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Synthesis and resolution of an α-phenyl substituted *ortho*-palladated matrix

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Abstract

A novel *ortho*-palladated benzylaminate matrix bearing phenyl substituent at the α-carbon stereocenter was prepared in the racemic state by direct intramolecular palladation of tertiary diphenylmethylamine with palladium(II) acetate; its structure and palladacycle conformation were determined by ^{1}H NMR studies of the mononuclear triphenylphosphine adduct. The resolution of the dimeric complex was performed via recrystallization of its diastereomeric (*S*)-prolinate derivatives. The absolute configuration (R_C,R_C) of the enantiopure dimer thus obtained was determined by an X-ray diffraction investigation of the less soluble (R_C,S_CS_N)-diastereomer of its (*S*)-prolinate adduct.

1. Introduction

After a long period of nearly complete monopoly of *ortho*-palladated derivatives of *N*,*N*-dimethyl-1-(1-naphthyl)ethylamine[1–13] and its conformationally less rigid[14] α-methylbenzylamine analogue[15–23] in all fields of stereochemical applications, only over the last few years has the structural diversity of this promising kind of organometallic matrix begun to expand.[24–28] Recently, a considerable influence of the side chain structure of the benzylaminate palladacycle on the chiral recognition ability was demonstrated.[29] As the practical result, a modification of the palladacycle structure was shown to be a powerful tool for the enhancement of these complexes efficiency as resolving[30,31] or derivatizing agents.[32] The present work describes the preparation, in enantiopure state, of the first benzylaminate palladacycle bearing a phenyl substituent on the α-carbon stereocenter. Until now only achiral α,α-diphenyl substituted analogues have been reported,[33] without any spectral and structural characterization.

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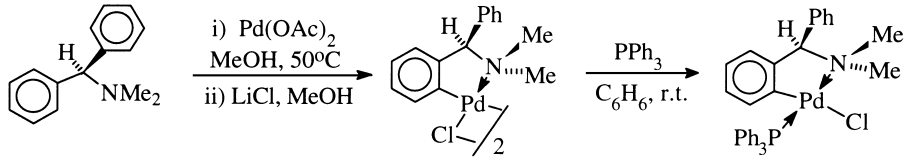
2. Results and discussions

2.1. ortho-*Palladated complexes: synthesis and characterization*

Racemic chloro-bridged dimer **1** was obtained in a yield of 85% upon heating an equimolar mixture of palladium(II) acetate and *N*,*N*-dimethyldiphenylmethylamine (HL) in methanol at 50°C followed by anion exchange. It was converted into the mononuclear triphenylphosphine derivative **2** by a standard μ-Cl bridge cleavage reaction (Scheme 1).



Scheme 1.

The ^{1}H NMR study of racemic adduct **2** has shown that the five-membered palladacycle exists preferentially in the λ(S_C) or δ(R_C) conformation with the α-Ph substituent in the axial position, which is typical for the benzylaminate derivatives bearing the bulky *tert*-Bu substituent at the carbon stereocenter.[31,32,34] This conclusion may be inferred from the $^4J_{HP}$ value of 4.1 Hz for the α-methine proton and confirmed by the results of nuclear Overhauser effect (NOE) measurements (see Fig. 1).

Namely, an NOE enhancement of both axial and equatorial NMe group signals (3.1 and 1.2%, respectively) under the irradiation of the α-methine proton, a dipolar interaction of the equatorial NMe group with the *ortho*-protons of the α-Ph substituent (2% enhancement) and the absence of a similar effect for the axial NMe group (Fig. 1a) may be mentioned in support of the λ(S_C) or δ(R_C) conformation of the palladacycle. The irradiation of NMe^{ax} and NMe^{eq} protons also results in the NOE enhancement of the α-CH resonance in the expected ratio (4.5 and 2.0%, respectively). This set of interactions is impossible in the case of the alternative δ(S_C) or λ(R_C) conformation of palladacycle (see Fig. 1b).

