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Intramolecular Diamination of Alkenes with Palladium(II)/Copper(II) Bromide and IPy_2BF_4: The Role of Halogenated Intermediates

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Abstract: The oxidative intramolecular diamination of alkenes with tethered ureas and related groups as the nitrogen source has been investigated both with the iodonium reagent IPy_2BF_4 (Py = pyridine) and under palladium catalysis in the presence of copper(II) bromide as a reoxidant. For terminal alkenes, the two procedures enable selective and high-yielding transformations. Studies with deuterated material led to the conclusion that the reactions proceed through different stereochemical pathways. An advanced protocol for palladium-catalyzed diamination through six-membered-ring annulation was also developed, and the first examples of the intramolecular diamination of internal alkenes are described. In this case, the same stereochemical outcome was observed for the iodonium-promoted and palladium-catalyzed transformations. On this basis, it was possible to determine the importance of aminohalogenated intermediates in both diamination reactions. Overall, the disclosed procedures broaden significantly the synthetic applicability of the oxidative intramolecular diamination of alkenes.

Keywords: alkenes · diamines · iodonium salts · oxidation · palladium

Introduction

Nitrogenated compounds are of major pharmaceutical, biological, and medicinal interest. As a consequence, the development of synthetic approaches to the selective incorporation of nitrogen functional groups into organic frameworks is an important endeavor.[1] The direct transfer of nitrogen compounds to alkenes is a versatile strategy for the construction of aminated compounds. As both amines and alkenes are nucleophilic in character, this approach usually relies on suitable electrophilic promoters to exercise reaction control. In principle, such transformations may result in the 1,2-difunctionalization of alkenes, depending on the subsequent manipulation of the second carbon atom of the former double bond. Apart from hydroamination reactions, were this position undergoes protonation, there have been numerous reports on additional 2-functionalization. One particularly interesting reaction consists of a direct 1,2-diamination of alkenes. In principle, this procedure establishes an economical approach to the important class of vicinal diamines.[2] Such a reaction was pioneered in the 1970s by one of our research groups in studies on the use of thallium(III) and mercury(II) compounds as promoters.[3] Additional research included the use of stoichiometric amounts of palladium,[4] copper,[5] and preformed imidoosmium reagents.[6] In contrast to the use of stoichiometric promoters, catalytic diamination was developed only recently with palladium and nickel catalysts.[7–9]

We describe herein approaches to the diamination of internal alkenes with halogenated reagents and discuss the role of the intermediate 2-halogenated amine derivatives in the palladium-catalyzed diamination of alkenes.

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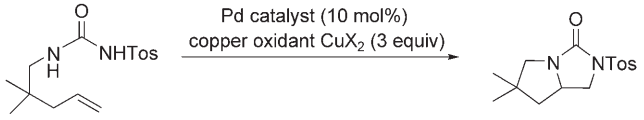
Results and Discussion

Copper(II) Bromide as a Reoxidant for the Intramolecular Diamination of Alkenes

Copper(II) salts serve as important intermediary and terminal oxidants in palladium catalysis. The industrial Wacker process for acetaldehyde production from ethylene is by far the most prominent example of the use of copper(II) salts in this way.[10] On the laboratory scale, reactions such as the asymmetric Wacker-type oxidation,[11] aminobromination,[12,13] and dibromination[14] have been added to the broad range of palladium-catalyzed oxidation processes.[15] The use of stoichiometric amounts of copper acetate for diamination has been reported;[5] however, attempts to develop palladium-catalyzed diamination reactions in the presence of copper(II) bromide resulted previously only in aminobromination and related reactions.[16–19]

After some experimentation, we found that copper(II) bromide serves as an efficient reoxidant of palladium in the oxidative diamination of terminal alkenes. Screening experiments identified DMF as the best solvent and potassium carbonate as the optimum base (Table 1). In general, the reaction has the characteristics of the previously reported diamination with iodosobenzene diacetate as the reoxidant.[7] It requires a catalytic amount of palladium(II) and a stoichiometric amount of a base for deprotonation of the tosylated urea group, and it does not proceed in the absence of the palladium catalyst or the base. Attempts to carry out the reaction under aerobic conditions similar to those used for the Wacker oxidation met with little success. The requirement for anaerobic conditions suggests that the ratio of copper(II) to the palladium catalyst is a key issue, and that copper(II) bromide must be present in high concentration throughout the course of the reaction.

Table 1. Optimization of the reaction conditions with $CuBr_2$ as the terminal oxidant.



1a 2a

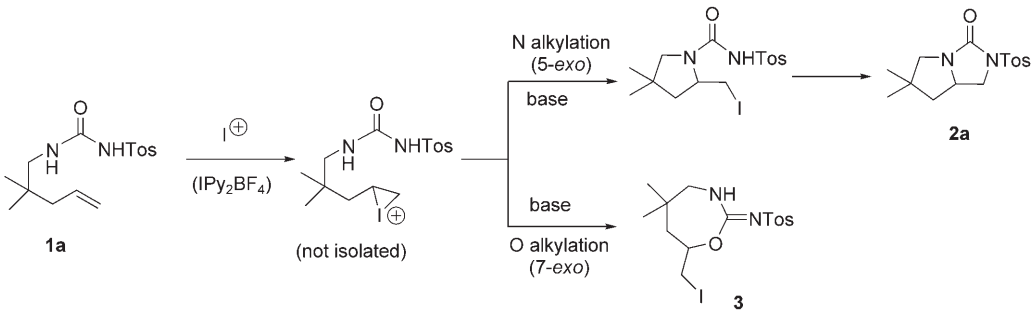
Entry	Pd source	Cu source	Base (1 equiv)	Solvent	T [°C]	Conv. [%]
1	$Pd(OAc)_2$	$CuBr_2$	Me_4NOAc	THF	26	8
2	$Pd(OAc)_2$	$CuBr_2$	K_2CO_3	THF	26	95[a]
3	$Pd(OAc)_2$	$CuCl_2$	K_2CO_3	1,4-dioxane	90	95[a]
4	No Pd	$CuBr_2$	K_2CO_3	THF	26	0
5	$Pd(OAc)_2$	$CuBr_2$	Me_4NOAc	CH_2Cl_2	26	63
6	No Pd	$CuBr_2$	Me_4NOAc	CH_2Cl_2	26	0
7	$Pd(OAc)_2$	$CuBr_2$[b]	K_2CO_3	DMF	40	30
8	$Pd(OAc)_2$	$CuBr_2$	NEt_3	DMF	26	–[c]
9	$Pd(OAc)_2$	$CuBr_2$	K_2CO_3	DMF	26	77
10	$Pd(OAc)_2$	$CuBr_2$	K_2CO_3	DMF	40	100[d]
11	$[PdCl_2(CH_3CN)_2]$	$CuBr_2$	K_2CO_3	DMF	40	100[d]
12	$[Pd_2(dba)_3]$	$CuBr_2$	K_2CO_3	DMF	40	100[d]

[a] A significant amount of tosylamide resulting from decomposition was observed in the crude product by NMR spectroscopy. [b] $CuBr_2$: 0.3 equivalents, oxygen (1 atm). [c] A complex product mixture that included the starting material was obtained. No diamination product was observed. [d] The only product detected was the diamination product, which was isolated in more than 95% yield. dba = dibenzylideneacetone, DMF = *N*,*N*-dimethylformamide.

IPy_2BF_4-Based Transformation

Iodonium ions are a useful synthetic equivalent for a transition metal in the functionalization of unsaturated carbon–carbon bonds.[20] Their application in the amination of alkenes and related functionalization processes has been investigated previously.[21–26] We decided to apply the reagent IPy_2BF_4 (Py = pyridine) to the intramolecular cyclization of ω-alkenyl ureas, which served as suitable starting materials in the earlier metal-catalyzed diamination reactions.[7,8] At the outset, it was expected that the functionalization of the alkene with an iodonium ion[27] followed by 5-*exo* cyclization would furnish a vicinal iodoamine, which should undergo subsequent ring closure to give the cyclic urea (Scheme 1). This reaction was indeed observed as the major pathway and yielded **2a** in initially 30% yield. The replacement of CH_2Cl_2 with toluene as the solvent and an increase in the reaction time led to an increase in the yield of **2a** to 72%. When the reaction temperature was increased to 120°C, **2a** was obtained in 92% yield (Table 2).

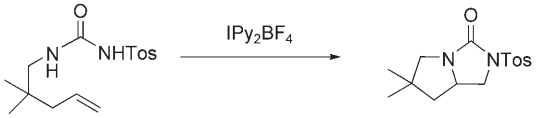
Further modification of the reaction conditions did not lead to beneficial results. For example, the presence of various bases did not improve the formation of **2a**, and the replacement of IPy_2BF_4 with the conventional reagent



1a

Scheme 1. Reaction pathways for the oxidation of **1a** in the presence of IPy_2BF_4. The base is pyridine. Tos = *p*-toluenesulfonyl.

Table 2. Optimization of the reaction conditions for the IPy_2BF_4-mediated diamination.



1a 2a

Entry	IPy_2BF_4 [equiv]	Solvent	T [°C]	t [min]	Yield[a] [%]
1[b]	1.1	CH_2Cl_2	0	60	30
2	1.1	CH_2Cl_2	0	60	47
3	1.5	CH_2Cl_2	26	60	50
4	1.5	DMF	26	60	50
5	1.5	THF	26	150	55
6	1.5	*t*BuOH	26	150	60
7	1.5	CH_3CN	26	150	60
8	1.5	toluene	26	150	72
9	1.5	toluene	120	150	92

[a] Yield of isolated **2a**. [b] The reaction was carried out in the presence of HBF_4 (1.1 equiv) as an additive.

iodine[28] led to a drop in the yield of the diamination product.

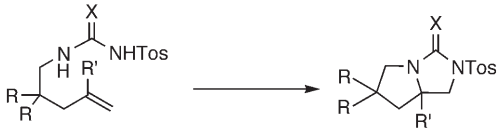
Despite the efficient formation of **2a** in these reactions, the formation of a significant amount of a side product was always observed. The side product was identified as the *O*-alkylation product **3**, which results from competing 7-*exo* ring opening of the initial iodonium intermediate (Scheme 1).[29,30] Careful NMR spectroscopic studies revealed that at the initial high concentration of the reactants, ring opening of the iodonium cation by the oxo group occurs. This pathway is made possible by the mesomeric nature of the urea functionality, which induces sufficient nucleophilicity at the carbonyl oxygen atom so that the 7-*exo* process can compete successfully with the usually preferred 5-*exo* cyclization required for diamination.

Diamination of Alkenes Employing IPy_2BF_4 and Palladium(II) Catalysis

Having optimized the two protocols, we surveyed the diamination of alkenes to give pyrrolidine-annulated ureas (Table 3). As expected, the transformation was found to be quite general, both under palladium catalysis and with the iodonium reagent. The reaction proceeded cleanly with 2,2-disubstituted alkenes to give bicylic products with a quaternary stereocenter with complete selectivity and in high yields. The structure of these products was determined unambiguously by X-ray crystal-structure analysis of compound **2e**.

