SYNLETT Spotlight 97

Chiral Ketone Catalysts Derived from D-Fructose

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This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

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Introduction

In 1996, a new chiral ketone **1** (1,2;4,5-di-isopropylidene-D-erythro-2,3-hexodiure-2,6-pyranose), derived from inexpensive D-fructose, was reported by Shi and co-workers as a highly active asymmetric epoxidation catalyst.¹ This rapidly developed into a new class of highly efficient catalysts for the asymmetric epoxidation of a wide range of olefins.²

Preparation

Ketones **1**, **2** and **3** were prepared from D-fructose in excellent yields.^{3a,4,5} Ketone **4** was prepared from D-glucose.^{3c,6}

Abstract

(A) Ketone **1** is an efficient epoxidation catalyst for *trans*-disubstituted and trisubstituted olefins with potassium peroxomonosulfate (Oxone) as the oxidant.^{1,3a,7} Cheap dilute 30% H₂O₂, a green oxidant, shows an enantioselectivity comparable to that of Oxone.^{8,9}

(B) Hydroxyalkenes can be asymmetrically epoxidized by chiral ketone **1** with Oxone or H₂O₂. As shown, asymmetric epoxidation of *trans*-β-hydroxymethylstyrene can be achieved in 98% ee and 85% yield.¹⁰

(C) A highly effective and mild asymmetric monoepoxidation of conjugated dienes with chiral ketone **1** and Oxone presents an efficient approach to prepare enantiomerically enriched vinyl epoxides. The enantiomeric excess for the major monoepoxides ranges from 89% to 97%.¹¹

(D) For the asymmetric epoxidation of conjugated enynes using chiral ketone **1** as the catalyst and Oxone or H₂O₂ as the oxidant, a high ee up to 95% is obtained.¹² Double bonds in conjugated enynes can also be selectively epoxidized by ketone **2** and Oxone.⁴

(E) Chiral oxy-substituted epoxides or hydroxy ketones can be synthesized through the enantioselective epoxidation of chiral silyl enol ethers or enol esters catalyzed by ketone **1** and Oxone.¹³

(F) Through the asymmetric epoxidation of 2,2-disubstituted vinylsilanes, chiral 2,2-disubstituted α,β -epoxysilanes can be synthesized.¹⁴ Upon desilylation, the corresponding 1,1-disubstituted terminal epoxides are obtained without any loss in enantioselectivity.

(G) The kinetic resolution of racemic 1,3- and 1,6-disubstituted cyclohexene via chiral ketone **1** has been demonstrated.¹⁵

(H) Asymmetric epoxidation of several *trans*-disubstituted and trisubstituted α,β -unsaturated esters was achieved with high yields and ee values, using a system consisting of ketone **2** and oxone.⁴

(I) For the asymmetric epoxidation of terminal olefins, ketone **1** shows a similar reactivity to ketone **4**, but a much lower enantioselectivity.¹⁶

(J) Ketone **1** shows both a lower reactivity and a lower enantioselectivity than ketone **4** for the asymmetric epoxidation of *cis*-disubstituted olefins.³

(K) The enantioselectivity obtained with ketone **3** is very similar to that of ketone **1** in the asymmetric epoxidation of *trans*-disubstituted and trisubstituted olefins, hydroxyalkenes and chiral enol esters. However, the catalyst consumption is greatly decreased from 20–30 mol% for ketone **1** to 1–5 mol% for ketone **3**.⁵

References

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- (9) Y_{oxone} or Y_{H2O2} stands for the yield when Oxone or H₂O₂ is used as the oxidant; while Y₁, Y₃ or Y₄ stands for the yield when ketone **1**, **3** or **4** is used as the catalyst.
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