DOI: 10.1002/chem.201200335

Versatile Switching in Substrate Topicity: Supramolecular Chirality Induction in Di- and Trinuclear Host Complexes

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Abstract: Supramolecular chirality effects have been achieved both for ditopic and monotopic substrates by using a programmable bis-salphen scaffold that incorporates either two or three Zn nuclei. The dinuclear host shows preferential chirogenesis in the presence of ditopic systems, whereas effective chirality transfer to the trinuclear complex is realized through monotopic binding. The mode of binding in the trinuclear host has been investigated through X-ray crystallography, CD measurements, UV/Vis spectroscopy, and DFT analysis. The bis-salphen scaffold holds promise for the development of substrate-specific host systems useful for determination of the absolute configuration of various types of organic molecules.

Keywords: atropisomers · chirogenesis · monotopicity · Schiff bases · supramolecular chemistry

Introduction

Chirality represents an important phenomenon in chemical sciences and in particular in the area of asymmetric synthesis,[1] in which the production and analysis of chiral molecules has been the subject of extensive and ongoing investigation. Supramolecular chirality,[2] such as found in the DNA double helix in biological systems[3] has been less studied but has the propensity to be exploited in many different ways. Supramolecular chirogenesis,[4] that is, the induction of chirality by means of a chiral substrate that locks a host molecule into a preferred chiral state, is an emerging field of science that has great potential for the determination of absolute configurations of various substrates[5] and for use in enantioselective catalysis[6] and material science.[7] In most of these reported chirogenesis strategies, a nonchiral host contains two binding sites that are useful for binding of ditopic chiral guests. Upon binding of suitable guest molecules, the structure of the host system is locked into one favored chiral conformation. In this context, Borovkov and Inoue reported on ethane-bridged bisporphyrin systems that show interesting chirogenesis effects in the presence of distinct ditopic chelators.[8] Despite the effectiveness of ditopic binding in chirogenesis phenomena, chiral induction through monotopic binding of a chiral guest remains extremely challenging.[9] Monotopic binding of suitable substrates is highly attractive due to potential new applications, such as the development of new chiral (supramolecular) ligands, and improved protocols for the determination of absolute conformations of a wide range of structurally different chiral substrates. We report herein on an unusual trinuclear Schiff base host complex in which the conformation is rigidified by a central Zn ion; coordination of a series of suitable monotopic ligands to this central Zn ion results in effective chirality transfer to the host as supported by circular dichroism (CD) spectroscopy. X-ray analysis, UV/Vis spectroscopy, and density functional theory (DFT) calculations have further been used to obtain more insight in the preferred binding of the guests to this host under these conditions.

Results and Discussion

Although bis-porphyrins have been widely studied as hosts in supramolecular chirogenesis,[4,8] salphen-based hosts [salphen = *N*,*N*′-1,2-phenylenebis-(salicylimine)] have recently been reported as effective systems for binding of chiral carboxylates.[5a] Salphen systems have emerged as powerful structures in supramolecular science and catalysis[10] due to their huge potential as versatile building blocks. In a previous contribution[5a] we reported on a bis-Zn(salphen) host comprised of a biphenyl spacer in which the conformation can be controlled upon binding of chiral acids. The bis-Zn(salphen) host contained a built-in acetic acid guest that needed to be exchanged for chiral carboxylates to induce a chirogenesis effect. We realized that this built-in guest prohibited the use of this supramolecular host system for other types of more weakly binding ditopic guests and set out to

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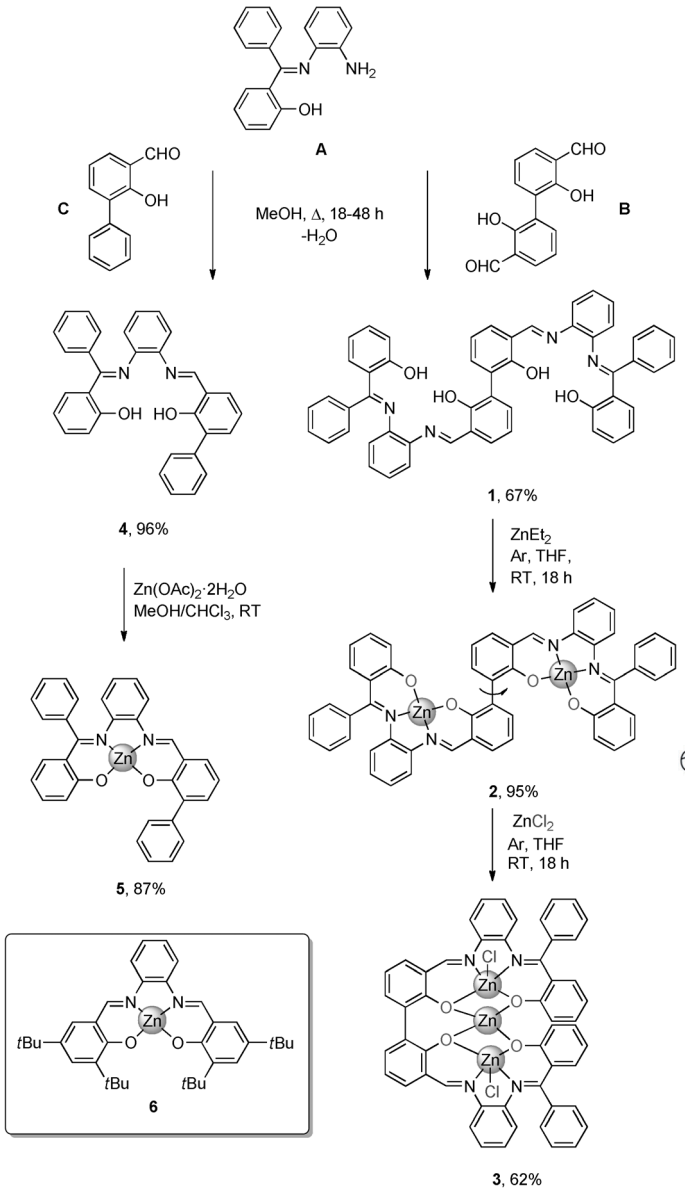
Supporting information for this article is available on the WWW under http://dx.doi.org/10.1002/chem.201200335.

