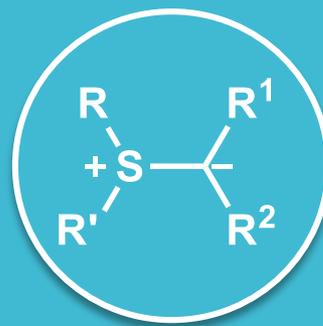


Recent Advances in the Catalytic Cyclization Reactions of Sulfur Ylides

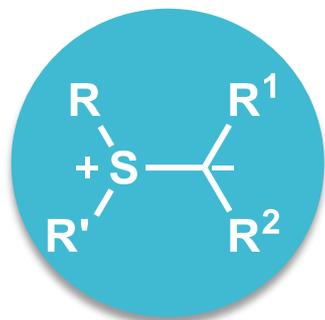
Reporter: Baoli Chen

Supervisor: Prof. Huang

Date: 2018-09-18



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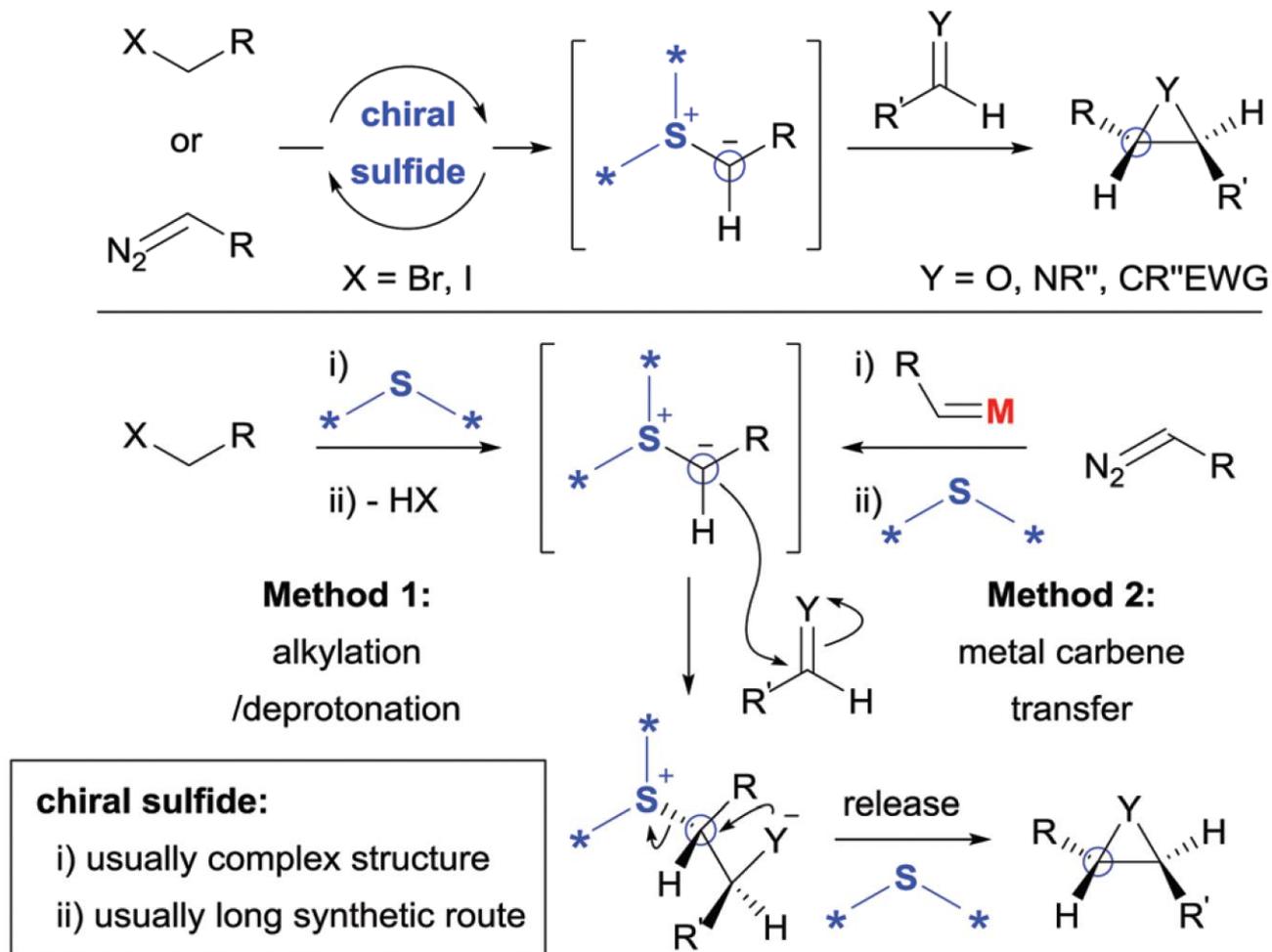
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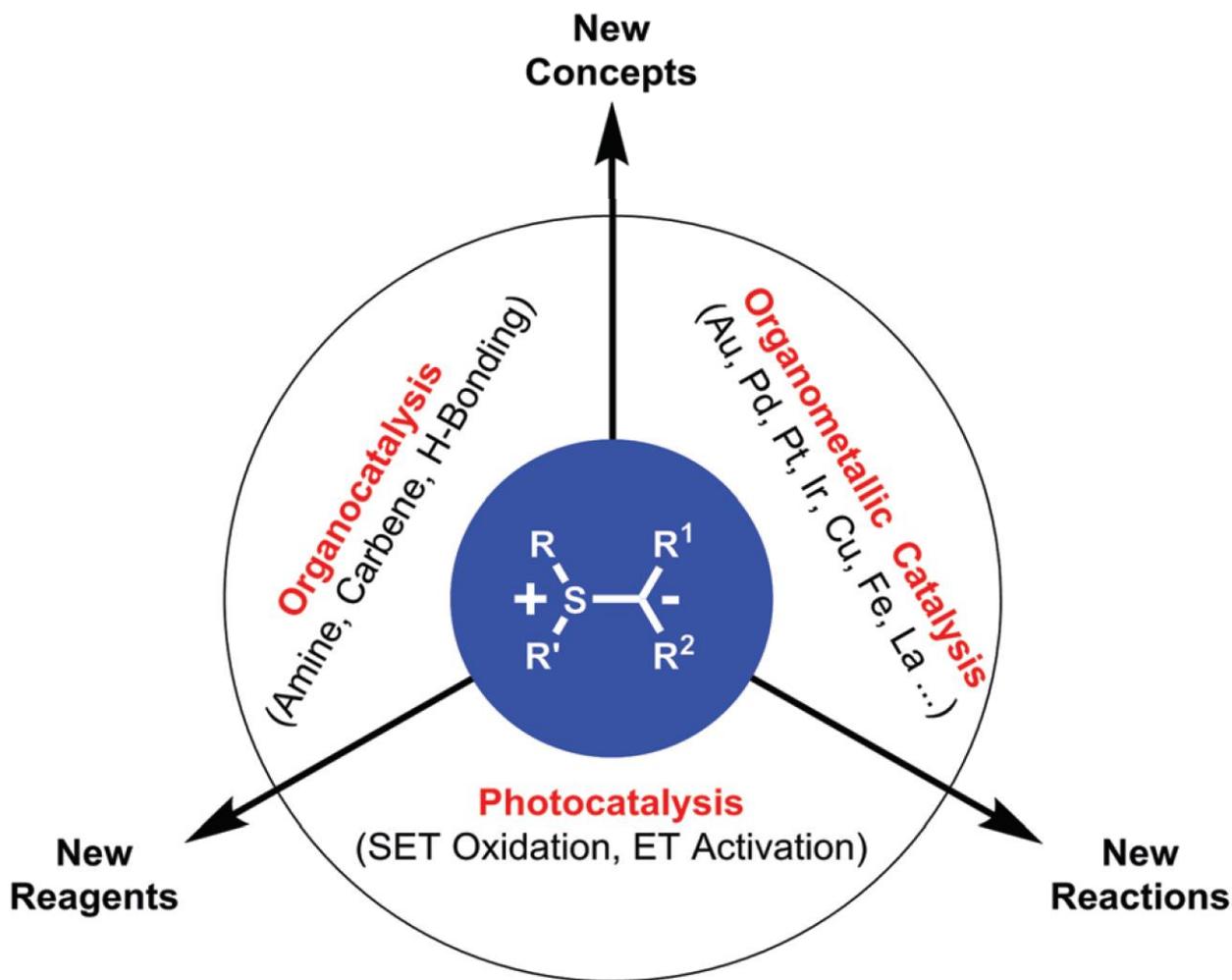
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High loading of chiral sulfides

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Summary of work beyond sulfide-centric catalysis

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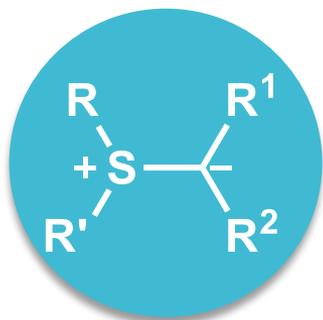
04 Transition-metal-catalyzed cyclizations

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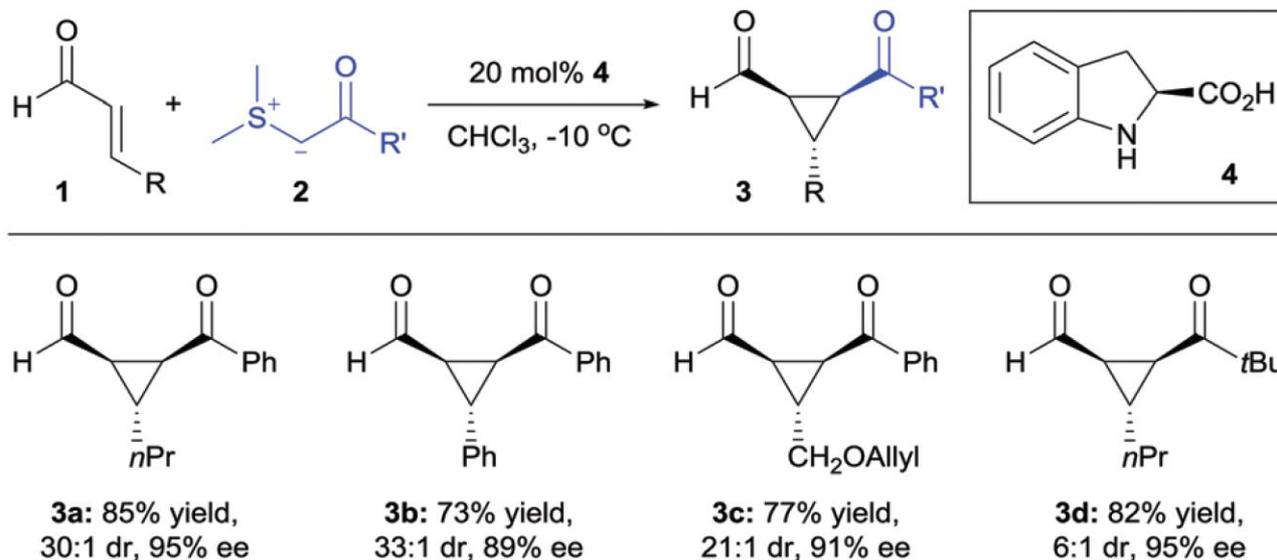
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2. Organocatalytic asymmetric cyclizations

