同济大学
TONGJI UNIVERSITY

同济大学化学科学与工程学院
School of Chemical Science and Engineering

The Yang Research Group
Precise Synthesis Lab at Tongji University

王飞课题组相关研究介绍

Topic report

汇报人：李安妮　　**时间：2026.01.09**

目 录

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第一部分 作者简介

王飞 教授

教育经历：

- 2007-2011 青岛科技大学，本科，导师：侯万国 教授
- 2011-2016 中国科学院上海有机所，博士，导师：刘国生 教授

工作经历：

- 2016-2017 中国科学院上海有机所，研究助理，导师：刘国生教授
- 2017-2020 美国University of Wisconsin – Madison，博士后，导师：Shannon S. Stahl
- 2021-至今 南开大学化学学院 特聘研究员

研究领域：

有机合成方法学：自由基化学、不对称催化；目前聚焦于自由基介导的（对映体）选择性胺化。

第二部分 脂肪族叠氮化物对未活化烯烃的加氢胺化反应

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Communication

Hydroamination of Unactivated Alkenes with Aliphatic Azides

Si-Ming Jia, Yi-Hang Huang, Zhan-Lin Wang, Fang-Xu Fan, Bo-Han Fan, Hao-Xiang Sun, Hao Wang,* and Fei Wang*

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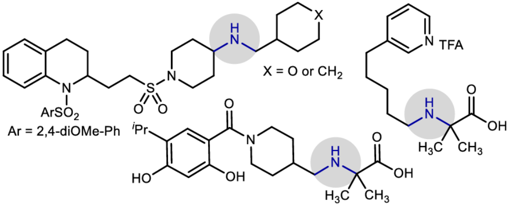
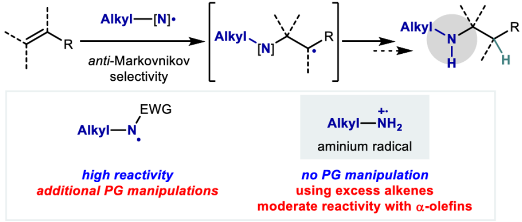
第二部分 脂肪族叠氮化物对未活化烯烃的加氢胺化反应

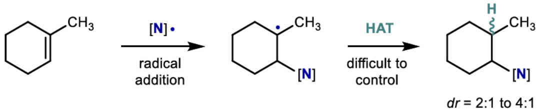
A. Selected Examples of Bioactive Dialkylamines



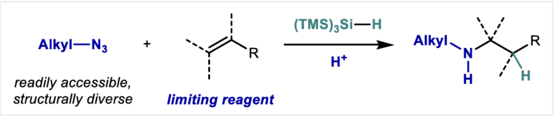
B. Dialkylamine Synthesis via NCR-Mediated Alkene Hydroamination (*Prior Arts*)



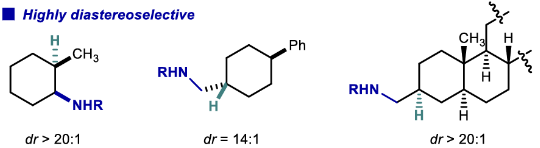
C. A General Limitation in NCR-Mediated Alkene Hydroamination: Poor *dr*



D. Alkene Hydroamination with Aliphatic Azides (*This Work*)



- ***Broad substrate scope***
- ***Mild reaction conditions***
- ***Highly diastereoselective***
- ***Transition metal-free***
- ***Amenable to amination of complex alkenes***



第二部分 脂肪族叠氮化物对未活化烯烃的加氢胺化反应

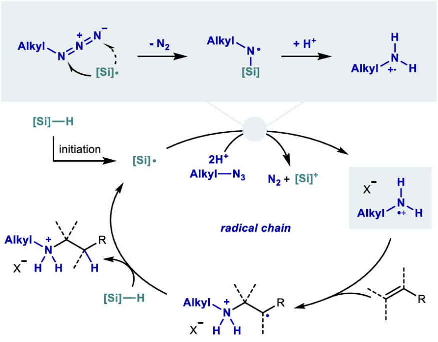


Figure 2. Proposed reaction pathway.

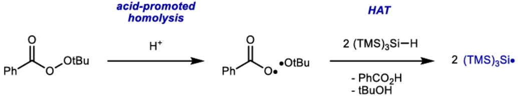
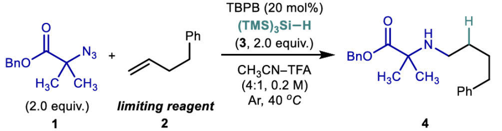


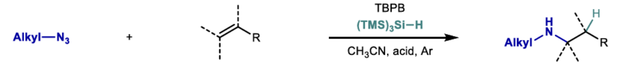
Table 1. Reaction Conditions Examination[a]



entry	deviation from the conditions shown above	yield of **4** (%)
1	none	78
2	at room temperature	75
3	TsOH (4.0 equiv) instead of TFA	89
4	TsOH (2.0 equiv) instead of TFA	71
5	CH_3SO_3H (4.0 equiv) instead of TFA	61
6	using 1.0 equiv of **1** and **3**	55
7	using 1.0 equiv of **1** and **3**, TsOH (4.0 equiv)	54
8	in the absence of acid	0

[a] ^{1}H NMR yields with 1,3,5-trimethoxybenzene as an external standard.

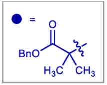
第二部分 脂肪族叠氮化物对未活化烯烃的加氢胺化反应



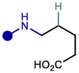
aliphatic azides

unactivated alkenes
limiting reagent

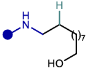
secondary amines



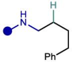
Scope of alkenes



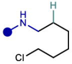
6, 89%



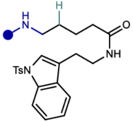
7, 71%



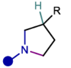
4, 88%
83% for 5 mmol sacle
(1.36 g)



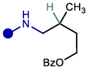
5, 90%



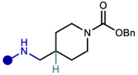
11, 68%



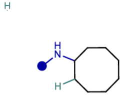
12, R = H, 76%
13, R = CH₃, 75%



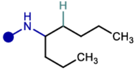
14, 77%



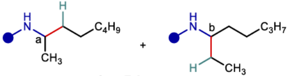
15, 73%



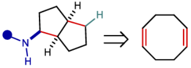
16, 87%



from E-alkene
18, 54%

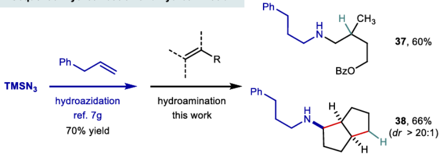


from E-2-octene
19, 67% (a:b = 5:4)



22, 82% (*dr* > 20:1)

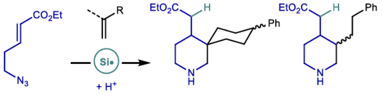
Sequential hydroazidation and hydroamination



37, 60%

38, 66%
(*dr* > 20:1)

Piperidine synthesis via [4+2] annulation

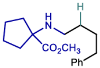


39

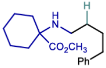
40, 70% (*dr* = 3:1)

41, 38% (*dr* = 3:2)

Scope of aliphatic azides



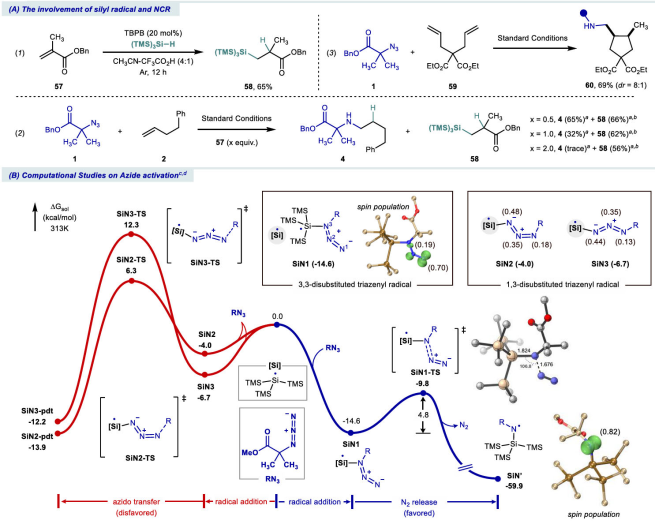
23, 84%



24, 83%

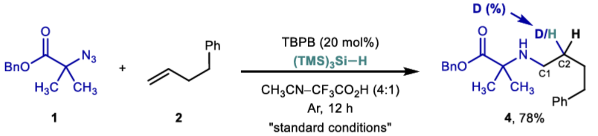
第二部分

脂肪族叠氮化物对未活化烯烃的加氢胺化反应



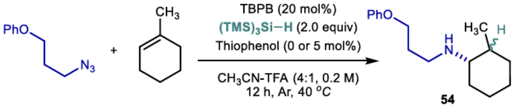
第二部分 脂肪族叠氮化物对未活化烯烃的加氢胺化反应

(C) Hydrogen atom transfer

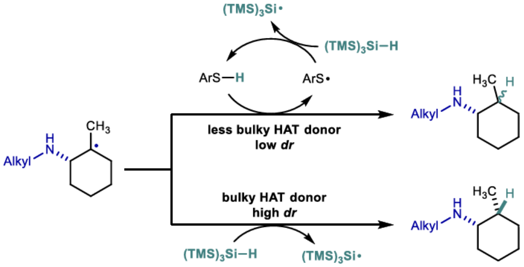


Entry	Deviation from the standard conditions	Yield[a]	D (%)
1	With (TMS)$_3$Si–D	65%	>95
2	$CD_3CN–CF_3CO_2D$ (4:1)	72%	<3
3	Entry 2 and 4-F-PhSH (10 mol%)	62%	48
4	Entry 2 and 2,4,6-TRIP-PhSH (10 mol%)	62%	31

(D) Diastereoselectivity rationale

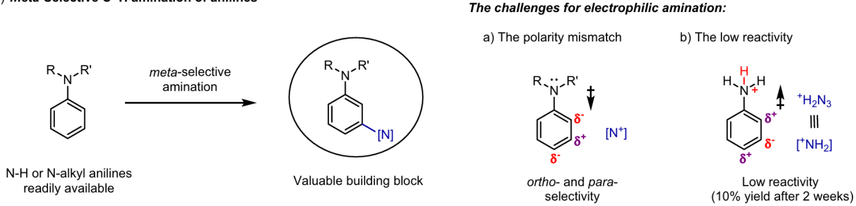


Entry	Conditions	Yield (%)[a]	*dr*
1	Without thiophenol (standard conditions)	88 (*cis*) + 3 (*trans*) (78% isolated yield)	> 20:1
2	With 4-F-PhSH (5 mol%)	58 (*cis*) + 27 (*trans*)	~ 2:1
3	With 2,4,6-TRIP-PhSH (5 mol%)	67 (*cis*) + 18 (*trans*)	~ 4:1