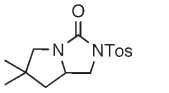
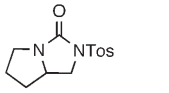
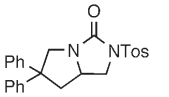
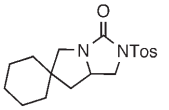
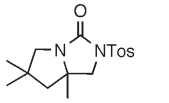
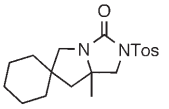
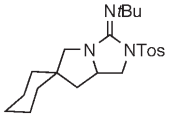
Alkene diamination with IPy_2BF_4 is the first selective general method for this type of functionalization. The high selectivity for diamine formation over the potentially competing alkoxyiodination in the first step is a simple function of temperature. To the best of our knowledge, this observation is also unprecedented in this type of oxidation chemistry.

Table 3. Generality of the diamination protocols.[a]

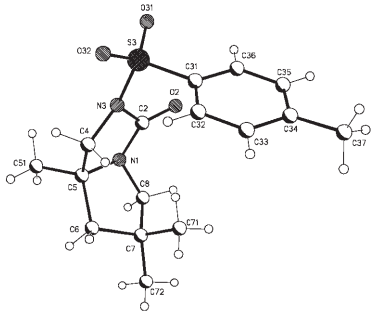


1a: R = Me, R' = H, X = O
1b: R, R' = H, X = O
1c: R = Ph, R' = H, X = O
1d: R_2 = -$(CH_2)_5$-, R' = H, X = O
1e: R = Me, R' = Me, X = O
1f: R_2 = -$(CH_2)_5$-, R' = Me, X = O
4: R_2 = -$(CH_2)_5$-, R' = H, X = N*t*Bu

2a–f, 5

Product		Yield[b] [%]	Yield[c] [%]
	**2a**	92	88
	**2b**	85	91
	**2c**	95	79
	**2d**	92	90
	**2e**	75	70
	**2f**	83	84
	**5**	99	85

[a] Reaction conditions: 1) with IPy_2BF_4: **1** (0.1 M in toluene), IPy_2BF_4 (1.5 equiv), 120 °C, 16 h; 2) under Pd catalysis: **1** (0.5 M in DMF), $Pd(OAc)_2$ (10 mol %), K_2CO_3 (1 equiv), $CuBr_2$ (3 equiv), 40 °C, 16 h. [b] Yield of the isolated product obtained with IPy_2BF_4 after purification. [c] Yield of isolated product obtained with $Pd(OAc)_2$ and $CuBr_2$ after purification.



2e (X-ray structure)

The discovery that copper bromide can serve as an efficient reoxidant of palladium is important in the light of existing catalytic methods, as it overcomes the drawback of

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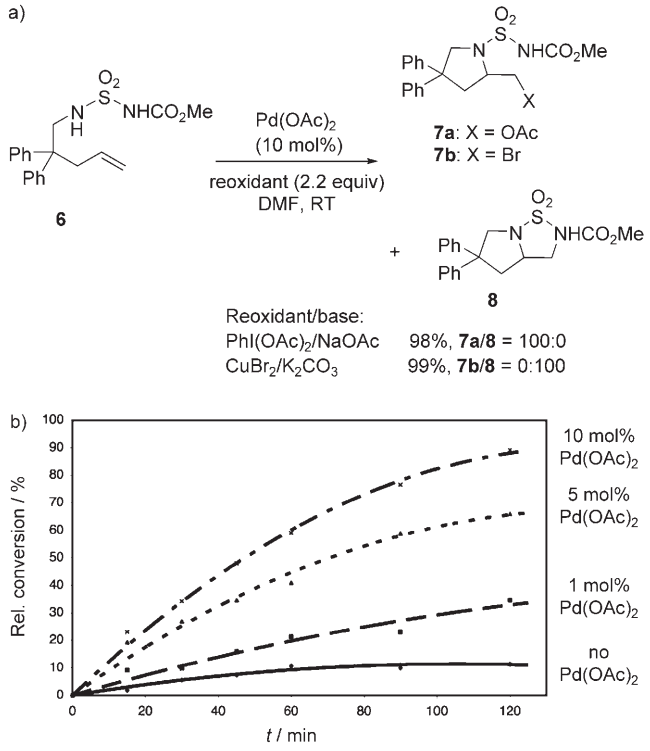
the use of iodosobenzene diacetate as the terminal reoxidant. Furthermore, the high selectivity of the palladium-catalyzed process for diamination is significant, as related procedures for alkene amination in the presence of halogenated copper salts often suffer from incomplete selectivity in ring formation, and a halogen atom is often incorporated into the organic skeleton.[13b,19]

The scope of the reaction could be extended to a related guanidine substrate, the electronic nature of which mirrors that of the parent urea. The oxidative cyclization of **4** by both procedures furnished the desired compound **5** as a single product (Table 3).[31] This outcome is noteworthy with respect to the final C–N bond formation, as apparently both reactions favor incorporation of the tosylamide as the more nucleophilic nitrogen in comparison to the tert-butyl amino group.[32]

The use of copper(II) bromide as a reoxidant can also overcome the problem of chemoselectivity in Pd-catalyzed diamination reactions with sulfamides such as **6** as the nitrogen source. $PhI(OAc)_2$-induced oxidation under our previously elaborated conditions for urea cyclization led exclusively to the aminoacetoxylation product **7a** (Scheme 2).[7,8,33] The replacement of this oxidant with $CuBr_2$ led to complete and selective diamination to yield the desired cyclic sulfamide **8**.[34] The presence of a base is necessary; after extensive screening, sodium phosphate was found to be the most suitable.



Scheme 2. a) Intramolecular diamination of alkenes with sulfamides as the nitrogen source. b) Variation of the reaction progress with time with different amounts of catalyst.

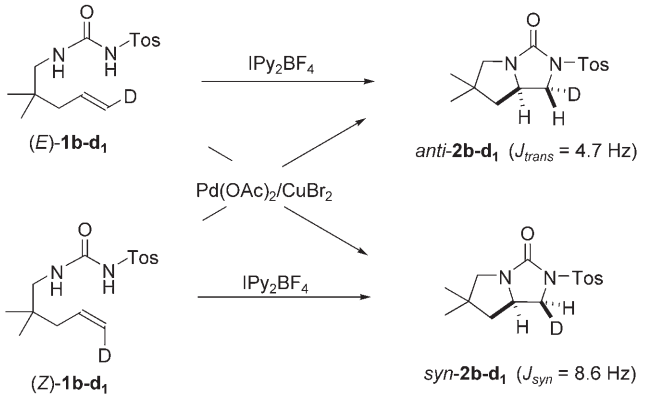
Careful optimization of the reaction conditions showed that the use of copper bromide as a reoxidant has a crucial effect on the overall reaction, whereas diamination was not observed at all in the presence of copper chloride or copper acetate. A background reaction for diamination with $CuBr_2$ itself was detected, although it was rather slow and stopped at about 10% yield. Plots of relative conversion versus time in Scheme 2 show a significant rate acceleration for reactions in the presence of a catalytic amount of palladium acetate: The presence of 10 mol% of the palladium catalyst led to complete product formation in about 2 h, whereas a reaction time of 5 h was required with 5 mol% of the catalyst. Generally, the reaction was fastest with 2.2 equivalents of $CuBr_2$. The reaction could be carried out without a decrease in the yield under aerobic conditions with 1 equivalent of $CuBr_2$; however, conversion stopped when the amount of copper bromide was decreased further. The potential aminobromination product **7b** was not observed, which suggests that the reaction proceeds without the involvement of brominated intermediates. Deuterium labeling, as described in the next section for the related urea substrates (Scheme 3), led to identical conclusions.

As a major drawback, the overall yields of the reactions remained below 65% for a variety of substrates. Control experiments revealed[35] that the cyclized sulfamides are stable under the given oxidation conditions. Hence, the decomposition of the starting material by copper(II) salts remains a major issue. Similarly, IPy_2BF_4 induces decomposition of the sulfamide group. The oxidation of **6** with IPy_2BF_4 gave **8** in low yield (38%).

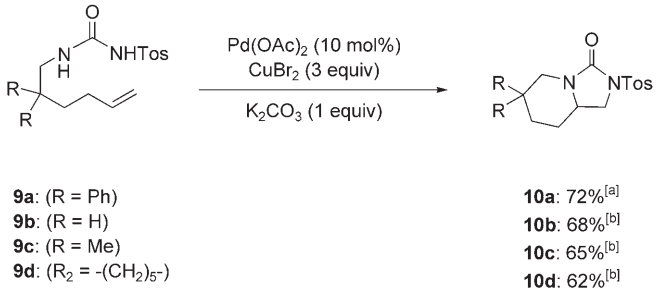
Stereochemical Analysis

Selective deuterium incorporation at the terminal position of the alkene was employed as a mechanistic probe, as described for a related palladium-catalyzed reaction in the presence of iodosobenzene diacetate.[7,8] We found that the *anti*-configured product **2b-d$_1$** was obtained from the oxidation of (*E*)-**1b-d$_1$** with IPy_2BF_4 and from the oxidation of (*Z*)-**1b-d$_1$** under palladium catalysis. The diastereomeric product *syn*-**2b-d$_1$** resulted from the oxidation under the same conditions of the isomeric precursors (*Z*)-**1b-d$_1$** and (*E*)-**1b-d$_1$**, respectively (Scheme 3).

The palladium(II)/copper(II) system and the IPy_2BF_4 reagent thus promote diamination by complementary stereochemical pathways. On the basis of these results, it is reasonable to assume that the latter proceeds by clean *anti* aminoiodination followed by S_N2 replacement of the iodide group in the second step in an *anti* manner. In the case of palladium, the reaction should be initiated by the precoordination of palladium to the deprotonated amide.[7b] Subsequent *syn* aminopalladation[36] would lead to the aminopalladated intermediate,[37] as disclosed previously by some of us.[38] In view of the final configuration, C–N bond formation in the second step should occur with inversion of configuration and is best described as an S_N2-type replacement of palladium with the second nitrogen atom.[7b] The involvement of



Scheme 3. Determination of stereochemical pathways.



