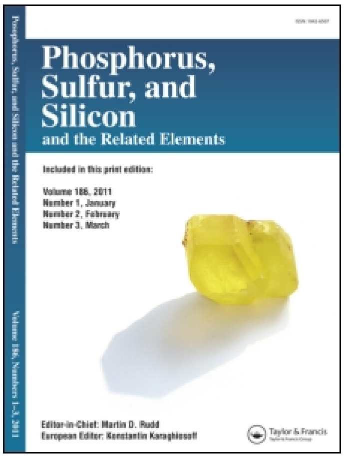


Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

Resolution and Characterization of 2,2'-Bis(Diphenylphosphino)-1,1'-Bibenzimidazole (BIMIP): the First Chiral Atropisomeric Diphosphine Ligand with Hindered Rotation around a N-N Bond

Patrizia Antognazza; Tiziana Benincori; Sabrina Mazzoli; Franco Sannicolo; Tullio Pilati

To cite this Article Antognazza, Patrizia , Benincori, Tiziana , Mazzoli, Sabrina , Sannicolo, Franco and Pilati, Tullio(1999) 'Resolution and Characterization of 2,2'-Bis(Diphenylphosphino)-1,1'-Bibenzimidazole (BIMIP): the First Chiral Atropisomeric Diphosphine Ligand with Hindered Rotation around a N-N Bond', Phosphorus, Sulfur, and Silicon and the Related Elements, 144: 1, 405 — 408

To link to this Article: DOI: 10.1080/10426509908546267

URL: http://dx.doi.org/10.1080/10426509908546267

Phosphorus, Sulfur and Silicon, 1999, Vol. 144-146, pp. 405-408
Reprints available directly from the publisher
Photocopying permitted by license only

Resolution and Characterization of 2,2'-Bis(Diphenylphosphino)-1,1'-Bibenzimidazole (BIMIP): the First Chiral Atropisomeric Diphosphine Ligand with Hindered Rotation around a N-N Bond

PATRIZIA ANTOGNAZZA[a], TIZIANA BENINCORI[a], SABRINA MAZZOLI[a], FRANCO SANNICOLO[a] and TULLIO PILATI[b]

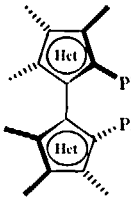
[a]*Dipartimento di Chimica Organica e Industriale dell'Università, and CNR Centro Sintesi e Stereochimica Speciali Sistemi Organici, Milano, 20133, Italy and*
[b]*CNR Istituto per lo Studio delle Relazioni fra Struttura e Reattività Chimica, Milano, 20133, Italy*

2,2'-Bis(diphenylphosphino)-1,1'-bibenzimidazole BIMIP) was resolved in an enantiomerically pure state through a kinetic resolution process effected by complexation of the racemate with half of the stoichiometric amount of a chiral aminopalladium complex. The enantiopure diphosphine was fully characterized by X-ray diffractometric analysis.

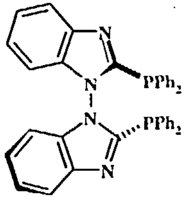
Keywords: chiral diphosphines; resolution; kinetic resolution; transition metal complexes; asymmetric catalysis

INTRODUCTION

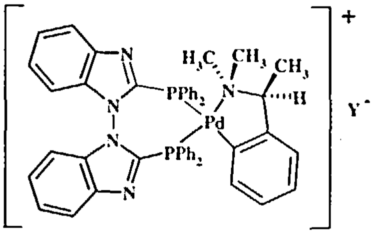
For the last two years we have been studying a class of chiral diphosphines featuring an atropisomeric backbone composed of two interconnected five-membered aromatic heterocycles which are schematically represented by general formula 1[1].



1



2 (BIMIP)



4a : Y = Cl   4b : Y = BPh$_4$

The advantages of this design are manifold: it combines improved synthetic accessibility and the possibility of modulating phosphorus donicity according to the stereoelectronic requirements imposed by reaction typology and substrate characteristics. This fine tuning can be carried out either by changing the supporting heterocycle or the position of the phosphino groups on it.

So far we have synthesized, resolved and successfully applied in asymmetric hydrogenation reactions several diphosphines with 3,3'-bithianaphthene[2], 3,3'-bithiophene[1] and 2,2'-biindole[3] backbones. We have recently published the synthesis of racemic 2,2'-bis(diphenylphosphino)-1,1'-bibenzimidazole (BIMIP) (2)[4], which is the first chiral atropisomeric diphosphine ligand with hindered rotation around a N-N bond. All efforts to resolve this' ligand were unsuccessful. This paper reports the successful resolution of diphosphine **2** and its full analytical and spectroscopic characterization.