explore the construction of carboxylate-free systems. This is an important requisite for new host structures based on bis-Zn(salphen) scaffolds because carboxylate binding proved to be strong ($K_a = 3.8 \times 10^{10}\,M^{-1}$). This very high association of acids to bis-Zn(salphen) hosts limited the use of the first-generation host[5a] to exchange only with other, though chiral, carboxylic acids with similar high binding affinities. The replacement of the RCOOH unit by other potentially ditopic substrate systems based on N,N-, N, O- or O,O-coordination patterns was, therefore, not conceivable at relatively low guest/host ratios. We therefore designed a new acid-free host framework (i.e., **2** in Scheme 1) that is able to directly bind various ditopic guest molecules.

To construct these new types of bis-Zn(salphen) hosts, we took advantage of the higher stability of ketimines versus aldimines,[11] and ligand **1** could be easily isolated in good yield by a combination of monoketimine **A** with dialdehyde **B**.[12] The isolation of **1** is a prerequisite for producing a guest-free host; metalation of **1** by using $ZnEt_2$ proceeds almost quantitatively and gives bis-Zn(salphen) **2** in 95% yield. Complex **2** contains an array of O-donor atoms that may be useful for coordination to cations. We envisioned that cation binding by these O-atoms would significantly reduce its flexibility, and furthermore would lead to a structure with a central Lewis acidic binding site. Upon treatment of **2** with an ethereal solution of $ZnCl_2$, tri-Zn complex **3** (62%) was subsequently obtained; isolation of **3** from **2** is greatly facilitated by simple and selective extraction of **2** by using CH_2Cl_2 to give pure **3**, or by filtration of the reaction mixture. The difference between both multinuclear systems is easily observed by ^1H NMR spectroscopy ([D_7]DMF); whereas **2** is characterized by an imine resonance at $\delta = 9.00$ ppm, in **3** ($\delta = 9.29$ ppm) this is located significantly more downfield as a result of the presence of a third Lewis acid center bound to the four O donors. Further confirmation of the connectivity pattern in **2** and **3** was provided by MALDI(+) mass spectrometry (see the Supporting Information), and in the case of **3** by X-ray diffraction studies (Figure 1). Complex **5** (prepared by using monoaldehyde **C**) and known Zn(salphen) **6** were used as mononuclear references for the spectroscopic studies.

The structure determined for **3**[13] represents an unusual trinuclear supramolecular system in which the two exterior Zn metal centers are axially ligated by a chloride anion. The



Scheme 1. Synthesis of **2–3** via precursor bis-ligand **1**; also shown are the mononuclear compounds **5** and **6** used as controls in this study.

