

Synthesis of tetracoordinated rhodium(I) complexes with chiral Schiff bases prepared from dehydroabietic acid

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New optically active Schiff bases **16–19** have been prepared from dehydroabietic acid **1** and have been used as ligands to synthesize tetracoordinated rhodium(I) complexes **20–27**.

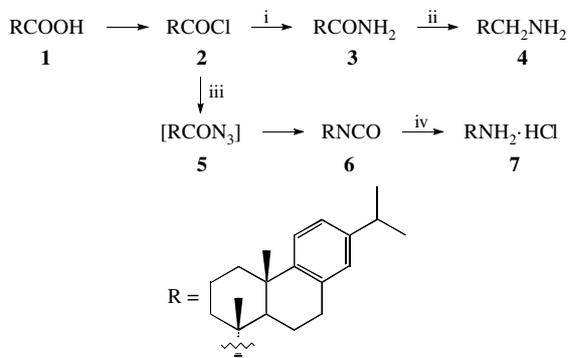
Synthesis of numerous pharmacologically valuable compounds is based on catalytic enantioselective reduction of prochiral ketones to optically active carbinols. Apart from direct hydrogenation, reactions of hydrosilylation and hydrogen transfer promoted by transition metal complexes with chiral P,N-donor ligands can be used to achieve the transformation under discussion.^{1–3} The use of tetra- and pentacoordinated rhodium(I)- and iridium(I)-complexes with Schiff bases, prepared by interaction between optically active amines and heteroaromatic aldehydes, provided high chemical and optical yields of the products of reduction of acetophenone and its homologues.^{4,5}

Having defined the synthesis of chiral ligands as the key objective in the concept we are developing for the various uses of natural higher terpenoids, we notice that resin acids have been studied only slightly in this respect. The adducts of levopimaric acid with maleic anhydride and *p*-quinone were shown to be promising starting compounds for the synthesis of optically active phosphorus-containing ligands.^{6,7}

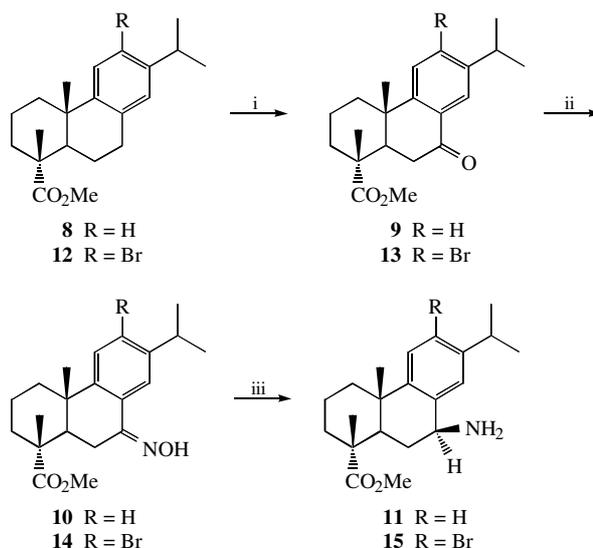
The purpose of the present work was to synthesize tetracoordinated rhodium(I) complexes with chiral Schiff bases prepared from dehydroabietic acid **1**.⁸ The treatment of its acyl chloride **2**⁹ with a saturated NH₃ solution in methanol at 0 °C produced amide **3** (92%), which was then reduced using a three-fold excess of LiAlH₄ to dehydroabietylamine **4** (75%). The latter compound is the same as that described in refs. 10 and 11.

The interaction of acyl chloride **2** with NaN₃ and thermal rearrangement of the intermediate azide **5** resulted in dehydroabietyl isocyanate **6**,⁹ which was heated with concentrated hydrogen chloride in benzene to obtain amine hydrochloride **7** (65%).

Amine **11** was synthesized according to the following procedure (Scheme 2). Methyl dehydroabiectate **8** was oxidized by KMnO₄ immobilized on Al₂O₃ to produce methyl-7-ketodehydroabiectate **9**,¹² which was readily transformed to the corresponding oxime **10** (75%) under the action of



Scheme 1 Reagents and conditions: i, NH₃, MeOH, 0 °C, 2 h; ii, LiAlH₄, Et₂O, 35 °C, 8 h; iii, NaN₃, Me₂CO, 0 °C, 1 h, then MePh, 100 °C, 1.5 h; iv, HCl, C₆H₆, 80 °C, 5 h.