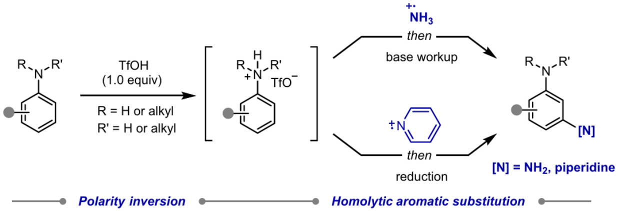


第二部分 均裂芳香取代中质子化诱导极性翻转实现芳香胺的间位选择性C–H胺化

(b) ***meta*-Selective C–H amination of anilines**



(c) **A polarity inversion strategy for *meta*-selective amination of anilines with ammoniumyl and pyridinium radicals**



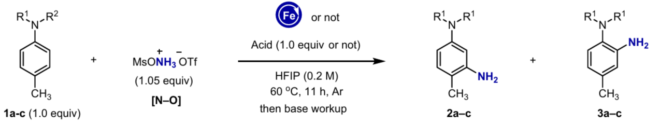
- ***Protonation-enabled polarity inversion***
- ***High meta-selectivity with broad scope***
- ***Direct incorporation of an NH_2 group***
- ***Streamlined synthesis of bioactive molecules***

CCS Chem. **2025**, *7*, 3606–3615.

第二部分

均裂芳香取代中质子化诱导极性翻转实现芳香胺的间位选择性C–H胺化

Table 1 | *Reaction Development*



1a-c (1.0 equiv) **[N–O]** **2a–c** **3a–c**

Entry	Substrate	R^1	R^2	Solvent	Acid	Yield/**2**	**2/3**
1	**1a**	H	H	HFIP	No	14%	2:1
2	**1a**	H	H	HFIP	HCl	N.D.	—
3	**1a**	H	H	HFIP	H_2SO_4	16%	2:1
4	**1a**	H	H	HFIP	TFA	30%	2:1
5	**1a**	H	H	HFIP	MsOH	28%	2:1
6	**1a**	H	H	HFIP	Tf_2NH	42%	4:1
7	**1a**	H	H	HFIP	TfOH	71%	6:1
8[a]	**1a**	H	H	HFIP	TfOH	72%, 65%[b]	6:1
9	**1a**	H	H	CH_3NO_2	TfOH	10%	1:2:1
10	**1a**	H	H	CH_3OH	TfOH	N.D.	—
11	**1a**	H	H	CH_3CN	TfOH	N.D.	—
12	**1a**	H	H	THF	TfOH	N.D.	—
13[a]	**1b**	CH_3	H	HFIP	TfOH	67%, 70%[b]	8:1
14[a]	**1c**	CH_3	CH_3	HFIP	TfOH	87%, 81%[b]	>20:1

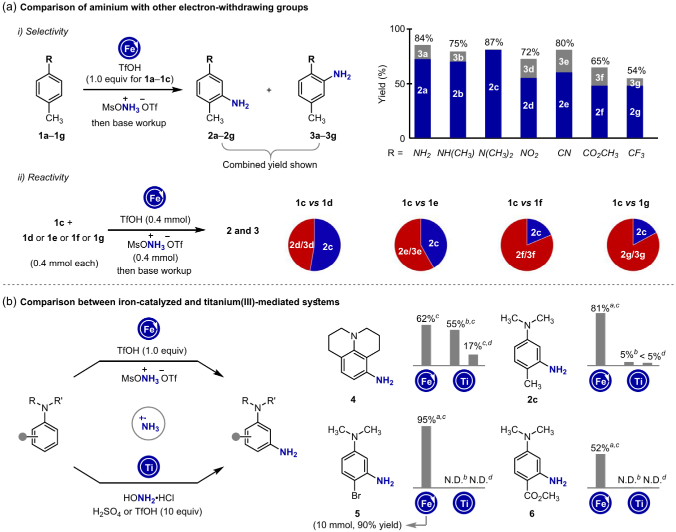
Note: Yields and selectivity were determined by ^{1}H-NMR analysis with CH_2Br_2 as internal standard.

[a] With $FeSO_4$•$7H_2O$ (5 mol %) as catalyst, reaction time is 3 h.

[b] Isolated yield.

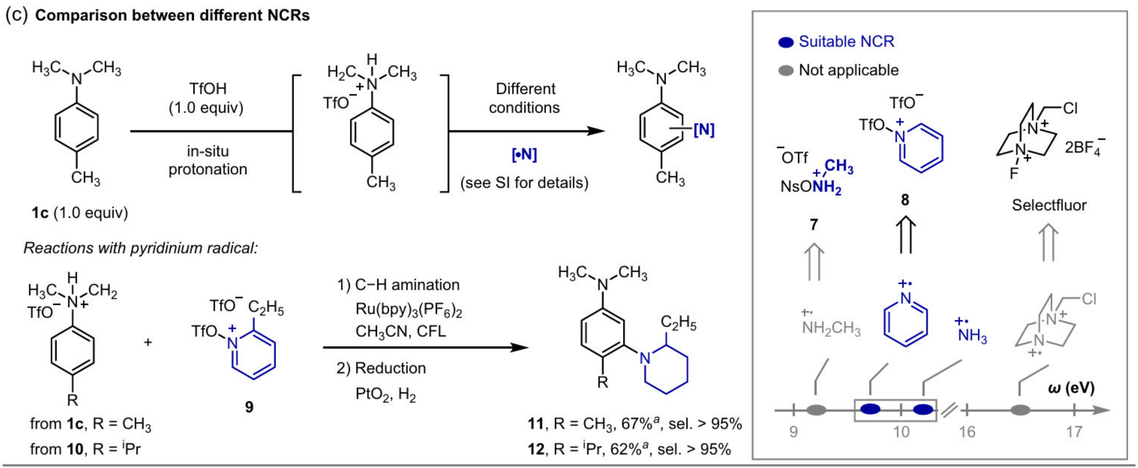
第二部分

均裂芳香取代中质子化诱导极性翻转实现芳香胺的间位选择性C–H胺化


(a) **Comparison of aminium with other electron-withdrawing groups**

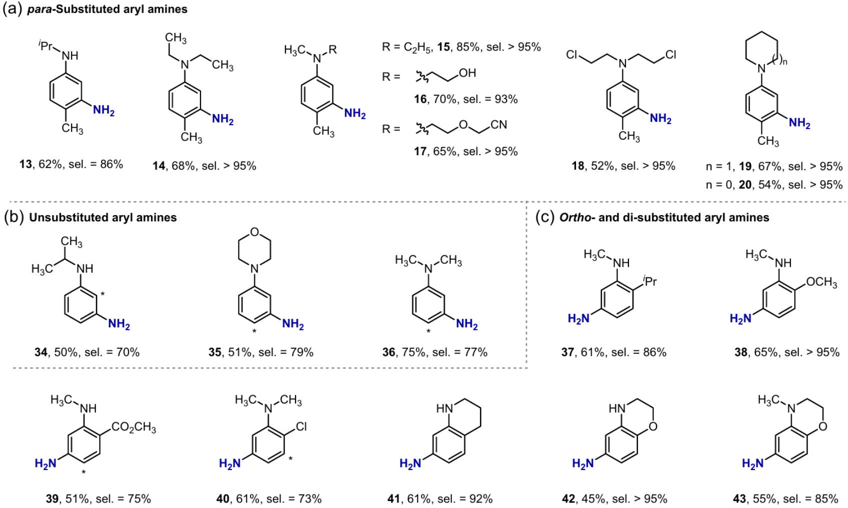
(b) **Comparison between iron-catalyzed and titanium(III)-mediated systems**

第二部分 均裂芳香取代中质子化诱导极性翻转实现芳香胺的间位选择性C–H胺化



第二部分

均裂芳香取代中质子化诱导极性翻转实现芳香胺的间位选择性C–H胺化



(a) ***para*-Substituted aryl amines**

13, 62%, sel. = 86%

14, 68%, sel. > 95%

R = C_2H_5, **15**, 85%, sel. > 95%

16, 70%, sel. = 93%

17, 65%, sel. > 95%

18, 52%, sel. > 95%

n = 1, **19**, 67%, sel. > 95%

n = 0, **20**, 54%, sel. > 95%

(b) **Unsubstituted aryl amines**

34, 50%, sel. = 70%

35, 51%, sel. = 79%

36, 75%, sel. = 77%

(c) ***Ortho*- and di-substituted aryl amines**

37, 61%, sel. = 86%

38, 65%, sel. > 95%

39, 51%, sel. = 75%

40, 61%, sel. = 73%

41, 61%, sel. = 92%

42, 45%, sel. > 95%

43, 55%, sel. = 85%

第三部分 利用铁氨基自由基实现芳烃的位点选择性C–H胺化

nature › nature catalysis › articles › article

Article | Published: 01 April 2024

Site-selective arene C–H amination with iron-aminyl radical

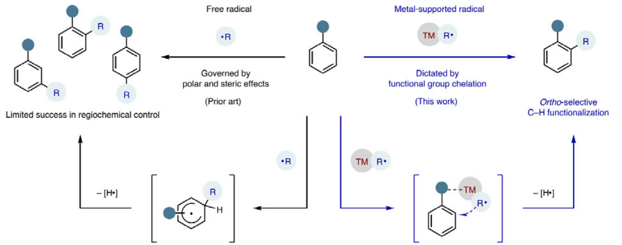
Chao-Rui Ma, Guan-Wang Huang, Hui Xu, Zhan-Lin Wang, Zheng-Hao Li, Jun Liu, Yin Yang, Gongyu Li, Yanfeng Dang ✉ & Fei Wang ✉

Nature Catalysis **7**, 636–645 (2024) | Cite this article

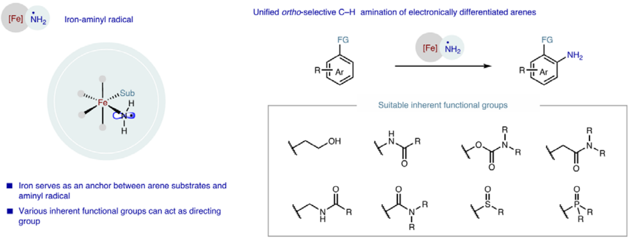
第三部分

利用铁氨基自由基实现芳烃的位点选择性C–H胺化

a The positional selectivity in HAS with free radical and metal-supported radical



