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*Short Communication*

# Axialchiral Macrocyclic Diphosphines

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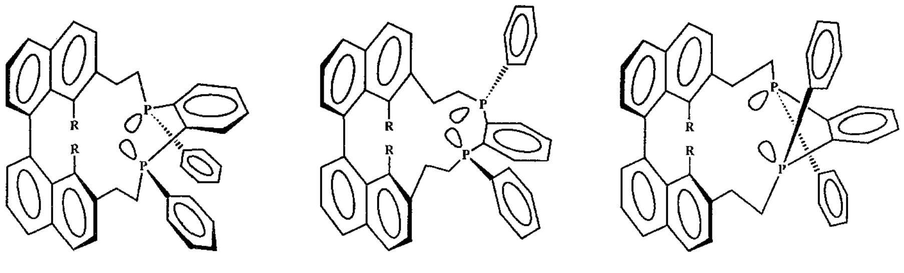
**Summary.** Two cyclic diphosphines, **1** and **2**, have been prepared which show a remarkable stability against oxidation. This result is discussed on the basis of their rigid conformation, directing the lone pairs of the P-atoms towards the center of the cycle.

**Keywords.** Axial chirality; Macrocyclic diphosphines; Separation of diastereomers.

### Axialchirale makrocyclische Diphosphine (Kurze Mitt.)

**Zusammenfassung.** Die zyklischen Diphosphine **1** und **2** wurden dargestellt. Ihre bemerkenswerte Oxidationsbeständigkeit wird durch deren starre Konformation erklärt, die bewirkt, daß die *lone pairs* der P-Atome in das Zentrum des Zyklus gerichtet sind.

Among macrocyclic compounds crown ethers and their N- and S-analogs have been subjects of considerable interest for several reasons, especially during the last decade [1]. In contrast only little attention has been paid to cyclic (poly)phosphines [2]. This seems even more surprising as their use in transition metal catalysis,



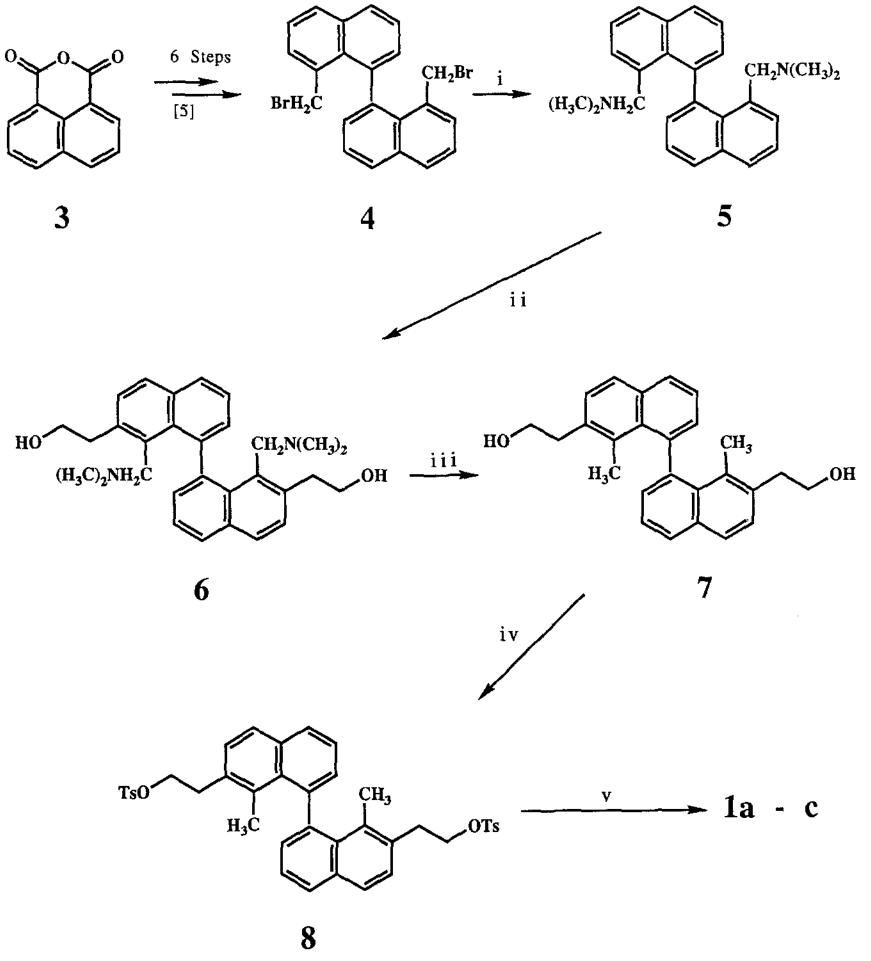
a ($C_1$) b ($C_2$) c ($C_2$)

