CHEMISTRY LETTERS, pp. 437-440, 1982.

PREPARATION OF NEW CATION-EXCHANGERS DERIVED FROM TOYOPEARL GEL AND THEIR APPLICATION TO THE RESOLUTION OF COBALT(III) COMPLEXES

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Cation-exchangers with tartrate residues as chiral exchanging groups were newly prepared from Toyopearl gel. Short columns of these exchangers were successfully used for a highly efficient resolution of cobalt(III) complexes such as $[Co(en)_3]^{3+}$, $[Co(tn)_3]^{3+}$, and *fac*-$[Co(\beta\text{-ala})_3]$; complete resolutions were effected by a recycling chromatographic technique.

Previously we prepared chiral cation-exchange Sephadex derivatives, TA(ES)- and TA(ET)-Sephdex, with tartrate residues of the ester and ether types respectively, and successfully applied their columns to the chromatographic resolution of cobalt(III) complexes.[1-3] In another attempt, we prepared the Sephadex derivatives with chiral cation-exchanging groups derived from L-amino acids, although they were not so efficient as TA-Sephadex.[4] Sephadex and its derivatives are so soft that their column volume are easily varied with the changes of the pressure applied, the solvent, or the concentration of an eluent. They are not suitable for the chromatography using an organic solvent and for the high performance liquid chromatography (HPLC).

Therefore, we intended to prepare chiral cation-exchangers with tartrate groups using a more rigid gel base and to achieve more efficient chromatographic resolution with their columns.

In the present work, Toyopearl HW-40(Fine), commercially available from Toyo Soda Co., was used as the base gel of cation-exchangers. This white resin is a kind of synthetic gel containing hydroxyl groups; it is spherically shaped like beads for chromatographic use.

Toyopearl derivatives with cation-exchanging tartrate residues were prepared according to the method which we used previously for the preparation of TA-Sephadex;[1],[2] the method is briefly outlined below. The new exchangers of the ester and ether types are named TA(ES)- and TA(ET)-Toyopearl respectively.

TA(ES)-Toyopearl was prepared by the reaction of Toyopearl with L-tartaric acid. Dry Toyopearl(60 g) was mixed with a concentrated aqueous solution of L-tartaric acid(170 g). The mixture was air-dried and then heated at about 110 °C for 10 hours. The product was washed with water and then treated with a 0.1 M Na_2CO_3 solution for the conversion of tartaric acid residues to the sodium form.

The product, TA(ES)-Toyopearl, was white particles preserving the spherical shape. Its exchange capacity[1)] for $[Co(en)_3]^{3+}$ was 0.35 mmol/g. The capacity can be easily regulated by the duration of heating. The reaction temperature of about 110 °C seems to be critical, for the reaction at higher temperatures caused partial distortion of the particles.

D-TA(ES)-Toyopearl was prepared in a similar way by using D- instead of L-tartaric acid. The exchange capacity for $[Co(en)_3]^{3+}$ was 0.33 mmol/g.

TA(ET)-Toyopearl was prepared by the reaction of Toyopearl with diethyl L-tartrate. Dry Toyopearl(60 g) was mixed with diethyl L-tartrate(210 ml). After the addition of concd. H_2SO_4(3 ml) to the mixture, the suspension was stirred and heated at about 60 °C for 84 hours. It was filtered and washed with water. The product, a pale-yellow gel, was then treated with a 0.2 M Na_2CO_3 solution overnight to result in the hydrolysis of the diethyl L-tartrate residues coupled onto Toyopearl. The pale-yellow color was mostly removed during the procedure. No appreciable deformation was observed of the bead-like shape of the starting material, while partial fragmentation occurred probably because of a prolonged mechanical stirring; these fragments were readily decanted off. The exchange capacity of TA(ET)-Toyopearl thus prepared and refined was 0.33 mmol/g.

For the comparison with TA-Toyopearl, an achiral cation-exchange Toyopearl was prepared with sodium 2-chloroethanesulfonate according to the known method for the preparation of SE-cellulose.[5)] The product remained unchanged in the shape and color of the particles. It is a cation-exchanger containing sulfoethoxy groups in substituition for hydroxyl ones. The exchange capacity can be controlled by varying the reaction time or the ratio of the reactants. For the present work, it was adjusted to 0.34 mmol/g for the comparison with TA-Toyopearl derivatives.

Table The Cation-Exchanging Toyopearl Derivatives Prepared

Derivatives	Ion-exchanging Groups	Capacities
SE-Toyopearl	$\mathrm{TPL{-}O{-}(CH_2)_2{-}SO_3^-}$	0.34 mmol/g
TA(ES)-	$\mathrm{TPL{-}OOC{-}CH(OH){-}CH(OH){-}COO^-}$	0.35 mmol/g
D-TA(ES)-		0.30 mmol/g
TA(ET)-	$\mathrm{TPL{-}O{-}CH(COO^-){-}CH(OH){-}COO^-}$	0.33 mmol/g

The Toyopearl derivatives prepared are summarized in the Table, in which Toyopearl is abbreviated to TPL as well as in the Figures below.