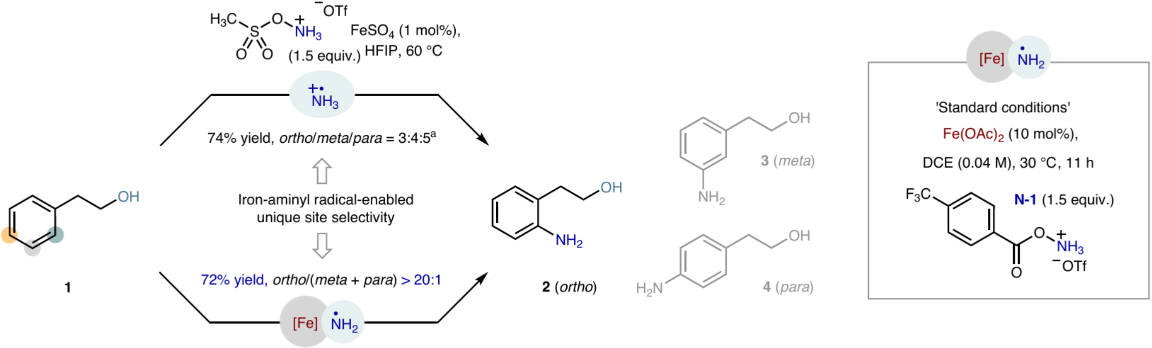
c *Ortho*-selective arene C–H amination with iron-aminyl radical



- Iron serves as an anchor between arene substrates and aminyl radical
- Various inherent functional groups can act as directing group

第三部分 利用铁氨基自由基实现芳烃的位点选择性C–H胺化

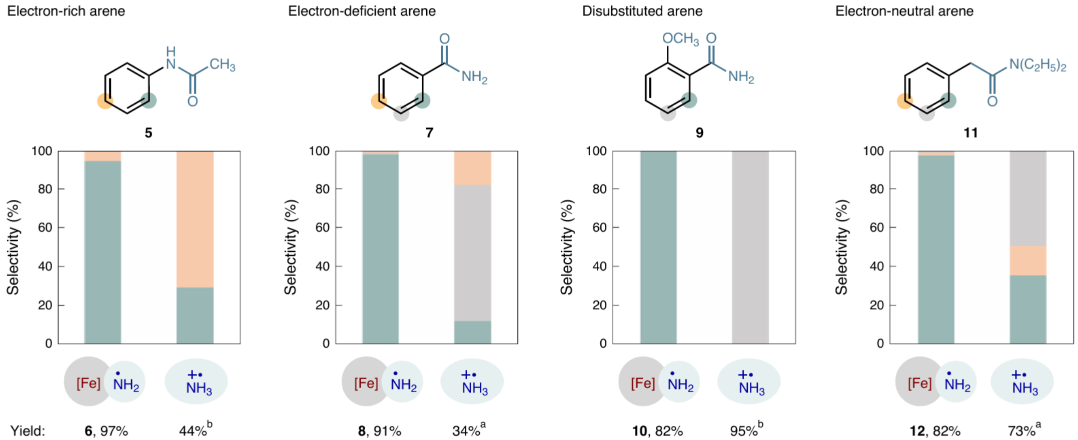
a The optimized reaction conditions and site selectivity comparison with existing method via ammoniumyl radical



第三部分

利用铁氨基自由基实现芳烃的位点选择性C–H胺化

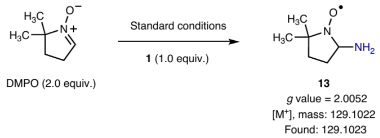
b Site selectivity comparison between ammoniumyl radical- and iron-supported NCR-mediated HAS for arene C–H amination



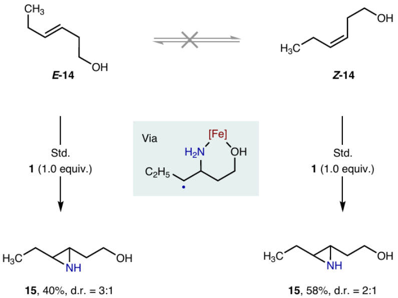
第三部分

利用铁氨基自由基实现芳烃的位点选择性C–H胺化

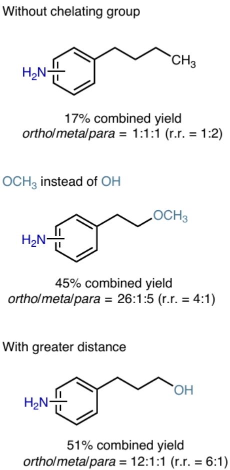
a EPR analysis of the reaction mixture with DMPO as spin trap



b The reaction of alkenes under standard conditions

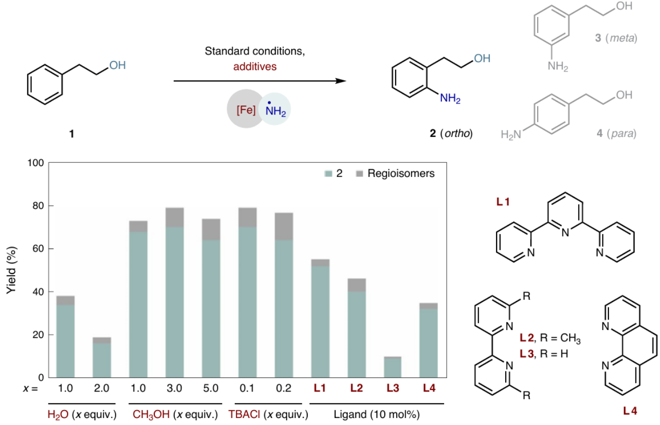


c Control experiments

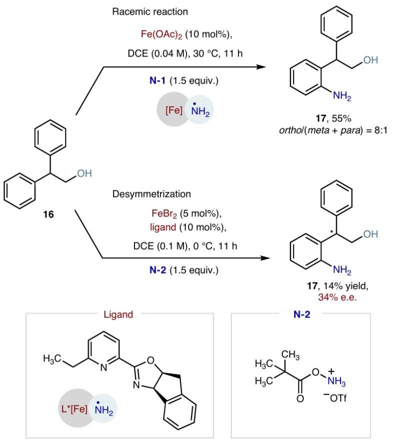


第三部分 利用铁氨基自由基实现芳烃的位点选择性C–H胺化

d Additive effects

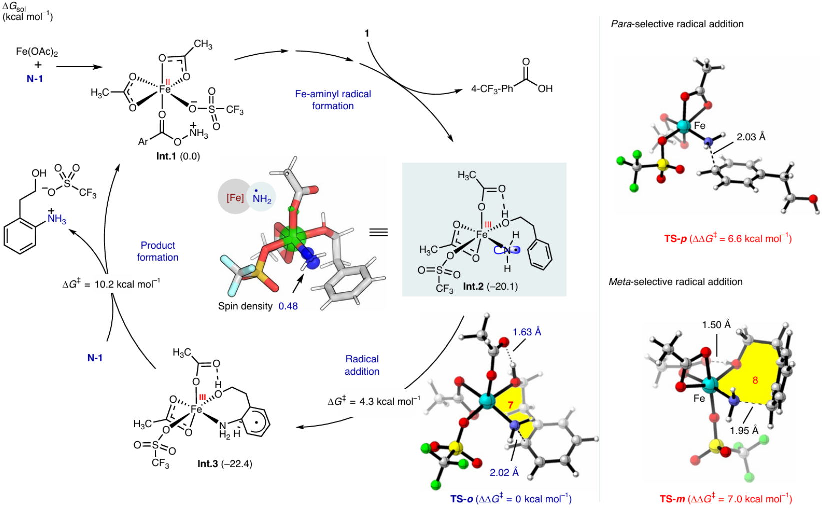


e Preliminary results for desymmetric arene C–H amination



第三部分

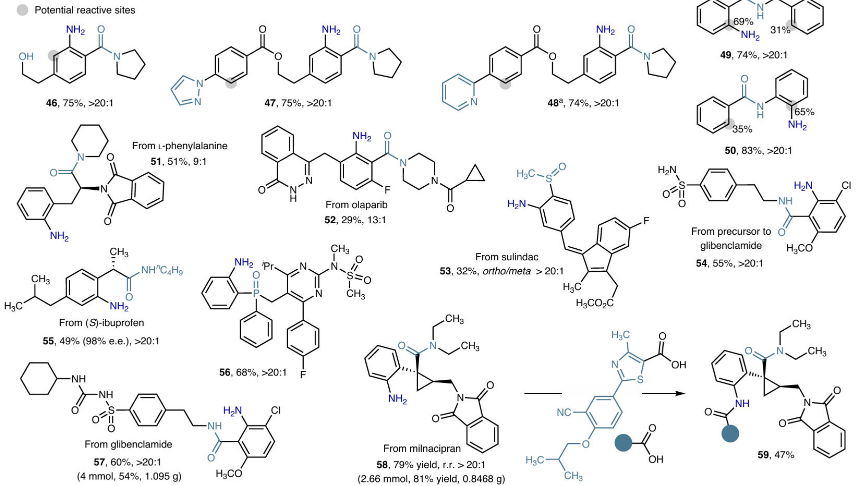
利用铁氨基自由基实现芳烃的位点选择性C–H胺化



第三部分

利用铁氨基自由基实现芳烃的位点选择性C–H胺化

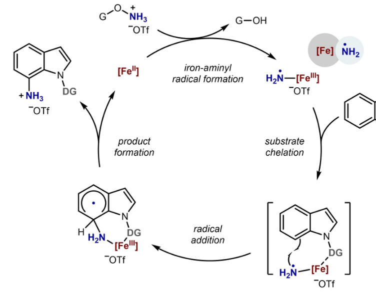
b Competition experiments and late-stage C–H amination of complex arene substrates



第三部分

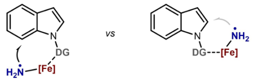
铁催化吲哚的C-7选择性NH_2胺化反应

A. Proposed catalytic cycle

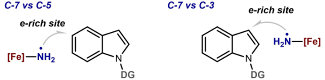


The challenges:

- *Directed radical addition, C-7 vs C-2*



- *Non-directed radical addition ("background" reaction), C-7 vs C-3/5*

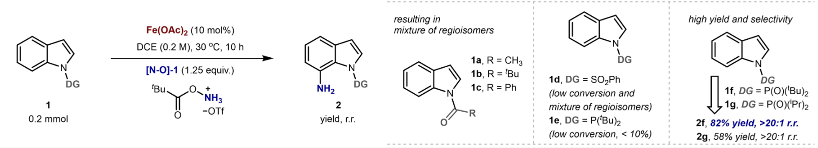


The solution:

Identifying a DG that could

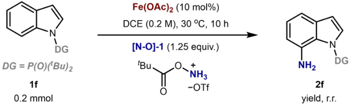
- *orientate the iron-aminyl radical to the C-7 position selectively*
- *coordinate with the iron catalyst effectively*
- *deactivate C-5 and C-3 positions sufficiently*

B. Examination of different chelating groups



Angew. Chem. Int. Ed. **2024**, *63*, e202412103.

