

Letter

# Enantioselective Michael addition reactions catalyzed by a new heterobimetallic asymmetric complex <sup>1</sup>

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## Abstract

A heterobimetallic catalyst obtained by reaction of  $\text{LiAlH}_4$  with aminodiol derived from natural (+)-tartaric acid promotes asymmetric Michael addition of malonic esters, thiophenols and nitro alkanes to cyclic and acyclic enones with excellent yields albeit low enantiomeric excess. © 1999 Elsevier Science B.V. All rights reserved.

*Keywords:* Asymmetric Michael addition; Heterobimetallic catalyst; Enones; Malonates

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## 1. Introduction

Catalytic asymmetric Michael addition reaction by chiral metal complexes has been recognised as an efficient method for obtaining asymmetric centres [1–5]. There has also been sustained interest in the development and use of enantiomerically pure  $C_2$ -symmetric diols to form metal alkoxides and its derivatives as the chiral source to produce products with high enantioselectivity [6]. A recent advance in the asymmetric Michael addition reaction is the discovery of a heterobimetallic multifunctional asymmetric catalyst reported by Shibasaki et al. [7–11]. In a series of reports, these authors elaborated the ability of heterobimetallic complexes of BINOL–aluminium or lanthanide–alkali metals in bringing about highly enantioselective Michael addition reactions. Recently, Manickam and Sundararajan, reported a new type of catalyst from aminodiol derived from styrene oxide [12]. In this paper, we report the synthesis of a new  $C_2$ -symmetric heterobimetallic complex for asymmetric Michael addition reactions with excellent yields albeit low enantiomeric excess.


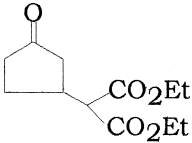

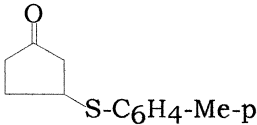
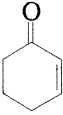
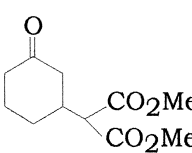
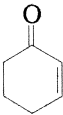
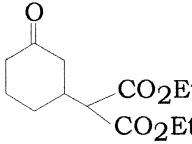
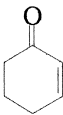
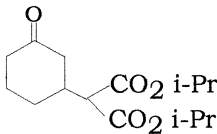
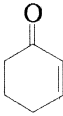
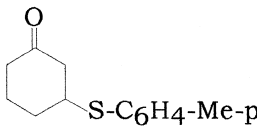
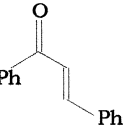
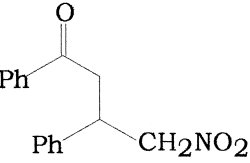
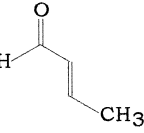
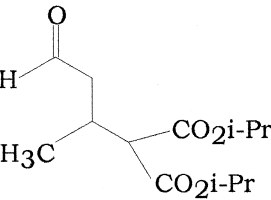
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<sup>1</sup> ICT Communication No.: 4052.

Table 1

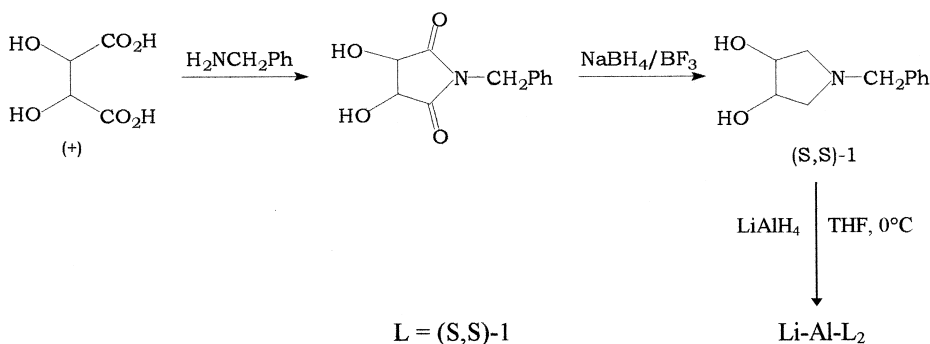
Michael addition of malonic esters, thiophenols and nitroalkanes to acyclic and cyclic enones in the presence of heterobimetallic complex