Scheme 4. Diamination of alkenes in the presence of copper(II) bromide. Reaction conditions: [a] DMF, room temperature, 12–22 h; [b] 1,4-dioxane, 70 °C, 12 h.

halogenated intermediates in the palladium-catalyzed reaction can be ruled out on the basis of the deuterium-labeling study, as can the involvement of radical intermediates. (In contrast, radical intermediates are involved in the related copper-promoted intramolecular alkene diamination.)[5b]

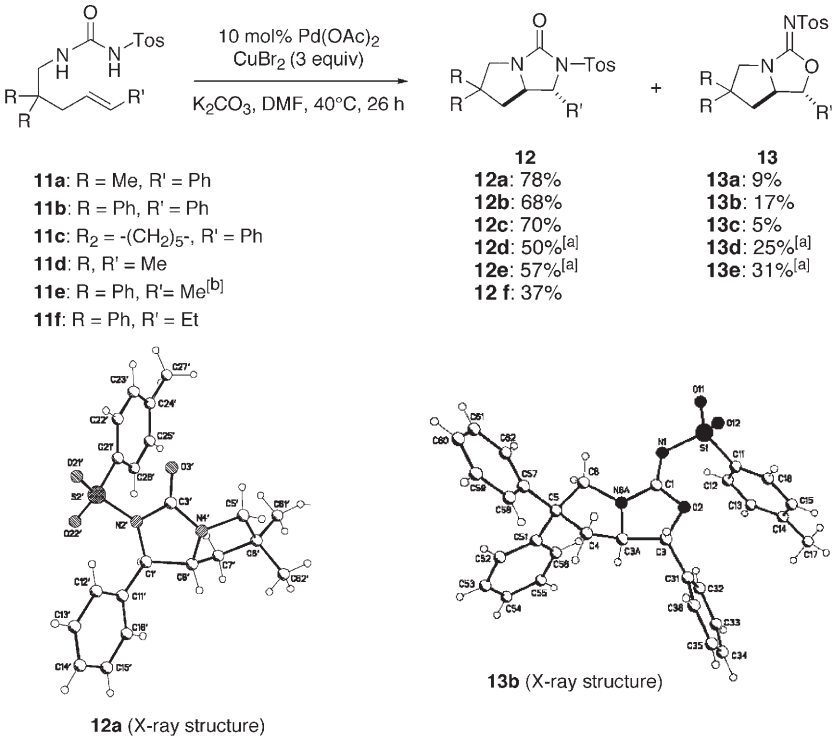
Six-Membered-Ring Annulation

The present amination protocol with copper(II) bromide as the reoxidant overcomes the limitations associated previously with diamination reactions to give piperidine-annulated urea derivatives. The earlier protocol for the preparation of diamines fused to a six-membered ring with the iodosobenzene diacetate reoxidant had the significant drawback of low reaction rates and the requirement of a high catalyst loading of palladium acetate (25 mol%) for complete conversion within 48 h.[7a] Nickel catalysis[8] for this purpose is of similarly low efficiency. Reactions with $CuBr_2$ as the reoxidant now proceed readily in the presence of 10 mol% of the palladium catalyst (Scheme 4) and have an increased average turnover of 6–7. Quantitative conversion was observed for all reactions in Scheme 4, and the products were obtained in the indicated yields after purification by column chromatography.[39] In contrast to related aminobromination reactions, the present diamination protocol is highly selective for the formation of six-membered-ring products.

Internal Alkenes

Another benefit of $CuBr_2$ as the reoxidant in palladium-catalyzed alkene amidation is that nonterminal alkenes can be employed as substrates. The $PhI(OAc)_2$-based diamination of urea substrates with internal alkenes had met with pronounced difficulties.[40]

The reaction was studied for substrates with various substitution patterns (Scheme 5). Generally, the stereospecificity of the reaction could be unambiguously deduced from the ^1H NMR coupling constant between the hydrogen atoms bound to the carbons on the former double bond in the substrate. This coupling constant ranged from 1.8 to 2.6 Hz, which indicates a *trans* positioning of the substituents of the newly formed cyclic urea. This assignment was confirmed



Scheme 5. Diamination of internal alkenes. [a] The yields are based on recovered starting material. [b] The substrate was used as a 9:1 mixture of *E* and *Z* isomers.

unambiguously by the X-ray crystal-structure analysis of compound **12a**. Minor amounts of the corresponding *O*-alkylated derivatives **13** were formed as side products. Although the quantity of **13** formed varied from case to case, we were unable to suppress its formation completely. The constitution and relative *anti* configuration of these side products were determined by X-ray crystal-structure analysis of derivative **13b**. Compound **11e** was used as a 9:1 mixture of *E* and *Z* isomers. A minor *syn* isomer of **12e** was identified by NMR spectroscopy of the crude product, which was composed of *anti* and *syn* isomers in a 9:1 ratio. This result suggests that the process is stereospecific with respect to the geometry of the double bond.

As the majority of catalytic aminopalladation processes are restricted to reactions of terminal alkenes, our procedure with copper(II) bromide is of particular value. The reaction of substrates with internal alkenes leads to clean formation of 1,2-difunctionaliyed compounds as the only isolable products.

Iodonium reagents open an additional pathway for product diversification. At room temperature, internal alkenes undergo clean alkoxyiodination, as observed for substrate **11b** (Scheme 6). X-ray crystal-structure analysis of the product **14** confirmed overall antiperiplanar functionalization. The related phenyl-substituted alkenes **11a–c** were converted in the presence of IPy_2BF_4 at room temperature into mixtures of **12** and **13**, in which the latter prevailed. In analogy with the general trend for terminal alkenes (Table 2), the selectivity can be reversed in favor of diamination by carrying out the reaction in toluene at elevated temperature (120°C; Table 4).

Particularly intriguing is the fact that the diamination of internal alkenes leads to the same products with IPy_2BF_4 and under palladium catalysis. On the basis of the deuterium-labeling experiment described earlier and in view of the stereochemical pathway that leads to the alkoxyiodination product **14**, a sequence of two *anti* C–N bond-forming steps appears to be the most likely mechanistic rationale with the IPy_2BF_4 reagent. The stereochemical pathways for the palladium-catalyzed diamination of terminal and internal alkenes must differ in one step. A *syn* aminopalladation has been proven to occur in the initial step with terminal alkenes and is also assumed for the case of internal alkenes. The consequent formation of a chelated aminopalladation intermediate **A** (Scheme 7) explains the absence of β-hydride-elimination and epimerization pathways, especially in the case of substrates such as **8a**, in which benzylic positions exist.

Table 4. Diamination of internal alkenes.[a]

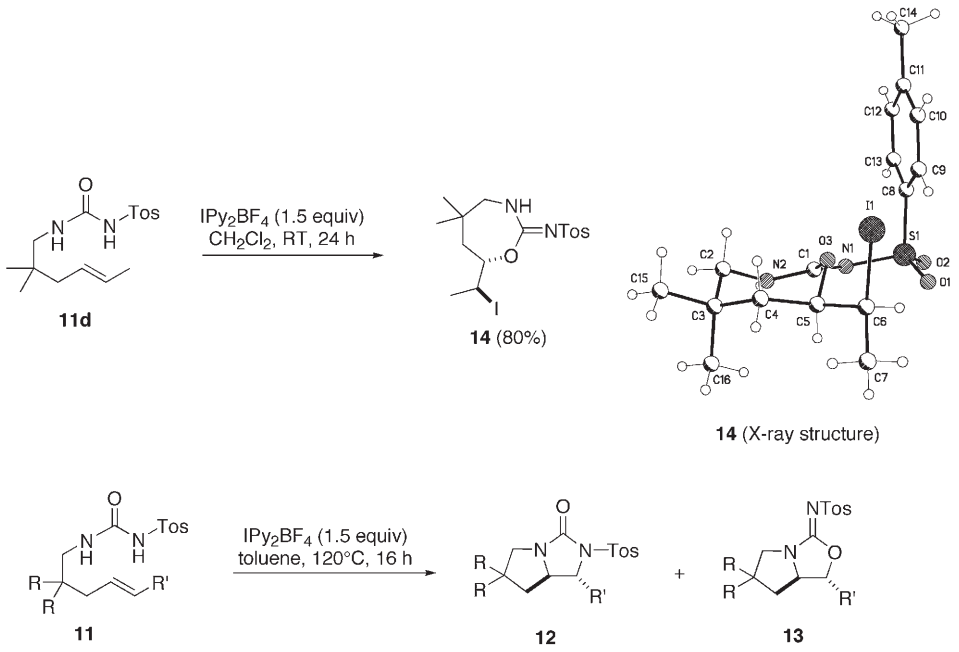
Entry	11	Conv. [%]	12/13	Yield [%]
1[b]	**11a**	40	25:75	n.d.[c]
2	**11a**	100	72:28	**12a**: 69, **13a**: 22
3	**11b**	100	70:30	**12b**: 64, **13b**: 28
4	**11c**	100	72:28	**12c**: 70, **13c**: 20
5	**11d**	100	42:58	**12d**: 39, **13d**: 55

[a] Reaction conditions: IPy_2BF_4 (1.5 equiv), toluene, 120°C, 16 h. [b] The reaction was carried out at room temperature in CH_2Cl_2 for 24 h. [c] Not determined.

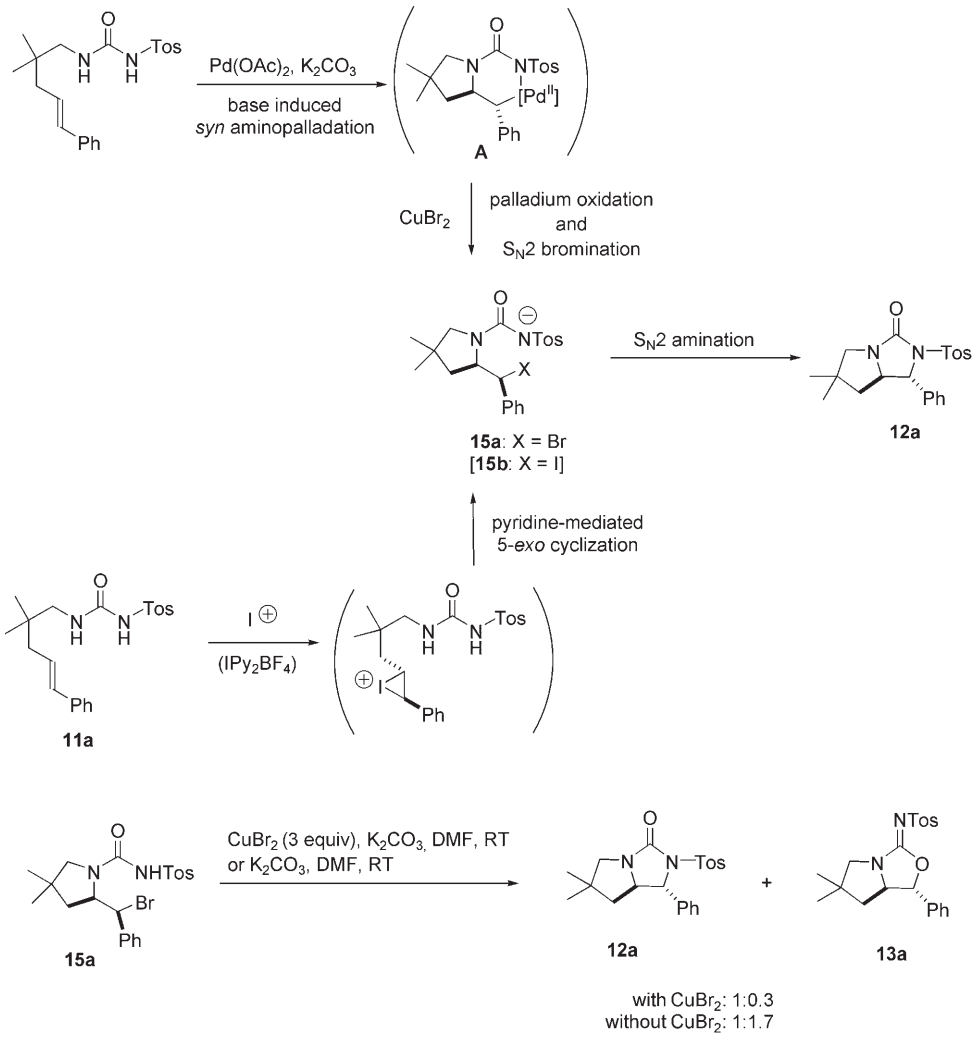
The most reasonable mechanistic scenario involves a halogenated intermediate and a sequence of *syn* aminopalladation, *anti* bromination/depalladation, and *anti* C–N bond formation. The former two steps are stereochemically identical to *anti* aminohalogenation, and hence the overall stereochemical sequence is equivalent to the outcome of the iodonium-mediated reaction (Scheme 7). The intermediate that results from aminobromination was synthesized independently by the treatment of **1a** with *N*-bromosuccinimide.[41]

The isolation of the aminobromination product **15a** enabled detailed study of the course of the second reaction step. It was found that the presence of copper bromide is crucial to ensure that amination is favored over competing oxygenation in the second C–X bond-forming step. Without the copper salt, oxygenation occurs to a greater extent and is comparable to that observed in the IPy_2BF_4-mediated process. We presume that in the presence of copper bromide, complexation of the carbonyl group leads to the preferential formation of **12**.[42]

As palladium catalysis involving aminobrominated intermediate **15** proceeds readily at



Scheme 6. Diversity of the Ipy_2BF_4-mediated 1,2-difunctionalization of internal alkenes.