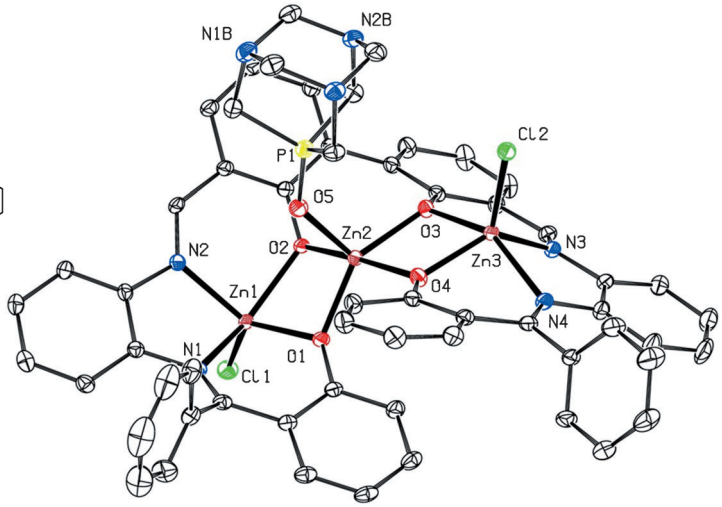


Figure 1. X-ray molecular structure determined for **3** in the presence of 1,3,5-triaza-7-phosphaadamantane oxide. Ellipsoids were drawn at the 40% probability level. Cocrystallized solvent molecules and H atoms are omitted for clarity. Selected bond lengths [Å] and angles [°]: Zn1–N1 = 2.1718(14), Zn1–N2 = 2.0570(15), Zn1–O(1) = 1.9860(13), Zn1–O2 = 2.1144(11), Zn1–Cl1 = 2.2204(5), Zn2–O1 = 1.9735(12), Zn2–O2 = 2.0401(13), Zn2–O3 = 2.0082(11), Zn2–O4 = 2.0192(13), Zn2–O5 = 2.0209(13); N2-Zn1-N1 = 77.92(6), O1-Zn1-O2 = 77.99(5), O1-Zn1-N2 = 125.15(6), O2-Zn1-N1 = 142.92(5), O2-Zn1-Cl1 = 109.64(4), N1-Zn1-Cl1 = 107.42(4), O2-Zn2-O4 = 169.835, O3-Zn2-O1 = 139.11(5), O1-Zn2-O4 = 97.16(6), O1-Zn2-O5 = 110.09(5), O4-Zn2-O5 = 97.45(5).

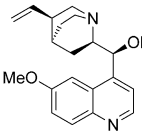
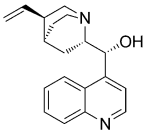
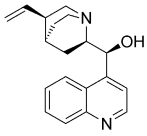
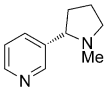
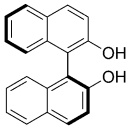
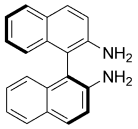
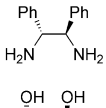
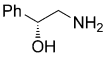
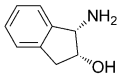
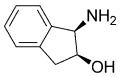
charge of these two anions is balanced by a third Zn cation [Zn2] that is located in the interior of the structure and is ligated by four O atoms of the bis-salphen scaffold that reside in an approximately planar arrangement around Zn2. The coordination geometry around Zn2 is completed by the presence of an axially interacting phosphine oxide that was present during the crystallization process. The presence of the latter demonstrates that suitable monotopic, chiral ligands may be able to induce a preferred conformation of the biphenyl backbone in Zn_3 structure **3** resulting in an excess of one of the two atropisomers having either *P* or *M* helical conformations. This is an additional and important advantage over the first-generation host,[5a] amplifying the application potential to a wide range of ditopic and monotopic substrates.

Both multinuclear Schiff base complexes **2** and **3** were then combined with a number of potentially ditopic and monotopic chiral substrates (O and N donors) to examine the chiral induction effects (Table 1, Figure 2, and the Supporting Information). Typical ditopic systems, such as diamines and diols, produced a clear CD response in the presence of Zn_2 complex **2**, whereas in most cases these same substrates caused only a slight CD response or no response at all in the presence of trinuclear **3**. Interestingly, when substrates with typical monotopic binding modes to Lewis acid metals were combined with **3**, significantly higher CD responses were noted compared with **2**. A selection of (cinchona) alkaloids and a chiral pyrrolidine gave fairly similar results (i.e., a comparable increase in the molar ellipticity) and showed principally CD responses in the presence of **3**. As expected, mononuclear complexes **5** and **6** showed no CD responses for various substrates, including cinchonidine, quinidine, (−)-nicotine and (*R*)-dimethylamino pyrrolidine, which demonstrates the need for the bis-salphen scaffold in the generation of chirogenesis effects.

The alkaloids are comprised of an N-heterocyclic fragment that is able to axially coordinate to the central Zn ion,[14] whereas the tertiary amines in these structures have been reported to only bind very weakly.[15] The fact that no observable changes were noted in the CD spectra recorded for (−)-nicotine and (*R*)-dimethylamino pyrrolidine with Zn_2 complex **2** is further testament to the negligible coordination of the tertiary amine functions (see the Supporting Information). For the cinchona alkaloid structures, it seems plausible to suggest some degree of ditopic binding in the presence of **2** involving a N,O-coordination pattern. The binding of cinchonidine to **3** was then further investigated by UV/Vis spectroscopy and fitting of the titration data to a 1:1 binding model gave an association constant K_a of $3.3\times10^4\,\text{M}^{-1}$. The presence of a clear isosbestic point in the UV/Vis spectra indicates that multiple binding of cinchonidine guests under these conditions is not favored (see the Supporting Information) and exemplifies the preferred binding of monotopic systems to the central Zn ion in **3** under these conditions.