To note, the ^{1}H NMR pattern of the resonances of the *ortho*-palladated phenylene ring protons is rather complicated. These signals are separated from the other aromatic proton resonances and reveal as an ABCDX spin system (with X=^{31}P). Although they have a non-first order multiplicity (probably, due to an influence of the α-Ph substituent), the sequence of these signals (in the spectra measured in $CDCl_3$) remains the same, as that typical for the phosphine derivatives of the α-alkyl substituted

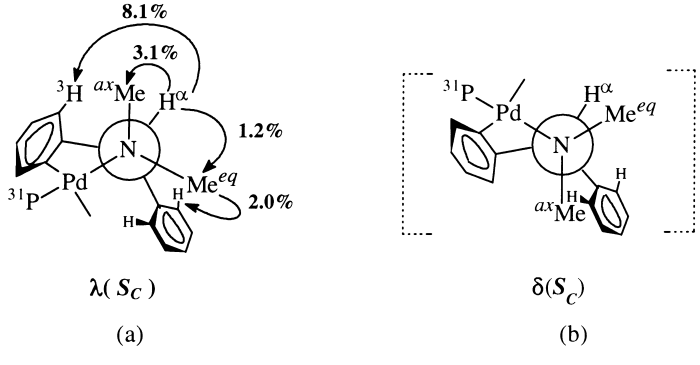


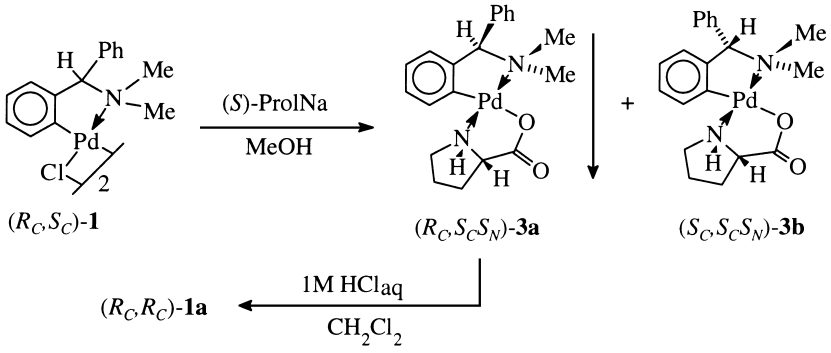
Figure 1. Newman projections of (S_C)-palladacycle along the N–C(α) bond for NOE-derived λ(S_C) conformation for (S_C)*-**2** (a), and that for the alternative δ(S_C) conformation (b)

palladacycles,[31,34] i.e. from C^6H at high field to C^3H at low field. The latter signal was identified on the basis of its considerable NOE enhancement under the irradiation of the α-CH proton (8.1%).

A rather large broadening of the signal of the *ortho*-protons of the α-Ph substituent (apparent singlet with the line width $\Delta\nu_{1/2}$ ca. 23 Hz in d_8-toluene at ambient temperature) should be mentioned as the specific peculiarity of the ^1H NMR spectra of adduct **2** and other mononuclear derivatives of dimer **1** (see below). This signal becomes sharper and acquires a doublet form at elevated temperatures ($\Delta\nu_{1/2}$ 15 Hz at 60°C). Such a behaviour may be considered as an indication for a rather restricted rotation of this substituent around the (α)C–C(*ipso*) bond. The low-field position of the resonance of the α-Ph *ortho*-protons (δ ca. 8 ppm for adduct **2**, compared to δ 7.42 ppm for starting ligand HL) may be caused by some kind of interaction with the palladium center (cf. Dunina et al.[31]); however, the simple deshielding effect of the palladated phenylene ring cannot be excluded at this stage.

