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meso-Tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylic Anhydride: A Platform to Benzoporphyrin Derivatives

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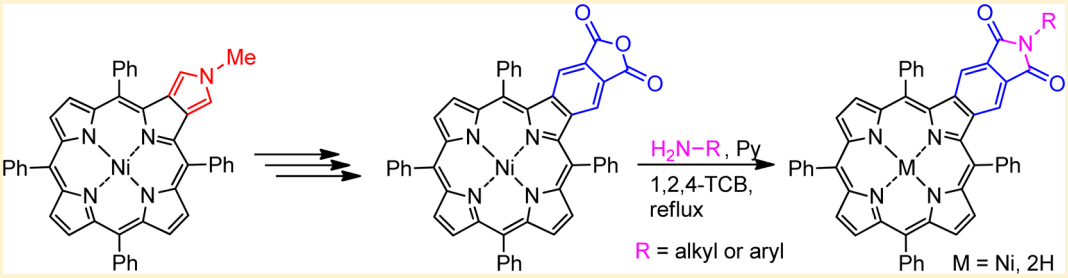
Supporting Information



ABSTRACT: A method to synthesize *meso*-tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylic anhydride is reported. This compound reacts with alkylamines and arylamines to afford the corresponding "phthalimides" in moderate to excellent yields. The reaction of the title compound with benzene-1,4-diamine or with benzene-1,3-diamine yields the corresponding *N*,*N*′-(phenylene)bisphthalimides, whereas with benzene-1,2-diamine or naphthalene-1,8-diamine it affords heterocyclic-fused porphyrins. Molecular mechanics simulations elucidates the multiplicity of signals observed in the NMR spectra of the *N*,*N*′-(1,4-phenylene)bisphthalimide **11**. This molecule exhibits two preferential conformations corresponding to a coplanar and an almost perpendicular arrangement of the benzoporphyrin units relative to the central benzenic ring.

INTRODUCTION

Porphyrins with π-extended conjugation have received much attention within the scientific community in recent years. Such type of compounds display improved photophysical and electrochemical properties and are particularly useful for applications in medicine and materials sciences.[1−4] The extension of the macrocyclic π-system through β,β'-fused aromatic rings typically causes significant red-shifts in the absorption bands of these compounds, making them potential candidates for use in photodynamic therapy,[5−8] and lowering the HOMO−LUMO energy gap, which is relevant for application as light-harvesters for dye-sensitized solar cells.[9]

Recent methods for the synthesis of porphyrins bearing one to four β,β'-fused benzo-, naphtho-, or other polycyclic aromatic groups involve a cascade reaction based on the Heck reaction of polybromoporphyrins,[5,6,9,10] the allylation of polybromoporphyrins followed by ring-closure metathesis and oxidation,[11] the use of dihydroisoindoles,[12−16] the electrocyclization of butadienylporphyrins,[17] and the reaction of 2-formyl-5,10,15,20-tetraphenylporphyrin with aryl methyl ketones and ammonium acetate in the presence of La(OTf)$_3$.[18]

Some years ago, Smith and collaborators reported the Diels−Alder reaction of pyrroloporphyrin **1a** with dimethyl acetylenedicarboxylate (DMAD).[19,20] This reaction leads to the formation of a mixture of two isomeric bisadducts of type **2** (Scheme 1), which by thermal decomposition in refluxing 1,2,4-trichlorobenzene (1,2,4-TCB) affords the benzoporphyrin diester **3** as the main product.[20] We have also been interested in developing new synthetic routes to pyrrolo[3,4-*b*]-porphyrins[21] and recently demonstrated that *N*-methylpyrrolo-[3,4-*b*]porphyrin **1** acts as a diene in Diels−Alder reactions with singlet oxygen, leading to the formation of the corresponding 1,3-dioxopyrrolo[3,4-*b*]porphyrin.[22] We now demonstrate that pyrroloporphyrin **1** may be converted, in good yield, into the corresponding benzoporphyrin-2^2,2^3-dicarboxylic anhydride **5**, which is an excellent platform to synthesize a range of interesting benzoporphyrin derivatives.

RESULTS AND DISCUSSION

The synthetic route to the benzoporphyrin-2^2,2^3-dicarboxylic anhydride **5** is outlined in Scheme 1. The first step involved the reaction of pyrrolo[3,4-*b*]porphyrin **1** with an excess of DMAD in refluxing toluene for 1 h. A drastic color change (from dark green to dark red) was observed, and the TLC of the reaction mixture revealed the absence of the starting porphyrin and the formation of a single product (R_f smaller than that of porphyrin **1**). The mass (m/z = 1007) and ^{1}H NMR spectra (four singlets corresponding to methyl ester groups at 3.64, 3.70, 3.76, and 3.82 ppm) of the new dark red compound are compatible with a bisadduct structure. The latter also shows three singlets at 1.98 (N−CH$_3$), 5.39 (N−CH), and 7.21 (C═CH) ppm.

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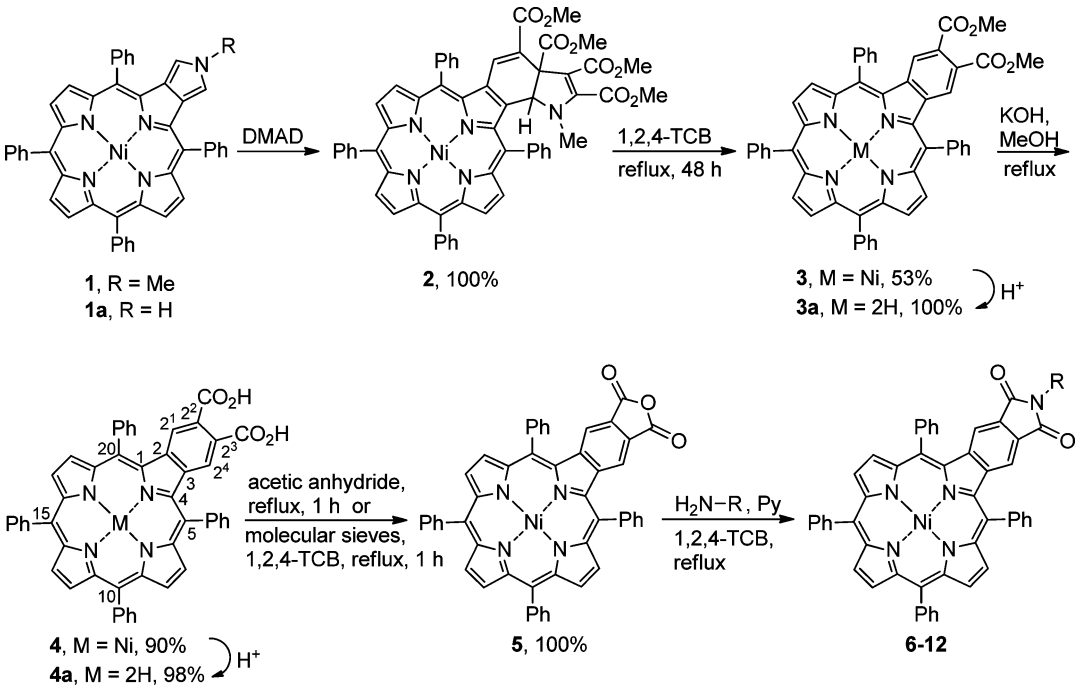
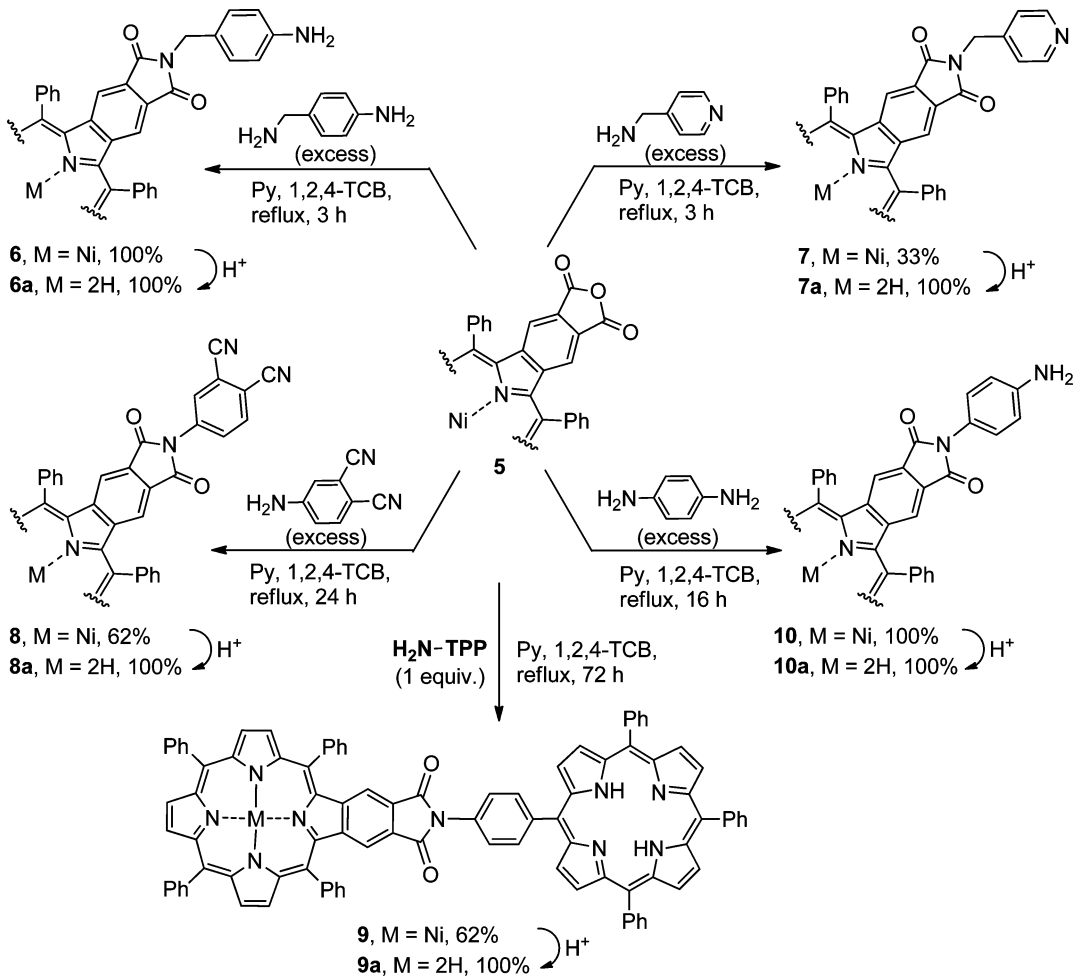
Scheme 1



