

0957-4166(94)E0011-X

Relative and Absolute Configurations of Diastereomeric Macrocyclic Diphosphine Ligands and their Ni(II) Complexes

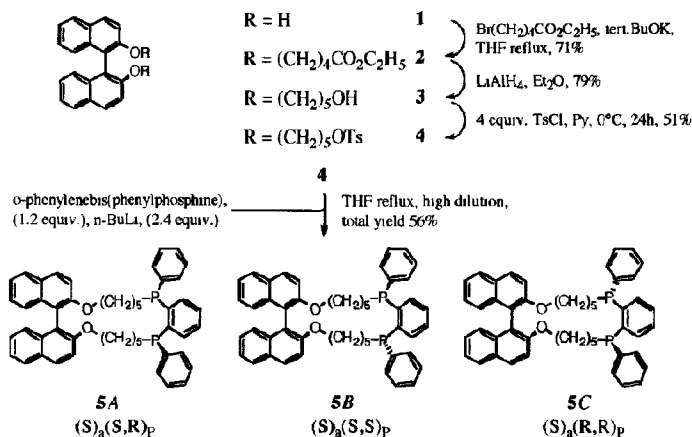
Michael Widhalm^a and Gerd Klitschar^b

^aInstitut für Organische Chemie, Universität Wien, A-1090 Wien, Austria.

^bInstitut für Physikalische Chemie, Universität Graz, A-8010 Graz, Austria.

Abstract: The 20 membered chiral diphosphine ligands **5A-C** were prepared under high dilution conditions as a mixture of diastereomers. The absolute and relative configurations could be established on the basis of NMR and CD spectroscopy of the ligands and their Ni(II) complexes. The assignment was confirmed by a crystal structure analysis of the Ni complex of **5B**.

The majority of chemical conversions, especially the reactions on more complex carbon skeletons, leads to the formation of stereoisomers. As the absolute and/or relative configuration of the educts are usually known, only the relative configurations of stereogenic centers created during the transformation need to be estimated for a complete stereochemical assignment. The latter is frequently done by NMR methods or on the basis of different reactivities of the isomers in sterically sensitive conversions (e.g. ring forming reactions of appropriately oriented functional groups). Problems will arise if the stereogenic centers are not in proximity but separated from each other by a non-chiral portion of the molecule. In such cases often only X-ray structure analyses could be decisive.



During the course of our work on macrocyclic compounds¹ we prepared chiral diphosphine ligands like **5** with a binaphthyl unit. **5** was accessible from **1** in four steps as outlined in the scheme². As the ring closing

step introduced two stereogenic P centers in addition to the inherent chiral binaphthyl moiety, the formation of three (chiral) diastereomers *A* - *C* has to be taken into account. The cyclisation of the ditosylate **4** with dilithium *ortho*-phenylenebis(phenylphosphine) was conducted under high dilution conditions and afforded a mixture of the isomers which could be separated by chromatography (SiO_2 , CH_2Cl_2 - petroleum ether, 4:6) to give the pure diastereomers as white foams in a ratio *A*:*B*:*C* = 80:13:7³. From NMR spectroscopy (^1H , ^{13}C , ^{31}P) an unequivocal distinction by NMR analysis between the C_1 -symmetrical diastereomer *A* and the two diastereomers *B* and *C*, which are intrinsically C_2 -symmetric, was possible without doubt [e.g. in ^{31}P NMR an AB system (-26.09 and -26.45 ppm, $J = 150$ Hz) was observed for *A* but A_2 systems for *B* and *C* (singulets at -21.89 and -19.48 ppm, resp.)]. However it was not possible to distinguish between configurations *B* and