R= $CH_3$ **1**
$OCH_3$ **2**

**Fig. 1.** Diastereomers of compounds **1** and **2**

especially in asymmetric synthesis – if optically active ligands are employed – might be a promising goal for intensive investigations. From that point of view binaphthyl based cyclic diphosphines have been choosen for studies to obtain informations about their stereochemistry, conformational stability and complexation ability.

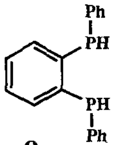
As first representatives of this type of ligand structures **1** and **2** have been synthesized. Inspection of a molecular model showed that in both cases severe steric interactions would be present, so that the preferred or exclusive formation of a single diastereoisomer might occur, superimposing the preceding formation the two diastereoisomeric dilithium diphosphides (*dl* **9**-$Li_2$ and *meso* **9**$Li_2$). In those cycles under discussion three asymmetric elements are present – the axial chirality



Reaction conditions:

i $(CH_3)_2NH$ (10 equiv.), benzene, 110°C, 48h
ii 1. *t*-BuLi, ether. 2.ethyleneoxid (excess)
iii 1. $CH_3I$(excess), $CH_3CN$. 2. Na-Hg,$H_2O$,80°C, 24h
iv *p*-TsCl, Py, 0°C, 48h

vi. 1.



**9**

, *n*-BuLi (2 equiv.) in THF

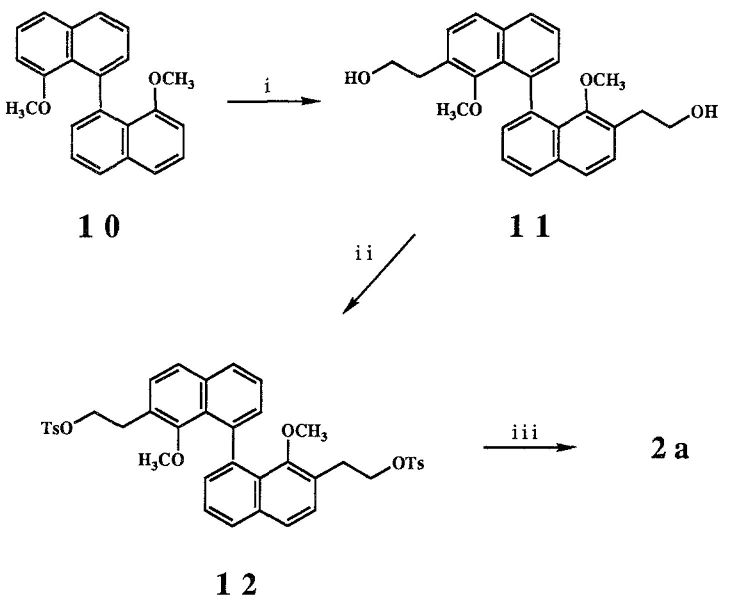
2. Coupling of **9**-$Li_2$ and **8** under high dilution conditions in refluxing THF.

Scheme 1

of the binaphthyl moiety and two (identical) asymmetric P atoms. If the *meso*-configurated dilithium diphosphide reacts with the ditosylate (**8** or **12**), this results in the formation of one $C_1$-symmetric diastereoisomer (**1 a**, **2 a**), while a $C_2$-symmetrical dilithium compound gives rise to two $C_2$-symmetrical diastereoisomers (**1 b** and **c** or **2 b** and **c**, resp., see Fig. 1). Therefore the occurrence of three chiral diastereoisomers has to be expected.