Scheme 2



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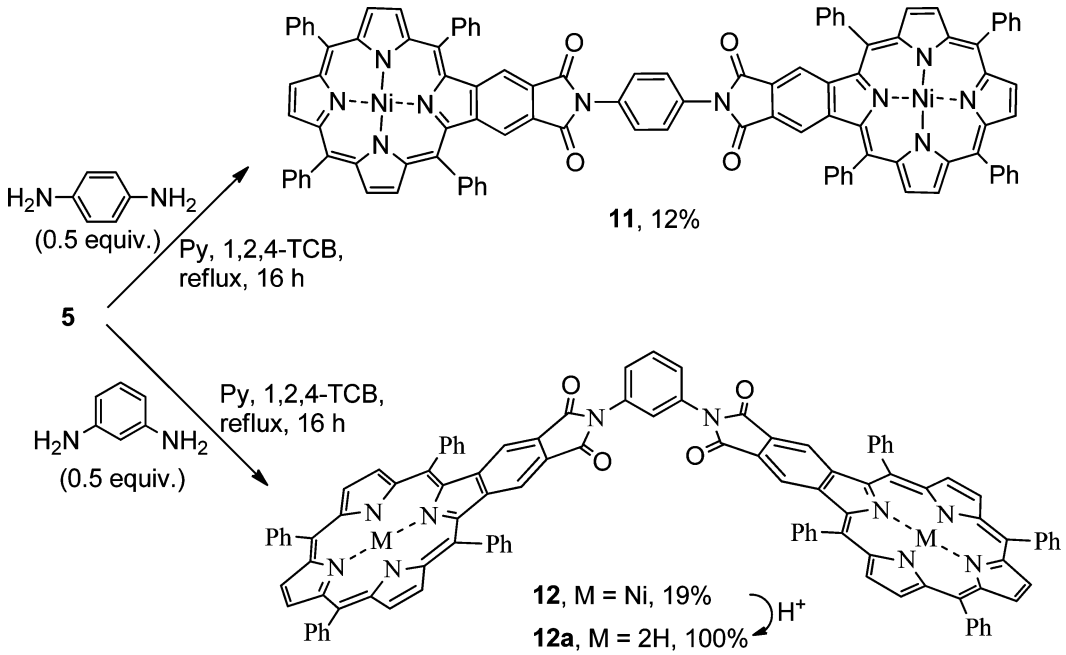
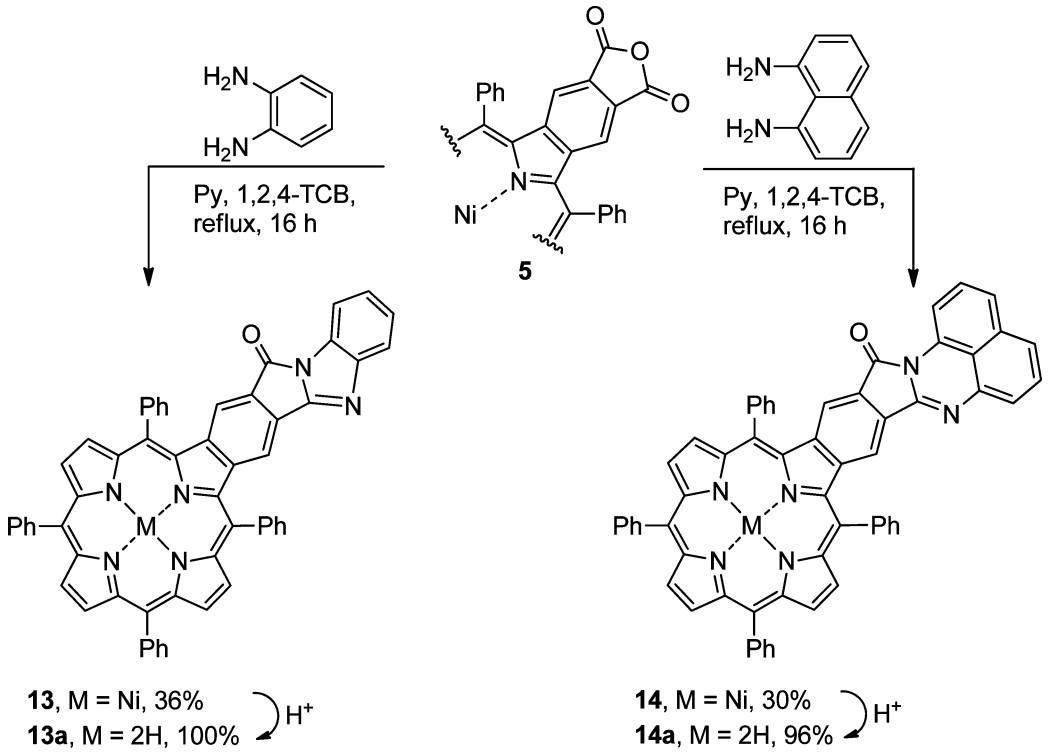
Scheme 3



Scheme 4



These data and the correlations (^3J) observed in the $^1H-^{13}C$ HMBC spectrum fully support the structure **2** (Supporting Information).

The next step consisted of the thermal decomposition of compound **2** in refluxing 1,2,4-TCB. Purification by column chromatography (silica gel) afforded a major fraction identified by MS and NMR as benzoporphyrin-2^2,2^3-dicarboxylic ester **3** (53% yield). The conversion of the diester **3** into anhydride **5** involved the hydrolysis of the ester groups to the "phthalic" acid **4** (90% yield) followed by dehydration in refluxing acetic anhydride. After the evaporation of the acetic anhydride under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH, and compound **5** was obtained in quantitative yield as a dark green solid. However, because we wanted to react "phthalic" anhydride **5** with amines (requiring the prior removal of the acetic anhydride), the following alternative procedure to generate anhydride **5** was developed. Heating a 1,2,4-TCB solution of diacid **4** at reflux for 1 h, in the presence of powdered 4Å molecular sieves, led to the total conversion of the starting compound into anhydride **5**. The subsequent

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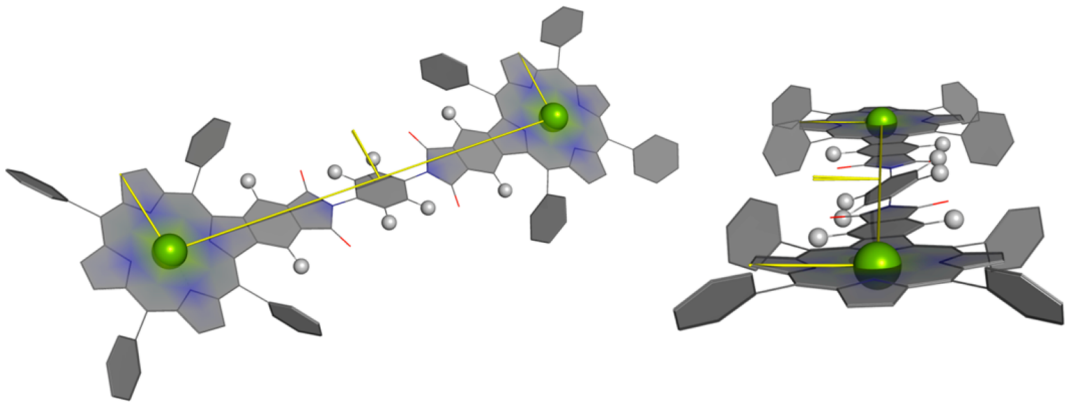

Figure 1. Predominant conformation $\mathbf{11}_{\parallel}$ adopted by compound **11** in chloroform. Both fused-ring fragments (containing the porphyrinic units) lie on the same plane, with the central benzenic ring only slightly deviating (~10°) from coplanarity to the porphyrinic plane. Color code: oxygen, red; nitrogen, blue; carbon, gray; nickel, green; hydrogen, white. All hydrogens, apart from H_b and H_f (shown as white spheres), were omitted for sake of clarity.

