Highly flexible synthesis of indenylethylamines as ligand precursors for titanium complexes

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Dedicated to Professor Jürgen Martens in honor of his outstanding contribution to synthetic organic chemistry

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Abstract
Various indenylethylamines are synthesized for the first time by reductive amination of 2-(1*H*-inden-1-yl)acetaldehyde with commercially available primary amines. In addition, a new two-step synthesis of 2-(1*H*-inden-1-yl)acetaldehyde that uses inexpensive indene and 2-bromo-1,1-diethoxyethane as starting materials is presented. Finally, a selected indenylethylamine is used as a ligand precursor for the synthesis of a corresponding indenylethylamido titanium complex. The latter result paves the way for applications of corresponding complexes as catalysts for important chemical reactions.

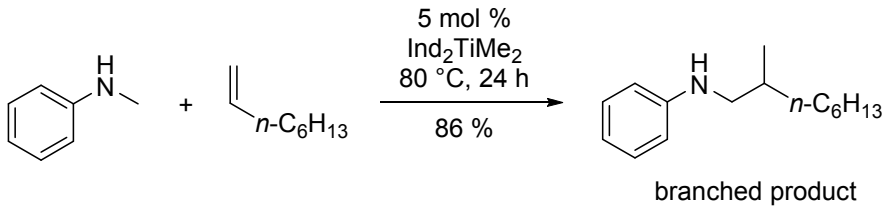
Keywords: Amines, hydroaminoalkylation, indene, reductive amination, titanium

Introduction

Transition metal complexes which are formed by coordination of ligands to metals are widely used as catalysts for a plethora of synthetically useful chemical transformations. However, in most cases, extensive optimization studies are necessary to finally develop an efficient and reliable new catalytic reaction. A common and powerful possibility to optimize transition metal catalysts is the variation of the ligands which are bound to the metal center and as a consequence, an ever-present demand for new ligand motifs exists in transition metal chemistry.

The titanium-catalyzed hydroaminoalkylation of alkenes (Scheme 1)[1−11] is a relatively new and promising method for a waste-free synthesis of industrially important amines. The reaction takes place by addition of the α-C−H bond of an amine across a C−C double bond and gives access to α-alkylated amines in a single step and with 100 % atom efficiency. Among the various titanium-catalysts, bis(η^5-indenyl)dimethyltitanium (Ind_2TiMe_2)[12] was found to be an excellent

catalyst for the highly regioselective hydroaminoalkylation of 1-alkenes with *N*-methylanilines (Scheme 1).[5] In addition, the catalyst can be used for corresponding reactions of styrenes[5] and 1,3-butadienes[9] even though reduced regioselectivities are observed in these cases. On the other hand, dialkylamines and *N*-alkylanilines bearing alkyl groups larger than a methyl group do not undergo successful hydroaminoalkylation reactions in the presence of Ind_2TiMe_2.

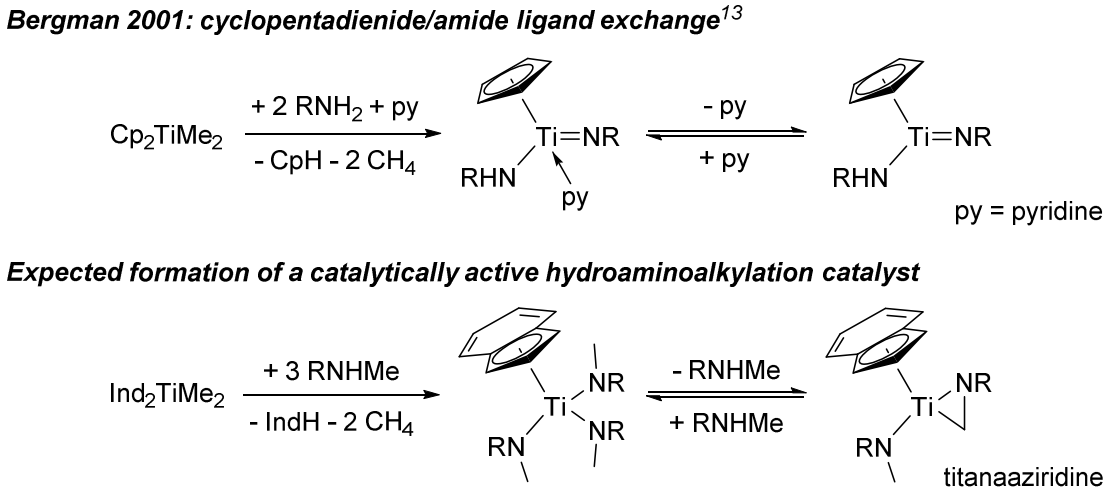


Scheme 1. Ind_2TiMe_2-catalyzed hydroaminoalkylation reaction of 1-octene with *N*-methylaniline.[5]

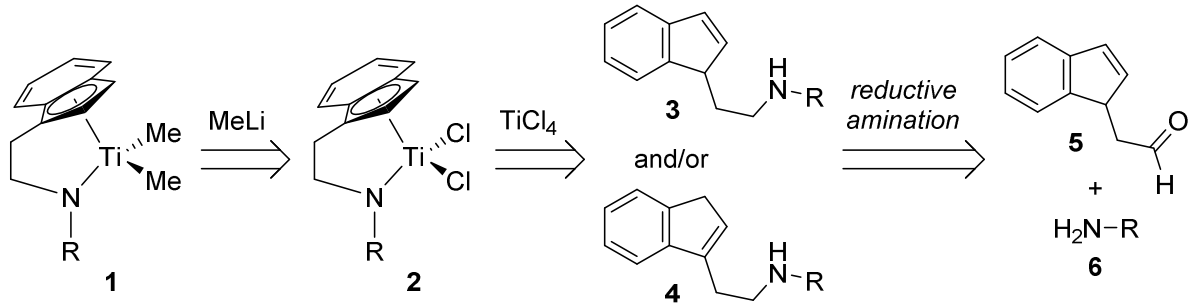
The reaction mechanism of the titanium-catalyzed hydroaminoalkylation of alkenes has already been studied in detail[6] and it is generally accepted that titanaaziridines are the catalytically active species. These highly strained intermediates are formed under the reaction conditions from a catalyst precursor and the amine substrate. However, it is well established that in the presence of amines, bis(η^5-cyclopentadienyl)titanium precursors (Cp_2TiL_n) undergo an unexpected cyclopentadienide/amide ligand exchange reaction that results in the formation of mono(η^5-cyclopentadienyl)titanium(amido) complexes ($Cp(RNH)TiL_n$, Scheme 2).[13] In analogy, it can be assumed that the catalyst precursor Ind_2TiMe_2 used for hydroaminoalkylation reactions of alkenes undergoes a comparable ligand exchange reaction with the amine substrate and as a result, the expected catalytically active titanaaziridine formed from Ind_2TiMe_2 possesses only one indenyl ligand and an amido ligand (Scheme 2). However, these two ligands are expected to remain bonded to the titanium center during the entire catalytic cycle and as a consequence, they both determine the activity of the catalytic species.

A major drawback of the expected ligand exchange of one indenyl ligand against an amido ligand is the fact that the reactivity of the catalytically active titanaaziridine is directly influenced by the nature of the amine substrate. Consequently, the undesirable possibility exists that a certain class of amine substrates, e.g. aromatic amines, deliver catalytic species of high activity while the use of other classes of amines, e.g. alkylamines, results in poorly active catalysts. One approach to avoid this unwanted dependency of the activity of the catalytic species on the nature of the amine substrate is to use a catalyst precursor that contains a chelating ligand with a bridged amido indenyl ligand. Corresponding silyl-linked amido cyclopentadienyl or amido indenyl ligands have extensively been used for the synthesis of various so-called constrained geometry catalysts in recent years,[14] but the notoriously labile Si-N-linkage encouraged us to focus on more stable catalyst precursors with chelating indenylethylamido ligands which are shown in Scheme 3 (general structure **1**). In this context, it must also be noted that the potential

new class of hydroaminoalkylation catalyst precursors of type **1** offers the additional possibility to fine-tune the catalyst by varying the substituent R bound to the nitrogen atom of the chelating ligand. From a retrosynthetic point of view, dimethyl titanium complexes of structure **1** should be easily accessible from the corresponding dichloro titanium complexes **2** and a nucleophilic methylation reagent, e.g. methyl lithium. Unfortunately, complexes of type **2** have not been described in the literature.



