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Accessing Tricyclic Imines Comprising a 2-Azabicyclo[2.2.2]octane Scaffold by Intramolecular Hetero-Diels–Alder Reaction of 4-Alkenyl-Substituted *N*-Silyl-1,4-dihydropyridines

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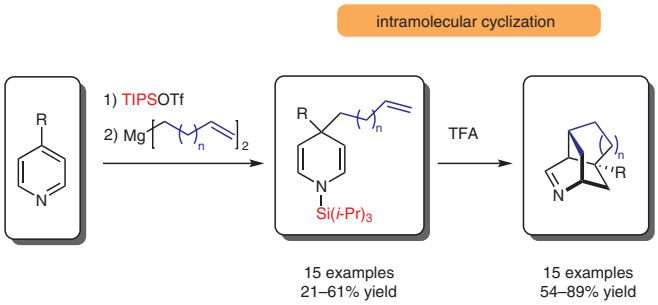

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Abstract Tricyclic imines inheriting a 2-azabicyclo[2.2.2]octane (isoquinuclidine) scaffold were provided with high regioselectivity in moderate to very good yields by a smooth, broadly applicable intramolecular hetero-Diels–Alder reaction of various 4-ω-alkenyl-substituted 1,4-dihydropyridines (DHPs) under trifluoroacetic acid catalysis. The required 4,4-disubstituted 1,4-DHPs were obtained by introduction of ω-alkenyl moieties of varying chain length via diorganomagnesium reagents into the 4-position of diversely 4-substituted pyridines after prior N-activation with triisopropylsilyltriflate.

Key words intramolecular hetero-Diels–Alder reaction, 2-azabicyclo[2.2.2]octane, polycycles, 1,4-dihydropyridines, diorganomagnesium reagents, heterocycles

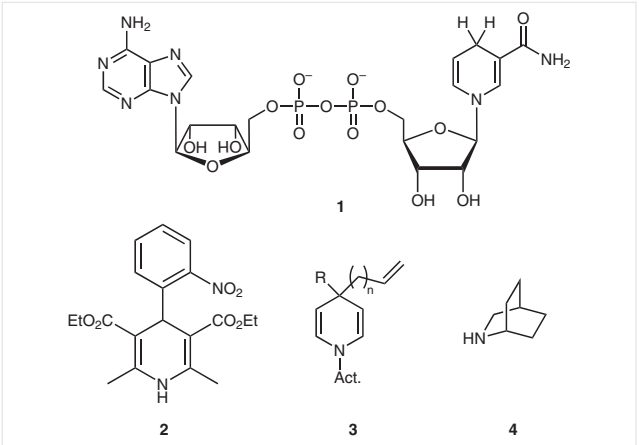

Figure 1 Structures of NADH (**1**), nifedipine (**2**), general structure of a 4-ω-alkenyl-substituted 1,4-DHP **3** and 2-azabicyclo[2.2.2]octane (**4**)

The 1,4-dihydropyridine (1,4-DHP) moiety is a common scaffold frequently found in compounds of synthetic or natural origin with important biological activities. Prominent examples to be mentioned are nicotinamide adenine dinucleotide (NADH (**1**), Figure 1), which is an ubiquitous coenzyme for redox reactions in cells, or nifedipine (**2**), which is listed by the WHO for healthcare systems as an essential drug for the treatment of hypertension.[1] Throughout the years, many different concepts for the synthesis of 1,4-DHPs have been published which are commonly either based on Hantzsch-type condensation reactions or 1,4-addition of nucleophiles to pyridinium salts, mostly *N*-acyl pyridinium and *N*-alkyl pyridinium salts.[1a,c,2]

Whereas a large variety of either 4-mono- or 4,4-disubstituted 1,4-DHPs with alkyl or aryl residues in the 4-position have been synthesized, only limited examples of 1,4-DHPs **3** with a 4-ω-alkenyl substituent are known. Thereby, the most prevalent 4-ω-alkenyl moiety is the allyl residue. Known 4-allyl-monosubstituted 1,4-DHPs have almost exclusively been generated by addition of organometallic derivatives such as allylcalcium,[3] allylstannane,[4] allylmagnesium reagents,[5] or allylcuprates[6] to either *N*-acyl[4a,7] and *N*-alkylpyridinium ions[5b,6] or pyridines lacking prior activation.[3,8]

All these methods suffer from severe drawbacks such as a poor regioselectivity for competing 1,4- and 1,2-addition reactions, high toxicity, and laborious methods for the preparation of the required organometallic reagents or the need for pyridine rings equipped with residues for neighboring-group assistance. Syntheses of 4-monosubstituted 1,4-DHPs with as compared to the allyl unit extended ω-alkenyl chains in 4-position are, however, scarce. Few such compounds were obtained either only as side products in syntheses by Krow et al. and Comins et al. aiming at the construction of 2-ω-alkenyl-substituted 1,2-DHPs or by Rudler et al. by employing silyl ketene acetals, derived from pent-4-enoic and hex-5-enoic acid, in addition reactions to pyridinium ions.[9]

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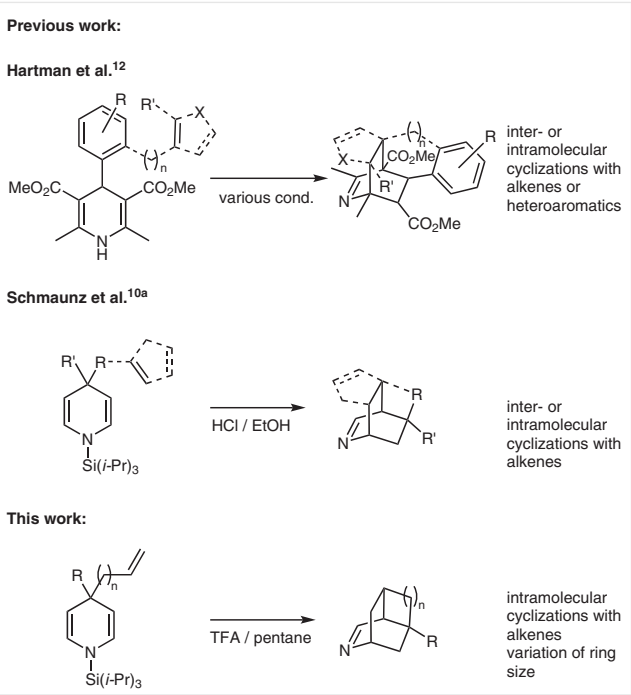
Even less explored are the syntheses of 4,4-disubstituted 1,4-DHPs with one of the two 4-substitutents being an ω-alkenyl moiety. So far such compounds have only been isolated by Wanner et al., Krow et al., and Okuda et al., though they provide a highly useful synthetic access to isoquinuclidine derivatives.[3a,9a,10] The isoquinuclidine ring system **4** (2-azabicyclo[2.2.2]octane) is found in many alkaloids, e.g., in ibogaine, and has also been used as intermediate in the synthesis of oseltamivir.[11] Examples demonstrating the accessibility of compounds with an 2-azabicyclo[2.2.2]octane skeleton as core unit by employing 4-monosubstituted 1,4-DHPs, obtained by Hantzsch dihydropyridine syntheses, in inter- or intramolecular cyclization reactions have been published by Hartman et al. (Scheme 1).[10a,12] The use of 4,4-disubstituted *N*-silyl 1,4-DHPs obtained from trapping reactions of *N*-dihydropyridinium ions with nucleophiles in inter- or intramolecular hetero-Diels–Alder reactions under acidic conditions has been demonstrated by us.[10a,12]



Scheme 1 Comparison of previously reported and present syntheses accessing compounds with a 2-azabicyclo[2.2.2]octane core unit

This had also included the preparation of 4-allyl-substituted *N*-silyl-1,4-DHP and their intramolecular cyclization to give the corresponding 2-azabicyclo[2.2.2]octane derivatives. With the present study we intended to develop a method giving for the first time access to a broad range of 4,4-disubstituted *N*-silyl-1,4-DHP with one of the 4-substituents in the 4-position being an ω-alkenyl residue of varying chain length which should finally be used for intramolecular cyclization reactions to give the corresponding tricyclic imines with a 2-azabicyclo[2.2.2]octane core structure.[10,13]

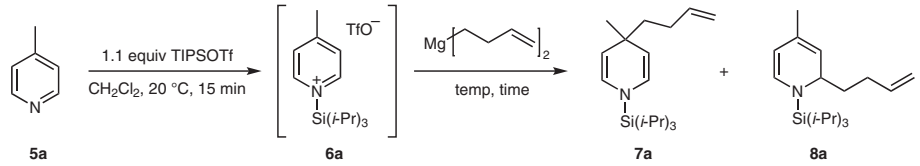
To study the feasibility of the introduction of ω-alkenyl moieties (other than allyl groups) into the 4-position of 4-substituted pyridine derivatives, as the first step of the overall sequence for the preparation of isoquinuclidine derivatives, 4-methylpyridine **5a** was chosen as model system, because the methyl group gives neither rise to large steric nor electronic effects. Furthermore, based on the knowledge from previous experiments that aimed at the synthesis of 4,4-disubstituted 1,4-dihydropyridines, only diorganomagnesium reagents should be used, at least for initial experiments, because these had proven superior reactivity as compared to Grignard reagents.[10b,13a,b]

For the first experiments, a but-4-en-1-yl residue was chosen for the addition reactions to 4-methylpyridine (**5a**). When 4-methylpyridine (**5a**) was treated with TIPSOTf (1.1 equiv) in CH_2Cl_2 at 20 °C for 15 min to generate the pyridinium ion **6a** and subsequently with di(but-3-en-1-yl)magnesium (2 equiv in THF/Et_2O, 1:1) at –78 °C followed by slowly warming the reaction mixture to –50 °C (Table 1, entry 1), the desired 1,4-dihydropyridine **7a** could be obtained in a yield of 22%. Similar low yields had been observed before for the addition of allyl residues to 4-substituted pyridines after prior N-silylation.[10] However, to our delight with a ratio of 81:19 in favor of the 1,4-dihydropyridine **7a** as compared to the 1,2-dihydropyridine **8a**, the regioselectivity was quite satisfying.

In subsequent reactions, the crude reaction products obtained after aqueous workup were analyzed with regard to their composition by ^{1}H NMR spectroscopy using 2,4,6-collidine as internal standard for quantification. That way the amount of formed 1,4-dihydropyridine **7a** could be directly determined ('NMR' yield). In addition, at the same time also the amount of formed 1,2-dihydropyridine **8a** could be directly specified, which was otherwise strongly impeded as 1,2-dihydropyridines are generally higher susceptible to oxidation typically resulting in the formation of the corresponding aromatic systems.

Though in case of the addition of a *tert*-butyl moiety to a *N*-silylpyridinium ion lowering the temperature from –78 °C to –85 °C had been found beneficial with regard to the yield of the 1,4-addition product,[13a] the opposite was true in the present case employing di(but-3-en-1-yl)magnesium as nucleophile. When the addition of di(but-3-en-1-yl)magnesium to **6a** was performed at –85 °C, only a diminished yield of 8% was obtained (Table 1, entry 2 vs. entry 1).[13a] Hence, in further experiments pyridinium ion **6a** was treated with di(but-3-en-1-yl)magnesium at –60 °C, –40 °C, and –30 °C, respectively (Table 1, entries 3–5). Thereby, the yield for the 4-addition product **7a** rose from 29% (Table 1, entry 3) to 33% (Table 1, entry 4), and finally to 41% (Table 1, entry 5). Additionally, in all three experiments an improved regioselectivity of 92:8 independent from the

Table 1 Optimization of the Addition of Di(but-3-en-1-yl)magnesium to *N*-TIPS 4-Methylpyridinium Triflate **6a**



5a **6a** **7a** **8a**

Entry	R_2Mg (equiv)	Temp (°C)	Time (h)	NMR yield (%)[a]			NMR ratio of **7a**/**8a**[a]	Isolated yield of **7a** (%)
				7a	**8a**	Total		
1	2.0	–78 to –50	2	–[b]	–[b]	–[b]	81:19[c]	22
2	2.0	–85	2	6	–[d]	6	–[d]	8
3	2.0	–60	2	29	2	31	92:8	29
4	2.0	–40	2	34	3	37	92:8	33
5	2.0	–30	2	43	4	47	92:8	41
6	2.0	0	2	45	4	49	92:8	–[e]
7	1.1	–30	2	41	4	45	92:8	42
8	0.55	–30	2	44	4	48	91:9	44
9	1.1	–30	18	44	2	46	96:4	44

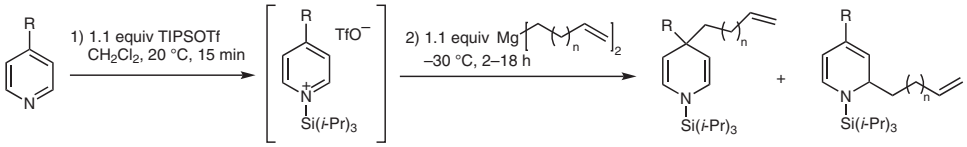
[a] The yield of **7a** and **8a** in the crude product and the product ratio were determined by ^{1}H NMR spectroscopy with 2,4,6-collidine as internal standard. Upward deviations of the isolated yield from the NMR yield are within the expected accuracy of measurement. [14]
[b] Not determined.
[c] Determined using ^{1}H NMR spectroscopy without internal standard.
[d] Not determinable due to low signal intensity.
[e] Not determinable due to the formation of inseparable side products.

reaction temperature was observed (Table 1, entries 3–5). A further increase of the temperature to 0 °C led only to a minor improvement of the NMR yield (compare Table 1, entries 5 and 6) with the regioselectivity being unchanged. However, due to extensive formation of inseparable side products, this result could not be confirmed as no pure product could be isolated. Hence, a temperature of –30 °C was considered best for performing trapping reactions of intermediate pyridinium ions such as **6a** and was therefore applied for further experiments.