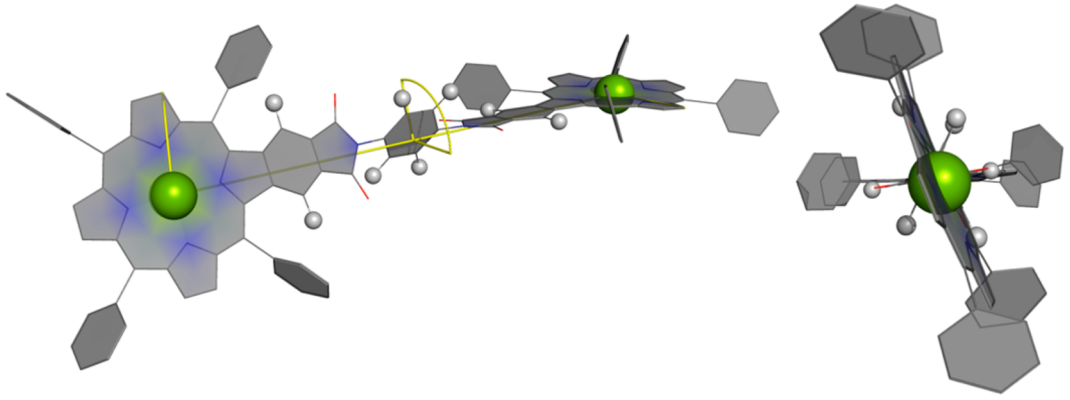

Figure 2. Predominant conformation $\mathbf{11}_{\perp}$ adopted by compound **11** in chloroform. Both fused-ring fragments are perpendicular to each other, with the central benzenic ring forming an interplanar angle of *ca.* 70° with each of the fused-ring frames. Coding as in Figure 1.

addition of amines to the *in situ* generated anhydride resulted in the formation of the expected "phthalimides". This new procedure allowed a one-pot conversion of diacid **4** into a range of imides (Schemes 2 and 3) and other heterocyclic-fused benzoporphyrin derivatives (Scheme 4).

The reaction of the *in situ* generated anhydride **5** with alkylamines and arylamines afforded phthalimides **6**–**10** in moderate to quantitative yields. The reaction with alkylamines (4-aminobenzylamine and pyridin-4-ylmethylamine) was much faster (3 h) than with arylamines (16–72 h), reflecting the differences in the reactivity of these two types of compounds. These different reactivities also account for the regioselective formation of imide **6**, whose structural identity was supported by the presence of a singlet at δ 4.70 ppm in the ^{1}H NMR spectrum that correlates with a carbonyl carbon in the ^{1}H–^{13}C HMBC spectrum.

The reaction of anhydride **5** with 4-aminophthalonitrile and 5-(4-aminophenyl)-10,15,20-triphenylporphyrin (H_2N-TPP) afforded the expected imides **8** and **9** in 62% yield in both cases. The structures of the new compounds were confirmed by their mass and NMR spectra.

The reaction of anhydride **5** with benzene-1,4-diamine, benzene-1,3-diamine and benzene-1,2-diamine was also considered. When a large excess of benzene-1,4-diamine was used, imide **10** was obtained in quantitative yield (Scheme 2). However, using 0.5 equiv of benzene-1,4-diamine or benzene-1,3-diamine, the anticipated symmetric bisporphyrin derivatives **11** and **12** were obtained, albeit in low yields (Scheme 3). The formation of these bisporphyrins was confirmed by their mass spectra (m/z = 1652).

The analysis of the NMR spectra of the bisporphyrins **11** and **12** raised interesting conformational issues. As expected, the ^{1}H NMR spectrum of compound **12** is compatible with a symmetric structure, showing a singlet at δ 7.52 ppm assigned to the resonances of the four protons of the "phthalimide" groups and a singlet and two doublets at δ 8.69, 8.70, and 8.78 ppm, respectively, ascribed to the 12 β-pyrrolic protons. The ^{13}C NMR spectrum of the free base **12a** shows only one signal corresponding to the resonances of the four carbonyl carbons at 167.1 ppm.[23] Surprisingly, the ^{1}H NMR spectrum of compound **11** is more complex than anticipated for such a symmetrical structure, exhibiting three singlets at δ 7.41, 7.53, and 7.65 ppm (ascribed to the four protons of the "phthalimide" groups and the four protons of the *p*-phenylene group) and a multiplet at δ 8.68–8.79 ppm due to the 12 β-pyrrolic protons. Moreover, the ^{13}C NMR spectrum shows two peaks at 167.4 and 168.6 ppm attributed to the resonances of the carbonyl carbons. Initially, we considered the possibility of having a mixture of two compounds (in a *ca.* 1:1 ratio), but this was ruled out on the basis of the TLC (one spot) and the mass spectrum. The multiplicity of the NMR signals of compound **11** was then attributed to the presence of different conformational isomers, a hypothesis that was confirmed by molecular mechanics simulations (*vide infra*).

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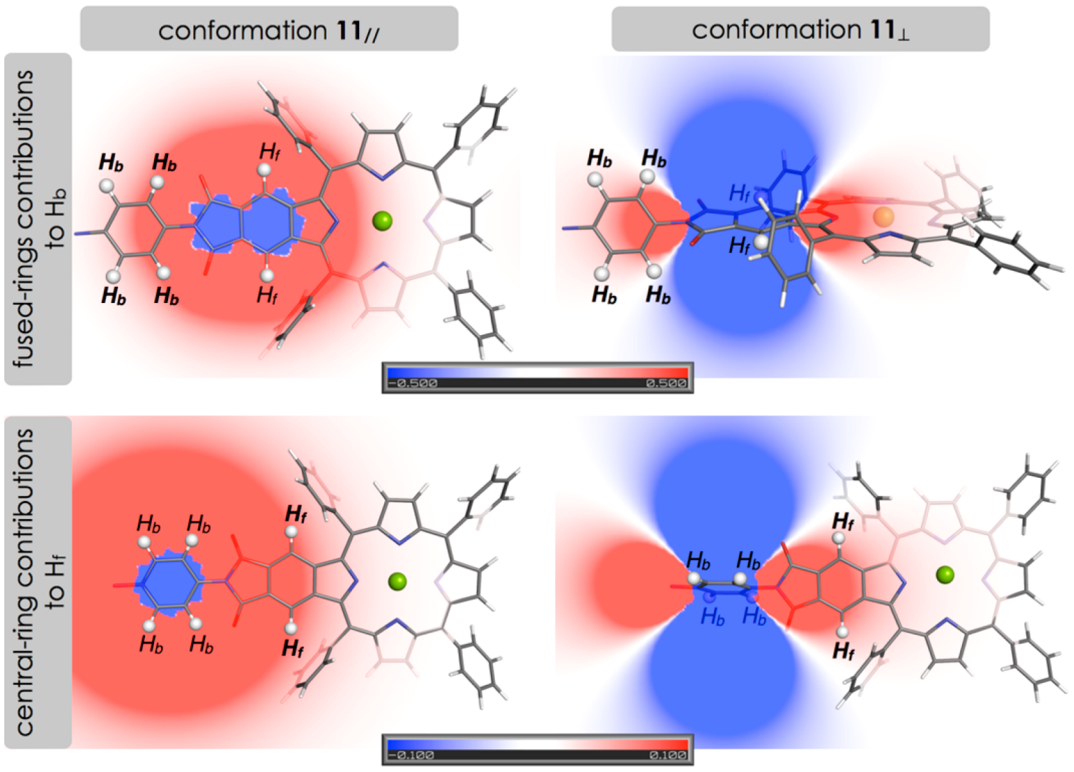

Figure 3. Maps of fused- and central-ring current contributions (top and bottom rows, respectively) to the H_b and H_f chemical shifts in conformations $\mathbf{11}_{\parallel}$ and $\mathbf{11}_{\perp}$ (left and right columns, respectively), according to the Haigh−Mallion model. Protons on blue areas experience chemical shielding, whereas those on red areas sustain chemical deshielding. The color code is different on both rows (−0.5 to 0.5 ppm in the upper row and −0.1 to 0.1 ppm in the lower) and the magnitude of the contributions is qualitative; a single porphyrinic fragment is shown, for the sake of clarity. Remaining details are given in Figure 1.

