

Cyclic Oligopyrroles as Sensors for Absolute Configuration Determination of Carboxylic Acids

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Introduction

Understanding the role of chirality in medicine, technology and nature requires facile methods for the absolute configuration determination. Chiral carboxylic acids, amino acids among them, are of great importance in development of new therapeutic drugs and other precursors for next generation materials. Cyclic oligo- and polypyrroles (pyrrole_n, n > 7) have been found to have excellent physico-chemical properties such as λ_{max} at 400-650 nm with high absorption coefficient, metal guest insertion (one or more) in their cavity, and flexibility.

Among ((1.0)_n) type cyclic polypyrroles, the number of the pyrrole subunit has been found to be controlling the macrocycle backbone conformation and with the numbers 8, 12 and 16 the macrocycle adopts a figure eight type helical shape. Various factors affect to the basicity of the pyrrole subunit, and rate and energy barrier of the chirality interconversion in these flexible macrocycles. Thus, using the properties what these polypyrroles possess, we have found that some of them can sense the chirality of carboxylic acids at low concentrations at room temperature.

Results and Discussion

We employed circular dichroism (CD) exciton chirality method¹ and found that a variety of carboxylic acids upon forming a host-guest complex with (1.0.1.0.1.0.1.0) oligopyrroles (Figure 1) induce CD spectrum at macrocycle absorption region and in which the sign of the 1st Cotton effect is determined solely by the absolute configuration of the carboxylic acid (Figure 2).²

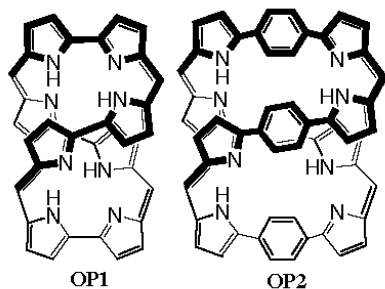


Figure 1. The cyclooctapyrroles used in this study as chirality sensors for carboxylic acids. Pyrrole β -ethyl and *meso*-phenyl substituents are omitted for clarity.

The addition of the chiral carboxylic acid to the present oligopyrroles caused clear bathochromic shifts in the UV-vis spectra due to the formation of carboxylic acid ligated OP1 and OP2. The shifts are because of the formation of protonated OP1 and OP2. The CD spectra are silent for the both oligopyrroles but the addition of the chiral carboxylic acid causes bisignate CD signal band formation most likely due to the chiral carboxylate binding into the cavity of OP1 and OP2.

The plausible mechanism for the generation of the CD signals can be explained based on the coupling of the electronic transition dipole moments x and y in two dipyrrolylmethene subunits (Figure 3). The figure eight conformation can be considered as having two helicene loops, both turning to the same direction. The direction of the helicene turn can be determined by CD spectroscopic measurements and can be rationalized as clockwise or anti-clockwise direction of the coupling electronic transition dipole moments.

Controlling the sensitivity of the present oligopyrroles towards carboxylic acid complexation can be easily done by variation of the

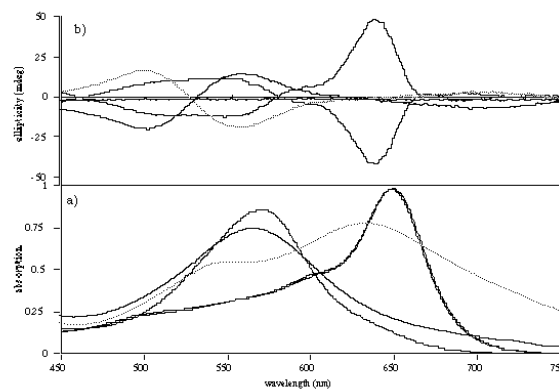


Figure 2. a) UV-vis spectra and b) CD spectra of OP1 in the absence (black) and presence of (*S*)-(+)-hexahydromandelic acid (red) or (*R*)-(-)-hexahydromandelic acid (blue) and OP2 in the absence (magenta) and presence of N-BOC-L-Asp-4-OBz (green) or N-BOC-D-Asp-4-OBz (cyan) in CH₂Cl₂/MeOH at 298 K.

meso-phenyl substituents. Strong electron donating substituents in the *meso*-phenyl groups show remarkable effects in the pyrrole nitrogen basicity

The larger cavity size in OP2 allows facile absolute configuration determination of larger carboxylic acids, such as BOC amino acids.

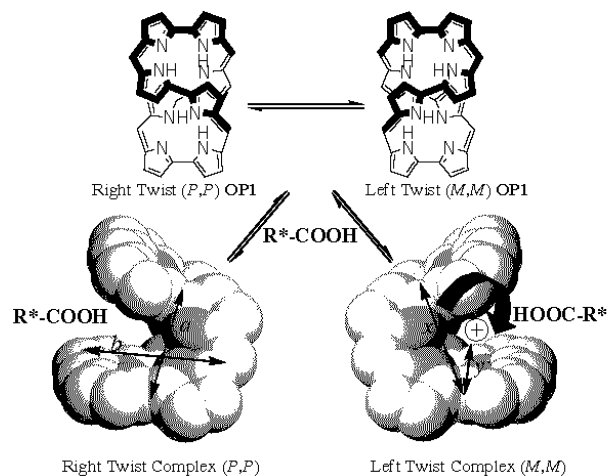


Figure 3. Chirality induction in octapyrrolin OP1 upon binding of chiral carboxylic acids. Coupling of the electronic transitions (x and y) of two dipyrrolylmethene subunits yielding positive 1st Cotton effect. The pyrrole β -ethyl and *meso*-phenyl substituents have been omitted for clarity.

Conclusions

Absolute configuration of various synthetic and natural chiral carboxylic acids can be determined easily based on the idea of supramolecular chirogenesis. Two examples show that the cavity size of the cyclic oligopyrrole host molecule plays crucial role upon binding of large guest molecules.

References

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