Scheme 7. Mechanistic pathways to a common intermediate, and the influence of copper bromide on the selectivity of the final C–X bond-forming step.

room temperature, it is safe to postulate that the elevated temperature required for the iodonium-mediated diamination of terminal alkenes is only necessary to establish selectivity in the initial iodination step; for internal alkenes, the selectivity between amination and alkoxylation is also temperature-dependent.

Conclusions

In summary, we have discovered copper(II) bromide to be a versatile reoxidant for the palladium-catalyzed diamination of alkenes. The reactions, which are characterized by their operational ease, lead to selective ring formation, proceed well for terminal and internal alkenes, and open new perspectives in diamine synthesis from alkenes. The substrate scope with the palladium(II)/copper(II) bromide combination is significantly broader than for related procedures described previously: Urea, guanidine, and sulfamide derivatives can be used.

Several important points have emerged from the present study: First, palladium(II) salts alone do not induce product formation; hence, a palladium(II)/palladium(0) cycle cannot be solely responsible for diamination. Second, copper bromide must be involved in the final C–N bond-forming step. Copper bromide is responsible for both the activation of the urea carbonyl group and concentration-dependent catalyst turnover. Finally, the second C–N bond-forming step differs in its stereochemical course for internal and terminal alkenes. As substantiated by deuterium labeling, X-ray analysis, and extensive comparison of the products with those from reactions with IPy_2BF_4, the course of which has been established for many examples, this difference is the consequence of a significant difference in the mechanism for the formation of the second C–N bond (Scheme 8).

In conclusion, we have described new procedures based on the use of an iodonium promoter (IPy_2BF_4) or palladium catalysis for the intramolecular diamination of alkenes. These two attractive and complementary protocols for rapid, productive, and economical intramolecular diamina-

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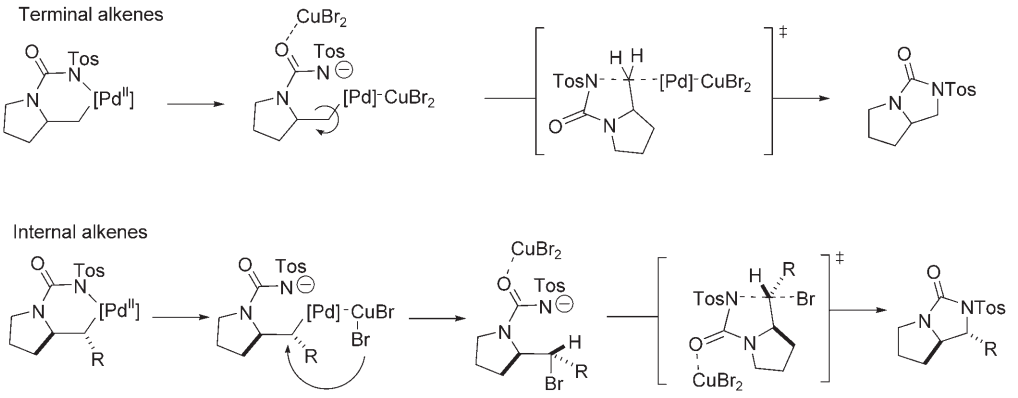

Scheme 8. Mechanistic processes for the diamination of terminal and internal alkenes.

tion lead to cyclic urea, sulfamide, and guanidine derivatives under convenient conditions.

Experimental Section

General

All organic reagents, unless noted otherwise, were purchased from Acros. $Pd(OAc)_2$ was purchased from Acros. Dichloromethane was dried over $CaCl_2$ and distilled from CaH_2. Toluene, THF, and Et_2O were distilled from Na/benzophenone. Absolute DMF was purchased from Fischer Chemicals and stored over molecular sieves (4 Å). Column chromatography was performed with silica gel (Merck, type 60, 0.063–0.2 mm). Reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25-mm E. Merck silica-gel plates (60F-254) with UV light as the visualizing agent and 10% ethanolic phosphomolybdic acid or ninhydrin solution and heat as developing agents. NMR spectra were recorded on Bruker Avance 400-MHz, Bruker DPX 300-MHz, and Bruker DRX 500-MHz spectrometers. Chemical shifts in NMR spectra are reported in ppm downfield from tetramethylsilane. The following calibrations were used: $\delta_H(CHCl_3)=7.26$ ppm, $\delta_C(CHCl_3)=77.00$ ppm. MS (LC–ESI) experiments were performed with an Agilent 1100 HPLC instrument and a Bruker micro-TOF instrument (ESI). Unless otherwise stated, a Supelco C8 column (5 cm × 4.6 mm, 5-μm particles) was used with a linear elution gradient from 100% H_2O (0.5% HCO_2H) to 100% MeCN in 13 min at a flow rate of 0.5 mL min^{-1}. MS (EI) and HRMS experiments were performed on a Kratos MS 50 instrument at the service centers at the Kekulé Department, Bonn University.

All urea starting materials were synthesized from the corresponding amines[43] by treatment with 4-toluenesulfonyl isocyanate in absolute dichloromethane: Absolute dichloromethane (10 mL) and the amine (5 mmol, 1.0 equiv) were placed in a flame-dried Schlenk flask. The reaction mixture was cooled to 0°C, and 4-toluenesulfonyl isocyanate (5.5 mmol, 1.1 equiv) was added dropwise. The reaction mixture was allowed to warm to room temperature and stirred for 1 h. Evaporation of the solvent provided the crude product. Unless stated specifically, the urea derivatives were purified by crystallization from $CHCl_3$ to remove the 4-toluenesulfonyl amide.

Procedure A: Pd-Catalyzed Diamination

The urea starting material (0.25 mmol), $Pd(OAc)_2$ (5.6 mg, 10 mol%), K_2CO_3 (35 mg, 1 equiv), and $CuBr_2$ (168 mg, 3 equiv) were placed in a flame-dried Schlenk tube. Dry DMF (2.5 mL, 0.1 M) was added under inert atmosphere, and the mixture was stirred for 16 h at 40°C then allowed to cool to room temperature. A saturated, aqueous solution of $Na_2S_2O_3$ (2 mL) was then added to quench the reaction, and the mixture was stirred for a further 30 min. Brine (10 mL) was added, and the mixture was extracted with CH_2Cl_2 (3 × 20 mL). The organic phase was dried over $MgSO_4$, concentrated, and purified by flash chromatography.

Procedure B: IPy_2BF_4-Mediated Diamination

The urea starting material (0.25 mmol) and IPy_2BF_4 (1.5 equiv) were placed in a flame-dried Schlenk tube, dry toluene (2.5 mL, 0.1 M) was added under inert atmosphere, and the resulting mixture was heated rapidly to 120°C. The reaction mixture was stirred for 16 h at 120°C then allowed to cool to room temperature. A saturated, aqueous solution of $Na_2S_2O_3$ (2 mL) was then added to quench the reaction. Water was added (10 mL), and the mixture was extracted with CH_2Cl_2 (3 × 20 mL). The organic phase was dried over $MgSO_4$, concentrated, and purified by flash chromatography.

Starting Materials

1b: *N*-((2,2-Dimethylpent-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**1b**) was synthesized according to the procedure described previously[8] and isolated in 99% yield after flash chromatography (CH_2Cl_2/EtOAc = 5:1 *v*/*v*). IR (KBr): $\tilde{\nu}$ = 3432, 3057, 3024, 2925, 2859, 1725, 1596, 1485, 1447, 1392, 1348, 1296, 1255, 1187, 1160, 1095, 912, 812, 760, 741, 703, 685, 665, 586, 549 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.57 (pseudo quint, J = 7.2 Hz, 2H), 2.01 (pseudo q, J = 7.2 Hz, 2H), 2.43 (s, 3H), 3.22 (pseudo q, J = 7.0 Hz, 2H), 4.95–5.01 (m, 1H), 5.05 (dq, J = 7.8, 17.2 Hz, 1H), 5.75 (ddt, J = 6.8, 10.4, 17.2 Hz, 1H), 6.57 (t, J = 5.2 Hz, 1H, NH), 7.30 (d, J = 8.0 Hz, 2H), 7.77 (d, J = 8.0 Hz, 2H), 8.83 ppm (br, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.6, 28.6, 30.8, 39.7, 115.4, 126.9, 129.7, 129.9, 137.3, 144.7, 151.8 ppm; MS (LC–ESI): *m*/*z* (%): 283.3 $[M]^+$ (100), 213.2 (7), 172.2 (32), 155.1 (63), 132.2 (23), 109.2(14), 91.3 (99), 86.4 (83), 69.5 (13); HRMS: *m*/*z* calcd for $C_{13}H_{18}N_2O_3S$: 282.1038; found: 282.1041.

1f: *N*-(((1-(2-Methylprop-2-en-1-yl)cyclohexyl)methyl)aminocarbonyl)-4-methyl-benzenesulfonamide (**1f**) was synthesized according to the procedure described previously[7b] and isolated in 82% yield after flash chromatography (hexanes/EtOAc = 2:1 *v*/*v*). IR (KBr): $\tilde{\nu}$ = 3339, 3119, 2930, 1664, 1555, 1452, 1346, 1242, 1156, 1122, 1089, 1022, 892, 813, 671, 574, 549, 502 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.1–1.5 (m, 10H), 1.68 (s, 3H), 1.90 (s, 2H), 2.35 (s, 3H), 3.10 (d, J = 6.0 Hz, 2H), 4.62 (s, 1H), 4.82 (s, 1H), 6.56 (t, J = 6.0 Hz, 1H, NH), 7.20 (d, J = 8.4 Hz, 2H), 7.70 (d, J = 8.4 Hz, 2H), 9.47 ppm (br, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.5, 21.6, 25.3, 26.0, 32.4, 33.9, 37.4, 46.1, 115.2, 126.9, 129.9, 136.9, 142.5, 144.6, 152.0 ppm; MS (LC–ESI): *m*/*z* (%): 365.4 $[M+H]^+$ (100), 309.1 (10), 214.2 (30), 199.19 (15), 168.4 (10), 79.4 (55); HRMS: *m*/*z* calcd for $C_{19}H_{28}N_2NaO_3S$: 387.1713; found: 387.1713.