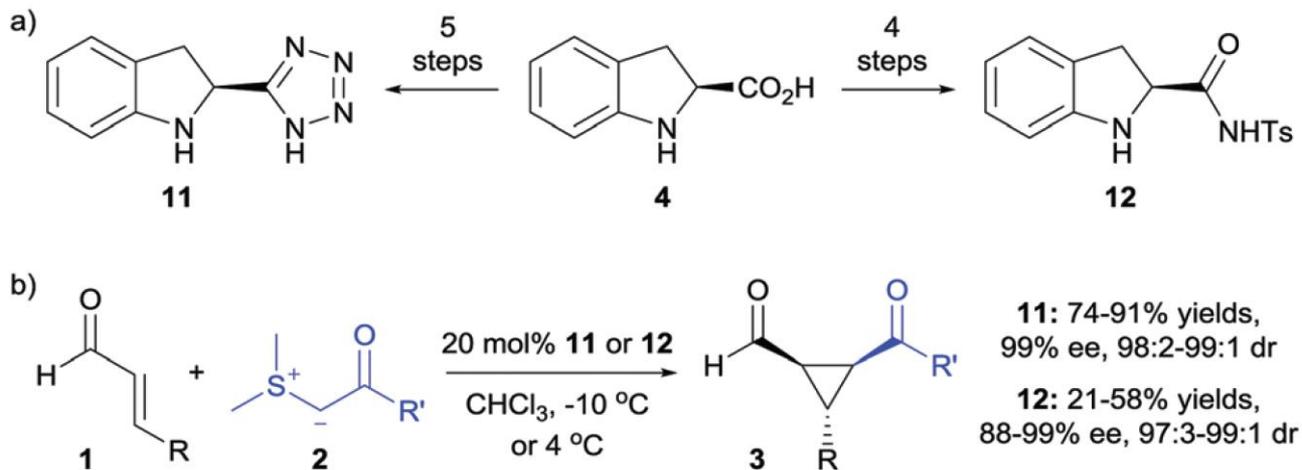
2.1. Asymmetric aminocatalysis



Enantioselective cyclopropanations of sulfur ylides with aldehydes

2. Organocatalytic asymmetric cyclizations

Improved chiral amine catalysts

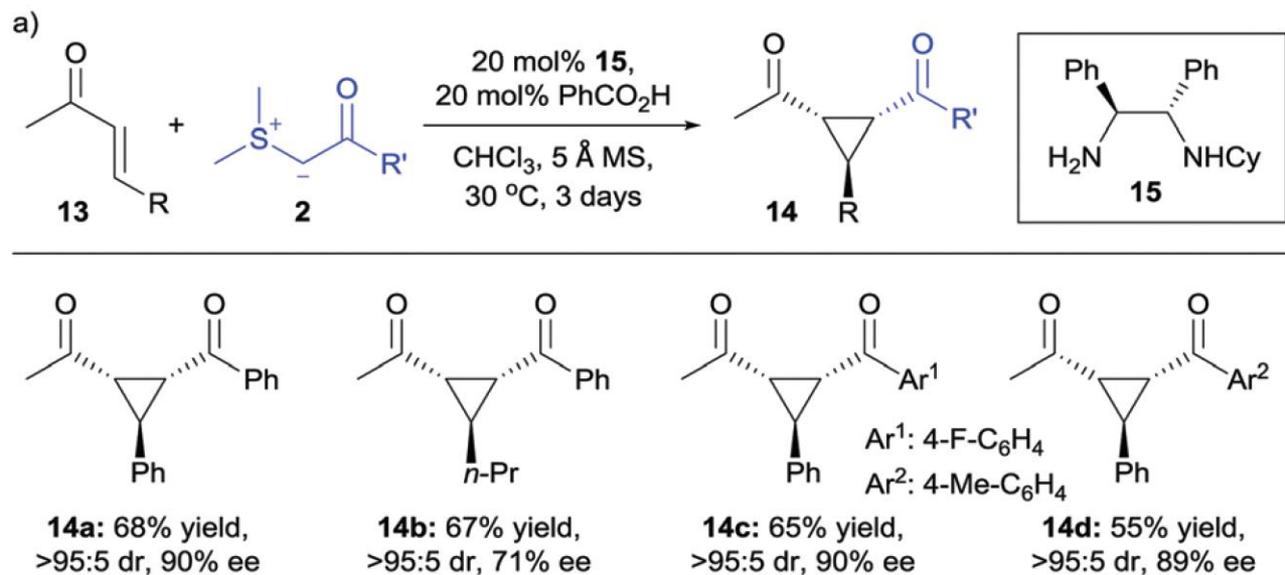


P. I. Arvidsson, *et al. J. Org. Chem.* **2007**, 72, 5874–5877

P. I. Arvidsson, *et al. Tetrahedron: Asymmetry* **2007**, 18, 1403–1409

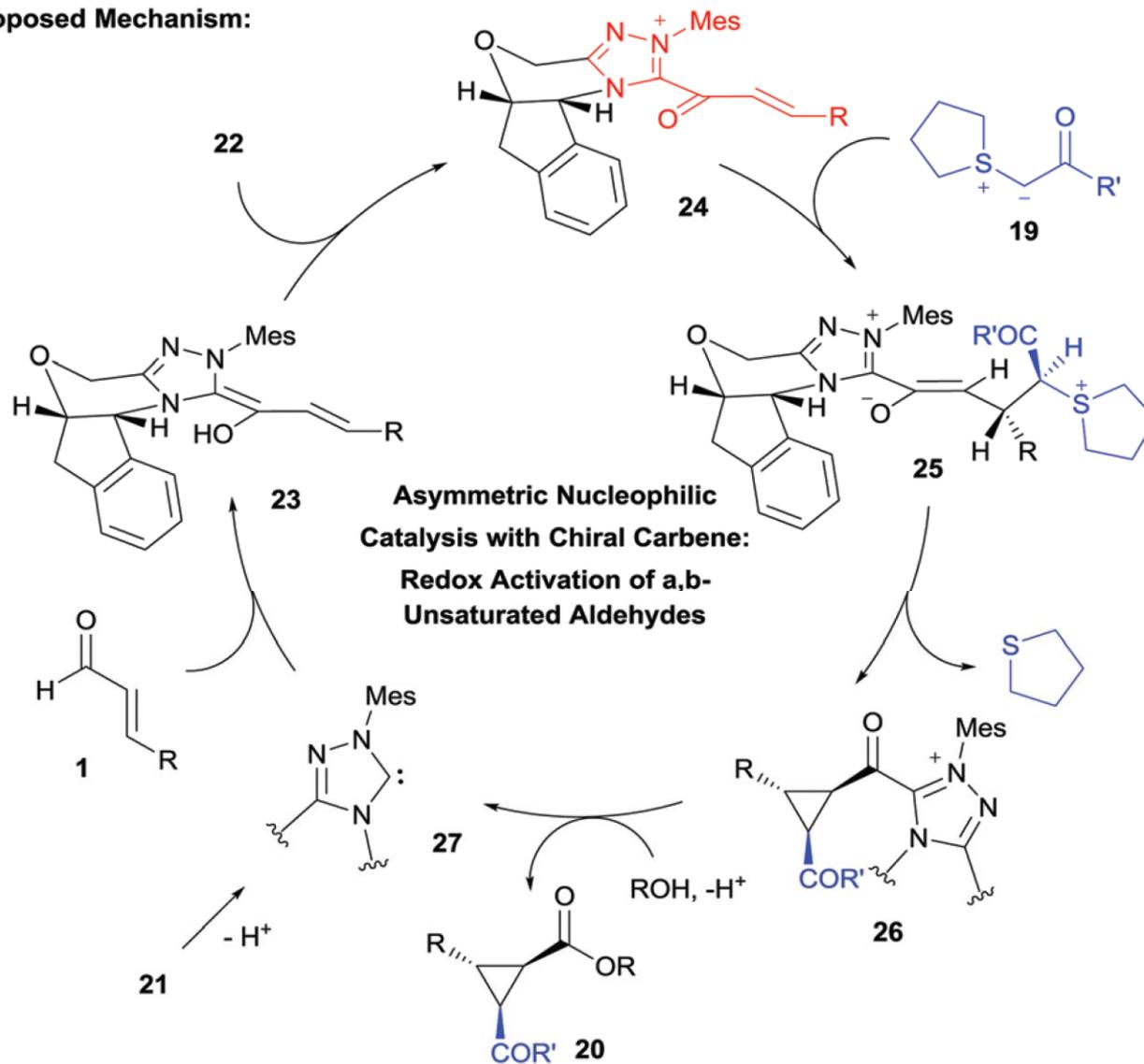
2. Organocatalytic asymmetric cyclizations

Chiral diamine catalyst



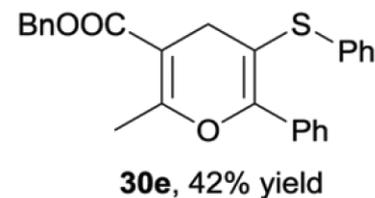
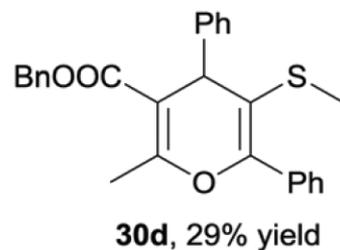
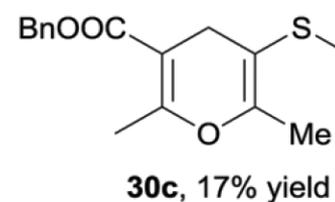
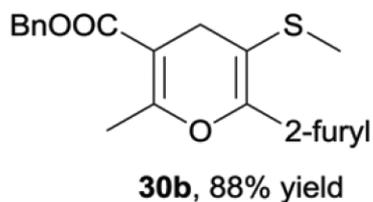
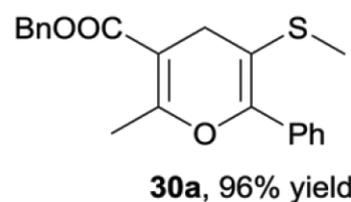
2. Organocatalytic asymmetric cyclizations

Proposed Mechanism:



2. Organocatalytic asymmetric cyclizations

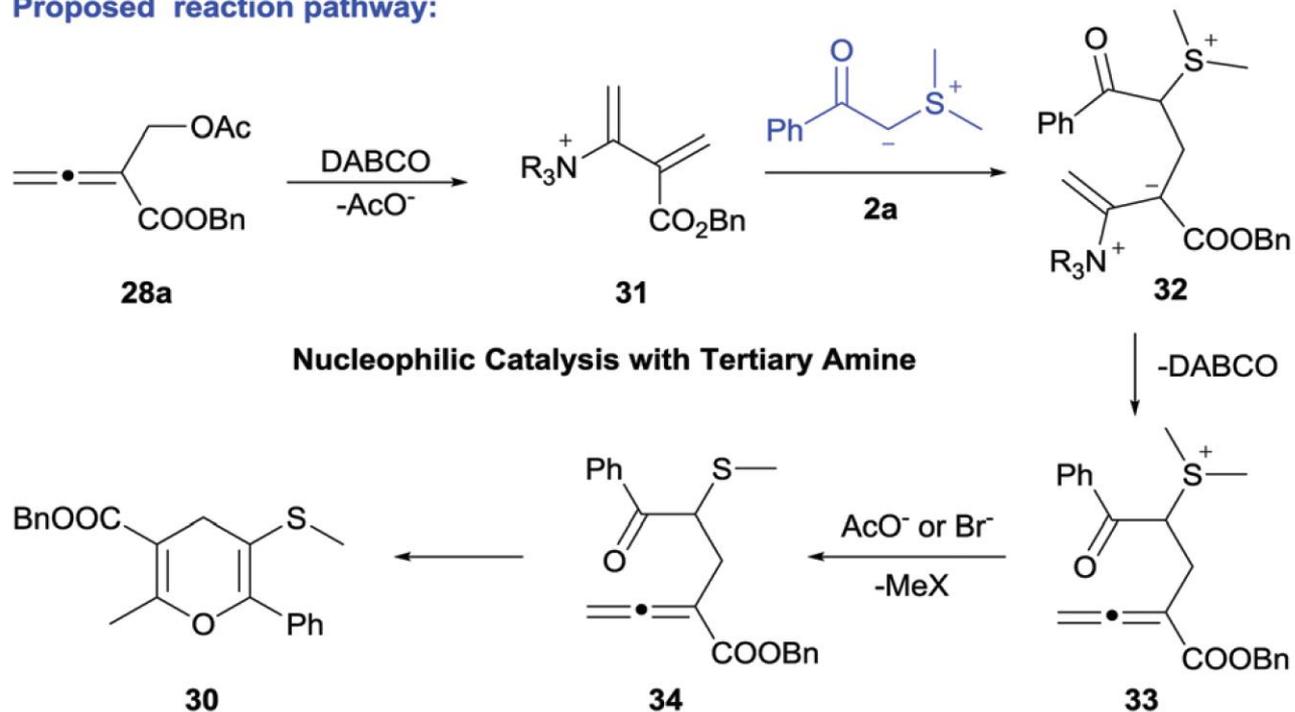
DABCO-catalysed formal [3+3] annulations



2. Organocatalytic asymmetric cyclizations

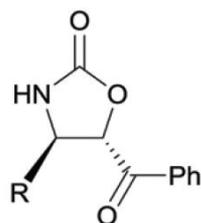
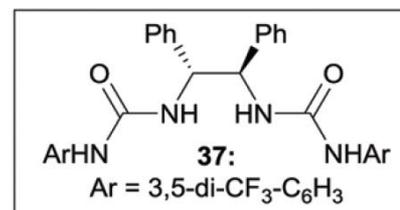
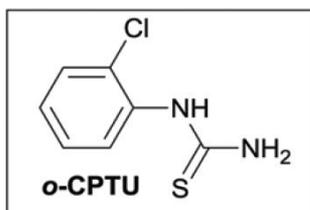
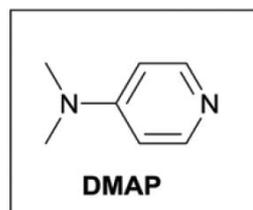
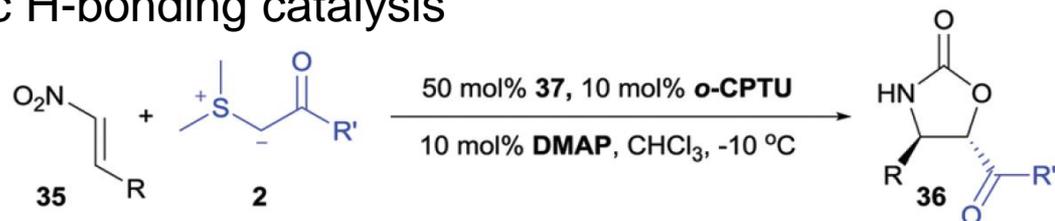
DABCO-catalysed formal [3+3] annulations

Proposed reaction pathway:



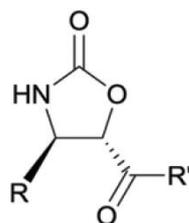
2. Organocatalytic asymmetric cyclizations

2.3 Asymmetric H-bonding catalysis



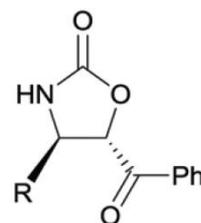
(R = 2-MeO-C₆H₄)

36a: 88% yield,
90% ee, >95:5 dr



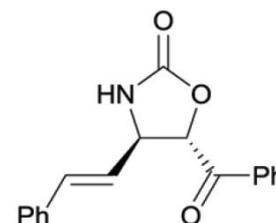
(R = R' = 4-MeO-C₆H₄)

36b: 80% yield,
88% ee, >95:5 dr

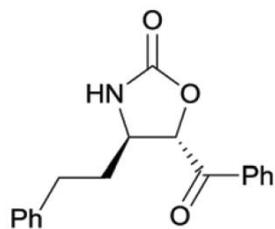


(R = 3,4-di-F-C₆H₃)

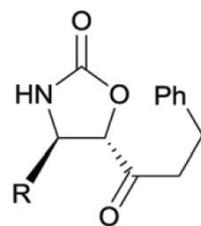
36c: 75% yield,
82% ee, >95:5 dr



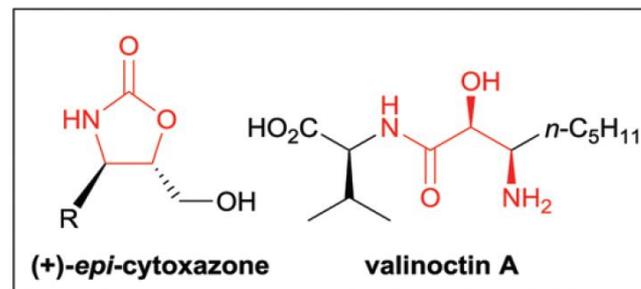
36d: 87% yield,
82% ee, >95:5 dr



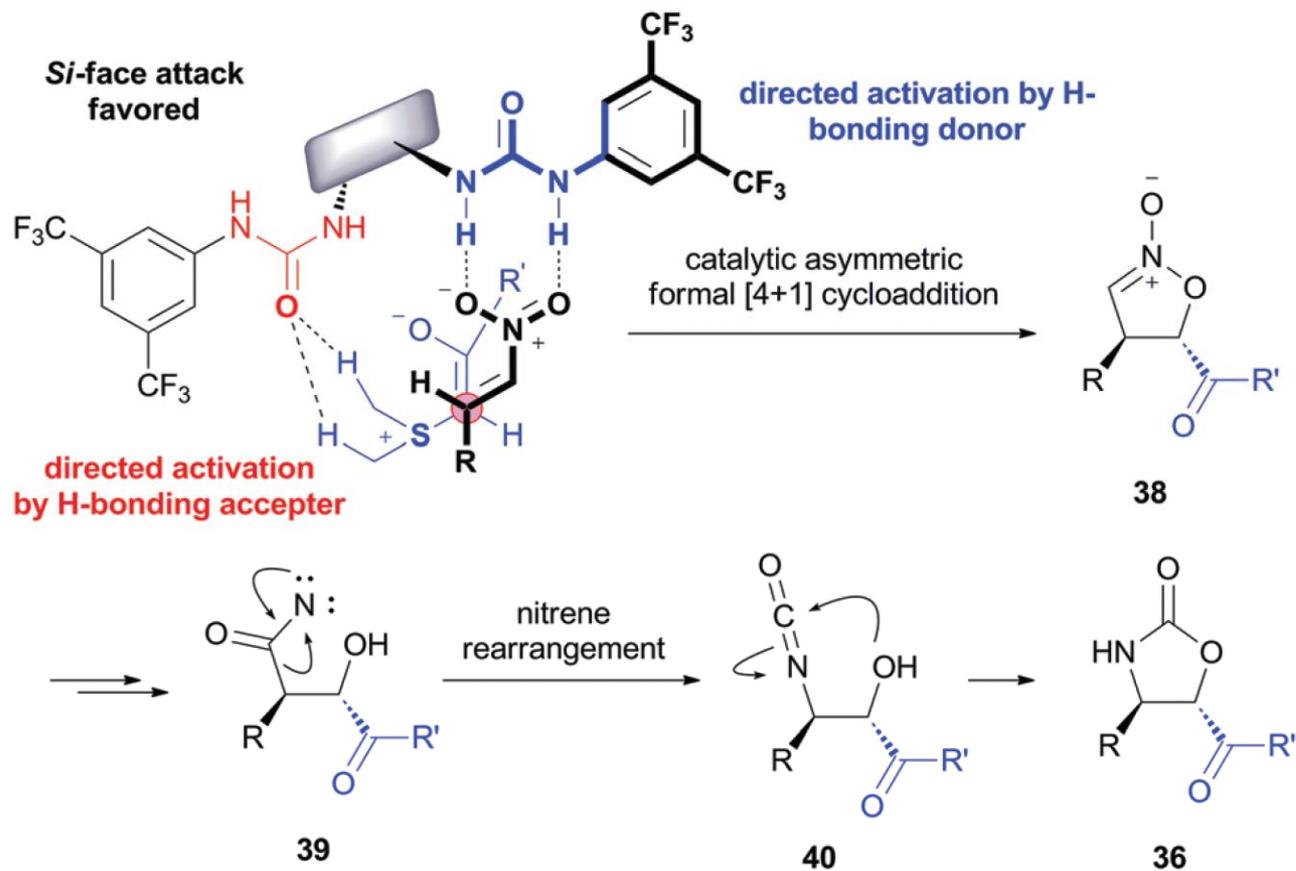
36e: 67% yield,
94% ee, >95:5 dr



36f: 72% yield,
80% ee, >95:5 dr

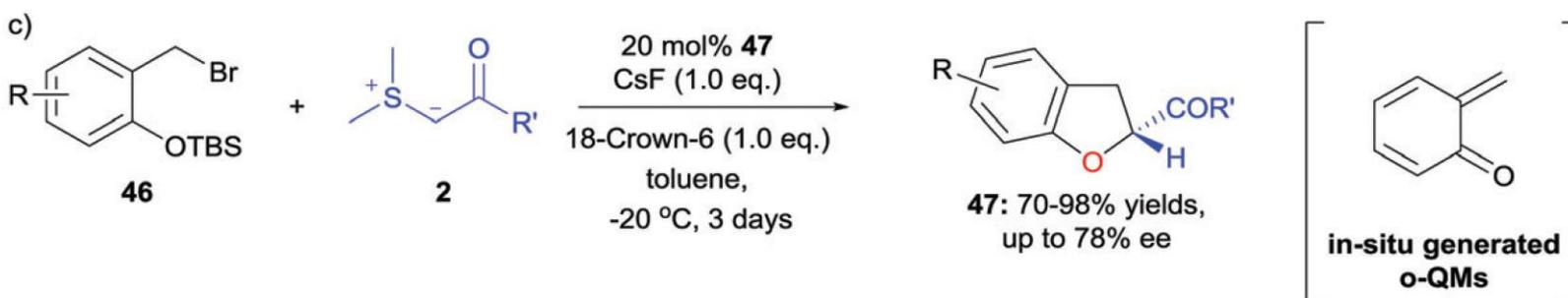
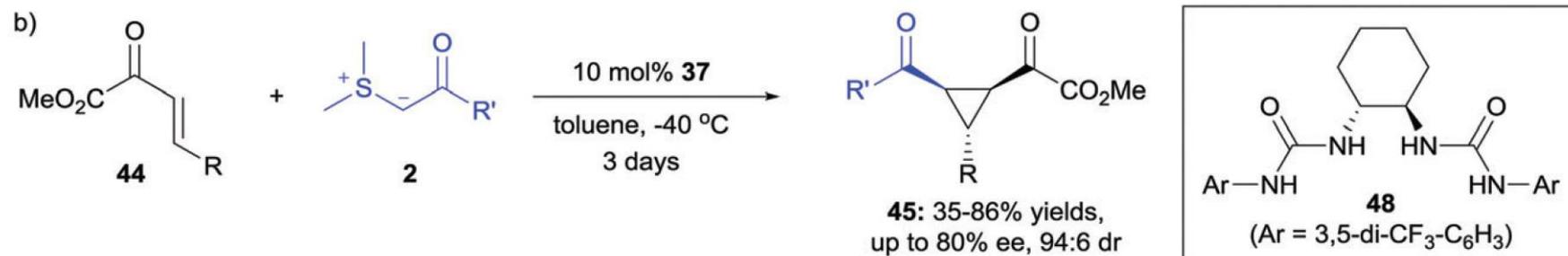
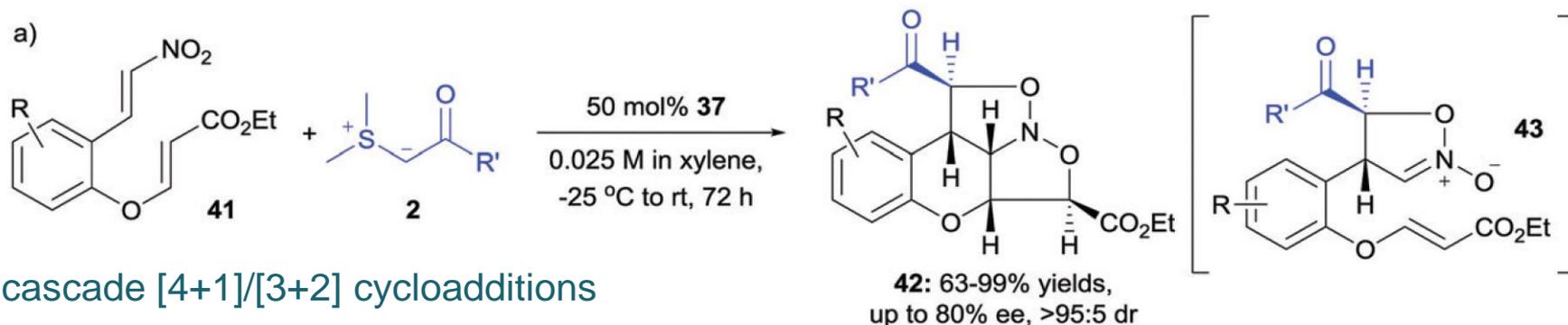


