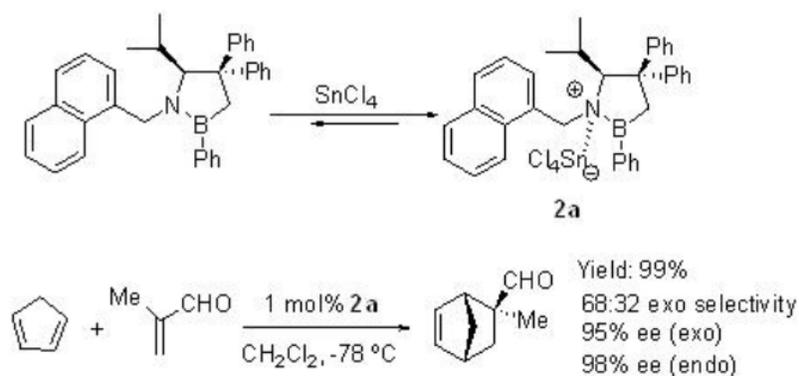


1.2: Lewis Acid-Assisted Lewis Acid (LLA)

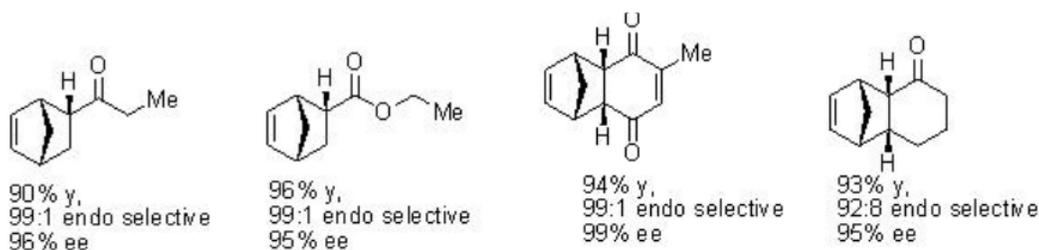
In Lewis acid assisted chiral Lewis acids (LLAs), achiral Lewis acid is added to activate chiral Lewis acid via complex formation. The reactivity of LLA is much greater compared to that of achiral Lewis acid, and thus, the latter's presence does not affect the selectivity of the reaction.

Diels-Alder Reaction

The LLA **2a**, derived from chiral valine-based oxazaborolidine and SnCl_4 as an activator, has been utilized as an efficient catalyst for the Diels-Alder reaction of a wide range of substrates (Scheme 1.2.1). In this system, the LLA **2a** is more reactive compared to SnCl_4 and the *ee* is not affected because of the addition of excess SnCl_4 .



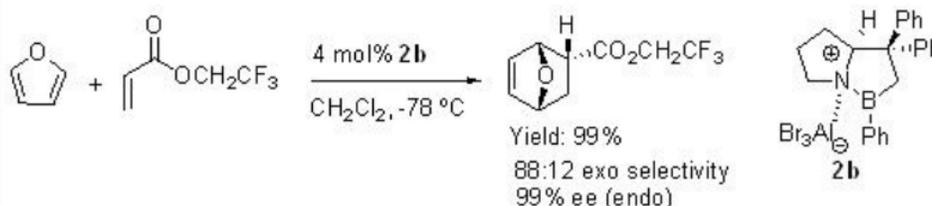
Additional examples:



K. Futatsugi, H. Yamamoto, *Angew. Chem. Int. Ed. Engl.* **2005**, *44*, 1484.

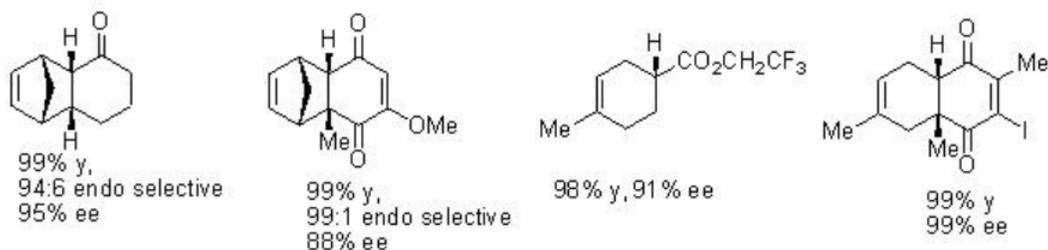
Scheme 1.2.1

The LLA **2b**, derived from the complexation of AlBr_3 with chiral oxazaborolidine, has been shown as a useful catalyst for the Diels-Alder reaction (Scheme 1.2.2). The observed results suggest that LLA **2b** is considerably more efficient than the corresponding BLA **1a** or **1b** since 10-20 mol% of BLA is usually needed for the optimum results.