第三部分 铁催化吲哚的C-7选择性NH_2胺化反应



Entry	Solvent	Fe loading	Conversion	Yield of **2f**[a]	r.r.
1	DCE	10 mol%	100%	82%	> 20:1
2	PhF	10 mol%	100%	72%	> 20:1
3	MTBE	10 mol%	84%	76%	> 20:1
4	DME	10 mol%	16%	7%	1.4:1
5	THF	10 mol%	12%	3%	-
6	CH_3OH	10 mol%	23%	5%	-
7	**HFIP**	10 mol%	**100%**	**83%** (81%)[b]	**> 20:1**
8[c]	HFIP	10 mol%	47%	44%	> 20:1
9[d]	HFIP	10 mol%	87%	80%	> 20:1
10[e]	HFIP	10 mol%	90%	80%	> 20:1
11[f]	HFIP	10 mol%	5%	n.d.	-
12[g]	**HFIP**	10 mol%	**100%**	**92%** (88%)[h]	**> 20:1**
13[g]	**HFIP**	**1 mol%**	**100%**	**92%**	**> 20:1**
14[g]	HFIP	0.1 mol%	94%	83%	> 20:1
15[g,i]	HFIP	0.01 mol%	55%	45%	> 20:1
16[g]	HFIP	-	9%	n.d.	-

aminating reagents:

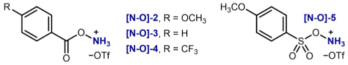


Figure 3. Reaction development. [a] Yields and selectivity were determined by ^1H NMR analysis. [b] Isolated yield in a 0.4 mmol scale. [c] With **[N-O]-2**. [d] With **[N-O]-3**. [e] With **[N-O]-4**. [f] With **[N-O]-5**. [g] With 1.1 equiv. of **[N-O]-1**. [h] Isolated yield in a 0.2 mmol scale. [i] The reaction was run for 24 hours. r.r. (regioisomeric ratio) refers to the ratio of the desired C-7 amination product and a sum of the detectable regioisomers.

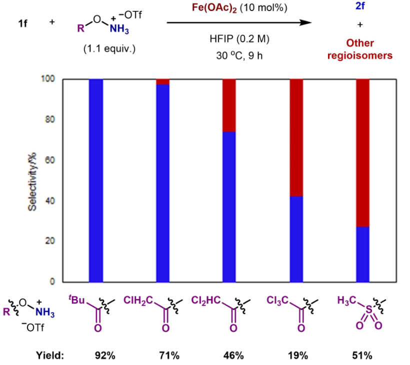
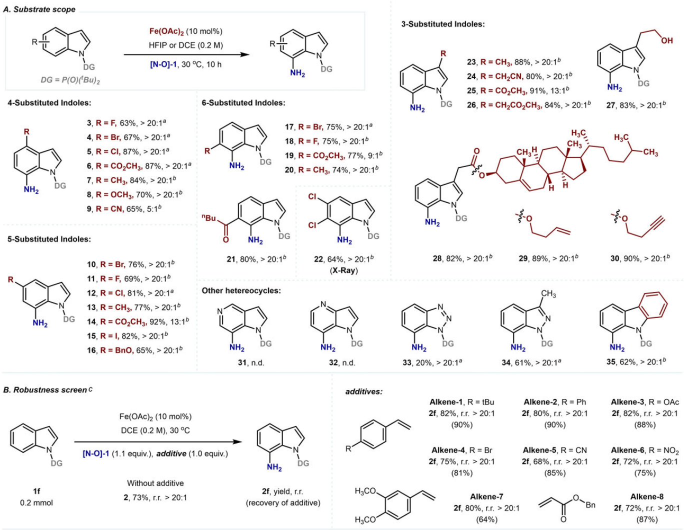


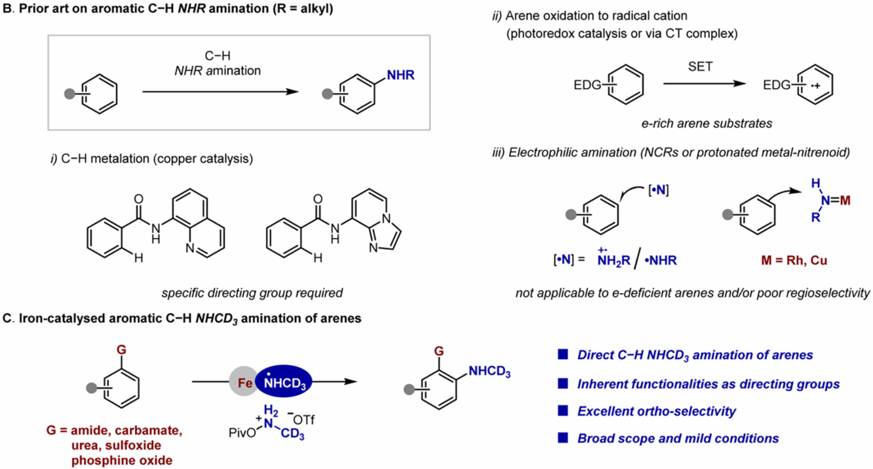
Figure 5. Control experiments with different aminating reagents.

第三部分

铁催化吲哚的C-7选择性NH_2胺化反应

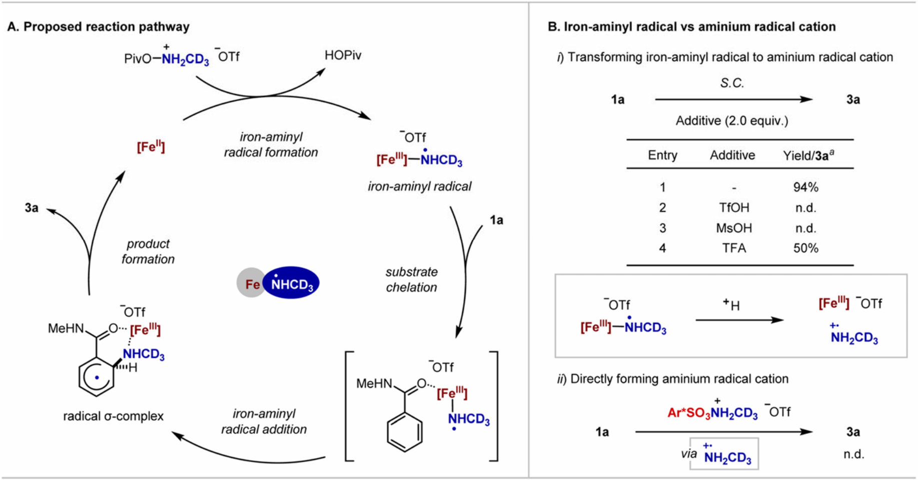


第三部分 铁催化选择性芳香C-H胺化合成N-CD_3芳胺



Chem. Sci. **2025**, *16*, 19350–19356.

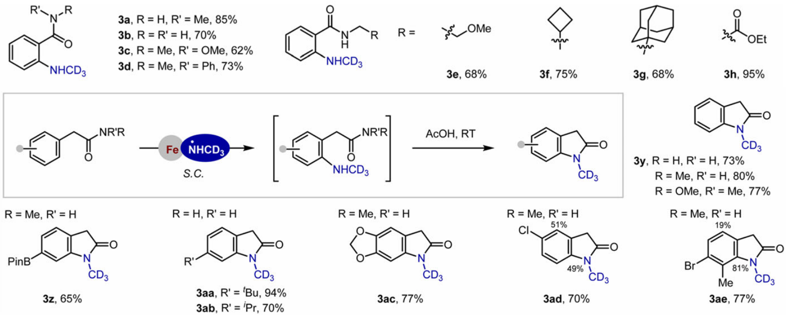
第三部分 铁催化选择性芳香C-H胺化合成N-CD_3芳胺



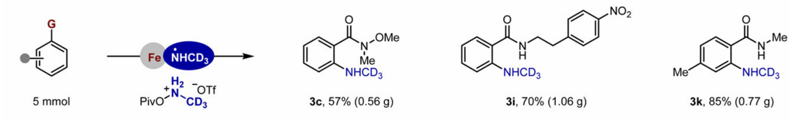
Entry	Additive	Yield/3a[a]
1	-	94%
2	TfOH	n.d.
3	MsOH	n.d.
4	TFA	50%

EPR证明NCR参与

第三部分 铁催化选择性芳香C-H胺化合成N-CD$_3$芳胺



A. Scale-up experiments



一级、二级和三级苯甲胺的兼容性极佳

第三部分

铁催化配体辅助的烯烃模块化氨化双官能化

ACS Catalysis

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Research Article

Iron-Catalyzed Ligand-Enabled Modular Aminative Difunctionalization of Alkenes

Hao-Xiang Sun,[‖] Guorong Li,[‖] Zhan-Lin Wang,[‖] Shi-Xiong Tang, Zheliang Yuan,[*] Qian Peng,[*] and Fei Wang[*]

Cite This: *ACS Catal.* 2025, 15, 17844–17855

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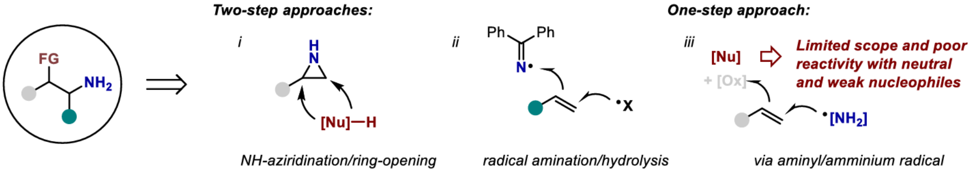
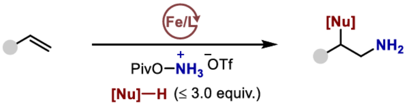
第三部分 铁催化配体辅助的烯烃模块化氨化双官能化

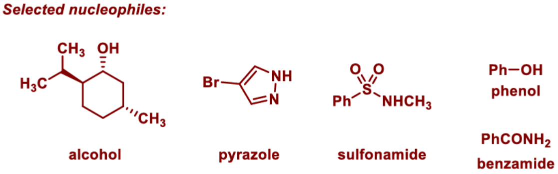
B. Aminative difunctionalization of alkenes to approach primary alkylamines.