The synthesis of **1** is outlined in *Scheme 1* [3, 4]. Starting from naphthalic acid anhydride (**3**), 8,8′-bisbrommethyl-1,1′-binaphthyl (**4**) was prepared in 27% overall yield according to literature methods [5]. **4** was converted to 8,8′-bis(N,N-dimethylamino)methyl-1,1′-binaphthyl (**5**) (92%) by treatment with dimethylamine (10 equiv. 110°C, 48 h). Reaction of **5** with *t-Bu*Li and subsequent treatment with ethyleneoxide (excess) afforded the diaminodiol **6** in 48% yield. The corresponding dimethiodide of **5**, accessible by refluxing **5** with $CH_3I$ in $CH_3CN$, was treated with sodium amalgam (10 equiv., 80°C, 24 h) to give 7,7′-bis(2-hydroxyethyl)-8,8′-dimethyl-1,1′-binaphthyl (**7**) (52%). **7** was tosylated in the usual way to give **8**. The overall yield of **8** (from **3**) was 4.9%.

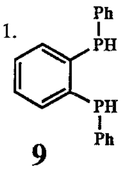
**9** was accessible in 3 steps from dichlorophenylphosphine according to literature



Reaction conditions:

i 1. *n*-BuLi, ether.
2. ethyleneoxide (excess)
ii *p*-TsCl, Py, 0°C, 48h

iii 1.



**9**

, *n*-BuLi
(2 equiv.) in THF

2. Coupling of **9**-$Li_2$ and **12** under high dilution conditions in refluxing THF.

Scheme 2

methods [6]. The ring closure reaction was conducted under high dilution conditions in refluxing *THF* under Ar [7]. A mixture of cyclic diphosphines **1 a–c** was obtained which could be partially separated by preparative t.l.c. ($SiO_2$, $CH_2Cl_2$/*n*-hexane, 1:1). The $C_1$-symmetrical diastereoisomer **1 a** was isolated in 38% yield (m.p.: 207–210°C, *$^1$H-n.m.r.*: δ 1.38 (3 H, s, Ar-$\mathbf{CH_3}$), 1.53 (3 H, s, Ar-$\mathbf{CH_3}$), 2.07 (1 H, m, $\mathbf{CH_2CH_2}$), 2.30–2.50 (2 H, m, $\mathbf{CH_2CH_2}$), 2.69 (3 H, m, $\mathbf{CH_2CH_2}$), 2.88 (1 H, m, $\mathbf{CH_2CH_2}$), 3.14 (1 H, m, $\mathbf{CH_2CH_2}$), 6.88 (1 H, m, Ar-**H**), 7.10 (2 H, m, Ar-**H**), 7.21 (1 H, t, *J* ~ 7 Hz, Ar-**H**), 7.25–7.48 (12 H, m, Ar-**H**), 7.52 (2 H, m, Ar-**H**), 7.65 (1 H, dd, *J* 7 Hz, 1.5 Hz, Ar-**H**), 7.67 (1 H, dd, *J* 7 Hz, 1.5 Hz, Ar-**H**), 7.74 (2 H, t, *J* 8.3 Hz, Ar-**H**), 7.88 (1 H, dd, *J* 8 Hz, 1.5 Hz, Ar-**H**), 7.95 (1 H, dd, *J* 8.1 Hz, 1.4 Hz, Ar-H). *$^{31}$P-n.m.r.*: δ −44.07, $P_A$; −45.50, $P_B$; (AB-system, $J_{AB}$ 135.4 Hz). Ms. (350°C) [*z*/e (rel%)]: 294 (100), 305 (90), 314 (10), 628 (47).) and 17% of a mixture of **1 b** + **c** (8 : 2, estimated by n.m.r. integration). From this mixture **1 b** crystallized preferently from *c*-hexane/benzene, which retained some solvent tenaciously. (M.p.: 173–183°C, *$^1$H-n.m.r.*: δ 1.83 (6 H, s, Ar-$\mathbf{CH_3}$), 2.42 (2 H, m, $\mathbf{CH_2}$-P), 2.84 (2 H, m, $\mathbf{CH_2}$-Ar), 3.10 (2 H, m, $\mathbf{CH_2}$-P), 3.35 (2 H, m, $\mathbf{CH_2}$-Ar), 6.40 (2 H, d, *J* 8.4 Hz, Ar-**H**), 6.84 (2 H, m, Ar-**H**), 7.01 (2 H, m, Ar-**H**), 7.35–7.56 (16 H, m, Ar-**H**), 7.84 (2 H, dd, *J* 7.9 Hz, 1.7 Hz, Ar-**H**). *$^{31}$P-n.m.r.*: δ −39.27 (2 P, s). M.s. (270°C): The obtained spectrum was superimposable onto that of the diastereoisomer **1 a**. No spectroscopic characterization of **1 c** was possible because of too little substance.