Scheme 1.2.2

Additional examples:

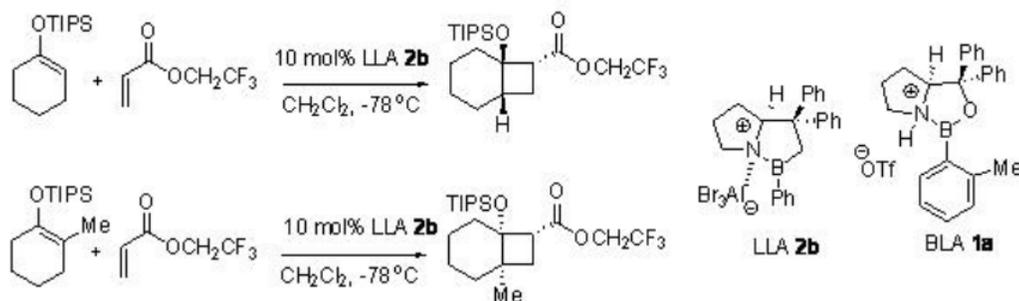


D. Liu, E. Canales, E. J. Corey, *J. Am. Chem. Soc.* **2007**, *129*, 1498.

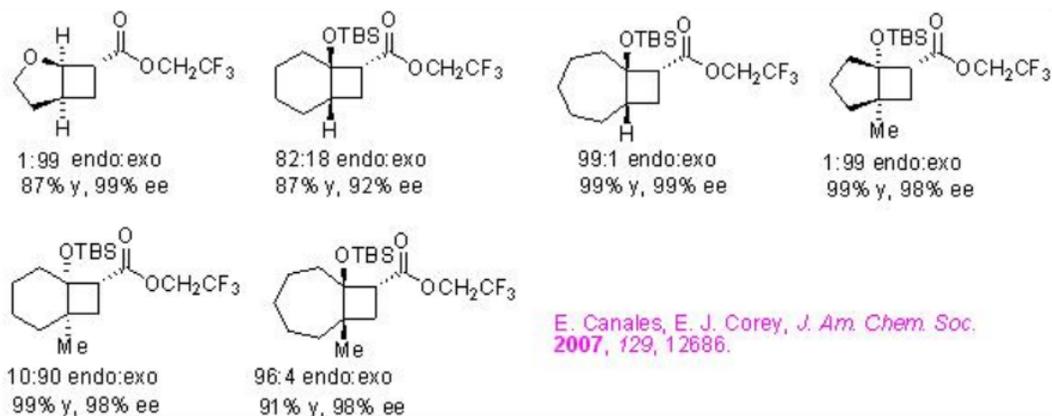
Scheme 1.2.3

[2+2]-Cycloaddition

The utility of LLA **2b** has been further extended to [2+2]-cycloaddition reactions of trifluoroethyl acrylate with enol ethers (Scheme 1.1.1). The protonated BLA **1a** was found to inferior to LLA **2b** in catalyzing the [2+2]-cycloaddition due to side reactions involving the enol ether component. The stereochemical outcome could be predicted using the transition states proposed earlier in Scheme 1.1.3, Lecture 1.



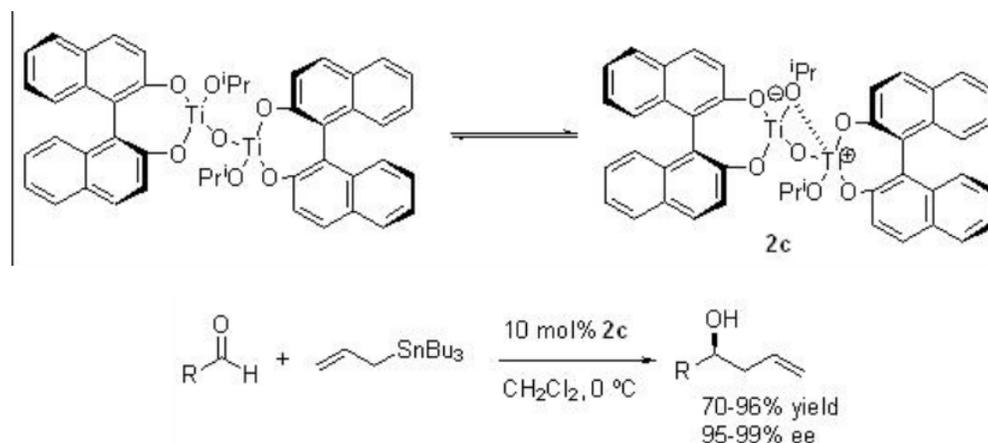
Examples:



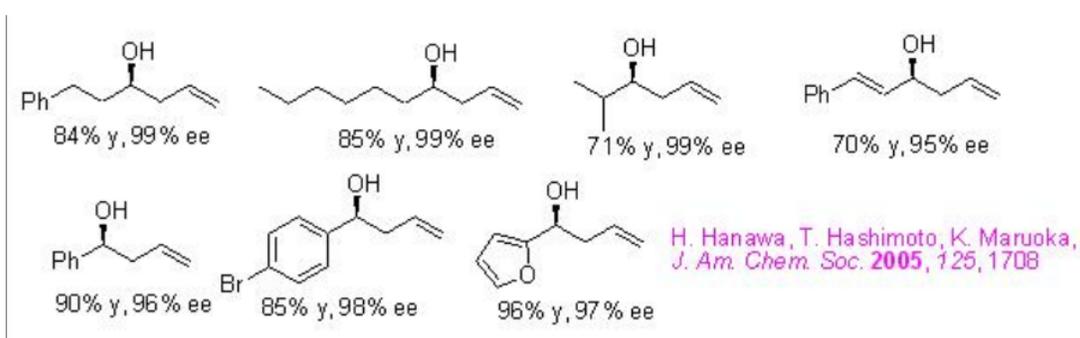
Scheme 1.2.4

Allylation

Maruoka group has developed chiral *bis*-Ti oxide complex **2c** as LLA (Lewis Acid-Assisted chiral Lewis Acid) for the enantioselective allylation of aldehydes with allylbutyltin (Scheme 1.2.5).

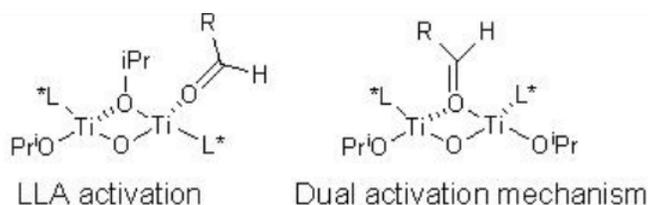


Examples:



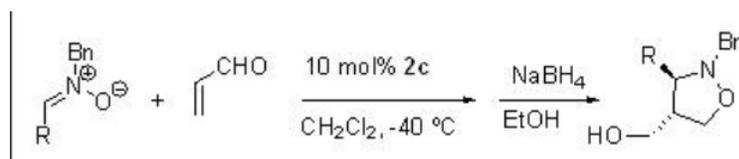
Scheme 1.2.5

For the high reactivity of the catalyst **2c**, two different transition states are proposed (Scheme 1.2.6). In the first, intramolecular coordination of one isopropoxy oxygen to the other titanium has been proposed which could lead to enhancement in Lewis acidity of the original Ti center for the carbonyl activation. In the second system, the simultaneous coordination of the two Ti centers to the carbonyl group has been proposed which may also lead to the high reactivity.

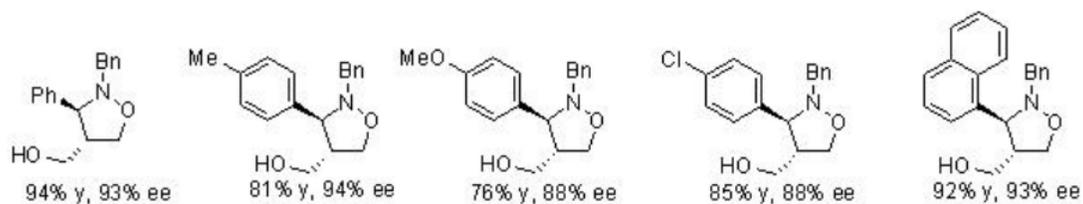


Scheme 1.2.6

The catalyst **2c** has also been found to be effective for 1,3-dipolar cycloaddition reaction between diazoacetates and α -substituted acroleins to give 2-pyrazolines with a quaternary carbon centre (Scheme 1.2.7).



Examples:



T. Kano, T. Hashimoto, K. Maruoka, *J. Am. Chem. Soc.* **2005**, *127*, 11926

Scheme 1.2.7

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