DFT analysis (see the Supporting Information) of the 1:1 host–guest complex **3**·cinchonidine was performed to establish the preferred conformation of the host upon binding of (−)-cinchonidine. For both diastereoisomers (*M*)-(−) and (*P*)-(−), the UV/Vis and CD traces were calculated and compared with the observed data (Figure 3). The computational data for the (*M*)-(−) diastereoisomer is in good agreement with the experimental data, showing a first (larger) negative Cotton effect followed by a smaller second positive Cotton effect. The electronic transitions responsible for these effects have host-based π–π* character, as supported by frontier orbital analysis (see the Supporting Information).

Table 1. UV/CD response after chiral guest addition.[a]

Host/Guest	Guest structure	λ_{max} [nm]	$\Delta\varepsilon$ [$\text{M}^{-1}\text{cm}^{-1}$]
2/quinidine		438	−2.5
3/quinidine		444	−4.6
2/cinchonidine		408	−2.5
3/cinchonidine		410	−4.8
2/cinchonine		410	3.6
3/cinchonine		428	4.9
2/(−)-nicotine		0	0
3/(−)-nicotine		432	2.4
2/(*R*)-dimethylamino pyrrolidine		0	0
3/(*R*)-dimethylamino pyrrolidine		462	3.6
2/(*S*)-binol		430	4.4
3/(*S*)-binol		0	0
2/(*S*)-binaphthyldiamine		458	31.7
3/(*S*)-binaphthyldiamine		0	0
2/(*R,R*)-diphenyl ethylenediamine		468	46.4
3/(*R,R*)-diphenyl ethylenediamine		470	10.5
2/(*R,R*)-pentanediol		434	1.3
3/(*R,R*)-pentanediol		0	0
2/(*R*)-phenylglycinol		422	4.9
3/(*R*)-phenylglycinol		422	2.5
2/(−)-amineindanol		446	25.8
3/(−)-amineindanol		450	2.4
2/(+)-amineindanol		448	−22.4
3/(+)-amineindanol		458	2.3

[a] Measured at RT after addition of 20 equivalents of chiral guest to the corresponding host (2×10^{-5} M) freshly prepared in CH_2Cl_2.

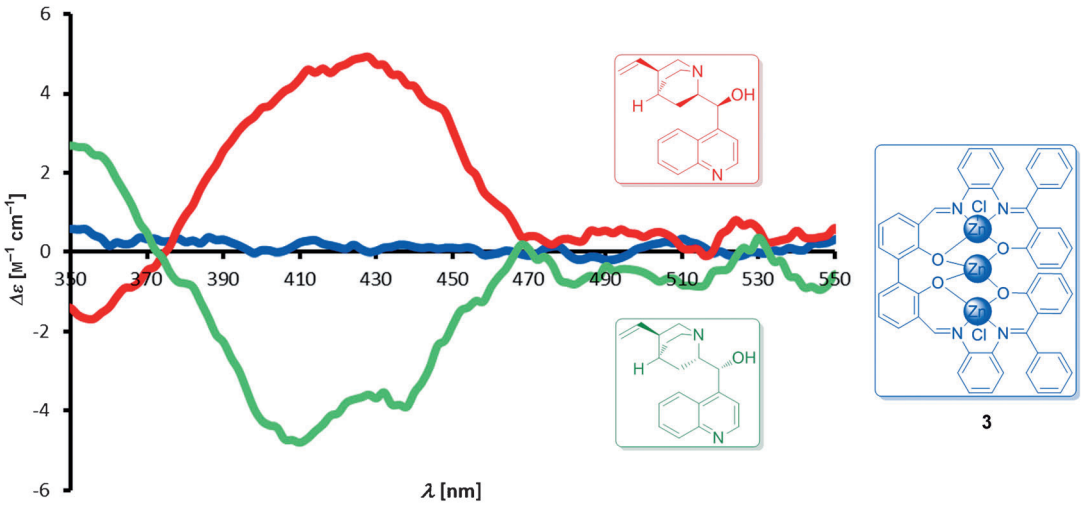


Figure 2. CD spectra of trinuclear complex **3** combined with 20 equivalents of cinchonine (red trace) or cinchonidine (green trace) in CH_2Cl_2 at RT. Blue trace: complex **3** without additive.

