



# P,S-ligands for Ir-catalyzed Asymmetric Hydrogenation of Minimally Functionalized Olefins – A Theoretical Study

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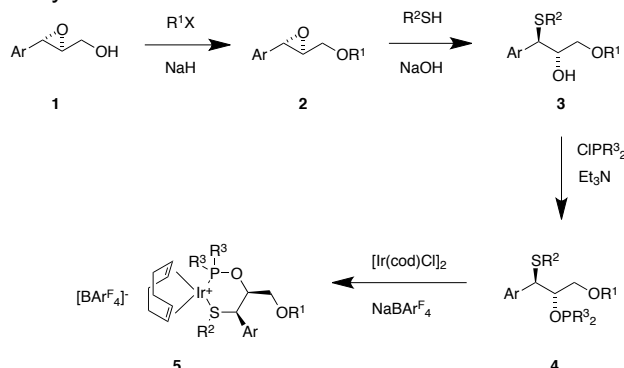
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## INTRODUCTION

Due to its simplicity, atom economy, and high efficiency, asymmetric hydrogenation is an attractive approach for the preparation of enantiomerically enriched chiral compounds. The asymmetric hydrogenation of olefins lacking adjacent polar groups has however proven to be difficult.

Recently, a class of P,S-ligands, derived from chiral epoxides (Scheme 1), was developed in the group, and employed in Pd-catalyzed asymmetric allylic substitution,<sup>1</sup> and in Rh-catalyzed hydrogenation of dehydroamino acids.<sup>2</sup>



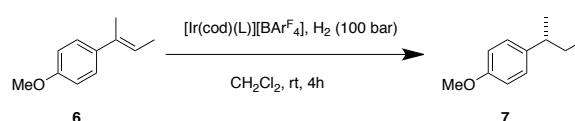
**Scheme 1.** Preparation of P,S-ligands and Ir-complexes.

## RESULTS AND DISCUSSION

Inspired by the work on Ir-catalyzed hydrogenation using carbohydrate-derived P,N-ligands,<sup>3</sup> the above-mentioned P,S-ligands have been used successfully to hydrogenate the minimally functionalized olefin **6** (Table 1), and similar substrates.

In order to explain the selectivity, a theoretical study has been initiated. Two ligands, **L1** and **L2**, were chosen, and all possible transition states leading to either R or S were calculated (16 for each ligand). The free energy differences between the most stable transition states leading to either enantiomer were then calculated and compared with experimental values (Table 1). Relevant transition states were then recalculated, with introduction of methyl groups, to obtain the free energy differences for **L3** and **L4**.

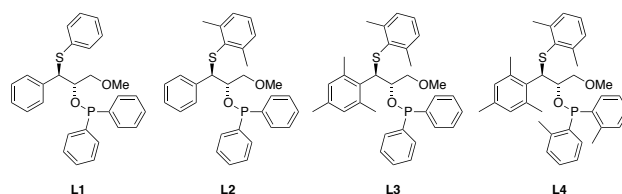
**Table 1.** Experimental and theoretical results.



Ligand	Conv. [%]	ee [%]	$\Delta\Delta G_{\text{exp}}^{\ddagger}$ [kJ/mol]	$\Delta\Delta G_{\text{cal}}^{\ddagger}$ [kJ/mol]
<b>L1</b>	100	44	2.3	4.5
<b>L2</b>	100	64	3.8	8.5
<b>L3</b>	ND*	ND*	ND*	14.2
<b>L4</b>	100	95	9.1	13.7

\*ND = not determined.

**Figure 1.** P,S-ligands investigated theoretically.



## CONCLUSION

Despite the fact that the calculated free energy differences are systematically higher than the experimental values, the general trend is reproduced well. The not yet tested **L3** appears promising.

## ACKNOWLEDGEMENTS

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