4: Following a modification of a literature procedure,[44] a 100-mL flask under nitrogen atmosphere was connected to an addition funnel and a nitrogen-pressure equilibrator. The flask was charged with triphosgene (0.570 g, 1.92 mmol) and toluene (10 mL) and cooled to approximately 10°C with an ice bath. A solution of the urea **1d** (1.952 g, 5.58 mmol) in absolute toluene (12 mL) was added slowly from the addition funnel

over a period of approximately 25 min. The resulting mixture was warmed to room temperature, and neat *tert*-butylamine (17 mmol, 1.90 mL) was then added dropwise over a period of 15 min, during which the temperature rose gradually. After the complete addition of *tert*-butylamine, the dropping funnel was exchanged for a reflux condenser, and the reaction mixture was heated at reflux for 5 h then cooled to room temperature. Diethyl ether (20 mL) was then added to induce the precipitation of a white solid, which was collected by filtration and washed several times with diethyl ether. The combined filtrates were evaporated under reduced pressure, and the residue was purified by column chromatography (silica gel, *n*-hexane/Et_2O/CH_2Cl_2 = 3:4:1 *v*/*v*/*v*); R_f = 0.39) to give *N*-((((1-allylcyclohexyl)methyl)amino)*tert*-butylimino)methyl-4-methylbenzenesulfonamide (**4**; 0.725 g, 33%) as a white solid. IR (KBr): $\tilde{\nu}$ = 3671, 3340, 3261, 3190, 3116, 2926, 2854, 1662, 1593, 1553, 1456, 1348, 1164, 1090, 890, 815, 667, 588, 575, 548 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 1.07–1.34 (m, 10H), 1.21 (s, 9H), 1.90 (d, J = 7.6 Hz, 2H), 2.35 (s, 3H), 3.03 (d, J = 6.0 Hz, 2H), 4.98 (d, J = 10.4 Hz, 1H), 5.00 (d, J = 17.2 Hz, 1H), 5.68 (ddt, J = 7.6, 10.4, 17.2 Hz, 1H), 6.51 (t, J = 6.0 Hz, 1H, NH), 7.21 (d, J = 8.4 Hz, 2H), 7.71 ppm (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.3, 21.6, 26.0, 28.7, 33.2, 36.8, 40.4, 46.3, 51.5, 117.8, 126.9, 129.8, 134.0, 136.9, 144.5, 152.4 ppm; HRMS: *m*/*z* calcd for $C_{22}H_{35}N_3O_2S$: 405.2450; found: 405.2437.

6: A Burgess-type DMAP (4-dimethylaminopyridine) reagent[45] (10 mmol, 1 equiv; derived from MeOH instead of *t*BuOH) was added in one portion to a solution of 2,2-diphenyl-4-pentenamine (10 mmol) in CH_2Cl_2 (100 mL). The resulting mixture was stirred for 2 days at room temperature, and then the reaction was quenched by the addition of saturated, aqueous NH_4Cl. The mixture was extracted with CH_2Cl_2 (3× 50 mL), and the organic phase was dried with $MgSO_4$ and concentrated. Flash chromatography (CH_2Cl_2/EtOAc = 5:1 *v*/*v*) of the residue gave methyl (((2,2-diphenylpent-4-en-1-yl)amino)sulfonyl)carbamate (**6**; 80%) as a white solid. IR (KBr): $\tilde{\nu}$ = 3677, 3294, 3232, 2979, 2959, 1718, 1447, 1436, 1367, 1346, 1251, 1168, 1070, 975, 919, 858, 783, 754, 727, 699, 630, 611, 592 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz): δ = 2.89 (d, J = 7.2 Hz, 2H), 3.58 (s, 3H), 3.64 (d, J = 6.4 Hz, 2H), 4.55 (t, J = 6.4 Hz, 1H, NH), 4.94 (dd, J = 1.8, 9.9 Hz, 1H), 5.03 (dd, J = 1.8, 17.0 Hz, 1H), 5.26 (ddt, J = 7.2, 9.9, 17.0 Hz, 1H), 7.07 (d, J = 7.6 Hz, 4H), 7.14–7.20 (m, 2H), 7.21–7.27 (m, 4H), 7.60 ppm (br, 1H, NH); ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 41.1, 49.2, 50.1, 53.6, 119.3, 126.8, 127.7, 128.5, 133.1, 144.4, 151.4 ppm; MS (EI): *m*/*z* (%): 374.2 $[M]^+$ (1), 331.1 (8), 301.1 (12), 258.1 (4), 242.1 (4), 220.2 (46), 207.2 (100), 195.2 (65), 178.1 (10), 165.1 (20), 152.1 (5), 129.1 (90), 115.1 (5), 91.1 (42), 77.1 (3), 59.1 (2); HRMS: *m*/*z* calcd for $C_{19}H_{22}N_2O_4S$: 374.1300; found: 374.1283.

9a: *N*-((2,2-Diphenylhex-5-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**9a**) was synthesized according to a procedure described previously[7b] and isolated in 80% yield after crystallization from $CHCl_3$. IR (KBr): $\tilde{\nu}$ = 3350, 3135, 3068, 3022, 2945, 2848, 1690, 1552, 1450, 1352, 1158, 1091, 912, 825, 785, 707, 661, 584, 543 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ = 1.68–1.74 (m, 2H), 2.05–2.11 (m, 2H), 2.40 (s, 3H), 3.92 (d, J = 5.5 Hz, 2H), 4.84–4.90 (m, 2H), 5.64 (ddt, J = 6.4, 9.6, 17.7 Hz, 1H), 6.19 (t, J = 5.5 Hz, 1H, NH), 7.12–7.42 (m, 14H), 8.51 ppm (s, 1H, NH); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.6, 28.9, 36.3, 47.3, 49.7, 114.5, 126.6, 126.8, 127.8, 128.4, 129.8, 136.5, 138.2, 144.5, 145.0, 151.9 ppm; MS (EI): *m*/*z* (%): 448.2 $[M]^+$, 407.1 (5), 394.1 (20), 274.1 (4), 251.2 (20), 234.2 (20), 221.2 (55), 205.1 (2), 197.0 (55), 193.1 (10), 180.1 (30), 167.1 (70), 155.0 (75), 152.1 (20), 143.1 (15), 128.1 (5), 117.1 (30), 103.1 (15), 91.1 (100), 77.1 (5), 65.1 (15), 63.1 (5), 51.1 (5); HRMS: *m*/*z* calcd for $C_{26}H_{28}N_2O_3S$: 448.1821; found: 448.1838.

9b: *N*-((Hex-5-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**9b**) was synthesized according to the procedure described previously[7b] and isolated in 86% yield after crystallization from $CHCl_3$. IR (KBr): $\tilde{\nu}$ = 3345, 3196, 3094, 2919, 1665, 1552, 1486, 1347, 1250, 1168, 1117, 1107, 1009, 922, 814, 712, 661, 579, 543 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ = 1.31–1.37(m, 2H), 1.45–1.51 (m, 2H), 2.02 (dtt, J = 7.3, 7.0, 1.3 Hz, 2H), 2.43 (s, 3H), 3.21 (td, J = 7.0, 5.8 Hz, 2H), 4.94–5.00 (m, 2H), 5.74 (ddt, J = 17.0, 10.2, 6.6 Hz, 1H), 6.54 (t, J = 5.8 Hz, 1H, NH), 7.29 (d, J = 8.5 Hz, 2H), 7.77 (d, J = 8.5 Hz, 2H), 8.97 ppm (s, 1H, NH); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.6, 25.8, 28.9, 33.2, 40.1, 114.8, 126.9, 129.8, 136.8, 138.2, 144.6, 152.0 ppm; MS (EI): *m*/*z* (%): 296.1 $[M]^+$, 255.1 (1), 253.1 (4), 227.0 (4), 215.1 (8), 197.0 (36), 171.1 (18), 155.0 (86), 141.1 (10), 125.1 (6), 108.1 (22), 91.1 (100), 82.1 (10), 65.1 (14), 56.1 (10); HRMS: *m*/*z* calcd for $C_{14}H_{20}N_2O_3S$: 296.1195; found: 296.1212.

9c: *N*-((2,2-Dimethylhex-5-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**9c**) was synthesized according to the procedure described previously[7b] and isolated in 90% yield after crystallization from $CHCl_3$. IR (KBr): $\tilde{\nu}$ = 3391, 3129, 3012, 2955, 2925, 2832, 1701, 1568, 1440, 1342, 1163, 1091, 999, 917, 825, 666, 595, 554 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ = 0.76 (s, 6H), 1.10–1.17 (m, 2H), 1.86–1.92 (m, 2H), 2.36 (s, 3H), 2.99 (d, J = 6.0 Hz, 2H), 4.86–4.92 (m, 2H), 5.67 (ddt, J = 6.4, 10.2, 17.1 Hz, 1H), 6.55 (t, J = 6.0 Hz, 1H, NH), 7.23 (d, J = 8.5 Hz, 2H), 7.70 (d, J = 8.5 Hz, 2H), 8.62 ppm (s, 1H, NH); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.6, 24.7, 28.2, 34.1, 38.7, 50.0, 114.3, 126.9, 129.9, 136.8, 138.9, 144.7, 151.9 ppm; MS (EI): *m*/*z* (%): 324.2 $[M]^+$, 228.1 (8), 197.0 (52), 169.1 (10), 155.0 (86), 110.1 (12), 91.1 (100), 73.1 (28), 55.1 (18); HRMS: *m*/*z* calcd for $C_{16}H_{24}N_2O_3S$: 324.1508; found: 324.1501.

9d: *N*-(((1-(But-3-en-1-yl)cyclohexyl)methyl)aminocarbonyl)-4-methylbenzenesulfonamide (**9d**) was synthesized according to the procedure described previously[7b] and isolated in 82% yield after crystallization from $CHCl_3$. IR (KBr): $\tilde{\nu}$ = 3334, 3259, 3116, 2924, 2860, 1662, 1558, 1456, 1340, 1254, 1168, 1092, 891, 814, 665, 548 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ = 1.15–1.42 (m, 12H), 1.88–1.94 (m, 2H), 2.43 (s, 3H), 3.13 (d, J = 5.8 Hz, 2H), 4.91–4.97 (m, 2H), 5.73 (ddt, J = 6.4, 10.2, 17.0 Hz, 2H), 6.55 (t, J = 5.8 Hz, NH), 7.30 (d, J = 8.5 Hz, 2H), 7.77 (d, J = 8.5 Hz, 2H), 8.73 ppm (s, 1H, NH); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.3, 21.6, 26.1, 27.3, 33.4, 34.7, 36.1, 46.3, 114.3, 126.9, 129.9, 136.8, 138.9, 144.7, 151.9 ppm; MS (EI): *m*/*z* (%): 364.1 $[M]^+$, 350.1 (4), 309.1 (18), 292.1 (2), 269.1 (4), 254.1 (3), 228.0 (14), 215.0 (12), 197.0 (18), 195.2 (8), 171.0 (56), 155.0 (80), 136.1 (8), 112.1 (6), 108.1 (30), 91.1 (100), 65.1 ppm (16); HRMS: *m*/*z* calcd for $C_{19}H_{28}N_2O_3S$: 364.1821; found: 364.1825.

