

GENERATION AND INTRAMOLECULAR CATIONIC
CYCLIZATIONS OF N-TOSYLIMINES DERIVED
FROM ENOLIZABLE ALDEHYDES

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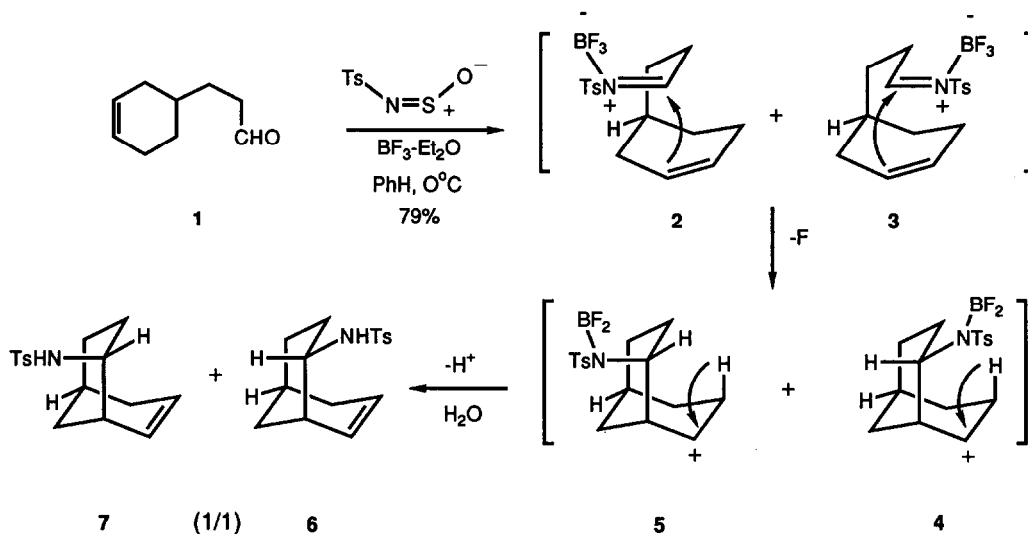
Abstract: Boron trifluoride etherate promotes both *in situ* formation of N-tosyliminium complexes from olefinic enolizable aldehydes and N-sulfinyl-p-toluenesulfonamide, and subsequent intramolecular electrophilic cyclization to afford homoallylic amines.

Although ene reactions are now widely recognized as powerful tools for organic synthesis,¹ examples of imines acting as enophiles are still rare. There are only a few documented cases of apparently concerted imino ene reactions,² along with several instances of processes affording formal ene-like products which may arise via stepwise, ionic mechanisms.³ This latter type of reaction is very closely related to the large body of work on cationic additions of olefins to iminium salts.⁴

We have recently been exploring inter- and intramolecular ene reactions of N-tosylimines derived from glyoxylates,^{2b} a transformation first reported by Achmatowicz.^{2a} As part of our efforts to extend this methodology, we became interested in the possibility of effecting ene reactions with N-tosylimines derived from enolizable aldehydes. The possibility of imine tautomerization in these cases had to be considered as a potential problem.

To our knowledge, sulfonylimines of enolizable aldehydes are unknown, although Kresze, *et al.* have reported efficient methodology for syntheses of N-tosylimines of non-enolizable aldehydes.⁵ We thus decided to apply the Kresze procedure to an enolizable aldehyde, and the results are shown in Scheme 1. Treatment of aldehyde 1 with N-sulfinyl-p-toluenesulfonamide at 0°C in the presence of boron trifluoride etherate (0.5 equiv) gave a 79% yield of a 1:1 mixture of bicyclo[3.3.1]sulfonamides 6 and 7. We believe that 1 reacts with the sulfinyl compound⁵ to afford a Lewis acid complexed N-tosyliminium intermediate (cf 2/3). Based upon the fact that epimeric sulfonamide cyclization products are formed, along with results discussed below, it seems reasonable that the iminium salt cyclizes via a non-concerted process. Therefore, cyclization of iminium ion conformers 2 and 3 would afford carbonium ions 5 and 4, respectively, which upon deprotonation yield the observed ene-like products. Other Lewis acids such as Me₂AlCl and SnCl₄ gave complex product mixtures, while in the absence of a catalyst no reaction occurred.