S.No.	Enone	Donor	Product	Yield <sup>a,b</sup> (%)	$[\alpha]_D^{25}$	ee <sup>c,d</sup> (%)
1		$\begin{matrix} \text{CO}_2\text{Et} \\ \text{CO}_2\text{Et} \end{matrix}$		100 (98)	+3.5 (c=1, CHCl <sub>3</sub> )	10
2		p-Me-C <sub>6</sub> H <sub>4</sub> SH		98 (96)	---	---
3		$\begin{matrix} \text{CO}_2\text{Me} \\ \text{CO}_2\text{Me} \end{matrix}$		100 (97)	+2.0 (c=1, CHCl <sub>3</sub> )	16
4		$\begin{matrix} \text{CO}_2\text{Et} \\ \text{CO}_2\text{Et} \end{matrix}$		100 (95)	+1.1 (c=2.5, CHCl <sub>3</sub> )	32
5		$\begin{matrix} \text{CO}_2 \text{ i-Pr} \\ \text{CO}_2 \text{ i-Pr} \end{matrix}$		100 (98)	---	---
6		p-Me-C <sub>6</sub> H <sub>4</sub> SH		98 (96)	+3.5 (c=1, C <sub>6</sub> H <sub>6</sub> )	5
7		CH <sub>3</sub> NO <sub>2</sub>		97 (95)	+2.8 (c=1, CH <sub>2</sub> Cl <sub>2</sub> )	7
8		$\begin{matrix} \text{CO}_2 \text{ i-Pr} \\ \text{CO}_2 \text{ i-Pr} \end{matrix}$		98 (95)	+3.2 (c=1, CHCl <sub>3</sub> )	20

<sup>a</sup>Determined by <sup>1</sup>H NMR Spectroscopy (200 MHz, CDCl<sub>3</sub>). Isolated yields are given in parentheses.<sup>b</sup>Time = 36 h except in the case of entries 2 and 6 where time = 1 h.<sup>c</sup>ee: Based on the specific rotation values.<sup>d</sup>Absolute configuration is R.

## 2. Experimental

The new heterobimetallic catalyst was synthesized in three steps from readily available natural (+)-tartaric acid. The known aminodiol (*S,S*)-1, prepared in two steps from natural (+)-tartaric acid [13] reacts readily with  $\text{LiAlH}_4$  (0.5 eq) in THF to give a heterobimetallic complex in situ with the evolution of hydrogen (Eq. 1).



In order to evaluate the efficiency of heterobimetallic complex towards asymmetric Michael addition reactions, we adopted a procedure similar to the one reported by Arai et al. [8]. Typically, the heterobimetallic complex was generated in situ by the reaction of aminodiol with  $\text{LiAlH}_4$  (0.5 eq). To this, the enones and donors were added and the reaction was followed by TLC. After completion of the reaction, the mixture was quenched with 1 N HCl. The Michael adducts were separated by flash column chromatography with ethyl acetate:hexane (1:9) as eluant. Various malonic esters, thiols and nitro alkanes were reacted with cyclic and acyclic enones in the presence of the catalyst (10 mol%). The results obtained are detailed in Table 1.

## 3. Results and discussion

The results shown in Table 1 reveal that yields are quantitative and the reaction time for the formation of Michael adducts is less compared with those employing Na–Ga–BINOL (143 h) [7], Li–Al–BINOL (72 h) [8] complexes. The enantiomeric excess of the products were calculated with the specific rotation values available in the literature [14–16]. We also performed Michael addition of enones with thiols and nitro alkanes to demonstrate the versatility of the method with substrates other than malonic esters. Nitromethane, 2-nitropropane with cyclopentenone gave racemic products with quantitative yields, whereas dimethyl malonate with chalcone gave 100% yield with 6% ee.

## 4. Conclusion

In conclusion, we have developed a new  $\text{C}_2$ -symmetric heterobimetallic catalyst for asymmetric Michael addition of malonic esters, thiols and nitro alkanes to cyclic and acyclic enones with excellent yields albeit low enantioselectivity. The aminodiol is easily synthesized from readily

available and inexpensive natural (+)-tartaric acid and can be recycled. The isolation and structural characterization of the  $C_2$ -symmetric heterobimetallic catalyst and to improve the enantiomeric excess of Michael adducts by varying the ligands is under progress.

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