In order to render the trapping reactions of the pyridinium ions more economic, it was intended to reduce the equivalents of the diorganomagnesium species employed. Accordingly, in the next experiments only 1.1 or 0.55 equivalents, respectively, of di(but-3-en-1-yl)magnesium have been applied. In both cases, the yield of the main regioisomer **7a**, the 4-addition product, as well as the ratio of regioisomers (**7a**/**8a**) remained largely unchanged in comparison to the reaction performed under identical conditions, but with 2.0 equivalents of di(but-3-en-1-yl)magnesium (Table 1, entries 5, 7, and 8). Also the extension of the reaction time from 2 h to 18 h for the trapping of the intermediate *N*-silylpyridinium ion **6a** with 1.1 equivalents of the diorganomagnesium species (at –30 °C) did not markedly alter the outcome of the reaction (Table 1, entry 9 vs. entry 7), the yield and the regioselectivity being only slightly increased (yield 44%, **7a**/**8a** = 96:4; Table 1, entry 9), indicating that the reaction is mostly complete within 2 h. Though the application of 0.55 equivalents of the diorganomagnesium species for the trapping reaction had actually led to a slightly better product yield (44% vs. 42%), future reactions were intended to be performed with 1.1 equivalents of the diorganomagnesium species as this was thought to be more reliable, whereas 0.55 equivalents should only be used when the organometallic species is tedious to prepare.

Next, the so far developed standard reaction conditions were utilized to perform addition reactions with a set of differently 4-substituted pyridine derivatives including **5a**, i.e., **5a**–**e**, employing diorganomagnesium species exhibiting either allyl, homoallyl, or pent-4-en-1-yl residues as nucleophiles. When the pyridine derivatives **5b**–**e** after activation with 1.1 equivalents of TIPSOTf in CH_2Cl_2 were treated with 1.1 equivalents of di(but-3-en-1-yl)magnesium at –30 °C for 18 h according to the aforementioned standard procedure, the addition products **7b**–**e** and **8b**–**e** were obtained in fair to good overall yields (Table 2, entries 2–5: total NMR yields 40–80%; **7b**–**e** 35–54%). In any case, the desired 1,4-addition products **7b**–**e** were clearly predominating though the regioselectivity observed for the addition of di(but-3-en-1-yl)magnesium to pyridine **5a** of 96:4 (**7a**/**8a** = 96:4, Table 2, entry 1 identical to Table 1, entry 9) had dropped to 76:24 to 88:12 (Table 2, entries 2–5). This reduction of regioselectivity is likely to be attributed to the

Table 2 Trapping of Various 4-Substituted *N*-TIPS-Pyridinium Ions with Di(ω-alkenyl)magnesium Reagents



5a–e **6a–e** **A** **7a–e** **9a–e** **11a–e** **B** **8a–e** **10a–e** **12a–e**

Entry	Starting material		n	Time (h)	Products		NMR yield (%)[a]			NMR ratio of **A**/**B**[a]	Isolated yield of **A** (%)
		R			**A**	**B**	**A**	**B**	**Total**		
1	**5a**	Me	1	18	**7a**	**8a**	44	2[b]	46[b]	96:4[b]	44[b]
2	**5b**	Ph	1	18	**7b**	**8b**	62	18	80	78:22	54
3	**5c**	Bn	1	18	**7c**	**8c**	35	5	40	88:12	35
4	**5d**	4-MeOC$_6$H$_4$	1	18	**7d**	**8d**	45	12	57	79:21	40
5	**5e**	4-MeOC$_6$H$_4$CH$_2$	1	18	**7e**	**8e**	40	12	52	76:24	39
6	**5a**	Me	2	18	**9a**	**10a**	44	1	45	98:2	43
7	**5b**	Ph	2	2	**9b**	**10b**	62	7	69	90:10	59
8	**5c**	Bn	2	18	**9c**	**10c**	38	5	43	88:12	37
9	**5d**	4-MeOC$_6$H$_4$	2	18	**9d**	**10d**	62	17	79	78:22	61
10	**5e**	4-MeOC$_6$H$_4$CH$_2$	2	18	**9e**	**10e**	45	12	57	79:21	41
11	**5a**	Me	0	2	**11a**	**12a**	33	25	58	57:43	35
12	**5b**	Ph	0	2	**11b**	**12a**	35	44	79	44:56	33
13	**5c**	Bn	0	2	**11c**	**12b**	21	47	68	31:69	21
14	**5d**	4-MeOC$_6$H$_4$	0	2	**11d**	**12d**	24	40	60	37:63	23
15	**5e**	4-MeOC$_6$H$_4$CH$_2$	0	2	**11e**	**12e**	22	57	79	28:72	23

[a]The yield of **A** and **B** in the crude product and the product ratio were determined using ^{1}H NMR spectroscopy with 2,4,6-collidine as internal standard. Upward deviations of the isolated yield from the NMR yield are within the expected accuracy of measurement. [14]
[b] Identical to Table 1, entry 9.

increased steric demand of the 4-substitutents in **5b–e** as compared to that of the 4-methyl group in **5a** hampering the addition of the nucleophiles to the 4-position of the *N*-silylpyridinium ions **6b–e**. 1,4-Dihydropyridines **7b–e** could be easily separated from 1,2-dihydropyridines **8b–e** despite their physiochemical similarities. This was accomplished in a two-step sequence by first exposing the crude reaction mixture to air for oxidation, to which the 1,2-dihydropyridines were far more susceptible than the corresponding 1,4-dihydropyridines, the latter of which could then easily be isolated by column chromatography.

The optimized conditions proved also well suited for the addition of a pent-4-en-1-yl moiety to the *N*-silylpyridinium ions **6a–e**. When the *N*-silylpyridinium salts **6a–e** were reacted with di(pent-4-en-1-yl)magnesium, the 1,4- and 1,2-addition products **9a–e** and **10a–e** were obtained in good overall yield. Thereby, the obtained results closely reflect the outcome of the but-4-en-1-yl addition reactions, not only in regard of the overall yield (Table 2, entries 6–10: total NMR yields 43–79%; **9a–e** 37–61%), but also of the regioselectivity (from 78:22 up to 98:2; see Table 2, entries 6–10). Only for the addition of the pent-4-en-1-yl residue to activated pyridinium derivative **5d** an exception was found. In that case, the yields for **9d**/**10d** and pure **9d** were distinctly higher than the yields observed for the addition of di(but-3-en-1-yl)magnesium to this pyridinium salt (Table 2, entry 9 vs. entry 4).

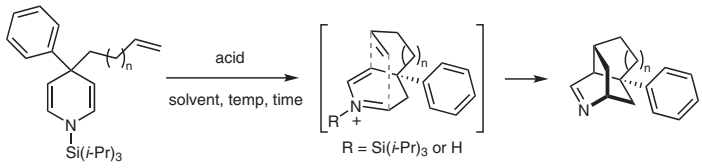
Finally, the optimized reaction conditions were applied to the addition of an allyl moiety to the 4-substituted pyridine derivatives **5a–e** via their iminium salts **6a–e** in order to construct the corresponding 4-allyl-substituted 1,4-dihydropyridines (Table 2, entries 11–15). This had previously proved to be quite challenging since the desired 4-allyl-substituted 1,4-dihydropyridines could be isolated[10,13b] in low yields only, either due to the formation of complex reaction mixtures or due to the preferred 2-addition of the allyl residue.

Although the yields for the 1,4-dihydropyridines **11a–e** (Table 2, entries 11–15) were still in a low range, and the regioselectivity was predominantly on the side of the 2-addition product, significant improvements could be achieved. For the synthesis of the known 4-phenylpyridine-derived 1,4-dihydropyridine **11b** (Table 2, entry 12) the yield rose to 33% (lit. [10b] 20%) and the regioselectivity of 44:56 (lit.[10b] 20:78) was notably shifted towards the formation of the 4-addition product. A raise in yield to 21% (lit.[10b] 12%) and a shift in regioselectivity to 31:69 (lit.[10b] 21:70) could also be observed for the synthesis of the 4-benzyl-substituted 1,4-dihydropyridine **11c** (Table 2, entry 13), albeit to a lesser extent. The differences regarding yield and regioselectivity are likely to be due to the distinctly higher reaction temperature compared to the one applied in the reactions described in literature leading to a, in our case advantageous, less 2-selective addition reaction.[10b,13b] For the addition of an allyl moiety to the 4-methylpyridine (**5a**) derived iminium salt **6a** even a preference for the 1,4-dihydropyridine **11a** could be observed, the ratio of isomers amounting to 57:43 (Table 2, entry 11), which is presumably to be assigned to the lower steric hindrance of the methyl group in iminium salt **6a** as compared to that of the 4-residues in **6b–e**. Within this row, also the syntheses of 1,4-dihydropyridines **11d–e** from the corresponding iminium salts **6d** and **6e** proceeded successfully with yields of 23% and with a ratio of isomers of 37:63 (for **11d**) and 28:72 (for **11e**), respectively.

With the 4-ω-alkenyl-substituted 1,4-dihydropyridines **7a–e**, **9a–e**, and **11a–e** in hand the intramolecular hetero-Diels–Alder reactions of these compounds were studied. Here, as in literature the term hetero-Diels–Alder reaction is used to denote [4+2] cycloaddition reactions independent of whether these reactions proceed via a concerted or stepwise reaction mechanism, an issue not yet clarified for the present and closely related transformation reactions.[10a,12,15]

Intramolecular cycloaddition reactions of 4,4-disubstituted 1,4-dihydropyridines displaying, e.g., an allyl residue in the 4-position of an *N*-silyl-1,4-dihydropyridine under acid-catalyzed reaction conditions have already been reported before by us (see example from literature; Table 3, entry 1).[10a] Thereby, the respective *N*-silyl-1,4-dihydropyridines were treated with hydrogen chloride in ethanol at 80 °C for 1 h. When these conditions were applied to 1,4-dihydropyridine **7b** exhibiting in addition to a phenyl residue a but-3-en-1-yl moiety in 4-position and therefore being structurally closely related to dihydropyridine **11b** after a reaction time of 60 min, the desired 3-phenyl-9-azatricyclo[4.3.1.$0^{3,7}$]dec-8-en (*rac*-**14b**) was obtained in good yield of 78% (Table 3, entry 2). As a control of the reaction progress by TLC had indicated that the reaction had gone to completion quite rapidly, i.e., within a few minutes, it appeared appropriate to test milder reaction conditions. Hence, the reaction temperature was reduced from 80 °C to 30 °C.

Table 3 Cyclization of 4-Alkenyl-Substituted 1,4-Dihydropyridines under Varying Conditions



7b, **9b**, **11b** *rac*-**13b**, *rac*-**14b**, *rac*-**15b**

Entry	Dihydropyridine	n	Acid (equiv)	Solvent	Temp (°C)	Time (min)	Product	Yield (%)
1	**11b**	0	HCl (10)	EtOH	80	60	*rac*-**13b**	63[a]
2	**7b**	1	HCl (10)	EtOH	80	60	*rac*-**14b**	78[b]
3	**7b**	1	HCl (10)	EtOH	30	15	*rac*-**14b**	94
4	**9b**	2	HCl (10)	EtOH	30	15	*rac*-**15b**	decomp.
5	**9b**	2	AcOH (10)	CH_2Cl_2	20	15	*rac*-**15b**	decomp.
6	**9b**	2	TfOH (10)	CH_2Cl_2	20	15	*rac*-**15b**	traces
7	**9b**	2	TFA (10)	CH_2Cl_2	20	15	*rac*-**15b**	21
8	**9b**	2	TFA (5)	MeOH	20	15	*rac*-**15b**	decomp.
9	**9b**	2	TFA (15)	pentane	20	15	*rac*-**15b**	74

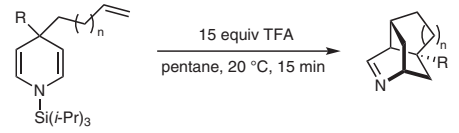
a Data obtained from the literature.[10a]
b Conditions adopted from the literature. [10a]

This led to an excellent yield of 94% whereby a reaction time of 15 min was fully sufficient (Table 3, entry 3). As reported for the cycloaddition for related reaction systems, also in the present case no regioisomers of *rac*-**14b** could be detected.[10a] Surprisingly, attempts to cyclize 1,4-dihydropyridine **9b** exhibiting a pent-4-en-1-yl moiety in 4-position under the same conditions at 30 °C gave rise to decomposition products only (Table 3, entry 4). Therefore, in a series of experiments, 1,4-dihydropyridine **9b** was subjected to varying reaction conditions, in order to identify those that might affect the desired cycloaddition reaction to *rac*-**15b** and possibly be suitable for this type of transformation in general.

In the next experiments, EtOH was replaced by CH_2Cl_2 as solvent and instead of HCl (10 equiv) acetic acid (10 equiv) and trifluoromethanesulfonic acid (10 equiv), respectively, were used. In the case of acetic acid again only decomposition products could be observed after a reaction time of 15 min though the reaction temperature had been further lowered to 20 °C, whereas with trifluoromethanesulfonic acid traces of the product could be identified in the crude reaction product by ^{1}H NMR spectroscopy. Indicating that a less strong acid might be necessary, the cyclization was carried out with trifluoroacetic acid under otherwise identical reaction conditions yielding 21% of the desired cyclization product *rac*-**15b** (Table 3, entry 7). When CH_2Cl_2 was again replaced by MeOH, a cyclization attempt carried out with trifluoroacetic acid (Table 3, entry 8) as before, except that the acid equivalents were reduced from 10 to 5 equivalents, led to decomposition products only. Hence as a consequence, a far less polar solvent, i.e., pentane, should be tested as reaction solvent. Indeed, when the cyclization of dihydropyridine **9b** was attempted in pentane with trifluoroacetic acid (15 equiv) at 20 °C, the desired tricyclic imine *rac*-**15b** could be obtained in a good yield, i.e., 74% (Table 3, entry 9). Application of fewer equivalents of trifluoroacetic acid (i.e., 5 or 10 equiv) led to a reduced conversion and increased side-product formation as was determined by ^{1}H NMR spectroscopic analysis of the crude reaction products.