2.2. Resolution of racemic dimer and solution structure of (S)-prolinate derivative

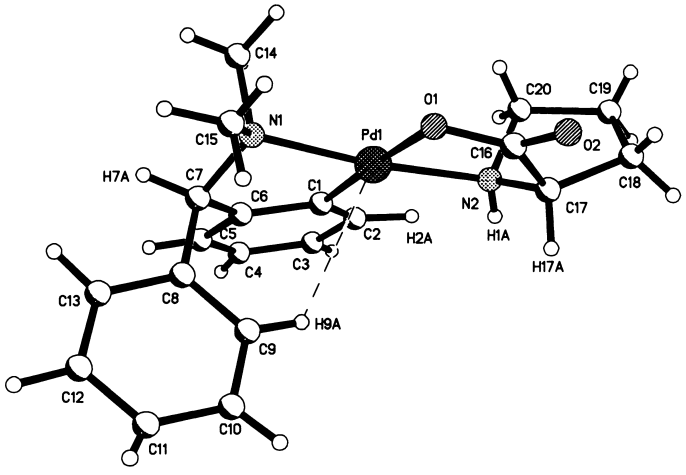
The resolution of racemic dimeric complex **1** was performed using (*S*)-prolinate as an auxiliary ligand (Scheme 2):



Scheme 2.

In the reaction of racemic dimer **1** with two molar equivalents of sodium (*S*)-prolinate, the formation of the 1:1 mixture of diastereomeric adducts (R_C,S_CS_N)-**3a** and (S_C,S_CS_N)-**3b** was detected by means of ^1H NMR spectroscopy. After its single slow recrystallization from methanol, the less soluble diastereomer (R_C,S_CS_N)-**3a** was isolated in a yield of 51% and >98% *de* (according to the ^1H NMR data). A subsequent protonation of this diastereomer under two-phase conditions leads to enantiopure dimer (R_C,R_C)-**1a** in a yield of 97%.

The structure and stereochemistry of less soluble diastereomer (R_C,S_CS_N)-**3a** was established on the basis of the ^1H NMR spectral data. The signal assignments (including those of prolinate ligand) were performed using the homonuclear decoupling and NOE experiments. The spectral pattern of the resonances of the *ortho*-palladated phenylene ring corresponds to a complicated ABCD spin system. Irradiation of the α-methine proton results in a response of the C^3H proton (at δ 6.69 ppm, 3.6%); further irradiation of the C^3H proton offers the possibility of identifying the adjacent C^4H proton of phenylene group (as a complicated signal at δ 6.98 ppm, 6.9%). Irradiation at the frequency of broad multiplet of (*S*)-prolinate NH proton (apparent quartet at δ 3.68 ppm) results in the 12.3% enhancement of the resonance of one of the aromatic protons of the palladated phenylene group (δ 6.92 ppm). The latter resonance must be identified only as that caused by the C^6H proton, because this aromatic H is the only one closely disposed with respect to the prolinate NH proton (at the distance of 2.41 Å for **3a** in the crystal state, see Fig. 2).



Selected bond lengths (A) and angles (deg.)

Pd(1)-C(1)	1.975(3)
Pd(1)-N(2)	2.037(2)
Pd(1)-N(1)	2.060(3)
Pd(1)-O(1)	2.102(2)
N(1)-C(15)	1.483(4)
N(1)-C(14)	1.486(4)
N(1)-C(7)	1.513(3)
C(1)-Pd(1)-N(2)	99.86(10)
C(1)-Pd(1)-N(1)	81.63(10)
N(2)-Pd(1)-N(1)	173.79(9)
C(1)-Pd(1)-O(1)	175.64(9)
N(2)-Pd(1)-O(1)	80.93(9)
N(1)-Pd(1)-O(1)	98.05(9)

Figure 2. X-Ray structure of diastereomer (R_C,S_CS_N)-**3a**. $C_{20}H_{24}N_2O_2Pd$, *M* 430.81, orthorhombic space group $P2_12_12_1$, *a* 9.766(5), *b* 12.446(9), *c* 15.302(9) Å, *V* 1860(2) Å^3, *Z* 4, d_{calc} 1.539 g cm^{-3}, Mo-K$_\alpha$ radiation, μ(Mo-K$_\alpha$) 1.013 mm^{-1}; 293 K; the final *R* and R_w values are 0.0192 and 0.0496, respectively, for 3283 independent reflections corrected for absorption by Ψ-scan curve

Two other responses were observed in the above-mentioned NOE experiment (with the NH proton irradiation), namely, an enhancement of the aliphatic resonances, at δ 4.19 ppm and δ 3.40 ppm (10.8% and 3.3%, respectively). These signals can be identified as belonging to the α-protons of the pyrrolidine cycle arranged on the same side of the five-membered heterocycle as the NH proton, i.e. to the $C^{2'}H$ proton (as the most low-field *quasi*-quartet resonance) and one of the $C^{5'}H$ protons, *cis*-arranged to the NH group, respectively. Starting from these data, further assignments of the other resonances of the prolinate ligand were performed using the routine spin–spin coupling technique (see Experimental).