RESULTS AND DISCUSSION

Two principal methods are known for obtaining enantiopure diphosphines. The first is fractional crystallization of the diastereomeric adducts produced by reaction of racemic diphosphine oxide with a chiral enantiopure acid, followed by alkaline decomplexation and reduction of enantiopure diphosphine oxide with trichlorosilane[5]. This method is not suitable for use in the present case since the diphosphine oxide corresponding to BIMIP (**2**) is too electron-poor to give adducts with carboxylic and sulphonic acids. This is well demonstrated by the electrochemical oxidative potential of BIMIP (1.15 V), which makes this ligand the most electron-poor system, not only of our biheteroaromatic series, but also among the most popular commercially-available diphosphines[4]. The second method calls for fractional crystallization of the diastereomeric complexes obtained by reaction of racemic diphosphine with a chiral enantiopure aminopalladium derivative[6]. We found through ^{31}P NMR spectroscopy that racemic BIMIP reacted quantitatively and quickly with di-μ-chloro-bis[(S)-dimethyl(α-methylbenzyl)aminato-C^2N]-dipalladium(II) (**3**), in $CDCl_3$, solution, to give the complex **4a**. The addition of a stoichiometric amount of $NaBPh_4$ in toluene solution produced the cationic complex **4b**. However, we were not able to induce substantial diastereomeric enrichment through crystallization of the resulting diastereomeric complexes. We did observe that the complexation reaction does not develop at the same rate for the two enantiomers and that a kinetic resolution process is active. If a quarter of a mole of complexing reagent **3** is used for one mole of racemate, a 30% diastereomeric enrichment is produced in the palladium complexes, as well as a 30% enantiomeric excess in the uncomplexed diphosphine. At this point it is very easy to separate the complexed diphosphine from the uncomplexed one through column chromatography. Repeated crystallization of the 30% enantiomerically enriched diphosphine gave enantiomerically pure (+)-BIMIP (+)-**2**: $[\alpha]_D^{25} = +32.4°$, c = 0.5 (benzene). Decomplexation of the crude 30% diastereomerically enriched complex with sodium cyanide yielded a diphosphine 30% enantiomerically enriched in the levrorotatory enantiomer which could, in turn, be obtained in an enantiomerically pure state by crystallization from ethyl acetate. Evaluation of optical purity was effected by complexation of enantiopure diphosphines with the same aminopalladium reagent **3** used for resolution: the signals pertaining to one diastereoisomer were totally absent in the ^{31}P NMR spectrum of the other.

Structural characterization of (+)-BIMIP was effected by single crystal diffractometric analysis (FIGURE 1). According to the Flack test, the absolute configuration of (+)-**2** is M. CD curves are reported in FIGURE 2.

Availability of this very electron-poor diphosphine in an enantiomerically pure state opens new possibilities in a less explored field of asymmetric catalysis.

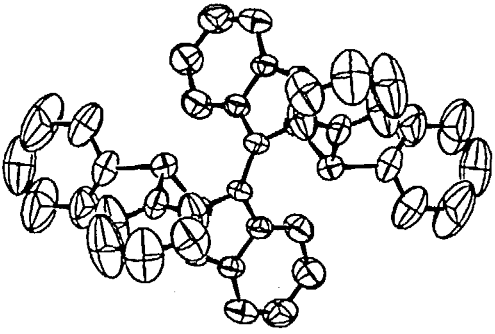


FIGURE 1 ORTEP II view of (+)-**2**; ellipsoids at 50% probability level.

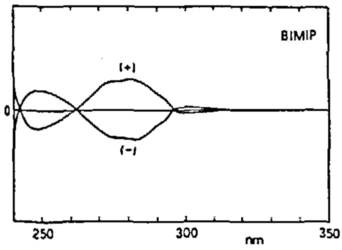


FIGURE 2 Circular Dicroism curve of (+)- and (-)-BIMIP

EXPERIMENTAL PART

Resolution of (±)-2,2'-bis(diphenylphosphino)–1,1'-bibenzimidazole (±)-(2). A solution of **3** (0.35 g) in benzene (10 ml) was added to a solution of (±)-**2** (1.46 g) in benzene (70 ml) at room temperature under argon and the mixture stirred for 12 hours in darkness. The solvent was removed under reduced pressure and the residue was column chromatographed under nitrogen using a mixture of CH_2Cl_2:AcOEt – 8:2 as eluant. The first fractions eluted gave (+)-**2** (0.64 g); $[\alpha]_D^{25} = +9.6°$ (c = 0.5 benzene) which was further purified through repeated crystallizations from degassed AcOEt under N_2 (0.084 g); m.p. 265°C; $[\alpha]_D^{25} = +32.4°$ (c=0.5 benzene). Elution with MeOH gave 30% diastereomerically enriched (^{31}P NMR) [(S)-dimethyl (α-methylbenzyl)aminato-C^2N]- [2.2'-bis(diphenlyphosphino) bibenzimidazole]palladium(II) tetraphenylborate (1.10 g) (**4b**), which underwent decomplexation without any further purification. A solution of the latter in CH_2Cl_2 was treated with a solution of NaCN (5.0 g) in H_2O (30 ml) and stirred under nitrogen for 36 hrs. at room temperature. The organic layer was separated, dried (Na_2SO_4) and the solvent removed under reduced pressure to give a residue which was column chromatographed under nitrogen using a degassed mixture of CH_2Cl_2: AcOEt – 8:2 as eluant. The first fractions gave 30% enantiomerically enriched (-)-**2** (0.035 g); $[\alpha]_D^{25}$= -9.0° (c = 0.5 benzene) which was further purified through crystallization from AcOEt degassed under N_2 (0.014 g); m.p. 263°C; $[\alpha]_D^{25}$ = - 30.5° (c = 0.5 benzene).

