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The first NH aldimine organometallic compound. Isolation and crystal structure†

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The first NH aldimine organometallic derivative is unexpectedly formed by the cleavage of the nitrogen–carbon bond of the amino acid fragment of the Schiff base 2,4,6-$Me_3C_6H_2CH{=}NCH(CH_2Ph)COOEt$ when the imine is treated with palladium acetate.

NH aldimines have been proposed as unstable intermediates in many reactions and their highly unstable nature is well documented.[1] The first evidence for the existence of the NH aldimines, containing a saturated alkyl group, was reported in 1982[1a] and PhCH=NH was identified in 1985 by NMR studies in $C_6D_5CD_3$ at −70 °C and by the reaction with methylamine to yield *N*-benzylidenemethylamine *via* a transimination reaction.[1b] Only two NH aldimines have ever been isolated, in both cases at low temperatures.[1c,d] Recently, Chen and Brown have reported the synthesis of stable adducts of these imines with boranes, as new intermediates for using these ligands in organic synthesis.[2] Besides this, the formation of NH aldimines, during monoamine oxidases (MAO) catalyzed transformation of amines, has been established by biosynthetic investigations.[3] Monoamine oxidases are primarily responsible for norepinephrine, serotonin and dopamine metabolism and MAO inhibitors are used as antidepressant agents (depression has been associated with decreased functional amine-dependent synaptic transmission).[4]

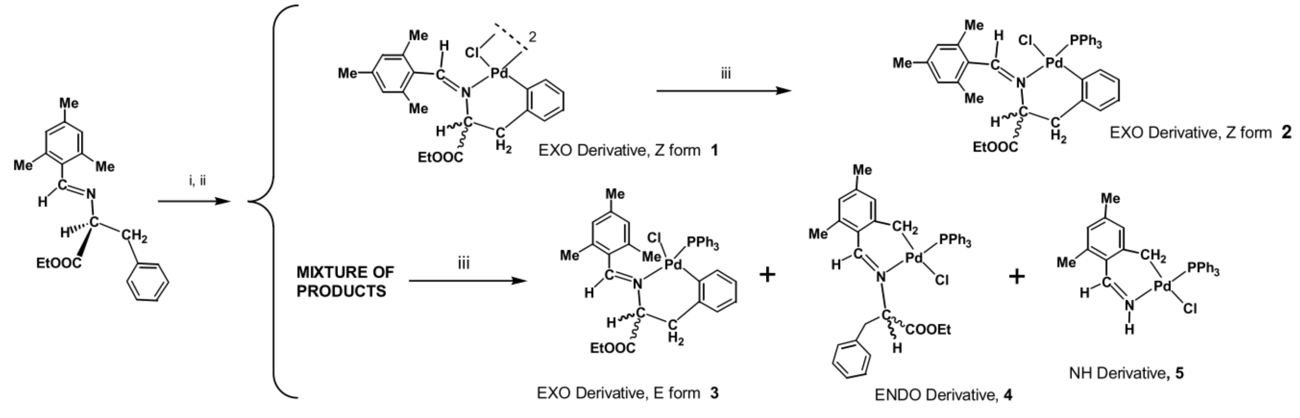
As part of our continuing studies on the synthesis of metallacycles containing N-donor ligands[5] we have investigated the action of palladium acetate on the Schiff base 2,4,6-$Me_3C_6H_2CH{=}NCH(CH_2Ph)COOEt$, obtained by condensation of mesitaldehyde with the L-phenylalanine ethyl ester.[6] The reaction was performed in toluene for 1 h at room temperature and the reaction residues were treated with LiCl in acetone for 30 min to afford a mixture of compounds. The chloro-bridged *exo*-cyclopalladated dimer **1** (that contains the imine in the *Z*-form) was isolated, after purification by SiO_2 column chromatography, in the first colored band (Scheme 1).[7] A complex mixture of products were eluted in the second colored band. Reaction of dimer **1** with PPh_3 afforded the mononuclear *exo*-complex $[PdCl(C–N)(PPh_3)]$ **2**. The reaction between PPh_3 and the mixture of compounds obtained in the second colored band afforded a new mixture of compounds that were separated by SiO_2 column chromatography, to afford the *exo*-derivative **3** (that contains the imine in the *E*-form), the *endo* metallacycle **4** and the NH aldimine derivative **5**, in 20, 25 and 15% yield, respectively. Compound **5** is unexpectedly formed by the cleavage of the nitrogen–carbon bond of the amino acid fragment and, to the best of our knowledge, is the first NH aldimine organometallic derivative described.[8]

