アカデミックプログラム［B講演］ | 10. 有機化学—有機金属化合物：口頭B講演

2025年3月26日(水) 13:00 ~ 14:50 [F]2101(第4学舎 2号館 [1階] 2101)

[[F]2101-1pm] 10. 有機化学—有機金属化合物

座長：道場 貴大、百合野 大雅

英語
13:00 ~ 13:20
[[F]2101-1pm-01]
多環芳香族炭化水素をレドックスメディエーターとして用いた鉄触媒C–Nカップリング反応の開発
○呉 東冉[1]、道場 貴大[1]、中村 正治[1] (1. 京都大学)

英語
13:20 ~ 13:40
[[F]2101-1pm-02]
ルテニウム–リチウム複合触媒系によるアシル化含窒素複素芳香族化合物の不斉シアノ化
○う しん[1]、百合野 大雅[2,3]、大熊 毅[2,3] (1. 北大院総合化学、2. 北大院工、3. フロンティア化学教育研究センター)

13:40 ~ 13:50
休憩

英語
13:50 ~ 14:10
[[F]2101-1pm-03]
ロジウム触媒交換反応による非対称ペプチドトリカルコゲニド–SSS–/–SSSe–結合生成
○矢﨑 雅菜[1]、苑田 和大留[1]、有澤 美枝子[2] (1. 九大院生資環、2. 九大院農)

英語
14:10 ~ 14:30
[[F]2101-1pm-04]
ロジウム触媒を用いた[2+2+2]付加環化反応による軸不斉ジアリールエーテルの不斉合成
○佐藤 悠[1]、田中 健[1] (1. 東京科学大学)

日本語
14:30 ~ 14:50
[[F]2101-1pm-05]
鎖状共役ポリエンと内部アルキンのビシクロ環化付加反応および機構考察
○富田 雄介[1]、平野 雅文[1] (1. 東農工大院工)

Development of iron-catalyzed C–N coupling reaction using polycyclic aromatic hydrocarbon as redox mediator

([1]*Graduate School of Engineering, Kyoto University*) ○Dongran Wu[1], Takahiro Doba[1], Masaharu Nakamura[1]

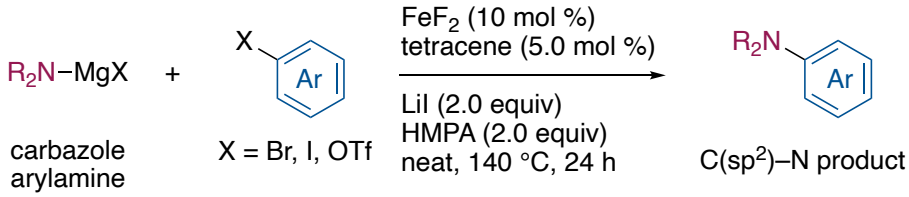
Keywords: Iron catalysis, C–N coupling reaction, Polycyclic aromatic hydrocarbon, Redox mediator, Organic electronic materials **【5 words at most】**

Arylamine functionalities are pivotal in the fields of organic electronics, agrochemicals, and pharmaceuticals. Since the 1980s, significant advancements in arylamine synthesis have been achieved through palladium-catalyzed C–N coupling reactions. Despite these achievements, catalytic systems employing more abundant and less toxic first-row transition metals remain underdeveloped. Although the most investigated ones are copper-catalyzed C–N coupling reactions[1], the oxidative addition of copper(I) species into aryl halides presents considerable challenges. Nickel-catalyzed C–N coupling has also garnered substantial attention, in which reductive elimination can be facilitated via one-electron oxidation of a nickel(II) species with a photoredox catalyst[2].

In contrast, iron-catalyzed C–N coupling with aryl halides remains significantly challenging, primarily due to the difficulty of achieving oxidative addition of aryl halides to iron species[3].

To address the challenges associated with the oxidative addition of aryl halides to iron, we aimed to develop a catalytic system that integrates the iron catalytic cycle with a redox mediator capable of facilitating single-electron transfer from an electron-rich iron species to an aryl halide. Due to their structural diversity and chemical stability, polycyclic aromatic hydrocarbons (PAHs) were selected as redox mediators.

Specifically, 10 mol % of FeF_2 was used as catalyst, magnesium amide was made from carbazole and reacted with aryl bromide under 140 ℃ for 24 h to give the desired product. 2 equivalents of HMPA and lithium iodine were added to accelerate the reaction. Adding 5 mol % of tetracene showed the highest reactivity among the many PAHs we tested. Various substrate studies were conducted and will be discussed in the presentation.