The reaction conditions so far developed for the cyclization of dihydropyridine **9b** were then applied to the 1,4-dihydropyridines **9a** and **9c–e** analogous to **9b**, but differing from the latter with regard to the second non-pent-4-en-1-yl substituent in 4-position (**9a**: R = Me, **9c**: R = Bn, **9d**: R = 4-$MeOC_6H_4$; **9e**: R = 4-$MeOC_6H_4CH_2$, Table 4). When the 1,4-dihydropyridines **9a** and **9c–e** (see Table 2) were subjected to the aforementioned standard conditions, i.e., trifluoroacetic acid (15 equiv) in pentane at 20 °C for 15 min, the intramolecular cyclization afforded *rac*-**15a** and *rac*-**15c–e** in moderate to very good yields (Table 4, entries 1–4, 54–89%). Next, to check whether the newly found reaction conditions are suitable for the intramolecular hetero-Diels–Alder reaction in general, the latter was also carried out with the 1,4-dihydropyridines **7a–e** bearing a but-3-en-1-yl residue (Table 4, entries 5–9) and **11a–e** (Table 4, entries 10–14) exhibiting an allyl moiety. The formation of the desired tricyclic imines *rac*-**14a–e** from the 4-homoallyl-substituted 1,4-dihydropyridines **7a–e** proceeded successfully in very good yields (79–89%, Table 4, entries 5–9) with the new standard method.

Table 4 Synthesis of Various Tricyclic Imines



7a–e, **9a**, **9c–e**, **11a–e** *rac*-**13a–e**, *rac*-**14a–e**, *rac*-**15a**,**c–e**

Entry	1,4-Dihydropyridine	R	n	Product	Yield (%)
1	**9a**	Me	2	*rac*-**15a**	77
2	**9c**	Bn	2	*rac*-**15c**	74
3	**9d**	4-$MeOC_6H_4$	2	*rac*-**15d**	54
4	**9e**	4-$MeOC_6H_4CH_2$	2	*rac*-**15e**	89
5	**7a**	Me	1	*rac*-**14a**	79
6	**7b**	Ph	1	*rac*-**14b**	84
7	**7c**	Bn	1	*rac*-**14c**	86
8	**7d**	4-$MeOC_6H_4$	1	*rac*-**14d**	89
9	**7e**	4-$MeOC_6H_4CH_2$	1	*rac*-**14e**	85
10	**11a**	Me	0	*rac*-**13a**	84
11	**11b**	Ph	0	*rac*-**13b**	85
12	**11c**	Bn	0	*rac*-**13c**	83
13	**11d**	4-$MeOC_6H_4$	0	*rac*-**13d**	85[a]
14	**11e**	4-$MeOC_6H_4CH_2$	0	*rac*-**13e**	67[a]

[a]Pentane/EtOH, 4:1 was used as the solvent system.

Comparing the cyclization of 1,4-dihydropyridine **7b** under the former already published[10a] (EtOH, HCl, see Table 3, entries 2 and 3) and the newly developed cyclization conditions (see Table 4, entry 6) revealed that with the new standard method (TFA, pentane) an increase in yield (84% vs. 78%) was achieved in comparison to the literature known method[10a] (Table 4, entry 6 vs. Table 3, entry 2). Though the previously achieved excellent yield of 94% for the tricyclic imine *rac*-**14b**, obtained under the adapted literature method[10a] (see Table 3, entry 3), could not be reached with the new standard method. The decrease in yield to 84% was acceptable considering the broader applicability of the new method, which was proven by the successful cyclization of the 4-allyl-substituted 1,4-dihydropyridines **11a–e**. Good to very good yields (67–85%) were obtained for the formation of the tricyclic imines *rac*-**13a–e**. The syntheses of the known 4-azatricyclo-[3.3.1.0^{2,7}]non-3-enes *rac*-**13b** and *rac*-**13c** (Table 4, entries 11 and 12) resulted in yields of 85% (lit.[10a] 63%) and

83% (lit.[10a] 92%), respectively, showing a significant improvement in the first case and only a marginally worse result in the second one compared to our previously described cyclization method.[10a]

In conclusion, we have successfully synthesized a series of 4-ω-alkenyl-substituted 1,4-DHP that were employed in subsequent cyclization reactions yielding the corresponding tricyclic imines. The approach introduced is the first one to focus on the addition of ω-alkenyl-moieties of varying chain length to the 4-position of already 4-substituted pyridine derivatives in order to provide 4,4-disubstituted 1,4-DHP. To the current state of knowledge, the obtained yields and regioselectivities for the C-4 addition products are superior to all literature methods. The intermediate ω-alkenyl-substituted 1,4-DHP derivatives proved to be excellent precursors for a smooth intramolecular hetero-Diels–Alder reaction which provided various tricyclic imines with high yield. The therefore newly developed cyclization method is easy, fast, and broadly applicable to the synthesis of miscellaneous tricyclic ring systems with a 2-azabicyclo[2.2.2]octane scaffold.

All anhydrous reactions were performed under an argon atmosphere in oven-dried glassware. Solvents were distilled prior to use and THF, Et_2O, 1,4-dioxane, and CH_2Cl_2 were dried according to standard procedures under a nitrogen atmosphere.[16] All chemicals were used as purchased from the supplier without further purification. TLC plates purchased from Merck KGaA (silica gel 60 F254 or aluminum oxide 60 F254 on aluminum sheets, neutral) were employed as the stationary phase. Flash chromatography was conducted with silica gel 60 (40–63 µm mesh size) from Merck KGaA or with activated basic alumina Brockmann I (150 µm mesh size) from Sigma-Aldrich, which was adjusted to Brockmann III activity grade prior to use.[17] For the determination of melting points a BÜCHI 510 melting point apparatus was used. All melting points are uncorrected. Infrared spectra of solid substances were measured as KBr pellets and oils as film with a Perkin Elmer Paragon 1000 and a Jasco FT/IR-410. HRMS was carried out with a Finnigan LTQ FT (ESI) and a Finnigan MAT 95 (EI). ^{1}H NMR and ^{13}C NMR spectra were recorded with a Avance III HD Bruker BioSpin (400 or 500 MHz) and referenced to the solvent residual peak as internal standard and analyzed with MestReNova (Version 12.0.0 – 20080; Mestrelab Research S.L.; released 26.09.2017).[18] 4-(4-Methoxybenzyl)pyridine (**5e**) was synthesized according to literature.[19]

Procedures

Preparation of Diorganomagnesium Solutions

Commercially available allylmagnesium chloride (2 m in THF) was diluted to a concentration of 1 m with THF and converted into di(allyl)magnesium with 1,4-dioxane according to the procedure mentioned below.

Magnesium turnings (1.5 equiv) were covered with THF (0.13 mL/mmol), and a solution of the organic halide (1.0 equiv) in THF (0.8 mL/mmol) was added dropwise to keep the reaction mixture boiling mildly. After complete addition stirring was continued for 1 h at 20 °C followed by addition of 1,4-dioxane (1.1 equiv) and further stirring for 1 h at 20 °C. The resulting suspension was centrifuged (30 min, 3000 g), the supernatant was separated, and the remaining slurry was suspended in Et_2O to retrieve the same volume as before. Centrifugation was repeated (30 min, 3000 g), and the supernatants were combined. The concentration of the diorganomagnesium solution was determined according to Yong et al.[20]

Synthesis of 4,4-Disubstituted 1-*N*-Triisopropylsilyl-1,4-dihydropyridines; General Procedure (GP1)

To a solution of the 4-substituted pyridine derivative in CH_2Cl_2 (0.86 mL/mmol) was added TIPSOTf (1.1 equiv). After stirring for 15 min at r.t., the resulting mixture was cooled to –30 °C and the corresponding R_2Mg solution (1.1 equiv) was added dropwise. The reaction was quenched after the time indicated by the addition of water (10 mL/mmol), and the aqueous layer was extracted with CH_2Cl_2 (3 × 10 mL/mmol). The organic layers were combined, dried over $MgSO_4$, and concentrated under vacuum. Quantification of the dihydropyridines in the crude product was done by ^{1}H NMR spectroscopy using 2,4,6-collidine as internal standard. The crude material was stirred under air for the period specified to oxidize side products and then purified by flash chromatography (FC).

Synthesis of Tricyclic Imines; General Procedure (GP2)

TFA (15 equiv) was added to a solution of the 4,4-disubstituted 1-*N*-triisopropylsilyl-1,4-dihydropyridine (1.0 equiv) in pentane (10 mL/mmol) in one portion, and the resulting mixture was stirred for 15 min at 20 °C. The reaction was quenched by the addition of K_2CO_3 (8 equiv), and a 1:1 mixture of 2 M $HCl_{aq.}$ and EtOH (40 mL/mmol) was added. The solution was washed with pentane (6 × 20 mL/mmol) and adjusted to pH = 9 with K_2CO_3. The aqueous layer was extracted with CH_2Cl_2 (4 × 20 mL/mmol), the organic layers were combined, dried over Na_2SO_4, and the solvent was removed under vacuum. The crude product was purified by FC.

4-(4-Methoxyphenyl)pyridine (5d)

Pyridine (1.45 g, 18.3 mmol, 1.47 mL) was dissolved in CH_2Cl_2 (22 mL) at 20 °C, and TIPSOTf (6.35 g, 20.1 mmol, 5.57 mL) was added. The solution was stirred for 15 min, cooled to –78 °C, and a solution of di(4-methoxyphenyl)magnesium (0.46 M in THF/Et_2O, 1:1, 20.1 mmol, 44 mL) was added dropwise. Stirring was continued for 12 h within the reaction mixture was slowly warmed to –50 °C. The reaction was stopped by the addition of H_2O (100 mL) and subsequently extraction with CH_2Cl_2 (4 × 100 mL) followed. The organic phases were combined, dried ($MgSO_4$), and the solvent was removed under vacuum. The neat intermediate product was stirred under air at 20 °C for 96 h, dissolved in CH_2Cl_2 (50 mL), and extracted with 2M HCl (5 × 80 mL). The combined aqueous phases were washed with Et_2O (2 × 80 mL), the pH was adjusted to 9 with K_2CO_3, and the aqueous layer was extracted with CH_2Cl_2 (4 × 80 mL). Combination of the CH_2Cl_2 phases following drying with $MgSO_4$ and removal of the solvent under vacuum provided the product which was purified by FC (SiO_2; EtOAc/MeOH, 97:3).

Yield: 2.25 g (66%); colorless solid; mp 93 °C; R_f = 0.45 (SiO_2, EtOAc/MeOH, 97:3).

IR (film): 3084, 2968, 2937, 2841, 1606, 1523, 1487, 1286, 1255, 1227, 1188, 1036, 1016, 810, 569, 499 cm^{-1}.

^{1}H NMR (500 MHz, CD_2Cl_2): δ = 3.85 (s, 3 H, OCH_3), 6.99–7.04 (m, 2 H, CHC*H*COCH$_3$), 7.46–7.50 (m, 2 H, NCHC*H*), 7.61–7.65 (m, 2 H, C*H*CHCOCH$_3$), 8.56–8.60 (m, 2 H, NC*H*CH).

^{13}C NMR (125 MHz, CD_2Cl_2): δ = 55.9 (CH_3), 115.0 (CHCHCOCH$_3$), 121.4 (NCHCH), 128.6 (CHCHCOCH$_3$), 130.8 (CCHCHCOCH$_3$), 148.1 (NCHCHC), 150.8 (NCHCH), 161.2 ($COCH_3$).

HRMS (EI): *m/z* [M$^+$] calcd for $C_{12}H_{11}NO$: 185.0835; found: 185.0833.

The analytical data accord with the literature.[21]

4-(But-3-en-1-yl)-4-methyl-1-triisopropylsilyl-1,4-dihydropyridine (7a)

Synthesis according to GP1 from 4-methylpyridine (**5a**, 93 mg, 1.00 mmol, 97 μL), TIPSOTf (337 mg, 1.00 mmol, 296 μL), and di(but-3-en-1-yl)magnesium (0.23 m in THF/Et_2O, 1:1, 1.10 mmol, 4.78 mL). The reaction was stopped after 18 h. Quantitative determination indicated 135 mg (44%) of dihydropyridine **7a** followed by stirring under air for 1 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **7a**.

Yield: 134 mg (44%); colorless oil; R_f = 0.97 (Al_2O_3; pentane).

IR (film): 3076, 3039, 2945, 2868, 1668, 1639, 1601, 1464, 1286, 1074, 974, 883, 733, 669 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.02 (s, 3 H, CH_3), 1.08 (d, *J* = 7.2 Hz, 18 H, CH(CH_3)$_2$), 1.18–1.29 (m, 5 H, CH_2CH$_2$CH, CH(CH$_3$)$_2$), 2.00–2.09 (m, 2 H, CH$_2$CH_2CH), 4.15–4.20 (m, 2 H, NCHCH), 4.88 (ddt, *J* = 10.2, 2.3, 1.3 Hz, 1 H, CH$_2$CH$_2$CHCH_2^a), 4.94–5.01 (m, 1 H, CH$_2$CH$_2$CHCH_2^b), 5.88 (ddt, *J* = 16.8, 10.2, 6.6 Hz, 1 H, CH$_2$CHCH$_2$), 5.96–6.01 (m, 2 H, NCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 (CH(CH$_3$)$_2$), 18.0 (CH(CH_3)$_2$), 31.0 (CH$_2$CH_2CH), 33.8 (CH_3), 33.9 (CCH_3), 45.1 (CH_2CH$_2$CH), 107.8 (NCHCH), 113.4 (CH$_2$CH$_2$CHCH_2), 128.3 (NCHCH), 140.5 (CH$_2$CHCH$_2$).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{19}H_{36}NSi$: 306.2612; found: 306.2610.

