Clay as a Medium for Optical Resolution: Chromatographic Resolution of 2,3-Dihydro-2-methyl-5,6-diphenylpyrazine on a Λ-[Ru(phen)$_3$]$^{2+}$ (phen = 1,10-phenanthroline) Montmorillonite Column

Akihiko Yamagishi

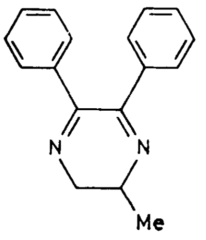
Department of Chemistry, Faculty of Science, Hokkaido University, Sapporo 060, Japan

DL-2,3-Dihydro-2-methyl-5,6-diphenylpyrazine was partially resolved on a 2 × 1.2 cm o.d. column of Λ-[Ru(phen)$_3$]$^{2+}$ (phen = 1,10-phenanthroline) montmorillonite when it was eluted with 1 : 2 (v/v) methanol–water solvent.

Recently the author has initiated study into liquid chromatography using columns of clay–metal chelate adducts.[1,2] The use of this method arose from the finding that certain tris-chelated metal complexes tended to pair with their optical antipodes adsorbed on a colloidal clay, leading to racemic adsorption.[3,4] This pairing can take place even between enantiomers of different metal complexes. As a result, a racemate of complex M^1 can be resolved on a clay on which an enantiomer of another chelate (*e.g.* Λ-M^2) has been adsorbed [equation (1)]; Λ-M^1.Λ-M^2 denotes a 'pseudo' racemic pair formed on a clay surface.[1,2]

$$\text{rac. } M^1 + \Lambda\text{-}M^2\text{–clay} \rightarrow \Lambda\text{-}M^1.\Lambda\text{-}M^2\text{–clay} + \Lambda\text{-}M^1 \tag{1}$$

We now report that a similar kind of clay column is capable of resolving an organic racemate, DL-2,3-dihydro-2-methyl-5,6-diphenylpyrazine (**1**). The compound was chosen because it may potentially be regarded as a two-bladed propeller. The results demonstrate the unique properties of a clay as a medium for recognizing the chirality of organic molecules.



(1)

A 2 × 1.2 cm o.d. column containing Λ-[Ru(phen)$_3$]$^{2+}$ montmorillonite was used.[†] The clay–metal chelate adduct had a basal spacing [*d*(001)] of 18.0 Å, which is about 5.5 Å larger than the *d*(001) (12.5 Å) of sodium montmorillonite. Compound (**1**) (1.3 mg) in methanol (1 ml) was loaded on the column. Through this methanol–water (1 : 2 v/v) was passed at a rate of 0.1 ml min^{-1}. The solution from the column contained only (**1**) as solute whose concentration was calculated from the electronic spectra, using the molar extinction coefficient of ϵ (365 nm) = 530 dm^3 mol^{-1} cm^{-1}. The efficiency of resolution was determined from the o.r.d. curves at 210–700 nm.

The chromatographic results are given in Table 1. The appearance of optical rotation together with the inversion of its sign at 400 nm demonstrated the successful resolution of (**1**). The molecular rotation at 400 nm for the pure L-isomer of (**1**) was determined to be −2750 in a separate experiment.[5]

[†] Synthesized by replacing 67% of the Na$^+$ ions in sodium montmorillonite (Kunipia G, Kunimine Ind. Co., Japan) with Λ-[Ru(phen)$_3$]$^{2+}$.

Table 1. Chromatographic results for DL-2,3-dihydro-2-methyl-5,6-diphenylpyrazine on a Λ-$[Ru(phen)_3]^{2+}$-montmorillonite column.[a,b]

Volume/ ml	Concentration/ 10^{-4} M	Molecular rotation at 400 nm	Percentage resolution[c]/%
1.7	6.6	−530	20
1.7	3.4	−1100	42
1.7	3.0	−270	10
1.7	2.8	−270	10
1.7	2.6	−160	6.0
1.7	2.3	−110	4.2
3.4	1.7	+1200	45
3.4	1.4	+1000	38
3.4	1.1	+1200	45
3.4	0.75	+2300	87

[a] The eluting solvent was 1 : 2 (v/v) methanol–water. [b] 1.3 mg of the compound was loaded on the column. [c] Calculated on the basis of a molecular rotation at 400 nm of the L-isomer of −2750.

The maximum percentage of resolution, [*R*], was calculated to be 42% for the L- and 87% for the D-isomer. Further, [*R*] was found to be [6.6% (L), 25% (D)] and [5.3% (L), 3.6% (D)] when 1 : 1 and 2 : 1 (v/v) methanol–water were used as eluants, respectively. Thus, the efficiency of resolution fell with decrease in the water content.

Similar experiments were performed on columns of other kinds of ion-exchangers on which Δ-$[Ru(phen)_3]^{2+}$ had been preadsorbed, using the cation-exchange resins Dowex 50-X8, SP-Sephadex C25, and kaoline (ASP-100, Engelhard, U.S.A.). When compound (**1**) was eluted on these columns (1—2 × 1.2 cm o.d.) with 1 : 2 (v/v) methanol–water, no optical rotation due to (**1**) was observed within 0.01 deg cm^{-1}. Thus these columns did not resolve (**1**).

Since sodium montmorillonite does not have an asymmetric structure, the resolution must have occurred at the sites occupied by Λ-$[Ru(phen)_3]^{2+}$. Compound (**1**) may be regarded as a propeller-like molecule, as the two phenyl groups can rotate in the same direction with respect to the pyrazine ring.[6] Left- or right-wing propellers are possible, then, and these stack suitably with adsorbed Λ-$[Ru(phen)_3]^{2+}$, depending on the space relation of (**1**) to the latter. Since Λ-$[Ru(phen)_3]^{2+}$ itself may be regarded as a left-wing propeller, the right- or left-wing propeller-type of (**1**) is a preferred stacking partner, according to whether (**1**) is placed by the side, or over the head, of Λ-$[Ru(phen)_3]^{2+}$, respectively. Such selectivity may lead to the resolution of a racemic mixture of (**1**).

Received, 20th July 1982; Com. 847

References

1 A. Yamagishi, *J. Chem. Soc., Chem. Commun.*, 1981, 1168.

2 A. Yamagishi, *Inorg. Chem.*, 1982, **21**, 3393.

3 A. Yamagishi and M. Soma, *J. Chem. Soc., Chem. Commun.*, 1981, 539.

4 A. Yamagishi and M. Soma, *J. Am. Chem. Soc.*, 1981, **103**, 4640.

5 The L-isomer of (**1**) was synthesized according to the method of R. D. Gillard and J. D. Pedrosa, *J. Chem. Soc., Dalton Trans.*, 1979, 1779.

6 Benzil forms such a two-bladed propeller in the crystalline state (C. J. Brown and R. Sadanaga, *Acta Crystallogr.*, 1965, **18**, 158).