2. Organocatalytic asymmetric cyclizations



A proposed stereo-induction mode and mechanism

2. Organocatalytic asymmetric cyclizations



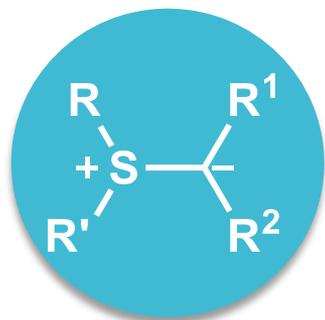
The application in other enantioselective cyclizations of sulfur ylides

W.-J. Xiao, et al. *Angew. Chem. Int. Ed.* **2009**, *48*, 9542–9545

W.-J. Xiao, et al. *J. Org. Chem.* **2011**, *76*, 281–284

W.-J. Xiao, et al. *Eur. J. Org. Chem.* **2017**, *52*, 233–236

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Metal carbenoids, alkynes and alkenes, carbamates

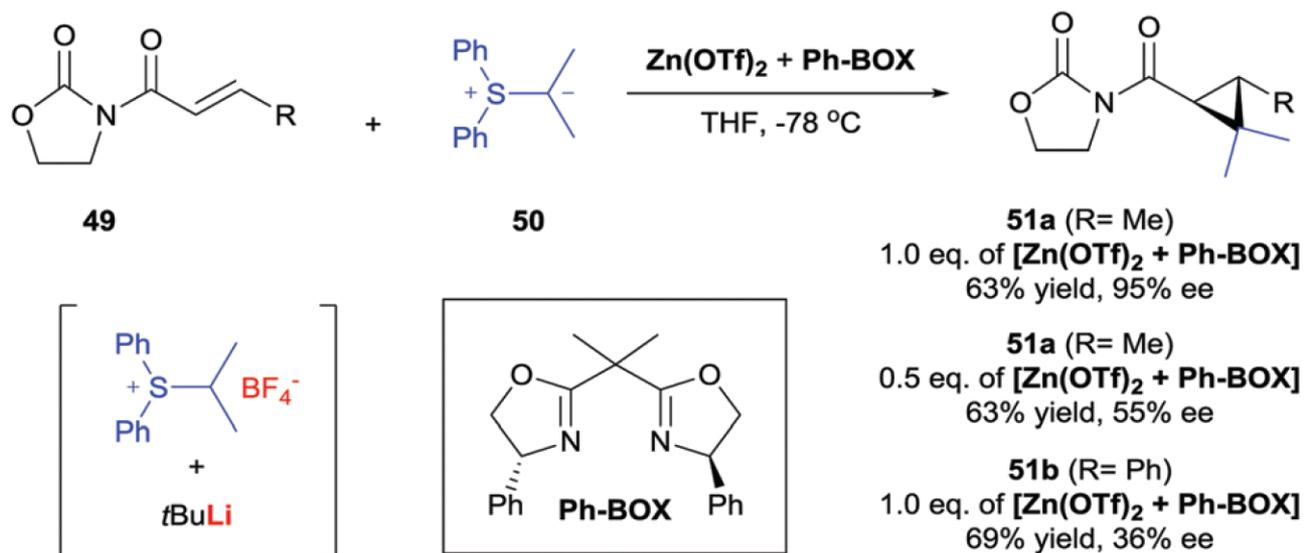
05 Photocatalytic cyclizations

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3. Lewis-acid-catalysed asymmetric cyclizations

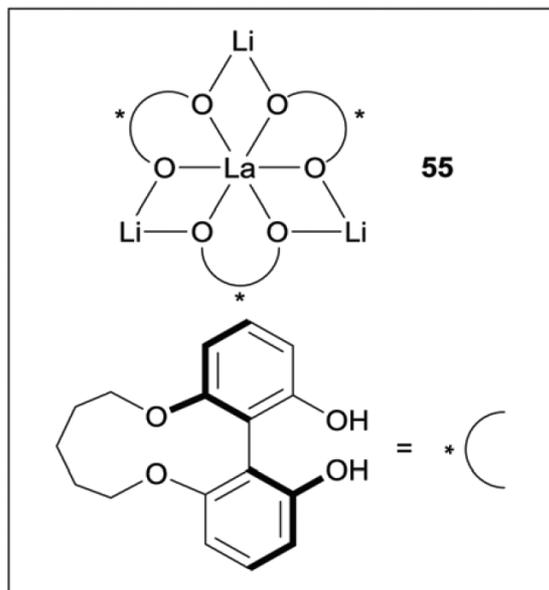
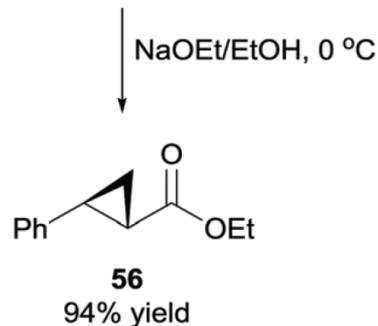
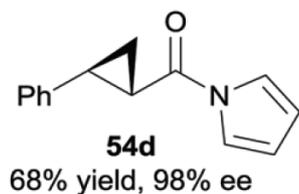
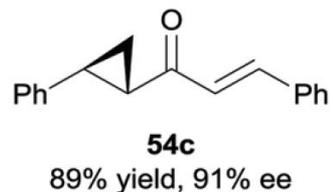
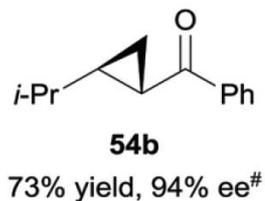
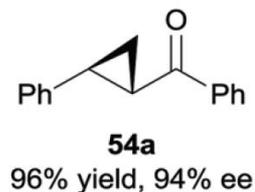
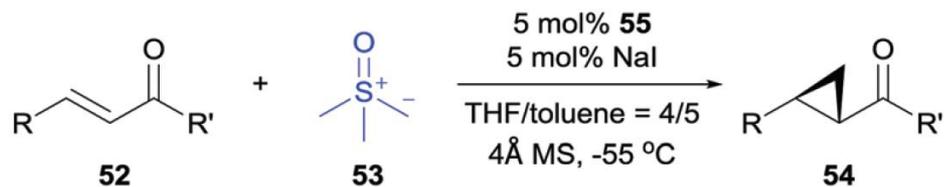
3.1. Lewis-acid-catalysed asymmetric cyclopropanation, epoxidation



The enantiopurity of products is highly dependent on the loading of chiral Lewis acid

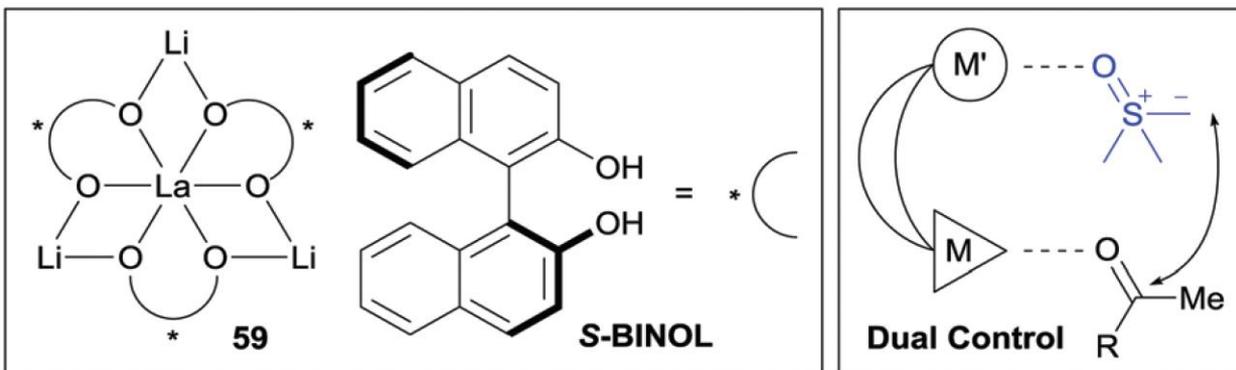
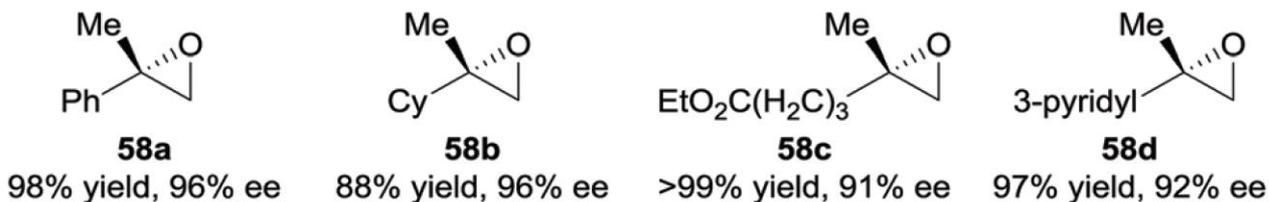
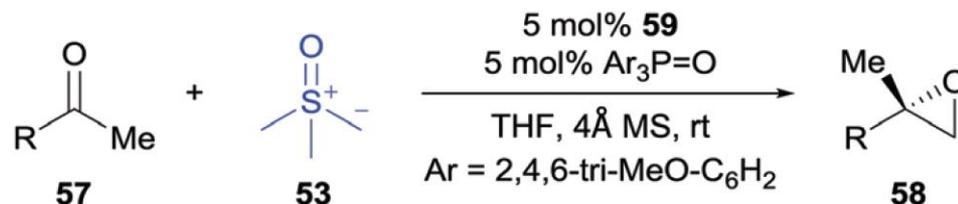
3. Lewis-acid-catalysed asymmetric cyclizations

La-catalysed asymmetric cyclopropanation



3. Lewis-acid-catalysed asymmetric cyclizations

La-catalysed asymmetric epoxidation

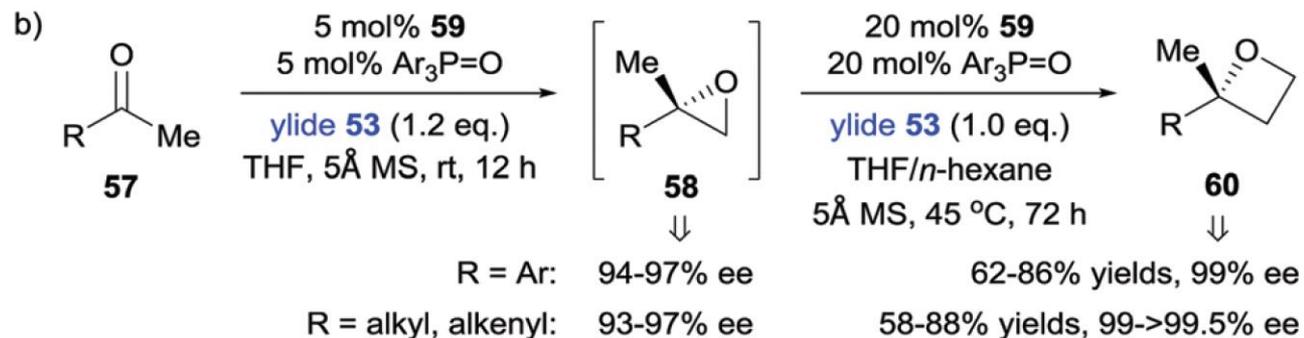
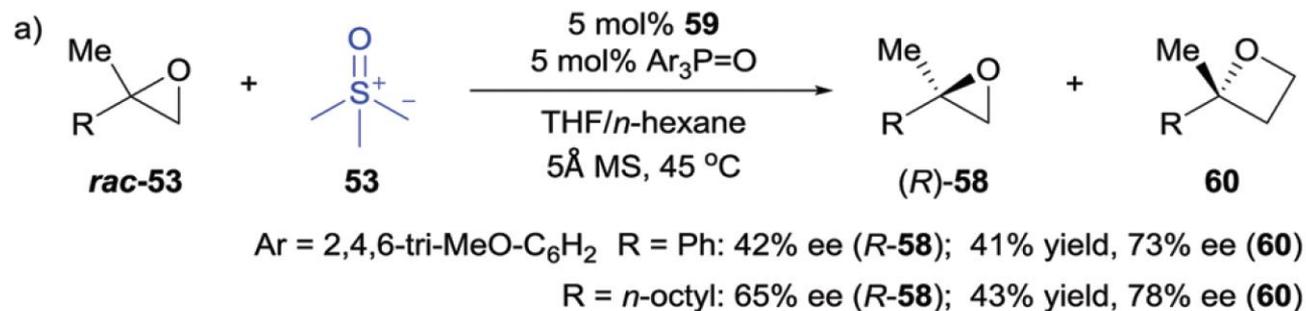