Scheme 2. Ligand exchange reactions of Cp_2TiMe_2 and Ind_2TiMe_2 in the presence of amines.



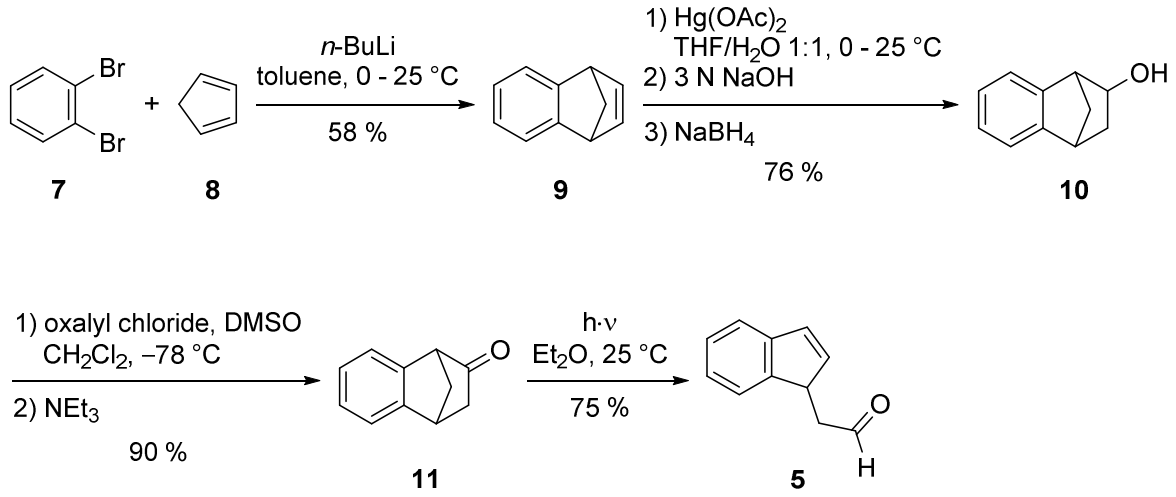
Scheme 3. Retrosynthetic strategy for the preparation of indenylethylamido titanium complexes.

Herein we describe the first preparative example of a general method for the synthesis of indenylethylamido dichloro titanium complexes of type **2** that relies on the reaction of titanium tetrachloride with dilithiated indenylethylamines **3** or **4** (Scheme 3). In addition, we present a new and highly flexible method for the synthesis of indenylethylamines **3**/**4** which are needed as ligand precursors for the planned synthesis of additional new titanium complexes. As the key-step for the formation of the indenylethylamines **3**/**4**, a reductive amination of 2-(1*H*-inden-1-yl)acetaldehyde (**5**) with widely available primary amines **6** is used. This highly flexible reaction

offers a simple way to alter the nature of the substituent R bound to the nitrogen atom of the indenylethylamines **3**/**4**.

Results and Discussion

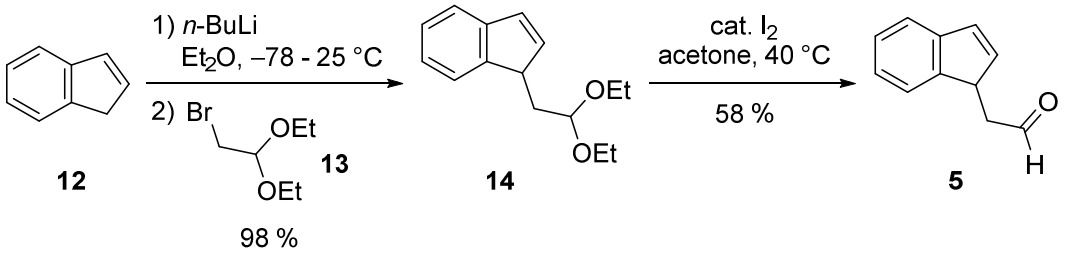
To the best of our knowledge, only one procedure for the synthesis of the desired aldehyde **5** can be found in the literature. The corresponding report by Ipaktschi describes a photochemical ring opening of benzonorbornanone (**11**) using a 450 W mercury high pressure lamp that directly converts **11** into **5** (Scheme 4).[15] Our synthesis of the required starting material **11** began with a Diels-Alder reaction between cyclopentadiene (**8**) and benzyne which can easily be generated in situ from 1,2-dibromobenzene (**7**) and *n*-butyllithium.[16] After the resulting benzonorbornadiene (**9**) had been obtained in moderate yield of 58 % an oxymercuration and a subsequent Swern oxidation gave access to ketone **11** in 68 % combined yield over these two steps. For the final photochemical ring opening, ketone **11** was then irradiated with UV-light in diethyl ether using a 450 W mercury high pressure lamp. As monitored by ^{1}H NMR spectroscopy, a reaction time of 24 h was necessary to reach full conversion. Finally, distillation of the crude product delivered the pure aldehyde **5** in 75 % yield. Although the described four-step protocol can be used successfully for the multi-gram synthesis of aldehyde **5**, the low overall yield of only 30 % and the time consuming experimental procedures as well as the expensive starting materials must be regarded as severe drawbacks to this synthetic approach.



Scheme 4. Initially performed four-step synthesis of aldehyde **5**.

In search of a more convenient synthesis of aldehyde **5**, we then found that lithiated indene (**12**) smoothly undergoes a nucleophilic substitution reaction with commercially available and inexpensive 2-bromo-1,1-diethoxyethane (**13**) to give the corresponding indenylethylacetal **14** in

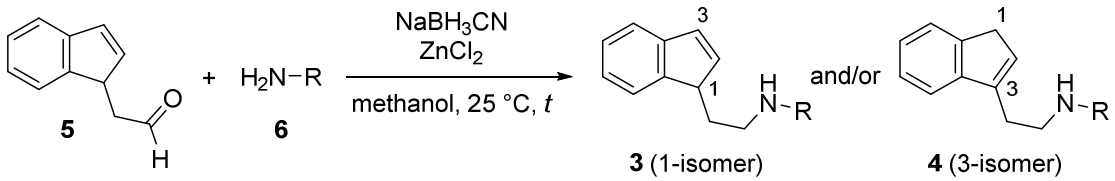
excellent yield of 98 % (Scheme 5). After aqueous work-up, acetal **14** was already obtained with high purity (97 % as determined by GC analysis) and therefore, the crude product could directly be used for the subsequent acetal cleavage. For that purpose, acetal **14** was stirred in acetone in the presence of a catalytic amount of iodine (10 mol %) at 40 °C for 2 h.[17] Although aldehyde **5** could only be isolated in moderate yield of 58 % from the crude reaction mixture, the new and shorter two-step synthesis of **5** gave a significantly improved overall yield of 57 % and it is less time-consuming than the four-step alternative.