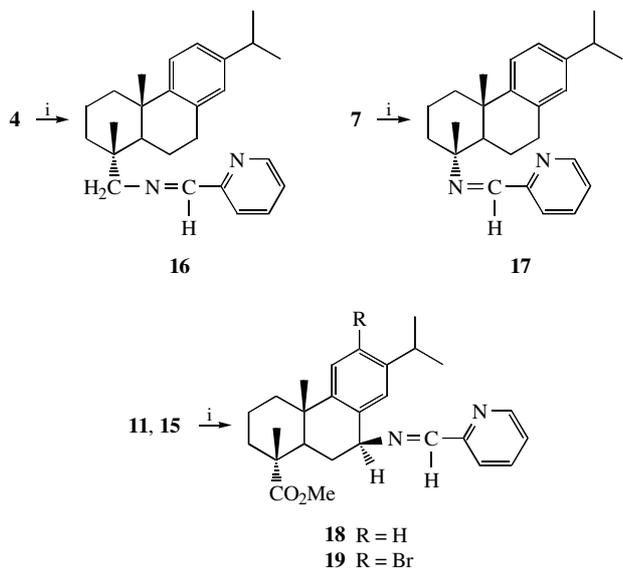
Scheme 2 Reagents and conditions: i, KMnO₄/Al₂O₃, Me₂CO, 20 °C, 12 h; ii, NH₂OH·HCl, AcONa, EtOH, 78 °C, 3 h; iii, H₂, PtO₂, MeOH/HCl, 20 °C, 1.5 h, then Et₃N, Et₂O, 20 °C.

NH₂OH·HCl. This compound was hydrogenated over a PtO₂ catalyst in the presence of an equimolar quantity of HCl in methanol to produce a mixture of products, from which the target compound, methyl 7-aminodehydroabiectate **11** (80%) was isolated after neutralization using column chromatography on SiO₂. A comparative analysis of ¹H and ¹³C NMR spectra recorded for hydrochloride **7** and amines **4**, **11**[†] suggested that the (-)-configuration of the NH₂ group in compound **11** was favoured. A similar example of the selective reduction of oximes is the preferential formation of (-)-amines in the catalytic (PtO₂) hydrogenation of some oximino-derivatives of mono-terpenes and steroids.^{13,14} Oxidation of methyl 12-bromo-dehydroabiectate **12** with KMnO₄/Al₂O₃ in acetone gave methyl 12-bromo-7-ketodehydroabiectate **13** (85%). Oxime **14** synthesized from this was hydrogenated over PtO₂ under the same conditions as oxime **10**. A mixture of products was obtained, among which methyl 7(-)-amino-12-bromodehydroabiectate **15** (56%) was isolated.

The reaction between pyridine-2-carboxaldehyde and amine **4** was conducted in benzene in the presence of anhydrous Na₂SO₄ and gave azomethine **16** (67%).[‡] Chiral Schiff bases **17** (52%), **18** (60%) and **19** (54%) were synthesized in the same way from amines **7**, **11** and **15**, respectively.

Chiral rhodium(I) complexes **20–27** were prepared through interaction of ligands **16–19** with di-(-)-chlorobis(cyclooctadiene)dirhodium and NaClO₄ or NaBF₄ in methanol.

Reduction of acetophenone to phenethyl alcohol by means of a hydrogen transfer reaction under the conditions given elsewhere⁴ was used as an example for the preliminary



Scheme 3 Reagents and conditions: i, pyridine-2-carboxaldehyde, Na₂SO₄, C₆H₆, 20 °C, 2 h.

estimation of the catalytic activity and enantioselectivity of the new complexes. For example, at [cat.] = 1.6 × 10⁻⁴ M and ratios of [sub.]/[cat.] = 1000, [propan-2-ol]/[sub.] = 80, the transformation of acetophenone in boiling propan-2-ol catalysed by complex **20**[‡] produced (+)-(*R*)-phenethyl alcohol at 50% conversion and a moderate optical yield (12%) {[α]_D²⁰ +5.1° (neat), lit.⁴ [α]_D²⁰ +43.6° (neat)}.