The same NOE experiments gave valuable information regarding the geometry of complex **3a** and the palladacycle conformation. First, the above-mentioned dipolar interaction between the prolinate NH group and the C^6H proton of the palladated phenylene ring may be considered as an unambiguous support for the *trans*-(*N*,*N*)-geometry of prolinate adduct (R_C,S_CS_N)-**3a**. A rather large enhancement of the resonance of the axial NMe group (δ 7.47 ppm, 4.6%) indicates to the conservation of the same δ(R_C) conformation of the palladacycle in this case, as it was shown above for phosphine adduct **2** (see Fig. 1).

To note, both *ortho*-protons of the α-Ph group of complex **3a** are equivalent on the NMR time scale and appear as a very broad *quasi*-singlet resonance at δ 7.48 ppm (with the line width $\Delta\nu_{1/2}$ ca. 36 Hz) in spectra measured at room temperature, which becomes sharper at 55°C ($\Delta\nu_{1/2}$ 13 Hz). It is indicative of the restricted rotation of the α-Ph group around the (α)C–C(*ipso*) bond, similar to the above-mentioned behaviour observed for the PPh_3 adduct **2**.

2.3. X-Ray study of diastereomer ($R_CS_CS_N$*)-**3a***

The absolute configuration of α-carbon stereocenter in dimer **1a** thus prepared was determined by an X-ray single diffraction study of mononuclear precursor (R_C,S_CS_N)-**3a**. Molecular structure, numbering scheme and selected bond lengths and angles of this diastereomer are presented in Fig. 2.

The (R_C) configuration of the α-carbon stereocenter of palladacycle is confirmed independently using (S_CS_N)-prolinate as a reference point and based on the anomalous X-ray scattering method with the Flack

parameter −0.01(2). The geometric parameters of the molecule are in the range of the values typical for the *ortho*-palladated derivatives of tertiary α-alkyl substituted benzylamines previously studied. The tetrahedral distortion of palladium coordination environment is moderate, with the angle between the $\{Pd^1C^1N^1\}$ and $\{Pd^1N^2O^1\}$ planes equal to 8.1°.

Benzylaminate palladacycle has an envelope-like conformation, with a bend along the $Pd^1\cdots C^7$ bond of 38.4° and averaged intrachelate torsion angle of 23.1°. Its δ(R_C)-stereochemistry with the axially oriented α-Ph group is in full agreement with the conformation deduced from the ^{1}H NMR data in solution. The angle between the bond C^7–C^8 and the mean coordination plane $\{Pd^1C^1N^1N^2O^1\}$ is equal to 166.2° (i.e. adjacent angle 13.8°).

Several arguments may be given in support to an assumption about some kind of interaction between the α-Ph group and the palladium atom: (i) the α-substituent is disposed nearly orthogonally in regard to the mean coordination plane, with the angle between the $\{C^8C^9C^{10}C^{11}C^{12}C^{13}\}$ and $\{Pd^1C^1N^1N^2O^1\}$ planes of 103.9°; (ii) one of two *ortho*-protons of the α-Ph group (H^{9A}) is directed to the metal center, with the dihedral angle $\angle Pd^1C^7C^8C^9$ of −25.8°; (iii) a rather short contact between this *ortho*-proton and palladium atom ($H^{9A}\cdots Pd^1$) at 2.847 Å distance may be mentioned. All these features allow us to suppose, that the *ortho*-H···Pd interaction may contribute at some extent into the stabilization of the δ(R_C)-palladacycle conformation, with the axially arranged α-Ph substituent which is capable of screening efficiently one of two axial positions at the metal center.