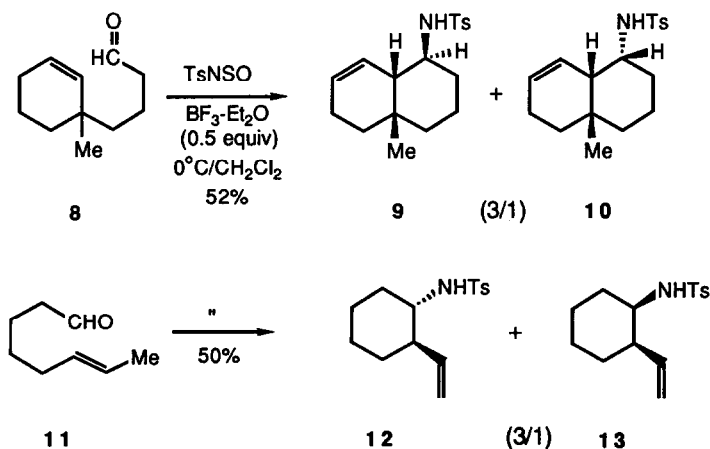
Scheme 1



Interestingly, competing processes such as intramolecular aldehyde ene reaction¹ or intermolecular ene reactions between the *N*-sulfinyl compound and the olefin^{6,7} (or enolized aldehyde⁷) were not observed.

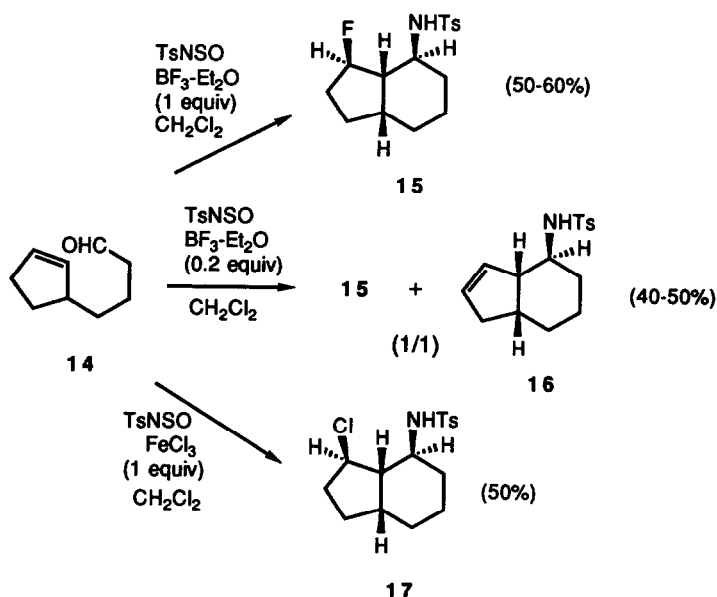
The two additional examples of the cyclization methodology in Scheme 2 show a higher level of stereoselectivity. Aldehyde 8 was converted to a 3/1 mixture of epimers 9 and 10, both having a *cis*-fused decalin system.⁸ Acyclic enal 11 also yielded a 3/1 mixture of *trans* and *cis* ene products 12 and 13.

Scheme 2



The cyclization of aldehyde **14** took a slightly different course (Scheme 3). Treatment of **14** with the N-sulfinylsulfonamide and one equivalent of boron trifluoride etherate gave a single fluorosulfonamide **15** having the stereochemistry shown.⁸ If the amount of BF_3 is reduced, mixtures of **15** and ene product **16** were produced. This result is consistent with the mechanism shown in Scheme 1. Attack of fluoride ion⁹ from the less congested exo face of the intermediate carbonium ion would yield **15**. The fact that β -proton elimination is slow probably reflects the ring strain present in ene product **16**. If ferric chloride is used as catalyst, chloride **17** is formed as a single stereoisomer.⁸

Scheme 3



These preliminary studies have demonstrated that N-sulfonyliminium complexes can be produced in situ from a variety of simple enolizable aldehydes and that these species act as electrophiles in intramolecular cyclizations with olefins. It should be noted that most iminium salts previously used in ene reactions² or cationic^{3,4} cyclizations are either derived from non-enolizable aldehydes or are incorporated into rings. We are exploring further applications of the chemistry of these structurally unique electron deficient N-tosylimines.

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