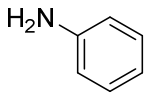
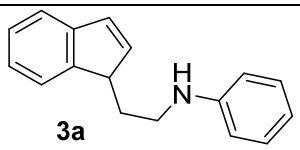
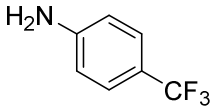
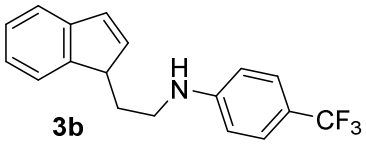
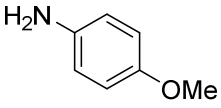
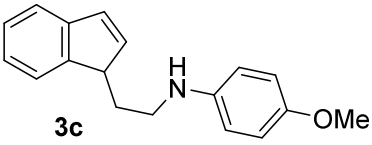
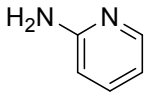
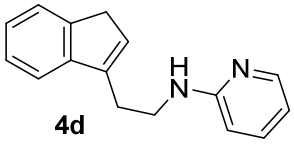
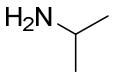
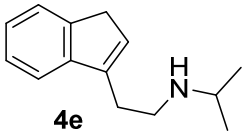
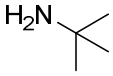
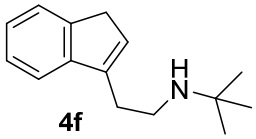
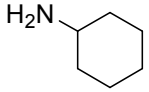
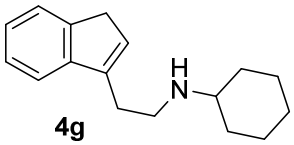
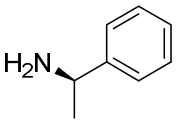
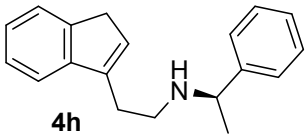


Scheme 5. Optimized two-step synthesis of aldehyde **5**.

With key-intermediate **5** in hand we then performed a number of reductive aminations[18] with various primary aryl- and alkylamines (Table 1). All reactions were carried out under ambient conditions and the progress of the reactions was monitored by TLC analysis. As expected, treatment of a solution of aldehyde **5** in methanol with the corresponding amines **6a**-**h** and subsequent reduction with a solution of $NaBH_3CN$ and $ZnCl_2$ in methanol gave the amination products **3a**-**c** and **4d**-**h** in moderate to excellent yields (51-91 %). Interestingly, the use of arylamines always resulted in the selective formation of the corresponding 1-isomer (**3a**-**c**) of the amination products (Table 1, entries 1-3) whereas most of the more basic pyridinyl- and alkylamines were converted to the thermodynamically more stable 3-isomers (**4d**-**g**, Table 1, entries 4-7). Only the reaction of the chiral substrate (*R*)-1-phenylethylamine (**6h**) with aldehyde **5** gave a mixture of the corresponding 1- and 3-isomer **3h** and **4h** in a ratio of 16:84 (Table 1, entry 8). Although the products **3a**-**c** and **4d**-**h** were fully characterized by IR, ^1H and ^{13}C NMR spectroscopy and mass spectrometry it can be noted that a single-crystal X-ray structure analysis of the hydrochloride of product **4h** (**4h**·**HCl**) could additionally be obtained (for details, see the supplementary material). To find out whether the reductive amination can also be used for the synthesis of multi-gram quantities of the desired products we additionally performed two selected reactions on a 30 mmol scale. For that purpose, we chose aniline (**6a**) and *iso*-propylamine (**6e**) as typical examples of aryl- and alkylamines. Gratifyingly, both reactions proceeded smoothly and the products **3a** and **4e** were obtained in yields of 89 % and 59 %, respectively. These results which are even slightly better than those presented in Table 1 (entries 1 and 5) clearly prove that the new process can deliver sufficient quantities of indenylethylamines for the planned investigation of this class of compounds as ligand precursors in transition metal chemistry.

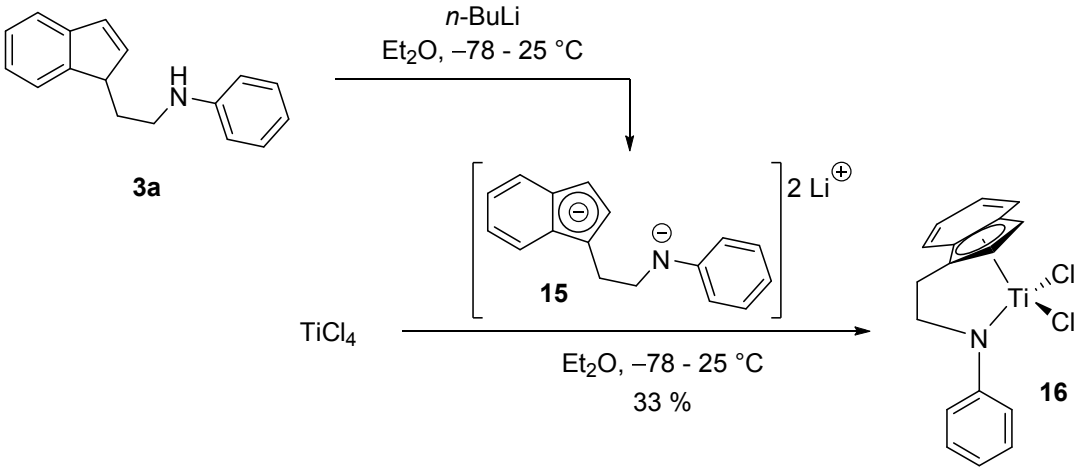
Table 1. Reductive amination of aldehyde **5** with selected primary amines



Entry	Amine	*t* [h]	Isolated Product	Yield [%][a]
1	 **6a**	0.5	 **3a**	86[b]
2	 **6b**	0.25	 **3b**	91
3	 **6c**	2	 **3c**	87
4	 **6d**	24	 **4d**	60
5	 **6e**	2	 **4e**	51[b]
6	 **6f**	2	 **4f**	83
7	 **6g**	2	 **4g**	65
8	 **6h**	2	 **4h**	80[c]

[a] Reaction conditions: 1) amine (4.5 mmol), aldehyde **5** (3.0 mmol), MeOH (6 mL), 25 °C, 5 min; 2) $NaBH_3CN$ (3.3 mmol), $ZnCl_2$ (1.7 mmol), MeOH (6 mL), 25 °C, 0.25 - 24 h; isolated yield. [b] The reaction was also carried out on a 30 mmol scale with a slightly better yield. [c] Only major isomer presented. A mixture of the 1- and the 3-isomer in a ratio of **3h**/**4h** = 16:84 (GC analysis) was obtained.

To finally prove the general suitability of the synthesized indenylethylamines as ligand precursors for the preparation of transition metal complexes we converted compound **3a** with two equivalents of *n*-butyllithium into the corresponding dilithium salt (**15**) and treated it with titanium tetrachloride in diethyl ether (Scheme 6).



Scheme 6. Synthesis of the representative indenylethylamido complex **16**.

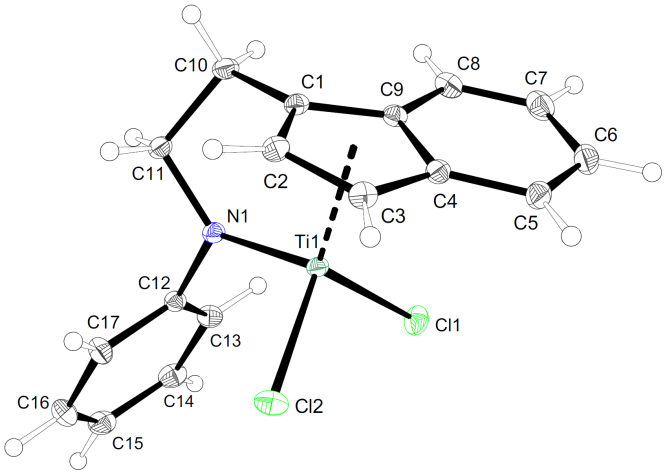


Figure 1. X-ray crystal structure of indenylethylamido complex **16**. Ellipsoids are drawn at the 50 % probability level (grey, C – white, H – green, Cl – blue, N – teal, Ti). Selected bond lengths [Å] and angles [°]: Ti1-N1 1.8934(4), Ti1-Ct 2.029, Ti1-Cl1 2.2706(2), Ti1-Cl2 2.2898(2); N1-Ti1-Ct 104.7, N1-Ti1-Cl1 105.55(1), N1-Ti1-Cl2 104.88(1), Cl1-Ti1-Cl2 103.82(1), C11-N1-Ti1 127.60(3), C12-N1-Ti1 116.81(3), N1-C11-C10 107.50(4) [Ct is the centroid of the five-membered ring C1-C4, C9].[19]

