# Glycerolato-1*O*,2*O* Complexes of Platinum(II): Solid and Solution State Structures of $[(R^*,R^*),(R^*)]$-(±)-$[\overline{PtOCH_2CH(O})CH_2OH\{1,2\text{-}C_6H_4(PMePh)_2\}]\cdot 2MeOH$

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Reaction of $(R^*,R^*)$-(±)-$[Pt(OMe)_2\{1,2\text{-}C_6H_4(PMePh)_2\}]$ in benzene–methanol with glycerol produces an equilibrium mixture of glycerolato-1*O*,2*O* diastereoisomers, epimeric at 2*O*, that exist in $[^2H_2]$dichloromethane predominantly as internally hydrogen-bonded monomers; in a typical second-order asymmetric transformation pure $[(R^*,R^*),(R^*)]$-(±)-$[\overline{PtOCH_2CH(O})CH_2OH\{1,2\text{-}C_6H_4(PMePh)_2\}]\cdot 2MeOH$ crystallizes from the solution as an externally hydrogen-bonded centrosymmetric dimer of asymmetric monomers of opposite helicity.

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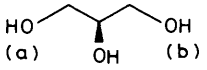
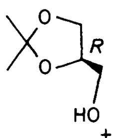
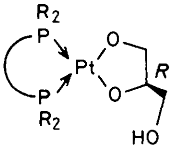


(1)



(±)-(2)†



(±)-(3)

The chemical differentiation of the enantiotopic terminal hydroxy groups of glycerol (**1**) as a classical prochiral substrate in natural and artificial systems has long been an area of interest. On the one hand, chiral glycerol derivatives play key roles as substrates for glycolytic enzymes in intermediary metabolism;[1] on the other hand, with suitable protection,[2] as in (**2**), they serve as building blocks for a variety of important biologically active molecules, including phospholipids,[3] β-adrenergic blocking agents,[4] prostaglandins,[5] certain antibiotics,[6] and acyclonucleotides.[7] Glycerol itself, however, is seriously considered as a precursor in enzymic syntheses only;[8] the main sources of chiral glycerol synthons are

D-mannitol,[9] L-serine,[10] and L-ascorbic acid.[11] We report here the first use of a platinum(II) auxiliary for the discrimination of the terminal hydroxy groups of glycerol in complexes of type (**3**). Platinum(II) alkoxides are reactive species for organic syntheses, but few transition metal glycolates[12] or glycerolates[13] are known.

The complex $(R^*,R^*)$-(±)-[Pt(OMe)$_2${1,2-$C_6H_4$(PMePh)$_2$}]†‡ in benzene–methanol reacts with 1 equiv. of (**1**) at 20 °C to give a solution of $[(R^*,R^*),(R^*)]$-(±)- and $[R^*,R^*),(S^*)]$-(±)-(**4**) with 3 : 2 diastereoselectivity. In a typical second-order asymmetric transformation the solution yields only $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH upon dilution with diethyl ether (95% of substance). In the solid state $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH was shown by X-ray analysis§ to be bound into a centrosymmetric dimer by external hydrogen bonding between asymmetric monomers of opposite helicity (Figure 1). In the structure, one molecule of methanol of crystallization is hydrogen bonded to O(2), the other is hydrogen bonded to a triflate ion in the lattice. Upon dissolution in [$^2H_2$]dichloromethane the bismethanol solvate rearranges with redistribution of glycerolato ligands (even at −90 °C) into the 3 : 2 equilibrium mixture of diastereoisomers, which were shown by vapour pressure osmometry to be monomeric and by $^1H$ n.m.r. spectroscopy to be predominantly internally hydrogen bonded (Scheme 1). Thus, the 500 MHz $^1H$ n.m.r. spectrum of $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH in [$^2H_2$]dichloromethane at 25 °C contains, in addition to the two sets of resonances for the non-equivalent PMe groups of each diastereoisomer in the ratio 3 : 2, the following two features: a widely separated pair of doublets of doublets due to the slowly exchanging $CH_2OH$ of each diastereoisomer in the closed-ring conformation in equilibrium with a relatively small concentration of the open or non-hydrogen bonded forms of the diastereoisomers (singlet $CH_2OH$ resonance due to fast exchange); and an almost overlapping pair of quartets of medium intensity for equilibrium concentrations of $CH_3OH$ in slow exchange with the internally hydrogen bonded $CH_2OH$ of each diastereoisomer. The 1,3-dioxolane (**2**) and related compounds also display intramolecular hydrogen bonding,[15] and we have shown that there is a slow exchange between $CH_3OH$ and (**2**) in [$^2H_2$]dichloromethane at 25 °C. Details of the $^1H$, $^{13}C$, $^{31}P$, and $^{195}Pt$ n.m.r. spectra of $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH are given in the caption to