All the new organometallic compounds obtained were characterised by elemental analysis, IR spectra and ^1H and ^{31}P NMR experiments. In some cases 2D-NMR experiments and positive FAB-mass spectra were carried to complete the characterisation.[9] The high field shift of the aromatic protons of the palladated ring in compounds **2**, due to the aromatic rings of the phosphine, indicates the *cis* disposition of the phosphorous relative to the metallated carbon atom, and the chemical shift of the phosphorous confirms this arrangement.[5,10]

The structure of **2** was determined by X-ray diffraction (Fig. 1).[11,12] This complex is a six-membered *exo*-metallacycle that contains the imine in the *Z*-form.

The structure of the NH aldimine derivative **5** was also determined by X-ray diffraction (Fig. 2).[12,13] It should be noted that the molecules in unit cell are linked in pairs by two N–H···Cl intermolecular bonds.

All the attempts carried out for the synthesis of palladium coordinated NH aldimines, by reaction between NH_3 and mesitylaldehyde in different solvents and reaction conditions were unsuccessful. Nevertheless we found that compound **5** can also be obtained from the cyclometallation reaction of Schiff



Scheme 1 *Reagents and conditions*: (i) $Pd(AcO)_2$, toluene, 1 h.; (ii) LiCl, acetone, 30 min; (iii) PPh_3, acetone, 30 min.

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† Electronic supplementary information (ESI) available: experimental section. See http://www.rsc.org/suppdata/cc/b2/b211808d/

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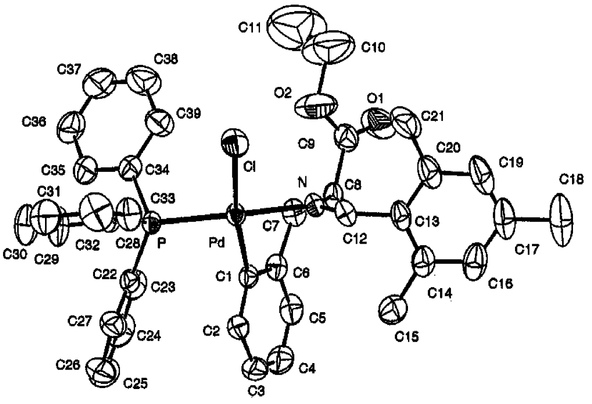

Fig. 1 ORTEP plot of **2**. Selected bond lenghts (Å) and angles (°): Pd–C(1) 2.002(2), Pd–N 2.109(2), Pd–P 2.2543(7), Pd–Cl 2.4010(7), O(1)–C(9) 1.164(4), O(2)–C(9) 1.294(4), N–C(12) 1.264(4), N–C(8) 1.483(3); C(1)–Pd–N 81.78(9), C(1)–Pd–P 90.58(7), N–Pd–Cl 89.79(6), P–Pd–Cl 98.88(3).

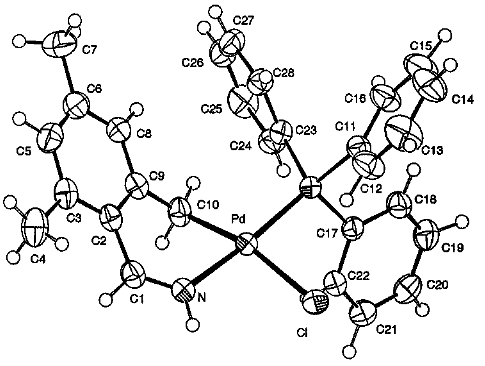

Fig. 2 ORTEP plot of **5**. Selected bond lenghts (Å) and angles (°): Pd(1)–C(10) 2.041(5), Pd(1)–N 2.067(3), Pd(1)–P(2) 2.2597(10), Pd(1)–Cl 2.4354(12), N–C(1) 1.275(5), C(1)–C(2) 1.454(6); C(10)–Pd(1)–N 82.39(17), C(10)–Pd(1)–P(2) 94.15(12), N–Pd(1)–Cl 88.67(12), P(2)–Pd(1)–Cl 95.17(4).

base 2,4,6-$Me_3C_6H_2CH$=NCH(Ph)COOMe, which contains the 2-phenylglycine fragment. These results show that the reactivity of the amino acid fragment plays a crucial role in the synthesis of **5**.

