N*-phenylaldimine is less active and no arizidine was detected when it was treated with dimethyl sulfur silylated allylide probably due to ylide rearrangement (Scheme 1).[8] Furthermore, few reports appeared in literature on the reaction of allylic ylide with aliphatic imines but *tert*-butyl *N*-tosyl imine. In a previous study on ylide chemistry,[9] we reported that sulfur and telluronium allylides[10] were good reagents for the preparation of vinylcyclopropanes and vinylepoxides. Considering that allylic telluronium ylide is more reactive and less prone to rearrangement than the corresponding sulfur ylide,[9c,9h,11] we tried the aziridination of telluronium allylide with less active imines and found that this reaction proceeded well to give the desired aziridines with high stereoselectivity. Moreover, we also found that a variety of *N*-Boc alkylimines with different structures, prepared *in situ* from compound **4**,[12] are good substrates when telluronium allylides were used. In this communication, we wish to report the preliminary results.



Scheme 1

Telluronium salt **1a**, after deprotonation by LDA, reacted with *N*-phenylimine **2a** at −78 °C to afford the corresponding aziridine with high *trans*-selectivity in 29% yield. Further study showed that the yield of this arizidination was dependant on the reaction conditions. As shown in Table 1, no aziridine was detected when either KOBu^t or KHMDS was employed as the base in THF (Entries 2 and 4). The yield was improved to moderate when NaHMDS or NaHMDS/LiBr was used as base instead of LDA (Entries 1, 5–6). The best base, in our screened conditions, was LiHDMS. In this case, the desired product was obtained in 66% yield. Solvents also influenced strongly the yields (Entries 7–11). In THF or toluene, the addition of 3 equivalents of HMPA increased the yields from moderate to high. In our screened conditions, interestingly, all of the solvents and the bases gave high stereoselectivity.[13]



(1)

To determine the generality of this reaction, a variety of aromatic *N*-phenylaldimines with different structures were evaluated under the optimal conditions. As shown in Table 2, all the aromatic *N*-phenylaldimines were good substrates to afford the desired products in moderate to high yields. In all cases, excellent *trans*-selectivity was observed. Allylic telluronium salt **1b** also worked to give the vinylaziridine but both the yield and selectivity decreased slightly (Table 2, Entry 7).

Usually, aliphatic imines are regarded as less active than aromatic imines. They are easily to be isomerized into enamine under the reaction conditions (eqn. (2)) and a few alkylimines but *tert*-butyl *N*-tosylimine was applied to the ylide aziridination.

By a one-pot strategy, we are pleased to find that telluronium allylide **1a′** could react with *N*-Boc-aliphatic imines, produced *in situ* from compound **4**,[12] to afford *cis*–*N*-Boc-aziridines in good yields with good stereoselectivity (Scheme 2).[13] As shown in Table 2, several *N*-Boc imines with linear or branched alkyl substituents

Table 1 The effects of reaction conditions on the aziridination of telluronium salt **1a** with imine **2a**[a]

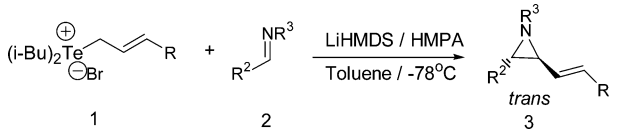
Entry	Solvent	Base	Yield (%)[b]	*trans* : *cis*[c]
1	THF	LDA	29	98/2
2	THF	KOBu^t	0	—
3	THF	LiTMP	36	98/2
4	THF	KHMDS	0	—
5	THF	NaHMDS	55	97/3
6	THF	NaHMDS/LiBr	62	97/3
7	THF	LiHMDS	66	98/2
8	DME	LiHMDS	30	98/2
9	Toluene	LiHMDS	62	98/2
10	THF/HMPA[d]	LiHMDS	84	98/2
11	Toluene/HMPA[d]	LiHMDS	82	97/3

[a] Reaction was carried out at −78 °C, **2a**/**1a**/**base** = 1/1.4/1.4. [b] Isolated yield based on **2a**. [c] Determined by ^{1}H NMR. [d] 3 equivalents of HMPA used.

† Electronic supplementary information (ESI) available: experimental section. See http://www.rsc.org/suppdata/cc/b4/b400464g/

DOI: 10.1039/b400464g

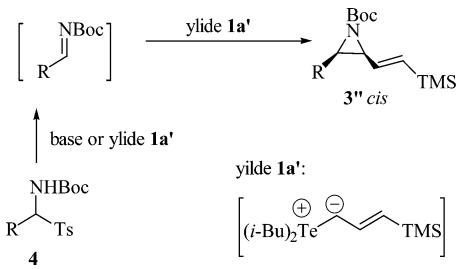
Table 2 Stereoselective synthesis of aziridines[a]