M. Shibasaki, *et al. J. Am. Chem. Soc.* **2008**, *130*, 10078–10079

M. Shibasaki, *et al. Molecules*, **2012**, *17*, 1617–1634

3. Lewis-acid-catalysed asymmetric cyclizations

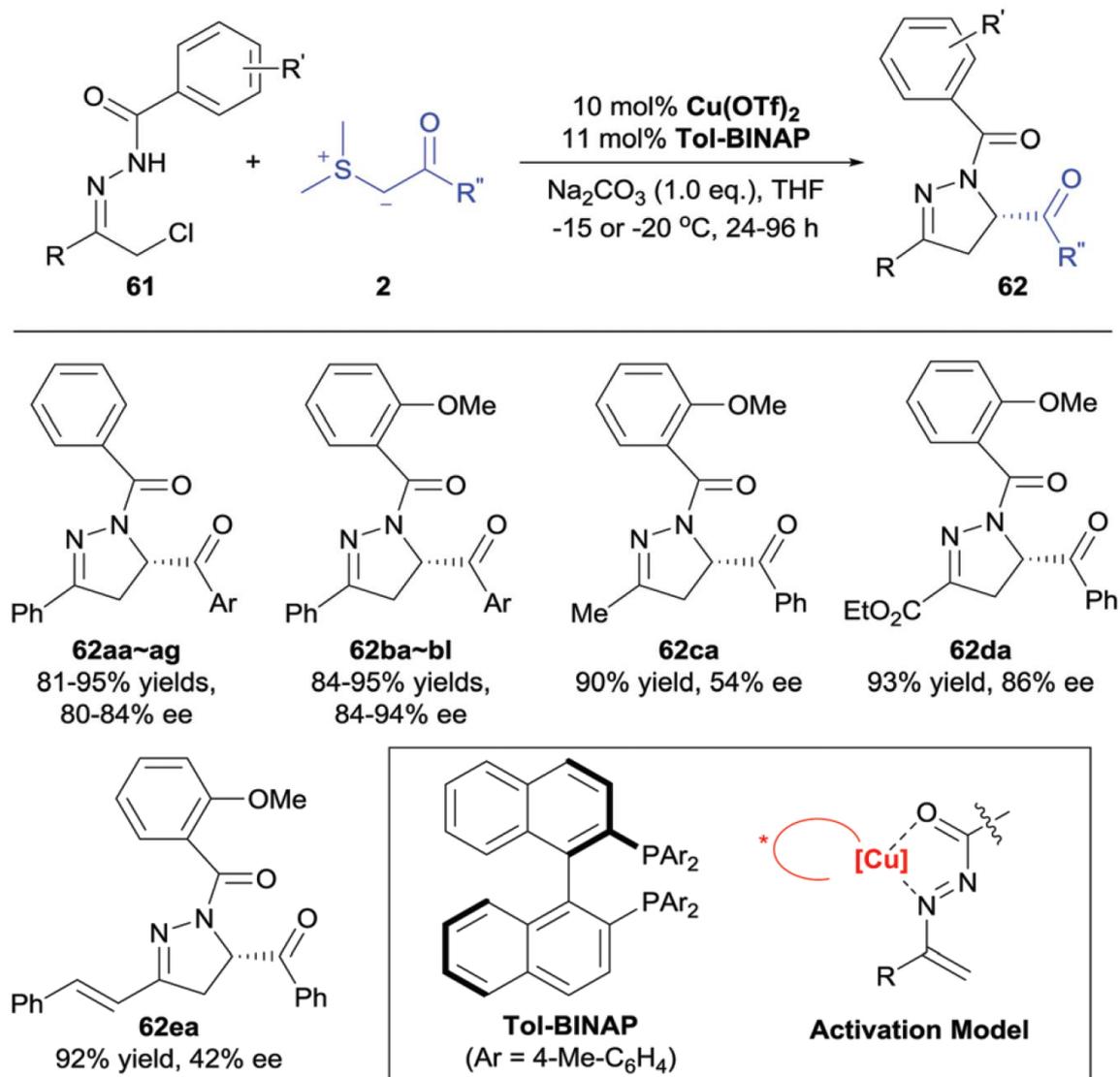
Catalytic asymmetric kinetic resolution



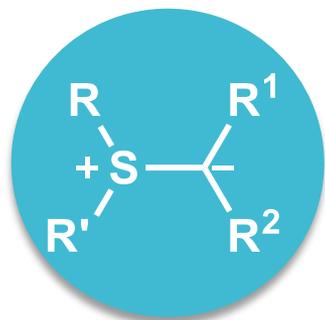
one-pot sequential reaction

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04 **Transition-metal-catalyzed cyclizations**

Metal carbenoids, alkynes and alkenes, carbamates

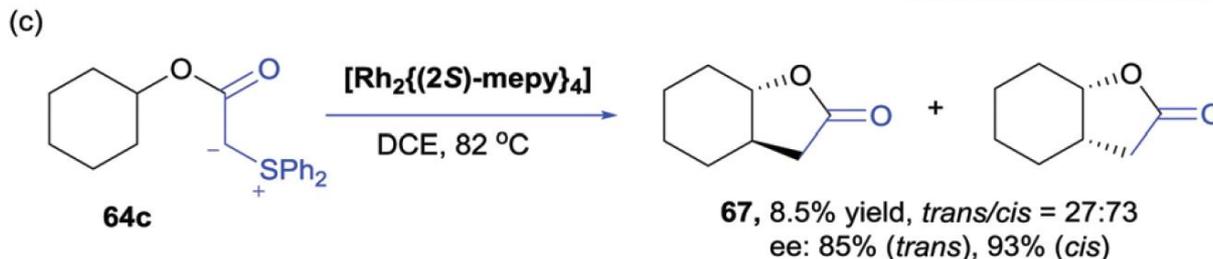
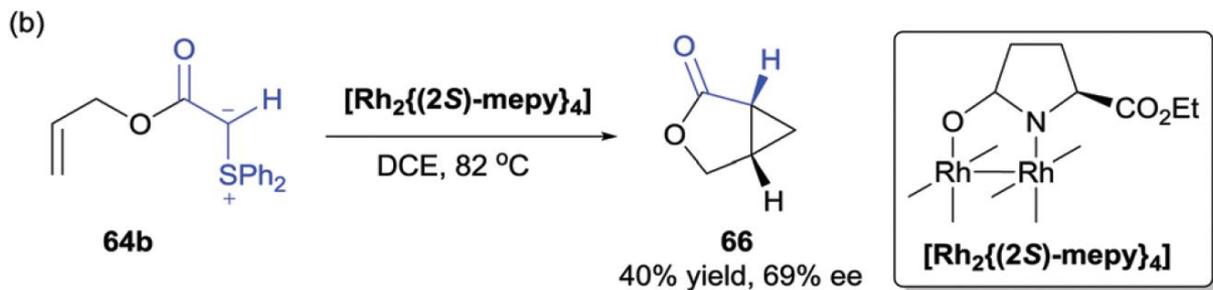
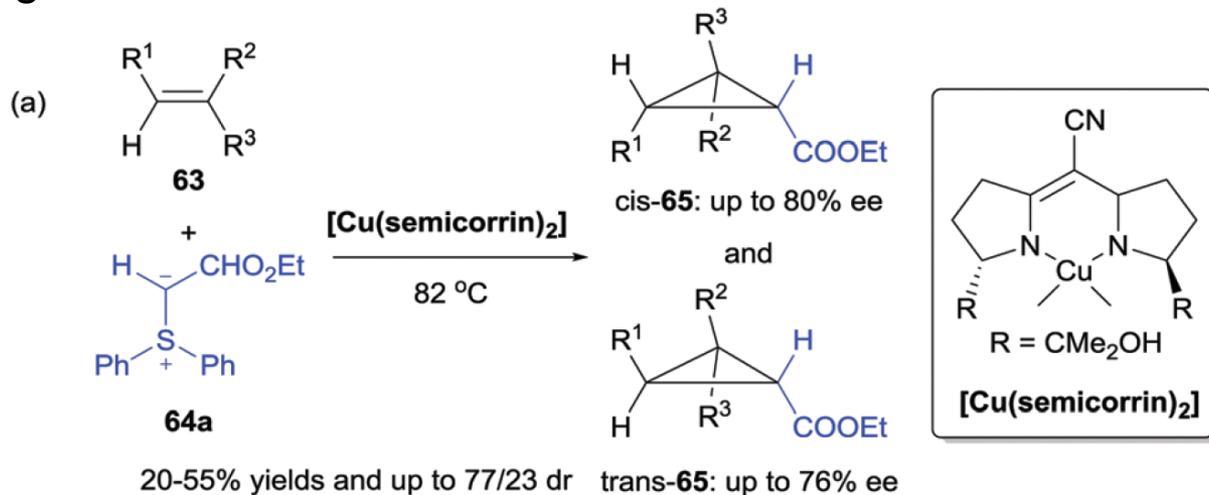
05 Photocatalytic cyclizations

SET, ET

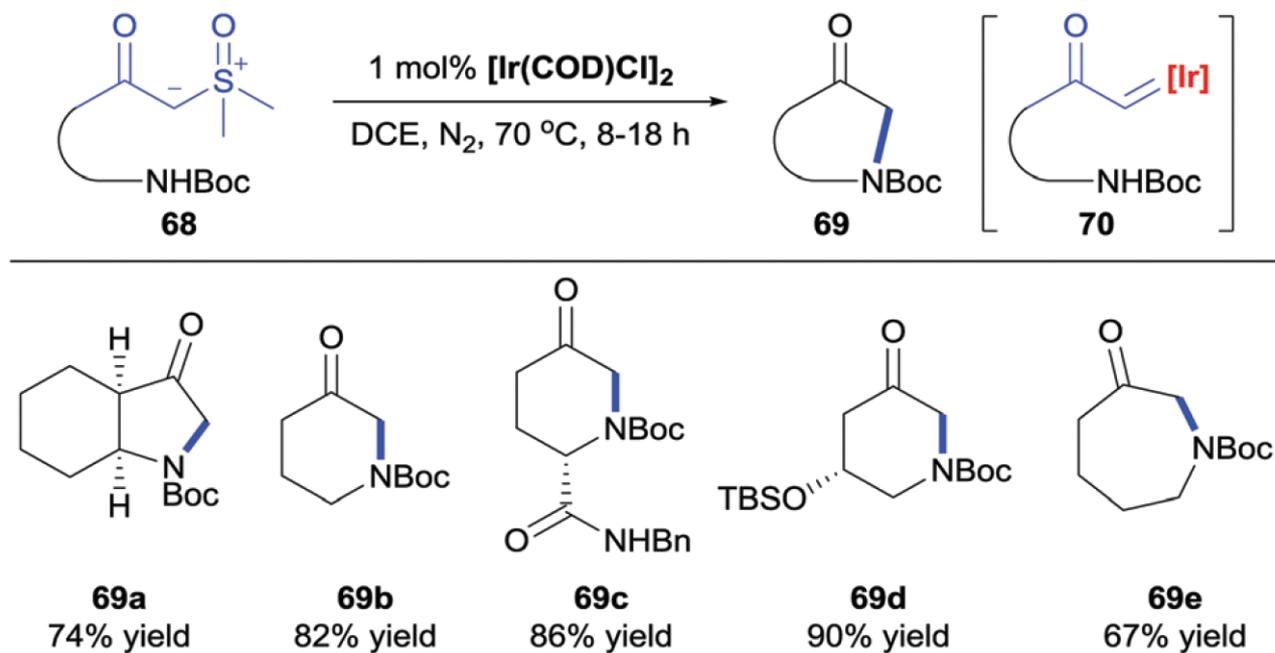
06 Conclusions

4. Transition-metal-catalyzed cyclizations

4.1. Through the formation of metal carbenoids



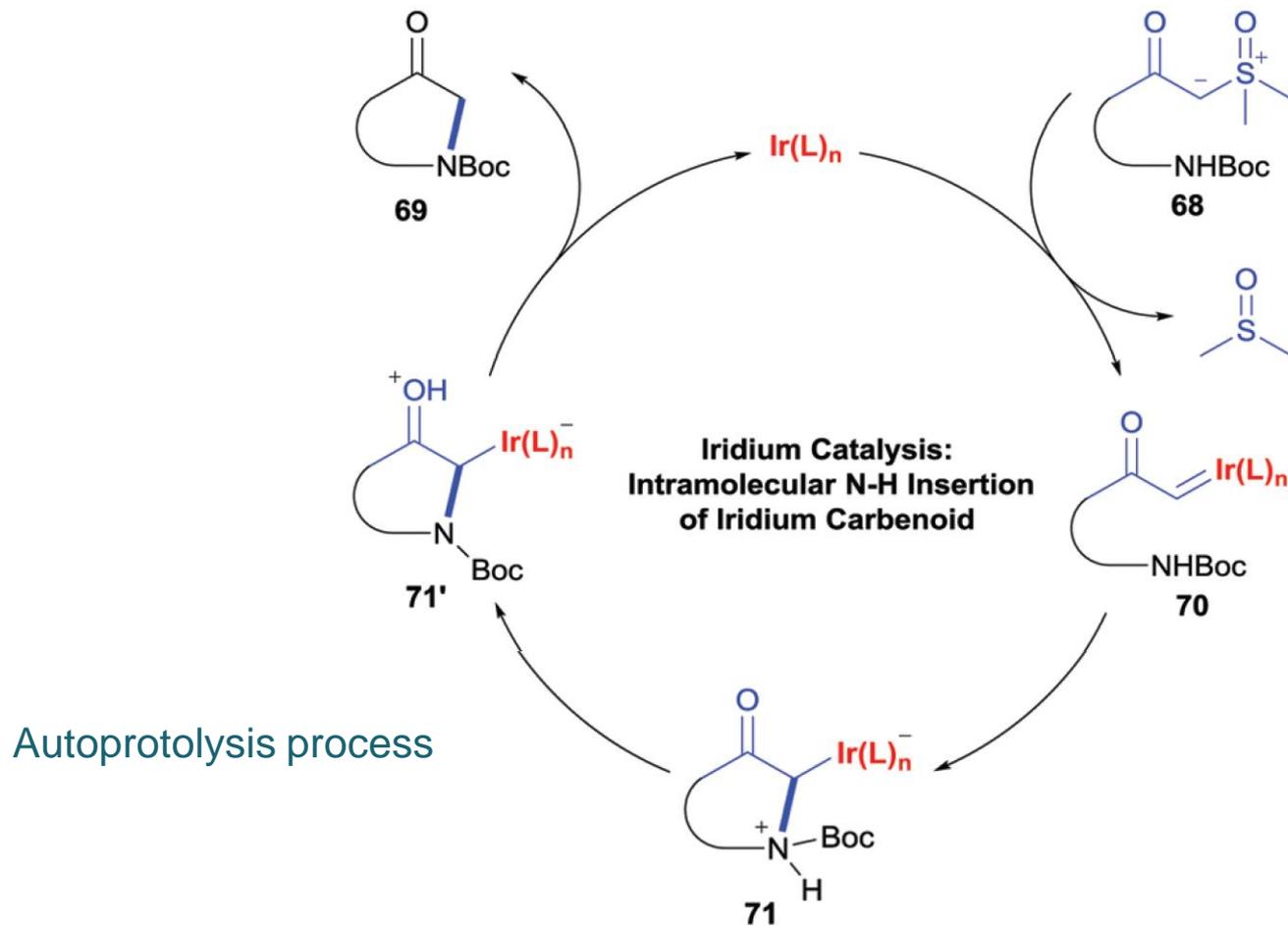
4. Transition-metal-catalyzed cyclizations