The Toyopearl cation-exchangers were used in the column-chromatographic resolution of cobalt(III) complexes. The resolution was carried out in a way similar to that described previously;[6)] a recycling-chromatographic technique[7)] was employed in the present work.

Columns(ϕ1.6 × 39±1 cm) of the Tyopearl derivatives were

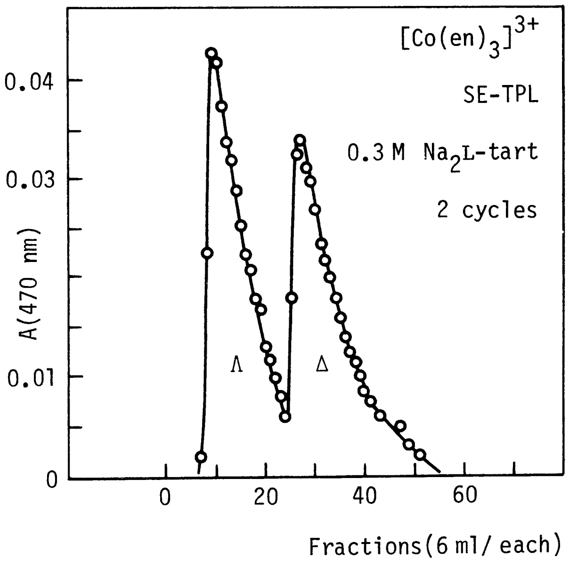

Fig. 1. Elution on a SE-Toyopearl column.

prerared in Amicon column tubes(GAJ 16 × 45) equipped with flow adaptors for recycling. The effluent from a column end was pumped up to the column head through a flow adaptor by a peristaltic pump. The flow rate of the eluent was about 40 ml/hour except in the elution of *fac*-[Co(β-ala)$_3$].

Figures 1 to 5 show the results of the elutions of the cobalt(III) complexes. The complex, the ion-exchanger, the eluent, and the column length(39 cm × numbers of recycling) are shown in this order in each Figure.

Each elution curve showed distinctly split bands corresponding to the optical antipodes of a complex, which were identified by CD spectral measurements. All the Toyopearl derivatives prepared had similar exchange capacities. Thus, their efficiencies in the resolution of [Co(en)$_3$]$^{3+}$ can be readily compared with one another by surveying the elution curves taking note of the column sizes; the quantities of the complex were almost the same (about 40 mg) for all the runs.

Complete resolution of [Co(en)$_3$]$^{3+}$ was attained on a column of either TA(ES)-Toyopearl or TA(ET)-Toyopearl with a Na$_2$SO$_4$ solution as an eluent. The former, the

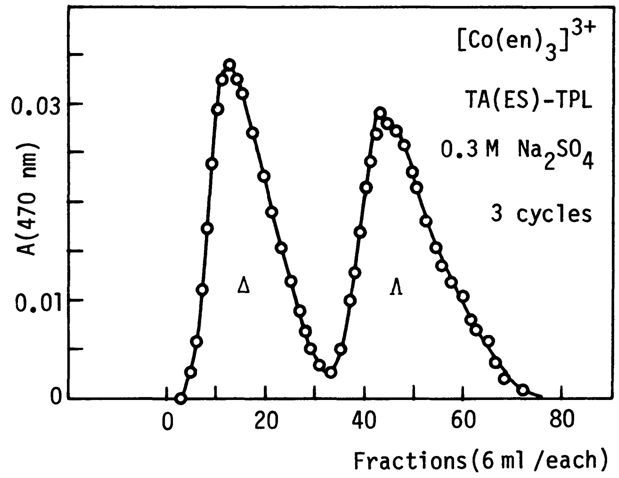

Fig. 2. Elution on a TA(ES)-Toyopearl column.

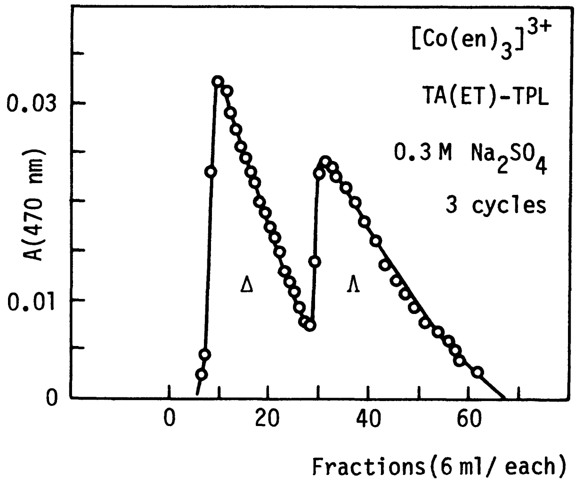

Fig. 3. Elution on a TA(ET)-Toyopearl column.