11a: *N*-(((4*E*)-2,2-Dimethyl-5-phenylpent-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**11a**) was synthesized according to the procedure described previously[7b] and isolated in 70% yield after crystallization from $CHCl_3$/hexane (2:1, v/v). IR (KBr): $\tilde{\nu}$ = 3681, 3381, 3333, 3123, 3029, 2960, 2933, 1675, 1597, 1547, 1493, 1547, 1448, 1342, 1161, 1119, 1090, 1020, 983, 970, 918, 876, 814, 756, 694, 666, 548 cm^{-1}; ^1H NMR (400 MHz, CD_2Cl_2): δ = 0.87 (s, 6H), 2.04 (dd, J = 0.9, 7.6 Hz, 2H), 2.40 (s, 3H), 3.09 (d, J = 6.1 Hz, 2H), 6.20 (dt, J = 7.6, 15.8 Hz, 1H), 6.38 (d, J = 15.8 Hz, 1H), 6.57 (t, J = 5.9 Hz, 1H), 7.20 (tt, J = 1.2, 6.4 Hz, 1H), 7.27–7.38 (m, 6H), 7.77 ppm (d, J = 8.5 Hz, 2H); ^{13}C NMR (100 MHz, CD_2Cl_3): δ = 21.2, 24.5, 35.1, 43.0, 49.6, 125.9, 126.1, 126.7, 127.0, 128.4, 129.8, 132.7, 136.7, 137.4, 144.9, 152.1 ppm; MS (EI): *m*/*z* (%): 386.2 $[M]^+$, 295.1 (4); 269.1 (10), 252.2 (2), 215.2 (6), 196.1 (40), 172.2 (52), 155.0 (72), 117.1 (42), 91.1 (100), 72.1 (20), 65.1 (14); HRMS: *m*/*z* calcd for $C_{21}H_{26}N_2O_3S$: 386.1664; found: 386.1661.

11b: *N*-(((4*E*)-2,2-Diphenyl-5-phenylpent-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**11b**) was synthesized according to the procedure described previously[7b] and isolated in 78% yield after crystallization from $CHCl_3$/hexane (2:1, v/v). IR (KBr): $\tilde{\nu}$ = 3635, 3369, 3057, 3027, 2926, 1686, 1597, 1541, 1495, 1445, 1343, 1157, 1089, 968, 883, 813, 748, 700, 667, 585, 546 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 2.41 (s, 3H), 3.02 (d, J = 7.0 Hz, 2H), 4.01 (d, J 5.2 Hz, 2H), 5.81 (dt, J = 7.2, 15.8 Hz, 1H), 6.28 (d, J = 15.8 Hz, 1H), 6.41 (t, J = 5.0 Hz, 1H), 7.15–7.41 (m, 18H), 7.51 ppm (d, J = 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.5, 40.9, 47.0, 50.1, 125.0, 126.0, 126.6, 126.7, 17.0, 127.8, 128.3, 128.3, 129.6, 133.6, 136.6, 137.2, 144.3, 144.7, 152.0 ppm; MS (ESI): *m*/*z* (%): 1027.4 $[2M+Li]^+$ (5), 659.5 (20), 517.2 $[M+Li^+]$ (100); HRMS: *m*/*z* calcd for $C_{31}H_{30}LiN_2O_3S$: 517.2132; found: 517.2130.

11c: *N*-(((1-((2*E*)-3-Phenylprop-2-en-1-yl)cyclohexyl)methyl)aminocarbonyl)-4-methylbenzenesulfonamide (**11c**) was synthesized according to the procedure described previously[7b] and isolated in 83% yield after crystallization from $CHCl_3$/hexane (2:1, v/v). IR (KBr): $\tilde{\nu}$ = 3674, 3332, 3062, 2926, 1659, 1553, 1454, 1346, 1239, 1164, 1090, 972, 884, 813, 754, 691, 665, 575, 548 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 0.80–0.91 (m, 10H), 2.11 (d, J = 7.6 Hz, 2H), 2.36 (s, 3H), 3.15 (d, J = 6.1 Hz, 2H), 6.15 (dt, J = 7.6, 15.8 Hz, 1H), 6.43 (d, J = 15.8 Hz, 1H), 6.63 (t, J = 6.1 Hz, 1H), 7.17–7.36 (m, 8H), 7.76 ppm (d, J = 8.2 Hz, 2H); ^{13}C NMR

(100 MHz, $CDCl_3$): δ = 14.1, 21.3, 21.5, 26.0, 33.4, 37.5, 60.4, 125.6, 126.1, 126.8, 127.1, 128.5, 129.8, 132.8, 136.8, 137.3, 144.6, 152.1 ppm; MS (ESI): *m/z* (%): 549.3 (30), 511.2 (15), 464.3 (20), 433.2 $[M+Li]^+$ (100), 384.4 (30), 348.2 (15); HRMS: *m/z* calcd for $C_{24}H_{30}LiN_2O_3S$: 433.2132; found: 433.2169.

11d: *N*-(((4*E*)-2,2-Dimethylhex-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**11d**) was synthesized according to the procedure described previously[7b] and purified by flash chromatography (EtOAc/hexane = 2:1 *v/v*). The use of 90% crotyl chloride led to a 9:1 *E*/*Z* product mixture (80% combined yield), which was used in the diamination. IR (KBr): $\tilde{\nu}$ = 3685, 3355, 3089, 2957, 2891, 1697, 1675, 1546, 1466, 1340, 1242, 1161, 1093, 915, 888, 666, 588, 553 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 0.79 (s, 6H), 1.67 (d, *J* = 5.6 Hz, 3H), 1.81 (d, *J* = 6.4 Hz, 2H), 2.43 (s, 3H), 3.02 (d, *J* = 6.1 Hz, 2H), 5.32–5.48 (m, 2H), 6.63 (t, *J* = 5.8 Hz, 1H), 7.30 (d, *J* = 8.2 Hz, 2H), 7.78 (d, *J* = 8.5 Hz, 2H), 9.07 ppm (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 18.0, 21.6, 24.7, 34.7, 42.9, 49.6, 126.6, 126.9, 128.3, 129.9, 136.8, 144.6, 152.2 ppm; MS (EI): *m/z* (%): 324.1 $[M]^+$, 269.1 (22), 227.1 (8), 215.1 (12), 197.0 (32), 169.1 (8), 155.0 (86), 139.0 (4), 110.1 (44), 91.1 (100), 72.1 (28), 55.1 (22); HRMS: *m/z* calcd for $C_{16}H_{24}N_2O_3S$: 324.1508; found: 324.1523.

11e: *N*-(((4*E*)-2,2-Phenylhex-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**11e**) was synthesized according to the procedure described previously[7b] and crystallized from $CHCl_3$/hexane (2:1, v/v). The use of 90% crotyl chloride led to a 9:1 *E*/*Z* product mixture (90% combined yield), which was used in the diamination. IR (KBr): $\tilde{\nu}$ = 3965, 3362, 3135, 3029, 2925, 2853, 1686, 1597, 1549, 1496, 1447, 1351, 1152, 1089, 1035, 968, 898, 814, 759, 702, 671, 585, 546, 512, 500 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 1.52 (dd, *J* = 1.5, 6.4 Hz, 3H), 2.41 (s, 3H), 2.76 (d, *J* = 7.0 Hz, 2H), 3.89 (d, *J* = 5.0 Hz, 2H), 4.97 (dtq, *J* = 1.5, 7.0, 15.4 Hz, 1H), 5.32 (dq, *J* = 6.4, 15.2 Hz, 1H), 6.30 (t, *J* = 4.7 Hz, 1H), 7.12–7.41 (m, 14H), 8.78 ppm (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 18.0, 21.6, 40.7, 46.9, 49.7, 125.4, 126.5, 126.8, 127.9, 128.3, 129.4, 129.7, 136.6, 144.4, 145.1, 151.7 ppm; MS (ESI): *m/z* (%): 903.4 (30) $[2M+Li]^+$, 455.2 (100) $[M+Li]^+$; HRMS: *m/z* calcd for $C_{26}H_{28}LiN_2O_3S$: 455.1976; found: 455.1968.

11f: *N*-(((4*E*)-2,2-Diphenylhept-4-en-1-yl)aminocarbonyl)-4-methylbenzenesulfonamide (**11f**) was synthesized according to the procedure described previously.[8] (Instead of 1-bromopent-2-ene, the corresponding mesylated alcohol was used as the electrophile.) The product was isolated in 67% yield after flash chromatography (CH_2Cl_2/hexane/EtOAc = 3:3:0.6 *v/v/v*). IR (KBr): $\tilde{\nu}$ = 3687, 3443, 3368, 3133, 3030, 2958, 2923, 2894, 2842, 2785, 1681, 1596, 1547, 1495, 1445, 1351, 1152, 1089, 1038, 889, 815, 758, 702, 670, 587 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 0.82 (t, *J* = 7.6 Hz, 3H), 1.86 (pseudo quint, *J* = 7.3 Hz, 2H), 2.41 (s, 3H), 2.75 (d, *J* = 7.0 Hz, 2H), 3.89 (d, *J* = 5.3 Hz, 2H), 4.95 (dt, *J* = 7.3, 15.2 Hz, 1H), 5.30 (dt, *J* = 6.4, 15.2 Hz, 1H), 6.28 (t, *J* = 5.2 Hz, 1H), 7.13–7.41 (m, 14H), 8.04 ppm (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.7, 21.5, 25.6, 40.5, 46.9, 49.7, 123.2, 126.4, 126.7, 127.9, 128.2, 129.7, 136.6, 136.9, 144.3, 145.0, 151.9 ppm; MS (ESI): *m/z* (%): 475.2 $[M+Na]^+$ (25), 469.2 $[M+Li]^+$ (100); HRMS: *m/z* calcd for $C_{27}H_{30}LiN_2O_3S$: 469.2132; found: 469.2133.

Products of Diamination Reactions

10a: Hexahydro-6,6-diphenyl-2-tosylimidazo[1,5-*a*]pyridin-3-(5*H*)-one (**10a**) was synthesized according to procedure A and isolated in 72% yield after flash chromatography (EtOAc/hexanes = 1:1 *v/v*). IR (KBr): $\tilde{\nu}$ = 3659, 3054, 3022, 2950, 2924, 2863, 1733, 1599, 1432, 1357, 1282, 1184, 1108, 1091, 904, 825, 754, 735, 705, 663, 597, 573, 548 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 1.04 (d pseudo q, *J* = 2.9, 13.2 Hz, 1H), 1.84 (d pseudo q, *J* = 3.5, 13.2 Hz, 1H), 2.29 (d pseudo t, *J* = 3.2, 13.4 Hz, 1H), 2.49 (s, 3H), 2.62 (d pseudo q, *J* = 2.9, 13.5 Hz, 1H), 2.81 (d, *J* = 14.0 Hz, 1H), 3.11 (pseudo t, *J* = 9.1 Hz, 1H), 3.62 (dddd, *J* = 3.8, 7.9, 8.8, 11.9 Hz, 1H), 4.07 (dd, *J* = 8.9, 9.1 Hz, 1H), 4.62 (dd, *J* = 2.6, 14.0 Hz, 1H), 7.05–7.18 (m, 8H), 7.24 (pseudo t, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 7.9 Hz, 2H), 7.91 ppm (d, *J* = 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.6, 27.1, 33.8, 48.7, 49.0, 51.1, 125.9, 126.4, 126.6, 127.3, 128.0, 128.4, 128.5, 129.5, 134.8, 143.2, 144.6, 146.3, 152.3 ppm; MS (LC–ESI): *m/z* (%): 447.4 $[M+H]^+$ (100), 214.2 (10), 151.2 (10), 79.3 (60); HRMS: *m/z* calcd for $C_{26}H_{26}N_2O_3S$: 446.1664; found: 446.1661.