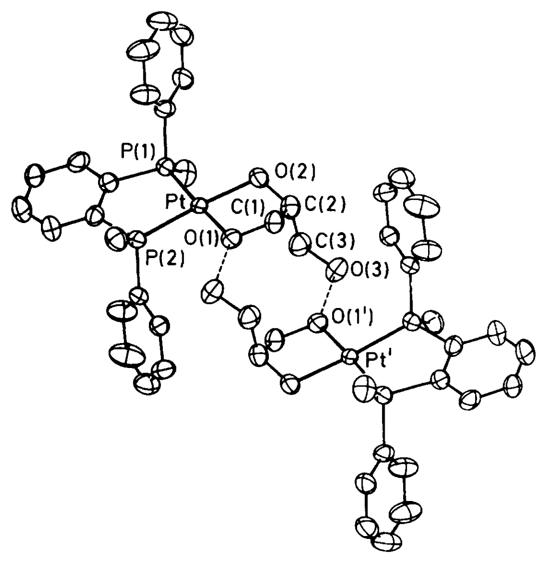
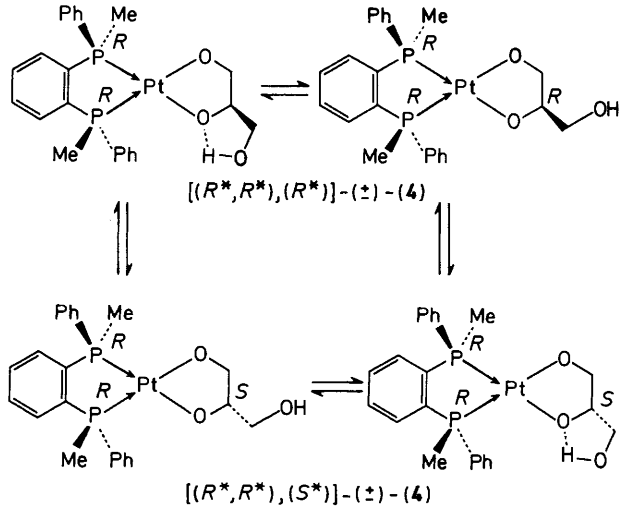


**Figure 1.** Molecular structure of $[(R^*,R^*),(R^*)]$-(±)-(**4**) showing dimer formation. Selected bond distances (Å) and angles (°) are as follows: Pt–P(1) 2.203(2), Pt–P(2) 2.200(2), Pt–O(1) 2.028(5), Pt–O(2) 2.039(6), O(1)–C(1) 1.421(10), O(2)–C(2) 1.430(10), C(1)–C(2) 1.505(12), C(2)–C(3) 1.527(12), O(3)–C(3) 1.430(10), O(3). .O(1') 2.666(8), P(1)–Pt–P(2) 87.28(8), P(1)–Pt–O(1) 177.7(2), P(1)–Pt–O(2) 95.1(2), P(2)–Pt–O(1) 94.4(2), P(2)–Pt–O(2) 176.2(2), O(1)–Pt–O(2) 83.4(2).



**Scheme 1.** Selected n.m.r. data for $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH in $CD_2Cl_2$ at 25 °C {$[R^*,R^*),(R^*)]$-(±)-(**4**) (a) : $[(R^*,R^*),(S^*)]$-(**4**) (b) 3 : 2 (assignment arbitrary)}: $\delta_H$ (500 MHz) 2.276, 2.272 (d of d's, $^2J_{PH}$ 11.26 Hz, $^3J_{PtH}$ 32.20 Hz, PMe), 2.737 (d of d, $^3J_{HH}$ 3.09, 7.68 Hz, $CH_2OH$, H-bonded), 3.285 (d of d, $^3J_{HH}$ 4.11 and 5.90 Hz, $CH_2OH$, H-bonded), 2.682 (s, $CH_2OH$, non H-bonded; MeOH), 3.287, 3.298 (d, $^3J_{HH}$ 5.23 Hz, $CH_3OH$, H-bonded), 3.294 (s, $CH_3OH$, non H-bonded), and 3.564, 3.566 (q's, $^3J_{HH}$ 5.23 Hz, $CH_3OH$, H-bonded); $\delta_C$ (50.35 MHz) 64.54, 64.88 (m's, $CH_2OH$), 75.26 (m, $PtOCH_2$), and 82.39 (m, PtOCH); $\delta_P$ (80.98 MHz) 22.55, 23.27 [ABq, $J_{PP}$ 9.36, $J_{PtP}$ 3257 and 3307 Hz (a)], 22.31, 22.97 [ABq, $J_{PP}$ 9.36, $J_{PtP}$ 3252 and 3313 Hz, (b)]; $\delta_{Pt}$ (40.80 MHz) −2732 [d of d, $J_{PtP}$ 3257 and 3307 Hz, (a)], and −2729 [d of d, $J_{PtP}$ 3252 and 3313 Hz, (b)]. Chemical shifts are given relative to $Me_4Si$($^1H$), 85% $H_3PO_4$($^{31}P$), or aq. $H_2PtCl_6$($^{195}Pt$). Only one enantiomer of each diastereoisomer depicted.