1 2 3

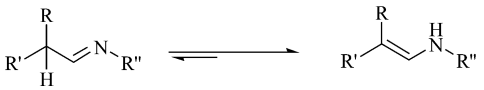
Entry	R	R^2	R^3	Yield (%)[b]	*trans*/*cis*[c]
1[d]	TMS	Ph	Ph	84	98/2
2	TMS	*p*-MeC_6H	Ph	70	99/1
3	TMS	*p*-$MeOC_6H_4$	Ph	52	96/4
4	TMS	*o*-$MeOC_6H_4$	Ph	71	99/1
5	TMS	*p*-ClC_6H_4	Ph	83	98/2
6[d]	TMS	*p*-$CF_3C_6H_4$	Ph	64	98/2
7	H	Ph	Ph	37	80/20
8[e]	TMS	$(CH_3)_2CH$	Boc	77[f]	9/91
9[e]	TMS	Cy	Boc	71[f]	7/93
10[e]	TMS	n-Bu	Boc	50[f]	14/86

[a] Reaction were carried out at −78 °C, **2a**/**1a**/**base** = 1/1.4/1.4 and 3 equivalents of HMPA used. [b] Isolated yields based on imines. [c] Determined by ^{1}H NMR. [d] In THF at −78 °C. [e] In THF at −78 °C and NaHMDS as the base. [f] Isolated yields based on *N*-Boc imines.



Scheme 2

worked well (Entries 8–10). And thus, this strategy extended the substrate scope of ylide aziridination greatly.



(2)

In summary, we demonstrated that telluronium allylides could react with *N*-phenylarylimines without activating agents to afford aryl-substituted vinylaziridines with high *trans*-selectivity, complementary to the selectivity in the similar azirination of sulfur ylide in the presence of Lewis acid.[6c] Noticeably, we also developed a one-pot strategy for the highly stereoselective synthesis of alkyl-substituted *N*-Boc-*cis*-vinylaziridines.[14] This method provides a facile way for the preparation of vinylaziridines. The mild conditions and the readily available starting materials, together with the synthetic useful vinylaziridines, make this method potentially useful in organic synthesis.

We are grateful for financial support from the National Natural Sciences Foundation of China.

Notes and references

1 (*a*) D. Tanner, *Angew. Chem., Int. Ed. Engl.*, 1994, **33**, 599; (*b*) H. M. I. Osborn and J. B. Sweeney, *Tetrahedron: Asymmetry*, 1997, **8**, 1698; (*c*) A. H. Li, L. X. Dai and V. K. Aggarwal, *Chem. Rev.*, 1997, **97**, 2341; (*d*) T. Ibuka, *Chem. Soc. Rev.*, 1998, **27**, 145; (*e*) H. Stamm, *J. Prakt. Chem.*, 1999, **341**, 319; (*f*) B. Zwanenburg and P. ten Holte, *Stereoselective Heterocyclic Synthesis III*, ed. P. Metz. Topics in Current Chemistry. Springer, Berlin, 2001, **Vol. 216**, p. 93.

2 (*a*) For a review, see: W. A. Remers and B. S. Iyengar, *Recent Progress in the Chemical Synthesis of Antibiotics*, ed. G. Lukacs and M. Ohno. Springer, Berlin, 1990, p. 415; (*b*) T. Fukuyama, F. Nakatsubo, A. J. Cocuzza and Y. Kishi, *Tetrahedron Lett.*, 1977, 295; (*c*) F. E. Ziegler and M. Belema, *J. Org. Chem.*, 1997, **62**, 1083.

3 For example: (*a*) J. M. Mohan, B. S. Uphade, V. R. Choudhary, Y. Ravindranathan and A. Sudalai, *Chem. Commun.*, 1997, 1429; (*b*) L. Casarrubios, J. A. Perez, M. Brookhart and J. L. Templeton, *J. Org. Chem.*, 1996, **61**, 8358; (*c*) V. K. Aggarwal, A. Thompson, R. V. H. Jones and M. C. H. Standen, *J. Org. Chem.*, 1996, **61**, 8368; (*d*) V. K. Aggarwal, *Synlett*, 1998, 329; (*e*) V. K. Aggarwal and M. Ferrara, *Org. Lett.*, 2000, **2**, 4107; (*f*) V. K. Aggarwal, E. Alonso, G. Fang, M. Ferrara, G. Hynd and M. Procelloni, *Angew. Chem. Int. Ed.*, 2001, **40**, 1433; (*g*) T. Akiyama, S. Ogi and K. Fuchibe, *Tetrahedron Lett*, 2003, **44**, 4011; (*h*) H. Suga, A. Kakehi, S. Ito, T. Ibata, T. Fudo, Y. Watanabe and Y. Kinoshita, *Bull. Chem. Soc. Jpn.*, 2003, **76**, 189; (*i*) P. Mueller and C. Fruit, *Chem. Rev.*, 2003, **103**, 2905; (*j*) C. Stevens, M. Gallant and N. De Kimpe, *Tetrahedron Lett.*, 1999, **40**, 3457.