C. This work: Iron-catalyzed modular aminative difunctionalization of alkenes.

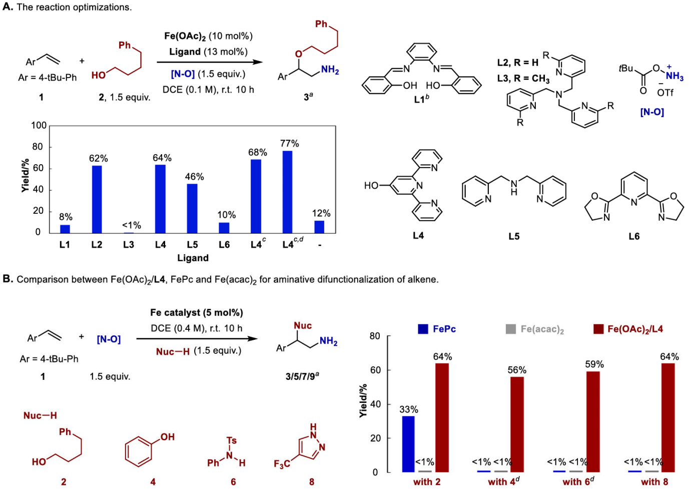


- *Broad scope of nucleophiles*
- *One-step and simple operation*
- *Avoiding the use of nucleophile in large excess*



第三部分

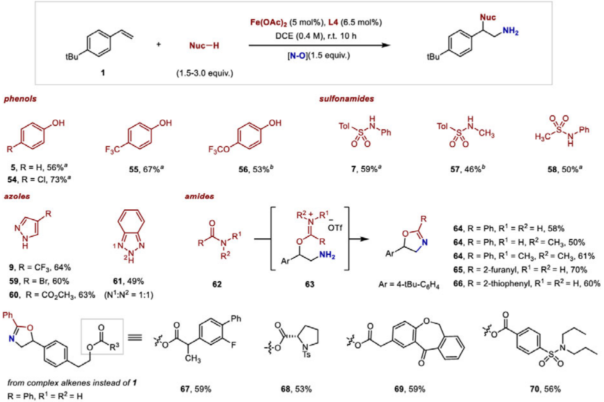
铁催化配体辅助的烯烃模块化氨化双官能化

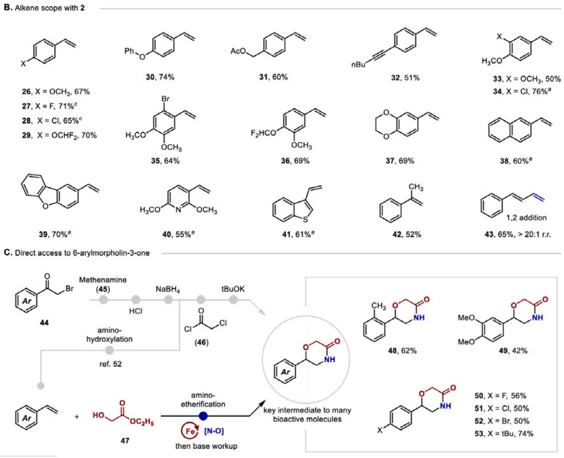

A. The reaction optimizations.

B. Comparison between Fe(OAc)$_2$/**L4**, FePc and Fe(acac)$_2$ for aminative difunctionalization of alkene.

Figure 2. Reaction development and comparison with the existing catalysts for amino-functionalization of alkenes. [a]Yields were determined using ^{1}H NMR analysis. [b]10 mol % ligand was used. [c]0.4 M, 5 mol % Fe(OAc)$_2$, and 6.5 mol % ligand. [d]3.0 equiv of the nucleophile.

第三部分 铁催化配体辅助的烯烃模块化氨化双官能化





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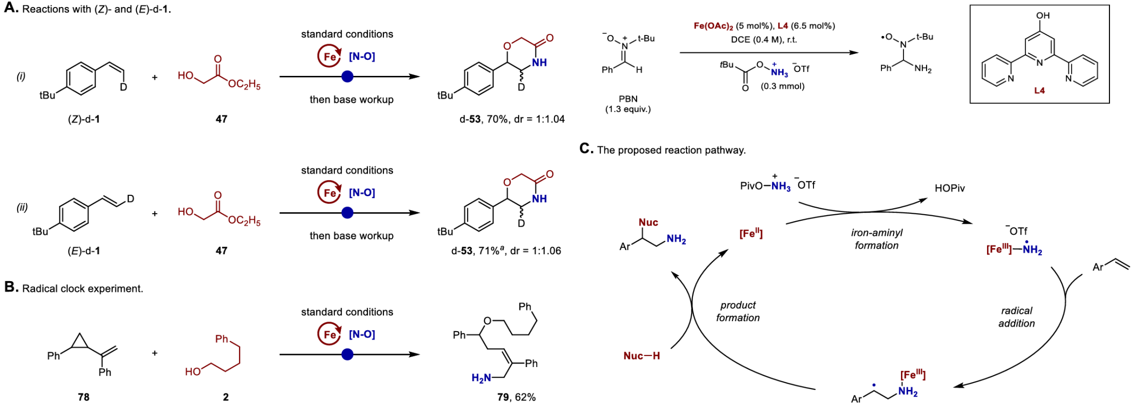
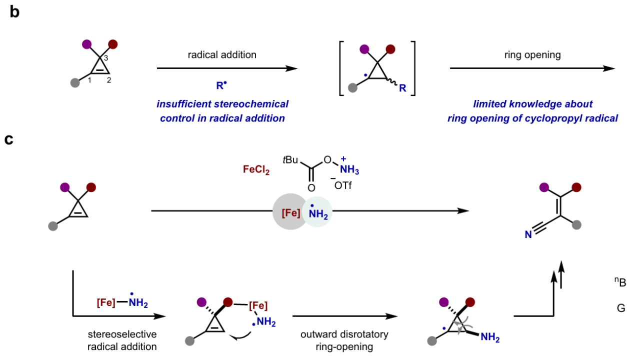
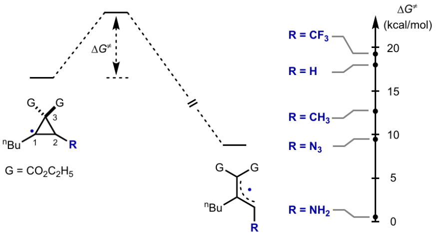


第三部分

通过铁氨基自由基与环丙烯的胺化开环反应立体选择性合成四取代及三取代烯基腈。





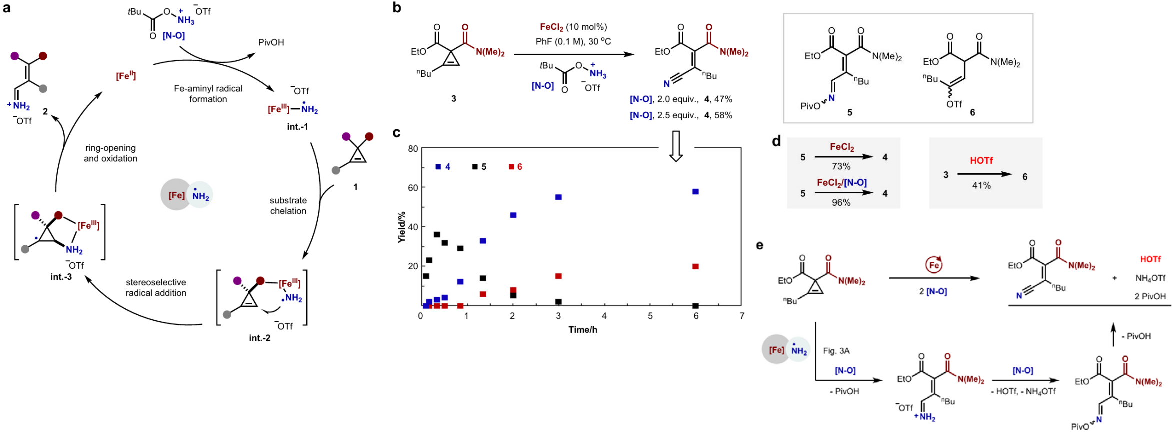
- ■ *Stereoselective radical addition with iron-aminyl radical*
- ■ *Outward disrotatory ring-opening of cyclopropyl radical*
- ■ *Stereoselective synthesis of tetra- and tri-substituted alkenyl nitriles*

Fig. 2 | DFT calculations for ring-opening of different cyclopropyl radicals. The results clearly display that amino substituent could drastically reduce the kinetic barrier for ring-opening.

Nat. Commun. **2025**, *16*, 3168.

第三部分

通过铁氨基自由基与环丙烯的胺化开环反应立体选择性合成四取代及三取代烯基腈。



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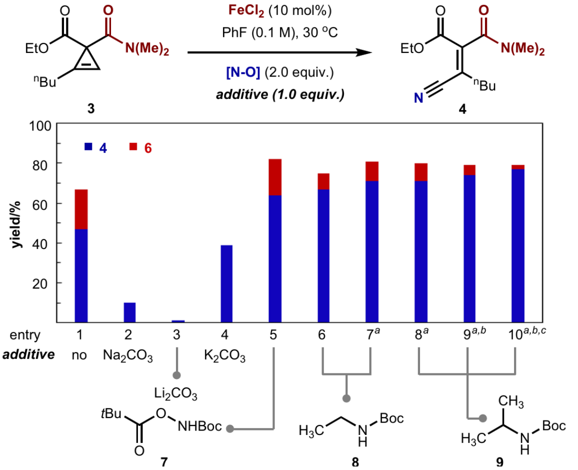
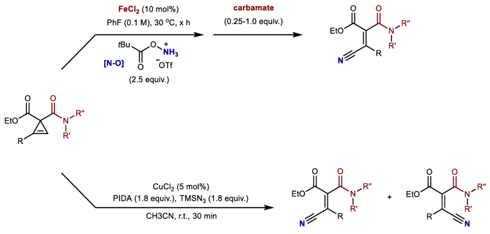
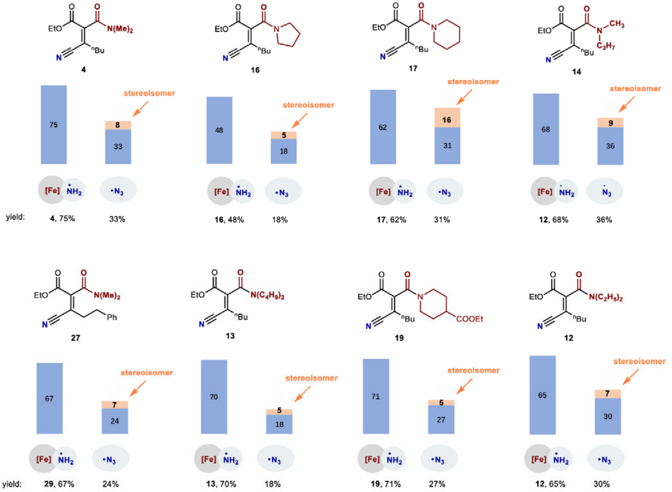


Fig. 4 | **Examination of acid scavengers.** The additive effect on the reaction. [a]The additive was added into the reaction mixture after 0.5 h. [b]2.5 equiv. of [**N-O**] was used. [c]0.5 equiv. of additive was used. All yields were determined by ^{1}H-NMR analysis with CH_2Br_2 as internal standard.