Another interesting modification of **5** involved its reaction with benzene-1,2-diamine and naphthalene-1,8-diamine in refluxing 1,2,4-TCB; porphyrins **13** and **14** were obtained in 36% and 30% yield, respectively (Scheme 4). The mass spectra of the resulting products (m/z = 863 and m/z = 913, respectively) confirm that, after the formation of the imide, an intramolecular condensation between the remaining amino group and the spatially close carbonyl group occurred. The NMR data are also in agreement with the proposed structures. The formation of this type of heterocyclic compounds from the reaction of phthalic anhydrides and benzene-1,2-diamines (or naphthalene-1,8-diamines) is known in the literature.[24,25]

The demetalation of phthalimides **6**−**10** and **12** and compounds **13** and **14** was carried out with H_2SO_4/CH_2Cl_2 (1:9) at room temperature. In almost all cases, the corresponding free bases were obtained in quantitative yield.

Molecular Mechanics/Dynamics Simulations. In order to elucidate the multiplicity of the NMR signals of bisporphyrin **11**, molecular mechanics simulations were performed. These studies revealed that compound **11** exhibits two preferential conformations, characterized by the arrangement of the fused-ring frames relative to the central benzenic ring: a coplanar arrangement (Figure 1; henceforth denoted $\mathbf{11}_{\parallel}$), where both fused-ring frames are almost coplanar to the central ring plane, and an almost perpendicular arrangement (Figure 2; $\mathbf{11}_{\perp}$), where the two frames make a *ca.* 70° interplanar angle with the central benzenic plane.

The interconversion $\mathbf{11}_{\parallel} \leftrightarrow \mathbf{11}_{\perp}$ occurs freely in the gas phase due to the absence of significant intramolecular stereochemical impediments. Interestingly, a different situation occurs in solution. All-atom molecular dynamics simulations of $\mathbf{11}_{\parallel}$ and $\mathbf{11}_{\perp}$ in chloroform showed that both conformations coexist in solution, with no significant $\mathbf{11}_{\parallel} \leftrightarrow \mathbf{11}_{\perp}$ interconversion being observed during the course of the several 100 ns long simulations (Figures S41 and S42 in the Supporting Information). Interactions of the chloroform molecules with the carbonyl oxygen atoms (via $Cl_3C-H\cdots O{=}C$ hydrogen bonding) are responsible for locking rotations about the $C_{benzene}$-N bond in $\mathbf{11}_{\perp}$, whereas intramolecular $C{=}O\cdots H-C_{benzene}$ hydrogen bonds forming a rather stable six-membered ring account for the stabilization of conformation $\mathbf{11}_{\parallel}$. Both mechanisms, along with the bulkiness of the porphyrinic fragments, lead to a very slow rotation of the different ring fragments about the $C_{benzene}$-N bonds. Therefore, we submit that both conformations coexist in solution with an interconversion rate that is slow on the NMR time scale. Accordingly, the relative disposition of the aromatic moieties in both conformations renders magnetically unequivalent the protons of the central benzylidene ring of the phthalimide units. Therefore, in order to qualitatively study the conformational dependence of the proton chemical shifts of **11**, the semiempirical Haigh−Mallion model[26] was employed. Despite its simplicity, this model accurately describes the contribution to the chemical shifts of induced ring currents in systems ranging from proteins to inclusion complexes. A recent work by Zonta et al.[27] has shown that the Haigh−Mallion model correlates very well with nucleus-independent chemical shifts (NICS), currently the method of choice for the assessment of ring current contributions to chemical shifts in organic molecules.

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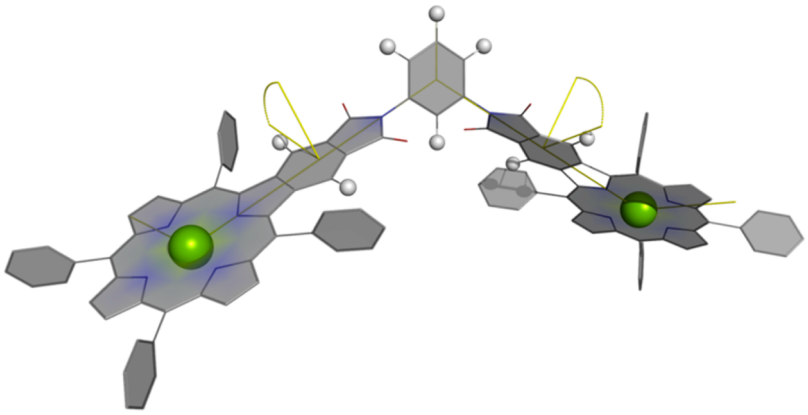

Figure 4. Predominant conformation of compound **12** in chloroform. Each of the fused-ring fragments form an interplanar angle of *ca.* 70° with the central benzenic ring. Coding as in Figure 1.

Conformation $\mathbf{11}_{\parallel}$ presents, on average, the protons of the central and benzo-fused groups (henceforth denoted H_b and H_f, respectively) on the molecular plane, outside the shielding cones originated by the neighbor aromatic units (Figure 3, left column), whereas conformation $\mathbf{11}_{\perp}$ has the H_b protons on a plane nearly perpendicular to both fused-ring frames (Figure 3, right column). Hence, the ring current effects due the fused ring systems contribute differently to the H_b protons chemical shifts, such that these are expected to be more deshielded in conformation $\mathbf{11}_{\parallel}$. In a similar way, the contributions to the central benzenic ring H_f chemical shifts are also expected to be different, being also more deshielded in conformation $\mathbf{11}_{\parallel}$. These results justify the break of symmetry patent in the experimental spectra.

A similar analysis was performed for compound **12**. Although a comparable discussion of the ring current contributions to the H_b and H_f chemical shifts was carried out, compound **12** was found to possess only one preferable conformation in chloroform, one in which the central benzenic ring forms, simultaneously, a *ca.* 70° interplanar angle with both porphyrinic fragments (Figure 4; see also Figures S49 and S50 in Supporting Information). Hence, both H_b and H_f protons experience, essentially, a single magnetic environment and, thus, exhibit no resonance splitting, in accord with the experimental spectra.

■ CONCLUSION

A synthetic route to *meso*-tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylic anhydride was reported. As shown in Scheme 2, this anhydride reacts with alkylamines and arylamines to afford the corresponding *N*-substituted "phthalimides" in moderate to excellent yields. The new "phthalimides" may be used in subsequent transformations: for instance, compounds **6** and **10** may be further functionalized at the amino group, the pyridyl group in **7** may be used for constructing supramolecular systems or cationization, and **8** may be a precursor of phthalocyanines bearing benzoporphyrin units.

Since the title compound reacts like phthalic anhydride, it is expected that it may be used to decorate any primary amine, or polyamines, with benzoporphyrin units.

■ EXPERIMENTAL SECTION

General Information. ^{1}H and ^{13}C NMR spectra were recorded in two NMR spectrometers operating at 500.13 and 125.77 MHz or at 300.13 and 75.47 MHz, respectively. $CDCl_3$ was used as solvent (except when indicated) and tetramethylsilane (TMS) as internal reference. The chemical shifts are expressed in δ (ppm) and the coupling constants in hertz. Unequivocal ^{1}H assignments were made using 2D COSY and NOESY experiments (mixing time of 800 ms), while ^{13}C assignments were made on the basis of 2D HSQC and HMBC experiments (delay for long-range *J* C/H couplings were optimized for 7 Hz). Mass spectra and HRMS were recorded using $CHCl_3$ as solvent (except when indicated) and 3-nitrobenzyl alcohol (NBA) as matrix. The UV−vis spectra were recorded using $CHCl_3$ as solvent. Column chromatography was carried in silica gel (230−400 mesh). Preparative thin-layer chromatography was carried out on 20 cm × 20 cm glass plates coated with silica gel (0.5 mm thick). Analytical TLC was carried out on precoated sheets with silica gel (0.2 mm thick). All solvents and reagents were used without further purification.

