

Molecular Cages as Nanoreactors for Supramolecular Catalysis

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INTRODUCTION

Supramolecular catalysis is an enticing field because of the similar properties supramolecular structures have compared to natural enzymes. The cavity of these supramolecular structures can be altered to recognize specific guests through non-covalent interaction. Usually these molecular vessels are formed *via* covalent bonds, but studies on self-assembled molecular cages are more promising. These cages are easier to synthesize and functionalize, making them more desirable for catalysis.

Alternative Pathway to Different Product

Confinement as well as the non-covalent interactions between the guest and host will offer opportunity to form products that differ from products that are formed in bulk solution.¹ The products formed may be regioisomers or stereoisomers of their counterparts in a bulk solvent environment. The discovery of these new reaction pathways is a growing application of the molecular cages.²

Pre-Organization for Rate Enhancement

Similar to the enzyme, the position of substrate is not only controlled by the size and shape of the cavity, it is also influenced by non-covalent interactions like hydrogen bonding and electrostatic interaction. The effective molarity of reacting species can be enhanced with pre-organization effect. Furthermore, pre-organization decrease conformation change required for reactions and thus enhancing the kinetic rate.³

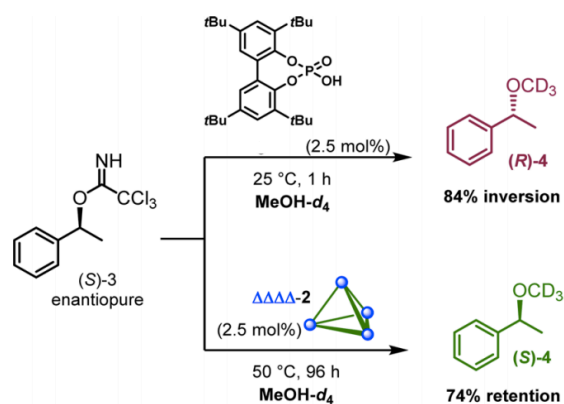


Figure 1: Different selectivity pathway to enantiomers

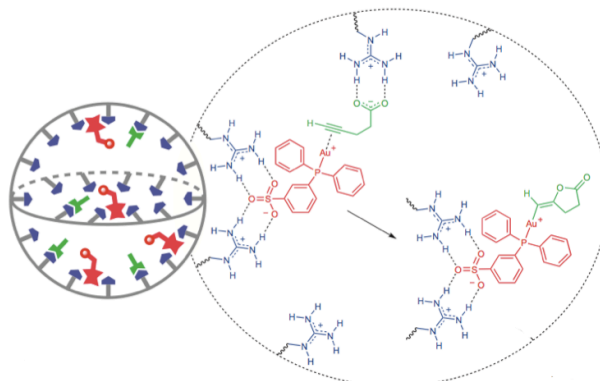


Figure 2: Pre-organization for both substrates and catalysts

Multicatalytic Tandem Reaction

Generally, each synthetic procedure needs purification to obtain the product, which is not economical. Therefore, it is desirable that several consecutive catalytic reactions can be conducted in one pot to enhance the efficiency. However, multicatalytic tandem reactions are difficult to achieve due to the compatibility problems of catalyst, substrates and high-energy intermediates in the one-pot reaction. Molecular cages provide compartmentalization for catalysis, providing good physical barriers and good substrate selectivity, it is desirable to use molecular cages to conduct multicatalytic tandem reactions.⁴

Limitation of Turnover

Even though the supramolecular catalyst involves with successful substrate binding and reaction inside the cavity, expulsion of product from the binding pocket to gain turnover is still very challenging. Until now, there is no conventional method to solve the turnover problem. However, there are limited examples that solve the turnover problems. For instance, Reek and his coworkers showed that the polarity change of the substrate and the product could result in different binding affinity to the molecular cage with positive charge to gain high turnover.³

CONCLUSION AND FUTURE DIRECTIONS

The benefits of supramolecular catalysis conducted inside the self-assembled molecular cage include their different product selectivity compared to conventional homogeneous reaction. In addition, the modification inside the cage offers opportunity to enhance kinetic rate by having pre-organization within the cavity. Even though there are still problems with high turnover, possible application in multicatalytic tandem reaction will encourage more research groups to overcome these challenges.

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