In conclusion we have shown that the highly unstable NH aldimines can be obtained by reaction between palladium acetate and phenylalanine derivatives and that these species, when coordinated to palladium, are so stable that can easily be characterized and their crystal structure determined by X-ray diffraction. The synthesis of new NH aldimines from other biologically important ligands, in the presence of transition metals, and experiments for clarifying the mechanism of the formation of the NH aldimine derivatives are currently in progress.

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8 *Characterization data* for **5**: elemental analysis: calc. for $C_{28}H_{27}ClNPPd$: C, 61.11, H, 4.94, N, 2.55; found: C 61.1, H 4.9, N 2.6%. ^1H NMR (400 MHz, $CDCl_3$): δ 2.15 (s, 3H, Me); 2.36 (s, 3H, Me); 2.81 (d, 2H, $^3J_{HP}$ 5.6 Hz, CH_2Pd); 6.08 (s, 1H, aromatic); 6.74 (s, 1H, aromatic); 7.39–7.42 (m, 6H, aromatic); 7.63–7.70 (m, 9H, aromatic); 8.49 (t, 1H, $^4J_{HP}$ 13.2, $^3J_{HH}$ 13.2 Hz, HC=N); 9.22 (br d, 1H, $^3J_{HH}$ 13.2 Hz, HN), $^{31}P\{^1H\}$ NMR (101.26 MHz, $CDCl_3$), δ 34.19 s.

9 Complete racemization of the Schiff base takes place during the cyclopalladation reaction.

10 (*a*) The destabilizing effect of two soft ligands in mutual *trans* positions has been called *antisymbiosis*, see: J. A. Davies and F. R. Hartley, *Chem. Rev.*, 1981, **81**, 79; (*b*) R. G. Pearson, *Inorg. Chem.*, 1973, **12**, 712; (*c*) R. Navarro and E. P. Urriolabeitia, *J. Chem. Soc., Dalton Trans*, 1999, 4111. Recently the term *transphobia* has been proposed to describe the difficulty of coordinating mutually *trans* phosphine and aryl ligands in palladium complexes, see (*d*) J. Vicente, J. A. Abad, A. D. Frankland and M. C. Ramírez de Arellano, *Chem. Eur. J.*, 1999, **5**, 3066; (*e*) J. Vicente, A. Arcas, D. Bautista and P. G. Jones, *Organometallics*, 1997, **16**, 2127; (*f*) J. Vicente, J. A. Abad, F. S. Hernández-Mata and P. G. Jones, *J. Am. Chem. Soc.*, 2002, **124**, 3848.

11 *Crystallographic data*: for **2**: $C_{39}H_{39}ClNO_2PPd$, M_w = 726.53, triclinic, $P\bar{1}$, a = 10.9750(10), b = 11.0460(10), c = 15.1750(10) Å, α = 75.4050(10), β = 80.8580(10), γ = 82.3680(10)°, V = 1749.4(3) Å^3, Z = 2. For 5884 observed reflections the final R (on F) factor was 0.034, wR (on F^2) = 0.078 for $I > 2\sigma(I)$. CCDC 184188. For **5**: $C_{28}H_{27}ClNPPd$, M_w = 550.33, monoclinic, $P2_1/c$, a = 10.1670(10), b = 24.9410(10), c = 10.6240(10) Å, β = 114.2640(10)°, V = 2456.0(3) Å^3, Z = 4. For 3524 observed reflections the final R (on F) factor was 0.045, wR (on F^2) = 0.136 for $I > 2\sigma(I)$. CCDC 1841887. See http://www.rsc.org/suppdata/cc/b2/b211808d/ for crystallographic data in CIF or other electronic format.

12 Data collected in an MAR345 diffractometer with a image plate detector, graphite monochromatized Mo-Kα radiation. The structures were solved by Direct methods, using SHELXS computer program (G. M. Sheldrick, 1977, A computer program for determination of crystal structure, University of Göttingen, Germany) and refined by a full-matrix least-squares method, with the SHELX97 computer program.