3. Conclusion

The first example of benzylaminate palladacycle bearing a rather bulky phenyl substituent at the α-carbon stereocenter has been efficiently prepared in an enantiopure state by a single crystallization of its (*S*)-prolinate derivative. Both X-ray and ^{1}H NMR spectral study of its mononuclear derivatives have shown that the palladacycle exists preferably in the λ(S_C) or δ(R_C) conformation, with the α-Ph substituent in the axial position both in solution and in the solid state. It may be proposed that an interaction of the *ortho*-protons of the α-Ph group with the palladium atom contributes at some extent into the stabilization of this conformation of the palladacycle.

The evaluation of a new palladacycle ability to chiral recognition is now under investigation.

4. Experimental

4.1. General

^{1}H and ^{31}P NMR spectra were recorded with a Varian VXR-400 spectrometer operating at the frequencies 400 and 161.9 MHz for ^{1}H and ^{31}P nuclei, respectively. The measurements were carried out at ambient temperature in $CDCl_3$ solutions (unless otherwise indicated). The chemical shifts are reported in δ-scale in parts per million relative to TMS as internal standard for protons and relative to H_3PO_4 as an external reference for the ^{31}P nuclei. The assignment of signals was performed on the basis of homonuclear decoupling, NOE experiments and spectra simulation.

4.2. Solvents and starting materials

Benzene, hexane and ether were dried over appropriate drying agents and then distilled under argon from Na; anhydrous MeOH was prepared by distillation from MgOMe; dichloromethane was passed through a short Al_2O_3 column and distilled under argon; acetone of highest purity, and [D_1]chloroform (from Aldrich) were used as received. Triphenylphosphine was purified by two-fold recrystallization from a benzene/hexane mixture; palladium(II) acetate was purchased from Aldrich and used as received.

4.3. Ligand synthesis

N,*N*-Dimethyldiphenylmethylamine (HL) was synthezised in a yield of 62% by methylation[35] of the corresponding primary amine (prepared by reported method[36]): mp 132–135°/5 mmHg; R_f 0.57 (Silufol, C_6H_6:MeOH 5:1). Anal. calcd for $C_{15}H_{17}N$: C, 85.26; H, 8.11; N, 6.63. Found: C, 85.12; H, 8.20; N, 6.57. ^{1}H NMR ($CDCl_3$): δ 2.192 (s, 6H, NMe_2), 4.053 (s, 1H, α-CH), 7.159 (t, 2H, $^3J_{HH}$ 7.3 Hz, *para*-H of Ph rings), 7.258 (t, 4H, $^3J_{HH}$ 7.7 Hz, *meta*-H of Ph rings), 7.424 (d, 4H, $^3J_{HH}$ 7.3 Hz, *ortho*-H of Ph rings).

4.4. Preparation of ortho-palladated complexes

4.4.1. Racemic di-μ-chlorobis[2-{1-(dimethylamino)benzyl}phenyl-2*C*,N]dipalladium **1**

The solution of amine HL (0.200 g, 0.95 mmol) and palladium acetate (0.213 g, 0.95 mmol) in MeOH (8 mL) was heated at 50°C for 1.5 h under the TLC control (Silufol, ether:heptane 3:1). The reaction mixture was cooled and treated at rt by the three-fold excess of lithium chloride (0.121 g, 2.85 mmol) in MeOH (4 mL) under stirring (40 min). The precipitate formed was filtered, washed by MeOH and purified by short dry column chromatography[37,38] on Silpearl (h 1 cm, d 2 cm) using ether:heptane 3:1 mixture as eluent. After drying and reprecipitation from benzene by hexane racemic dimer **1** was isolated in a yield of 85% (0.276 g, 0.39 mmol) as light-yellow amorphous powder. Mp (dec.) 195–196°C; R_f 0.53 (Silufol, ether:heptane 3:1). Anal. calcd for $C_{30}H_{32}Cl_2N_2Pd_2$: C, 51.16; H, 4.58; N, 3.98. Found: C, 51.47; H, 4.82; N, 3.51.