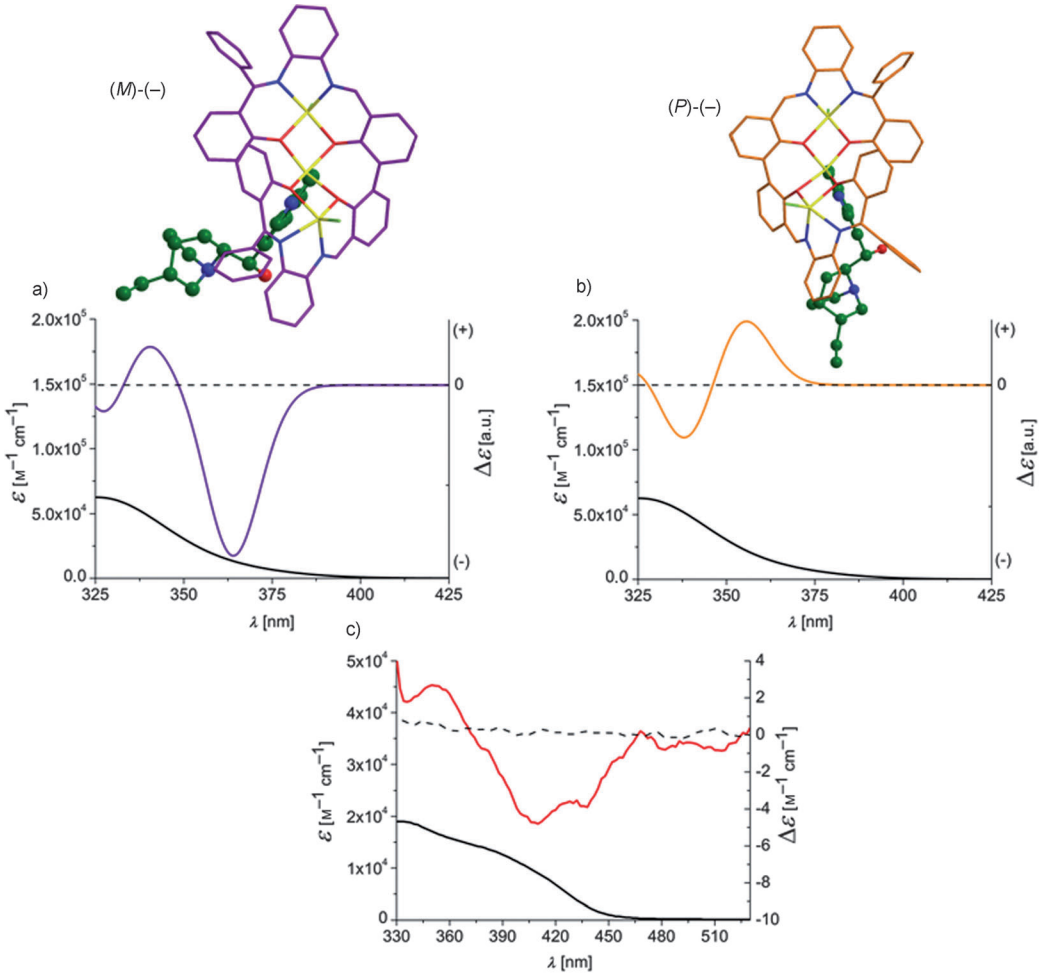


Figure 3. Computed UV/CD traces for a) the *M* conformation and b) *P* conformation of **3** for the host–guest complex **3**·cinchonidine. c) observed UV/CD spectrum.

The CD data also imply that **3** will preferentially adopt the (*P*)-(+)-conformation in the presence of (+)-cinchonine as substrate (cf. Figure 2).

Conclusion

We present herein a new bimetallic salphen scaffold that can be simply rigidified by using a metal cation. The presence of this cation creates a new host system **3** that allows for monotopic binding of chiral substrates, whereas parent complex **2** is especially suited for ditopic binding of various chiral guest molecules. In both cases, supramolecular chirality effects have been observed through CD measurements and the conformational isomerism was further analyzed by DFT. Complex **2** has great potential as a programmable and modular host system (unlike the first-generation host)[5a] for the binding of a large variety of substrates through either ditopic or monotopic (cf. **3**, after divalent cation addition) coordination patterns and thus the development of effective systems for measuring absolute configurations of chiral molecules.

Experimental Section

General methods: All starting materials were purchased from commercial sources and used without further purification. Compounds (*E*)-2-(((2-aminophenyl)imino)(phenyl)methyl)phenol (**A**)[12a] 3,3′-diformyl-2,2'-dihydroxy-1,1′-biphenyl (**B**),[12b] 2-hydroxy-[1,1′-biphenyl]-3-carbaldehyde (**C**)[16] and Zn(salphen) complex **6**[17] were prepared by using a previously reported methodology. Elemental analyses were performed at the Unidad de Análisis Elemental of the University of Santiago de Compostela (Spain). All NMR measurements were carried out by using a Bruker-400 MHz spectrometer at ambient temperature unless stated otherwise, and chemicals shifts are given in parts per million versus TMS. Mass spectrometric data were obtained from the Research Support unit of the ICIQ, and MALDI-TOF experiments were carried out with pyrene as matrix. UV/Vis spectra were recorded by using a Shimadzu UV1800 Spectrophotometer. CD spectra were measured on a Chirascan instrument from Applied Photophysics.