**2** was prepared similar to **1** [3]; the required ditosylate **12** was obtained from 8,8′-dimethoxy-1,1′-binaphthyl (**10**) [8] in 2 steps (*Scheme 2*). The subsequent ring closure reaction afforded **2 a** in 41% yield as the only isolable product. (*$^1$H-n.m.r.*: δ 2.01–2.12 (1 H, m, $\mathbf{CH_2CH_2}$), 2.38–2.61 (5 H, m, $\mathbf{CH_2CH_2}$), 2.58 (3 H, s, $\mathbf{OCH_3}$), 2.75 (3 H, s, $\mathbf{OCH_3}$), 2.77–2.86 (1 H, m, $\mathbf{CH_2CH_2}$), 3.12–3.25 (1 H, m, $\mathbf{CH_2CH_2}$), 6.83–6.88 (1 H, m, Ar-**H**), 7.04 (1 H, ps. td, *J* 7.5 Hz, 1.5 Hz, Ar-**H**), 7.08 (1 H, d, *J* 8.5 Hz, Ar-**H**), 7.12–7.55 (17 H, m, Ar-**H**), 7.63 (1 H, d, *J* 8.5 Hz, Ar-**H**), 7.65 (1 H, d, *J* 8.5 Hz, Ar-**H**), 7.82 (1 H, dd, *J* 8 Hz, 1.5 Hz, Ar-**H**), 7.89 (1 H, m, Ar-H, m, Ar-**H**). *$^{31}$P-n.m.r.*: δ −29.791 (2 P, bs). M.s. (260°C) [*z*/e (rel%)]: 294 (100), 305 (62), 366 (27), 583 (6), 628.5 (78), 629 (36), 659 (43), 660 (20).

In both cases the described macrocycles are well crystallizing compounds which proved to be largely stable to oxidation, even in solution. This enabled a purification by simple t.l.c. or recrystallization steps.

Another aspect is the accessibility of the lone pairs of P, which might strongly influence their reactivity towards oxygen and their readiness for the formation of transition metal complexes. Force field calculations for **1 a–c** and **2 a–c** generally revealed that their conformative mobility was significantly restricted by steric interaction and preferred conformations show efficiently shielded P-atoms. Obviously steric requirements are dominating thus overcoming the electrostatic repulsion arising from the proximity of the P-lone pairs. This result is in agreement with their inertness towards oxidation.

Despite of these unfavourable steric features, all diphosphines described above served as ligands in transition metal complexes with Ni(II) and Pd(II). To confirm the stereochemical assignment (v.s.) and to elucidate the question of the preferred conformations of free ligands and complexes, X-ray crystal structure analysis will be attempted.

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[1] Cf.: Lehn J.-M. (1988) Angew. Chem. **100**: 91 and literature cited therein

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[3] Full experimental details will be given in a forthcoming paper

[4] *N.m.r.*-spectra were taken on a Bruker AM 400 WB instrument in $CD_2Cl_2$ and chemical shifts $\delta$ are given in ppm rel. to tetramethylsilane ($^1H$), or 85% $H_3PO_4$ ($^{31}P$); *$^{31}P$-n.m.r.* are recorded in a proton decoupled mode. M.s.: Varian MAT-CH7. M.p.: Kofler-melting point apparatus, uncorrected

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