^{1}H NMR ($CDCl_3$)†: δ 2.443, 2.455, 2.514, 2.517 (s, 3H, NMe^{eq}), 2.954, 2.979, 3.029, 3.031 (s, 3H, NMe^{ax}), 4.908, 4.915, 4.920 (s, 1H, α-CH); 6.638, 6.885, 7.231, 7.401 (a series of overlapping multiplets of aromatic protons of α-Ph and palladated phenylene groups).

4.4.2. Racemic chloro[2-{1-(dimethylamino)benzyl}phenyl-2*C*,N](triphenylphosphine)palladium **2**

The solution of stoichiometric amounts of racemic dimer **1** (0.035 g, 0.05 mmol) and triphenylphosphine (0.026 g, 0.10 mmol) in benzene (4 mL) was stirred for 30 min at rt. The reaction mixture was concentrated and treated by heptane to give adduct **2** as light-yellow amorphous powder in a yield of 92% (0.055 g, 0.09 mmol). Mp (dec.) 205–207°C; R_f 0.50 (Silufol, ether:heptane 10:1). Anal. calcd for $C_{33}H_{31}ClNPPd$: C, 64.51; H, 5.09; N, 2.28. Found: C, 64.86; H, 5.01; N, 2.20.

^{31}P NMR ($CDCl_3$): δ 40.85 ppm (s). ^{1}H NMR ($CDCl_3$, 26°C): palladacycle signals: δ 2.599 (d, 3H, $^4J_{HP}$ 2.7 Hz, NMe^{eq}), 2.953 (d, 3H, $^4J_{HP}$ 1.6 Hz, NMe^{ax}), 4.869 (d, $^4J_{HP}$ 4.1 Hz, 1H, α-CH); 6.33–6.41 (m, AB part of ABCDX system with X=^{31}P, 2H, C^6H+C^5H), 6.757 (m, C part of ABCDX system, 1H, C^4H), 6.847 (br.d, D part of ABCDX system, 1H, C^3H), 7.961 (br.s, 2H, $\Delta\nu_{1/2}$ 19 Hz, *ortho*-H of α-Ph

† The spectrum contains four sets of signals (partially overlapped) in the ca. 1:1:1:1 ratio caused by *cis*/*trans* isomers of two diastereomers of (R_C,R_C)* and (R_C,S_C) configuration.

group), 7.38 (m, 3H, *meta*-H and *para*-H of α-Ph group); phosphine signals: δ 7.766 (m, 6H, $^3J_{HP}$ 10.9 Hz, *ortho*-H of PPh groups); 7.428 (m, 3H, *para*-H of PPh groups); 7.33–7.40 (m, 6H, *meta*-H of PPh groups).

^{1}H NMR (d$_8$-toluene, 60°C): palladacycle signals‡: δ 2.732 (br.s, 3H, $\Delta\nu_{1/2}$ 9 Hz, NMe^{eq}), 2.951 (br.s, 3H, $\Delta\nu_{1/2}$ 7.5 Hz, NMe^{ax}), 4.816 (d, $^4J_{HP}$ 4.0 Hz, 1H, α-CH); 6.669 (m, B part of ABCDX system with X=^{31}P, 1H, $^5J_{HP}$ 0.5 Hz, $^3J_{54}$ 7.3 Hz, $^3J_{56}$ 7.6 Hz, $^4J_{35}$ 1.6 Hz, C^{5}H), 6.885 (m, A part of ABCDX system, 1H, $^4J_{HP}$ 6.5 Hz, $^3J_{56}$ 7.6 Hz, $^4J_{46}$ 0.9 Hz, C^{6}H), 6.921 (m, C part of ABCDX system, 1H, $^3J_{34}$= $^3J_{45}$=7.3 Hz, $^4J_{46}$ 0.9 Hz, C^{4}H), 6.977 (m, D part of ABCDX system, 1H, $^3J_{34}$ 7.3 Hz, $^4J_{35}$ 1.6 Hz, C^{3}H), 8.067 (br.d, 2H, $^3J_{HH}$ 7.7 Hz, $\Delta\nu_{1/2}$ 15 Hz, *ortho*-H of α-Ph group), ~7.3–7.4 (m, 3H, *meta*-H and *para*-H of α-Ph group); phosphine signals: δ 8.122 (m, 6H, $^3J_{HP}$ 11.7 Hz, *ortho*-H of PPh groups); 7.22–7.28 (m, 9H, *meta*-H and *para*-H of PPh groups).