4-(But-3-en-1-yl)-4-phenyl-1-triisopropylsilyl-1,4-dihydropyridine (7b)

Synthesis according to GP1 from 4-phenylpyridine (**5b**, 686 mg, 4.42 mmol), TIPSOTf (1.48 g, 4.86 mmol, 1.31 mL), and di(but-3-en-1-yl)magnesium (0.27 m in THF/Et_2O, 1:1, 4.86 mmol, 18.0 mL). The reaction was stopped after 18 h. Quantitative determination indicated 1.00 g (62%) of dihydropyridine **7b** followed by stirring under air for 2 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **7b**.

Yield: 882 mg (54%); orange solid; mp 46 °C; R_f = 0.57 (Al_2O_3; pentane).

IR (KBr): 3076, 3053, 2945, 2866, 1666, 1460, 1286, 1076, 1053, 972, 906, 885, 690, 521 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.11 (d, *J* = 7.3 Hz, 18 H, CH(CH_3)$_2$), 1.22–1.34 (m, 3 H, CH(CH$_3$)$_2$), 1.71–1.79 (m, 2 H, CH_2CH$_2$CH), 2.10–2.19 (m, 2 H, CH$_2$CH_2CH), 4.40 (d, *J* = 7.4 Hz, 2 H, NCHCH), 4.94 (ddd, *J* = 10.2, 1.9, 1.0 Hz, 1 H, CH$_2$CH$_2$CHCH_2^a), 5.00–5.08 (m, 1 H, CH$_2$CH$_2$CHCH_2^b), 5.95 (ddt, *J* = 16.8, 10.2, 6.5 Hz, 1 H, CH$_2$CHCH$_2$), 6.14 (d, *J* = 7.5 Hz, 2 H, NCHCH), 7.15 (t, *J* = 7.3 Hz, 1 H, CCHCHCH), 7.33 (t, *J* = 7.5 Hz, 2 H, CCHCHCH), 7.42 (d, *J* = 8.3 Hz, 2 H, CCHCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 (CH(CH$_3$)$_2$), 18.0 (CH(CH_3)$_2$), 30.9 (CH$_2$CH_2CH), 41.7 (CCH_2CH$_2$), 42.3 (CH_2CH$_2$CH), 106.3 (NCHCH), 113.8 (CH$_2$CH$_2$CHCH_2), 125.4 (CCHCHCH), 126.8 (CCHCHCH), 128.2 (CCHCHCH), 128.3 (NCHCH), 140.1 (CH$_2$CHCH$_2$), 152.5 (CCHCHCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{24}H_{38}NSi$: 368.2768; found: 368.2766.

4-(But-3-en-1-yl)-4-benzyl-1-triisopropylsilyl-1,4-dihydropyridine (7c)

Synthesis according to GP1 from 4-benzylpyridine (**5c**, 748 mg, 4.42 mmol, 0.71 mL), TIPSOTf (1.48 g, 4.86 mmol, 1.31 mL), and di(but-3-en-1-yl)magnesium (0.27 m in THF/Et_2O, 1:1, 4.86 mmol, 18.0 mL). The reaction was stopped after 18 h. Quantitative determination indicated 590 mg (35%) of dihydropyridine **7c** followed by stirring under air for 1 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **7c**.

Yield: 557 mg (33%); colorless solid; mp 39 °C; R_f = 0.88 (Al_2O_3; pentane).

IR (KBr): 3061, 3028, 2943, 2866, 1670, 1462, 1288, 1063, 972, 881, 746, 698, 661, 499 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.98 (d, *J* = 7.3 Hz, 18 H, CH(CH_3)$_2$), 1.09–1.21 (m, 3 H, CH(CH$_3$)$_2$), 1.27–1.34 (m, 2 H, CH_2CH$_2$CH), 2.03–2.13 (m, 2 H, CH$_2$CH_2CH), 2.54 (s, 2 H, CCH$_2$C), 4.07–4.13 (m, 2 H, NCHCH), 4.90 (ddt, *J* = 10.2, 2.3, 1.2 Hz, 1 H, CH$_2$CH$_2$CHCH_2^a), 4.96–5.03 (m, 1 H, CH$_2$CH$_2$CHCH_2^b), 5.90 (ddt, *J* = 17.1, 10.3, 6.6 Hz, 1 H, CH$_2$CHCH$_2$), 5.92–5.97 (m, 2 H, NCHCH), 7.10–7.15 (m, 3 H, CCHCHCH, CCHCHCH), 7.17–7.23 (m, 2 H, CCHCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.5 (CH(CH$_3$)$_2$), 17.9 (CH(CH_3)$_2$), 31.4 (CH$_2$CH_2CH), 39.8 (CCH_2CH$_2$), 43.4 (CH_2CH$_2$CH), 52.3 (CCH_2C), 105.9 (NCHCH), 113.5 (CH$_2$CH$_2$CHCH_2), 125.6 (CCHCHCH), 127.4 (CCHCHCH), 129.3 (NCHCH), 131.1 (CCHCHCH), 139.2 (CCHCHCH), 140.4 (CH$_2$CHCH$_2$).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{25}H_{40}NSi$: 382.2925; found: 382.2922.

4-(But-3-en-1-yl)-4-(4-methoxyphenyl)-1-triisopropylsilyl-1,4-dihydropyridine (7d)

Synthesis according to GP1 from 4-(4-methoxyphenyl)pyridine (**5d**, 648 mg, 3.50 mmol), TIPSOTf (1.18 g, 3.85 mmol, 1.03 mL), and di(but-3-en-1-yl)magnesium (0.27 m in THF/Et_2O, 1:1, 3.85 mmol, 14.3 mL). The reaction was stopped after 18 h. Quantitative determination indicated 626 mg (45%) of dihydropyridine **7d** followed by stirring under air for 2 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **7d**.

Yield: 559 mg (40%); colorless solid; mp 54 °C; R_f = 0.13 (Al_2O_3; pentane).

IR (KBr): 3076, 3051, 2951, 2868, 1668, 1508, 1290, 1254, 1176, 1059, 976, 833, 692, 665, 501 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.11 (d, *J* = 7.4 Hz, 18 H, CH(CH_3)$_2$), 1.28 (sept, *J* = 7.4 Hz, 3 H, CH(CH$_3$)$_2$), 1.69–1.75 (m, 2 H, CH_2CH$_2$CH), 2.10–2.18 (m, 2 H, CH$_2$CH_2CH), 3.80 (s, 3 H, OCH_3), 4.33–4.38 (m, 2 H, NCHCH), 4.94 (ddt, *J* = 10.2, 2.2, 1.1 Hz, 1 H, CH$_2$CH$_2$CHCH_2^a), 5.00–5.08 (m, 1 H, CH$_2$CH$_2$CHCH_2^b), 5.95 (ddt, *J* = 16.8, 10.2, 6.6 Hz, 1 H, CH$_2$CHCH$_2$), 6.10–6.15 (m, 2 H, NCHCH), 6.85–6.90 (m, 2 H, CHC(OCH$_3$)), 7.30–7.36 (m, 2 H, CHCHC(OMe)).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.6 (CH(CH$_3$)$_2$), 18.0 (CH(CH_3)$_2$), 31.0 (CH$_2$CH_2CH), 41.0 (CCH_2CH$_2$), 42.2 (CH_2CH$_2$CH), 55.4 (CH_3), 106.6 (NCHCH), 113.5 (CHC(OCH$_3$)), 113.7 (CH$_2$CH$_2$CHCH_2), 127.8 (CHCHC(OCH$_3$)), 128.1 (NCHCH), 140.2 (CH$_2$CHCH$_2$), 145.1 (CCHCHC(OCH$_3$)), 157.3 ($COCH_3$).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{25}H_{40}NOSi$: 398.2874; found: 398.2872.

4-(But-3-en-1-yl)-4-4-methoxybenzyl)-1-triisopropylsilyl-1,4-dihydropyridine (7e)

Synthesis according to GP1 from 4-(4-methoxybenzyl)pyridine (**5e**, 598 mg, 3.00 mmol), TIPSOTf (1.01 g, 3.30 mmol, 0.89 mL), and di(but-3-en-1-yl)magnesium (0.26 m in THF/Et_2O, 1:1, 3.30 mmol, 12.7 mL). The reaction was stopped after 18 h. Quantitative determination indicated 494 mg (40%) of dihydropyridine **7e** followed by stirring under air for 2 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **7e**.

Yield: 483 mg (39%); colorless solid; mp 45 °C; R_f = 0.18 (Al_2O_3; pentane).

IR (KBr): 3084, 3037, 2949, 2864, 2360, 1670, 1510, 1286, 1240, 1063, 972, 881, 768, 690, 662, 499 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 0.98 (d, *J* = 7.4 Hz, 18 H, $CH(CH_3)_2$), 1.10–1.20 (m, 3 H, $CH(CH_3)_2$), 1.25–1.32 (m, 2 H, CH_2CH_2CH), 2.03–2.12 (m, 2 H, CH_2CH_2CH), 2.47 (s, 2 H, CCH_2C), 3.76 (s, 3 H, CH_3), 4.05–4.10 (m, 2 H, NCHCH), 4.90 (ddt, *J* = 10.2, 2.3, 1.2 Hz, 1 H, $CH_2CH_2CHCH_2^a$), 4.96–5.03 (m, 1 H, $CH_2CH_2CHCH_2^b$), 5.89 (ddt, *J* = 17.1, 10.3, 6.6 Hz, 1 H, CH_2CHCH_2), 5.92–5.96 (m, 2 H, NCHCH), 6.73–6.79 (m, 2 H, $CHC(OCH_3)$), 7.01–7.06 (m, 2 H, CHCHC(OMe)).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.5 ($CH(CH_3)_2$), 17.9 ($CH(CH_3)_2$), 31.4 (CH_2CH_2CH), 39.8 (CCH_2CH_2), 43.3 (CH_2CH_2CH), 51.3 (CCH_2C), 55.3 (OCH_3), 105.9 (NCHCH), 112.9 ($CHC(OCH_3)$), 113.5 ($CH_2CH_2CHCH_2$), 129.3 (NCHCH), 131.4 ($CCHCHC(OCH_3)$), 131.9 ($CHCHC(OCH_3)$), 140.5 (CH_2CHCH_2), 157.8 ($COCH_3$).

HRMS (ESI): *m/z* $[M + H]^+$ calcd for $C_{26}H_{42}NOSi$: 412.3030; found: 412.3028.

4-Methyl-4-(pent-4-en-1-yl)-1-triisopropylsilyl-1,4-dihydropyridine (9a)

Synthesis according to GP1 from 4-methylpyridine (**5a**, 279 mg, 3.00 mmol, 290 µL), TIPSOTf (1.01 g, 3.30 mmol, 0.89 mL), and di(pent-4-en-1-yl)magnesium (0.23 m in THF/Et_2O, 1:1, 3.30 mmol, 14.5 mL). The reaction was stopped after 18 h. Quantitative determination indicated 422 mg (44%) of dihydropyridine **9a** followed by stirring under air for 1 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **9a**.

Yield: 414 mg (43%); colorless oil; R_f = 0.90 (Al_2O_3; pentane).

IR (film): 3078, 3039, 2945, 2868, 1668, 1462, 1286, 1076, 370, 883, 731, 665 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 1.00 (s, 3 H, CH_3), 1.08 (d, *J* = 7.2 Hz, 18 H, $CH(CH_3)_2$), 1.10–1.17 (m, 2 H, $CH_2CH_2CH_2CH$), 1.18–1.28 (m, 3 H, $CH(CH_3)_2$), 1.35–1.44 (m, 2 H, CH_2CH_2CH), 1.99–2.08 (m, 2 H, CH_2CH_2CH), 4.14–4.20 (m, 2 H, NCHCH), 4.91 (ddt, *J* = 10.2, 2.3, 1.3 Hz, 1 H, $CH_2CH_2CHCH_2^a$), 4.94–5.01 (m, 1 H, $CH_2CH_2CHCH_2^b$), 5.81 (ddt, *J* = 16.8, 10.2, 6.6 Hz, 1 H, CH_2CHCH_2), 5.94–6.00 (m, 2 H, NCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 ($CH(CH_3)_2$), 18.1 ($CH(CH_3)_2$), 25.6 ($CH_2CH_2CH_2$), 33.8 (CCH_3), 33.8 (CCH_3), 34.5 (CH_2CH_2CH), 45.5 ($CH_2CH_2CH_2CH$), 108.2 (NCHCH), 113.9 ($CH_2CH_2CHCH_2$), 128.0 (NCHCH), 139.7 (CH_2CHCH_2).

HRMS (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{38}NSi$: 320.2768; found: 320.2767.

4-(Pent-4-en-1-yl)-4-phenyl-1-triisopropylsilyl-1,4-dihydropyridine (9b)

Synthesis according to GP1 from 4-phenylpyridine (**5b**, 310 mg, 2.00 mmol), TIPSOTf (674 mg, 2.20 mmol, 590 µL), and di(pent-4-en-1-yl)magnesium (0.28 m in THF/Et_2O, 1:1, 2.20 mmol, 7.9 mL). The reaction was stopped after 2 h. Quantitative determination indicated 473 mg (62%) of dihydropyridine **9b** followed by stirring under air for 1 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **9b**.