4 For example: (*a*) Z. Li, K. R. Conser and E. N. Jacobsen, *J. Am. Chem. Soc.*, 1993, **115**, 5326; (*b*) D. A. Evans, M. M. Faul, M. T. Bilodeau, B. A. Anderson and D. M. Barnes, *J. Am. Chem. Soc.*, 1993, **115**, 5328; (*c*) S. Minakata, T. Ando, M. Nishimura, I. Ryu and M. Komatsu, *Angew. Chem. Int. Ed.*, 1998, **37**, 3392; (*d*) S. Taylor, J. Gullick, P. McMorn, P. C. D. Bethell, P. C. B. Page, F. E. Hancock, F. King and G. J. Hutchings, *J. Chem. Soc., Perkin Trans. 2*, 2001, 1714; (*e*) S. L. Jain, V. B. Sharma and B. Sain, *Tetrahedron Lett.*, 2003, **44**, 4385; (*f*) Y. Cui and C. He, *J. Am. Chem. Soc.*, 2003, **125**, 16202.

5 (*a*) A. H. Li, L. X. Dai and X. L. Hou, *Chem. Commun.*, 1996, 491; (*b*) A. H. Li, L. X. Dai and X. L. Hou, *J. Chem. Soc., Perkin Trans. 1*, 1996, 867; (*c*) A. H. Li, L. X. Dai, X. L. Hou and M. B. Chen, *J. Org. Chem.*, 1996, **41**, 4641; (*d*) A. H. Li, L. X. Dai and X. L. Hou, *J. Chem. Soc., Perkin Trans. 1*, 1996, 2725.

6 (*a*) X. L. Hou, X. F. Yang, L. X. Dai and X. F. Chen, *Chem. Commun.*, 1998, 747; (*b*) X. F. Yang, M. J. Zhang, X. L. Hou and L. X. Dai, *J. Org. Chem.*, 2002, **67**, 80971; (*c*) D. K. Wang, L. X. Dai and X. L. Hou, *Chem. Commun.*, 1997, 1231.

7 (*a*) V. K. Aggarwal, J. P. H. Charmant, C. Ciampi, J. M. Hornby, C. J. O'Brien, G. Hynd and R. Parsons, *J. Chem. Soc., Perkin Trans. 1*, 2001, 3159; (*b*) V. K. Aggarwal, E. Alonso, G. Fang, M. Ferrara, G. Hynd and M. Porcelloni, *Angew. Chem. Int. Ed.*, 2001, **40**, 1433.

8 J. A. Marshall, The Wittig Rearrangement, in *Comprehensive Organic Synthesis*, B. M. Trost and I. Fleming, Ed., Pergamon, Oxford, 1991, **Vol. 3**, p. 975. For detailed experimental data, please see supporting information†.

9 (*a*) S. Ye, Y. Tang and L. X. Dai, *J. Org. Chem.*, 2001, **66**, 1517; (*b*) Z.-Z. Huang, S. Ye, W. Xia and Y. Tang, *Chem. Commun.*, 2001, 1384; (*c*) S. Ye, Z.-Z. Huang, C.-A. Xia, Y. Tang and L.-X. Dai, *J. Am. Chem. Soc.*, 2002, **124**, 2432; (*d*) Z.-Z. Huang, S. Ye, W. Xia, Y.-H. Yu and Y. Tang, *J. Org. Chem.*, 2002, **67**, 3096; (*e*) Z.-Z. Huang and Y. Tang, *J. Org. Chem.*, 2002, **67**, 5320; (*f*) K. Li, Z.-Z. Huang and Y. Tang, *Tetrahedron Lett.*, 2003, **44**, 4137; (*g*) K. Li, X.-M. Deng and Y. Tang, *Chem. Commun.*, 2003, 2704; (*h*) W.-W. Liao, K. Li and Y. Tang, *J. Am. Chem. Soc.*, 2003, **125**, 13030.

10 For the preparation of the telluride and telluronium salt **1**, please see: (*a*) M. P. Balfe, C. A. Chaplin and H. Philips, *J. Chem. Soc.*, 1938, 341; (*b*) Z.-L. Zhou, Y.-Z. Huang and L.-L. Shi, *Tetrahedron Lett.*, 1992, **33**, 5827.

11 A. Osuka, Y. Mori, H. Shimizu and H. Suzuki, *Tetrahedron Lett.*, 1983, **24**, 2599.

12 For the preparation of compound **4**: (*a*) E. Bernacka, A. Klepacz and A. Zwierzak, *Tetrahedron Lett.*, 2001, **42**, 5093; (*b*) A. Klepacz and A. Zwierzak, *Tetrahedron Lett.*, 2002, **43**, 1079.

13 For stereochemical assignment of the aziridines, please see supporting information†.

14 For possible mechanism, please see supporting information†.