4.5. Racemic dimer ***1*** resolution

4.5.1. Diastereomeric (S)-prolinate complexes ***3a,b*** — preparation

The solution of the racemic dimer **1** (0.789 g, 1.12 mmol) and sodium (*S*)-prolinate (0.258 g, 2.24 mmol) in MeOH (100 mL) was stirred for 1 h at rt. The reaction mixture was evaporated to dryness, treated by water and extracted by dichloromethane (4×30 mL). After drying over sodium sulfate the organic layers were filtered and evaporated to dryness to give the diastereomeric mixture **3a**,**b** as colourless amorphous powder in a yield of 90% (0.869 g, 2.02 mmol). R_f 0.22 and 0.11 for **3a** and **3b**, respectively (Silufol, ethyl acetate:hexane:methanol 5:5:1), $[\alpha]_D^{20}$ 187.5 (*c* 0.4, dichloromethane).

4.5.2. Diastereomeric (S)-prolinate complexes ***3a,b*** — separation

The single slow recrystallization of the diastereomeric mixture **3a,b** from dichloromethane/ether at 0°C results in the precipitation of the less soluble diastereomer (R_C,$S_C S_N$)-**3a** as dichloromethane hemisolvate in a yield of 51% (0.223 g, 0.52 mmol) and >98% *de* (^{1}H NMR data). After drying in vacuo (7 torr) at rt, mp (dec.) 234–236°C; $[\alpha]_D^{20}$ 110 (*c* 0.4, dichloromethane). R_f 0.41 (Silufol, dichloromethane:methanol 10:1), R_f 0.22 (Silufol, ethyl acetate:hexane:methanol 5:5:1). Anal. calcd for $C_{20}H_{24}N_2O_2Pd\cdot 0.4CH_2Cl_2$: C, 52.71; H, 5.38; N, 6.03. Found: C, 52.68; H, 5.39; N, 6.17.

The recrystallization of the diastereomeric mixture remaining in the mother liquor from the dichloromethane–hexane under cooling results in the precipitation of the mixture enriched with other diastereomer (S_C,$S_C S_N$)-**3b** in a yield of 88% (0.383 g, 0.89 mmol) and 62% *de* (^{1}H NMR data). Mp (dec.) 210–212°C; $[\alpha]_D^{20}$ 235 (*c* 0.4; dichloromethane).

For diastereomer (R_C,$S_C S_N$)-**3a**: ^{1}H NMR ($CDCl_3$, 26°C): palladacycle signals: δ 2.491 (s, 3H, NMe^{eq}), 2.930 (s, 3H, NMe^{ax}), 5.144 (s, 1H, α-CH); 6.686 (m, D part of ABCD system, 1H, C^{3}H), 6.921 (m, A part of ABCD system, 1H, C^{6}H), 6.96–7.00 (m, BC part of ABCD system, 2H, C^{5}H+C^{4}H), 7.39–7.43 (m, 3H, *meta*-H and *para*-H of α-Ph group), 7.475 (br.s, 2H, $\Delta\nu_{1/2}$ 36 Hz, *ortho*-H of α-Ph group); (*S*)-prolinate signals: δ 1.721 (m, 1H, C$^{4'}$H), 2.032 (m, 1H, C$^{4'}$H), 2.261 (m, 1H, C$^{3'}$H), 2.362 (m, 1H, C$^{3'}$H), 3.338 (m, 1H, C$^{5'}$H), 3.400 (m, 1H, C$^{5'}$H), 3.681 (br.m, 1H, NH), 4.191 (ddd, 1H, $^3J_{HNCH_{2'}}$ 9.1, $^3J_{HCCH}$ 7.6 and 5.3 Hz, C$^{2'}$H). ^{1}H NMR ($CDCl_3$, 55°C): palladacycle signals: δ 2.485 (s, 3H, NMe^{eq}), 2.939 (s, 3H, NMe^{ax}), 5.096 (s, 1H, α-CH); 6.676 (m, 1H, C^{3}H), 6.898 (m, 1H, C^{6}H), 6.94–6.97 (m, 2H, C^{5}H+C^{4}H), 7.37–7.40 (m, 3H, *meta*-H and *para*-H of α-Ph group), 7.492 (br.s, 2H, $\Delta\nu_{1/2}$ 13 Hz, *ortho*-H of α-Ph group); (*S*)-prolinate signals: δ 1.718 (m, 1H, C$^{4'}$H), 2.034 (m, 1H, C$^{4'}$H),

