

Supplementary Information

Influence of non-covalent preorganization on supramolecular effective molarities

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Supplementary Information

Partially bound states analysis

The observed association constant for a complex that makes multiple intermolecular interactions is given by summing over all partially and fully bound states. The observed association constant K_{obs} is given by eqn (S1)

$$K_{obs} = fK_0 \tag{S1}$$

where f depends on the number and type of H-bonds that are made as well as the overall symmetry of the complex. There are four different classes of complexes, and the details of the equations used for f in each of these systems are provided below.

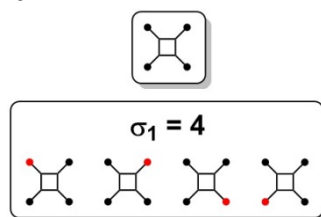
Complexes that make one H-bond

Fig. S.I Degenerate states for the complex that can make one intramolecular H-bond. Unbound phenol OH groups on the porphyrin are represented by black dots, phenol groups H-bonded to an ester group, amide group or a phosphine oxide group are represented by red dots. The panels are ordered zero and one H-bond from top to bottom and grouped by symmetry.

For complexes that can make only one intramolecular H-bond, the observed association constant for complex A (Fig. 2 of the main text) is given by eqn S.2, while the observed association constant for complex B, C, and D (Fig. 2), where no H-bonds are made, is given by eqn S.3. The value of K_1EM_1 , thus the value of EM_1 , can be determined from the relevant value of $\Delta\Delta G^0$ using eqn S.4 and eqn S.5.

$$f_A = 1 + \sigma_1 K_1 EM_1 \quad \text{S.2}$$

$$f_B = f_C = f_D = 1 \quad \text{S.3}$$

$$e^{-\frac{\Delta\Delta G^0}{RT}} = \frac{f_A f_D}{f_B f_C} = 1 + \sigma_1 K_1 EM_1 \quad \text{S.4}$$

$$K_1 EM_1 = \frac{e^{-\Delta\Delta G^0/RT} - 1}{\sigma_1} \quad \text{S.5}$$

Where K_1 is the intermolecular association constant for formation of the H-bonding interaction (K_{ref} in Table 7 of the main text), EM_1 is the effective molarity for the intramolecular interaction, and σ_1 is the statistical factor that accounts for the degeneracy of the fully bound state. In the complexes discussed here, the hydroxyporphyrins all have four identical H-bond donor sites, so $\sigma_1 = 4$ (Fig. S.I).

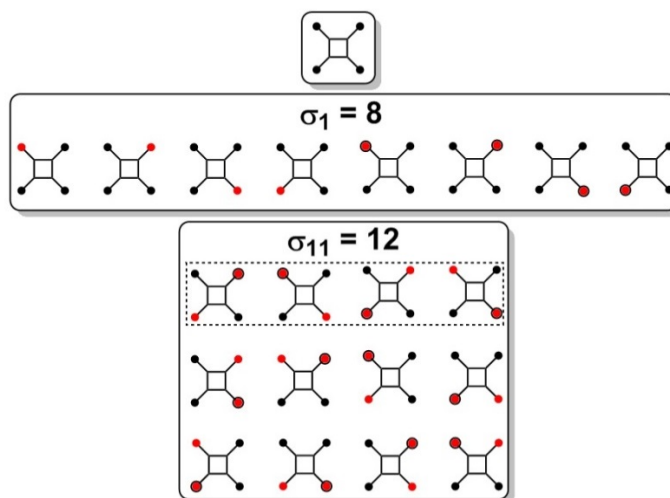
Complexes that make two identical H-bonds

Fig. S.2 Degenerate states for the complex that can make two identical intramolecular H-bonds. Unbound phenol OH groups on the porphyrin are represented by black dots, phenol groups H-bonded to ester groups, amide groups or phosphine oxide groups are represented by red dots. The panels are ordered zero, one and two H-bonds from top to bottom and grouped by symmetry. The *trans* arrangements are highlighted by the dotted box.