12a: 1-Phenyl-6,6-dimethyl-2-(4-methylbenzenesulfonyl)hexahydro-3*H*-pyrrolo[1,2-*c*]imidazol-3-one (**12a**) was synthesized according to procedures A and B and isolated as a white solid in 78% yield after flash chromatography (EtOAc/hexanes = 1:1 *v/v*; R_f = 0.8). IR (KBr): $\tilde{\nu}$ = 3673, 3440, 3032, 2958, 2928, 2873, 2853, 1727, 1596, 1455, 1382, 1361, 1268, 1186, 1172, 1142, 1087, 911, 812, 767, 749, 732, 706, 665, 602, 563, 602, 563, 543 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 1.06 (s, 3H), 1.08 (s, 3H), 1.46 (dd, *J* = 10.2, 12.2 Hz, 1H), 1.88 (dd, *J* = 6.0, 12.2 Hz, 1H), 2.36 (s, 3H), 2.81 (d, *J* = 12.6 Hz, 1H), 3.50 (d, *J* = 12.6 Hz, 1H), 3.71 (ddd, *J* = 2.1, 6.0, 10.2 Hz, 1H), 5.05 (d, *J* = 2.1 Hz, 1H), 7.12 (d, *J* = 8.5 Hz, 2H), 7.25–7.35 (m, 5H), 7.46 ppm (d, *J* = 8.4 Hz, 2H); ^1H NMR (400 MHz, CD_2Cl_2): δ = 1.00 (s, 3H), 1.05 (s, 3H), 1.33 (dd, *J* = 10.0, 12.3 Hz, 1H), 1.87 (dd, *J* = 6.1, 12.3 Hz, 1H), 2.40 (s, 3H), 2.80 (d, *J* = 11.5 Hz, 1H), 3.41 (d, *J* = 11.5 Hz, 1H), 3.70 (ddd, *J* = 2.4, 6.1, 10.0 Hz, 1H), 5.00 (d, *J* = 2.4 Hz, 1H), 7.21 (d, *J* 8.6 Hz, 2H), 7.30–7.37 (m, 5H), 7.53 ppm (d, *J* = 8.6 Hz, 2H); ^{13}C NMR (100 MHz, CD_2Cl_2): δ = 20.9, 27.2, 28.0, 39.1, 45.5, 58.6, 63.1, 64.8, 126.4, 127.5, 127.9, 128.3, 128.7, 135.4, 140.2, 144.3, 156.8 ppm; MS (ESI): *m/z* (%): 407.1 $[M+Na]^+$ (100), 385.2 (40); HRMS: *m/z* calcd for $C_{21}H_{24}N_2NaO_3S$: 407.1400; found: 407.1386.

12b: 1,6,6-Triphenyl-2-(4-methylbenzenesulfonyl)hexahydro-3*H*-pyrrolo-[1,2-*c*]imidazol-3-one (**12b**) was synthesized according to procedures A and B and isolated as a white solid in 68% yield after flash chromatography (EtOAc/hexanes = 1:1 *v/v*; R_f = 0.8). IR (KBr): $\tilde{\nu}$ = 3672, 3026, 2973, 2939, 2912, 1715, 1596, 1486, 1448, 1366, 1276, 1260, 1174, 1092, 944, 815, 802, 756, 733, 698, 665, 584, 548 ppm; ^1H NMR (400 MHz, $CDCl_3$): δ = 2.31 (pseudo t, *J* = 11.7 Hz, 1H), 2.37 (s, 3H), 2.63 (dd, *J* = 4.7, 11.7 Hz, 1H), 3.70 (ddd, *J* = 2.6, 4.7, 11.7 Hz, 1H), 4.05 (d, *J* = 12.0 Hz, 1H), 4.15 (d, *J* 12.0 Hz, 1H), 5.15 (d, *J* = 2.6 Hz, 1H), 7.08–7.16 (m, 7H), 7.20–7.25 (m, 3H), 7.26–7.32 (m, 7H), 7.44 ppm (d, *J* = 8.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.6, 43.6, 56.1, 57.8, 62.9, 64.5, 126.6, 126.7, 126.8, 126.9, 127.3, 128.0, 128.5, 128.6, 128.6, 128.8, 129.1, 135.7, 139.7, 144.4, 145.7, 146.0, 157.9 ppm; MS (ESI): *m/z* (%): 531 $[M+Na]^+$ (100), 515 $[M+Li]^+$ (20); HRMS: *m/z* calcd for $C_{31}H_{28}NaN_2O_3S$: 531.1713; found: 531.1769.

12c: 1′-Phenyl-2′-(4-methylbenzenesulfonyl)tetrahydro-3′*H*-spiro(cyclohexane-1,6′-pyrrolo[1,2-*c*]imidazol)-3′-one (**12c**) was synthesized according to procedures A and B and isolated as a white solid in 70% yield after flash chromatography (EtOAc/hexanes = 1:2 *v/v*; R_f = 0.75). IR (KBr): $\tilde{\nu}$ = 3673, 3433, 3090, 3034, 2925, 2848, 1723, 1594, 1496, 1478, 1454, 1371, 1334, 1261, 1211, 1168, 1136, 1104, 1090, 1059, 954, 860, 817, 803, 765, 706, 698, 665, 582, 546, 540, 520, 486 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 1.23–1.43 (m, 10H) 1.29 (dd, *J* = 10.2, 12.5 Hz, 1H), 1.99 (dd, *J* = 6.1, 12.5 Hz, 1H), 2.35 (s, 3H), 2.79 (d, *J* = 12.0 Hz, 1H), 3.55 (d, *J* = 12.0 Hz, 1H), 3.63 (ddd, *J* = 1.8, 6.1, 10.0 Hz, 1H), 5.01 (d, *J* = 1.8 Hz, 1H), 7.12 (d, *J* = 8.5 Hz, 2H), 7.27–7.32 (m, 5H), 7.48 ppm (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.5, 23.1, 23.7, 25.3, 36.4, 38.2, 43.7, 63.2, 64.4, 126.9, 127.9, 128.3, 128.7, 129.0, 135.6, 139.9, 144.2, 157.3 ppm; MS (LC–ESI): *m/z* (%): 425.4 (80), 228.3 (100); MS (ESI): *m/z* (%): 465 (5), 449 $[M+Na]^+$ (20), 431 $[M+Li]^+$ (100), 427 $[M+H]^+$ (5), 228 (5); HRMS (ESI): *m/z* calcd for $C_{24}H_{28}LiN_2O_3S$: 431.1976; found: 431.1967.

12d: 1,6,6-Trimethyl-2-(4-methylbenzenesulfonyl)hexahydro-3*H*-pyrrolo-[1,2-*c*]imidazol-3-one (**12d**) was synthesized according to procedures A and B and isolated as a white solid in 50% yield after flash chromatography (EtOAc/hexanes = 1:1 *v/v*; R_f = 0.7). IR (KBr): $\tilde{\nu}$ = 3463, 2960, 1735, 1390, 1358, 1260, 1171, 1089, 816, 662, 601, 569, 548 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ = 0.89 (s, 3H), 1.05 (s, 3H), 1.08 (dd, *J* = 9.9, 12.5 Hz, 1H), 1.56 (d, *J* = 6.4 Hz, 3H), 1.75 (dd, *J* = 6.1, 12.5 Hz, 1H), 2.41 (s, 3H), 2.72 (d, *J* = 12.7 Hz, 1H), 3.35 (d, *J* = 12.7 Hz, 1H), 3.42 (ddd, *J* = 2.3, 6.1, 9.9 Hz, 1H), 4.10 (dq, *J* = 2.3, 6.4 Hz, 1H), 7.30 (s, *J* = 8.2 Hz, 2H), 7.91 ppm (d, *J* = 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.6, 22.2, 27.9, 28.6, 39.7, 45.8, 56.7, 58.7, 64.0, 128.1, 129.4, 136.0, 144.5, 157.1 ppm; MS (ESI): *m/z* (%): 361.1 (40), 345.1 $[M+Na]^+$ (100), 323.1 (10); HRMS (ESI): *m/z* calcd for $C_{16}H_{22}NaN_2O_3S$: 345.1243; found: 345.1251.

12e: 1-Methyl-6,6-diphenyl-2-(4-methylbenzenesulfonyl)hexahydro-3*H*-pyrrolo[1,2-*c*]imidazol-3-one (**12e**) was synthesized according to procedure A and isolated as a white solid in 58% yield after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f = 0.7$). IR (KBr): $\tilde{\nu} = 3433$, 3024, 2925, 2859, 1727, 1596, 1485, 1447, 1392, 1348, 1296, 1255, 1187, 1159, 1095, 912, 812, 760, 741, 702, 666, 586, 549 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 1.56$ (d, $J = 6.4$ Hz, 3H), 1.91 (dd, $J = 11.0$, 11.7 Hz, 1H), 2.42 (s, 3H), 2.54 (dd, $J = 5.0$, 11.0 Hz, 1H), 3.40 (ddd, $J = 2.9$, 5.0, 11.8 Hz, 1H), 3.91 (d, $J = 12.0$ Hz, 1H), 4.04 (d, $J = 12.0$ Hz, 1H), 4.22 (dq, $J = 2.9$, 6.4 Hz, 1H), 7.01 (d pseudo t, $J = 1.5$, 6.4 Hz, 2H), 7.15–7.32 (m, 10H), 7.93 ppm (d, $J = 8.5$ Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 21.5$, 22.1, 43.4, 56.0, 56.2, 57.1, 63.4, 126.4, 126.5, 126.6, 126.8, 127.9, 128.3, 128.4, 129.4, 135.8, 144.5, 145.6, 145.9, 157.4 ppm; MS (ESI): *m*/*z* (%): 899.3 $[2M+Li]^+$ (10), 453.2 $[M+Li]^+$ (100); HRMS: *m*/*z* calcd for $C_{26}H_{26}LiN_2O_3S^+$: 453.1819; found: 453.1806.

12f: 1-Ethyl-6,6-diphenyl-2-(4-methylbenzenesulfonyl)hexahydro-3*H*-pyrrolo[1,2-*c*]imidazol-3-one (**12f**) was synthesized according to procedure A and isolated as a white solid in 37% yield after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f = 0.7$). IR (KBr): $\tilde{\nu} = 3057$, 2961, 2925, 1733, 1597, 1495, 1482, 1364, 1249, 1187, 1172, 1090, 1018, 816, 801, 759, 701, 666, 589, 547 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 0.86$ (t, $J =$ 7.6 Hz, 3H), 1.94–2.00 (m, 2H), 2.42 (s, 3H), 2.43–2.49 (m, 1H), 2.51 (dd, $J = 4.7$, 12.0 Hz, 1H), 3.45 (ddd, $J = 2.6$, 4.7, 10.8 Hz, 1H), 3.88 (d, $J =$ 11.7 Hz, 1H), 4.01 (d, $J = 11.7$ Hz, 1H), 4.13 (ddd, $J = 2.6$, 3.5, 6.4 Hz, 1H), 7.02 (dd, $J = 1.5$, 7.9 Hz, 2H), 7.32–7.17 (m, 10H), 7.94 ppm (d, $J =$ 8.5 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 7.8$, 21.3, 27.4, 43.9, 55.9, 57.2, 60.5, 60.8, 126.3, 126.6, 127.8, 128.2, 128.3, 129.2, 135.6, 145.5, 145.8, 157.7 ppm; MS (ESI): *m*/*z* (%): 927.4 (10), 547.1 (5), 467.2, $[M+Li]^+$ (100), 418.2 (20); HRMS: *m*/*z* calcd for $C_{27}H_{28}LiN_2O_3S$: 467.1976; found: 467.1967.