第三部分

通过铁氨基自由基与环丙烯的胺化开环反应立体选择性合成四取代及三取代烯基腈。





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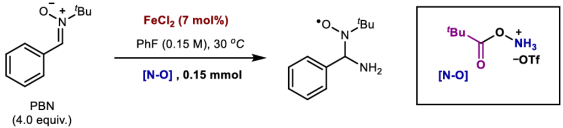

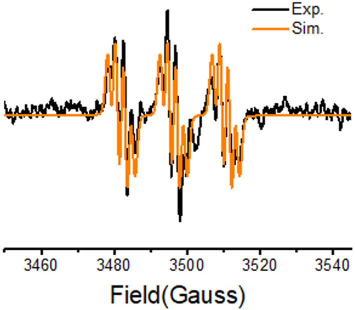

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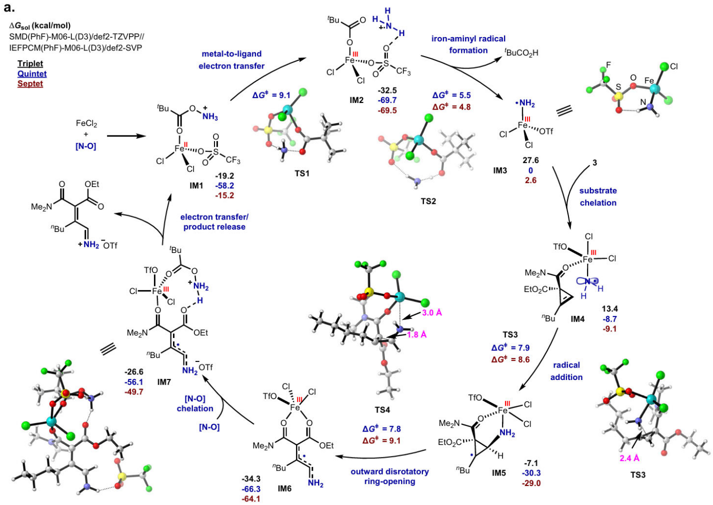
通过铁氨基自由基与环丙烯的胺化开环反应立体选择性合成四取代及三取代烯基腈。



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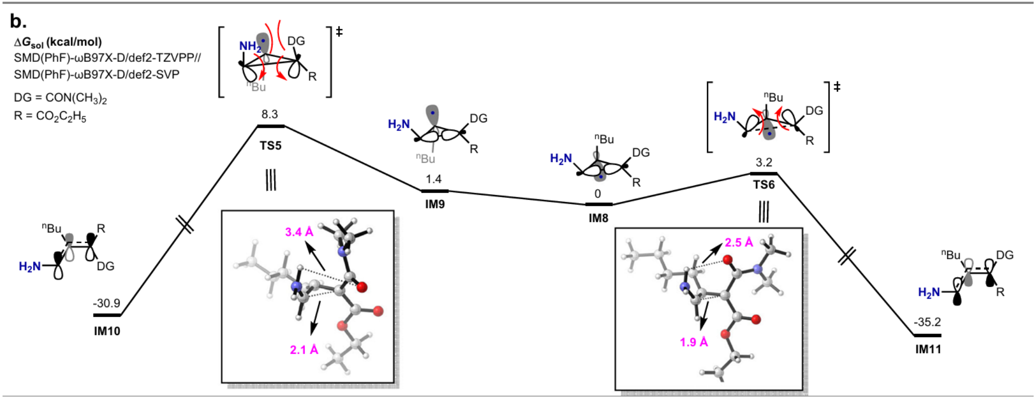

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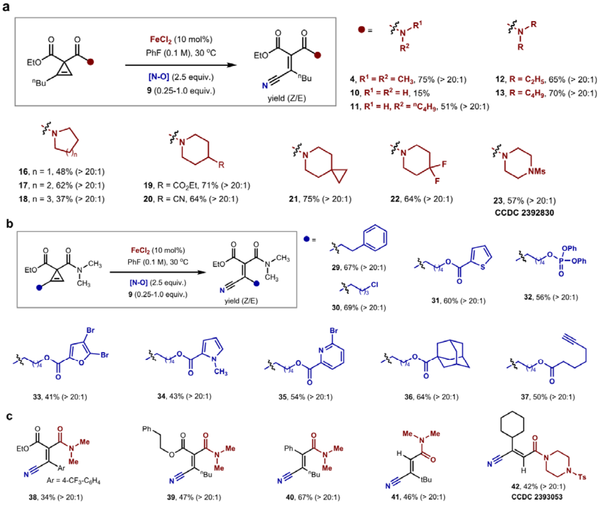
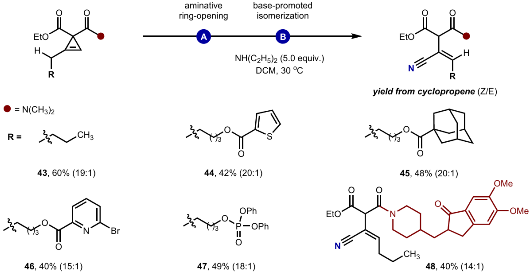
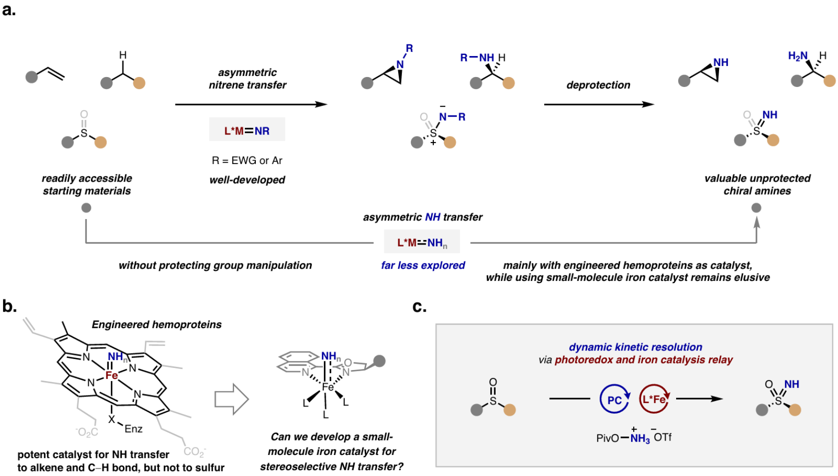




第三部分

铁催化立体选择性NH转移实现亚砜的动态动力学拆分



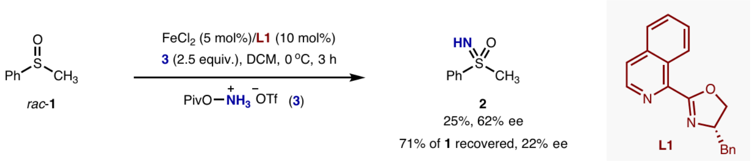
定向进化的血红素蛋白进行酶催化

Nat. Commun. **2025**, *16,* 1471.

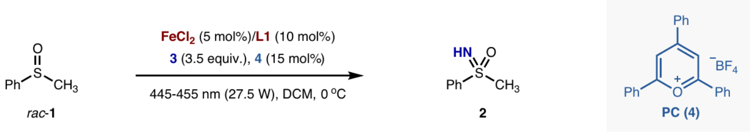
第三部分

铁催化立体选择性NH转移实现亚砜的动态动力学拆分

a. **Optimized conditions for kinetic resolution**[a]



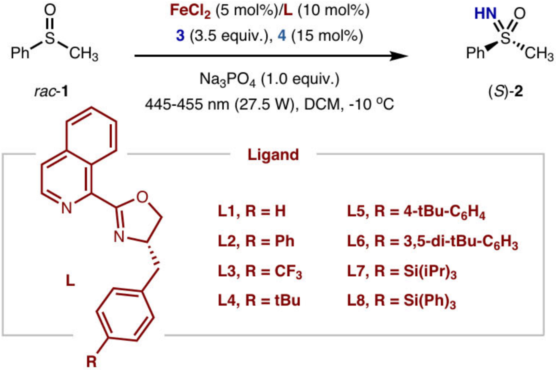
b. **Initial trials for dynamic kinetic resolution**[a]



Entry	Conditions	Recovered **1**		*NH*-sulfoximine **2**	
		yield/%	ee/%	yield/%	ee/%
1	as above	42%	2%	49%	70%
2	with Na_3PO_4 (1.0 equiv.)	20%	0%	61%	60%
3	with Na_3PO_4 (1.0 equiv.), -10 °C	36%	0%	54%	68%

第三部分 铁催化立体选择性NH转移实现亚砜的动态动力学拆分

C. Ligand assessment for iron-catalyzed dynamic kinetic resolution[a]

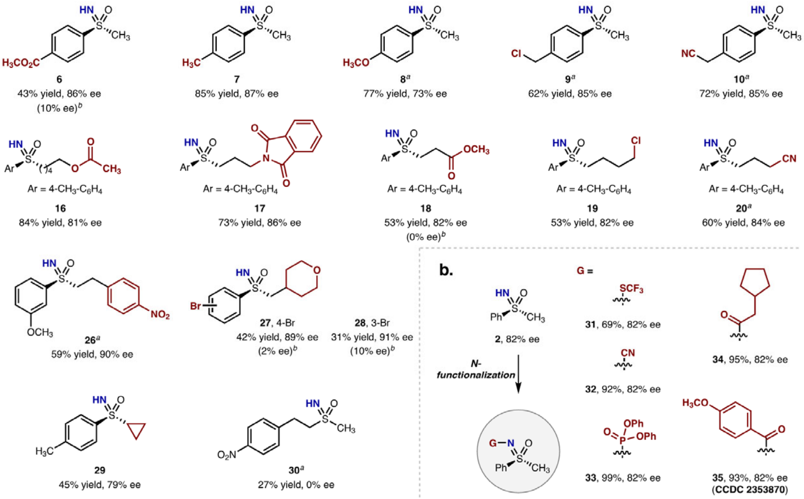


Entry	Ligand	*NH*-sulfoximine **2**	
		yield/%	ee/%
1	**L1**	54%	68%
2	**L2**	76%	64%
3	**L3**	41%	64%
4	**L4**	67%	66%
5	**L5**	69%	64%
6	**L6**	67%	74%
7	**L7**	70%	78%
8	**L8**	82%	80%
9[b]	**L8**	85%	82%