After separation from the formed lithium chloride, red-brown crystals of the expected new titanium complex **16** could be isolated in 33 % yield. Subsequently, the obtained solid material could be recrystallized from benzene-d_6 to give red crystals that were suitable for X-ray single-

crystal analysis. The solid-state structure of **16** (Figure 1)[19] reveals a slightly distorted tetrahedral geometry around the titanium center and proves the bidentate binding mode of the new indenylethylamido ligand. In this context, it must be noted that although silyl-linked amido cyclopentadienyl and amido indenyl complexes are well known,[14] corresponding complexes with aryl substituents bound to the nitrogen atom of the bidentate ligand are extremely rare in the literature.[20-23]

Conclusions

In summary, it was shown that the reductive amination of 2-(1*H*-inden-1-yl)acetaldehyde (**5**) with commercially available primary amines represents a highly flexible and efficient method for the synthesis of various indenylethylamines and in addition, a new two-step synthesis of aldehyde **5** that uses inexpensive indene and 2-bromo-1,1-diethoxyethane as starting materials was developed. Particularly noteworthy is that a selected indenylethylamine could already be used as a ligand precursor for the synthesis of a corresponding indenylethylamido titanium complex. This result clearly proves the suitability of indenylethylamines as starting materials for the synthesis of transition metal complexes and it paves the way for the planned investigation of corresponding complexes as catalysts for hydroaminoalkylation reactions of alkenes.

Experimental Section

General: All air and moisture sensitive reactions were carried out under an atmosphere of argon using standard Schlenk line techniques. Unless otherwise noted, all chemicals were purchased from commercial sources and were used without further purification. Cyclopentadiene was freshly distilled from dicyclopentadiene (93 %, stabilized) and iron powder under an argon atmosphere. Indene (90 %, stabilized) was purified by distillation (25 cm Vigreux column) at 3.00 mmHg and stored under an argon atmosphere over molecular sieves (4 Å) at −30 °C prior to use. All amines were purified by Kugelrohr distillation, degassed (freeze, pump, thaw) and stored under an argon atmosphere. Dichloromethane (99.8 %, extra dry with molecular sieves) was purchased from Acros Organics and used as received. DMSO was distilled from CaH_2 and stored under an argon atmosphere over molecular sieves (4 Å) prior to use. Diethyl ether, toluene and benzene-d_6 were dried by distillation from sodium. Light petroleum ether (PE) and *tert*-butyl methyl ether (MTBE) for flash chromatography were purified by distillation. Flash chromatography was carried out with a Büchi Sepacore® Flash System X10 using Büchi Sepacore® Flash Cartridges (40 g silica gel) or Büchi PLASTIGLAS® columns with silica gel from Fluka (particle size 0.037-0.063 mm). For thin layer chromatography, ALUGRAM® TLC aluminium sheets with fluorescent indicator (254 nm) from Macherey-Nagel were used. All substances were detected with UV light. As light source for the photochemical reaction a water-

cooled Hanovia L 469 A 450 W mercury high pressure lamp was used. Melting points were determined with a Schorpp-Gerätetechnik melting point MPM-H2 apparatus and are uncorrected. IR spectra were recorded with a Bruker Tensor 27 spectrometer using an attenuated total reflection (ATR) method. Absorption values are given as wavenumbers (cm^{-1}). The intensities of the absorptions are given as weak (w), medium (m), strong (s), very strong (vs) and broad (br). NMR spectra were recorded with a Bruker Avance DRX or a Bruker Avance III spectrometer (^1H, 499.9 MHz; ^{13}C, 125.7 MHz; ^{19}F, 470.3 MHz) at 298 K. Chemical shifts (δ) are reported in ppm relative to the solvent residual peak of $CDCl_3$ (^1H, 7.26 ppm; ^{13}C, 77.00 ppm), benzene-d_6 (^1H, 7.16 ppm; ^{13}C, 128.00 ppm) or the signal of ferrocene (^1H, 4.00 ppm) or $CFCl_3$ (^{19}F, 0.00 ppm). Multiplicities are reported using the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; hept, heptet; m, multiplet; br., broad signal or their combinations. Coupling constants (*J*) are reported in Hz. The assignments of the multiplicities are based on DEPT, COSY, HMQC and HMBC spectra. Mass spectra (MS) or high-resolution mass spectra (HRMS) were recorded on a Finnigan MAT 95 spectrometer (EI) with an optional Linden CMS source (LIFDI) or on a Waters Q-TOF Premier spectrometer (ESI). GC analyses were performed on a Shimadzu GC-2010 plus gas chromatograph with a flame ionization detector.

Tricyclo[6.2.1.0^{2,7}]undeca-2,4,6,9-tetraene (9).[16] A flame-dried 500 mL three-necked round-bottom flask equipped with a Teflon®-coated oval stirring bar (2.5 cm), a septum, an argon-inlet and a dropping-funnel was charged with 1,2-dibromobenzene (**7**, 50.00 g, 212.0 mmol), freshly distilled cyclopentadiene (**8**, 14.01 g, 212.0 mmol) and toluene (250 mL). The flask was cooled to 0 °C and a solution of *n*-butyllithium (58.50 g, c = 2.5 mol·L^{-1} in hexanes, 212.0 mmol) was added dropwise over a period of 30 minutes. After the resulting white suspension had been stirred at 0 °C for additional ten minutes, the mixture was allowed to reach 25 °C and stirred overnight. Water (150 mL) was added and the layers were separated. The aqueous layer was extracted with PE (3×50 mL) and the combined organic layers were dried with $MgSO_4$, filtered and concentrated under vacuum. The crude product was purified by flash chromatography (SiO_2, PE) to give product **9** (17.45 g, 122.7 mmol, 58 %) as a colorless oil. R_f 0.34 (SiO_2, PE); IR (ATR, ν_{max}, cm^{-1}): 3067 (w), 2982 (w), 2934 (w), 2866 (w), 1454 (s), 1303 (s), 1007 (m), 830 (s); ^1H NMR (499.9 MHz, $CDCl_3$): δ_H 2.28 (1H, d, $^2J_{H,H}$ 7.0 Hz, CH_2), 2.36 (1H, d, $^2J_{H,H}$ 7.0 Hz, CH_2), 3.92 (2H, s, 2CH), 6.83 (2H, s, 2CH), 6.94-6.99 (2H, m, 2CH), 7.24-7.29 (2H, m, 2CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 50.3 (CH), 70.1 (CH_2), 121.5 (CH), 124.2 (CH), 143.0 (CH), 151.8 (C).