Tetramethyl 1-Methyl-7,12,17,22-tetraphenyl-3a,23b-dihydro-1*H*-pyrrolo[3,2-*a*]benzoporphyrin-2,3,3a,4-tetracarboxylate Nickel(II) Complex, 2. Dimethyl acetylenedicarboxylate (500 μL) was added to a solution of pyrroloporphyrin **1**[21] (500.0 mg, 0.690 mmol) in toluene (30 mL), and the reaction mixture was stirred at reflux for 1 h. During the reflux, a drastic change in color (from dark green to dark red) was observed, and at the end, the starting porphyrin was not detected by TLC. After cooling, the toluene was evaporated under reduced pressure, and the product was crystallized from dichloromethane/light petroleum. Compound **2** was obtained in quantitative yield (695.0 mg) as a dark red solid. ^{1}H NMR (300 MHz; $CDCl_3$) δ 1.98 (s, 3H), 3.64, 3.70, 3.76, 3.82 (4s, 12H), 5.39 (s, 1H), 7.21 (s, 1H), 7.63−7.79 (m, 14H), 7.95−7.98 (m, 6H), 8.46 (d, 1H, *J* = 5.1 Hz), 8.58 (d, 1H, *J* = 5.1 Hz), 8.64 (d, 1H, *J* = 5.1 Hz), 8.67 (d, 1H, *J* = 5.0 Hz), 8.69 (d, 1H, *J* = 5.0 Hz), 8.78 (d, 1H, *J* = 5.1 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 31.9, 50.8, 51.3, 51.7, 51.8, 69.1, 104.3, 118.5, 119.1, 119.2, 124.8, 127.0, 127.2, 127.8, 127.9, 128.1, 128.2, 128.8, 129.1, 129.2, 131.7, 132.1, 132.2, 132.5, 132.6, 132.7, 132.8, 132.9, 133.2, 133.3, 133.4, 133.6, 133.7, 133.8, 136.6, 137.7, 138.9, 139.1, 139.9, 139.96, 139.97, 143.2, 143.3, 143.4, 143.55, 143.63, 143.9, 154.1, 154.2, 163.4, 164.7, 166.2, 171.0; HRMS (ESI-FTICR) *m*/*z* $[M]^{+\bullet}$ calcd for $C_{59}H_{43}N_5NiO_8$ 1007.2460, found 1007.2458; UV−vis ($CHCl_3$) λ_{max} (log ε) 436 (5.18), 548 (4.08), 590 (4.05) nm.

Dimethyl 5,10,15,20-Tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylate (Nickel(II) Complex and Free Base), 3 and 3a. A solution of porphyrin **2** (40.0 mg, 39.7 μmol) in 1,2,4-trichlorobenzene (1,2,4-TCB) (5 mL) was heated at reflux for 48 h. After cooling, the reaction mixture was submitted to column chromatography (silica gel) using light petroleum and then dichloromethane as eluents; the first fraction was benzoporphyrin **3** (35.0 mg, 53% yield). The demetalation of compound **3** (10.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (1 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation of the solvent under reduced pressure,

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the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **3a** was obtained in quantitative yield (9.3 mg).

3: ^{1}H NMR (300 MHz; $CDCl_3$) δ 3.87 (s, 6H), 7.39 (s, 2H), 7.66−7.85 (m, 12H), 7.90−7.99 (m, 8H), 8.67−8.74 (m, 6H); HRMS (ESI-FTICR) m/z $[M]^{+\bullet}$ calcd for $C_{52}H_{36}N_4O_4$ 836.1928, found 836.1948; UV−vis ($CHCl_3$) λ_{max} (log ε) 432 (5.27), 545 (4.16), 578 (3.97) nm.

3a: ^{1}H NMR (300 MHz; $CDCl_3$) δ −2.67 (s, 2H), 3.90 (s, 6H), 7.39 (s, 2H), 7.75−7.93 (m, 12H), 8.17−8.23 (m, 8H), 8.71 (s, 2H), 8.87 (d, 2H, J = 5.0 Hz), 8.91 (d, 2H, J = 5.0 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 52.4, 118.0, 121.3, 125.9, 126.8, 127.86, 127.90, 128.1, 128.5, 129.0, 133.7, 134.1, 134.5, 141.7, 142.0, 143.1, 168.5; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{52}H_{35}N_4NiO_4^+$ 781.2809, found 781.2790; UV−vis ($CHCl_3$) λ_{max} (log ε) 430 (5.53), 521 (4.40), 554 (3.60) (shoulder), 655 (3.04) nm.

5,10,15,20-Tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylic Acid (Nickel(II) Complex and Free Base), 4 and 4a. A solution of KOH (550.0 mg) in methanol (7.5 mL) was added to a solution of diester **3** (35.0 mg, 41.9 μmol) in THF (2 mL) and pyridine (150 μL). The reaction mixture was stirred at reflux for 48 h. After this time, no starting material was detected by TLC. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid and extracted with CH_2Cl_2. After evaporation under reduced pressure, the product was submitted to column chromatography (silica gel) using CH_2Cl_2 and then CH_2Cl_2/MeOH (9.5:0.5) as the eluents. The major fraction was "phthalic" acid **4** (30.5 mg, 90% yield). The demetalation of compound **4** (10.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (1 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **4a** was obtained in quantitative yield (9.3 mg).

4: ^{1}H NMR (300 MHz; DMSO-d_6) δ 7.39 (broad s, 2H), 7.74−7.86 (m, 12H), 7.93−7.99 (m, 8H), 8.70−8.75 (m, 6H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 116.0, 120.4, 127.6, 128.5, 129.2, 132.5, 132.6, 133.0, 133.4, 133.9, 136.7, 139.3, 139.5, 141.1, 141.2, 142.0, 143.7, 168.9; HRMS (ESI-FTICR) m/z $[M]^{+\bullet}$ calcd for $C_{50}H_{32}N_4O_4$ 808.1615, found 808.1623; UV−vis ($CHCl_3$) λ_{max} (log ε) 437 (5.13), 549 (4.04), 583 (3.88) nm.

4a: ^{1}H NMR (300 MHz; DMSO-d_6) δ −2.77 (s, 2H), 7.60 (broad s, 2H), 7.83−7.96 (m, 12H), 8.20−8.24 (m, 8H), 8.65 (s, 2H), 8.84 (d, 2H, J = 5.1 Hz), 8.94 (d, 2H, J = 5.1 Hz); ^{13}C NMR (125 MHz, DMSO-d_6) δ 118.1, 121.3, 127.4, 128.4, 128.5, 129.3, 133.4, 134.4, 141.1, 141.4, 142.3, 169.0; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{50}H_{31}N_4NiO_4$ 753.2496, found 753.2486; UV−vis ($CHCl_3$) λ_{max} (log ε) 434 (5.26), 525 (4.36), 601 (3.91), 660 (3.20) nm.

5,10,15,20-Tetraphenylbenzoporphyrin-2^2,2^3-dicarboxylic Anhydride Nickel(II) Complex, 5. A solution of "phthalic" acid **4** (50.0 mg, 61.9 μmol) in acetic anhydride (15 mL) was stirred at reflux for 1 h. After this time, no starting material was detected by TLC. The acetic anhydride was evaporated under reduced pressure. (Note: small amounts of toluene (15 mL) were added to the reaction mixture during this process to facilitate the total evaporation of the acetic anhydride). Compound **5** was obtained quantitatively (48.8 mg) as a dark green solid after crystallization from CH_2Cl_2/MeOH. Alternatively, compound **5** can be prepared by refluxing a solution of "phthalic" acid **4** (30.0 mg) in 1,2,4-TCB (3 mL) for 1 h in the presence of powdered 4Å molecular sieves (30.0 mg). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.56 (s, 2H), 7.68−7.70 (m, 6H), 7.77−7.82 (m, 6H), 7.91−7.99 (m, 8H), 8.69−8.71 (m, 4H), 8.75−8.77 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 116.9, 120.5, 121.8, 125.8, 127.2, 128.1, 128.5, 129.3, 132.4, 132.60, 132.62, 133.2, 133.5, 135.6, 139.7, 139.8, 142.1, 142.7, 143.5, 144.2, 163.4; HRMS (ESI-FTICR) m/z $[M]^{+\bullet}$ calcd for $C_{50}H_{28}N_4NiO_3$ 790.1509, found 790.1504; UV−vis ($CHCl_3$) λ_{max} (log ε) 436 (4.37), 451 (5.27), 556 (4.21), 596 (4.17) nm.

