

SYNLETT Spotlight 301

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

Ytterbium Triflate: A Green Catalyst

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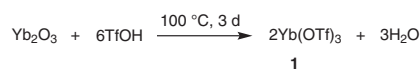
Introduction

Ytterbium triflate (**1**) is known to be a useful mild, versatile, and environmentally friendly Lewis acid catalyst. With the ever-increasing interest in the sustainable development, $\text{Yb}(\text{OTf})_3$ benefits from its characteristic features: High efficiency in green media, such as water and ionic liquids, recovery after reaction completion, and reusing without loss of activity.¹ Contrary to other Lewis acids, $\text{Yb}(\text{OTf})_3$ is effectively used in catalytic amounts and is widely employed in organic synthesis promoting several carbon–carbon and carbon–heteroatom bond formation, which include the aldol condensations, Mannich-type reaction, Diels–Alder cycloadditions, Friedel–Crafts acylation or alkylation, and heterocycle synthesis.¹ Moreover, taking its advantage of the affinity to nitrogen-containing compounds, which deactivate most Lewis

acids, $\text{Yb}(\text{OTf})_3$ enhances the reactivity of the imine group and catalyses an imine ene reaction providing useful homoallylic amines,² and also increases the yield of the Ugi four-component coupling.³

Preparation

Ytterbium triflate is commercial available but can also be readily prepared from ytterbium oxide (Yb_2O_3) and a solution of trifluoromethanesulfonic acid (TfOH) in deionized water (1:1 v/v).⁴

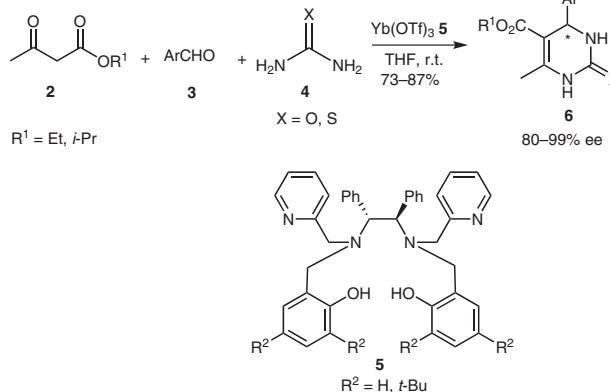


Scheme 1 Preparation of ytterbium triflate (**1**)

Abstracts

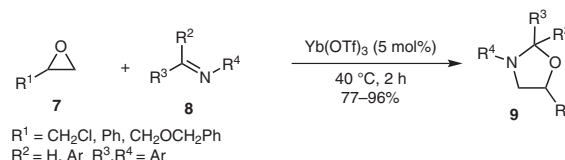
(A) One-Pot Synthesis of Dihydropyrimidines (DHPMs):

The highly efficient chiral ytterbium catalyst **5** has been developed and successfully employed on the multicomponent Biginelli reaction providing an enantioselective synthesis of chiral DHPMs **6**. This one-pot cyclocondensation of 1,3-ketoester **2**, aldehyde **3**, and urea or thiourea **4**, is accomplished in high yields and excellent enantioselectivity as well as high atom economy and safe waste as the catalyst could be recovered and reused several times without loss of ee. The DHPMs scaffold is an important pharmacophore and can be converted into other derivatives with potential pharmaceutical application.⁵



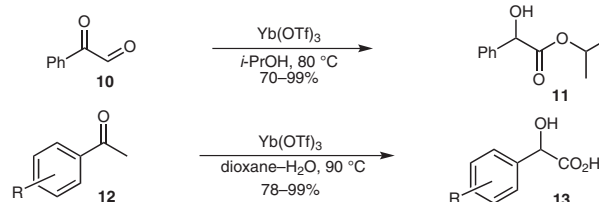
(B) Synthesis of 1,3-Oxazolidines:

$\text{Yb}(\text{OTf})_3$ promotes the solvent-free reaction of *N*-arylimines **8** and epoxides **7** to yield the corresponding [3+2] cycloaddition products **9**. This easy and environmentally sound method gives the products in high yields. 1,3-Oxazolidines are often used as chiral auxiliaries and intermediates in organic synthesis.⁶

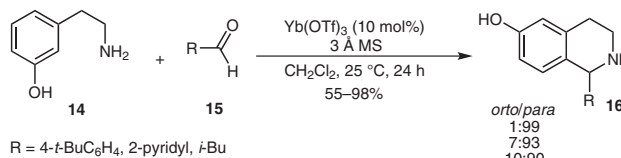


(C) *Oxidation–Cannizzaro Reaction:*

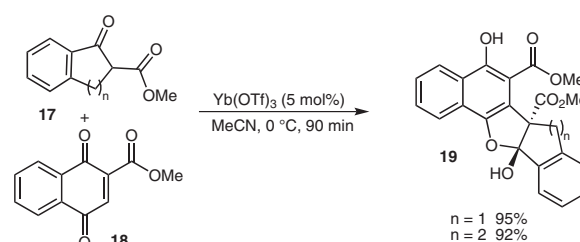
An eco-friendly method for the synthesis of either isopropyl esters **11** or *o*-hydroxyarylacetic acids **13** from substituted aromatic glyoxals **10** and aryl methyl ketones **12**, respectively, in the presence of Yb(OTf)₃ was reported. The products were isolated in good to excellent yields.⁷

(D) *Catalytic Pictet–Spengler Reaction:*

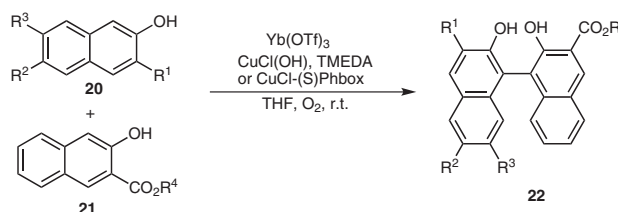
Kobayashi and co-workers have developed an efficient regioselective synthesis of synthetically useful isoquinoline derivatives (**16**). The cyclization between *m*-tyramine (**14**) and various aldehydes (**15**) occurred mainly at the para position to the phenolic hydroxyl group and gave the products in good to excellent yields.⁸

(E) *Conjugate Addition of β-Ketoesters to Activated Quinones:*

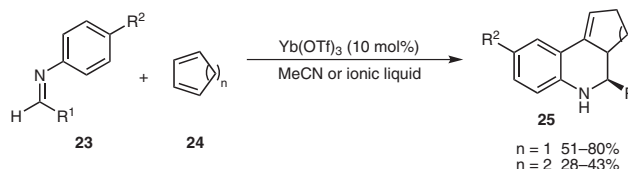
Kimpe and co-workers reported the conjugated addition of various β-ketoesters **17** to activated 1,4-naphthoquinones **18** mediated by catalytic amounts of Yb(OTf)₃. The adducts **19** were obtained in excellent yields.⁹

(F) *Selective Oxidative Cross-Coupling:*

Yb(OTf)₃ is used along with an achiral or a chiral copper complex in the synthesis of naphthol derivatives **22**. Employing this binary catalyst system the cross-coupling proceeded in a specific manner. In addition, when the copper complex was chiral the enantioselectivity were significantly affected. The latter procedure allows the synthesis of versatile chiral auxiliaries that have been successfully employed in asymmetric synthesis.¹⁰

(G) *Mild and Efficient Aza-Diels–Alder (ADA) Reaction:*

Six-membered nitrogen heterocycles display a wide range of potent biological activity and have aroused great synthetic interest. Recently, a very convenient route towards the synthesis of quinoline and phenanthridine derivatives **25** from the reaction of cyclopentadiene or cyclo-1,3-hexadiene **24** with various *N*-arylimines **23** by using Yb(OTf)₃ as catalyst was described. The conversion into an ionic liquid as a green reaction medium was also conducted.¹¹



References

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