I. K. Mangion, *et al.* *Org. Lett.* **2009**, *11*, 3566–3569

I. K. Mangion, *et al.* *Tetrahedron Lett.* **2010**, *51*, 5490–5492

4. Transition-metal-catalyzed cyclizations

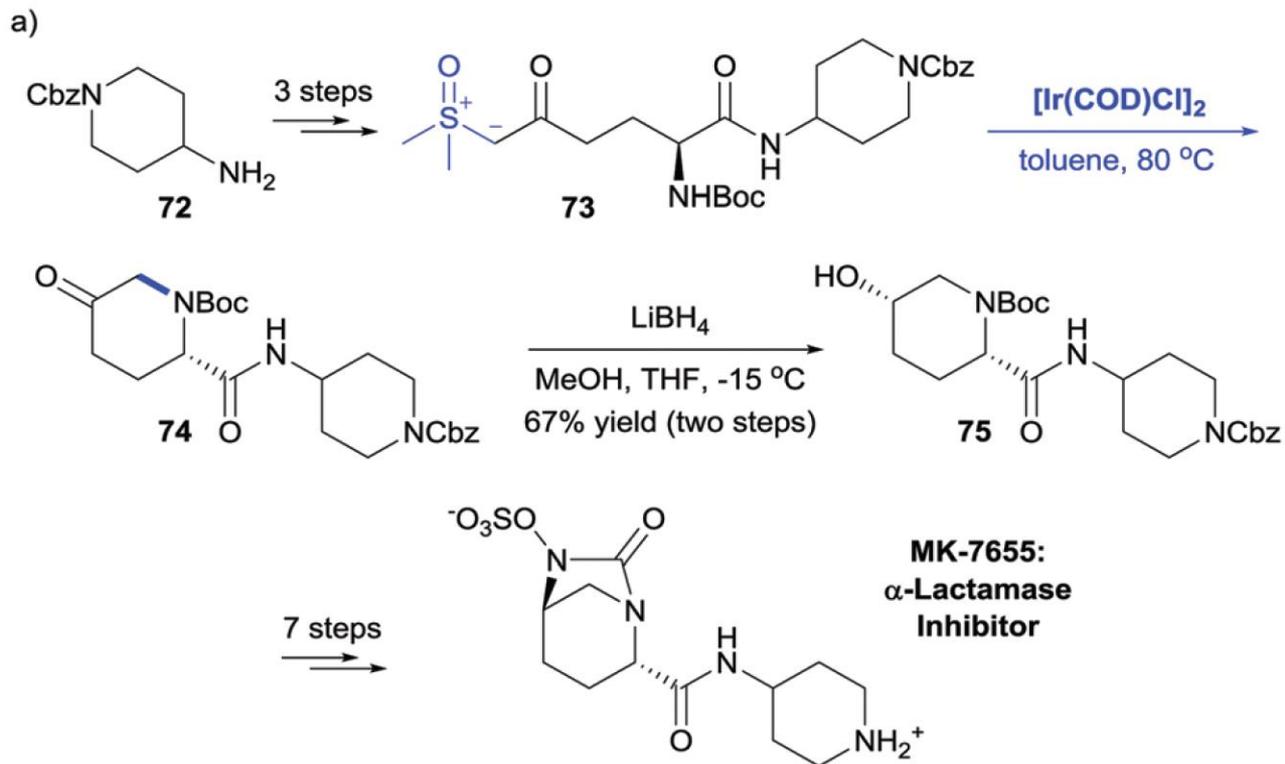


I. K. Mangion, *et al.* *Org. Lett.* **2009**, *11*, 3566–3569

I. K. Mangion, *et al.* *Tetrahedron Lett.* **2010**, *51*, 5490–5492

4. Transition-metal-catalyzed cyclizations

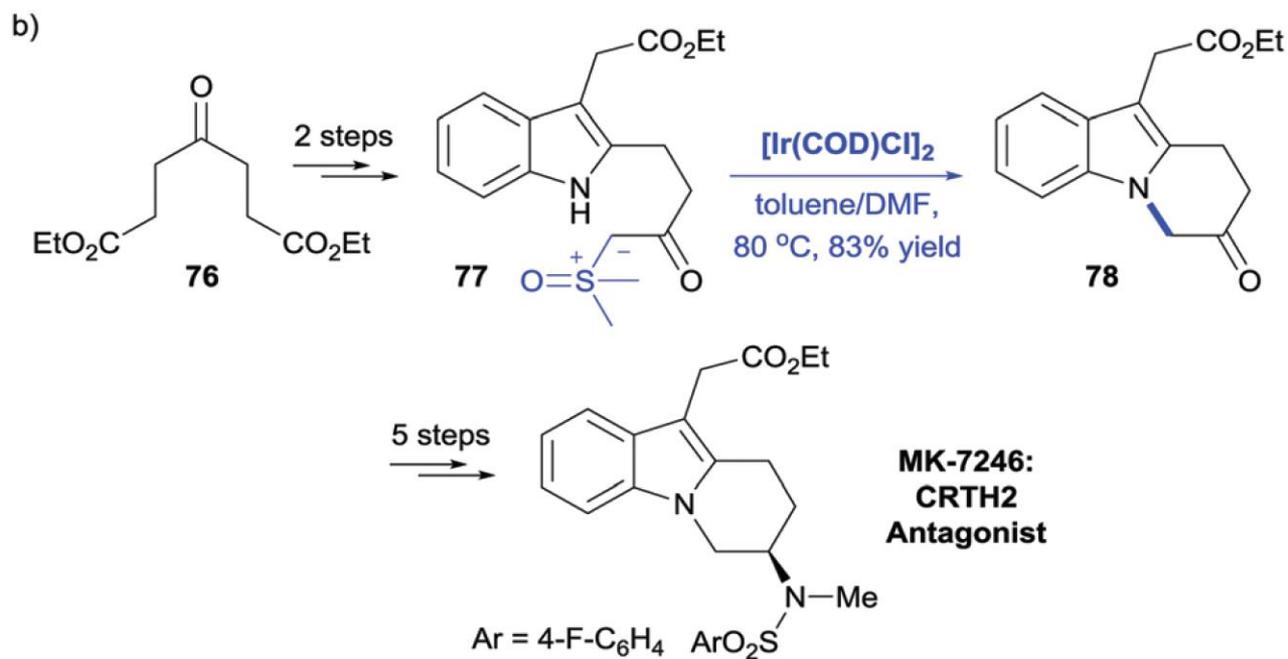
The preparation of pharmaceutical agents



I. K. Mangion, *et al. Org. Lett.* **2011**, *13*, 5480–5483
P. D. O'Shea, *et al. J. Org. Chem.* **2012**, *77*, 2299–2309

4. Transition-metal-catalyzed cyclizations

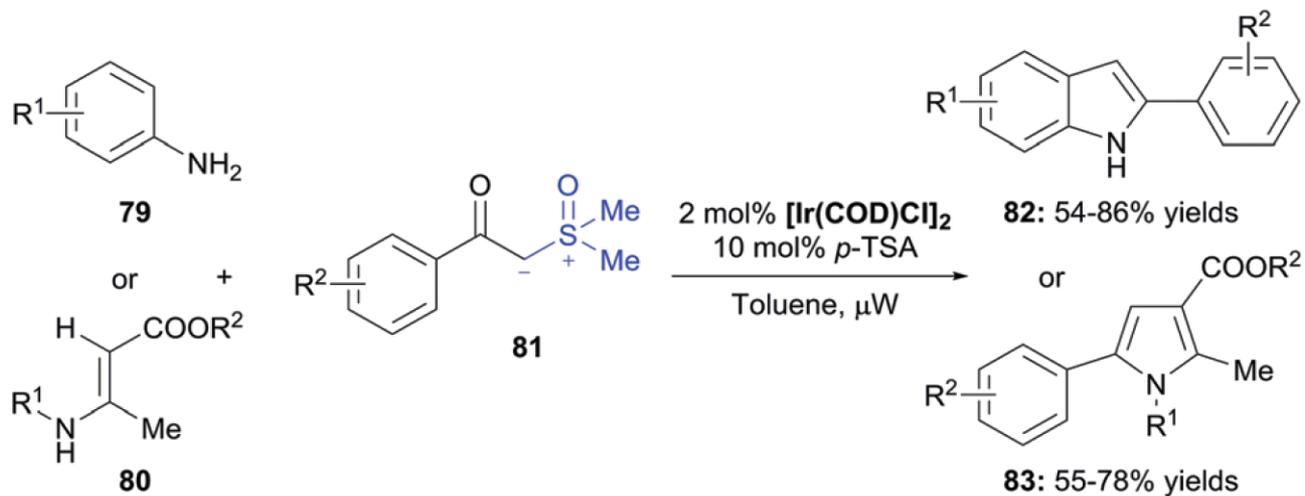
The preparation of pharmaceutical agents



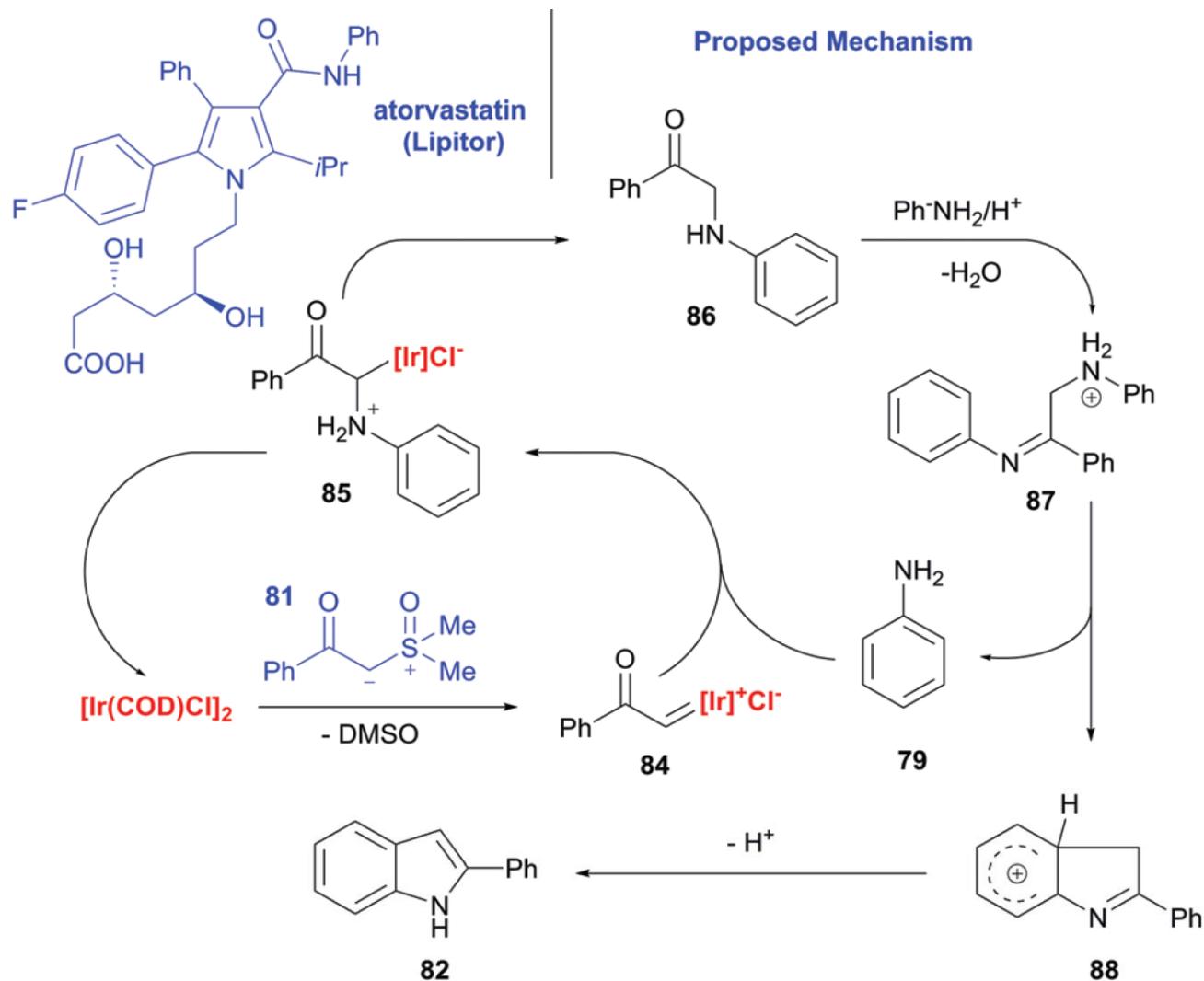
I. K. Mangion, *et al.* *Org. Lett.* **2011**, *13*, 5480–5483
P. D. O’Shea, *et al.* *J. Org. Chem.* **2012**, *77*, 2299–2309

4. Transition-metal-catalyzed cyclizations

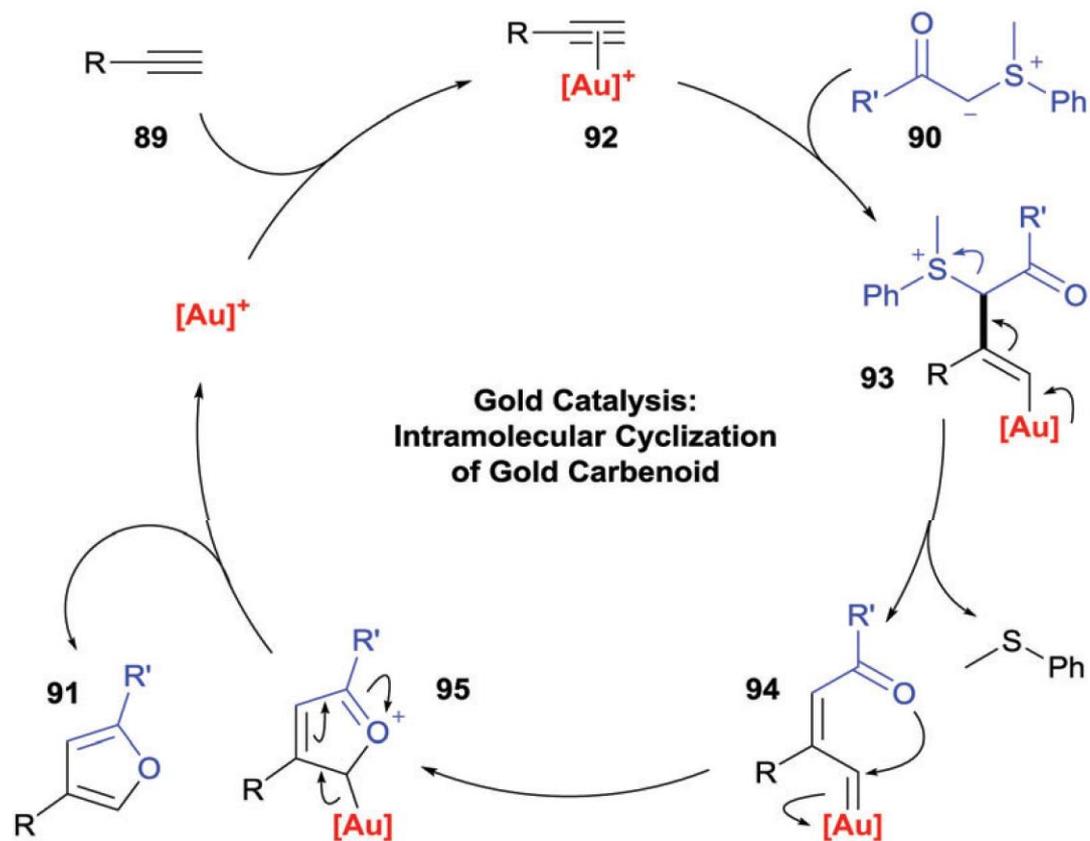
Ir/acid-co-catalysed cascade reactions for indole and pyrrole synthesis



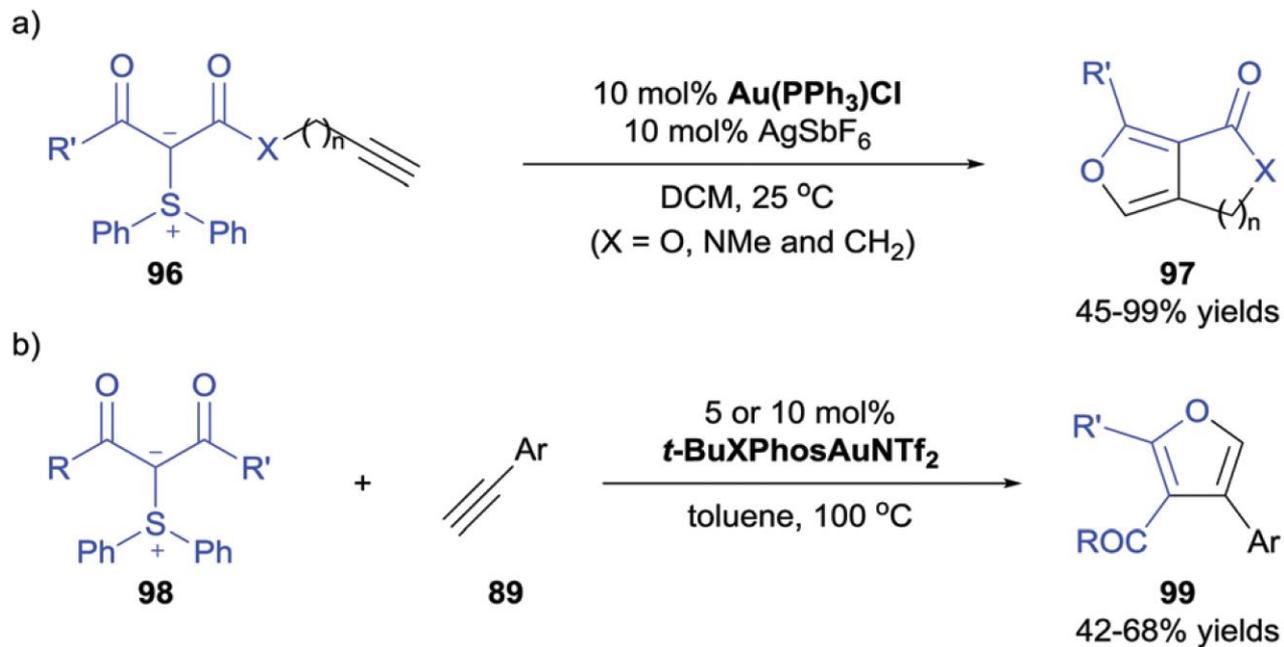
4. Transition-metal-catalyzed cyclizations



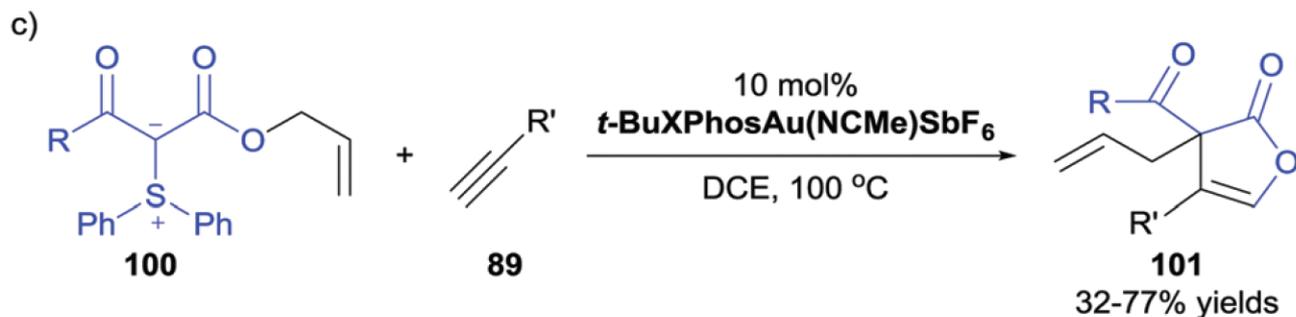
4. Transition-metal-catalyzed cyclizations