***N*-(4-Aminobenzyl)-5,10,15,20-tetraphenylbenzoporphyrin-2^2,2^3-dicarboximide (Nickel(II) Complex and Free Base), 6 and 6a.** Powdered 4Å molecular sieves (30.0 mg) were added to a solution of "phthalic" acid **4** (30.0 mg, 37.1 μmol) in 1,2,4-TCB (3 mL), and the mixture was stirred at reflux for 1 h. After cooling to rt, a solution of 4-aminobenzylamine (42.0 μL, 10 equiv) in dry pyridine (3 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 3 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute phthalimide **6**, which was obtained in quantitative yield (33.0 mg). The demetalation of compound **6** (10.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (1 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **6a** was obtained in quantitative yield (9.3 mg).

6: ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.70 (s, 2H), 6.65 (d, 2H, J = 8.5 Hz), 7.29 (d, 2H, J = 8.5 Hz), 7.40 (s, 2H), 7.63−7.78 (m, 10H), 7.84−7.98 (m, 10H), 8.66−8.68 (m, 4H), 8.73 (d, 2H, J = 5.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 41.3, 115.5, 116.6, 119.5, 120.2, 127.1, 127.8, 128.0, 128.3, 129.1, 130.3, 132.1, 132.2, 132.6, 132.9, 133.5, 136.5, 139.98, 140.02, 141.7, 142.3, 143.3, 143.5, 168.2; MS (MALDI-FTICR) m/z $[M + H]^+$ calcd for $C_{57}H_{37}N_6NiO_2$ 895.2326, found 895.2313; UV−vis ($CHCl_3$) λ_{max} (log ε) 445 (5.41), 552 (4.29), 587 (4.20) nm.

6a: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.67 (s, 2H), 4.72 (s, 2H), 6.61 (d, 2H, J = 9.0 Hz), 7.26−7.29 (m, 2H, overlapped with the $CHCl_3$ signal), 7.39 (s, 2H), 7.74−7.80 (m, 6H), 7.84−7.89 (m, 4H), 7.97−8.02 (m, 2H), 8.18−8.23 (m, 8H), 8.71 (s, 2H), 8.88 and 8.91 (AB system, 4H, J = 5.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): 41.3, 115.0, 118.5, 119.9, 121.2, 126.9, 127.9, 128.0, 128.1, 128.5, 129.0, 129,1, 130.2, 133.7, 134.5, 138.6, 139.2, 141.6, 141.9, 145.5, 145.9, 168.4; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{57}H_{39}N_6O_2$ 839.3129, found 839.3125; UV−vis ($CHCl_3$) λ_{max} (log ε) 441 (5.22), 526 (4.13), 562 (3.63), 604 (3.68), 662 (3.12) nm.

5,10,15,20-Tetraphenyl-*N*-(pyridin-4-ylmethyl)-benzoporphyrin-2^2,2^3-dicarboximide (Nickel(II) Complex and Free Base), 7 and 7a. Powdered 4Å molecular sieves (7.0 mg) were added to a solution of "phthalic" acid **4** (6.5 mg, 8.4 μmol) in 1,2,4-TCB (0.7 mL), and the mixture was stirred at reflux for 1 h. After cooling to rt, a solution of pyridin-4-ylmethylamine (100.0 μL) in dry pyridine (0.7 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 3 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute phthalimide **7**, which was obtained in 33% yield (2.4 mg). The demetalation of compound **7** (4.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (0.4 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **7a** was obtained in quantitative yield (3.4 mg).

7: ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.80 (s, 2H), 7.32−7.42 (broad m, 2H), 7.45−7.61 (m, 2H), 7.64−7.81 (m, 12H), 7.86−7.99 (m, 10H), 8.68−8.70 (m, 4H), 8.76 (d, 2H, J = 5.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 39.9, 116.7, 119.9, 120.3, 127.1, 127.2, 128.0, 128.4, 129.1, 132.2, 132.4, 132.7, 133.0, 133.5, 136.3, 139.9, 140.0, 141.90, 142.5, 143.4, 143.5, 167.9; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{56}H_{35}N_6NiO_2$ 881.2169, found 881.2153.

7a ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.66 (s, 2H), 4.83 (s, 2H), 7.32 (dd, 2H, J = 4.6 and 1.6 Hz), 7.44 (s, 2H), 7.73−7.81, 7.85−7.91, 7.97−8.03, 8.19−8.23 (4m, 20H), 8.54 (dd, 2H, J = 4.6 and 1.6 Hz), 8.72 (s, 2H), 8.90 and 8.92 (AB system, 4H, J = 5.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): 40.6, 118.6, 120.2, 121.3, 123.1, 126.9, 128.0, 128.1, 128.4, 128.6, 129.1, 133.7, 134.4, 134.5, 138.7, 139.1, 141.6, 141.8, 145.2, 145.7, 150.1, 168.1; MS (MALDI) m/z $[M + H]^+$ calcd for $C_{56}H_{37}N_6O_2$ 825.3, found 825.3; UV−vis ($CHCl_3$) λ_{max} (log ε) 446 (5.36), 530 (4.31), 566 (3.87), 607 (3.89), 666 (3.36) nm.

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***N*-(3,4-Dicyanophenyl)-5,10,15,20-tetraphenylbenzoporphyrin-2²,2³-dicarboximide (Nickel(II) Complex and Free Base), 8 and 8a.** Powdered 4Å molecular sieves (8.5 mg) were added to a solution of "phthalic" acid **4** (8.0 mg, 10.5 μmol) in 1,2,4-TCB (1 mL), and the mixture was stirred at reflux for 1 h. After cooling to rt, a solution of 4-aminophthalonitrile (25.0 mg, 174.7 μmol, ~17 equiv) in dry pyridine (1 mL) was added to the reaction mixture and it was stirred, at reflux (220 °C), for 24 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2 and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB and then CH_2Cl_2 was used to elute phthalimide **8**, which was obtained in 62% yield (6.0 mg). The demetalation of compound **8** (5.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (0.5 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4 and, after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **8a** was obtained in quantitative yield (4.6 mg).

8: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.53 (s, 2H), 7.66–7.72, 7.78–7.83, 7.87–7.99 (3m, 21H), 8.08 (dd, 1H, *J* = 8.6 and 2.1 Hz), 8.20 (d, 1H, *J* = 2.1 Hz), 8.71 (m, 4H), 8.78 (d, 2H, *J* = 5.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 113.9, 115.2, 115.5, 117.1, 117.3, 120.9, 121.1, 126.3, 127.6, 128.6, 128.9, 129.5, 129.6, 129.9, 132.8, 133.05, 133.13, 133.6, 134.0, 134.5, 136.4, 137.4, 140.2, 140.4, 142.6, 143.1, 143.9, 144.3, 145.2, 166.5; HRMS (ESI-FTICR) *m*/*z* $[M]^{+\bullet}$ calcd for $C_{58}H_{31}N_7NiO_2$ 915.1887, found 915.1878; UV–vis ($CHCl_3$) λ_{max} (log ε) 452 (5.17), 555 (4.27), 596 (4.27) nm.

8a: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.64 (s, 2H), 7.50 (s, 2H), 7.76–7.83 (m, 6H), 7.85 (d, 1H, *J* = 8.5 Hz), 7.88–7.93 (m, 4H), 8.01–8.04 (m, 2H), 8.07 (dd, 1H, *J* = 8.5 and 2.1 Hz), 8.20–8.25 (m, 9H), 8.74 (s, 2H), 8.93 and 8.96 (AB system, 4H, *J* = 5.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 113.3, 114.8, 115.1, 116.6, 118.7, 121.0, 121.5, 126.9, 126.9, 127.0, 127.9, 128.0, 128.1, 128.2, 128.8, 128.9, 129.2, 129.4, 133.7, 134.0, 134.5, 137.0, 138.9, 139.1, 141.4, 141.7, 146.2, 147.6, 155.7, 166.3; HRMS (ESI-FTICR) *m*/*z* $[M + H]^+$ calcd for $C_{58}H_{33}N_7O_2$ 860.2769, found 860.2764; UV–vis ($CHCl_3$) λ_{max} (log ε) 449 (5.17), 529 (4.28), 567 (3.92), 608 (3.88), 665 (3.37) nm.

***N*-[4-(10,15,20-Triphenylporphyrin-5-yl)phenyl]-5,10,15,20-tetraphenylbenzoporphyrin-2²,2³-dicarboximide (Nickel(II) Complex and Free Base), 9 and 9a.** Powdered 4Å molecular sieves (9.0 mg) were added to a solution of "phthalic" acid **4** (8.9 mg, 11.0 μmol) in 1,2,4-TCB (1 mL) and the mixture was stirred at reflux for 1 h. After cooling to rt, a solution of H_2N-TPP[28] (7.0 mg, 1 equiv) in dry pyridine (1 mL) was added to the reaction, and the mixture was stirred at reflux (220 °C) for 72 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute dyad **9**, which was obtained in 62% yield (9.6 mg). The demetalation of compound **9** (3.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (0.3 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **9** was obtained in quantitative yield (2.8 mg).