Tricyclo[6.2.1.0^{2,7}]undeca-2,4,6-trien-9-ol (10).[24] A 1000 mL round-bottom flask equipped with a Teflon®-coated oval stirring bar (2.5 cm) was charged with mercury(II) acetate (38.32 g, 120.3 mmol) and water (125 mL) followed by THF (125 mL) to form an orange suspension which was cooled to 0 °C. Alkene **9** (17.10 g, 120.3 mmol) was added dropwise and the resulting mixture was stirred at 25 °C for two hours to give a clear solution which was then treated with 3 N NaOH (125 mL) and a solution of sodium borohydride (2.28 g, 60.1 mmol) in 3 N NaOH (125 mL). After this mixture had been stirred for an additional hour, the resulting aqueous solution was decanted from precipitated mercury, saturated with sodium chloride and extracted with

MTBE (2×100 mL). The combined organic layers were dried with $MgSO_4$, filtered and concentrated under vacuum. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 4:1→1:2) and the obtained yellow solid was washed several times with PE at 0 °C to give product **10** (14.70 g, 91.7 mmol, 76 %) as a colorless solid. R_f 0.37 (SiO_2, PE/MTBE 2:1); mp 74-75 °C (according to ref. 24: mp 71-74 °C); IR (ATR, ν_{max}, cm^{-1}): 3253 (m, br.) (OH), 3072 (w), 3022 (w), 2962 (m), 2926 (m), 2875 (w), 2855 (w), 1470 (m), 1456 (m), 1407 (m), 1327 (m), 1285 (s), 1226 (m), 1075 (vs), 1045 (vs), 969 (vs); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.64 (1H, ddd, $^2J_{H,H}$ 12.5 Hz, $^3J_{H,H}$ 3.9 Hz, $^3J_{H,H}$ 2.3 Hz, CH_2), 1.82 (1H, ddd, $^2J_{H,H}$ 12.5 Hz, $^3J_{H,H}$ 6.7 Hz, $^3J_{H,H}$ 2.5 Hz, CH_2), 1.90-1.94 (1H, m, CH_2), 2.09 (1H, s, OH), 2.11 (1H, dt, $^2J_{H,H}$ 9.1 Hz, $^3J_{H,H}$ 1.3 Hz, CH_2), 3.25 (1H, s, CH), 3.31-3.35 (1H, m, CH), 3.99 (1H, d, $^3J_{H,H}$ 6.6 Hz, CH), 7.03-7.11 (2H, m, 2CH), 7.12-7.17 (1H, m, CH), 7.18-7.23 (1H, m, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 39.7 (CH_2), 42.9 (CH), 45.9 (CH_2), 52.2 (CH), 73.4 (CH), 120.6 (CH), 122.0 (CH), 125.5 (CH), 126.1 (CH), 144.4 (C), 149.4 (C).

Tricyclo[6.2.1.0^{2,7}]undeca-2,4,6-trien-9-one (11).[25] A flame-dried 1000 mL round-bottom Schlenk-flask equipped with a Teflon®-coated oval stirring bar (2.5 cm) and a septum was charged with oxalyl chloride (11.13 g, 87.7 mmol) and CH_2Cl_2 (200 mL) and was cooled to −78 °C. A solution of dimethyl sulfoxide (13.71 g, 175.4 mmol) in CH_2Cl_2 (40 mL) was added over a period of five minutes via syringe and the resulting mixture was stirred for 15 minutes. A solution of alcohol **10** (12.78 g, 79.7 mmol) in CH_2Cl_2 (80 mL) was added in portions over a period of five minutes via syringe to form a white suspension which was stirred for 15 minutes. Then triethylamine (40.35 g, 398.7 mmol) was added and the mixture was stirred for additional five minutes at −78 °C. The mixture was then allowed to reach 25 °C and water (400 mL) was added. The organic layer was separated and the aqueous layer was extracted with CH_2Cl_2 (400 mL). The combined organic layers were washed with brine (400 mL), diluted sulfuric acid (1 %, 400 mL), water (400 mL) and aqueous $NaHCO_3$ (5 %, 400 mL), dried with $MgSO_4$, filtered and concentrated under vacuum. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→1:1) to give product **11** (12.98 g, 82.1 mmol, 90 %) as a pale yellow oil. R_f 0.21 (SiO_2, PE/MTBE 9:1); IR (ATR, ν_{max}, cm^{-1}): 3069 (w), 3046 (w), 2973 (w), 2946 (w), 2918 (w), 2878 (w), 1742 (vs) (C=O), 1465 (m), 1460 (m), 1275 (m), 1122 (s), 979 (s); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.96 (1H, dd, $^2J_{H,H}$ 17.0 Hz, $^3J_{H,H}$ 4.5 Hz, CH_2), 2.26 (1H, dt, $^2J_{H,H}$ 9.6 Hz, $^3J_{H,H}$ 1.3 Hz, CH_2), 2.30 (1H, dd, $^2J_{H,H}$ 17.0 Hz, $^3J_{H,H}$ 3.9 Hz, CH_2), 2.43-2.49 (1H, m, CH_2), 3.57 (1H, s, CH), 3.64-3.68 (1H, m, CH), 7.11 (1H, td, $^3J_{H,H}$ 7.6 Hz, $^4J_{H,H}$ 1.2 Hz, CH), 7.15 (1H, td, $^3J_{H,H}$ 7.6 Hz, $^4J_{H,H}$ 1.2 Hz, CH), 7.24-7.30 (2H, m, 2CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 40.2 (CH_2), 41.6 (CH), 50.6 (CH_2), 57.8 (CH), 121.4 (CH), 123.4 (CH), 126.5 (CH), 127.2 (CH), 139.6 (C), 148.5 (C), 213.3 (C=O).

1-(2,2-Diethoxyethyl)-1*H*-indene (14). A flame-dried 1000 mL round-bottom Schlenk-flask equipped with a Teflon®-coated stirring bar (4 cm) and a septum was charged with indene (**12**, 16.84 g, 145.0 mmol) and diethyl ether (250 mL) and was cooled to −78 °C. A solution of *n*-butyllithium (44.02 g, c = 2.5 mol·L^{-1} in hexanes, 159.5 mmol) was added via syringe and the reaction mixture was allowed to reach 25 °C to form an orange solution. After the mixture had

been stirred at room temperature for two hours the flask was cooled to −78 °C and 2-bromo-1,1-diethoxyethane (**13**, 28.58 g, 145.0 mmol) was added via syringe. Then the reaction mixture was allowed to reach 25 °C and stirring at room temperature was continued for one hour. The resulting red solution was carefully hydrolyzed with water (200 mL) and the layers were separated. The aqueous layer was extracted with diethyl ether (2×100 mL) and the combined organic layers were washed with brine (200 mL), dried with $MgSO_4$ and filtered. Concentration under vacuum gave the acetal **14** (33.10 g, 142.5 mmol, 98 %) as a yellow oil with a purity of 97 % (GC). This material was used without further purification for the subsequent acetal cleavage. IR (ATR, ν_{max}, cm^{-1}): 3067 (w), 2976 (w), 2929 (w), 2877 (w), 1128 (s), 1057 (vs), 1019 (s), 776 (vs); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.21 (3H, t, $^3J_{H,H}$ 7.1 Hz, CH_3), 1.25 (3H, t, $^3J_{H,H}$ 7.1 Hz, CH_3), 1.68-1.76 (1H, m, CH_2), 2.20-2.27 (1H, m, CH_2), 3.47-3.61 (3H, m, CH, CH_2), 3.63-3.77 (2H, m, CH_2), 4.66-4.72 (1H, m, CH), 6.62 (1H, dd, $^3J_{H,H}$ 5.5 Hz, $^3J_{H,H}$ 1.8 Hz, CH), 6.62 (1H, dd, $^3J_{H,H}$ 5.5 Hz, $^4J_{H,H}$ 1.6 Hz, CH), 7.20 (1H, td, $^3J_{H,H}$ 7.4 Hz, $^4J_{H,H}$ 1.0 Hz, CH), 7.23-7.28 (1H, m, CH), 7.36 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH), 7.44 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 15.3 (CH_3), 15.4 (CH_3), 35.5 (CH_2), 46.6 (CH), 61.2 (CH_2), 61.4 (CH_2), 102.2 (CH), 121.0 (CH), 122.9 (CH), 124.7 (CH), 126.5 (CH), 130.7 (CH), 139.1 (CH), 144.1 (C), 147.5 (C); HRMS (ESI+) calcd. for $[C_{15}H_{20}O_2+Na]^+$: 255.1361. Found: 255.1363.

