# Preparation of a Novel Optically Active 8,8′-Bi-isoquinolyl and its Co-ordination as a Bridging Ligand in Rhodium(I) Complexes

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A novel optically active 7,7′-dimethoxy-8,8′-bi-isoquinolyl (**5**) with known absolute configuration has been prepared and has been found to co-ordinate to $Rh^I$ as a bridging ligand in $[RhCl(cod)]_2[\mu\text{-}(\pm)\text{-}(\mathbf{5})]$ (**6**) and $\{Rh_2(cod)_2[\mu\text{-}(+)\text{-}(\mathbf{5})]_2\}(ClO_4)_2$ (**8**) (cod = cyclo-octa-1,5-diene).

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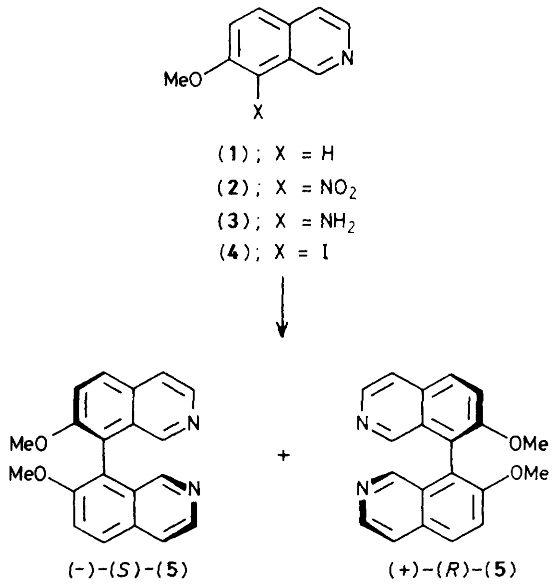
Recent advances in asymmetric catalyses with chiral transition metal compounds are due largely to the syntheses of sophisticated chiral ligands.[1] Of particular interest are bidentate phosphines,[2] hydroxy ligands,[3] and crown ethers[4] incorporating an axially dis-symmetric 1,1′-binaphthyl unit. Although bi- and poly-dentate heteroaromatic compounds with more than two nitrogen atoms, such as 2,2′-bipyridyl, are classical ligands in co-ordination chemistry, no axially chiral analogues have been reported. Here we describe the preparation of the novel optically active 7,7′-dimethoxy-8,8′-bi-isoquinolyl (**5**)



**Scheme 1**

$[\mathrm{RhCl(cod)}]_2$

$\downarrow$ (±)-(5)

$[\mathrm{RhCl(cod)}]_2[\mu\text{-}(\pm)\text{-}(\mathbf{5})]$
(6)

$\downarrow$ (±)-(5), 2 $\mathrm{AgClO_4}$

$\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(+)\text{-}(R)\text{-}(\mathbf{5})][\mu\text{-}(-)\text{-}(S)\text{-}(\mathbf{5})]\}(\mathrm{ClO_4})_2$
(7)

+

$\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(+)\text{-}(R)\text{-}(\mathbf{5})]_2\}(\mathrm{ClO_4})_2$
(+)-(*R*,*R*)-(8)

+

$\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(-)\text{-}(S)\text{-}(\mathbf{5})]_2\}(\mathrm{ClO_4})_2$
(−)-(*S*,*S*)-(8)

**Scheme 2**

with known absolute configuration. The compound (**5**) was found to co-ordinate to Rh$^{\mathrm{I}}$ as a bridging rather than a chelating ligand.

7-Methoxy-8-iodoisoquinoline (**4**) (m.p. 115—116 °C) was prepared *via* a sequence involving nitration of 7-methoxyisoquinoline (**1**),[5] reduction of the resulting nitroisoquinoline (**2**),[6] and diazotization of the aminoisoquinoline (**3**)[7] followed by the Sandmeyer reaction (22% overall yield). Ullmann coupling of (**4**) with activated copper powder[8] in *N*,*N*-dimethylformamide gave 7,7-dimethoxy-8,8′-bi-isoquinolyl (**5**)† (m.p. 183—184 °C, 40% yield).‡ Optical resolution of (±)-(**5**) was achieved by h.p.l.c. with a column packed with cellulose tris(3,5-dimethylphenylcarbamate) on silica gel;[9] elution with n-hexane–propan-2-ol (9 : 1) afforded optically pure (−)-(**5**) as the first fraction and then (+)-(**5**) with $[\alpha]_D^{21}$ ($\mathrm{CHCl_3}$) −160 and +159°, respectively. The absolute configuration of (−)-(**5**) was determined by a modification of the chiral recognition method developed by Miyano *et al.*[10] The intermolecular cyclization of (−)-7,7′-dihydroxy-8,8′-bi-isoquinolyl {m.p. 350 °C, $[\alpha]_D^{22}$ −153° ($\mathrm{CHCl_3}$), prepared by hydrolysis of (−)-(**5**)} with (±)-1,1′-binaphthyl-2,2′-dicarboxylic dichloride followed by hydrolysis, gave the recovered (−)-(**5**) and (−)-(*S*)-binaphthyl-2,2′-dicarboxylic acid {$[\alpha]_D^{21}$ −34° (0.1 M NaOH), m.p. 259—264 °C, 31% optical purity}. This result unequivocally indicates that (−)-(**5**) has the same (*S*) configuration. Reaction of (±)-(**5**) with 0.5 mol. equiv. of $[\mathrm{RhCl(cod)}]_2$ (cod = cyclo-octa-1,5-diene) in toluene at room temperature gave $[\mathrm{RhCl(cod)}]_2[\mu\text{-}(\pm)\text{-}(\mathbf{5})]$ (**6**)‡ as bright yellow crystals [m.p. 235—242 °C (decomp.), 90% yield].† Addition of $\mathrm{AgClO_4}$ to a suspension of (**6**) in MeOH in the presence of an equimolar amount of (±)-(**5**) afforded $\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(\mathbf{5})]_2\}(\mathrm{ClO_4})_2\cdot\mathrm{MeNO_2}$ [m.p. 235—273 °C (decomp.), 72% yield]† as yellow crystals (from $\mathrm{MeNO_2}$–MeOH). The doubly bridged dication is a 1 : 1 mixture of *meso*-$\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(+)\text{-}(R)\text{-}(\mathbf{5})][\mu\text{-}(-)\text{-}(S)\text{-}(\mathbf{5})]\}^{2+}$ (**7**)‡ and racemic $\{\mathrm{Rh_2(cod)_2}[\mu\text{-}(+)\text{-}(R)\text{-}(\mathbf{5})]_2\}^{2+}$ (**8**)‡ and its enantiomer, as confirmed by the observation of two MeO proton signals at δ 3.64(s) and 3.90(s) in an equal intensity. The optically active compound (**8**) was separately prepared by adding $\mathrm{AgClO_4}$ to a 1 : 2 mixture of $[\mathrm{RhCl(cod)}]_2$ and (+)-(**5**) in MeOH. Compound (**8**), recrystallized from $\mathrm{MeNO_2}$–MeOH, contains two moles of $\mathrm{MeNO_2}$ as crystallization solvent [m.p. 230—232 °C (decomp.), $[\alpha]_D^{27}$ + 127°(MeCN), 65% yield].† The relative orientation of the isoquinoline moieties in (**8**) probably differs significantly from that in the *meso*-modification (**7**) (Figure 1). Thus, the hydrogen atoms of (**5**) at positions 1 and 3 in (**8**) [δ 7.88(s) and 7.94(d), respectively] are more strongly shielded than the corresponding protons in (**7**) [δ 8.64(s) and 8.96(d), respectively].