Diketimine (1): (*E*)-2-(((2-aminophenyl)imino)(phenyl)methyl) phenol (500 mg, 1.75 mmol) and 3,3′-diformyl-2,2'-dihydroxy-1,1'- biphenyl (210 mg, 0.88 mmol) were dissolved in MeOH (10 mL) and the solution was heated at reflux for 24 h. The precipitate formed was then filtered to give the title compound as a yellow solid (yield: 461 mg, 67 %). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.66 (t, J_{HH} = 7.1 Hz, 2H; ArH), 6.82 (m, 2H; ArH), 6.90 (t, J_{HH} = 7.6 Hz, 2H; ArH), 7.06 (m, 10H; ArH), 7.17 (t, J_{HH} = 7.5 Hz, 4H; ArH), 7.23 (m, 10H; ArH), 7.45 (d, J_{HH} = 7.5 Hz, $^4J_{HH}$ = 1.4 Hz, 2H; ArH), 8.32 (s, 2H; CH_{ald}), 13.21 (s, 2H; OH), 14.07 ppm (s, 2H; OH); ^{13}C{^{1}H} NMR (125.5 MHz, $CDCl_3$): δ = 117.94, 118.10, 118.51, 119.59, 119.62, 119.72, 123.36, 125.63, 126.77, 127.98, 128.74, 129.01, 131.96, 132.52, 133.37, 134.69, 135.84, 140.54, 141.40, 158.84, 162.82, 163.66, 174.77 ppm; HRMS (MALDI+): *m/z* calcd for $C_{52}H_{39}N_4O_4$: 783.2971; found: 783.2982 $[M+H]^+$.

Bis-Zn(salphen) (2): $ZnEt_2$ (0.51 mL, 1 M in hexanes, 0.51 mmol) was slowly added to a solution of **1** (200 mg, 0.255 mmol) in anhydrous THF (20 mL). The reaction was stirred at RT for 18 h, then the orange precipitate was filtered and dried (yield: 220 mg, 95 %). ^{1}H NMR (400 MHz, [D$_7$]DMF): δ = 6.33 (t, J_{HH} = 7.5 Hz, 2H; ArH), 6.54 (d, J_{HH} = 7.4 Hz, 2H; ArH), 6.58 (d, J_{HH} = 8.9 Hz, 2H; ArH), 6.75 (d, J_{HH} = 8.4 Hz, 2H; ArH), 6.86 (t, J_{HH} = 7.8 Hz, 2H; ArH), 6.93 (d, J_{HH} = 8.2 Hz, 2H; ArH), 7.07 (t, J_{HH} = 7.7 Hz, 2H; ArH), 7.18 (t, J_{HH} = 7.7 Hz, 2H; ArH), 7.33 (m, 8H; ArH), 7.41 (d, J_{HH} = 7.2 Hz, 2H; ArH), 7.47 (m, 8H; ArH), 7.77 (d, J_{HH} = 8.0 Hz, 2H; ArH), 9.05 ppm (s, 2H; CH_{ald}); ^{13}C{^{1}H} NMR (125 MHz, [D$_7$]DMF, 298 K): δ = 113.42, 117.78, 121.25, 122.32, 124.52, 125.22, 126.20, 127.01, 129.41, 129.62, 130.14, 134.11, 135.54, 135.76, 137.89, 138.75, 140.99, 141.89, 163.34, 164.17, 172.43, 173.94, 174.86 ppm; MS (MALDI+): *m/z* calcd for $C_{52}H_{34}N_4O_4Zn_2$: 908.1; found: 908.1 $[M]^+$; elemental analysis calcd (%) for $C_{52}H_{34}N_4O_4Zn_2{\cdot}2H_2O$: C 66.05, H 4.05, N 5.92; found: C 66.03, H 3.53, N 5.78.

Bis-salphen-Zn$_3$ (3): $ZnCl_2$ (0.055 mL, 1 M in ethyl ether, 0.055 mmol) was added to a solution of **2** (50 mg, 0.055 mmol) in anhydrous THF (10 mL). The reaction was stirred at RT for 18 h, then the yellow precipitate was filtered off and dried (yield: 36 mg, 62 %). ^{1}H NMR (300 MHz, [D$_7$]DMF): δ = 6.13 (br s, 4H; ArH), 6.92 (m, 4H; ArH), 7.09 (t, J_{HH} = 6.1 Hz, 6H; ArH), 7.31 (m, 4H; ArH), 7.47 (t, J_{HH} = 7.3 Hz, 2H; ArH), 7.58 (m, 8H; ArH), 7.78 (d, J_{HH} = 7.7 Hz, 2H; ArH), 7.87 (d, J_{HH} = 8.1 Hz, 2H; ArH), 9.29 ppm (s, 2H; CH_{ald}); ^{13}C{^{1}H} NMR (125 MHz, [D$_7$]DMF): δ = 116.07, 116.15, 118.06, 122.16, 122.91, 124.28, 125.33, 126.98, 127.47, 127.84, 128.56, 128.57, 130.84, 131.73, 135.00, 137.00, 137.56, 138.61, 140.34, 141.32, 166.19, 166.88, 174.05 pp,; MS (MALDI+): *m/z* calcd for $C_{52}H_{34}ClN_4O_4Zn_3$: 1007.0; found: 1007.1 $[M-Cl]^+$; elemental analysis calcd (%) for $C_{52}H_{34}Cl_2N_4O_4Zn_3{\cdot}2H_2O{\cdot}5CH_2Cl_2$: C 45.44, H 3.21, N 3.72; found: C 45.69, H 2.20, N 4.05.