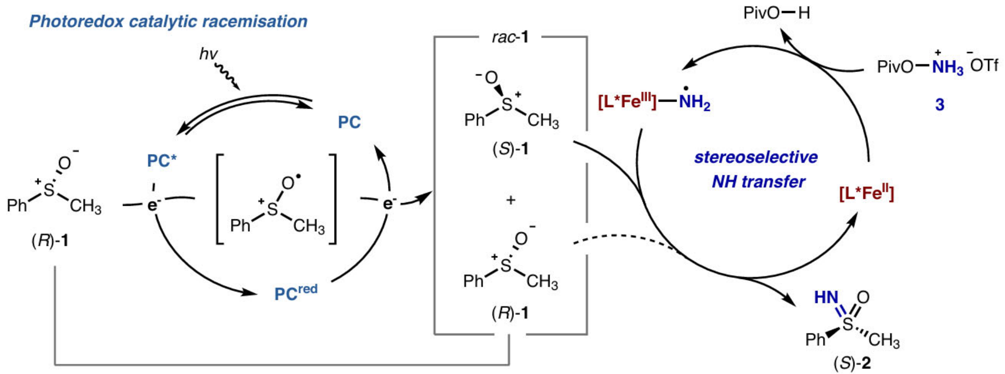
[a] The reactions were performed in 0.05 mmol scale and 10 mM in dichloromethane (DCM) for 3h. All yields were determined by ^1H NMR analysis with CH_2Br_2 as internal standard;ees were measured by HPLC on a chiral phase.[b] 5 mM.

第三部分

铁催化立体选择性NH转移实现亚砜的动态动力学拆分



第三部分 铁催化立体选择性NH转移实现亚砜的动态动力学拆分



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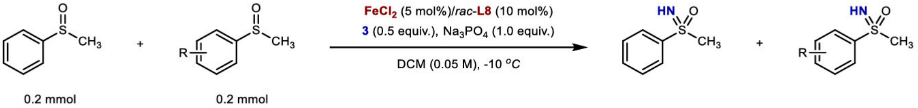

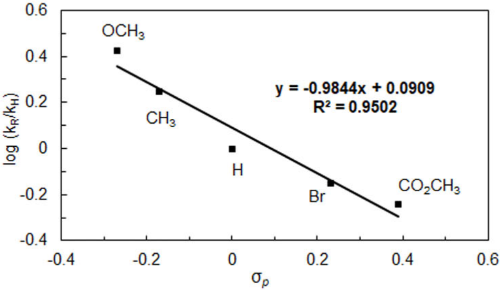

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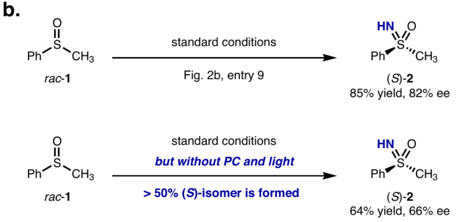
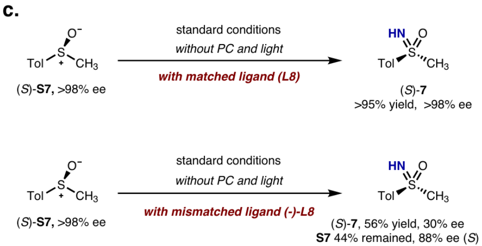
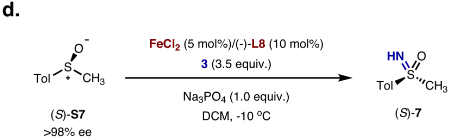
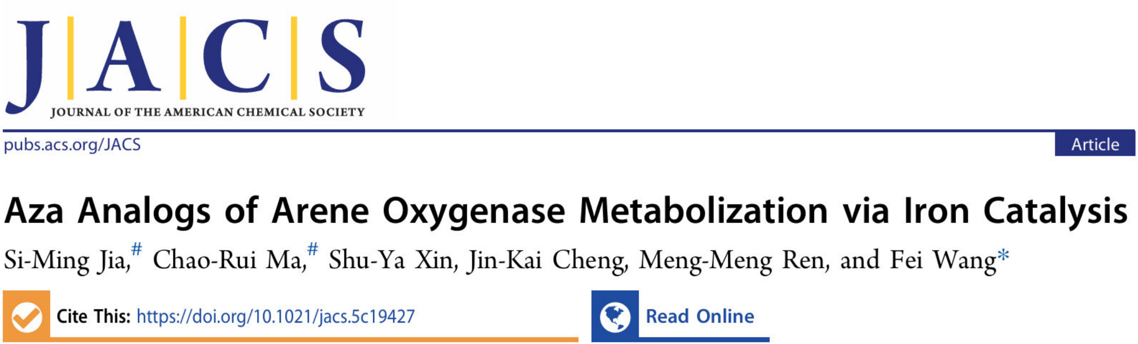






Entry	Deviation from the above conditions	yield/**S7** (ee/%)	yield/**7** (ee/%, *R*/*S*)
1	None	44% (88% ee)	56% (30% ee, *S*)
2	w/o (-)-**L8**	>99% (>98% ee)	0% (-)
3	w/o **$FeCl_2$**	>99% (>98% ee)	0% (-)
4	w/o **3**	>99% (>98% ee)	0% (-)
5	w/o Na_3PO_4	63% (97% ee)	37% (83% ee, *S*)
6	w/o (-)-**L8** and Na_3PO_4	>99% (>98% ee)	0% (-)
7	w/o **$FeCl_2$** and Na_3PO_4	>99% (>98% ee)	0% (-)
8	w/o **3** and Na_3PO_4	>99% (>98% ee)	0% (-)
9	w/o **$FeCl_2$**, (-)-**L8** and Na_3PO_4	>99% (>98% ee)	0% (-)
10	w/o **3**, (-)-**L8** and Na_3PO_4	>99% (>98% ee)	0% (-)

第三部分 铁催化芳烃加氧酶代谢氮类似物制备



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Aza Analogs of Arene Oxygenase Metabolization via Iron Catalysis

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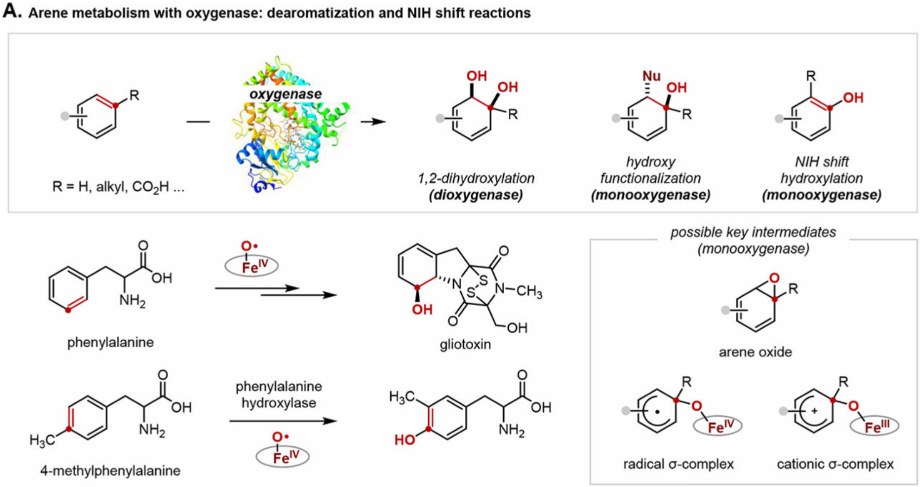

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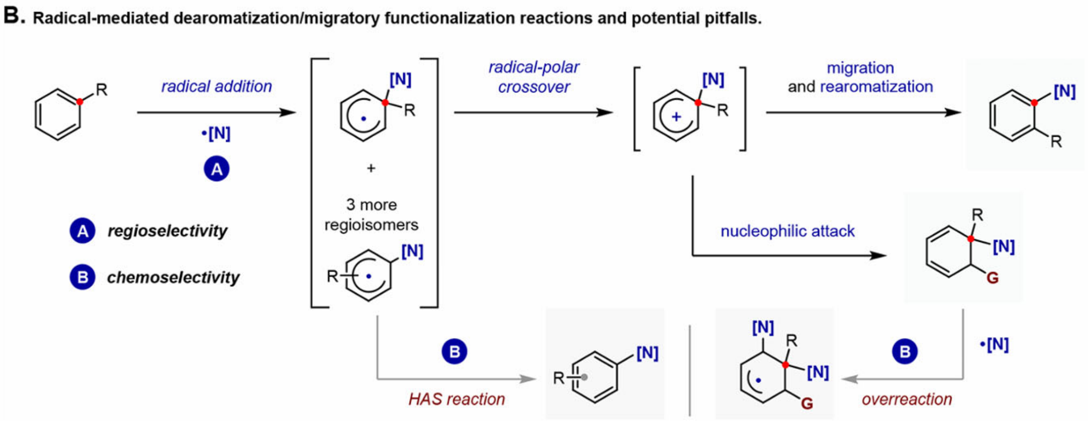

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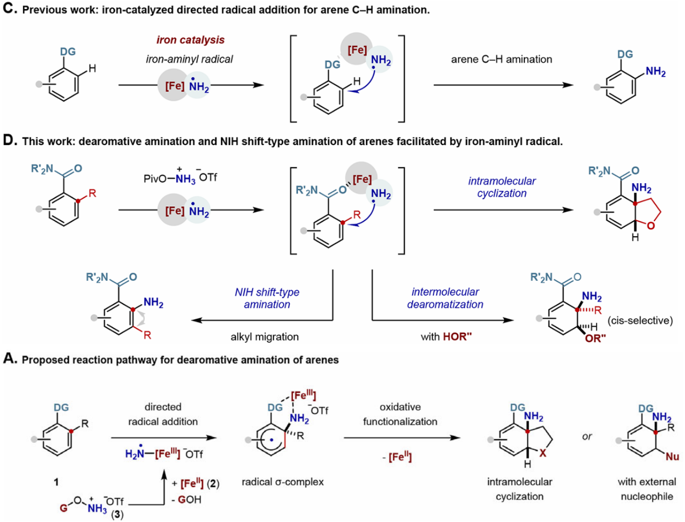