Yield: 451 mg (59%); orange solid; mp 53 °C; R_f = 0.65 (Al_2O_3; pentane).

IR (KBr): 3080, 3051, 2947, 2866, 2362, 1668, 1599, 1464, 1288, 1078, 978, 881, 746, 696, 667, 627, 499 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.11 (d, *J* = 7.5 Hz, 18 H, $CH(CH_3)_2$), 1.28 (sept, *J* = 7.5 Hz, 3 H, $CH(CH_3)_2$), 1.45–1.54 (m, 2 H, CH_2CH_2CH), 1.64–1.71 (m, 2 H, $CH_2CH_2CH_2CH$), 2.09–2.16 (m, 2 H, CH_2CH_2CH), 4.40 (d, *J* = 8.2 Hz, 2 H, NCHCH), 4.92–4.97 (m, 1 H, $CH_2CH_2CHCH_2^a$), 4.98–5.05 (m, 1 H, $CH_2CH_2CHCH_2^b$), 5.80–5.90 (m, 1 H, CH_2CHCH_2), 6.13 (d, *J* = 8.2 Hz, 2 H, NCHCH), 7.12–7.17 (m, 1 H, CCHCHCH), 7.30–7.36 (m, 2 H, CCHCHCH), 7.39–7.44 (m, 2 H, CCHCHCH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.6 ($CH(CH_3)_2$), 18.0 ($CH(CH_3)_2$), 25.5 (CH_2CH_2CH), 34.4 (CH_2CH_2CH), 41.8 (CCH_2), 42.7 (CCH_2), 106.6 (NCHCH), 114.2 ($CH_2CH_2CHCH_2$), 125.3 (CCHCHCH), 126.8 (CCHCHCH), 128.1 (CCHCHCH), 128.2 (NCHCH), 139.5 (CH_2CHCH_2), 152.7 ($CCCH_2$).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{25}H_{39}NSi$: 381.2846; found: 381.2854.

4-Benzyl-4-(pent-4-en-1-yl)-1-triisopropylsilyl-1,4-dihydropyridine (9c)

Synthesis according to GP1 from 4-benzylpyridine (**5c**, 508 mg, 3.00 mmol, 480 µL), TIPSOTf (1.01 g, 3.30 mmol, 0.89 mL), and di(pent-4-en-1-yl)magnesium (0.23 m in THF/Et_2O, 1:1, 3.30 mmol, 14.5 mL). The reaction was stopped after 18 h. Quantitative determination indicated 451 mg (38%) of dihydropyridine **9c** followed by stirring under air for 1 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **9c**.

Yield: 439 mg (37%); colorless solid; mp 39 °C; R_f = 0.70 (Al_2O_3; pentane).

IR (KBr): 3062, 3028, 2947, 2864, 2360, 1670, 1462, 1288, 1061, 972, 908, 881, 698, 661, 619 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 0.98 (d, *J* = 7.4 Hz, 18 H, $CH(CH_3)_2$), 1.15 (sept, *J* = 7.5 Hz, 3 H, $CH(CH_3)_2$), 1.20–1.26 (m, 2 H, CH_2CH_2CH), 1.40–1.49 (m, 2 H, CCH_2CH_2), 2.06 (q, *J* = 7.1 Hz, 2 H, CH_2CH_2CH), 2.52 (s, 2 H, CCH_2C), 4.07–4.12 (m, 2 H, NCHCH), 4.92 (ddt, *J* = 10.2, 2.2, 1.1 Hz, 1 H, $CH_2CH_2CHCH_2^a$), 4.96–5.02 (m, 1 H, $CH_2CH_2CHCH_2^b$), 5.83 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1 H, CH_2CHCH_2), 5.90–5.95 (m, 2 H, NCHCH), 7.09–7.15 (m, 3 H, CCHCHCH, CCHCHCH), 7.17–7.23 (m, 2 H, CCHCHCH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.5 ($CH(CH_3)_2$), 17.9 ($CH(CH_3)_2$), 25.9 (CH_2CH_2CH), 34.5 (CH_2CH_2CH), 39.8 (CCH_2CH_2), 43.8 (CCH_2CH_2), 52.2 (CCH_2C), 106.2 (NCHCH), 114.0 ($CH_2CH_2CHCH_2$), 125.5 (CCHCHCH), 127.4 (CCHCHCH), 129.0 (NCHCH), 131.1 (CCHCHCH), 139.3 (CCHCHCH), 139.7 (CH_2CHCH_2).

HRMS (ESI): *m/z* $[M + H]^+$ calcd for $C_{26}H_{42}NSi$: 396.3081; found: 396.3079.

4-(4-Methoxyphenyl)-4-(pent-4-en-1-yl)-1-triisopropylsilyl-1,4-dihydropyridine (9d)

Synthesis according to GP1 from 4-(4-methoxyphenyl)pyridine (**5d**, 741 mg, 4.00 mmol), TIPSOTf (1.35 g, 4.40 mmol, 1.18 mL), and di(pent-4-en-1-yl)magnesium (0.28 m in THF/Et_2O, 1:1, 4.40 mmol, 15.5 mL). The reaction was stopped after 18 h. Quantitative determination indicated 1.02 g (62%) of dihydropyridine **9d** followed by stirring under air for 2 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **9d**.

Yield: 1.01 g (61%); colorless solid; mp 64 °C; R_f = 0.17 (Al_2O_3; pentane).

IR (KBr): 3080, 2999, 2945, 2867, 1664, 1606, 1506, 1288, 1244, 1188, 1059, 970, 746, 665, 511 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 1.10 (d, *J* = 7.4 Hz, 18 H, $CH(CH_3)_2$), 1.28 (sept, *J* = 7.6 Hz, 3 H, $CH(CH_3)_2$), 1.43–1.53 (m, 2 H, CH_2CH_2CH), 1.60–1.68 (m, 2 H, CCH_2), 2.12 (q, *J* = 7.1 Hz, 2 H, $CH_2CH_2CH_2CH$), 3.79 (s, 3 H, CH_3), 4.35 (d, *J* = 8.2 Hz, 2 H, NCHCH), 4.90–4.96 (m, 1 H, $CH_2CH_2CHCH_2$[a]), 4.97–5.05 (m, 1 H, $CH_2CH_2CHCH_2$[b]), 5.84 (ddt, *J* = 16.8, 10.2, 6.5 Hz, 1 H, CH_2CHCH_2), 6.10 (d, *J* = 8.2 Hz, 2 H, NCHCH), 6.84–6.90 (m, 2 H, $CHC(OCH_3)$), 7.29–7.35 (m, 2 H, $CHCHC(OCH_3)$).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 ($CH(CH_3)_2$), 18.0 ($CH(CH_3)_2$), 25.5 (CH_2CH_2CH), 34.4 (CH_2CH_2CH), 41.0 (CCH_2), 42.7 (CCH_2), 55.4 (OCH_3), 106.9 (NCHCH), 113.5 ($CHC(OCH_3)$), 114.1 ($CH_2CH_2CHCH_2$), 127.8 ($CHCHC(OCH_3)$), 127.9 (NCHCH), 139.6 (CH_2CHCH_2), 145.4 ($CCHCHC(OCH_3)$), 157.3 ($COCH_3$).

HRMS (ESI): *m/z* $[M + H]^+$ calcd for $C_{26}H_{42}NOSi$: 412.3030; found: 412.3026.

4-(4-Methoxybenzyl)-4-(pent-4-en-1-yl)-1-triisopropylsilyl-1,4-dihydropyridine (9e)

Synthesis according to GP1 from 4-(4-methoxybenzyl)pyridine (**5e**, 598 mg, 3.00 mmol), TIPSOTf (1.01 g, 3.30 mmol, 0.89 mL), and di(pent-4-en-1-yl)magnesium (0.28 m in THF/Et_2O, 1:1, 3.30 mmol, 11.6 mL). The reaction was stopped after 18 h. Quantitative determination indicated 577 mg (45%) of dihydropyridine **9e** followed by stirring under air for 2 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **9e**.

Yield: 529 mg (41%); colorless oil; R_f = 0.19 (Al_2O_3; pentane).

IR (film): 2945, 2866, 1670, 1610, 1510, 1464, 1286, 1244, 1176, 1099, 1063, 970, 908, 883 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 0.97 (d, *J* = 7.3 Hz, 18 H, $CH(CH_3)_2$), 1.08–1.19 (m, 3 H, $CH(CH_3)_2$), 1.19–1.25 (m, 2 H, CCH_2CH_2), 1.38–1.49 (m, 2 H, CCH_2CH_2), 2.01–2.11 (m, 2 H, $CH_2CH_2CH_2CH$), 2.45 (s, 2 H, CCH_2C), 3.76 (s, 3 H, CH_3), 4.04–4.10 (m, 2 H, NCHCH), 4.92 (ddt, *J* = 10.2, 2.3, 1.2 Hz, 1 H, $CH_2CH_2CHCH_2$[a]), 4.95–5.03 (m, 1 H, $CH_2CH_2CHCH_2$[b]), 5.83 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1 H, CH_2CHCH_2), 5.89–5.95 (m, 2 H, NCHCH), 6.73–6.78 (m, 2 H, $CHC(OCH_3)$), 7.00–7.06 (m, 2 H, $CHCHC(OCH_3)$).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.5 ($CH(CH_3)_2$), 17.9 ($CH(CH_3)_2$), 25.9 (CCH_2CH_2), 34.5 (CH_2CH_2CH), 39.8 (CCH_2CH_2), 43.8 (CCH_2CH_2), 51.2 (CCH_2C), 55.3 (OCH_3), 106.2 (NCHCH), 112.9 ($CHC(OCH_3)$), 114.0 ($CH_2CH_2CHCH_2$), 129.0 (NCHCH), 131.6 ($CCHCHC(OCH_3)$), 131.9 ($CHCHC(OCH_3)$), 139.8 (CH_2CHCH_2), 157.7 ($COCH_3$).

HRMS (ESI): *m/z* $[M + H]^+$ calcd for $C_{27}H_{44}NOSi$: 426.3187; found: 426.3182.

4-Allyl-4-methyl-1-triisopropylsilyl-1,4-dihydropyridine (11a)

Synthesis according to GP1 from 4-methylpyridine (**5a**, 889 mg, 9.55 mmol, 0.93 mL), TIPSOTf (3.22 g, 10.5 mmol, 2.82 mL), and di(allyl)magnesium (0.36 m in THF/Et_2O, 1:1, 10.5 mmol, 29.5 mL). The reaction was stopped after 2 h. Quantitative determination indicated 919 mg (33%) of dihydropyridine **11a** followed by stirring under air for 3 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **11a**.

Yield: 977 mg (35%); colorless oil; R_f = 0.95 (Al_2O_3; pentane).

IR (film): 3074, 3043, 2947, 2868, 1670, 1600, 1464, 1286, 1076, 1053, 976, 883, 731, 687 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 1.04 (s, 3 H, CCH_3), 1.08 (d, *J* = 7.2 Hz, 18 H, $CH(CH_3)_2$), 1.18–1.30 (m, 3 H, $CH(CH_3)_2$), 1.99 (dt, *J* = 7.2, 1.2 Hz, 2 H, CCH_2CH), 4.21–4.28 (m, 2 H, NCHCH), 4.92–5.01 (m, 2 H, CCH_2CHCH_2), 5.85 (ddt, *J* = 17.0, 10.3, 7.2 Hz, 1 H, CH_2CHCH_2), 5.94–6.00 (m, 2 H, NCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 ($CH(CH_3)_2$), 18.0 ($CH(CH_3)_2$), 32.6 (CCH_3), 33.9 (CCH_3), 50.8 (CCH_2), 108.1 (NCHCH), 115.9 (CCH_2CHCH_2), 128.0 (NCHCH), 136.7 (CH_2CHCH_2).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{18}H_{33}NSi$: 291.2377; found: 291.2375.

4-Allyl-4-phenyl-1-triisopropylsilyl-1,4-dihydropyridine (11b)

Synthesis according to GP1 from 4-phenylpyridine (**5b**, 1.48 g, 9.55 mmol), TIPSOTf (3.22 g, 10.5 mmol, 2.82 mL), and di(allyl)magnesium (0.36 m in THF/Et_2O, 1:1, 10.5 mmol, 29.5 mL). The reaction was stopped after 2 h. Quantitative determination indicated 1.18 g (35%) of dihydropyridine **11b** followed by stirring under air for 4 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **11b**.

Yield: 1.11 g (35%); yellow solid; mp 33 °C; R_f = 0.90 (Al_2O_3; pentane).

IR (KBr): 3049, 2947, 2866, 1666, 1597, 1462, 1288, 1099, 1076, 1043, 978, 881, 762, 690, 663, 519 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 1.10 (d, *J* = 7.4 Hz, 18 H, $CH(CH_3)_2$), 1.27 (sept, *J* = 7.4 Hz, 3 H, $CH(CH_3)_2$), 2.52 (dt, *J* = 7.0, 1.2 Hz, 2 H, CCH_2CH), 4.42–4.48 (m, 2 H, NCHCH), 5.00–5.08 (m, 2 H, CCH_2CHCH_2), 5.83 (ddt, *J* = 17.4, 10.4, 7.0 Hz, 1 H, CH_2CHCH_2), 6.08–6.13 (m, 2 H, NCHCH), 7.15 (tt, 1 H, *J* = 7.5, 1.2 Hz, CCHCHCH), 7.30–7.36 (m, 2 H, CCHCHCH), 7.39–7.43 (m, 2 H, CCHCHCH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.6 ($CH(CH_3)_2$), 18.0 ($CH(CH_3)_2$), 41.6 (CCH_2), 48.2 (CCH_2), 106.5 (NCHCH), 116.4 (CCH_2CHCH_2), 125.4 (CCHCHCH), 126.8 (CCHCHCH), 128.1 (NCHCH), 128.2 (CCHCHCH), 136.5 (CH_2CHCH_2), 151.7 ($CCCH_2$).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{23}H_{35}NSi$: 353.2533; found; 353.2519.