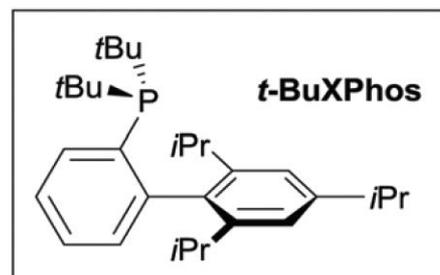
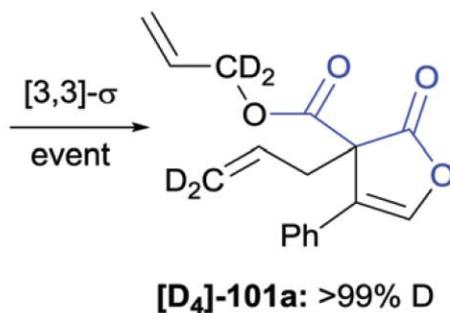
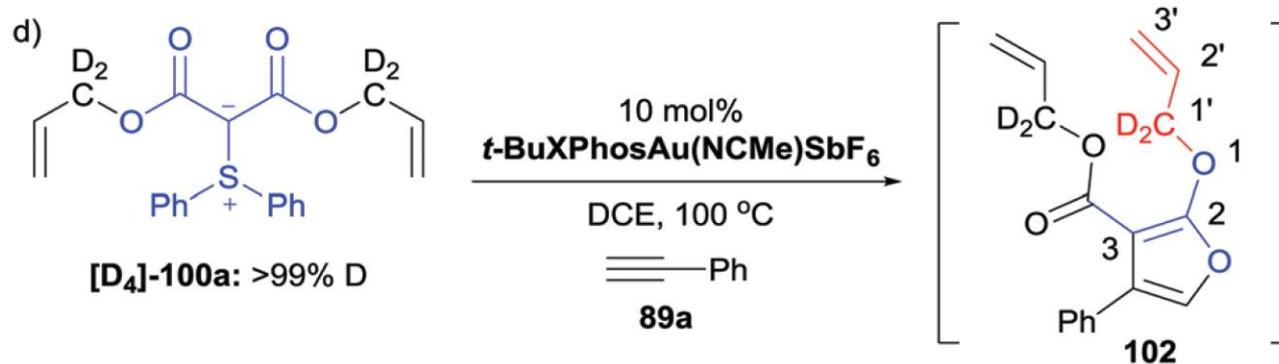
4. Transition-metal-catalyzed cyclizations



4. Transition-metal-catalyzed cyclizations

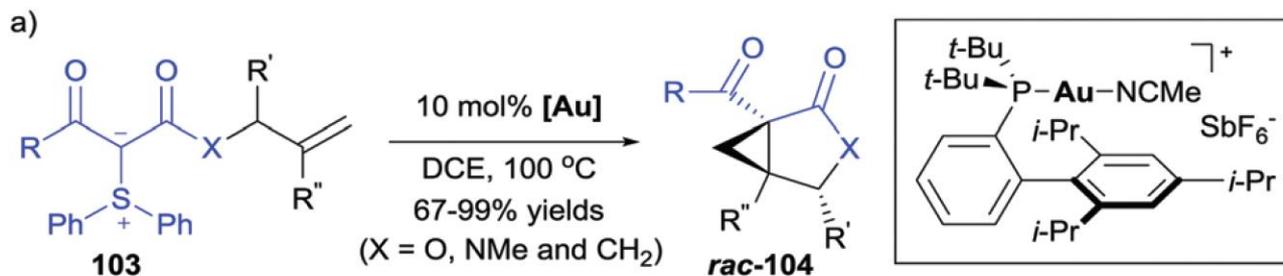


[3,3]-sigmatropic rearrangement

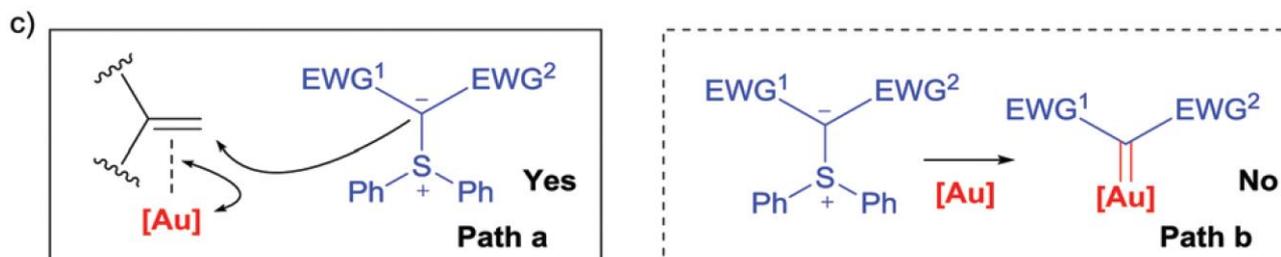


4. Transition-metal-catalyzed cyclizations

Au-catalyzed cyclopropanation of alkenes and allenes



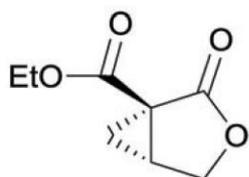
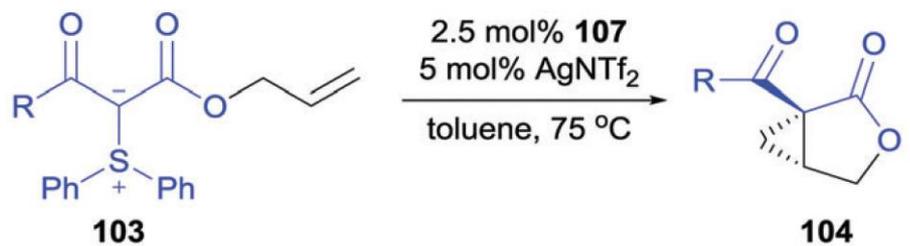
EWG¹ or EWG²: ArCO, RO₂C, NC, (EtO)₂PO or Br; R or R' = Ts, Ar, Bn or Me



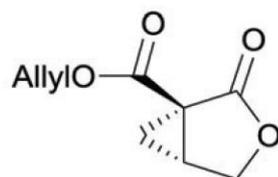
- N. Maulide, *et al. Chem. Sci.* **2013**, *4*, 1105-1110
N. Maulide, *et al. J. Org. Chem.* **2015**, *80*, 5719-5729
N. Maulide, *et al. Chem. Eur. J.* **2014**, *20*, 10636-10639.

4. Transition-metal-catalyzed cyclizations

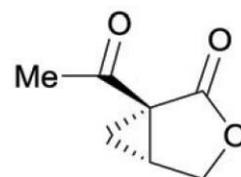
Intramolecular cyclopropanations catalyzed by a bimetallic chiral gold catalyst



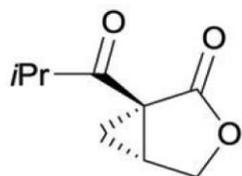
74%, 78% ee



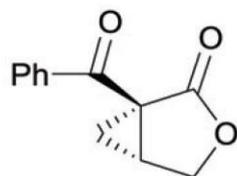
91%, 82% ee



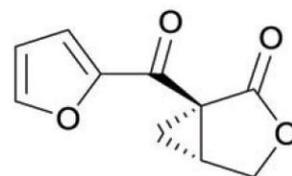
88%, 72% ee



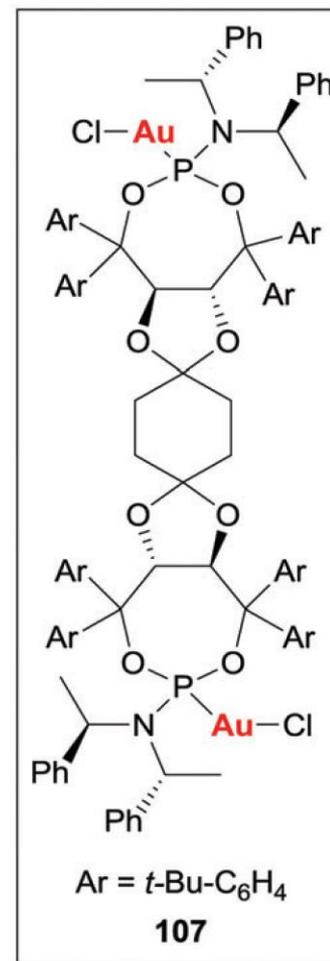
94%, 78% ee



99%, 82% ee

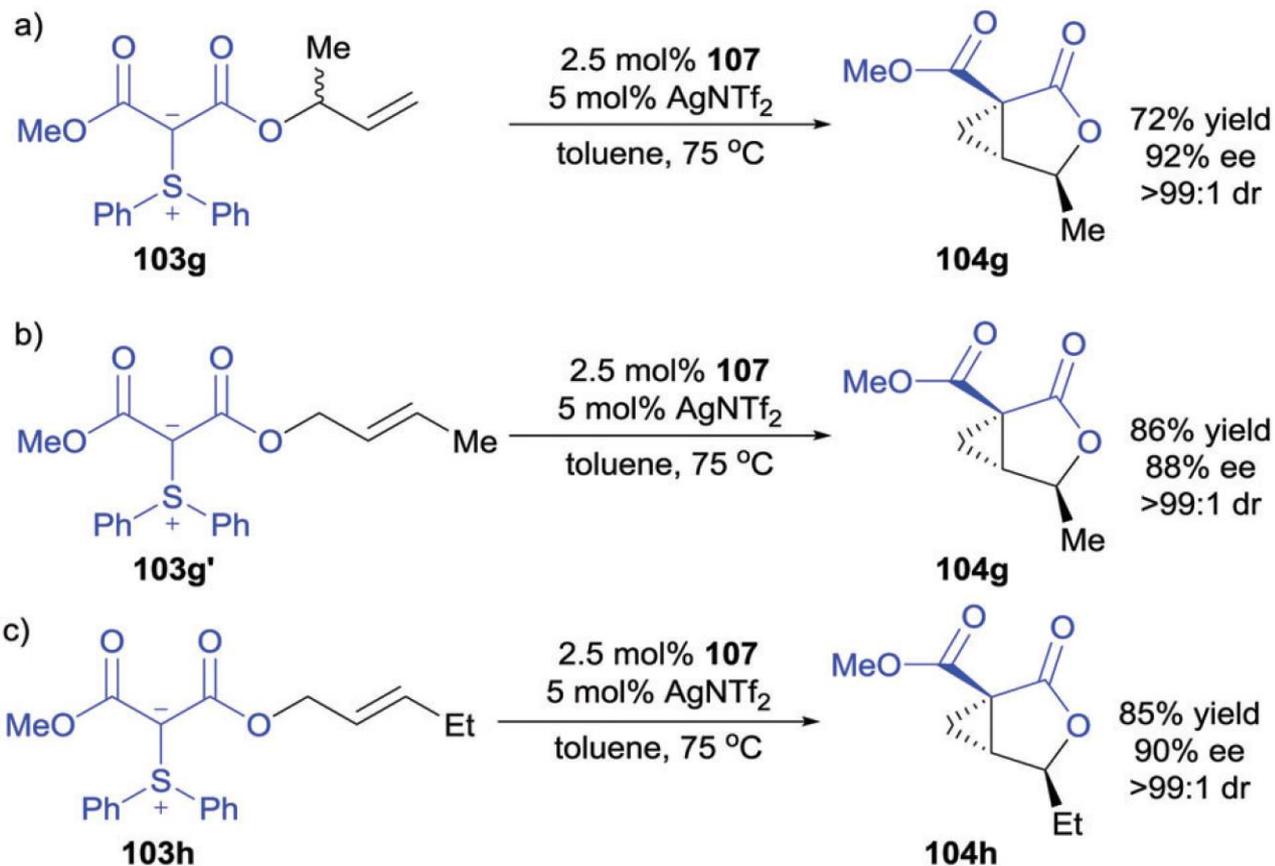


95%, 78% ee

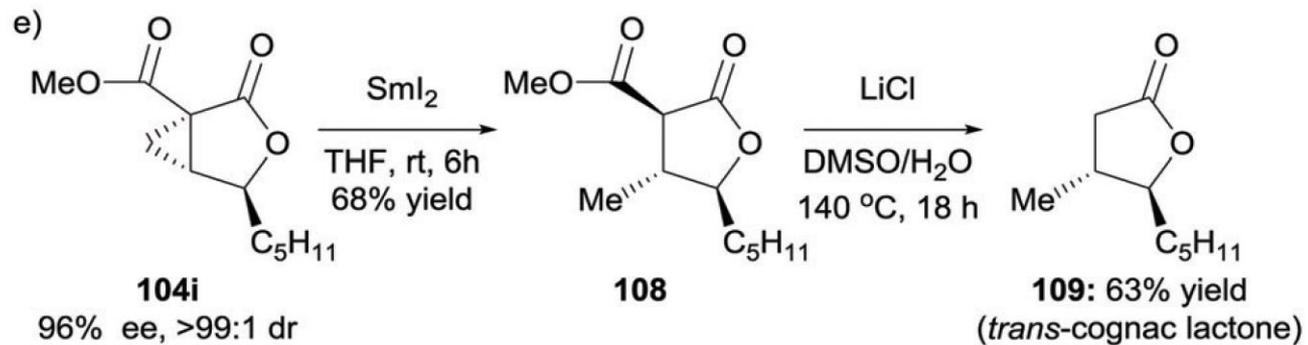
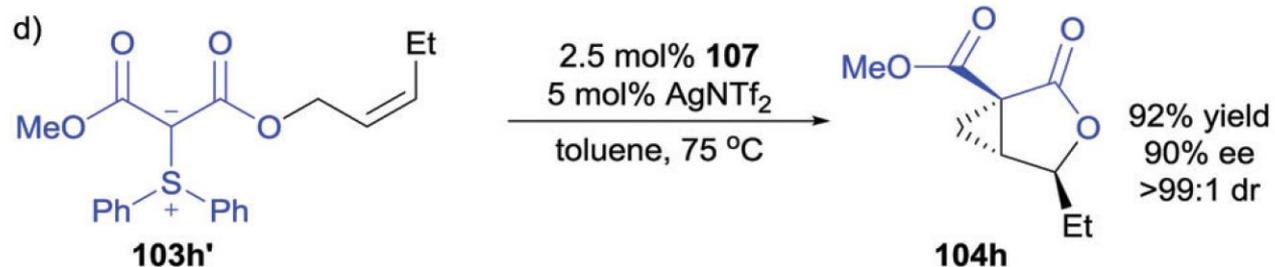


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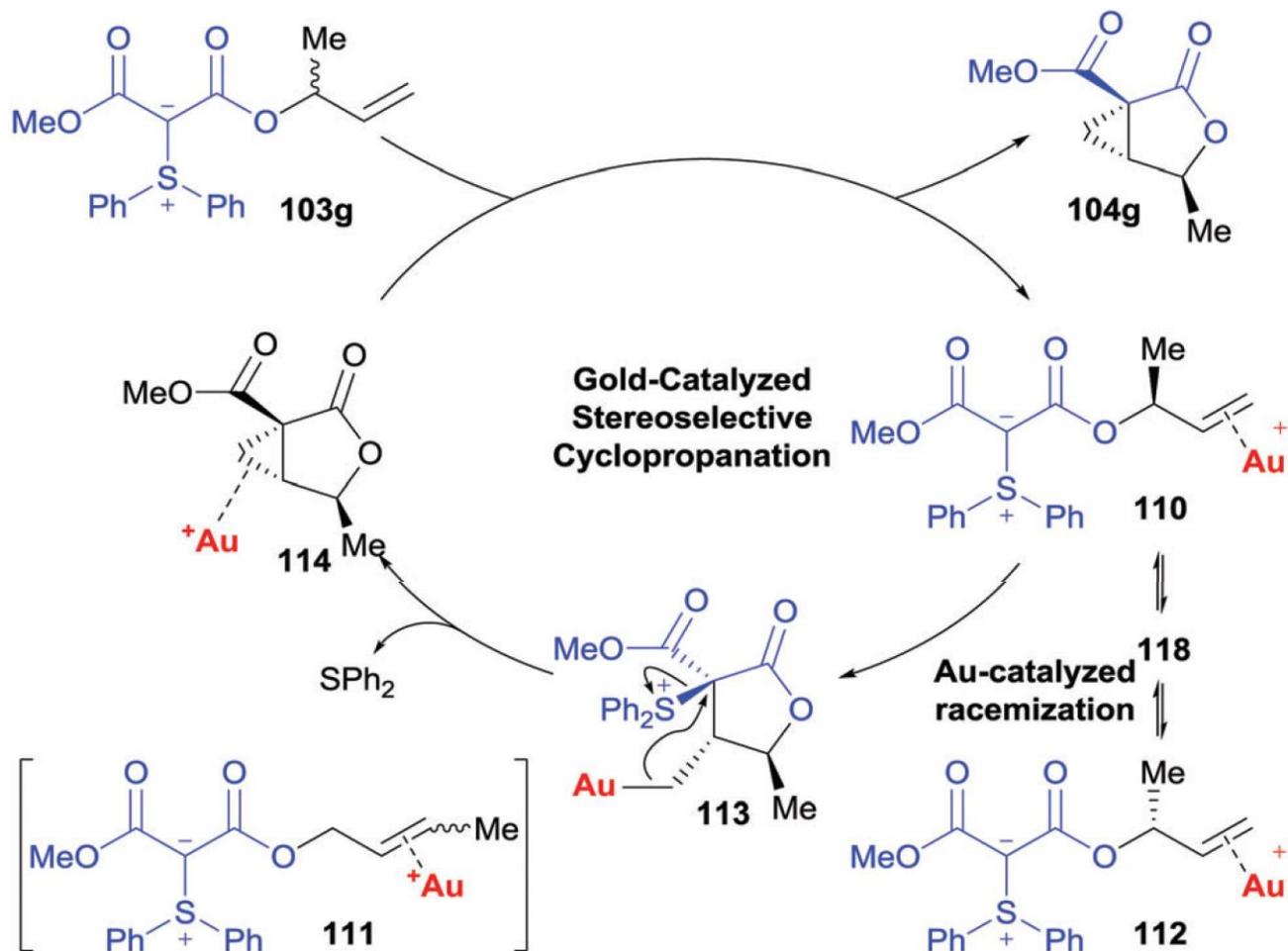
4. Transition-metal-catalyzed cyclizations