9: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.78 (s, 2H), 7.60 (s, 2H), 7.67–7.79 (m, 16H), 7.83–7.95 (m, 8H), 7.99–8.03 (m, 8H), 8.21–8.25 (m, 6H), 8.34 (d, 2H, *J* = 8.3 Hz), 8.72–8.74 (m, 4H), 8.83 (d, 2H, *J* = 5.0 Hz), 8.86–8.93 (m, 8H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 116.8, 119.0, 120.2, 120.3, 120.36, 124.42, 126.7, 127.1, 127.2, 127.7, 128.0, 128.5, 129.2, 131.8, 132.2, 132.4, 132.8, 133.0, 133.6, 134.6, 134.9, 136.4, 140.0, 140.1, 141.6, 141.9, 142.1, 142.5, 143.6, 143.7, 167.6; HRMS (ESI-FTICR) *m*/*z* $[M + H]^+$ calcd for $C_{94}H_{58}N_9NiO_2$ 1402.4067, found 1402.4084; UV–vis ($CHCl_3$) λ_{max} (log ε) 417 (5.59), 446 (5.38), 513 (4.46), 550 (4.53), 589 (4.46), 645 (3.96) nm.

9a: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.76 (s, 2H), −2.59 (s, 2H), 7.60 (s, 2H), 7.76–7.82, 7.90–7.98, 8.04–8.09, 8.23–8.37 (4m, 40H), 8.75 (s, 2H), 8.86–8.99 (m, 12H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 118.7, 119.0, 120.2, 120.6, 121.36, 124.44, 126.7, 126.9, 127.7, 128.0, 128.2, 128.4, 128.7, 129.2, 131.9, 133.8, 134.4, 134.6, 134.9, 138.8, 139.2, 141.6, 141.9, 142.2, 146.0, 148.3, 155.5, 167.9; HRMS (ESI-FTICR) *m*/*z* $[M + H]^+$ calcd for $C_{94}H_{59}N_9O_2$ 1346.4870, found 1346.4865; UV–vis ($CHCl_3$) λ_{max} (log ε) 417 (5.43), 443 (5.38), 523 (4.38), 555 (3.97), 602 (3.90), 644 (3.53), 657 (3.30) nm.

***N*-(4-Aminophenyl)-5,10,15,20-tetraphenylbenzoporphyrin-2²,2³-dicarboximide (Nickel(II) Complex and Free Base), 10 and 10a.** Powdered 4Å molecular sieves (10.0 mg) were added to a solution of "phthalic" acid **4** (10.0 mg, 12.4 μmol) in 1,2,4-TCB (1.2 mL), and the mixture was stirred at reflux for 1 h. A solution of benzene-1,4-diamine (50.0 mg) in dry pyridine (1.2 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 16 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute phthalimide **10**, which was obtained in quantitative yield (10.7 mg). The demetalation of compound **10** (10.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (1 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **10a** was obtained in quantitative yield (9.2 mg).

10: ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.75 (d, 2H, *J* = 8.6 Hz), 7.19 (d, 2H, *J* = 8.6 Hz), 7.47 (s, 2H), 7.66–8.00 (m, 20H), 8.69 (s, 2H), 8.70 (d, 2H, *J* = 4.9 Hz), 8.77 (d, 2H, *J* = 4.9 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 115.1, 116.6, 119.8, 120.3, 122.6, 127.1, 127.4, 127.6, 128.0, 128.4, 129.1, 132.1, 132.3, 132.7, 132.9, 133.5, 136.5, 139.96, 140.02, 141.7, 142.4, 143.5, 143.6, 146.1, 167.8; HRMS (ESI-FTICR) *m*/*z* $[M + H]^+$ calcd for $C_{56}H_{35}N_6NiO_2$ 881.2169, found 881.2158; UV–vis ($CHCl_3$) λ_{max} (log ε) 446 (5.20), 552 (4.16), 590 (4.09) nm.

10a: ^{1}H NMR (300 MHz; $CDCl_3$) δ −2.63 (s, 2H), 6.75 (d, 2H, *J* = 8.6 Hz), 7.20 (d, 2H, *J* = 8.6 Hz), 7.46 (s, 2H), 7.76–7.80 (m, 6H), 7.84–7.89 (m, 4H), 7.95–8.00 (m, 2H), 8.20–8.24 (m, 8H), 8.72 (s, 2H), 8.91 (AB system, 4H, *J* = 5.2 Hz); HRMS (ESI-FTICR) *m*/*z* $[M + H]^+$ calcd for $C_{56}H_{37}N_6O_2$ 825.2973, found 825.2967; UV–vis ($CHCl_3$) λ_{max} (log ε) 443 (5.18), 527 (4.07), 563 (3.60), 604 (3.63), 663 (3.07) nm.

Bisporphyrin 11. Powdered 4Å molecular sieves (9.0 mg) were added to a solution of "phthalic" acid **4** (7.9 mg, 9.8 μmol) in 1,2,4-TCB (1 mL), and the mixture was stirred at reflux for 1 h. A solution of benzene-1,4-diamine (0.53 mg, 4.9 μmol, 0.5 equiv) in dry pyridine (1 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 16 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute phthalimide **11** (2.0 mg, 12% yield). ^{1}H NMR (300 MHz; $CDCl_3$) δ 7.41 (s, 2H), 7.53 (s, 3H), 7.65 (s, 3H), 7.67–7.72 (m, 12H), 7.76–7.87 (m, 8H), 7.95–8.01 (m, 20H), 8.68–8.79 (m, 12H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 116.6, 116.7, 119.4, 120.1, 120.3, 126.3, 127.1, 127.8, 128.0, 128.3, 128.4, 129.1, 129.2, 132.1, 132.2, 132.26, 132.33, 132.7, 132.9, 133.0, 133.5, 136.4, 136.5, 140.0, 141.7, 141.8, 142.38, 142.44, 143.3, 143.6, 143.7, 167.4, 168.6; HRMS (ESI-FTICR) *m*/*z* $[M]^{+\bullet}$ calcd for $C_{106}H_{60}N_{10}Ni_2O_4$ 1652.3501, found 1652.3483; UV–vis ($CHCl_3$) λ_{max} (log ε) 387 (4.58), 450 (5.53), 554 (4.49), 592 (4.46) nm.

Bisporphyrins 12 and 12a. Powdered 4Å molecular sieves (9.5 mg) were added to a solution of "phthalic" acid **4** (10.5 mg, 13.0 μmol) in 1,2,4-TCB (1 mL), and the mixture was stirred at reflux for 1 h. A solution of benzene-1,3-diamine (0.70 mg, 6.5 μmol, 0.5 equiv) in dry pyridine (1 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 16 h. After cooling, the reaction mixture

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was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute dimer **12** (4.0 mg, 19% yield). The demetalation of compound **12** (8.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (1 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **12a** was obtained in quantitative yield (7.3 mg).

12: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.52 (s, 4H), 7.55−7.59 (m, 3H), 7.65−7.71, 7.76−7.83, 7.86−7.91, 7.95−8.01 (4m, 41H), 8.69 (s, 4H), 8.70 (d, 4H, J = 4.9 Hz), 8.78 (d, 4H, J = 4.9 Hz); MS (MALDI-FTICR) m/z $[M + H]^+$ calcd for $C_{106}H_{61}N_{10}Ni_2O_4$ 1653.3579, found 1653.3560; UV−vis ($CHCl_3$) λ_{max} (log ε) 448 (5.03), 560 (4.17), 597 (4.18) nm.

12a: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.61 (s, 4H), 7.52 (s, 4H), 7.58−7.62 (m, 3H); 7.75−7.82, 7.89−7.93, 7.98−8.04, 8.23−8.27 (4m, 41H); 8.74 (s, 4H), 8.94 (s, 8H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 118.7, 120.5, 121.3, 123.4, 124.9, 126.9, 127.9, 128.1, 128.1, 128.2, 128.6, 129.2, 132.6, 133.7, 134.3, 134.6, 138.7, 139.2, 141.6, 141.8, 145.9, 148.6, 155.6, 167.1; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{106}H_{65}N_{10}O_4$ 1541.5190, found 1541.5176; UV−vis ($CHCl_3$) λ_{max} (log ε) 446 (5.54), 527 (4.47), 564 (4.03), 605 (4.05), 662 (3.44) nm.

Compounds 13 and 13a. Powdered 4Å molecular sieves (18.0 mg) were added to a solution of "phthalic" acid **4** (17.6 mg, 13.0 μmol) in 1,2,4-TCB (1.8 mL), and the mixture was stirred at reflux for 1 h. A solution of benzene-1,2-diamine (2.4 mg, 1 equiv) in dry pyridine (1.5 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 16 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute porphyrin **13** (7.0 mg; 36% yield). The demetalation of compound **13** (5.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (0.5 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **13a** was obtained in 96% yield (4.5 mg).