4-Allyl-4-benzyl-1-triisopropylsilyl-1,4-dihydropyridine (11c)

Synthesis according to GP1 from 4-benzylpyridine (**5c**, 1.62 g, 9.55 mmol, 1.52 mL), TIPSOTf (3.22 g, 10.5 mmol, 2.82 mL), and di(allyl)magnesium (0.36 m in THF/Et_2O, 1:1, 10.5 mmol, 29.5 mL). The reaction was stopped after 2 h. Quantitative determination indicated 737 mg (21%) of dihydropyridine **11c** followed by stirring under air for 4 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **11c**.

Yield: 722 mg (21%); colorless oil; R_f = 0.63 (Al_2O_3; pentane).

IR (film): 3082, 3026, 2945, 2866, 1670, 1462, 1284, 1059, 1045, 1016, 991, 972, 920, 883, 743, 689, 662, 623, 511 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 0.98 (d, *J* = 7.4 Hz, 18 H, $CH(CH_3)_2$), 1.10–1.19 (m, 3 H, $CH(CH_3)_2$), 2.09 (d, *J* = 7.1 Hz, 2 H, CCH_2CH), 2.57 (s, 2 H, CCH_2C), 4.14–4.19 (m, 2 H, NCHCH), 4.97–5.05 (m, 2 H, CCH_2CHCH_2), 5.87–5.97 (m, 3 H, CH_2CHCH_2, NCHCH), 7.10–7.16 (m, 3 H, CCHCHCH, CCHCHCH), 7.18–7.24 (m, 2 H, CCHCHCH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.5 ($CH(CH_3)_2$), 17.9 ($CH(CH_3)_2$), 39.5 (CCH_2CH), 49.2 (CCH_2CH), 51.1 (CCH_2C), 106.1 (NCHCH), 116.0 (CCH_2CHCH_2), 125.6 (CCHCHCH), 127.5 (CCHCHCH), 129.0 (NCHCH), 131.1 (CCHCHCH), 136.9 (CH_2CHCH_2), 139.2 (CCHCHCH).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{24}H_{37}NSi$: 367.2690; found: 367.2699.

4-Allyl-4-(4-methoxyphenyl)-1-triisopropylsilyl-1,4-dihydropyridine (11d)

Synthesis according to GP1 from 4-(4-methoxyphenyl)pyridine (**5d**, 1.76 g, 9.55 mmol), TIPSOTf (3.22 g, 10.5 mmol, 2.82 mL), and di(allyl)magnesium (0.30 m in THF/Et_2O, 1:1, 10.5 mmol, 35.2 mL). The reaction was stopped after 2 h. Quantitative determination indicated 879 mg (24%) of dihydropyridine **11d** followed by stirring under air for 4 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **11d**.

Yield: 840 mg (21%); colorless solid; mp 47 °C; R_f = 0.39 (Al_2O_3; pentane).

IR (KBr): 3072, 2999, 2951, 2864, 1666, 1601, 1506, 1464, 1290, 1244, 1092, 1051, 982, 881, 829, 760, 690, 669, 516 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.10 (d, *J* = 7.4 Hz, 18 H, CH(CH_3)$_2$), 1.27 (sept, *J* = 7.5 Hz, 3 H, C*H*(CH_3)$_2$), 2.50 (dt, *J* = 7.0, 1.2 Hz, 2 H, CCH_2CH), 3.80 (s, 3 H, OCH_3), 4.39–4.44 (m, 2 H, NCHC*H*), 4.99–5.06 (m, 2 H, CCH_2CHCH_2), 5.83 (ddt, *J* = 17.4, 10.4, 7.0 Hz, 1 H, CH_2CHCH_2), 6.07–6.12 (m, 2 H, NC*H*CH), 6.85–6.91 (m, 2 H, C*H*CO), 7.30–7.36 (m, 2 H, C*H*CHCO).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.6 (C*H*(CH_3)$_2$), 18.0 (CH(CH_3)$_2$), 40.9 (CCH_2), 48.2 (CCH_2), 55.4 (OCH_3), 106.8 (NCHCH), 113.6 (*C*HCO), 116.3 (CCH_2CHCH_2), 127.8 (*C*HCHCO; NC*H*CH), 136.6 (CH_2CHCH_2), 144.4 ($CCCH_2$), 157.3 (*C*OCH_3).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{24}H_{37}NOSi$: 383.2639; found: 383.2657.

4-Allyl-4-(4-methoxybenzyl)-1-triisopropylsilyl-1,4-dihydropyridine (11e)

Synthesis according to GP1 from 4-(4-methoxybenzyl)pyridine (**5e**, 1.60 g, 8.03 mmol), TIPSOTf (2.71 g, 8.83 mmol, 2.37 mL), and di(allyl)magnesium (0.30 m in THF/Et_2O, 1:1, 8.83 mmol, 29.6 mL). The reaction was stopped after 2 h. Quantitative determination indicated 703 mg (22%) of dihydropyridine **11e** followed by stirring under air for 4 d. Purification by FC (Al_2O_3-basic, activity III, pentane) afforded **11e**.

Yield: 741 mg (23%); colorless oil; R_f = 0.50 (Al_2O_3; pentane).

IR (film): 3083, 3027, 2945, 2866, 2360, 1670, 1581, 1463, 1288, 1103, 1059, 1014, 993, 971, 914, 883, 688 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 0.98 (d, *J* = 7.5 Hz, 18 H, CH(CH_3)$_2$), 1.10–1.20 (m, 3 H, C*H*(CH_3)$_2$), 2.08 (d, *J* = 7.2 Hz, 2 H, CCH_2CH), 2.51 (s, 2 H, CCH_2C), 3.77 (s, 3 H, OCH_3), 4.14 (d, *J* = 8.0 Hz, 2 H, NCHC*H*), 4.95–5.07 (m, 2 H, CCH_2CHCH_2), 5.86–5.98 (m, 3 H, CH_2CHCH_2, NC*H*CH), 6.74–6.79 (m, 2 H, C*H*CO), 7.02–7.08 (m, 2 H, C*H*CHCO).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 11.5 (C*H*(CH_3)$_2$), 17.9 (CH(CH_3)$_2$), 39.6 (CCH_2CH), 49.1 (CCH_2CH), 50.1 (CCH_2C), 55.3 (OCH_3), 106.1 (NCHCH), 113.0 (*C*HCO), 115.9 (CCH_2CHCH_2), 129.0 (NCHCH), 131.4 (CCHCHCO), 131.9 (*C*HCHCO), 136.9 (CH_2CHCH_2), 157.8 (*C*OCH_3).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{25}H_{39}NOSi$: 397.2795; found: 397.2819.

***rac*-1-Methyl-4-azatricyclo[3.3.1.0^{2,7}]non-3-en (*rac*-13a)**

Synthesis according to GP2 from dihydropyridine **11a** (450 mg, 1.54 mmol) and TFA (2.65 g, 23.2 mmol, 1.78 mL) in pentane (15.4 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**13a**.

Yield: 174 mg (84%); yellow oil; R_f = 0.15 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 2949, 2858, 1614, 1452, 1375, 1350, 1333, 1269, 1160, 985, 916, 858, 829, 688 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 0.83 (dq, *J* = 12.4, 2.2 Hz, 1 H, NCHCH_2^aC), 0.92 (s, 3 H, CH_3), 1.01 (ddq, *J* = 12.6, 6.4, 1.9 Hz, 1 H, NCHCH_2^aCH), 1.17 (d, *J* = 9.1 Hz, 1 H, CCH_2^aCHCH), 1.60 (dd, *J* = 12.5, 3.2 Hz, 1 H, NCHCH_2^bCH), 1.68 (dd, *J* = 12.4, 3.1 Hz, 1 H, NCHCH_2^bC), 1.99 (ddt, *J* = 8.7, 6.6, 2.0 Hz, 1 H, CCH_2^bCHCH), 2.07 (q, *J* = 6.2 Hz, 1 H, NCHCHC*H*), 2.84–2.90 (m, 1 H, NCHC*H*), 4.48–4.53 (m, 1 H, NC*H*CH_2), 8.08 (d, *J* = 3.7 Hz, 1 H, NC*H*CH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 26.9 (CH_3), 27.6 (NCHCH_2CH), 30.7 (NCHCH_2CH), 38.7 (CCH_3), 38.9 (NCHCH_2C), 43.3 (CCH_2CHCH), 44.3 (NCHCH), 56.1 (N*C*HCH_2), 167.2 (N*C*HCH).

HRMS (EI): *m/z* $[M - H]^+$ calcd for $C_9H_{12}N$: 134.0964; found: 134.0962.

***rac*-1-Phenyl-4-azatricyclo[3.3.1.0^{2,7}]non-3-en (*rac*-13b)**

Synthesis according to GP2 from dihydropyridine **11b** (1.08 g, 3.05 mmol) and TFA (5.22 g, 45.8 mmol, 3.50 mL) in pentane (30.5 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**13b**.

Yield: 509 mg (85%); yellow oil; R_f = 0.66 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (KBr): 3024, 2995, 2935, 2860, 1676, 1610, 1493, 1446, 1333, 1288, 1077, 766, 750, 702, 687, 540 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.17 (ddq, *J* = 12.6, 6.2, 1.8 Hz, 1 H, NCHCH_2^aCH), 1.25 (dq, *J* = 12.7, 2.3 Hz, 1 H, NCHCH_2^aC), 1.60 (d, *J* = 9.2 Hz, 1 H, CCH_2^aCHCH), 1.79 (dd, *J* = 12.7, 3.2 Hz, 1 H, NCHCH_2^bCH), 2.02 (dd, *J* = 12.7, 3.0 Hz, 1 H, NCHCH_2^bC), 2.22 (q, *J* = 6.4 Hz, 1 H, NCHCHC*H*), 2.53 (ddt, *J* = 9.0, 6.8, 2.0 Hz, 1 H, CCH_2^bCHCH), 3.26–3.32 (m, 1 H, NCHC*H*), 4.63–4.68 (m, 1 H, NC*H*CH_2), 6.96–7.02 (m, 2 H, CC*H*CHCH), 7.14–7.19 (m, 1 H, CCHCHC*H*), 7.24–7.31 (m, 2 H, CCHC*H*CH), 8.34 (d, *J* = 3.7 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 27.6 (NCHCH_2CH), 30.9 (NCHCH_2CH), 41.0 (NCHCH_2C), 41.3 (CCH_2CHCH), 43.3 (NCH*C*H), 45.8 (CCH_2), 56.0 (N*C*H$(CH_2)_2$), 124.9 (CCHCHCH), 126.0 (CCHCH*C*H), 128.4 (CCH*C*HCH), 147.8 (*C*CCH_2) 166.9 (NCHCH).

HRMS (EI): *m/z* $[M]^+$ calcd for $C_{14}H_{15}N$: 197.1199; found: 197.1196.

***rac*-1-Benzyl-4-azatricyclo[3.3.1.0^{2,7}]non-3-en (*rac*-13c)**

Synthesis according to GP2 from dihydropyridine **11c** (690 mg, 1.88 mmol) and TFA (3.22 g, 28.2 mmol, 2.16 mL) in pentane (18.8 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**13c**.

Yield: 331 mg (83%); beige solid; mp 88 °C; R_f = 0.27 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (KBr): 3021, 2993, 2945, 2922, 2854, 1605, 1493, 1454, 1435, 1329, 1263, 1151, 771, 752, 704, 646, 484 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 0.99 (dq, *J* = 12.4, 2.3 Hz, 1 H, NCHCH_2^aC), 1.03 (ddq, *J* = 12.6, 6.7, 2.0 Hz, 1 H, NCHCH_2^aCH), 1.16 (d, *J* = 9.1 Hz, 1 H, CCH_2^aCHCH), 1.60 (ddd, *J* = 15.2, 12.5, 3.1 Hz, 2 H, NCHCH_2^bC; NCHCH_2^bCH), 2.07 (q, *J* = 5.8 Hz, 1 H, NCHCH$_2$C*H*), 2.12 (ddt, *J* = 9.0, 6.8, 2.0 Hz, 1 H, CCH_2^bCHCH), 2.47 (d, *J* = 13.3 Hz, 1 H, CCH_2^aC), 2.55 (d, *J* = 13.4 Hz, 1 H, CCH_2^bC), 2.96–3.02 (m, 1 H, NCHC*H*), 4.48–4.53 (m, 1 H, NC*H*CH_2), 7.02–7.06 (m, 2 H, CC*H*CHCH), 7.17–7.23 (m, 1 H, CCHCHC*H*), 7.23–7.29 (m, 2 H, CCHC*H*CH), 8.04 (d, *J* = 3.7 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 27.8 (NCHCH_2CH), 31.3 (NCHCH_2CH), 37.0 (NCHCH_2C), 41.3 (CCH_2CHCH), 42.4 (NCH*C*H), 43.2 (NCHCH*C*), 46.5 (CCH_2C), 55.9 (N*C*HCH_2), 126.3 (CCHCH*C*H), 128.3 (CCH*C*HCH), 129.7 (*C*CHCHCH) 138.2 (*C*CHCHCH), 166.9 (N*C*HCH).