4. Transition-metal-catalyzed cyclizations

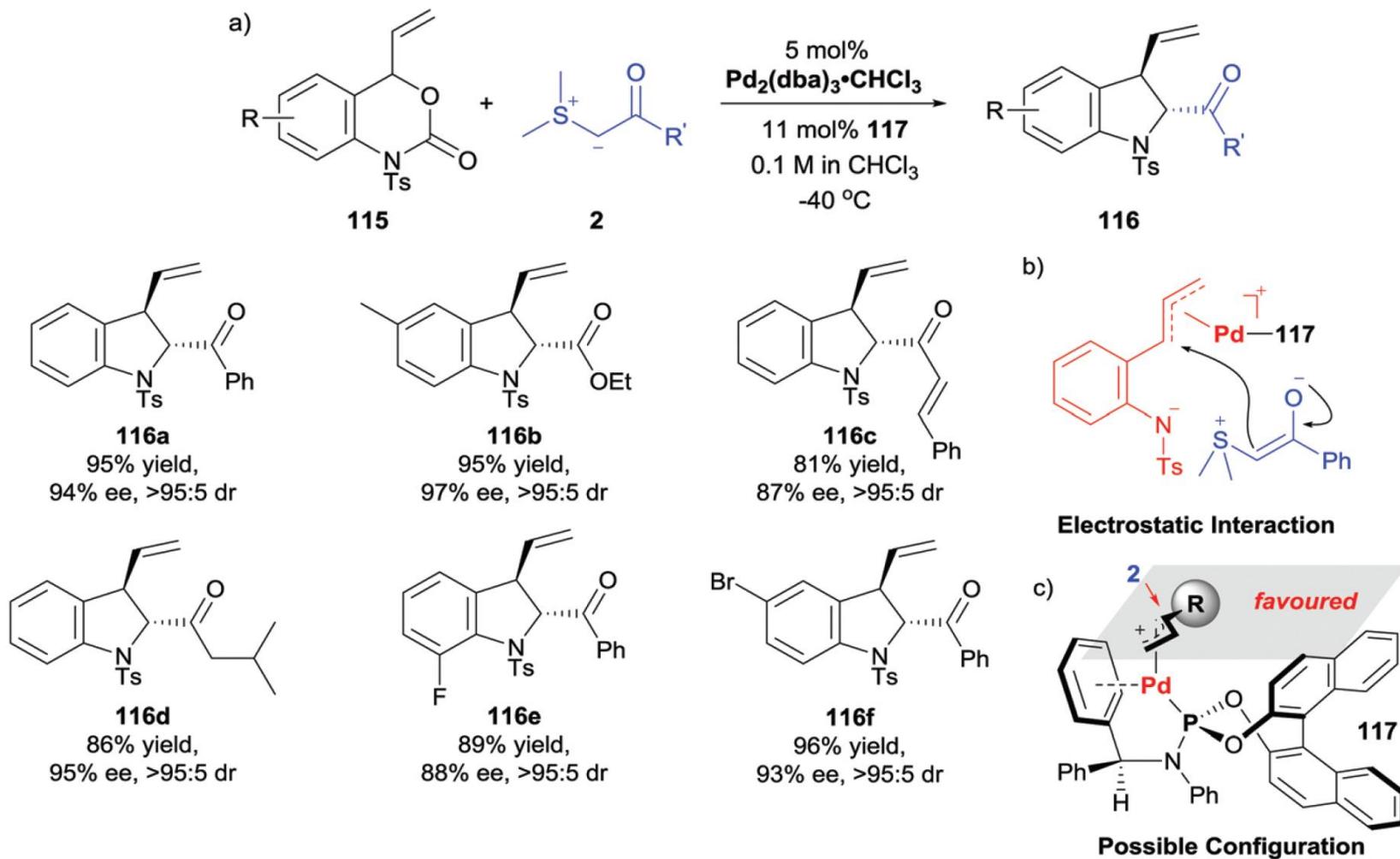


4. Transition-metal-catalyzed cyclizations



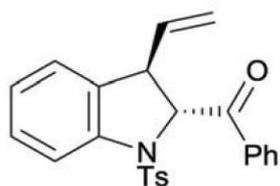
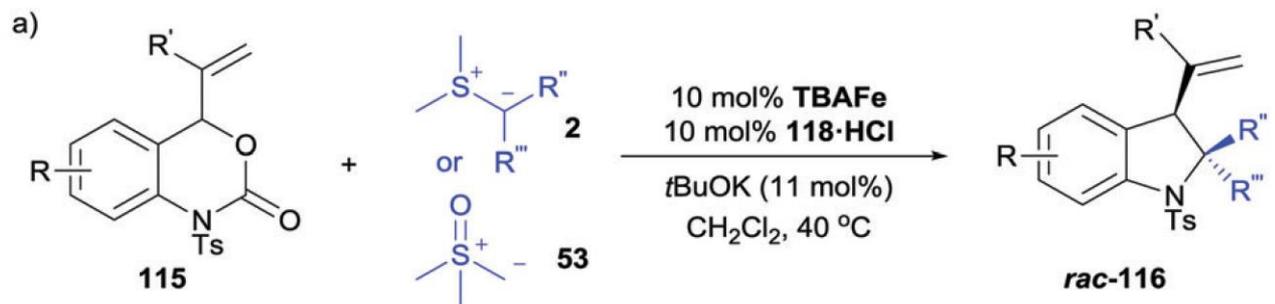
4. Transition-metal-catalyzed cyclizations

4.3. Through catalytic activation of allyl and propargyl carbamates

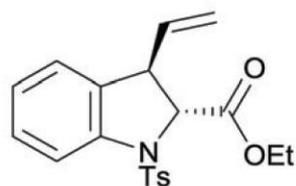


4. Transition-metal-catalyzed cyclizations

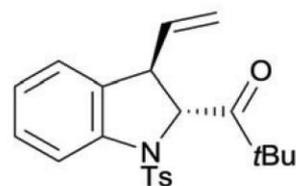
Fe-catalysed decarboxylative formal [4+1] cycloadditions



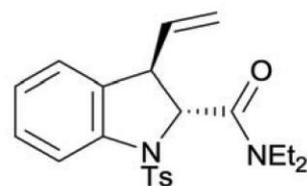
88% yield, >95:5 dr



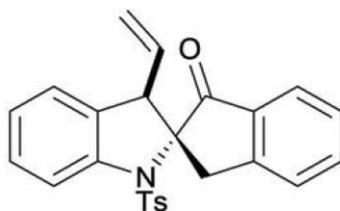
83% yield, >95:5 dr



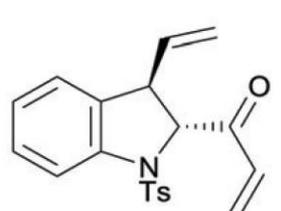
60% yield, >95:5 dr



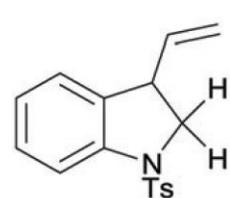
95% yield, >95:5 dr



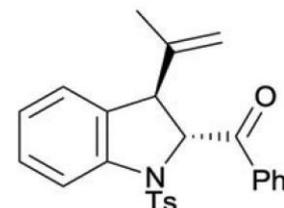
77% yield, > 95:5 dr



69% yield, >95:5 dr



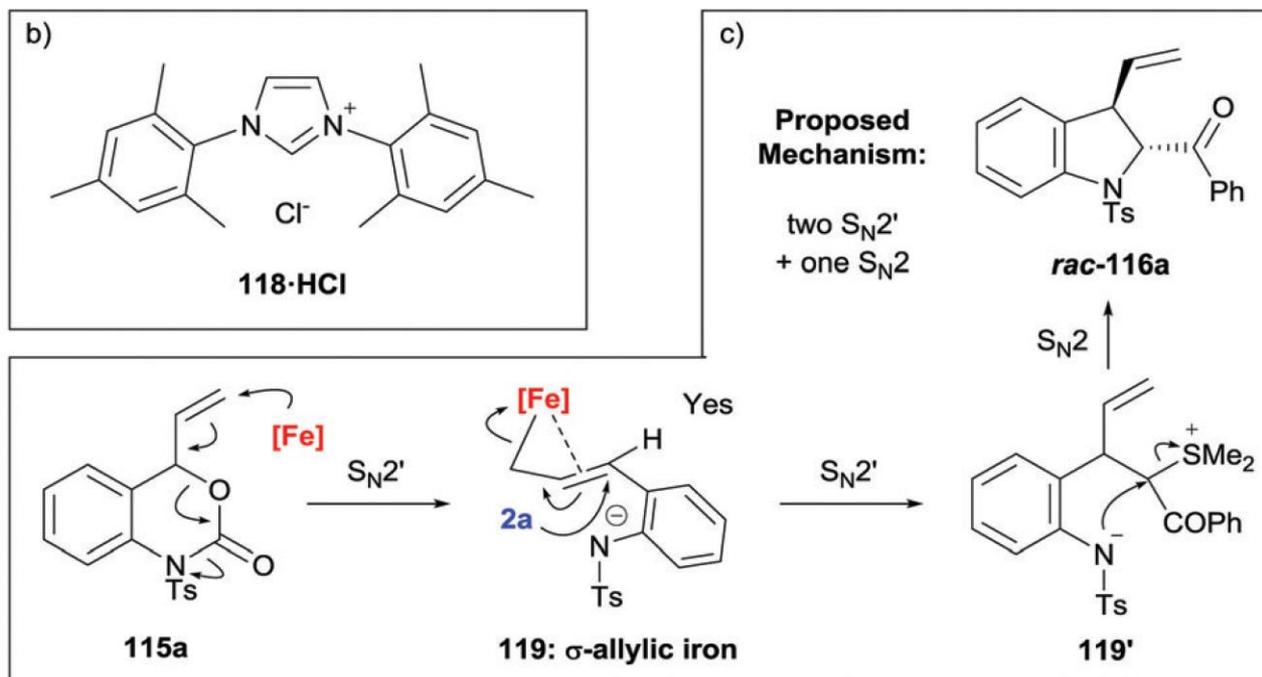
53% yield, > 95:5 dr



54% yield, >95:5 dr

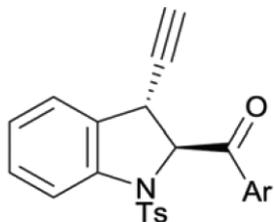
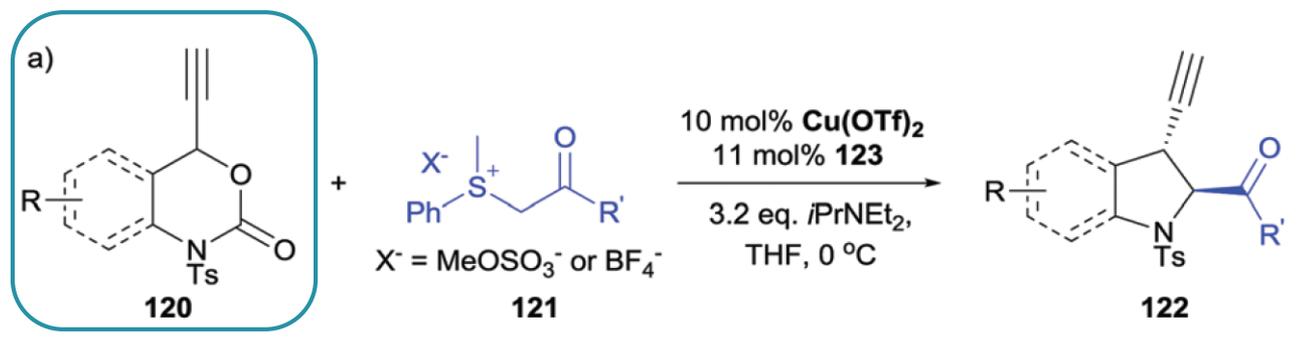
4. Transition-metal-catalyzed cyclizations

Different reaction pathway from Pd catalysis

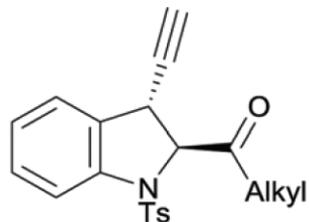


4. Transition-metal-catalyzed cyclizations

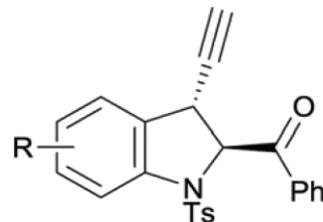
Cu-catalysed decarboxylative formal [4+1] cycloadditions



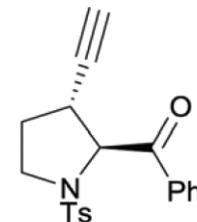
90-99% yields,
84-98% ee, >95:5 dr



90-99% yields,
91-95% ee, >95:5 dr



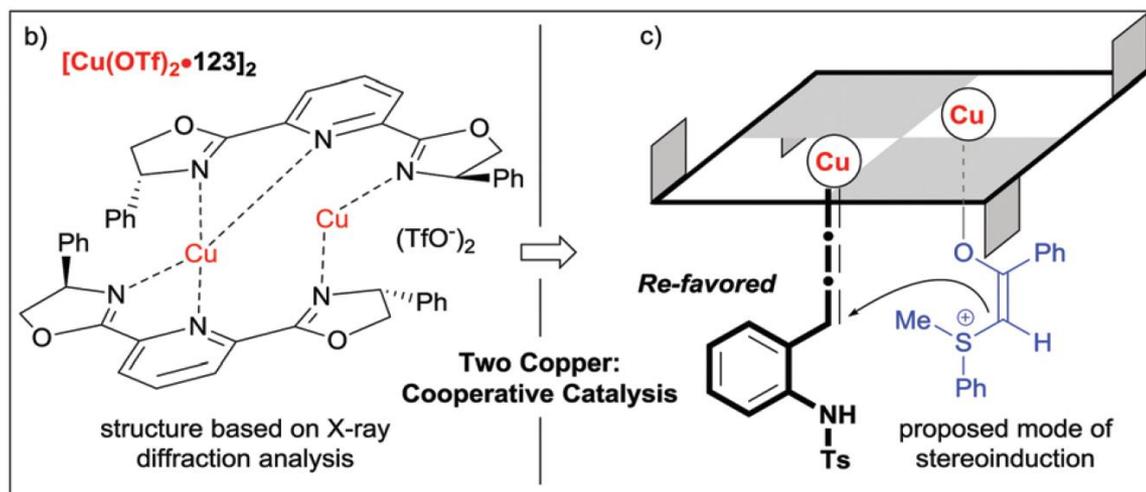
82-99% yields,
80-95% ee, >95:5 dr



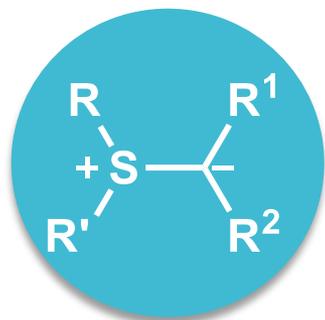
80% yield,
84% ee, >95:5 dr

Novel propargylic carbamate reagents

4. Transition-metal-catalyzed cyclizations



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Metal carbenoids, alkynes and alkenes, carbamates