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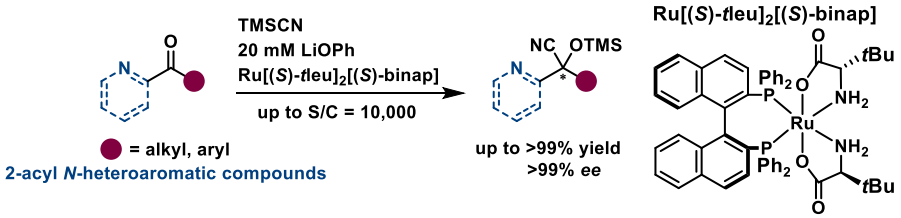
Asymmetric Cyanation of Acylated *N*-Heteroaromatic Compounds Using Ru–Li Combined Catalyst System

([1]*Graduate School of Chemical Sciences and Engineering, Hokkaido University* [2]*Division of Applied Chemistry, Faculty of Engineering, Hokkaido University,* [3]*Frontier Chemistry Center, Hokkaido University*) ○Zhen Wu,[1] Taiga Yurino,[2,3] Takeshi Ohkuma[2,3]

Keywords: Asymmetric Cyanation, Acylated *N*-Heteroaromatic Compounds, Ruthenium Complex, Lithium Salt

Catalytic asymmetric cyanation of ketones is an efficient method for constructing optically active cyanohydrins with quaternary carbon center, which serve as essential synthetic intermediates of natural compounds and pharmaceuticals.[1] One of the most important targets based on this background is cyanohydrins including *N*-heteroaromatic moieties. In 2007, Jacobsen and coworker reported a catalytic enantioselective cyanation of the simplest 2-acetylpyridine.[2] However, the approach requires a catalyst loading of 5 mol% and 12 hours reaction time, and this is the only reported example. We previously reported asymmetric cyanosilylation of various ketones catalyzed by Ru–Li combined system.[3,4] Chiral Ru(II)/diphosphine/amino acidate complex was the critical precursor of catalytic active species for the asymmetric cyanation. Building on these findings, we successfully developed an asymmetric cyanosilylation of 2-acylated *N*-heteroaromatic compounds.

Initially, 2-acetylpyridine was selected as the model substrate with trimethylsilyl cyanide (TMSCN) serving as the cyanide source. The combination of Ru(II)/(*S*)-BINAP/(*S*)-*t*-Leucinate and LiOPh was found to be the most suitable to the reaction: The cyanated product was obtained with >99% yield and 99% ee in 5-hour reaction at a substrate-to-catalyst molar ratio (S/C) of 500. Even with an extremely low catalyst loading of S/C = 10,000, the reaction completed without loss of enantioselectivity. Notably, 2-benzoylpyridine delivered exceptional results (>99% yield, >99% ee), despite the minimal steric differences between its aromatic substituents. The reaction is applicable not only to the 2-acylpyridines, but also to other 2-acyl *N*-heteroaromatic compounds including pyrazine, pyrimidine, quinoline, isoquinoline, and thiazole.



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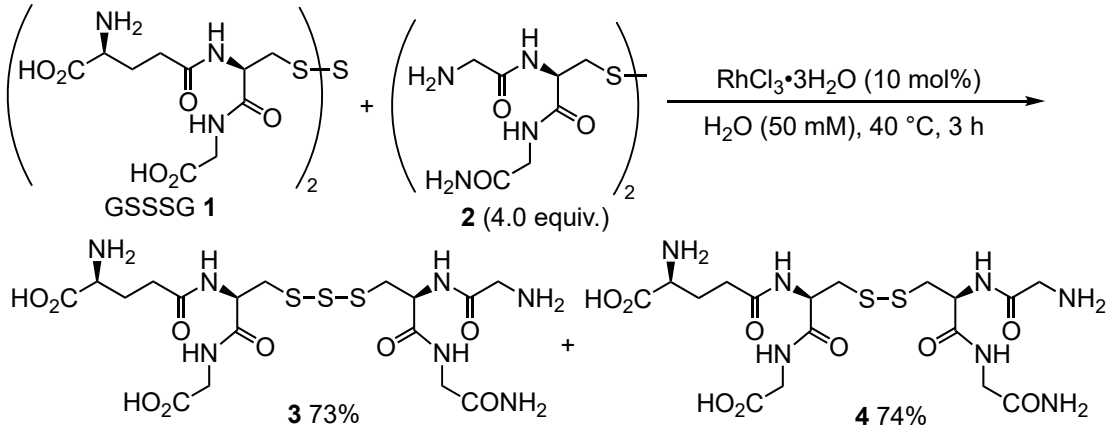
Unsymmetric Peptide Trichalcogenides –SSS–/–SSSe– Bond Formation by Rhodium-catalyzed Exchange Reaction