HRMS (EI): *m/z* [M]$^+$ calcd for $C_{15}H_{17}N$: 211.1356; found: 211.1354.

rac-1-(4-Methoxyphenyl)-4-azatricyclo[3.3.1.0^{2,7}]non-3-en (*rac*-13d)

Synthesis according to GP2 from dihydropyridine **11d** (840 mg, 2.19 mmol) and TFA (3.74 g, 32.8 mmol, 2.51 mL) in pentane/EtOH, 4:1 (22.0 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**13d**.

Yield: 421 mg (85%); yellow oil; R_f = 0.48 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 89:10:1).

IR (film): 2997, 2933, 2858, 2833, 1610, 1514, 1462, 1443, 1346, 1250, 1178, 1034, 827, 810, 675 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.16 (ddq, *J* = 12.6, 6.2, 1.9 Hz, 1 H, NCHCH_2^aCH), 1.23 (dq, *J* = 12.7, 2.3 Hz, 1 H, NCHCH_2^aC), 1.56 (d, *J* = 9.2 Hz, 1 H, CCH_2^aCHCH), 1.77 (dd, *J* = 12.6, 3.2 Hz, 1 H, NCHCH_2^bCH), 1.98 (dd, *J* = 12.7, 3.0 Hz, 1 H, NCHCH_2^bC), 2.20 (q, *J* = 6.3 Hz, 1 H, NCHCHC*H*), 2.50 (ddt, *J* = 9.1, 6.8, 2.0 Hz, 1 H, CCH_2^bCHCH), 3.22–3.27 (m, 1 H, NCHC*H*), 3.77 (s, 3 H, OCH_3), 4.61–4.66 (m, 1 H, NC*H*(CH_2)$_2$), 6.79–6.83 (m, 2 H, C*H*COCH$_3$), 6.89–6.93 (m, 2 H, C*H*CHCO), 8.32 (d, *J* = 3.7 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 27.6 (NCHCH_2*C*H), 30.9 (NCH*C*H$_2$CH), 40.9 (NCH*C*H$_2$C), 41.5 (C*C*H$_2$CHCH), 43.6 (NCH*C*H), 45.2 (*C*CH$_2$), 55.4 (OCH_3), 56.0 (N*C*HCH$_2$), 113.9 (*C*HCO), 126.0 (*C*HCHCO), 140.1 (*C*CCH$_2$), 157.9 (*C*OCH$_3$) 167.0 (N*C*HCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{15}H_{18}NO$: 228.1383; found: 228.1382.

rac-1-(4-Methoxybenzyl)-4-azatricyclo[3.3.1.0^{2,7}]non-3-en (*rac*-13e)

Synthesis according to GP2 from dihydropyridine **11e** (700 mg, 1.76 mmol) and TFA (3.01 g, 28.2 mmol, 2.02 mL) in pentane/EtOH, 4:1 (17.6 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**13e**.

Yield: 284 mg (67%); yellow oil; R_f = 0.42 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (KBr): 2995, 2933, 2852, 1684, 1610, 1512, 1464, 1441, 1351, 1333, 1302, 1244, 1178, 1036, 829, 681 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.97 (dq, *J* = 12.4, 2.2 Hz, 1 H, NCHCH_2^aC), 1.03 (ddq, *J* = 12.5, 6.3, 1.9 Hz, 1 H, NCHCH_2^aCH), 1.14 (d, *J* = 8.9 Hz, 1 H, CCH_2^aCHCH), 1.57 (dd, *J* = 12.5, 3.0 Hz, 1 H, NCHCH_2^bC), 1.61 (dd, *J* = 12.6, 3.2 Hz, 1 H, NCHCH_2^bCH), 2.03–2.12 (m, 2 H, NCHCH$_2$C*H*, CCH_2^bCHCH), 2.41 (d, *J* = 13.5 Hz, 1 H, CCH_2^aC), 2.48 (d, *J* = 13.6 Hz, 1 H, CCH_2^bC), 2.94–2.98 (m, 1 H, NCHC*H*), 3.78 (s, 3 H, OCH_3), 4.47–4.51 (m, 1 H, NC*H*CH$_2$), 6.78–6.82 (m, 2 H, CHCO), 6.93–6.97 (m, 2 H, C*H*CHCO), 8.03 (d, *J* = 3.7 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 27.8 (NCHCH_2*C*H), 31.3 (NCH*C*H$_2$CH), 36.9 (NCH*C*H$_2$C), 41.3 (C*C*H$_2$CHCH), 42.4 (NCH*C*H), 43.4 (NCH*C*HC), 45.6 (*C*CH$_2$C), 55.3 (OCH_3), 55.9 (N*C*HCH$_2$), 113.7 (*C*HCO), 130.3 (*C*CHCHCO), 130.5 (*C*HCHCO), 158.2 (*C*OCH$_3$), 167.0 (N*C*HCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{16}H_{20}NO$: 242.1539; found: 242.1538.

rac-3-Methyl-9-azatricyclo[4.3.1.0^{3,7}]dec-8-en (*rac*-14a)

Synthesis according to GP2 from dihydropyridine **7a** (380 mg, 1.24 mmol) and TFA (2.13 g, 18.7 mmol, 1.43 mL) in pentane (12.4 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**14a**.

Yield: 146 mg (79%); colorless oil; R_f = 0.21 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 3215, 2937, 2866, 1616, 1450, 1340, 1190, 1149, 1061, 985, 943, 874, 714 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.96 (s, 3 H, CH_3), 1.13–1.19 (m, 1 H, CHCH_2^aCH), 1.23 (ddt, *J* = 13.2, 3.1, 1.1 Hz, 1 H, CHCH_2^aC), 1.37–1.45 (m, 2 H, CHCH_2^bC, CCH_2^aCH$_2$), 1.46–1.54 (m, 1 H, CHCH_2^bCH), 1.54–1.63 (m, 2 H, CCH$_2$CH_2), 1.91–2.03 (m, 2 H, CCH_2^bCH$_2$, CHC*H*CH$_2$), 2.33 (t, *J* = 4.2 Hz, 1 H, CHC*H*CH), 4.14 (p, *J* = 2.6 Hz, 1 H, NC*H*CH$_2$), 8.24 (d, *J* = 4.1 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 28.2 (CH_3), 32.0 (CHC*H*$_2$CH$_2$), 34.1 (*C*HCH$_2$CH$_2$), 36.4 (CH*C*H$_2$CH), 39.8 (CHCH$_2$C*H*$_2$), 41.7 (CH$_2$*C*CH$_2$), 42.6 (C*C*H$_2$CH), 50.1 (NCH*C*H), 54.0 (N*C*HCH$_2$), 171.2 (N*C*HCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{10}H_{16}N$: 150.1277; found: 150.1276.

rac-3-Phenyl-9-azatricyclo[4.3.1.0^{3,7}]dec-8-en (*rac*-14b)

Synthesis according to GP2 from dihydropyridine **7b** (870 mg, 2.37 mmol) and TFA (4.05 g, 35.5 mmol, 2.72 mL) in pentane (23.7 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88.5:10:1.5) afforded *rac*-**14b**.

Yield: 420 mg (84%); colorless oil; R_f = 0.48 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88.5:10:1.5).

IR (film): 3055, 3022, 2997, 2945, 2868, 1618, 1495, 1444, 1340, 1188, 1034, 987, 760, 700 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.32 (dt, *J* = 13.3, 2.0 Hz, 1 H, CHCH_2^aCH), 1.54–1.62 (m, 1 H, CHCH_2^aCH$_2$), 1.65 (ddt, *J* = 13.2, 10.3, 2.9 Hz, 1 H, CHCH_2^bCH), 1.73 (ddt, *J* = 13.3, 3.0, 0.9 Hz, 1 H, CCH_2^aCH), 1.87 (dd, *J* = 13.3, 2.5 Hz, 1 H, CCH_2^bCH), 1.97–2.16 (m, 4 H, CHCH_2^bCH$_2$, CHCH$_2$CH_2, CHCH$_2$CH$_2$), 3.02 (t, *J* = 4.3 Hz, 1 H, CHC*H*CH), 4.24 (p, *J* = 2.6 Hz, 1 H, NC*H*CH$_2$), 7.11–7.16 (m, 1 H, CCHCHC*H*), 7.16–7.21 (m, 2 H, CC*H*CHCH), 7.23–7.29 (m, 2 H, CCHC*H*CH), 8.48 (d, *J* = 4.0 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 31.5 (CHCH$_2$CH$_2$), 34.0 (*C*HCH$_2$CH$_2$), 36.3 (CHCH$_2$CH), 41.1 (CHCH$_2$C*H*$_2$), 44.9 (C*C*H$_2$CH), 46.7 (NCH*C*H), 50.2 (*C*CH$_2$CH$_2$), 53.9 (N*C*HCH$_2$), 125.8 (CCHCHC*H*), 125.9 (CCHC*H*CH), 128.5 (CCHC*H*CH), 149.9 (*C*CCH$_2$), 170.5 (N*C*HCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{15}H_{18}N$: 212.1434; found: 212.1432.

rac-3-Benzyl-9-azatricyclo[4.3.1.0^{3,7}]dec-8-en (*rac*-14c)

Synthesis according to GP2 from dihydropyridine **7c** (540 mg, 1.41 mmol) and TFA (2.42 g, 21.2 mmol, 1.62 mL) in pentane (14.1 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88.5:10:1.5) afforded *rac*-**14c**.

Yield: 274 mg (86%); yellow oil; R_f = 0.40 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88.5:10:1.5).

IR (film): 3084, 3059, 3026, 2945, 2868, 1616, 1495, 1452, 1342, 762, 731, 704 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.17 (dd, *J* = 13.4, 2.4 Hz, 1 H, CHCH_2^aCH), 1.31 (dd, *J* = 13.2, 2.1 Hz, 1 H, CCH_2^aCH), 1.35–1.43 (m, 1 H, CHCH_2^aCH$_2$), 1.45–1.54 (m, 3 H, CHCH_2^bCH, CCH_2^bCH, CHCH$_2$CH_2^a), 1.72–1.80 (m, 1 H, CHCH$_2$CH_2^b), 1.84–1.94 (m, 2 H, CH-C*H*CH$_2$, CHCH_2^bCH$_2$), 2.42 (t, *J* = 4.2 Hz, 1 H, CHC*H*CH), 2.52 (s, 2 H, CCH_2C), 4.16 (p, *J* = 2.6 Hz, 1 H, NC*H*CH$_2$), 7.11–7.15 (m, 2 H, CC*H*-CHCH), 7.18–7.23 (m, 1 H, CCHCHC*H*), 7.24–7.29 (m, 2 H, CCHC*H*CH), 8.25 (d, *J* = 4.1 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 31.6 (CHCH$_2$CH$_2$), 33.2 (CHCHCH$_2$), 36.5 (CHCH$_2$CH$_2$), 36.9 (CHCH$_2$CH), 40.7 (CCH$_2$CH), 46.6 (CHCCH$_2$), 47.1 (CCH$_2$C), 47.8 (NCHCH), 53.7 (NCHCH$_2$), 126.3 (CCHCHCH), 128.1 (CCHCHCH), 130.3 (CCHCHCH), 138.8 (CCHCHCH), 171.0 (NCHCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{16}H_{20}N$: 226.1590; found: 226.1589.

rac-3-(4-Methoxyphenyl)-9-azatricyclo[4.3.1.0^{3,7}]dec-8-en (*rac*-14d)

Synthesis according to GP2 from dihydropyridine **7d** (545 mg, 1.37 mmol) and TFA (2.35 g, 20.6 mmol, 1.58 mL) in pentane (13.7 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**14d**.

Yield: 295 mg (89%); colorless solid; mp 97 °C; R_f = 0.17 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (KBr): 2999, 2939, 2868, 2835, 1614, 1512, 1335, 1306, 1259, 1238, 1180, 1036, 827, 555 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.31 (d, *J* = 13.2 Hz, 1 H, CHC*H*$_2^a$CH), 1.53–1.60 (m, 1 H, CHC*H*$_2^a$CH$_2$), 1.64 (ddt, *J* = 13.1, 10.3, 2.8 Hz, 1 H, CHC*H*$_2^b$CH), 1.71 (dt, *J* = 13.3, 2.8 Hz, 1 H, CC*H*$_2^a$CH), 1.83 (dd, *J* = 13.3, 2.4 Hz, 1 H, CC*H*$_2^b$CH), 2.00–2.13 (m, 4 H, CHC*H*$_2^b$CH$_2$, CHCH$_2$C*H*$_2$, C*H*CH$_2$CH$_2$), 2.97 (t, *J* = 4.3 Hz, 1 H, CHC*H*CH), 3.77 (s, 3 H, CH$_3$), 4.23 (p, *J* = 2.6 Hz, 1 H, NC*H*CH$_2$), 6.77–6.83 (m, 2 H, C*H*CO), 7.08–7.13 (m, 2 H, C*H*CHCO), 8.46 (d, *J* = 4.0 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 31.5 (CHCH$_2$CH$_2$), 34.0 (CHCH$_2$CH$_2$), 36.4 (CHCH$_2$CH), 41.1 (CHCH$_2$CH$_2$), 44.9 (CCH$_2$CH), 47.1 (NCHCH), 49.5 (CCH$_2$CH$_2$), 53.9 (NCHCH$_2$), 55.4 (CH$_3$), 113.8 (CHCO), 126.9 (CHCHCO), 142.2 (CCHCHCO), 157.6 (CO), 170.6 (NCHCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{16}H_{20}NO$: 242.1539; found: 242.1538.

rac-3-(4-Methoxybenzyl)-9-azatricyclo[4.3.1.0^{3,7}]dec-8-en (*rac*-14e)

Synthesis according to GP2 from dihydropyridine **7e** (465 mg, 1.13 mmol) and TFA (1.93 g, 16.9 mmol, 1.29 mL) in pentane (11.3 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**14e**.