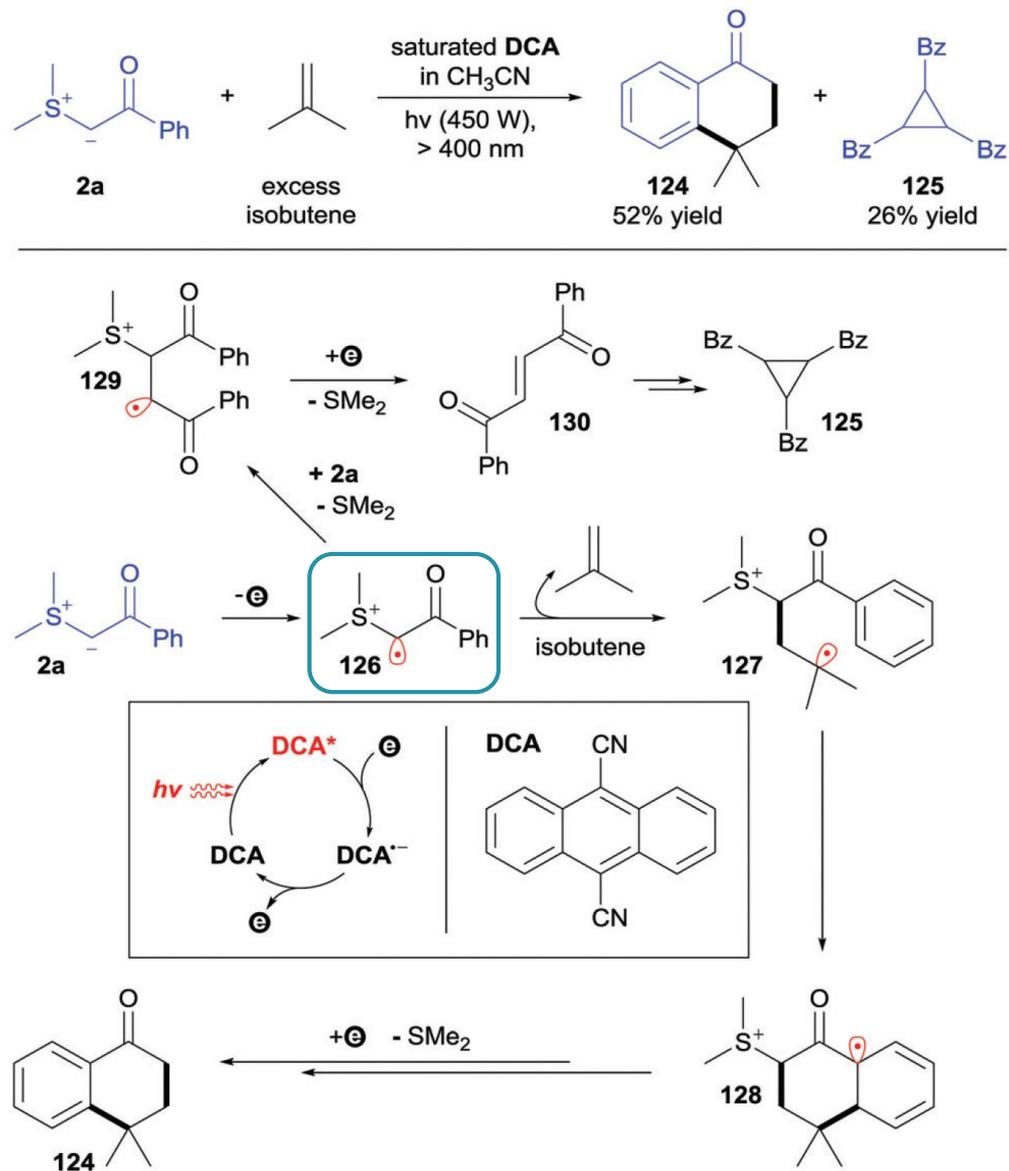
05 Photocatalytic cyclizations

SET, ET

06 Conclusions

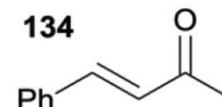
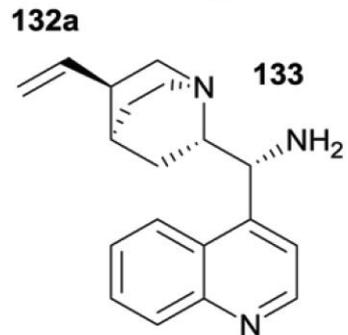
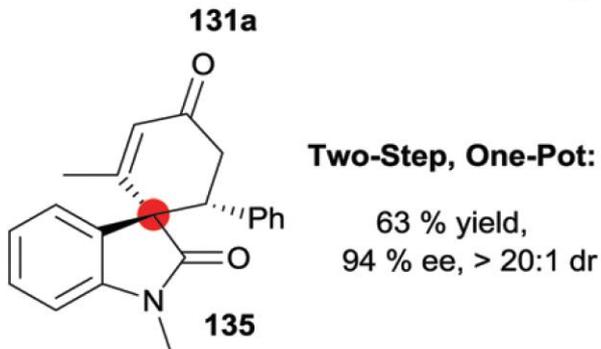
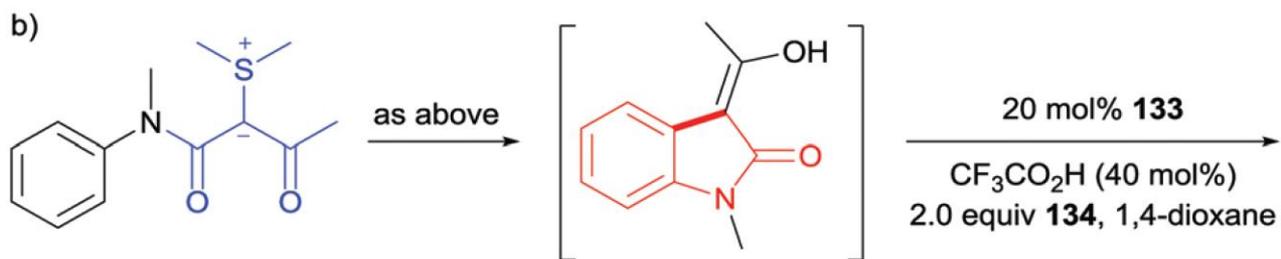
5. Photocatalytic cyclizations of sulfur ylides and related transformations

5.1 SET pathway

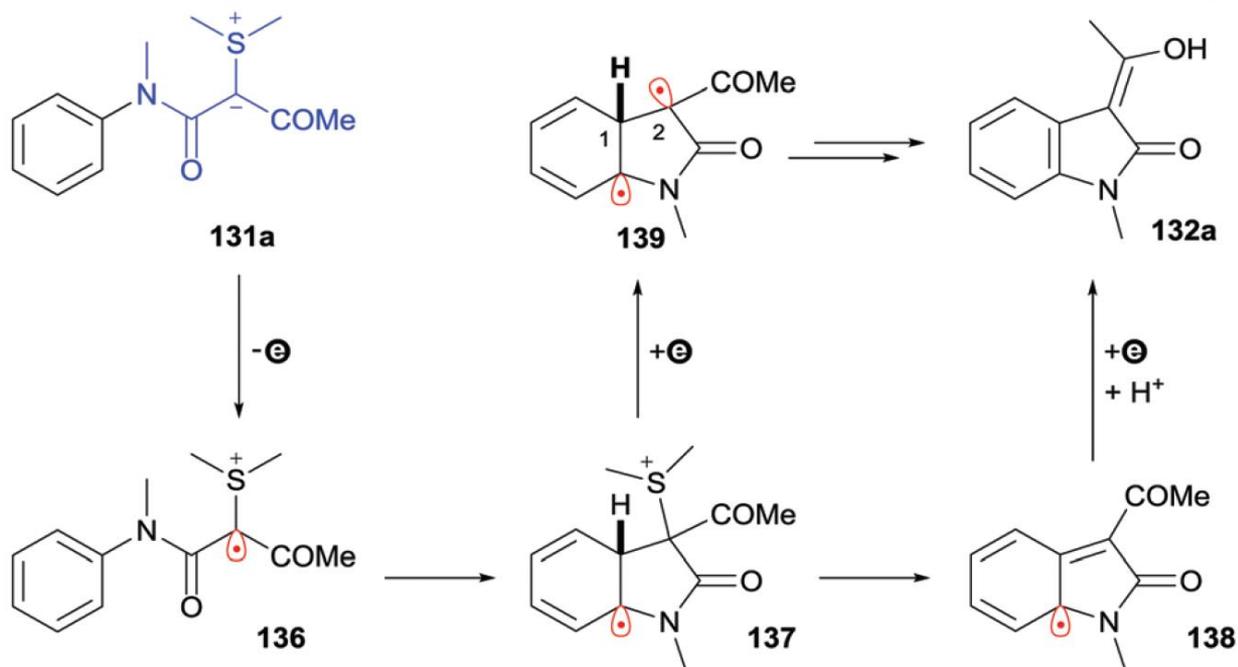
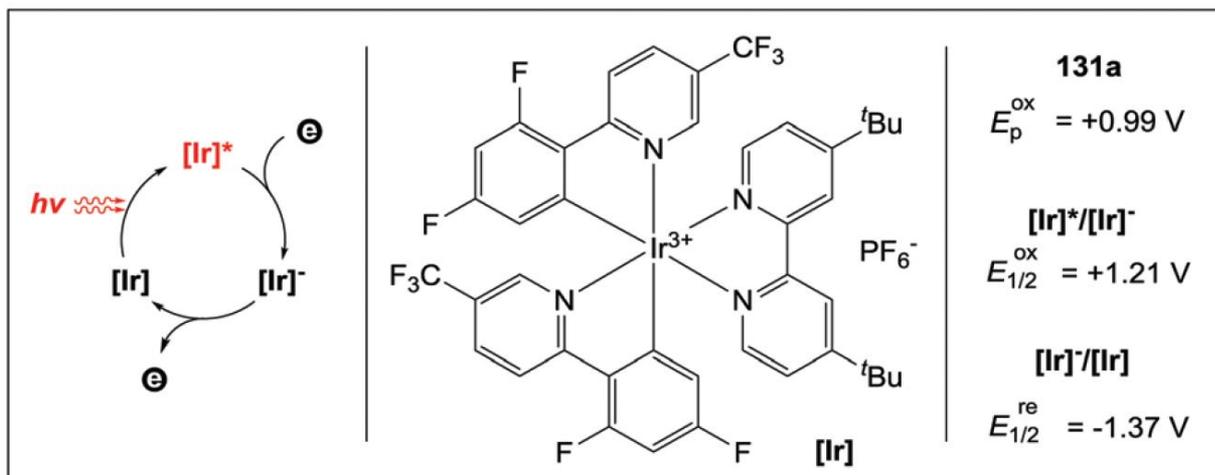


5. Photocatalytic cyclizations of sulfur ylides and related transformations

3-acyl oxindole synthesis through photocatalytic activation

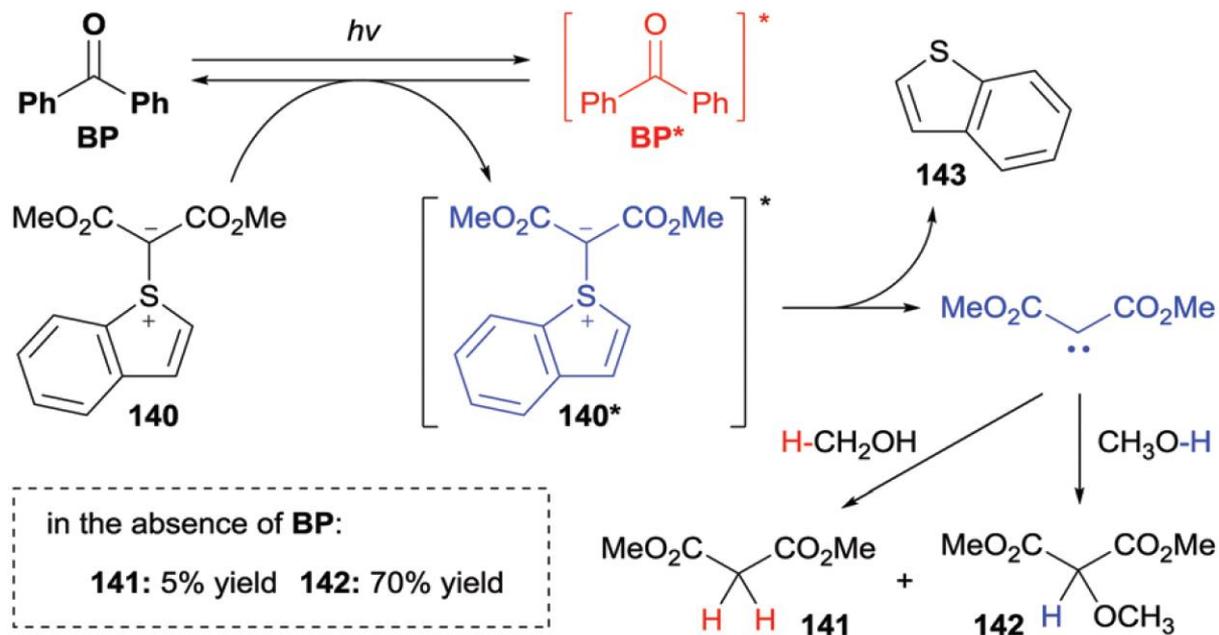
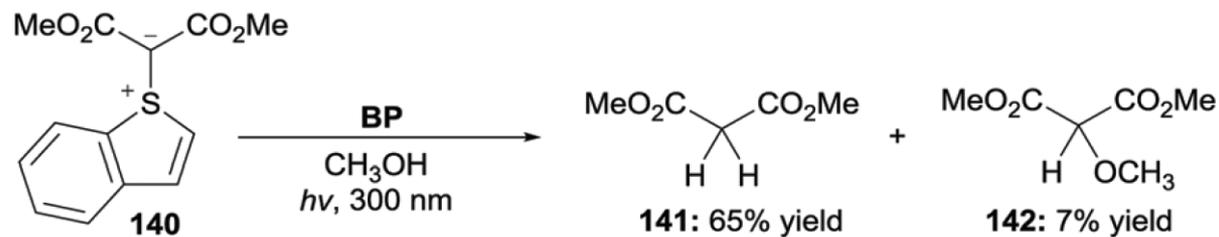


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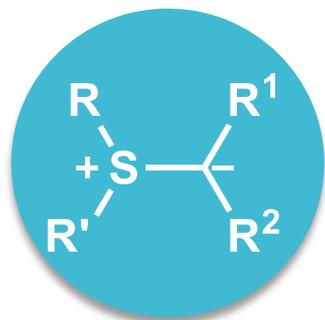


5. Photocatalytic cyclizations of sulfur ylides and related transformations

5.2. ET pathway- photolysis of sulfur ylides



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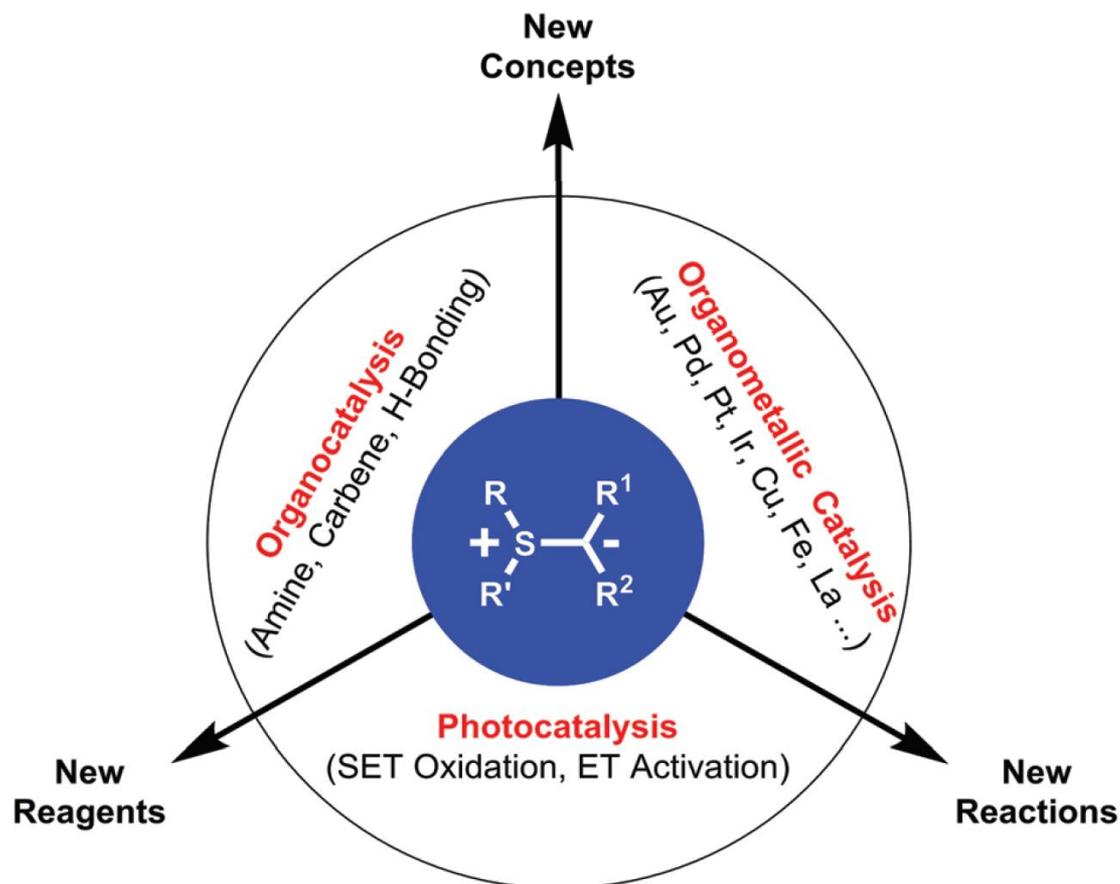
Metal carbenoids, alkynes and alkenes, carbamates

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06 Conclusions

6. Conclusions



- ◆ Avoidance of stoichiometric chiral pools
- ◆ Extension of reaction types and reagents

THANK YOU