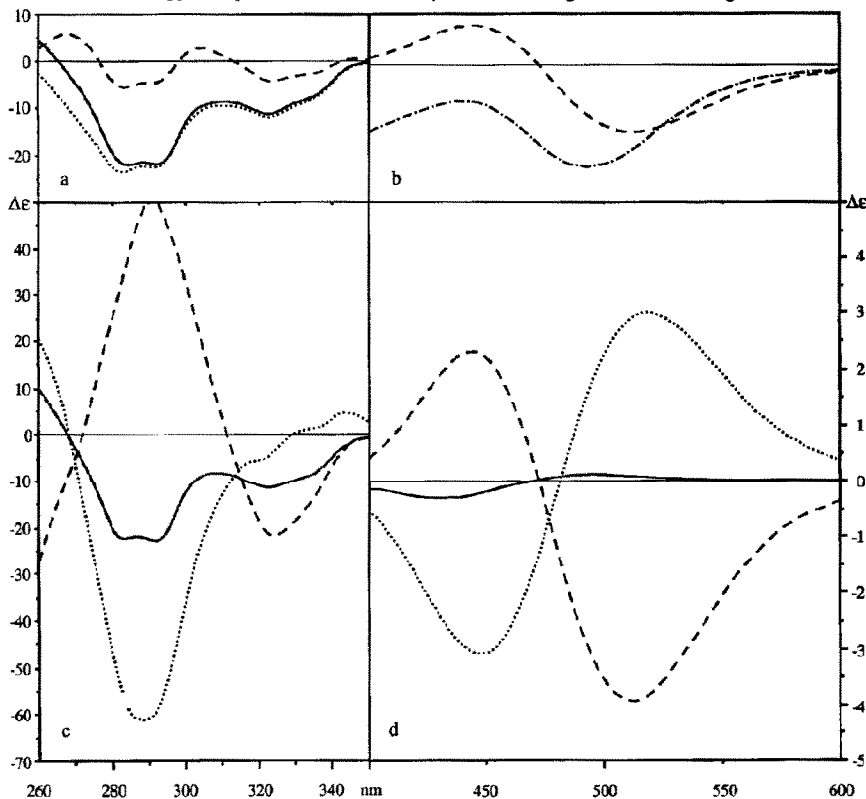
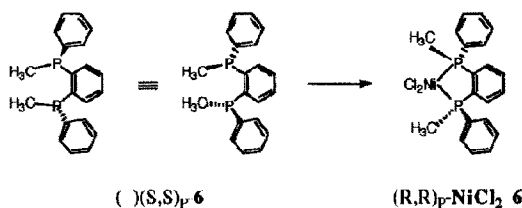


Figure 1. CD spectra (dichloromethane) of ligands (a) and Ni(II) complexes (c, d) with configurations *A* (—), *B* (---), *C* (.....). Optical comparison of isomer *B* of **5.NiCl₂** with the NiCl₂ complex of (*S,S*)-**6** (— · —) (b).

C by using NMR spectroscopy. The following procedure demonstrates how relative configurations can be determined by independent estimations of two absolute configurations by CD spectroscopy.

The synthesis started with optically active (*S*)_a-2,2'-dihydroxy-1,1'-binaphthyl. Therefore the absolute configuration of *A* had to be (*S*)_a(*S*,*R*)_p. The CD spectra of *5A*, *5B* and *5C* showed a significantly different shape, thus showing the influence by the stereochemistry at the phosphorus centers on the binaphthyl torsional angle⁴. The spectrum is obviously dominated by Cotton effects originated by the binaphthyl chromophore, while absorptions due to the Ph-P-(1,2-Ph)-P-Ph unit are weak and hidden under the more intensive biaryl bands. The situation is changed in the case of the corresponding Ni(II) complexes. *5A-C*-NiCl₂ are *cis*-diphosphine complexes with square planar geometry and the *ortho*-phenylene unit in the same plane. So the symmetry is not changed (fig.2). The UV spectra of the orange to orange-brown Ni complexes showed broad long wave length absorptions around 455 nm (ϵ 1080 - 1570) due to the central band of the crystal field. In the CD spectrum of *A* the corresponding Cotton effect is caused by a chiral perturbation of the non-chiral Ni complex unit with a "local" C_s symmetry (the *meso* form of the diphosphine) by the biaryl and is therefore comparably small [$\lambda(\Delta\epsilon)$ 494 (+0.11) 432 (-0.30)]. In contrast to *5A* the two C₂ symmetrical diastereomers, *5B,C*, show intensive bands but virtually mirror like shape in the spectral range between 400 and 600 nm (fig.1c,d). This is in accordance with the local C₂ symmetry and an enantiomeric relationship of this subunit in the diastereomers *B* and *C* (the *rac*-form of the diphosphine).