Yield: 244 mg (85%); yellow oil; R_f = 0.19 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 2995, 2945, 2868, 1614, 1512, 1464, 1441, 1342, 1302, 1248, 1178, 1036, 833, 820, 758 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.17 (dd, *J* = 12.9, 2.0 Hz, 1 H, CHC*H*$_2^a$CH), 1.30 (dd, *J* = 13.3, 2.3 Hz, 1 H, CC*H*$_2^a$CH), 1.35–1.43 (m, 1 H, CHC*H*$_2^a$CH$_2$), 1.44–1.54 (m, 3 H, CHC*H*$_2^b$CH, CC*H*$_2^b$CH, CHCH$_2$C*H*$_2^a$), 1.70–1.79 (m, 1 H, CHCH$_2$C*H*$_2^b$), 1.84–1.94 (m, 2 H, CHC*H*CH$_2$, CHC*H*$_2^b$CH$_2$), 2.40 (t, *J* = 4.3 Hz, 1 H, CHC*H*CH), 2.46 (s, 2 H, CC*H*$_2$C), 3.78 (s, 3 H, CH$_3$), 4.16 (p, *J* = 2.6 Hz, 1 H, NC*H*CH$_2$), 6.79–6.84 (m, 2 H, C*H*CO), 7.02–7.07 (m, 2 H, C*H*CHCO), 8.24 (d, *J* = 4.1 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 31.7 (CHCH$_2$CH$_2$), 33.3 (CHCHCH$_2$), 36.5 (CHCH$_2$CH$_2$), 36.9 (CHCH$_2$CH), 40.7 (CCH$_2$CH), 46.2 (CCH$_2$C), 46.7 (CHCCH$_2$), 47.8 (NCHCH), 53.8 (NCHCH$_2$), 55.3 (CH$_3$), 113.5 (CHCO), 130.9 (CCHCHCO), 131.2 (CHCHCO), 158.2 (CO), 171.0 (NCHCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{17}H_{22}N$: 256.1696; found: 256.1695.

rac-3-Methyl-10-azatricyclo[5.3.1.0^{3,8}]undec-9-en (*rac*-15a)

Synthesis according to GP2 from dihydropyridine **9a** (410 mg, 1.28 mmol) and TFA (2.19 g, 19.2 mmol, 1.47 mL) in pentane (12.8 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**15a**.

Yield: 160 mg (77%); yellow oil; R_f = 0.21 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 3404, 2993, 2922, 2862, 1614, 1469, 1454, 1338, 1134, 1001, 922, 892, 681, 642 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.80 (s, 3 H, CH$_3$), 1.05–1.19 (m, 3 H, CC*H*$_2^a$CH$_2$, NCHC*H*$_2^a$C, NCHC*H*$_2^a$CH), 1.26–1.39 (m, 2 H, CC*H*$_2^b$CH$_2$, CHC*H*$_2^a$CH$_2$), 1.39–1.60 (m, 5 H, CH$_2$C*H*$_2$CH$_2$, CHC*H*$_2^b$CH$_2$, NCHC*H*$_2^b$C, NCHC*H*$_2^b$CH), 1.70 (dp, *J* = 11.6, 3.4 Hz, 1 H, C*H*CH$_2$CH$_2$), 1.99 (t, *J* = 3.7 Hz, 1 H, NCHC*H*), 4.17–4.21 (m, 1 H, NC*H*CH$_2$), 8.37 (d, *J* = 4.2 Hz, 1 H, NC*H*CH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 17.1 (CH$_2$CH$_2$CH$_2$), 27.3 (CHCH$_2$CH$_2$), 28.4 (CHCH$_2$CH$_2$), 28.6 (CHCH$_2$CH), 32.0 (CCH$_3$), 32.3 (CH$_3$), 36.6 (NCHCH$_2$C), 37.8 (CCH$_2$CH$_2$), 46.3 (NCHCH), 54.8 (NCHCH$_2$), 174.8 (NCHCH).

HRMS (EI): *m/z* [M]$^+$ calcd for $C_{11}H_{17}N$: 163.1356; found: 163.1365.

rac-3-Phenyl-10-azatricyclo[5.3.1.0^{3,8}]undec-9-en (*rac*-15b)

Synthesis according to GP2 from dihydropyridine **9b** (200 mg, 0.52 mmol) and TFA (896 mg, 7.86 mmol, 0.60 mL) in pentane (5.2 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**15b**.

Yield: 87 mg (74%); yellow oil; R_f = 0.26 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 84:14:2).

IR (film): 3055, 3024, 2925, 2858, 1616, 1495, 1469, 1444, 1338, 1030, 955, 893, 760, 702 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.32–1.48 (m, 3 H, CHC*H*$_2^a$CH, CC*H*$_2^a$CH$_2$, CHC*H*$_2^a$CH$_2$), 1.54–1.68 (m, 3 H, CH$_2$C*H*$_2^a$CH$_2$, CHC*H*$_2^b$CH, CHC*H*$_2^b$CH$_2$), 1.69–1.83 (m, 2 H, CC*H*$_2^b$CH$_2$, CH$_2$C*H*$_2^b$CH$_2$), 1.88–2.01 (m, 3 H, NCHC*H*$_2$C, C*H*CH$_2$CH$_2$), 2.89 (t, *J* = 3.7 Hz, 1 H, NCHC*H*), 4.28 (p, *J* = 2.8 Hz, 1 H, NC*H*CH$_2$), 7.10–7.16 (m, 1 H, CCHCHC*H*), 7.22–7.30 (m, 4 H, CC*H*CHCH, CCHC*H*CH), 8.43 (d, *J* = 4.0 Hz, 1 H, NC*H*CH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 17.3 (CH$_2$CH$_2$CH$_2$), 27.2 (CHCH$_2$CH$_2$), 28.3 (CHCH$_2$CH$_2$), 29.4 (CHCH$_2$CH), 37.3 (NCHCH$_2$C), 40.5 (CCH$_2$CH$_2$), 40.7 (CCH$_2$), 42.1 (NCHCH), 54.2 (NCHCH$_2$), 125.7 (CCHCHCH), 126.1 (CCHCHCH), 128.4 (CCHCHCH), 152.6 (CCCH$_2$), 173.9 (NCHCH).

HRMS (EI): *m/z* [M]$^+$ calcd for $C_{16}H_{19}N$: 225.1512; found: 225.1506.

rac-3-Benzyl-10-azatricyclo[5.3.1.0^{3,8}]undec-9-en (*rac*-15c)

Synthesis according to GP2 from dihydropyridine **9c** (420 mg, 1.06 mmol) and TFA (1.81 g, 15.9 mmol, 1.22 mL) in pentane (10.6 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**15c**.

Yield: 188 mg (74%); colorless oil; R_f = 0.22 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 3084, 3057, 2926, 2848, 1014, 1495, 1469, 1450, 1340, 1120, 1068, 1025, 974, 758, 706 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.12–1.24 (m, 3 H, CC*H*$_2^a$CH$_2$, CHC*H*$_2^a$CH$_2$, CHC*H*$_2^a$CH), 1.32–1.58 (m, 7 H, CC*H*$_2^b$CH$_2$, CHC*H*$_2^b$CH$_2$, CHC*H*$_2^b$CH, CH$_2$C*H*$_2$CH$_2$, NCHC*H*$_2$C), 1.70 (dp, *J* = 10.2, 3.4 Hz, 1 H, C*H*CH$_2$CH$_2$), 2.09 (t, *J* = 3.7 Hz, 1 H, NCHC*H*), 2.35 (d, *J* = 13.2 Hz, 1 H, CCH$_2^a$C), 2.44 (d, *J* = 13.2 Hz, 1 H, CCH$_2^b$C), 4.23–4.29 (m, 1 H,

NC*H*CH$_2$), 7.09–7.13 (m, 2 H, CC*H*CHCH), 7.19–7.24 (m, 1 H, CCH-CHC*H*), 7.25–7.30 (m, 2 H, CCHC*H*CH), 8.51 (d, *J* = 4.1 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 16.7 ($CH_2CH_2CH_2$), 27.2 ($CHCH_2CH_2$), 28.1 ($CHCH_2CH_2$), 29.2 ($CHCH_2CH$), 33.9 (CCH_2CH_2), 35.3 ($NCHCH_2C$), 36.4 (CCH_2CH_2), 43.3 (NCHCH), 50.6 (CCH_2C), 54.6 ($NCHCH_2$), 126.3 (CCHCHCH), 128.0 (CCHCHCH), 130.9 (CCHCHCH), 137.9 (CCHCHCH), 174.7 (NCHCH).

HRMS (ESI): *m/z* [M+H]$^+$ calcd for $C_{17}H_{22}N$: 240.1747; found: 240.1745.

rac-3-(4-Methoxyphenyl)-10-azatricyclo[5.3.1.0^{3,8}]undec-9-en (*rac*-15d)

Synthesis according to GP2 from dihydropyridine **9d** (900 mg, 2.19 mmol) and TFA (3.74 g, 32.8 mmol, 2.51 mL) in pentane (21.9 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**15d**.

Yield: 301 mg (54%); colorless solid; mp 75 °C; R_f = 0.18 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (KBr): 2989, 2929, 2843, 1612, 1514, 1441, 1284, 1252, 1180, 1111, 1030, 893, 820, 690, 553 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.30–1.44 (m, 3 H, CHCH_2^aCH, CCH_2^aCH$_2$, CHCH_2^aCH$_2$), 1.52–1.64 (m, 3 H, CH$_2$CH_2^aCH$_2$, CHCH_2^bCH, CHCH_2^bCH$_2$), 1.66–1.75 (m, 2 H, CCH_2^bCH$_2$, CH$_2$CH_2^bCH$_2$), 1.85–1.96 (m, 3 H, NCHCH_2C, C*H*CH$_2$CH$_2$*JJ*), 2.81 (t, *J* = 3.7 Hz, 1 H, NCHC*H*), 3.76 (s, 3 H, OCH$_3$), 4.24–4.28 (m, 1 H, NC*H*CH$_2$), 6.77–6.82 (m, 2 H, CHCO), 7.13–7.18 (m, 2 H, C*H*CHCO), 8.39 (d, *J* = 3.9 Hz, 1 H, NC*H*CH).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 17.4 ($CH_2CH_2CH_2$), 27.3 ($CHCH_2CH_2$), 28.3 ($CHCH_2CH_2$), 29.4 ($CHCH_2CH$), 37.2 ($NCHCH_2C$), 39.9 (CCH_2), 40.5 (CCH_2CH_2), 42.5 (NCHCH), 54.3 ($NCHCH_2$), 55.4 (OCH_3), 113.8 (*C*HCO), 127.1 (*C*HCHCO), 144.8 (*C*CCH$_2$), 157.4 (*C*OCH$_3$), 174.0 (N*C*HCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{17}H_{22}NO$: 256.1696; found: 256.1694.

rac-3-(4-Methoxybenzyl)-10-azatricyclo[5.3.1.0^{3,8}]undec-9-en (*rac*-15e)

Synthesis according to GP2 from dihydropyridine **9e** (430 mg, 1.01 mmol) and TFA (1.73 g, 15.2 mmol, 1.16 mL) in pentane (10.1 mL). Purification by FC (Al_2O_3-basic, activity III, pentane/CH_2Cl_2/MeOH, 88:10:2) afforded *rac*-**15e**.

Yield: 241 mg (89%); yellow oil; R_f = 0.20 (Al_2O_3; pentane/CH_2Cl_2/MeOH, 88:10:2).

IR (film): 2993, 2925, 2848, 2062, 1882, 1612, 1512, 1468, 1442, 1248, 1178, 1122, 1036, 822, 758, 729, 700 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.10–1.23 (m, 3 H, CCH_2^aCH$_2$, CHCH_2^aCH$_2$, CHCH_2^aCH), 1.28–1.36 (m, 2 H, CCH_2^bCH$_2$, NCHCH_2^aC), 1.39 (dd, *J* = 13.6, 2.0 Hz, 1 H, NCHCH_2^bC), 1.41–1.58 (m, 4 H, CHCH_2^bCH$_2$, CHCH_2^bCH, CH$_2$CH_2CH$_2$,), 1.69 (dp, *J* = 10.0, 3.3 Hz, 1 H, C*H*CH$_2$CH$_2$), 2.07 (t, *J* = 3.8 Hz, 1 H, NCHC*H*), 2.28 (d, *J* = 13.2 Hz, 1 H, CCH$_2^a$C), 2.37 (d, *J* = 13.2 Hz, 1 H, CCH$_2^b$C), 3.79 (s, 3 H, OCH$_3$), 4.22–4.27 (m, 1 H, NC*H*CH$_2$), 6.78–6.84 (m, 2 H, C*H*CO), 6.98–7.05 (m, 2 H, C*H*CHCO), 8.49 (d, *J* = 4.2 Hz, 1 H, NC*H*CH).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 16.7 ($CH_2CH_2CH_2$), 27.2 ($CHCH_2CH_2$), 28.2 ($CHCH_2CH_2$), 29.2 ($CHCH_2CH$), 33.9 (CCH_2CH_2), 35.2 ($NCHCH_2C$), 36.4 (CCH_2CH_2), 43.3 (NCHCH), 49.7 (CCH_2C), 54.6 ($NCHCH_2$), 55.3 (OCH_3), 113.4 (*C*HCO), 130.0 (*C*CHCHCO), 131.7 (*C*HCHCO), 158.2 (*C*O-CH$_3$), 174.7 (NCHCH).

HRMS (ESI): *m/z* [M + H]$^+$ calcd for $C_{18}H_{24}NO$: 270.1852; found: 270.1851.

Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0039-1690619.

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