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Abstract

Title	Molecular design of chiral polymeric organocatalysts and their applications in asymmetric catalysis

(800 words)

Main-chain chiral polymeric organocatalysts have been designed and synthesized from the readily available and inexpensive cinchona alkaloids. Cinchona alkaloids are available in pseudoenantiomeric forms such as quinine, quinidine, cinchonine and cinchonidine. They are among the most privileged chirality inducer in the area of asymmetric catalysis. Due to their diverse chiral skeletons and functionalities several modifications have been done by several groups. The quinuclidine nitrogen of the cinchona alkaloid can easily be quaternized and the OH group also can be modified. The double bond of the cinchona alkaloid also can be hydrogenated and dehydrogenated. Thiol-ene click reaction and Heck coupling reaction also can be carried out at the double bond of cinchonidine. Based on versatile functionalities of cinchona alkaloid, several groups have reported monomeric, dimeric and polymeric organocatalyst containing quaternary ammonium salts.

Cinchona derived quaternary ammonium salts are one of the most popular organocatalysts in the field of asymmetric catalysis especially for the synthesis of unnatural α-amino acids. Although several works have been done with the side-chain chiral polymeric organocatalyst only a limited number of investigations have been carried out for the development and application of main-chain chiral polymeric organocatalyst. Traditionally, the polymer-supported chiral catalysts are prepared by anchoring highly enantioselective monomeric catalysts to flexible and sterically irregular polymer supports. Although a few enantioselective polymer catalysts have been obtained in this manner, a significant reduction of enantioselectivity is often observed after a monomeric catalyst is attached to a polymer support. This indicates that the microenvironment of the polymer is very important for the stereoselectivity of the catalyst. Because of the stereo-irregularity and flexibility of the traditional polymeric chiral catalysts, their catalytic sites do not have well defined microenvironment. It is very difficult to systematically modify the microenvironment of the catalytic sites in these polymers to improve their enantioselectivity. The microenvironment of the catalytic sites in rigid and sterically regular polymers can be systematically modified to produce highly enantioselective polymeric catalysts. The enantioselectivity of a monomeric catalyst can be maintained in a polymer catalyst by the use of a rigid and sterically regular polymer backbone. Compared with the traditional polymer-supported catalysts for which flexible and sterically irregular polymers are used, this new approach can better preserve the catalytic environment of the monomeric catalysts in the polymer as long as the catalytically active species are not aggregates of the monomers. These strategies not only make it possible to obtain easily reusable and highly enantioselective polymeric catalysts for many asymmetric reactions, but also can be further extended to construct polymeric chiral catalysts that are capable of multiple asymmetric catalytic reactions by incorporating different catalytic species in a polymer chain.

Therefore, designing of main-chain chiral polymeric organocatalyst is an important field of research in asymmetric catalysis for obtaining enantiopure compounds. To investigate the effect of main-chain chiral polymeric organocatalyst in asymmetric catalysis, we have designed several types of main-chain chiral polymers using different polymerization methods and applied them in asymmetric benzylation of glycine derivative and asymmetric epoxidation of chalcones.

In this thesis, chapter 1 describes the structural features of cinchona alkaloids and chapter 2 describes the general introduction and background of this thesis work.

Chapter 3 and 4 describe the novel synthesis of main-chain chiral ionic polymer using *ion exchange polymerization* and their application in asymmetric benzylation of glycine derivative. Cinchona derived dimeric quaternary ammonium salts and different types of disulfonate reacted together to give main-chain *ionic polymer*. The synthesized main-chain ionic polymers were employed as novel polymeric organocatalyst in asymmetric benzylation of glycine derivative to give a high enantioselectivities. Furthermore, the polymeric catalyst was recovered and reused.

Chapter 5 describes the synthesis of main-chain chiral polymers by the reaction between cinchona derived dimeric quaternary ammonium salts and aryl diiodide using *Heck coupling polymerization*. To our knowledge, there have been no reports on the application of main-chain chiral polymer synthesized by Heck reaction. In this work, we have employed the main-chain chiral polymers synthesized by *Heck coupling polymerization* as a novel polymeric organocatalyst in asymmetric benzylation of glycine derivative. In this case also quite a high enantioselectivity was obtained and the polymeric catalyst was recovered and reused.

Chapter 6 describes the synthesis of main-chain *ionic polymer* by the reaction of cinchonidine dimers and disulfonates. Cinchodine dimers were modified by iodobenzene at the double bond of cinchonidine using Heck coupling and then the modified cinchonidine dimer utilized in *ion exchnage polymerization* with different types of disulfonates to obtain novel type of main-chain *ionic polymer*. The polymers synthesized were applied in asymmetric benzylation of glycine derivative to give high yields and enantioselectivites.

Chapter 7 describes the synthesis of main-chain chiral polymers using *quternization polymerization* between cinchonidine dimer and dihalide. The cinchonidine dimer was synthesized by Heck coupling of cinchonidine and 4,4'-diaryldiiodide. 2 equivalents of cinchonidine reacted with 1 equivalent of 4,4'-diaryldiiodide to give a novel cinchonidine dimer where two cinchonidine units are connected through the double bond with 4,4'-diaryldiiodide. The polymers were applied in asymmetric benzylation of glycine derivative.

Chapter 8 describes the application of main-chain chiral polymeric organocatalyst in asymmetric epoxidation of chalcones. As the asymmetric epoxidation of chlacones are very sensitive to the catalyst structure, oxidant, solvent, temperature and base. Several types of main-chain chiral polymers have been screened in this work to find a suitable catalyst which gives higher enantioselectivity. Although several works have been done with monomeric dimeric and polymer-supported chiral organoctalyst, there has been almost no report on the application of main-chain chiral polymeric organocatalyst in asymmetric epoxidation of chalcones. In this work, for the first time we have applied main-chiral polymeric organocatlyst in asymmetric epoxidation of chalcones.

Chapter 9 describes the general summary of this thesis work.