Diastereomerically pure complexes 4b of (+)-2 and (-)-2 with 3. The reaction of enantiomerically pure (+)-**2** and (-)-**2** with **3** was performed directly in a NMR tube, according to a known procedure[7]. ^{31}P NMR spectrum of the complex resulting from (+)-**2** ($CDCl_3$) showed the following signals: δ 1.50 (d, 1P, J = 36.2); 21.17 (d, 1P, J = 36.2). ^{31}P NMR spectrum of the complex resulting from (-)-**2** ($CDCl_3$) showed the following signals: δ 0.75 (d, 1P, J = 36.2); 22.45 (d, 1P, J = 36.2).

Crystallographic data of (+)-2

$C_{38}H_{28}N_4P_2$. M_r = 602.58, trigonal, space group $P3_221$, colourless, 0.36×0.36×0.28 mm^3, a = 9.2053(10). c = 33.385(4) Å, V = 2450.0(5) $Å^3$, Z = 3, d_{calc} = 1.225 g cm^{-3}, λ(Mo*K*α) = 0.71073 Å, μ(Mo-*K*α) = 0.166 mm^{-1}, room temperature, data collection range $2.5 < \theta < 25.00$ °, ω scan mode, 3484 collected reflections, 2861 independent, 1997 observed [$I > 2\sigma(I)$]; data were collected on a Siemens-P4 diffractometer, with graphite monochromator. The molecule lies on a C_2 crystallographic axis. The structure was solved by SIR-92[8], and refined by full matrix least-squares based on F_o^2 (SHELXL-93)[9]; one of the two independent phenyl rings is disordered and was splitted in two mojeties with occupation factor 0.5/0.5; also the second phenyl ring presents high anisotropic displacements parameters. The phenyl groups were refined with restraints on geometric (and anisotropic displacements) parameters (SADI, SAME and SIMU instructions of SHELXL-93); H atoms fixed in calculated position; 254 parameter refined. 223 restraints; final disagreement factors based on F_o^2: R = 0.0459 and wR = 0.1028. *GOF* = 1.034; $\Delta/\sigma max$ = 0.023; $-0.17 < \Delta\rho < 0.16$. The absolute configuration was determined by the Flack[10] parameters whose final value was 0.03(15).

References

[1] P. Antognazza, T. Benincori, E. Brenna, E. Cesarotti, F. Sannicolò and L. Trimarco, *Int. Pat. Appl.:* PCT/EP95/02647.

[2] T. Benincoii, E. Brenna, F. Sannicolò, L. Trimarco, P. Antognazza and E. Cesarotti, *J. Chem. Soc., Chem. Commun.*, 685 (1995); *J. Org. Chem.*, **61**, 6244 (1996).

[3] F. Sannicolò et al., submitted for publication to the *J. Org. Chem.*,

[4] T. Benincori, E. Brenna, F. Sannicolò, L. Trimarco, P. Antognazza, E. Cesarotti, F. Demartin, T. Pilati and G. Zotti, *J. Organomet. Chem.*, **529**, 445 (1996).

[5] H. Takaya, K. Mashima and K. Koyano, *J. Org. Chem.*, **51**, 629 (1986).

[6] U. Berens, J.M. Brown, J. Long and R. Selke, *Tetrahedron: Asymmetry*, **7**, 285 (1996).

[7] N.K. Roberts and S.B. Wild, *J. Am. Chem, Soc.*, **102**, 6254 (1979).

[8] Altomare, G. Cascarano, G. Giacovazzo, A. Guagliardi, M. C. Burla, G. Polidori and M. Camalli. *J. Applied Crystallogr.*, **27**, 435, (1994).

[9] G. M. Sheldrick, SHELXL-93. *Program for the Refinement of Crystal Structure*, Univ. Göttingen, Germany.

[10] H. D. Flack, *Acta Cryst.*, **A39**, 876, (1983).