2-(1*H*-Inden-1-yl)acetaldehyde (5).[15] **Method A:** In a flame-dried 1500 mL three-necked tube equipped with a water-cooled 450 W Hg-high-pressure burner, a Teflon®-coated stirring bar (4 cm), a septum and an argon-inlet, ketone **11** (12.84 g, 81.2 mmol) was dissolved in diethyl ether (1.2 L). The mixture was irradiated at 25 °C for 24 hours (conversion was monitored by ^{1}H NMR spectroscopy) and afterwards, the solvent was removed under reduced pressure. Finally, the crude residue was distilled (17 cm Vigreux column, 0.011 mmHg) to give aldehyde **5** (9.59 g, 60.6 mmol, 75 %) as a colorless oil. **Method B:** A 2000 mL round-bottom flask equipped with a Teflon®-coated oval stirring bar (4 cm) was charged with acetone (1000 mL) and heated to 40 °C. Diethyl acetal **14** (17.42 g, 75.0 mmol) and iodine (1.90 g, 7.5 mmol) were added and the resulting mixture was stirred for two hours at 40 °C. Aqueous $Na_2S_2O_3$-solution (5 %, 500 mL) was added and the mixture was stirred for additional 15 minutes at 25 °C. Most of the acetone was then removed under reduced pressure and MTBE (500 mL) was added. The resulting layers were separated and the aqueous layer was extracted with MTBE (150 mL). The combined organic layers were washed with brine (150 mL), dried with $MgSO_4$, filtered and concentrated under vacuum. To remove unreacted acetale **14**, the crude product was purified by flash chromatography (SiO_2, PE/MTBE 19:1→1:1). Finally, the obtained orange oil was distilled (17 cm Vigreux column, 0.011 mmHg) to give aldehyde **5** (6.91 g, 43.7 mmol, 58 %) as a pale yellow oil. In both cases, aldehyde **5** was degassed (freeze, pump, thaw) and stored at −30 °C under an atmosphere of argon. R_f 0.23 (SiO_2, PE/MTBE 9:1); bp 68-69 °C at 0.011 mmHg (according to ref. 15: bp 76-77 °C at 0.2 mmHg); IR (ATR, ν_{max}, cm^{-1}): 3066 (w), 3013 (w), 2888 (w), 2823 (w) (CHO), 2726 (w) (CHO), 1720 (vs) (C=O); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 2.67 (1H, ddd, $^2J_{H,H}$ 17.6 Hz, $^3J_{H,H}$ 7.9 Hz, $^3J_{H,H}$ 1.4 Hz, CH_2), 2.91 (1H, ddd, $^2J_{H,H}$ 17.6 Hz, $^3J_{H,H}$ 5.9 Hz, $^3J_{H,H}$ 1.4 Hz, CH_2), 3.91-3.97 (1H, m, CH), 6.54 (1H, dd, $^3J_{H,H}$ 5.5 Hz, $^3J_{H,H}$ 1.9 Hz,

CH), 6.86 (1H, dd, $^{3}J_{H,H}$ 5.5 Hz, $^{4}J_{H,H}$ 1.8 Hz, CH), 7.21 (1H, td, $^{3}J_{H,H}$ 7.4 Hz, $^{4}J_{H,H}$ 1.0 Hz, CH), 7.29 (1H, t, $^{3}J_{H,H}$ 7.4 Hz, CH), 7.38 (1H, d, $^{3}J_{H,H}$ 7.4 Hz, CH), 7.41 (1H, d, $^{3}J_{H,H}$ 7.4 Hz, CH), 9.74 (1H, t, $^{3}J_{H,H}$ 1.4 Hz, CHO); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 44.2 (CH_2), 44.8 (CH), 121.4 (CH), 123.0 (CH), 125.2 (CH), 127.0 (CH), 132.0 (CH), 137.7 (CH), 144.0 (C), 146.2 (C), 201.0 (CHO).

General procedure for the reductive amination of aldehyde 5 with selected primary amines. A 50 mL round-bottom flask equipped with a Teflon®-coated stirring bar (1 cm) was charged with the primary amine (4.5 mmol) and methanol (6 mL). Aldehyde **5** (475 mg, 3.0 mmol) was added and the resulting solution was stirred for five minutes at 25 °C. Then a solution of sodium cyanoborohydride (207 mg, 3.3 mmol) and zinc chloride (225 mg, 1.7 mmol) in methanol (6 mL) was added dropwise and the solution was stirred for the appropriate time (see Table 1) at 25 °C (the conversion was monitored by TLC). The mixture was diluted with 0.1 N NaOH (25 mL) to form a white suspension which was extracted with MTBE (3×10 mL). The combined organic layers were washed with water (10 mL) and brine (10 mL), dried with $MgSO_4$, filtered and concentrated under vacuum to give the corresponding crude product which was purified by chromatography. All products were degassed (freeze, pump, thaw) and stored at −30 °C under an atmosphere of argon. *Storing under ambient conditions leads to decomposition of all products!*

***N*-[2-(1*H*-Inden-1-yl)ethyl]aniline (3a).** Aniline (**6a**, 419 mg, 4.5 mmol) was used as substrate. The reaction time was 30 minutes. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→1:1) to give product **3a** (607 mg, 2.6 mmol, 86 %) as a pale yellow oil. R_f 0.27 (SiO_2, PE/MTBE 9:1); IR (ATR, ν_{max}, cm^{-1}): 3409 (w) (NH), 3052 (w), 3020 (w), 2925 (w), 2857 (w), 1601 (vs), 1504 (vs), 1319 (s), 1259 (m); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.92-2.02 (1H, m, CH_2), 2.23-2.32 (1H, m, CH_2), 3.11-3.26 (2H, m, CH_2), 3.61 (1H, br. s, NH), 3.65 (1H, t, $^{3}J_{H,H}$ 6.5 Hz, CH), 6.56-6.62 (3H, m, 3CH), 6.73 (1H, t, $^{3}J_{H,H}$ 7.3 Hz, CH), 6.89 (1H, d, $^{3}J_{H,H}$ 5.3 Hz, CH), 7.20 (2H, t, $^{3}J_{H,H}$ 7.8 Hz, 2CH), 7.24 (1H, t, $^{3}J_{H,H}$ 7.4 Hz, CH), 7.31 (1H, t, $^{3}J_{H,H}$ 7.4 Hz, CH), 7.41 (1H, d, $^{3}J_{H,H}$ 7.4 Hz, CH), 7.46 (1H, d, $^{3}J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 30.9 (CH_2), 41.8 (CH_2), 48.4 (CH), 112.8 (CH), 117.3 (CH), 121.2 (CH), 122.8 (CH), 124.9 (CH), 126.7 (CH), 129.2 (CH), 131.5 (CH), 138.4 (CH), 144.2 (C), 147.0 (C), 148.0 (C); HRMS (ESI+) calcd. for $[C_{17}H_{17}N+H]^+$: 236.1439. Found: 236.1441.

***N*-[2-(1*H*-Inden-1-yl)ethyl]-4-(trifluoromethyl)aniline (3b).** 4-(Trifluoromethyl)aniline (**6b**, 725 mg, 4.5 mmol) was used as substrate. The reaction time was 15 minutes. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→1:2) to give product **3b** (827 mg, 2.7 mmol, 91 %) as a colorless oil. R_f 0.24 (SiO_2, PE/MTBE 4:1); IR (ATR, ν_{max}, cm^{-1}): 3418 (w) (NH), 3067 (w), 2930 (w), 2863 (w), 1617 (vs), 1535 (s), 1320 (vs), 1103 (vs), 1063 (vs); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.98-2.08 (1H, m, CH_2), 2.24-2.34 (1H, m, CH_2), 3.09-3.17 (1H, m, CH_2), 3.17-3.25 (1H, m, CH_2), 3.66 (1H, t, $^{3}J_{H,H}$ 5.9 Hz, CH), 3.84 (1H, br. s, NH), 6.52 (2H, d, $^{3}J_{H,H}$ 8.4 Hz, 2CH), 6.59 (1H, d, $^{3}J_{H,H}$ 5.2 Hz, CH), 6.92 (1H, d, $^{3}J_{H,H}$ 5.0 Hz, CH), 7.28 (1H, t, $^{3}J_{H,H}$ 7.2 Hz, CH), 7.35 (1H, t, $^{3}J_{H,H}$ 7.2 Hz, CH), 7.40-7.49 (4H, m, 4CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 30.4 (CH_2), 41.1 (CH_2), 48.2 (CH), 111.7 (CH), 118.6 (q, $^{2}J_{C,F}$ 32.5 Hz, C), 121.4 (CH), 122.7 (CH), 125.0 (CH), 125.1 (q, $^{1}J_{C,F}$ 270.3 Hz, CF_3), 126.5 (q, $^{3}J_{C,F}$ 3.6 Hz, CH),

126.8 (CH), 131.7 (CH), 138.1 (CH), 144.2 (C), 146.8 (C), 150.4 (C); ^{19}F NMR (470.3 MHz, $CDCl_3$): δ_F −60.8 (3F, s, CF_3); HRMS (ESI+) calcd. for $[C_{18}H_{16}F_3N+H]^+$: 304.1313. Found: 304.1313.