([1]*Graduate School of Bioenvironmental Science, Kyushu University*, [2]*Faculty of Agriculture, Kyushu University*) ○Masana Yazaki,[1] Wataru Sonoda,[1] Mieko Arisawa[2]

Keywords: Rhodium-catalyzed Exchange; Peptide Trisulfide; Disulfide; Diselenide; Water

Peptide polysulfides, which have various functions such as strong antioxidant and signal transduction activity, have recently attracting considerable interest. Previously, we reported rhodium-catalyzed synthesis of peptide polysulfides by insertion of sulfur into unprotected peptide disulfides.[1] Rhodium-catalyzed synthesis of unsymmetric trichalcogenides containing –S–S–S–/–S–S–Se– bonds using exchange reaction between peptide trisulfide and disulfides/diselenides was found.

Glutathione trisulfide (GSSSG) **1** (0.1 mmol) was reacted with a disulfide derivative of Gly-Cys-Gly **2**[2] (4.0 equiv.) in the presence of $RhCl_3 \cdot 3H_2O$ (10 mol%) in water (50 mM) at 40 °C for 3 h. Then, unsymmetric trisulfide **3** (0.073 mmol, 73%) and the disulfide **4** (0.074 mmol, 74%) were obtained with the recovery of **1** (0.024 mmol, 24%) and **2** (0.32 mmol, 80%). **3** and **4** were isolated by reverse-phase HPLC, and structures were determined by NMR, IR, Raman, and MS. By using diselenide derivatives instead of disulfide **2**, unsymmetric trichalcogenide compounds with an –S–S–Se– bond can be obtained. Selenium is larger in size, more polarizable, and more nucleophilic than sulfur. These peptide trichalcogenide compounds containing selenium are expected to have a higher bioaffinity with biomacromolecules and exhibit slightly different and interesting biological activities. The reaction smoothly proceeded in wide ranges of pH (1–8) using various unprotected peptides, and formed new unsymmetric trichalcogenide compounds containing –S–S–S–/–S–S–Se– bonds.



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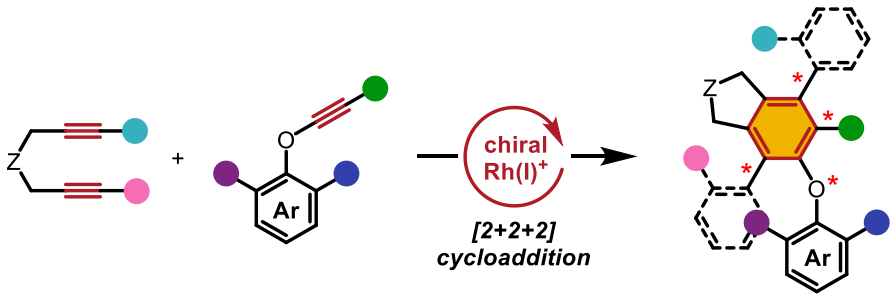
Asymmetric Synthesis of Axially Chiral Diaryl Ethers by Rh-Catalyzed [2+2+2] Cycloaddition

([1] *Department of Chemical Science and Engineering, Institute of Science Tokyo*)
○Yu Sato,[1] Ken Tanaka[1]

Keywords: axial chirality; diaryl ethers; asymmetric synthesis; [2+2+2] cycloaddition; rhodium

Diaryl ethers with bulky substituents at the ortho positions exhibit stable atropisomerism even at room temperature.[1] Atropisomeric diaryl ethers are expected to be used for novel catalysts and bioactive compounds because of their axial chirality and flexible ether structure, which led to extensive studies on their asymmetric synthesis in recent years. However, due to the instability of axial chirality, the asymmetric syntheses have been limited to desymmetrization reactions,[2] which have restricted the synthetically accessible structures.