The assignment of CD effects to absolute configurations was made by optical comparison with the NiCl₂ complex of **6**. **6** was easily accessible by treatment of dilithium *ortho*-phenylenebis(phenylphosphide) with an excess of methyl iodide⁵. A separation of diastereomers and enantiomers in one step was conveniently performed by repetitive chromatography on microcrystalline cellulose triacetate⁶. After three cycles the enantiomerically enriched fractions were eluted. The first one was optically inactive (*meso*), the second one showed negative and the third one positive optical rotation at 589 nm. The enantiomeric relationship of the latter and their chemical identity have been confirmed by CD and ¹H-NMR, resp. Wild et al. assigned the absolute chirality (*S,S*)_P to (–)₅₈₉-**6** on the basis of an X-ray structure analysis of the corresponding Pd(II) complex⁷. The preparation of the Ni(II) complex of **6** was accomplished by addition of a few drops of a concentrated NiCl₂ solution in ethanol to the CD sample of (–)-**6** in CH₂Cl₂. A CD spectrum of the resulting orange solution was run instantly to avoid precipitation or decomposition. Comparison of the long wavelength range with that of the Ni complexes of *5(B)* and *5(C)* revealed unambiguously a (*S,S*)_P configuration for *5(B)* (fig.1b). With this information in hands it was now possible to assign all absolute and relative chiralities as given on bottom of the scheme. The corresponding CD spectra of ligands and complexes are drawn in fig.1a,c,d.

An X-ray analysis of the racemic NiCl_2 complex of **5B** confirmed the previous assignment of (relative) configurations and the square planar geometry of the complex⁸. A stereo projection of the structure is shown below (H are omitted for clarity).

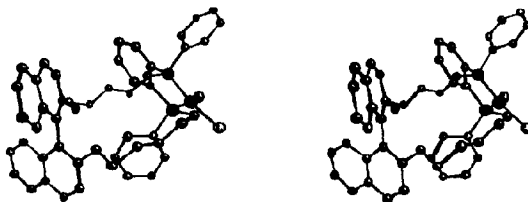


Figure 2: X-ray structure of $\text{NiCl}_2 \cdot 5B$

This procedure represents a convenient method for the assignment of diastereomers if heteroatoms with appropriate geometry and ligating properties are present which upon complexation give rise to long wavelength Cotton effects. The latter are predominantly caused by the chiral environment of the complexation sites. If their identification and assignment to certain (chiral) chromophores succeeds, an estimation of their absolute configuration will be possible. This method is fast and only a few milligramms of the sample and of an appropriate model compound as a reference are needed. No isolation and usually no purification of complexes will be required. So the sample can be prepared even *in situ* in the CD cuvette (if no quantitative measurements are intended). To show scope and limitations of this procedure a more extensive study, including related structures, is presently under progress.

Acknowledgement

This work was generously supported by the *Fonds zur Förderung der wissenschaftlichen Forschung in Österreich* (P6857, P8202)

References

- [1] M. Widhalm, C. Kratky, *Chem. Ber.* **1992**, *125*, 679 - 689.
- [2] Full experimental details will be given elsewhere.
- [3] All proposed structures of new compounds have been confirmed by NMR (¹H, ¹³C, ³¹P) and high resolution MS or elemental analysis.
- [4] S.F.Mason, R.H.Seal, D.R.Roberts, *Tetrahedron*, **1974**, *30*, 1671 - 1682. see also B.Suchod, A.Renault, J.Lajzerowicz, G.P.Spada, *J.Chem.Soc.(Perkin Trans.2)*, **1992**, 1839 - 1844.
- [5] E.P.Kyba, R.E.Davies, C.W.Hudson, A.M.John, S.B.Brown, M.J.McPhaul, L-K.Liu, A.C.Glover, *J.Am.Chem.Soc.*, **1981**, *103*, 3868 - 3875.
- [6] M. Widhalm, K. Schlögl, *Monatsh.Chem.*, **1984**, *115*, 1113 - 1120.
- [7] N.R.Roberts, S.B.Wild, *J.Am.Chem.Soc.* **1979**, *101*, 6254 - 6260.
- [8] Crystals grown from $\text{CH}_2\text{Cl}_2/\text{EtOH}$, dimensions: 0.20x0.20x0.15 mm³, measured on a Siemens P4 diffractometer ($\text{CuK}\alpha$ radiation) at 293 K. Data collection of 3130 data, 1729 observed ($F > 4\sigma$), space-group P2(1)2(1)2(1); cell dimensions [Å]: a=11.184(4), b=14.932(6), c=25.123(11); Z=4, R=0.094 (based on observed reflexes). Supplementary data (atomic coordinates, bond length, bond angles, torsional angles, structure factors) have been sent to the Cambridge Crystallographic Data Centre.

(Received in UK 9 December 1993; accepted 13 January 1994)