‡ The assignment of resonances of palladated phenylene ring protons was confirmed by the spectra simulation.

2.214 (m, 1H, $C^{3'}H$), 2.400 (m, 1H, $C^{3'}H$), 3.32–3.43 (m, 2H, $C^{5'}H_2$), 3.586 (br.dd, 1H, NH), 4.163 (m, 1H, $C^{2'}H$); solvate dichloromethane signal: δ 5.300 (s, 0.8H).

For diastereomer (S_C,S_CS_N)-**3b**: ^{1}H NMR ($CDCl_3$, 26°C)[§]: palladacycle signals: δ 2.457 (s, 3H, NMe^{eq}), 2.914 (s, 3H, NMe^{ax}), 4.715 (s, 1H, α-CH); 7.45 (br.s, 2H, $\Delta\nu_{1/2}$ 20 Hz, *ortho*-H of α-Ph group), 6.98, 7.40, 7.35 (m, remaining aromatic protons); (*S*)-prolinate signals: δ 1.787 (m, 1H, $C^{4'}H$), 2.023 (m, 1H, $C^{4'}H$), 2.30 (m, 2H, $C^{3'}H_2$), 3.395 (m, 1H, $C^{5'}H$), 3.480 (m, 1H, $C^{5'}H$), 4.265 (br.m, 1H, NH), 4.170 (m, 1H, $C^{2'}H$).

Dimer (R_C,R_C)-**1a** isolation. The solution of individual diastereomer (R_C,S_CS_N)-**3a** (0.078 g, 0.181 mmol) in CH_2Cl_2 (3 mL) was treated with aqueous 1N HCl (3 mL) under vigorous shaking during ca. 10 min. The aqueous layer was extracted with CH_2Cl_2 (2×2 mL), the organic layers were dried over Na_2SO_4, concentrated in vacuo to dryness to obtain dimer (R_C,R_C)-**1a** in a yield of 97% (0.061 g, 0.08 mmol) and >98% ee. Mp 175–177°C; $[\alpha]_D^{20}$ −132 (c 0.4, dichloromethane).

^{1}H NMR ($CDCl_3$)[¶]: δ 2.455, 2.518 (s, 3 H, NMe^{eq}), 2.953, 3.023 (s, 3H, NMe^{ax}), 4.918 (br. s, 1H, α-CH); 6.637, 6.885, 7.240, 7.401 (a series of overlapping multiplets of aromatic protons of α-Ph and palladated phenylene groups).

*4.6. X-Ray diffraction study of diastereomer (R_C,S_CS_N)-**3a***

The main crystallographic parameters are given in Fig. 2. The independent reflections (3283) were measured on an Enraf–Nonius CAD-4 diffractometer using the ω scan mode, with the scan range of 1.1 deg. The structure was solved by the direct methods and refined anisotropically for all non-hydrogen atoms using full-matrix least squares on F^2. The hydrogen atoms were refined using the 'riding' model. The absolute configuration was determined based on the Flack parameter (−0.01(2)). All the calculations were performed using the SHELXS-86[39] and SHELXS-93[40] software.

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[§] From the spectra of the **3b**:**3a** diastereomeric mixture in 5.8:1.4 ratio

[¶] The spectrum contains two sets of signals (partially overlapped) in the ca. 1:1 ratio caused by *cis*:*trans* isomers of one diastereomer of (R_C,R_C) configuration.

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