Ketimine (4): (*E*)-2-(((2-aminophenyl)imino)(phenyl)methyl) phenol (527 mg, 1.83 mmol) and 2-hydroxy-[1,1′-biphenyl]-3-carbaldehyde (362 mg, 1.83 mmol) were dissolved in (MeOH 10 mL) and stirred for 48 h. A yellow suspension was formed, and the yellow solid was filtered and washed with methanol (yield: 823 mg, 96 %). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.74 (t, J_{HH} = 7.6 Hz, 1H; ArH), 6.81–6.85 (m, 1H; ArH), 6.98–7.43 (m, 16H; ArH), 7.47 (m, 1H; ArH), 7.56 (d, J_{HH} = 6.9 Hz, 2H; ArH), 8.45 (s, 1H; CH_{ald}), 13.60 (s, 1H; OH), 14.07 ppm (s, 1H; OH); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 117.92, 118.05, 118.92, 118.98, 119.54, 119.62, 123.18, 125.48, 126.87, 127.05, 127.87, 128.03, 128.50, 128.96, 129.32, 129.82, 131.67, 132.39, 133.40, 134.18, 134.59, 137.40, 139.94, 141.60, 158.65, 162.70, 163.13, 163.15, 174.74 ppm; HRMS (ESI−, MeOH): *m/z* calcd for $C_{32}H_{23}N_2O_2$: 467.1760; found: 467.1772 $[M-H]^-$.

Zn(salphen) (5): A solution of **4** (100 mg, 0.21 mmol) in $CHCl_3$ (5 mL) and $Zn(OAc)_2{\cdot}2H_2O$ (56 mg, 0.26 mmol) in MeOH (5 mL) were combined and stirred for 18 h. Then the solvent was evaporated and the yellow residue triturated with MeOH to give the title compound as a yellow crystalline solid (yield: 97 mg, 87 %). ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 6.27 (t, J_{HH} = 8.1 Hz, 1H; ArH), 6.49 (d, $^3J_{HH}$ = 8.1 Hz, $^4J_{HH}$ = 1.1 Hz, 1H; ArH), 6.60 (t, J_{HH} = 7.5 Hz, 1H; ArH), 6.72 (d, $^3J_{HH}$ = 8.5 Hz, $^4J_{HH}$ = 1.1 Hz, 1H; ArH), 6.83 (m, 1H; ArH), 6.87 (d, $^3J_{HH}$ = 8.3 Hz, $^4J_{HH}$ = 1.8 Hz, 1H; ArH), 7.09 (m, 2H; ArH), 7.22–7.30 (m, 3H; ArH), 7.38–7.42 (m, 7H; ArH), 7.57 (d, J_{HH} = 7.1 Hz 1H; ArH), 7.77 (d, $^3J_{HH}$ = 8.1 Hz, $^4J_{HH}$ = 1.1 Hz, 2H; ArH), 8.90 ppm (s, 1H, CH_{ald}); ^{13}C{^{1}H} NMR (100 MHz, [D$_6$]DMSO): δ = 112.22, 122.98, 117.05, 120.13, 120.52, 123.20, 124.25, 125.54, 125.83, 125.93, 127.53, 128.24, 128.45, 128.66, 129.24, 133.04, 133.26, 134.31, 134.58, 135.91, 136.84, 139.61, 140.01, 140.08, 163.01, 169.81, 172.33, 173.49 ppm; MS (MALDI+): *m/z* calcd for $C_{32}H_{22}N_2O_2Zn$: 530.1; found: 530.2 $[M^+]$; elemental analysis calcd (%) for $C_{32}H_{22}N_2O_2Zn$: C 72.26, H 4.17, N 5.27; found: C 71.88, H 4.51, N 5.27.

CD measurements with different chiral guests: A solution of the corresponding chiral guest (2×10^{-3} M) in CH_2Cl_2 (400 μL) was added to a solution of either **2**, **3**, **5**, or **6** (2×10^{-5} M) in CH_2Cl_2 (2 mL) in a 1 cm quartz cuvette with a microliter syringe. CD and UV/Vis spectra were recorded simultaneously by using freshly prepared analyte solutions.