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† The stereochemical descriptors used here for racemates are consistent with recent Chemical Abstracts Service indexing practice; $R^*$ and $S^*$ refer to the relative absolute configurations of the chiral centres. Enantiomers have simplified descriptors.

‡ This compound was obtained from $(R^*,R^*)$-(±)-[$PtCl_2${1,2-$C_6H_4$(PMePh)$_2$}][14] by treatment with a freshly prepared solution of NaOMe in benzene–methanol at room temperature; it can be isolated as pale yellow air-sensitive crystals, m.p. 95—100 °C (decomp.). Selected n.m.r. data in $CD_2Cl_2$ at 25 °C: $\delta_H$ (200 MHz) 2.23 (d, $^2J_{PH}$ 11.22 Hz, $^3J_{PtH}$ 31.80 Hz, PMe) and 3.63 ($X_3AA'X'_3$ m, $n$ 7.18 Hz, {$^{31}P$}$^1H$ (s), $^3J_{PtH}$ 36.67 Hz, OMe); $\delta_c$ (50.35 MHz) 57.30 (br s, $OCH_3$); $\delta_P$ (80.98 MHz) 20.42 (s, $J_{PtP}$ 3337 Hz); $\delta_{Pt}$ (40.80 MHz) −2605 (t, $J_{PtP}$ 3337 Hz). All new compounds gave satisfactory analytical figures.

§ Crystal data: $[(R^*,R^*),(R^*)]$-(±)-(**4**)·2MeOH, $C_{25}H_{34}O_5P_2Pt$, $M$ = 671.55, triclinic, space group $P\bar{1}$, $a$ = 8.387(2), $b$ = 12.062(6), $c$ = 14.579(4) Å, $\alpha$ = 92.30(1), $\beta$ = 106.19(2), $\gamma$ = 108.02(2)°, $U$ = 1333.9 Å$^3$, $D_c$ = 1.67 g cm$^{-3}$ for $Z$ = 2, $F(000)$ = 664, $\mu$(Mo–$K_\alpha$) = 54.6 cm$^{-1}$. In space group $P\bar{1}$ both enantiomers are present. Of 4711 measured intensities (Phillips PW 1100/20; 20 °C), 3944 were considered observed [$I > 3\sigma(I)$]. After Lorentz, polarisation, and absorption corrections, the structure was solved by the heavy atom method. Subsequent refinement (full-matrix least-squares) afforded $R$ and $R'$ values of 0.040 and 0.049, respectively. Atomic co-ordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Notice to Authors, Issue No. 1.

Scheme 1. ¶ The equilibrium 3:2 ratio of diastereoisomers is not noticeably affected by solvent, concentration, or temperature.

The enantiomers of (±)-(**4**) have properties identical with those of the racemate in solution and show considerable potential for asymmetric synthesis.** Thus, [(*R*,*R*),(*R*)]/[(*R*,*R*),(*S*)]-(+)-(**4**), $[\alpha]_D$ + 150° ($CH_2Cl_2$), in dichloromethane reacts with $(NC)_2C{=}C(CN)_2$[16] to give a quantitative yield of the cyclic acetal (−)-$(NC)_2C{=}\overline{COCH_2CH(O)}CH_2OH$, $[\alpha]_D$ −2.8° ($CH_2Cl_2$), which was shown by $^{13}C$ n.m.r. spectroscopy in the presence of the shift reagent (+)-tris[3-(trifluoromethylhydroxymethylene)camphorato]europium-(III)(inverse gated decoupling experiment) to have an optical purity of 20%, reflecting dicyanoketene addition to the equilibrium concentrations of glycerolato-1*O*,2*O* diastereoisomers. Present work is concerned with the improvement of optical yields of these and related products.

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¶ The [(*R**,*R**),(*R**)] ⇌ [(*R**,*R**),(*S**)] interconversion may occur by intermolecular redistribution of glycerolate ligands or by intramolecular site exchange of the terminal oxygen atoms of the co-ordinated glycerolate, which are diastereotopic, or by a combination of these processes. Support for the intermolecular mechanism was provided by the observation (n.m.r. experiment) of ready diolate exchange between [(*R**,*R*),(*R**)]/[(*R**,*R*),(*S**)]-(±)-(**4**)·2MeOH and (*R**,*S**)-$[\overline{PtOCH_2CH_2O}\{1,2\text{-}C_6H_4(PMePh)_2\}]$ in [$^2H_2$]dichloromethane.

** The enantiomers of (**4**) were prepared from (*R*,*R*)-(+)- and (*S*,*S*)-(−)-$[PtCl_2\{1,2\text{-}C_6H_4(PMePh)_2\}]$[14] and sodium methoxide as described for the racemate.