***N*-[2-(1*H*-Inden-1-yl)ethyl]-4-methoxyaniline (3c).** 4-Methoxyaniline (**6c**, 554 mg, 4.5 mmol) was used as substrate. The reaction time was two hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→1:2) to give product **3c** (695 mg, 2.6 mmol, 87 %) as an orange oil. R_f 0.20 (SiO_2, PE/MTBE 4:1); IR (ATR, ν_{max}, cm^{-1}): 3392 (w) (NH), 3059 (w), 2930 (w), 2855 (w), 2831 (w), 1509 (vs), 1232 (vs), 1035 (s); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.89-1.99 (1H, m, CH_2), 2.20-2.29 (1H, m, CH_2), 3.07-3.21 (2H, m, CH_2), 3.24 (1H, br. s, NH), 3.63 (1H, t, $^3J_{H,H}$ 6.8 Hz, CH), 3.76 (3H, s, CH_3), 6.52-6.57 (2H, m, 2CH), 6.59 (1H, d, $^3J_{H,H}$ 5.5 Hz, CH), 6.77-6.81 (2H, m, 2CH), 6.87 (1H, d, $^3J_{H,H}$ 5.5 Hz, CH), 7.23 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.30 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.40 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH), 7.44 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 31.0 (CH_2), 42.9 (CH_2), 48.4 (CH), 55.8 (CH_3), 114.2 (CH), 114.9 (CH), 121.2 (CH), 122.8 (CH), 124.9 (CH), 126.6 (CH), 131.4 (CH), 138.5 (CH), 142.3 (C), 144.2 (C), 147.1 (C), 152.2 (C); HRMS (ESI+) calcd. for $[C_{18}H_{19}NO+H]^+$: 266.1545. Found: 266.1537.

***N*-[2-(1*H*-Inden-3-yl)ethyl]pyridin-2-amine (4d).** 2-Aminopyridine (**6d**, 424 mg, 4.5 mmol) was used as substrate. The reaction time was 24 hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→MTBE) to give product **4d** (423 mg, 1.8 mmol, 60 %) as a pale yellow solid. R_f 0.28 (SiO_2, PE/MTBE 1:2); mp 96-97 °C; IR (ATR, ν_{max}, cm^{-1}): 3226 (m) (NH), 3090 (w), 3017 (w), 2948 (w), 2860 (w), 1604 (vs), 1575 (vs), 1452 (vs), 1440 (vs); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 2.91 (2H, t, $^3J_{H,H}$ 6.8 Hz, CH_2), 3.37 (2H, s, CH_2), 3.65 (2H, q, $^3J_{H,H}$ 6.5 Hz, CH_2), 4.59 (1H, br. s, NH), 6.33 (1H, s, CH), 6.38 (1H, d, $^3J_{H,H}$ 8.4 Hz, CH), 6.54-6.60 (1H, m, CH), 7.23 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.31 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.38-7.44 (2H, m, 2CH), 7.48 (1H, d, $^3J_{H,H}$ 7.3 Hz, CH), 8.11 (1H, d, $^3J_{H,H}$ 4.2 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 27.8 (CH_2), 37.9 (CH_2), 40.5 (CH_2), 106.8 (CH), 112.8 (CH), 118.9 (CH), 123.8 (CH), 124.8 (CH), 126.1 (CH), 129.5 (CH), 137.3 (CH), 141.5 (C), 144.4 (C), 144.9 (C), 148.3 (CH), 158.7 (C); HRMS (ESI+) calcd. for $[C_{16}H_{16}N_2+H]^+$: 237.1392. Found: 237.1395.

[2-(1*H*-Inden-3-yl)ethyl](propan-2-yl)amine (4e). Isopropylamine (**6e**, 266 mg, 4.5 mmol) was used as substrate. The reaction time was two hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→MTBE) to give product **4e** (305 mg, 1.5 mmol, 51 %) as a pale yellow oil. R_f 0.16 (SiO_2, MTBE/MeOH 9:1); IR (ATR, ν_{max}, cm^{-1}): 3066 (w), 3020 (w), 2964 (m), 2899 (w), 2831 (w), 1463 (s), 1172 (s); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.08 (6H, d, $^3J_{H,H}$ 6.2 Hz, $2CH_3$), 1.32 (1H, br. s, NH), 2.78 (2H, t, $^3J_{H,H}$ 7.2 Hz, CH_2), 2.85 (1H, hept, $^3J_{H,H}$ 6.2 Hz, CH), 2.96 (2H, t, $^3J_{H,H}$ 7.2 Hz, CH_2), 3.35 (2H, s, CH_2), 6.28 (1H, s, CH), 7.21 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.30 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.39 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH), 7.47 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 23.0 (CH_3), 28.6 (CH_2), 37.8 (CH_2), 45.7 (CH_2), 48.6 (CH), 118.9 (CH), 123.7 (CH), 124.6 (CH), 126.0 (CH), 128.8 (CH), 142.3 (C), 144.4 (C), 145.2 (C); HRMS (ESI+) calcd. for $[C_{14}H_{19}N+Na]^+$: 224.1415. Found: 224.1418.

[2-(1*H*-Inden-3-yl)ethyl](2-methylpropan-2-yl)amine (4f). *tert*-Butylamine (**6f**, 329 mg, 4.5 mmol) was used as substrate. The reaction time was two hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→MTBE) to give product **4f** (535 mg, 2.5 mmol, 83 %) as a colorless oil. R_f 0.15 (SiO_2, MTBE/MeOH 9:1); IR (ATR, ν_{max}, cm^{-1}): 3066 (w), 3041 (w), 3018 (w), 2962 (m), 2903 (w), 1360 (m), 1231 (m); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 0.86 (1H, br. s, NH), 1.11 (9H, s, $3CH_3$), 2.73-2.78 (2H, m, CH_2), 2.93 (2H, t, $^3J_{H,H}$ 7.3 Hz, CH_2), 3.33-3.36 (2H, m, CH_2), 6.26-6.30 (1H, m, CH), 7.21 (1H, td, $^3J_{H,H}$ 7.4 Hz, $^4J_{H,H}$ 0.9 Hz, CH), 7.30 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.39 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH), 7.47 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 29.1 (CH_3), 29.3 (CH_2), 37.8 (CH_2), 41.0 (CH_2), 50.3 (C), 119.0 (CH), 123.7 (CH), 124.6 (CH), 126.0 (CH), 128.7 (CH), 142.4 (C), 144.4 (C), 145.2 (C); HRMS (ESI+) calcd. for $[C_{15}H_{21}N+H]^+$: 216.1752. Found: 216.1747.