Calculation of the association constant of 3 with cinchonidine: The UV/Vis titration data obtained by using **3** (see the Supporting Information) were analyzed by using SPECFIT/32 considering two colored species (free **3** and **3**⊃(−)-cinchonidine) with two components (**3** and (−)-cinchonidine). The concentration of **3** (2×10^{-5} M) was held constant and the concentration of (−)-cinchonidine was varied. The absorption spectrum of free **3** was imported into SPECFIT/32. The association constant of **3** with (−)-cinchonidine was determined to be $K_a = 3.3\times10^{-4}$ M^{-1}.

DFT calculations: All calculations were performed by using the Gaussian 09 (G09) program package[18] employing the DFT method with the CAM-B3LYP functional.[19] The LanL2DZ basis set[20] and effective core potential were used for the Zn and Cl atoms, and the split-valence 6-31G** basis set[21] was applied for all other atoms. Geometry optimizations of complex **3** were performed without any constraint and the nature of all stationary points was confirmed by normal-mode analysis. Thirty singlet excited states were determined starting from optimized geometry

by using non-equilibrium TDDFT[22] calculations. Simulations of the electronic spectrum and the CD spectrum were obtained using GaussSum 2.2.5 package.[23]

X-ray diffraction studies: The measured crystals were stable under atmospheric conditions; however, they were treated under inert conditions and immersed in perfluoropolyether as a protecting oil for manipulation. Data Collection: Measurements were made by using a Bruker–Nonius diffractometer equipped with an APPEX 2 4 K CCD area detector, a FR591 rotating anode with $Mo_{K\alpha}$ radiation, Montel mirrors, and a Kryoflex low-temperature device ($T=-173$ °C). Full-sphere data collection was used with ω and ϕ scans. Apex2 v. 2011.3 (Bruker–Nonius 2008) was used for data collection, Saint+ version 7.60A (Bruker AXS 2008) was used for data reduction, and SADABS v. 2008-1 (2008) was used for absorption correction. Structure solution was performed by using SHELXTL version 6.10 (Sheldrick, 2000).[24] Structure Refinement: SHELXTL-97-UNIX VERSION.

Acknowledgements

This work was supported by ICIQ, ICREA, and the Spanish Ministry of Economics and Competitiveness (MINECO, project CTQ2011-27385). We thank Dr. Noemí Cabello and Sofia Arnal for the mass spectrometric studies.

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[13] Crystallographic data for **3**·$C_6H_{12}N_3PO$: Formula $C_{61}H_{52}Cl_8N_7O_5P_1Zn_3$; $M_r=1473.84$; crystal size $0.20\times0.10\times0.05$ mm^3; triclinic; space group $P\bar{1}$; $a=12.5137(3)$ Å, $b=14.0186(4)$ Å, $c=19.9889(6)$ Å; $\alpha=94.5050(10)$°, $\beta=105.8490(10)$°, $\gamma=114.2540(10)$°; $V=3001.89(14)$°; $Z=1$; $\rho_{calcd}=1.630$ mg M^{-3}; $\mu(Mo_{K\alpha})=1.629$ mm^{-1}; $T=100(2)$ K; θ(min/max) = 1.08/37.30; 25607 reflections collected; 20881 unique reflections ($R_{int}=0.0274$); absorption correction empirical; refinement method: full-matrix least-squares on F^2 ; data/restraints/parameters: 20881/42/793; GOF on $F^2=1.019$; $R_1=0.0415$ and $wR_2=0.0975$ [$I>2\sigma(I)$]; $R_1=0.0661$ and $wR_2=0.1086$ (all data); largest diff. peak and hole: 1.104 and −0.845 e^3 Å^{-3} CCDC-853355 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

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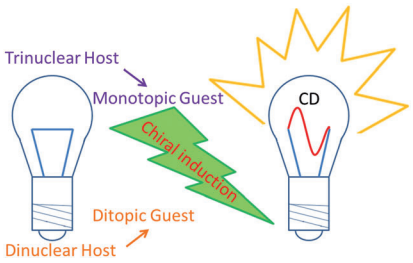
Received: January 31, 2012
Published online: ■■ ■■, 0000

Host with the most! Supramolecular hosts based on bis-Zn(salphen) scaffolds have been prepared that allow for either monotopic or ditopic binding of suitable chiral guest molecules; this binding results in chirogenesis effects that can be programmed through rigidification of the host by simple cation addition. This new host has potential for the determination of the absolute configurations of various chiral substrates through either di- or monotopic binding modes.



Supramolecular Chirality

*M. V. Escárcega-Bobadilla, G. Salassa, M. Martínez Belmonte, E. C. Escudero-Adán, A. W. Kleij** ..... ▮▮▮▮–▮▮▮▮

Versatile Switching in Substrate Topicity: Supramolecular Chirality Induction in Di- and Trinuclear Host Complexes