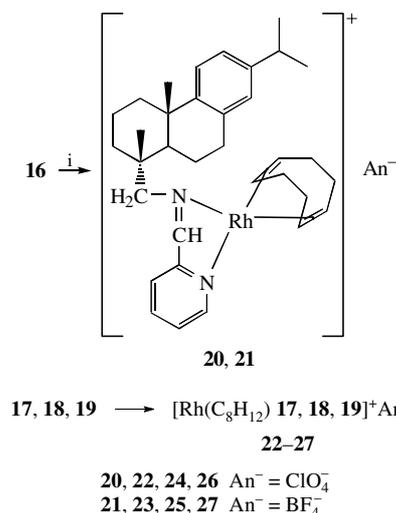
[†] A Bruker DRX 500 spectrometer was used to record ¹H and ¹³C NMR spectra for compounds **7** and **11**, and a Bruker AC-200 for compounds **16** and **20**.

7: mp 250 °C (decomp.), [α]_D²⁰ +49.6° (c 0.74, in CHCl₃); ¹H NMR (CDCl₃) δ: 1.19 (s, 3H, 18-H₃), 1.22 (d, 6H, 16-H₃, 17-H₃, *J* = 7 Hz), 1.46 (s, 3H, 19-H₃), 1.52 (m, 1H, 1-H_a, *J*_{hem} = 13 Hz, *J* = 13 Hz, *J* = 4 Hz), 1.73 (m, 1H, 3-H_a), 1.76–1.87 (m, 3H, 2-H₂, 6-H_a), 1.99 (d, 1H, 5-H, *J* = 13 Hz), 2.19–2.30 (m, 3H, 3-H_b, 6-H_b, 1-H_b), 2.81 (septet, 1H, 15-H, *J* = 7 Hz), 2.93 (m, 1H, 7-H_a, *J*_{hem} = 17 Hz, *J* = 7 Hz), 3.00 (m, 1H, 7-H_b, *J*_{hem} = 17 Hz, *J* = 11.5 Hz, *J* = 6.5 Hz), 6.88 (d, 1H, 14-H, *J* = 1.5 Hz), 6.98 (dd, 1H, 12-H, *J* = 8 Hz, *J* = 1.5 Hz), 7.13 (d, 1H, 11-H, *J* = 8 Hz), 8.4 (br. s, 3H, NH₂·HCl); ¹³C NMR (CDCl₃) δ: 18.72, 18.77 (C-2, C-6), 19.89 (C-19), 23.83 (C-16, C-17), 24.74 (C-18), 29.74 (C-7), 33.38 (C-15), 37.18 (C-1), 37.86 (C-10), 37.89 (C-3), 48.49 (C-5), 58.44 (C-4), 124.01 (C-12), 124.35 (C-11), 126.77 (C-14), 134.10 (C-8), 145.05 (C-9), 145.87 (C-13).

11: oil, [α]_D¹⁸ +13.9° (c 1.50, in CHCl₃); ¹H NMR (CDCl₃) δ: 1.21 (d, 6H, 16-H₃, 17-H₃, *J* = 7 Hz), 1.24 and 1.26 (s, 6H, 18-H₃, 19-H₃), 1.31–1.93 (m, 8H, 1-H₂, 2-H₂, 3-H₂, 6-H₂), 2.25 (dd, 1H, 5-H, *J* = 12 Hz, *J* = 2 Hz), 2.84 (septet, 1H, 15-H, *J* = 7 Hz), 3.64 (s, 3H, OCH₃), 4.01 (dd, 1H, 7-H₂, *J* = 10.5 Hz, *J* = 7.2 Hz), 7.03 (dd, 1H, 12-H, *J* = 8.0 Hz, *J* = 2.0 Hz), 7.13 (d, 1H, 11-H, *J* = 8.0 Hz), 7.28 (d, 1H, 14-H, *J* = 2.0 Hz); ¹³C NMR (CDCl₃) δ: 16.24 (C-19), 18.27 (C-2), 23.69, 23.84 (C-16, C-17), 25.41 (C-18), 33.21 (C-6), 33.47 (C-15), 36.32 (C-1)*, 37.31 (C-10), 37.90 (C-3)*, 43.77 (C-5), 47.12 (C-4), 51.47 (C-7), 51.77 (OCH₃), 123.98 (C-12)*, 124.92 (C-11), 125.14 (C-14)*, 138.24 (C-8), 146.14 (C-13), 146.55 (C-9), 178.54 (CO₂CH₃). Signal assignments follow the assumed formula.