13a: *N*-(6,6-Dimethyl-1-phenyltetrahydro-1*H*-pyrrolo[1,2-*c*][1,3]oxazol-3-ylidene)-4-methylbenzenesulfonamide (**13a**) was obtained as a side product from the reaction of **11a** under conditions A or B and isolated as a white solid after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f =$ 0.75). IR (KBr): $\tilde{\nu} = 3390$, 2956, 2871, 1594, 1436, 1306, 1299, 1287, 1154, 1080, 924, 872, 814, 734, 701, 671, 570, 553, 543 cm^{-1};^1H NMR (400 MHz, $CDCl_3$): $\delta = 1.10$ (s, 3H), 1.18 (s, 3H), 1.68 (dd, $J = 9.4$, 12.3 Hz, 1H), 1.94 (dd, $J = 6.1$, 12.3 Hz, 1H), 2.39 (s, 3H), 3.06 (d, $J = 11.4$ Hz, 1H), 3.48 (d, $J = 11.1$ Hz, 1H), 4.05 (d pseudo t, $J = 6.7$, 9.4 Hz, 1H), 5.48 (d, $J = 6.7$ Hz, 1H), 7.08 (dd, $J = 2.1$, 7.3 Hz, 2H), 7.21 (d, $J = 7.9$ Hz, 2H), 7.30–7.35 (m, 3H), 7.85 ppm (d, 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 21.4$, 27.4, 27.7, 42.6, 45.0, 59.4, 67.3, 88.0, 125.3, 127.2, 128.9, 128.9, 129.1, 136.8, 139.7, 142.3, 159.9 ppm; MS (ESI): *m*/*z* (%): 791.3 (40), 590.3 (10), 448.2 (20), 407.1 (10), 385.2 $[M+H]^+$ (100); HRMS: *m*/*z* calcd for $C_{21}H_{25}N_2O_3S$: 385.1580; found: 385.1541.

13b: *N*-(1,6,6-Triphenyltetrahydro-1*H*-pyrrolo[1,2-*c*][1,3]oxazol-3-ylidene)-4-methylbenzenesulfonamide (**13b**) was obtained as a side product from the reaction of **11b** under conditions A or B and isolated as a white solid after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f = 0.75$). IR (KBr): $\tilde{\nu} = 3387$, 3023, 1604, 1447, 1308, 1301, 1287, 1159, 1086, 872, 752, 698, 669, 565, 553 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 2.41$ (s, 3H), 2.60–2.72 (m, 2H), 3.96 (ddd, $J = 5.6$, 7.3, 9.7 Hz, 1H), 4.03 (d, $J =$ 11.4 Hz, 1H), 4.35 (d, $J = 11.4$ Hz, 1H), 5.52 (d, $J = 7.3$ Hz, 1H), 7.08–7.35 (m, 17H), 7.88 ppm (d, $J = 8.5$ Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta =$ 21.4, 42.6, 57.0, 58.4, 66.5, 88.0, 125.5, 126.4, 126.5, 126.9, 127.1, 127.8, 128.7, 128.8, 128.9, 129.0, 129.2, 136.2, 139.5, 142.5, 144.4, 144.7, 160.0 ppm; MS (ESI): *m*/*z* (%): 593.2 (20), 531.2 $[M+Na]^+$ (100), 366.3 (20), 304.3 (20); HRMS: *m*/*z* calcd for $C_{31}H_{28}N_2NaO_3S$: 531.1713; found: 531.1645.

13c: 1′-Phenyltetrahydro-3′-spiro(cyclohexane-1,6′-pyrrolo[1,3]oxazol-3-ylidene)-3′-one-4-methylbenzenesulfonamide (**13c**) was obtained as a side product from the reaction of **11c** under conditions A or B and isolated as a white solid after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f = 0.7$). IR (KBr): $\tilde{\nu} = 3408$, 2926, 2854, 1602, 1451, 1301, 1286, 1159, 1122, 1089, 872, 814, 741, 700, 588, 553 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): $\delta =$ 1.3–1.52 (m, 10H), 1.60 (dd, $J = 9.1$, 12.2 Hz, 1H), 2.04 (dd, $J = 6.7$, 12.2 Hz, 1H), 2.40 (s, 3H), 3.10 (d, $J = 11.6$ Hz, 1H), 3.55 (d, $J =$ 11.5 Hz, 1H), 3.99 (d pseudo t, $J = 6.4$, 9.1 Hz, 1H), 5.46 (d, $J = 6.4$ Hz, 1H), 7.06 (dd, $J = 1.5$, 7.0 Hz, 2H), 7.20 (d, $J = 7.9$ Hz, 2H), 7.30–7.35 (m, 3H), 7.85 ppm (d, $J = 8.2$ Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 21.4$, 22.9, 23.6, 25.4, 35.9, 37.3, 46.5, 66.5, 87.9, 125.3, 127.2, 128.8, 128.9, 129.0, 136.8, 139.7, 142.3, 159.9 ppm; MS (ESI): *m*/*z* (%): 670.4 (5), 527.1 (5), 447.2 $[M+Na]^+$ (100), 304.3 (15); HRMS: *m*/*z* calcd for $C_{24}H_{28}N_2NaO_3S$: 447.1713; found: 447.1708.

13d: *N*-(1,6,6-Trimethyltetrahydro-1*H*-pyrrolo[1,2-*c*][1,3]oxazol-3-ylidene)-4-methylbenzenesulfonamide (**13d**) was obtained as a side product from the reaction of **11d** under conditions B and isolated as a white solid after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f = 0.35$). IR (KBr): $\tilde{\nu} = 3165$, 3082, 2958, 2795, 1706, 1375, 1295, 1240, 1194, 1084, 935, 889, 821, 649, 565 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 1.11$ (s, 3H), 1.12 (s, 3H), 1.46 (d, $J = 6.2$ Hz, 3H), 1.45–1.50 (m, 1H), 1.84 (dd, $J = 6.4$, 12.3 Hz, 1H), 2.39 (s, 3H), 3.00 (d, $J = 11.4$ Hz, 1H), 3.39 (d, $J = 11.4$ Hz, 1H), 3.80 (d pseudo t, $J = 6.7$, 8.8 Hz, 1H), 4.63 (dq, $J = 6.1$, 6.7 Hz, 1H), 7.23 (d, $J = 7.9$ Hz, 2H), 7.84 ppm (d, $J = 8.5$ Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 20.0$, 21.5, 27.4, 27.7, 42.5, 44.6, 59.4, 66.3, 84.2, 127.0, 128.9, 139.9, 142.2, 160.3 ppm; MS (ESI): *m*/*z* (%): 423.1 (10), 345.1 $[M+Na]^+$ (100), 323.1 (40); HRMS: *m*/*z* calcd for $C_{16}H_{22}N_2NaO_3S$: 345.1243; found: 345.1205.

13e: *N*-(1-Methyl-6,6-diphenyltetrahydro-1*H*-pyrrolo[1,2-*c*][1,3]oxazol-3-ylidene)-4-methylbenzenesulfonamide (**13e**) was obtained as a side product from the reaction of **11e** under conditions A or B and isolated as a white solid after flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*; $R_f =$ 0.35). IR (KBr): $\tilde{\nu} = 3471$, 2979, 1597, 1443, 1299, 1164, 1087, 926, 839, 759, 700, 670, 565, 554 ppm; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 1.42$ (d, $J =$ 6.2 Hz, 3H), 2.39 (s, 3H), 2.41 (dd, $J = 9.7$, 12.0 Hz, 1H), 2.60 (dd, $J = 5.6$, 12.0 Hz, 1H), 3.68 (ddd, $J = 5.6$, 7.3, 9.7 Hz, 1H), 3.91 (d, $J = 11.4$ Hz, 1H), 4.25 (d, $J = 11.7$ Hz, 1H), 4.67 (dq, $J = 6.4$, 7.1 Hz, 1H), 7.11–7.30 (m, 12H), 7.85 ppm (d, $J = 8.2$ Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): $\delta =$ 19.7, 21.4, 42.2, 56.7, 58.2, 65.4, 84.1, 126.3, 126.4, 126.8, 127.0 (2C), 128.6, 128.7, 128.9, 139.6, 142.3, 144.4, 144.7, 160.2 ppm; MS (ESI): *m*/*z* (%): 669.5 (10), 453.2 $[M+Li]^+$ (100), 256.2 (20); HRMS: *m*/*z* calcd for $C_{26}H_{26}LiN_2O_3S$: 453.1819; found: 453.1828.

14: Dry CH_2Cl_2 (2.5 mL) was added to **11d** (0.25 mmol) and IPy_2BF_4 (1.5 equiv) in a flame-dried Schlenk tube under inert atmosphere, and the resulting solution (0.1 M) was stirred for 16 h at room temperature. The reaction was then quenched by the addition of saturated, aqueous $Na_2S_2O_3$ (2 mL). Brine (10 mL) was added, and the mixture was extracted with CH_2Cl_2 (3×20 mL). The organic phase was dried with $MgSO_4$ and concentrated. Flash chromatography (EtOAc/hexanes = 1:1 *v*/*v*) of the residue gave *N*-(7-(1-iodoethyl)-5,5-dimethyl-1,3-oxazepan-2-ylidene)-4-methylbenzenesulfonamide (**14**; 81%) as a yellow solid. IR (KBr): $\tilde{\nu} =$ 3146, 2962, 2874, 1663, 1618, 1459, 1377, 1335, 1165, 1090, 895, 812, 664, 583, 549 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): $\delta = 0.92$ (s, 3H), 1.03 (s, 3H), 1.61 (dd, $J = 2.5$, 12.3 Hz, 1H), 1.71 (dd, $J = 2.7$, 10.7 Hz, 1H), 1.78 (d, $J =$ 7.3 Hz, 3H), 2.33 (s, 3H), 3.01 (d, $J = 4.3$ Hz, 1H), 3.03 (d, $J = 4.3$ Hz, 1H), 3.50 (d, $J = 10.5$ Hz, 1H), 4.61–4.84 (m, 1H), 7.20 (d, $J = 8.0$ Hz, 2H), 7.73 (d, $J = 8.4$ Hz, 2H), 8.59 ppm (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 21.6$ (CH_3), 23.2 (CH_3), 24.8 (CH_3), 28.5 (CH_3), 30.0 (CH), 31.5 (C), 45.5 (CH_2), 53.0 (CH_2), 83.7 (CH), 126.9 (2×CH), 129.37 (2× CH), 139.71 (C), 142.64 (C), 163.16 ppm (C); HRMS (EI): *m*/*z* calcd for $C_{25}H_{24}N_2O_3S$: 450.0501; found: 450.0491.

*Crystal-Structure Determination of **2e**, **12a**, **13b**, and **14***

Crystallographic data were collected on a Nonius KappaCCD diffractometer or, in the case of **13b**, on a Nonius-Bruker APEXII diffractometer, at −150 °C with $Mo_{K\alpha}$ radiation ($\lambda = 0.71073$ Å). Structures were solved by direct or Patterson methods (in the case of **14**; SHELXS97[46]). Non-hydrogen atoms were refined anisotropically, hydrogen atoms with a riding model (H(N) in **14** free) against F^2 (full-matrix least squares, SHELXL-97[47]). For **14**, an empirical absorption correction was applied. Details of data collection and refinement are given in the Supporting Information. CCDC-655629 (**2e**), -655630 (**12a**), -665473 (**13b**), and -655631 (**14**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre at www.ccdc.cam.ac.uk/data_request/cif.

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