13: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.26−7.33 (m, 2H, overlapped with $CHCl_3$ signal), 7.40 (s, 1H), 7.48 (s, 1H), 7.64−7.71 (m, 6H), 7.72−7.78 (m, 2H), 7.80−7.85 (m, 4H), 7.89−7.99 (m, 10H), 8.66−8.69 (m, 4H), 8.76 (d, 1H, J = 5.0 Hz), 8.71 (d, 1H, J = 5.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): 112.5, 116.3, 116.9, 118.1, 120.1, 120.3, 121.2, 122.3, 124.9, 126.0, 127.1, 127.5, 128.0, 128.4, 129.0, 129.2, 129.9, 131.0, 132.1, 132.3, 132.7, 132.8, 132.9, 133.5, 136.3, 136.8, 140.0, 140.1, 141.4, 141.8, 141.9, 142.4, 142.5, 143.7, 144.1, 149.6, 156.9, 161.2; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{56}H_{33}N_6NiO$ 863.2064, found 863.2052; UV−vis ($CHCl_3$) λ_{max} (log ε) 453 (4.99), 554 (4.07), 595 (4.11) nm.

13a: ^{1}H NMR (500 MHz, $CDCl_3$) δ −2.60 (s, 2H), 7.28−7.32 (m, 2H, overlapped with the $CHCl_3$ signal), 7.40 (s, 1H), 7.49 (s, 1H), 7.72−7.80 (m, 8H), 7.88−7.95 (m, 4H), 8.01−8.07 (m, 2H), 8.21−8.25 (m, 8H), 8.71 (s, 2H), 8.87−8.91 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$): 112.5, 118.3, 118.8, 121.1, 121.3, 121.3, 122.8, 124.8, 126.0, 126.9, 127.9, 128.1, 128.2, 128.6, 128.8, 129.1, 129.2, 130.0, 132.0, 133.79, 133.84, 134.2, 134.3, 134.6, 141.60, 141.64, 141.7, 141.8, 141.9, 149.6, 157.1, 161.5, 164.3; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{56}H_{35}N_6O$ 807.2867, found 807.2864; UV−vis ($CHCl_3$) λ_{max} (log ε) 455 (5.11), 529 (4.18), 566 (3.89), 606 (3.78), 662 (3.26) nm.

Compounds 14 and 14a. Powdered 4Å molecular sieves (18.0 mg) were added to a solution of "phthalic" acid **4** (17.5 mg; 21.7 μmol) in 1,2,4-TCB (1.8 mL), and the mixture was stirred at reflux for 1 h. A solution of naphthalene-1,8-diamine (1.6 mg, 1 equiv) in dry pyridine (1.8 mL) was added to the reaction mixture, which was stirred at reflux (220 °C) for 16 h. After cooling, the reaction mixture was neutralized with an aqueous solution of citric acid, extracted with CH_2Cl_2, and evaporated under reduced pressure. The product was submitted to column chromatography (silica gel); light petroleum was used to remove the 1,2,4-TCB, and then CH_2Cl_2 was used to elute porphyrin **14** (6.0 mg, 30%). The demetalation of compound **14** (5.0 mg) was carried out with H_2SO_4/CH_2Cl_2 (1:9) (0.5 mL). After stirring at room temperature for 5 min, the mixture was neutralized with aqueous sodium carbonate and extracted with dichloromethane. The organic phase was dried over Na_2SO_4, and after evaporation under reduced pressure, the residue was crystallized from CH_2Cl_2/MeOH. Porphyrin **14a** was obtained in 96% yield (4.5 mg).

14: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41−7.55 (m, 5H), 7.60 (s, 1H), 7.66−7.71 (m, 6H), 7.79 (s, 1H), 7.82−7.88 (m, 4H), 7.94−8.01 (m, 10H), 8.51 (d, 1H, J = 7.5 Hz), 8.68−8.70 (m, 4H), 8.75−8.78 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 109.4, 116.2, 116.4, 118.3, 119.9, 120.3, 120.4, 121.9, 122.8, 125.0, 126.4, 127.1, 127.7, 128.0, 128.5, 128.9, 129.1, 131.9, 132.1, 132.7, 132.8, 132.85, 132.92, 133.5, 134.1, 136.7, 139.7, 140.1, 140.2, 140.3, 142.2, 143.4, 143.67, 143.72, 149.1, 164.8; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{60}H_{35}N_6NiO$ 913.2220, found 913.2211; UV−vis ($CHCl_3$) λ_{max} (log ε) 447 (5.14), 555 (4.43), 596 (4.60) nm.

14a: ^{1}H NMR (300 MHz, $CDCl_3$) δ −2.81 (s, 2H), 6.98−7.06, 7.13−7.18, 7.23−7.28 (3m, 5H), 7.51 (s, 1H), 7.67 (s, 1H), 7.75−7.81 (m, 6H), 7.92−7.99 (m, 4H), 8.04−8.10 (m, 2H), 8.15 (d, 1H, J = 6.8 Hz), 8.22−8.28 (m, 8H), 8.70 (s, 2H), 8.88−8.91 (AB system, 4H, J = 5.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 108.8, 118.1, 118.2, 118.4, 118.7, 120.2, 121.2, 121.6, 122.1, 124.5, 125.3, 126.9, 127.0, 127.2, 127.4, 127.9, 128.1, 128.2, 128.9, 129.0, 129.3, 131.7, 133.5, 133.7, 133.8, 134.1, 134.6, 138.4, 139.3, 141.7, 142.1, 144.6, 145.2, 148.9, 164.7; HRMS (ESI-FTICR) m/z $[M + H]^+$ calcd for $C_{60}H_{36}N_6O$ 857.3029, found 857.3025; UV−vis ($CHCl_3$) λ_{max} (log ε) 442 (5.22), 528 (4.42), 573 (4.39), 604 (4.11), 663 (3.24) nm.

Molecular Modeling. Parameters for compounds **11** and **12** were taken from the GAFF force field[29] using Antechamber,[30] whereas chloroform was described with parameters taken from Fox et al.;[31] atomic RESP[32,33] fitted partial charges for **11** and **12** were obtained from HF/6-31G* level calculations using Gaussian 09.[34]

Simulation boxes (*ca.* 55 × 55 × 55 Å^3 after equilibration) were constructed from one molecule of solute (**11** or **12**) inside a cubic box containing 1270 chloroform molecules. Simulations began with an initial solvent minimization procedure for the removal of close contacts between solute and solvent molecules, with the solute placed under strong positional restrains. The restrains were then removed, and the whole system was allowed to relax. Subsequently, a weak positional restrain was applied to the solute, and the system was heated to 300 K in the NVT ensemble for 0.5 ns, using the "velocity rescaling with stochastic term" thermostat ($\tau_{coupling}$ = 2.0 ps), and equilibrated under the NPT ensemble during 1.5 ns using the Berendsen barostat ($\tau_{coupling}$ = 5.0 ps) until the density of the system was brought to a plateau. The positional restraints used throughout both heating and equilibration procedures were definitely removed during the data collection period (100 ns in the NPT ensemble for each system). The LINCS algorithm[35] was used to constrain all hydrogen involving bond distances at their equilibrium values; periodic boundary conditions, along with a 12 Å nonbonded cutoff were used; long-range electrostatic interactions were calculated with the particle mesh Ewald (PME) method.[36]

Calculations of ring current contributions to proton chemical (δ_H) shifts were performed according to the Haigh−Mallion[26] model (δ_H = $iBG(\mathbf{r})$, where i and B are constants characteristic of the ring and $G(\mathbf{r})$ is a structural factor describing the position of the probe proton relative to the ring), using i = 1.0 and B = 5.455 × 10^{-6} Å, with a homemade Python program.

The principal components analysis of the solute molecules, shown in Supporting Information, was performed (for each system) as follows: (i) the 50,000 generated conformations during the 100 ns collection runs were fitted to the first structure of the set, in order to remove degrees of freedom due to molecular rotation and translation; the fit was performed through minimization of the mean square root deviation (rmsd) between heavy atoms; (ii) the covariance matrix (in

Cartesian coordinates space) was calculated for the fitted set; (iii) the eigenvectors and associated eigenvalues were then obtained upon diagonalization of the covariance matrix. In the case of compound **11**, the first principal component (PC_1) accounts for 80% of its overall motion, whereas in compound **12** it accounts for 65%.

■ ASSOCIATED CONTENT

Supporting Information

^1H, ^{13}C, and 2D NMR spectra of compounds **2**−**14** and representations of molecular mechanics/dynamics simulations for compounds **11** and **12**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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