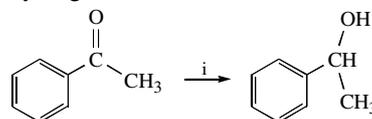
[‡] **16**: mp 107–108 °C (C₂H₅OH), [α]_D²⁴ +29.1° (c 0.48, CHCl₃); ¹H NMR (CDCl₃) δ: 1.07 (s, 3H, 18-H₃), 1.24 (d, 6H, 16-H₃, 17-H₃, *J* = 7 Hz), 1.26 (s, 3H, 19-H₃), 1.32–2.05 (m, 8H, 1-H₂, 2-H₂, 3-H₂, 6-H₂), 2.30 (d, 1H, 5-H, *J* = 13 Hz), 2.85 (m, 3H, 7-H₂, 15-H), 3.45 (d, 1H, 20-H_a, *J* = 12 Hz), 3.55 (d, 1H, 20-H_b, *J* = 12 Hz), 6.88 (s, 1H, 14-H), 7.01 (d, 1H, 12-H, *J* = 8 Hz), 7.19 (d, 1H, 11-H, *J* = 8 Hz), 7.30 (m, 1H, 5'-H, *J* = 8.5 Hz, *J* = 2 Hz), 7.70 (t, 1H, 4'-H, *J* = 8 Hz), 8.02 (d, 1H, 3'-H, *J* = 8 Hz), 8.36 (s, 1H, 1'-H), 8.60 (d, 1H, 6'-H, *J* = 5 Hz).

20: mp 210–220 °C (decomp.); ¹H NMR (CDCl₃) δ: 1.15 (d, 6H, 16-H₃, 17-H₃, *J* = 7 Hz), 1.19 (s, 3H, 18-H₃), 1.21 (s, 3H, 19-H₃), 1.31–2.15 [m, 8H, 1-H₂, 2-H₂, 3-H₂, 6-H₂, 4H (1,5-COD)], 2.27 (m, 1H, 5-H), 2.38–2.62 [m, 4H (1,5-COD)], 2.72–3.05 (m, 3H, 7-H₂, 15-H), 3.15 (d, 1H, 20-H_a, *J* = 11 Hz), 3.41 (d, 1H, 20-H_b, *J* = 11 Hz), 4.45 [m, 4H (1,5-COD)], 6.88 (s, 1H, 14-H), 6.94 (d, 1H, 12-H, *J* = 8 Hz), 7.11 (d, 1H, 11-H, *J* = 8 Hz), 7.68 (m, 1H, 5'-H), 7.85 (d, 1H, 6'-H, *J* = 5 Hz), 8.09 (m, 1H, 4'-H), 8.20 (d, 1H, 3'-H, *J* = 7.5 Hz), 8.55 (s, 1H, 1'-H).



Scheme 4 Reagents and conditions: i, [Rh(C₈H₁₂)Cl]₂, NaClO₄ or NaBF₄, MeOH, 20 °C, 0.5 h.

A further communication concerned with a detailed study of the catalytic activity and enantioselectivity of new rhodium(I)-complexes in hydrogen transfer reactions will follow.



Scheme 5 Reagents and conditions: i, PrⁱOH, **20**, 83 °C, 24 h.

This work was supported by the Russian Foundation for Basic Research (grant no. 96-15-97013).

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Received: Moscow, 27th November 1997

Cambridge, 8th January 1998; Com. 7/08971J