[2-(1*H*-Inden-3-yl)ethyl]cyclohexylamine (**4g).** Cyclohexylamine (**6g**, 446 mg, 4.5 mmol) was used as substrate. The reaction time was two hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→MTBE) to give product **4g** (469 mg, 1.9 mmol, 65 %) as a colorless oil. R_f 0.20 (SiO_2, MTBE/MeOH 9:1); IR (ATR, ν_{max}, cm^{-1}): 3234 (m) (NH), 3070 (w), 3021 (w), 2929 (vs), 2853 (vs), 1462 (s), 1372 (s), 1121 (vs); ^{1}H NMR (499.9 MHz, $CDCl_3$): δ_H 1.04-1.32 (5H, m, CH_2), 1.46 (1H, br. s, NH), 1.58-1.65 (1H, m, CH_2), 1.69-1.77 (2H, m, CH_2), 1.85-1.93 (2H, m, CH_2), 2.47 (1H, tt, $^3J_{H,H}$ 10.4 Hz, $^3J_{H,H}$ 3.6 Hz, CH), 2.78 (2H, t, $^3J_{H,H}$ 7.2 Hz, CH_2), 2.99 (2H, t, $^3J_{H,H}$ 7.2 Hz, CH_2), 3.34 (2H, s, CH_2), 6.27 (1H, s, CH), 7.21 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.30 (1H, t, $^3J_{H,H}$ 7.4 Hz, CH), 7.39 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH), 7.46 (1H, d, $^3J_{H,H}$ 7.4 Hz, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C 25.1 (CH_2), 26.2 (CH_2), 28.7 (CH_2), 33.6 (CH_2), 37.8 (CH_2), 45.1 (CH_2), 56.8 (CH), 119.0 (CH), 123.7 (CH), 124.6 (CH), 126.0 (CH), 128.8 (CH), 142.3 (C), 144.4 (C), 145.2 (C); HRMS (ESI+) calcd. for $[C_{17}H_{23}N+H]^+$: 242.1909. Found: 242.1903.

[2-(1*H*-Inden-1-yl)ethyl][(*R*)-1-phenylethyl]amine (3h) and [2-(1*H*-inden-3-yl)ethyl][(*R*)-1-phenylethyl]amine (**4h).** (*R*)-1-Phenylethylamine (**6h**, 545 mg, 4.5 mmol) was used as substrate. The reaction time was two hours. The crude product was purified by flash chromatography (SiO_2, PE/MTBE 9:1→MTBE) to give a mixture of the regioisomers **3h** and **4h** (633 mg, 2.4 mmol, 80 %, **3h**/**4h** 16:84) as a pale yellow oil. R_f 0.32 (SiO_2, MTBE/MeOH 19:1); IR (ATR, ν_{max}, cm^{-1}, mixture of **3h** and **4h**): 3061 (w), 3022 (w), 2960 (w), 2923 (w), 2885 (w), 2836 (w), 1451 (m), 1124 (m); ^{1}H NMR (499.9 MHz, $CDCl_3$, mixture of **3h** and **4h**) **4h**: δ_H 1.34 (1H, br. s, NH), 1.36 (3H, d, $^3J_{H,H}$ 6.6 Hz, CH_3), 2.71-2.90 (4H, m, $2CH_2$), 3.30-3.35 (2H, m, CH_2), 3.81 (1H, q, $^3J_{H,H}$ 6.6 Hz, CH), 6.20-6.24 (1H, m, CH), 7.13-7.37 (8H, m, 8CH), 7.43-7.47 (1H, m, CH); important signals of minor isomer **3h**: δ_H 1.30-1.35 (3H, m, CH_3), 1.61-1.74 (1H, m, CH_2), 2.01-2.05 (1H, m, CH_2), 2.53-2.70 (2H, m, CH_2), 3.50-3.58 (1H, m, CH), 3.75 (1H, q, $^3J_{H,H}$ 6.6 Hz, CH), 6.44-6.52 (1H, m, CH), 6.76-6.80 (1H, m, CH); ^{13}C NMR (125.7 MHz, $CDCl_3$, mixture of **3h** and **4h**) **4h**: δ_C 24.4 (CH_3), 28.4 (CH_2), 37.8 (CH_2), 45.9 (CH_2), 58.2 (CH), 119.0 (CH), 123.7 (CH), 124.6 (CH), 126.0 (CH), 126.5 (CH), 126.8 (CH), 128.4 (CH), 128.8 (CH), 142.2 (C), 144.4 (C), 145.2 (C), 145.7 (C); HRMS (ESI+) calcd. for $[C_{19}H_{21}N+H]^+$: 264.1752. Found: 264.1757.

Complex [{(η^5-C_9H_6)C_2H_4(η^1-NPh)}$TiCl_2$] (16). A flame-dried 100 mL round-bottom Schlenk-flask equipped with a Teflon®-coated oval stirring bar (2 cm) and a septum was charged with amine **3a** (1.34 g, 5.7 mmol) and diethyl ether (50 mL) and was cooled to −78 °C. A solution of *n*-butyllithium (3.14 g, c = 2.5 mol·L^{-1} in hexanes, 11.4 mmol) was added dropwise at −78 °C and subsequently, the resulting mixture was stirred at 25 °C for three hours to form a white suspension of the dilithium salt **15**. A flame-dried 250 mL round-bottom Schlenk-flask equipped with a Teflon®-coated oval stirring bar (2.5 cm) and a septum was charged with diethyl ether (50 mL) and cooled to −78 °C. Titanium tetrachloride (1.08 g, 5.7 mmol) was added via syringe and the resulting mixture was stirred for 15 minutes at −78 °C to form a yellow suspension. Then the suspension of dilithium salt **15** was added via Teflon®-cannula and the resulting mixture was stirred at 25 °C for two hours. The solvent was removed under reduced pressure, the residue was suspended in toluene (50 mL), filtered through Na_2SO_4 and the residue was washed with toluene (20 mL). The combined filtrates were concentrated under vacuum to a volume of approximately 30 mL and stored at −30 °C overnight to form red-brown crystals. The excess solvent was removed via syringe and the residue was dried under vacuum to give titanium complex **16** (668 mg, 1.9 mmol, 33 %) as a red-brown solid. mp 121-122 °C (dec.); IR (ATR, ν_{max}, cm^{-1}): 3098 (w), 3053 (w), 2934 (w), 2907 (w), 2853 (w), 1587 (m), 1478 (m), 1221 (m), 1200 (m), 1058 (m), 1042 (m), 1024 (m); ^{1}H NMR (499.9 MHz, benzene-d_6, ferrocene): δ_H 2.66-2.73 (1H, m, CH_2), 2.92-2.99 (1H, m, CH_2), 4.18-4.24 (1H, m, CH_2), 4.51-4.59 (1H, m, CH_2), 6.25 (1H, d, $^3J_{H,H}$ 3.3 Hz, CH), 6.38 (1H, d, $^3J_{H,H}$ 3.3 Hz, CH), 6.83-6.88 (1H, m, CH), 6.94-6.99 (2H, m, 2CH), 7.10-7.15 (2H, m, 2CH), 7.17-7.22 (1H, m, CH), 7.30-7.35 (1H, m, CH), 7.37-7.42 (2H, m, 2CH); ^{13}C NMR (125.7 MHz, benzene-d_6): δ_C 27.4 (CH_2), 77.6 (CH_2), 107.5 (CH), 120.7 (CH), 122.5 (CH), 123.1 (CH), 126.4 (CH), 127.0 (CH), 127.7 (C), 128.3 (CH), 128.3 (C), 128.4 (CH), 129.4 (CH), 135.4 (C), 153.4 (C); MS (LIFDI), *m/z* (%) = 355 ($C_{17}H_{15}{}^{37}Cl_2NTi$, 11), 353 ($C_{17}H_{15}{}^{35}Cl^{37}ClNTi$, 68), 351 ($C_{17}H_{15}{}^{35}Cl_2NTi$, 100). Red crystals suitable for X-ray single-crystal analysis were obtained from a solution of complex **16** (38 mg, 0.1 mmol) in benzene-d_6 (0.6 mL) which was stored in a sealed NMR tube at 25 °C for three hours.[19]

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Supplementary material

The traces of all NMR spectra reported in this paper, along with the IR spectra of the novel compounds and the X-ray data of compounds **4h·HCl** and **16** are accessible as Supplementary Data through the link to be found in the Contents page of the Journal.

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