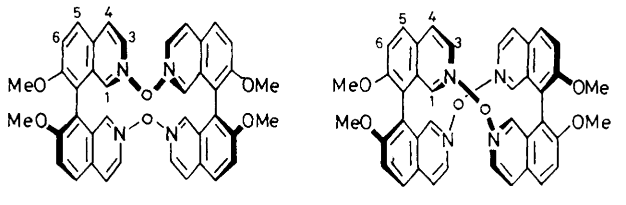


**Figure 1.** Views of (*R*,*S*)-(**7**) and (*R*,*R*)-(**8**) along non-bonded Rh · · · · Rh axis, cod molecules are omitted for clarity.

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† Satisfactory elemental analyses were obtained for all new compounds.

‡ $^1$H N.m.r. (100 MHz) data for (**5**) ($\mathrm{CDCl_3}$): δ 3.77 (s, MeO, 3H), 7.60 (br., ArH, 1H), 7.63 (d, *J* 8.6 Hz, ArH, 1H), 7.76 (d, *J* 8.6 Hz, ArH, 1H), and 8.15—8.61 (s, ArH, 2H). (**6**) ($\mathrm{CDCl_3}$): δ 1.65 (m, $\mathrm{CH_2}$, 4H), 2.48 (m, $\mathrm{CH_2}$, 4H), 3.75 (s, MeO, 3H), 3.9 (br., =CH, 4H), 7.60 (d, *J* 6.4 Hz, H-4, 1H), 7.62 and 7.89 (d, *J* 8.6 Hz, H-5 and H-6, 2H), 8.38 (d, *J* 6.4 Hz, H-3, 1H), and 8.56 (s, H-1, 1H). (**7**) ($\mathrm{CD_3NO_2}$): 1.6—3.0 (br.m, $\mathrm{CH_2}$, 4H), 3.64 (s, MeO, 3H), 4.0 (br., =CH, 2H), 7.88 (d, *J* 6.4 Hz, H-4, 1H), 7.76 and 8.08 (d, *J* 9.6 Hz, H-5 and H-6, 2H), 8.64 (s, H-1, 1H), 8.96 (d, *J* 6.4 Hz, H-3, 1H). (**8**) (270 MHz, $\mathrm{CD_3NO_2}$): δ 1.1 (m, $\mathrm{CH_2}$, 1H), 2.3 (m, $\mathrm{CH_2}$, 2H), 2.8 (m, $\mathrm{CH_2}$, 1H), 3.90 (s, MeO, 3H), 4.1 (m, =CH, 1H), 4.3 (m, =CH, 1H), 7.74 (d, *J* 6.4 Hz, H-4, 1H), 7.96 and 8.20 (d, *J* 9.6 Hz, H-5 and H-6, 2H), 7.78 (s, H-1, 1H), and 7.94 (d, *J* 6.4 Hz, H-3, 1H).

The failure of (**5**) to co-ordinate as a chelating ligand is rather expected from the non-coplanarity of two isoquinoline rings. The 1,1′-bi-isoquinolyl analogue, however, is capable of co-ordinating as a chelating ligand. Thus, reaction of 7,7′-dimethoxy-1,1′-bi-isoquinolyl (**9**) with $[RhCl(cod)]_2$ in MeOH and subsequent anion exchange with $ClO_4^-$ gave a mononuclear complex $[Rh(cod)(\mathbf{9})]ClO_4$ as red crystals. The details will be reported separately together with the $Rh^I$ complexes of optically active 7,7′-bridged-1,1′-bi-isoquinolyls.

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