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Spotlight 180

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

BINOL: A Versatile Chiral Reagent

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Dedicated to my research supervisor Dr. Pradeep Kumar

Introduction

The aim of enantioselective synthesis or catalysis is to produce chiral products starting from achiral substrates by exploiting the presence of chiral reagents. The enantiomeric atropisomers of 1,1′-binaphthyl-2,2′-diol (BINOL) are the best-known representatives of axially chiral molecules and were first prepared as racemate in 1873 by von Richter.[1] BINOL is used for both stoichiometric and catalytic asymmetric reactions.[2] The chiral atropisomers (*R*)-**1** ([α]$^{20}_{D}$ +35.5 THF, *c* 1), mp 205–211 °C and (*S*)-**1** ([α]$^{20}_{D}$ –34.5, THF, *c* 1), mp 205–211 °C are stable at high temperature and allow numerous asymmetric reactions under various experimental conditions (Figure 1).[3] BINOL-mediated asymmetric oxidation, reduction and C–C bond-forming reactions are well-established reactions in organic synthesis. BINOL (**1**) can be easily prepared from 2-naphthol using Cu–amine complexes to give racemic BINOL which can be converted into (*R*)-BINOL [(*R*)-**1**] or (*S*)-BINOL [(*S*)-**1**] by enzymatic resolution[4] or via chemical resolution (Scheme 1).[5]

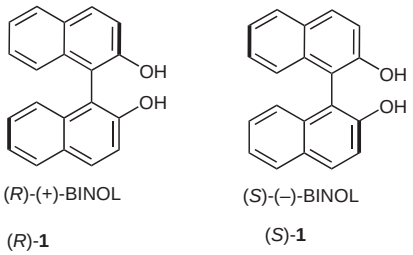
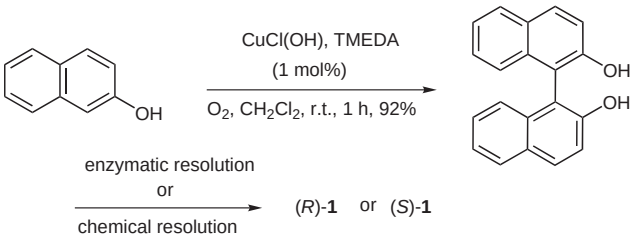


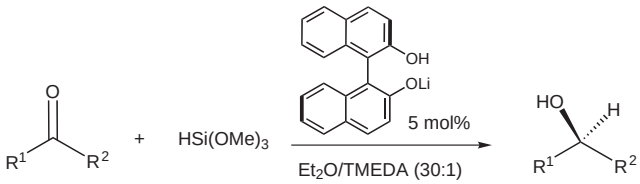
Figure 1



Scheme 1

Abstracts

(A) The catalytic asymmetric reduction of different ketones with transient hypervalent trialkoxy silanes in the presence of a small amount of a chiral nucleophile such as BINOL (**1**) underwent addition to the carbonyl group, forming the corresponding silyl-protected alcohols, which were cleaved during the work-up to give enantiomerically enriched alcohols.[6]



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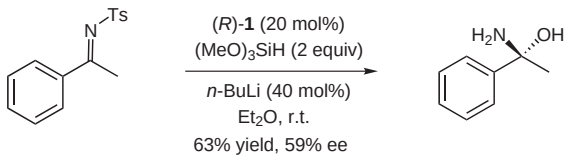
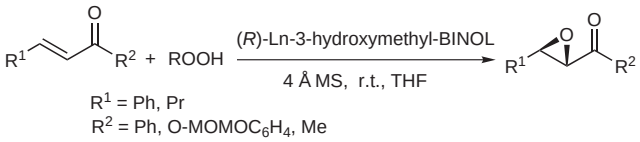
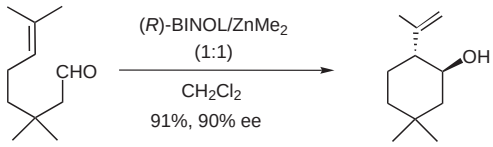
(B) Hosomi et al. reported an optically active lithium alkoxide which catalysed asymmetric reduction of imines with trimethoxysilanes affording the expected amines in moderate ee (up to 72%).[7]



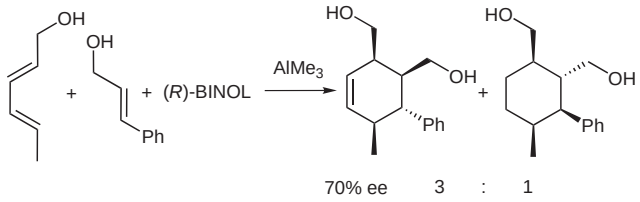
(C) Shibasaki et al. used lanthanum- or ytterbium-modified BINOL derivatives as catalysts in the asymmetric epoxidation of enones with *tert*-butyl hydroperoxide (TBHP).[8]



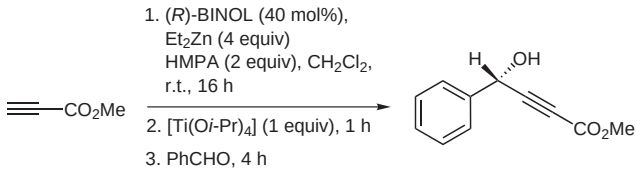
(D) Yamamoto et al. reported the first successful example of asymmetric induction which deals with a cyclisation in the presence of a BINOL–Al catalyst. Indeed, a catalyst prepared in situ from dimethyl zinc and optically pure (*R*)-(–)-BINOL promoted the cyclisation of 3-methylcitronellal to methylisopulegol as a single isomer with 90% ee.[9]



(E) Olsson et al. reported the Diels–Alder reaction between 'non-compatible' dienes and dienophiles by means of a temporary Al or Zr tethering.[10]



(F) Very recently, Pu, Yu and coworkers reported the highly enantioselective reaction of an alkynoate with aromatic and α,β-unsaturated aldehydes for the synthesis of optically active γ-hydroxy-α,β-acetylenic esters containing three adjacent and structurally very different functional groups which are very useful in the synthesis of highly functionalized organic molecules.[11]



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