In this study, we have developed the enantioselective synthesis of axially chiral diaryl ethers by cationic Rh(I)-catalyzed [2+2+2] cycloadditions of alkynyl ethers with 1,6-diynes. After optimizing the reaction conditions, the reaction proceeded with excellent yield and enantioselectivity. Furthermore, we also investigated the enantio- and diastereoselective synthesis of multiple atropisomeric axes, which have recently garnered significant attention in axially chiral compounds.[3] We also revealed the atropisomerism and their potential applications of synthesized axially chiral diaryl ethers.



✓ Various fanctional groups
✓ High regio-, diastereo and enantiosetectivity
✓ Multiple atropisomeric axes

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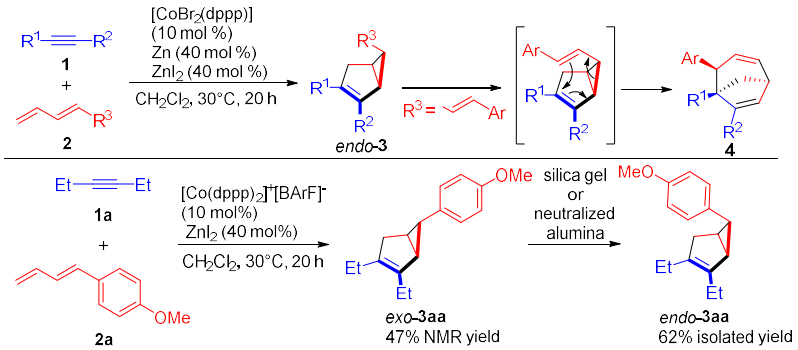
Bicycloaddition of Linear Conjugated Polyenes with Internal Alkynes and the Mechanistic Insights

(*Graduate School of Engineering, Tokyo University of Agriculture and Technology*)
○Yusuke Tomita, Sayori Kiyota, Nobuyuki Komine, Masafumi Hirano
Keywords: Bicycloaddition; Monovalent Cationic Cobalt Complex; Bicyclo[3.1.0]hex-2-ene; Bicyclo[3.2.1]octa-2,6-diene;

Cross-dimerization of alkynes with conjugated dienes attracted much attention. [$CoBr_2$(diphosphine)]/Zn/ZnI_2 system catalyzed the [4+2] and [2+2] cycloadditions giving cyclohexenes and alkenylcyclobutenes. In this paper, we disclose the first bicycloadditions of alkynes with conjugated dienes giving bicyclo[3.1.0]hex-2-enes and of alkynes with conjugated trienes giving bicyclo[3.2.1]octa-2,6-dienes.

A cobalt catalyst system [$CoBr_2$(dppp)]/Zn/ZnI_2 catalyzed diastereoselective bicycloaddition of internal alkynes with conjugated dienes in CH_2Cl_2 at 30˚C for 20 h to give bicyclo[3.1.0]hex-2-enes.[1] This is the first bicycloaddition between alkynes and conjugated dienes. To our surprise, a similar treatment of internal alkynes with conjugated trienes produced bicyclo[3.2.1]octa-2,6-dienes as a single diastereomer. This reaction is considered to give *endo*-6-alkenylbicyclo[3.1.0]hex-2-ene as an intermediate followed by the quick and spontaneous vinylcyclopropane rearrangement.

In these catalyst systems, [$CoBr_2$(dppp)]/Zn/ZnI_2, the initial divalent cobalt species is considered to be reduced by Zn and a cationic monovalent cobalt complex is a possible candidate. Reduction of [$CoBr_2$(dppp)] with sodium naphthalene followed by the treatment with NaBArF produced a monovalent cationic cobalt complex $[Co(dppp)_2]^+[BArF]^-$ in 36% yield. Treatment of hex-3-yne (**1a**) with (*E*)-1-(4-methoxyphenyl)buta-1,3-diene (**2a**) in the presence of $[Co(dppp)_2]^+[BArF]^-$ (10 mol%)/ZnI_2 (40 mol%) at 30˚C for 20 h in CH_2Cl_2 produced *exo*-2,3-diethyl-6-(4-methoxyphenyl)bicyclo[3.1.0]hex-2-ene (*exo*-**3aa**) as a single diastereomer, which isomerized to *endo*-2,3-diethyl-6-(4-methoxyphenyl)bicyclo[3.1.0]hex-2-ene (*endo*-**3aa**) during purification using a silica gel or neutralized alumina. We will discuss about the detailed mechanistic insight for the formation of these bicyclic compounds.



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