C. Previous work: iron-catalyzed directed radical addition for arene C–H amination.

D. This work: dearomative amination and NIH shift-type amination of arenes facilitated by iron-aminyl radical.

A. Proposed reaction pathway for dearomative amination of arenes

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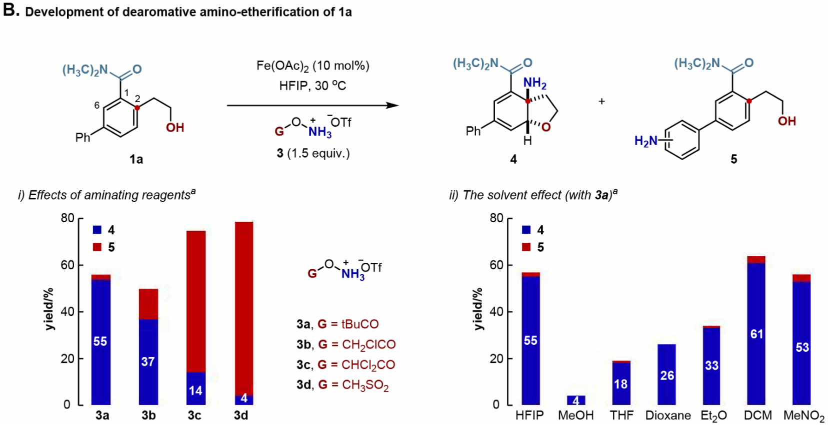

H−OG（离去基团的共轭酸）的高pKa值可能有利于铁−氨基自由基的形成，从而通过底物螯合实现选择性自由基加成。

反应中底物与溶剂可能竞争配位铁-氨基自由基，且溶剂分子中的弱C-H键也可能与其发生副反应，导致效率下降。

第三部分

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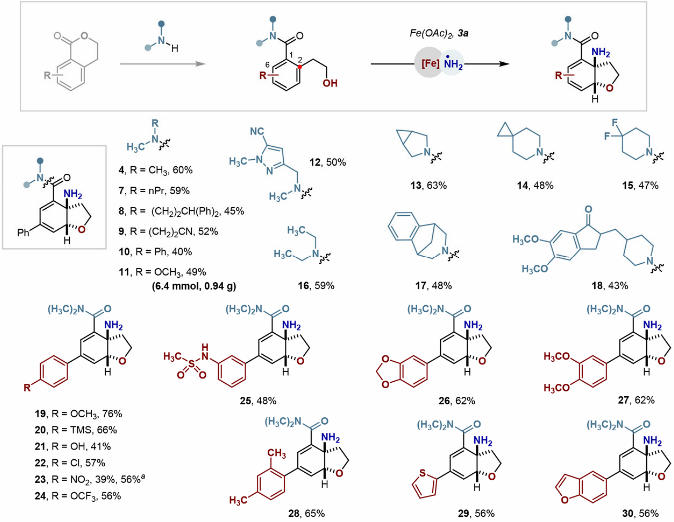


4, R = CH_3, 60%

7, R = nPr, 59%

8, R = $(CH_2)_2CH(Ph)_2$, 45%

9, R = $(CH_2)_2CN$, 52%

10, R = Ph, 40%

11, R = OCH_3, 49%
(6.4 mmol, 0.94 g)

12, 50%

13, 63%

14, 48%

15, 47%

16, 59%

17, 48%

18, 43%

19, R = OCH_3, 76%

20, R = TMS, 66%

21, R = OH, 41%

22, R = Cl, 57%

23, R = NO_2, 39%, 56%^{a}

24, R = OCF_3, 56%

25, 48%

26, 62%

27, 62%

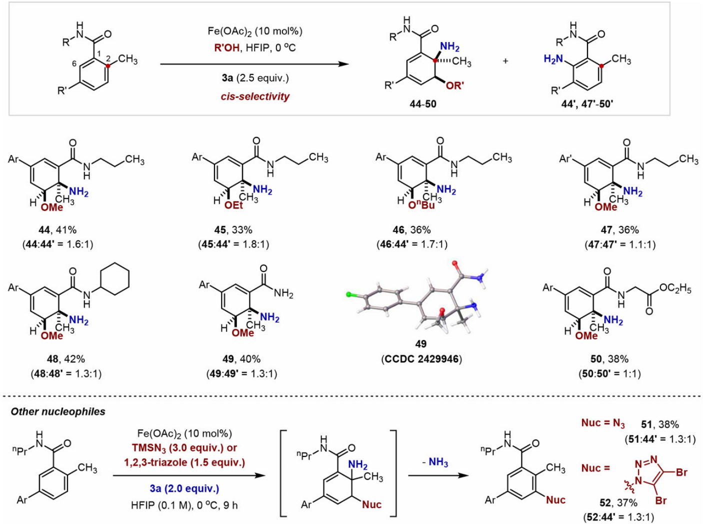
28, 65%

29, 56%

30, 56%

第三部分

铁催化芳烃加氧酶代谢氮类似物制备



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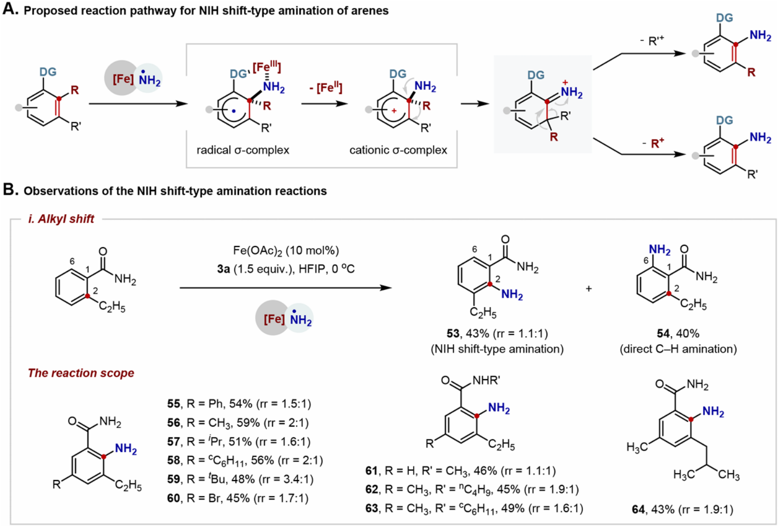
铁催化芳烃加氧酶代谢氮类似物制备


A. Proposed reaction pathway for NIH shift-type amination of arenes

B. Observations of the NIH shift-type amination reactions

i. Alkyl shift

53, 43% (rr = 1.1:1)
(NIH shift-type amination)

54, 40%
(direct C–H amination)

The reaction scope

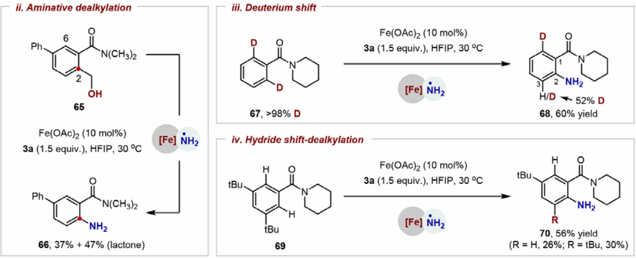
55, R = Ph, 54% (rr = 1.5:1)
56, R = CH_3, 59% (rr = 2:1)
57, R = ^{i}Pr, 51% (rr = 1.6:1)
58, R = $^cC_6H_{11}$, 56% (rr = 2:1)
59, R = ^{t}Bu, 48% (rr = 3.4:1)
60, R = Br, 45% (rr = 1.7:1)

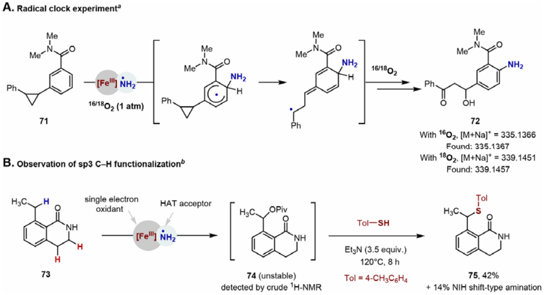
61, R = H, R' = CH_3, 46% (rr = 1.1:1)
62, R = CH_3, R' = $^nC_4H_9$, 45% (rr = 1.9:1)
63, R = CH_3, R' = $^cC_6H_{11}$, 49% (rr = 1.6:1)

64, 43% (rr = 1.9:1)

第三部分 铁催化芳烃加氧酶代谢氮类似物制备

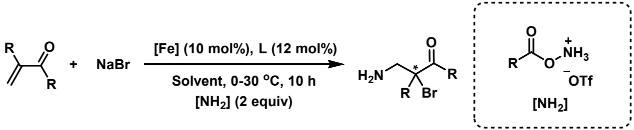
（DMPO）作为自旋捕获剂进行电子顺磁共振（EPR）光谱分析，证实了•NH_2自由基的参与

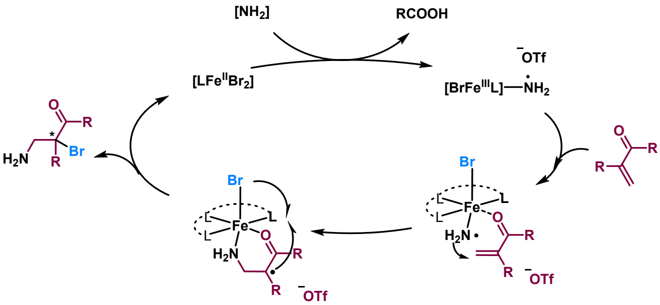




芳烃胺化反应可能经历“氢原子攫取→电子转移”路径，而不是直接的自由基加成。

Proposal


NaBr
[Fe] (10 mol%), L (12 mol%)
Solvent, 0-30 °C, 10 h
[NH2] (2 equiv)
H2N
R
Br
O
NH3
OTf
[NH2]


[NH2]
RCOOH
[LFeIIBr2]
[BrFeIIIL]—NH2
OTf
Br
Fe
L
O
R
H2N
OTf

感谢聆听

Topic report

汇报人：李安妮　　**时间：2025.12.24**