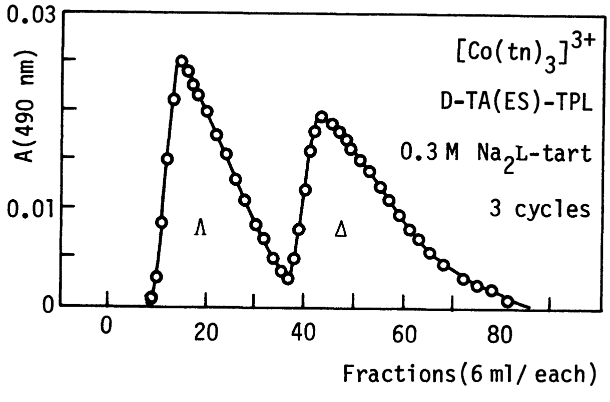

Fig. 4. Elution on a D-TA(ES)-Toyopearl column.

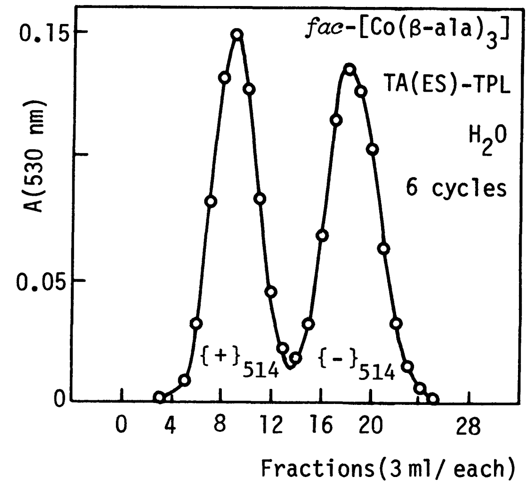

Fig. 5. Elution on a TA(ES)-Toyopearl column.[9]

ester-type derivatives, was particularly efficient, as was the case with Sephadex derivatives. Although the resolution of the complex can also be effected by the use of SE-Toyopearl column with a sodium L-tartrate (Na_2L-tart) eluent (Fig. 1), it is significant that $[Co(en)_3]^{3+}$ was completely resolved without optically active eluent on a column with chiral exchanging groups.

A clear-cut resolution of $[Co(tn)_3]^{3+}$ was acieved by making use of the doubly stereoselective effect of a D-TA(ES)-Toyopearl column and a Na_2L-tart eluent (Fig. 4), while a previous attempt using a D-TA(ES)-Sephadex column resulted in a partial resolution.3)

A non-electrolyte complex, *fac*-$[Co(\beta\text{-ala})_3]$,8) was eluted with water on a TA(ES)-Toyopearl column; the resolution was remarkable (Fig. 5). With D-TA(ES)-Toyopearl, the elution order of the optical antipodes was reversed. Although the complex could also be resolved chromatographically on a CM-Sephadex column,10) it should be noted that our present method gives an effluent containing 100 % optically pure *fac*-$[Co(\beta\text{-ala})_3]$ free from any salts; laborious procedures to eliminate the salt used as eluent can be omitted.

Toyopearl derivatives, which were prepared by simple and practical methods, have been shown to be widely applicable to the resolution of metal complexes. Other types of ion exchangers may as well be prepared from Toyopearl gel, while other complexes, either ionic or non-electrolyte, may as well be resolved with a column of a Toyopearl derivative.

In addition, an important advantage of Toyopearl derivatives over Sephadex ones is that they are harder gels. Therefore, Toyopearl derivatives are very likely to be used in HPLC under a reasonable pressure. Part of the work along this line has been successfully done. The results will be published elsewhere.

References

1) M. Fujita, Y. Yoshikawa, and H. Yamatera, Chem. Lett., 1974, 1515.
2) M. Fujita, Y. Yoshikawa, and H. Yamatera, Chem. Lett., 1975, 473.
3) M. Fujita, Y. Yoshikawa, and H. Yamatera, J. Chem. Soc., Chem. Commun., 1975, 941.
4) M. Fujita, M. Sakano, Y. Yoshikawa, and H. Yamatera, Bull. Chem. Soc. Jpn., 54, 3211 (1981).
5) J. Peška, J. Štamberg, and J. Hradil, Angew. Makromol. Chem., 53, 73 (1976).
6) J. Porath and H. Bennich, Arch. Biochem. Biophys., Suppl. 1, 152 (1962).
7) M. Sano, M. Fujita, K. Sasaki, Y. Yoshikawa, and H. Yamatera, Bull. Chem. Soc. Jpn., 54, 2823 (1981).
8) The complex, *fac*-$[Co(\beta\text{-ala})_3]$, was prepared according to M. B. Čelap, S. R. Niketić, T. J. Janjic, and V. N. Nicolić, Inorg. Chem., 6, 2063 (1967).
9) The $\{+\}_\lambda$ and $\{-\}_\lambda$ symbols represent the CD sign at λ nm; Y. Yoshikawa, Bull. Chem. Soc. Jpn., 49, 159 (1976).
10) H. Yoneda and T. Yoshizawa, Chem. Lett., 1976, 707.

(Received January 26, 1982)