


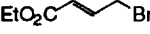








Table 1. Indium Trichloride-promoted Tin-mediated Allylation of Aldehydes<sup>a</sup>

| entry | aldehyde                             | Halide  | Conditions                                      | Yield (%) <sup>c</sup> | Isomer ratio <sup>b</sup><br>( <i>anti</i> : <i>syn</i> ) |
|-------|--------------------------------------|---|---|------------------------|---|
| 1     | C <sub>6</sub> H <sub>5</sub> CHO    |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 80                     | 50:50   |
| 2     | C <sub>6</sub> H <sub>5</sub> CHO    |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 45 <sup>d</sup>        | 99:1 <sup>5</sup>   |
| 3     | C <sub>6</sub> H <sub>5</sub> CHO    |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 96                     | 85:15   |
| 4     | CH <sub>2</sub> BrCHO                |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 55                     | 80:20   |
| 5     | 3-C <sub>5</sub> H <sub>4</sub> NCHO |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (24 h) | 51                     | 80:20   |
| 6     | C <sub>6</sub> H <sub>11</sub> CHO   |  | Sn, H <sub>2</sub> O (18 h)                     | 60                     | 85:15   |
| 7     | C <sub>6</sub> H <sub>11</sub> CHO   |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 65                     | 68:32   |
| 8     | C <sub>6</sub> H <sub>11</sub> CHO   |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (15 h) | 65                     | 99:1  |

a All reactions were carried out on 0.5-1 mmol scale. b The isomer ratio was determined by <sup>1</sup>H or <sup>13</sup>C NMR. c Isolated yield. d Balance of material is unreacted aldehyde.

The strong preference of reactions for the *anti* adduct for the (*E*)- and (*Z*)-alkyl crotonate suggests that transmetalation is involved. Transmetalation from allyltin with indium trichloride as Lewis acid would proceed via an S<sub>E</sub>2' process to produce compound **1** which further rearranged to crotylindium reagent to give compound **2a** and some **2b** due to thermodynamic stability. No isomerisation of the starting materials was observed after reactions. The high *anti* selectivity observed in these reactions can be explained by the six-membered transition state as depicted in Figure 1.

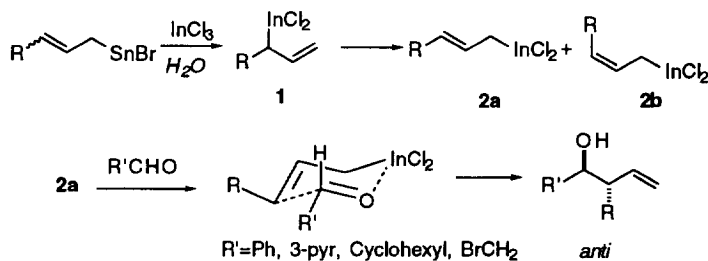


Figure 1

When the same strategy was applied to unprotected carbohydrates with the allyl bromide to investigate the reactivity and diastereofacial selectivity, the reaction was found to proceed smoothly at room temperature in water without heating or ultrasonication (eq 2). After the allylation reaction, the product was peracetylated with acetic anhydride following procedure as described by Whitesides.<sup>2g</sup> Interestingly, in most cases the reactions give the products in moderate to high diastereofacial selectivity. Especially noteworthy is the fact that hexoses reacted with allyl bromide under these conditions to give the corresponding products in high yield and

high diastereofacial selectivity (Table 2).

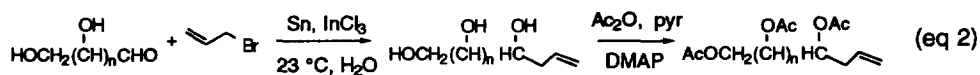










Table 2. Indium Trichloride-promoted Tin-mediated Allylation of Unprotected Carbohydrate<sup>a</sup>

| entry | starting sugar   | halide  | conditions                                      | yield(%) <sup>b</sup> | Isomer ratio <sup>c</sup><br>( <i>syn:anti</i> ) <sup>2g</sup> |
|-------|--|---|---|-----------------------|--|
| 1     | <br>L-arabinose |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (24 h) | 90                    | 75:25  |
| 2     | <br>D-Ribose    |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (24 h) | 92                    | 84:16  |
| 3     | <br>D-Mannose   |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (24 h) | 85                    | 94:6   |
| 4     | <br>D-Glucose   |  | Sn, InCl <sub>3</sub> , H <sub>2</sub> O (24 h) | 60                    | 95:5   |

<sup>a</sup> All reactions were carried out on 0.5-1 mmol scale. <sup>b</sup> Isolated yield after peracetylation and chromatography.

<sup>c</sup> As refer to C-2 hydroxyl group relative stereochemistry (determined by <sup>1</sup>H or <sup>13</sup>C NMR)

The formation of high *syn* selective product is most probably due to the 5-membered ring chelation between the C-1 carbonyl group, C-2 hydroxyl of the aldose and the allylindium formed in the transmetalation (Figure 2).

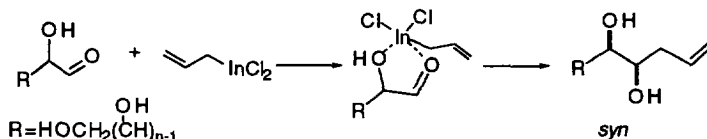


Figure 2

In summary, we reported a new tin-mediated allylation reaction promoted by indium trichloride in water. It is important to note that premixing of tin and indium trichloride is essential for the success of this reaction. It will serve as an attractive approach to the syntheses of homoallylic alcohols stereoselectively which may be readily transformed into various natural products. Further investigations are in progress to increase the applications of tin-mediated allylation reaction promoted by Lewis-acid in water such as the allylation of aldimines and the asymmetric version of the reaction.<sup>6</sup>

**References and Notes**

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3. (a) Marshall, J. A.; Hinkle, K. W. *J. Org. Chem.* **1995**, *60*, 1920. (b) Yasuda, M.; Miyai, T.; Shibata, I.; Baba, A. *Tetrahedron Lett.* **1995**, *36*, 9497. (c) We have recently found that the reactions proceeded albeit more slowly, with as little as 0.1 equiv. of indium trichloride with respect to tin and allylic bromide. In contrast to the system reported by Marshall and co-workers (ref. 3a), we have found that premixing of the indium trichloride, allylic bromide and tin increases rate and diastereofacial selectivity of the reaction. We are presently working to determine the fate of the tin species.
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6. This research was assisted financially by the National University of Singapore (Research Grant No. RP 940633, RP 930657 and 950609).

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