For complexes that can make two identical intramolecular H-bonds, the observed association constant for complex A (Fig. 2 of the main text) is given by eqn S.6, while the observed association constant for complex B (Fig. 2), where no H-bonds are made, is given by eqn S.7. The value of K_1EM_1 can be obtained from the relevant value of $\Delta\Delta G^0$ using eqn S.8 and eqn S.9. We assume that the values of K_1EM_1 for the first and the second H-bonds are constant. The fact that $\Delta\Delta G^0$ for the two armed ligands is always twice that for the one armed ligands supports this assumption.

$$f_A = 1 + \sigma_1 K_1 EM_1 + \sigma_{11} (K_1 EM_1)^2 \quad \text{S.6}$$

$$f_B = f_C = f_D = 1 \quad \text{S.7}$$

$$e^{-\frac{\Delta\Delta G^0}{RT}} = \frac{f_A f_D}{f_B f_C} = 1 + \sigma_1 K_1 EM_1 + \sigma_{11} (K_1 EM_1)^2 \quad \text{S.8}$$

$$K_1EM_1 = \frac{-\sigma_1 + \sqrt{\sigma_1^2 - 4\sigma_{11}(1 - e^{-\Delta\Delta G^0/RT})}}{2\sigma_{11}} \quad \text{S.9}$$

Where $\sigma_1 = 8$ and $\sigma_{11} = 12$ (four *trans* which are highlighted in Fig. S.2 and eight *cis* degenerate states).

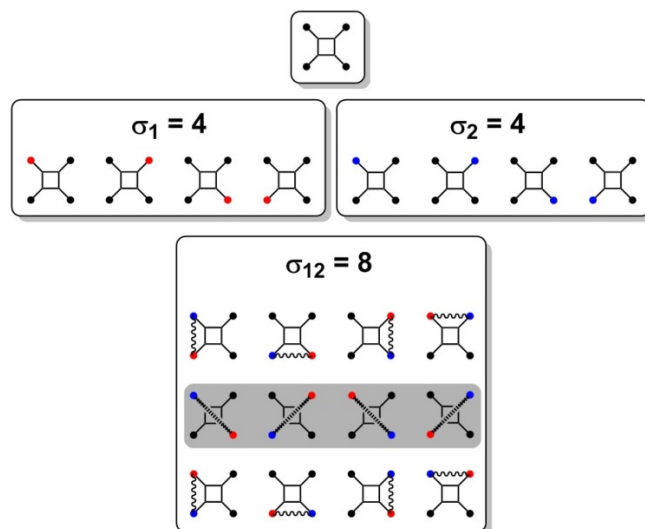
Complexes that make two different H-bonds

Fig. S.3 Degenerate states for the complex that can make two different intramolecular H-bonds. Unbound phenol OH groups on the porphyrin are represented by black dots, phenol groups H-bonded to the first ester groups are represented by red dots and phenol groups H-bonded to the second ester, amide or phosphine oxide groups are represented by blue dots. The covalent connectivity between two functional groups on the same side chain is represented by wiggly lines. The shaded complexes are structures that models suggest are geometrically impossible. The panels are ordered zero, one and two H-bonds from top to bottom and grouped by symmetry.

For complexes that can make two different intramolecular H-bonds, the observed association constant for complex A (Fig. 2 of the main text) is given by eqn S.10, While the observed association constant for complex B (Fig. 2) is given by eqn S.11. The value of K_2EM_2 can be obtained from eqn S.12 and eqn S.13. We assume that the effective molarity for formation of the first H-bond is not affected by the formation of the second H-bond. Thus, K_1EM_1 is assumed to be constant and can be determined from the appropriate DMC for the complex that makes only one H-bond, as described above (eqn S.2- eqn S.5).

$$f_A = 1 + \sigma_1 K_1 EM_1 + \sigma_2 K_2 EM_2 + \sigma_{12} K_1 EM_1 K_2 EM_2 \quad \text{S.10}$$

$$f_B = 1 + \sigma_1 K_1 EM_1 \quad \text{S.11}$$

$$f_C = f_D = 1 \quad \text{S.12}$$

$$e^{-\frac{\Delta\Delta G^0}{RT}} = \frac{f_A f_D}{f_B f_C} = \frac{1 + \sigma_1 K_1 E M_1 + \sigma_2 K_2 E M_2 + \sigma_{12} K_1 E M_1 K_2 E M_2}{1 + \sigma_1 K_1 E M_1} \quad \text{S.13}$$

$$K_2 E M_2 = \frac{(1 + \sigma_1 K_1 E M_1)(e^{-\frac{\Delta\Delta G^0}{RT}} - 1)}{\sigma_2 + \sigma_{12} K_1 E M_1} \quad \text{S.14}$$

where $\sigma_1 = \sigma_2 = 4$ and $\sigma_{12} = 8$ (we assume that the four *trans* states highlighted in Fig. S.3 are geometrically inaccessible and only the eight *cis* states are possible)

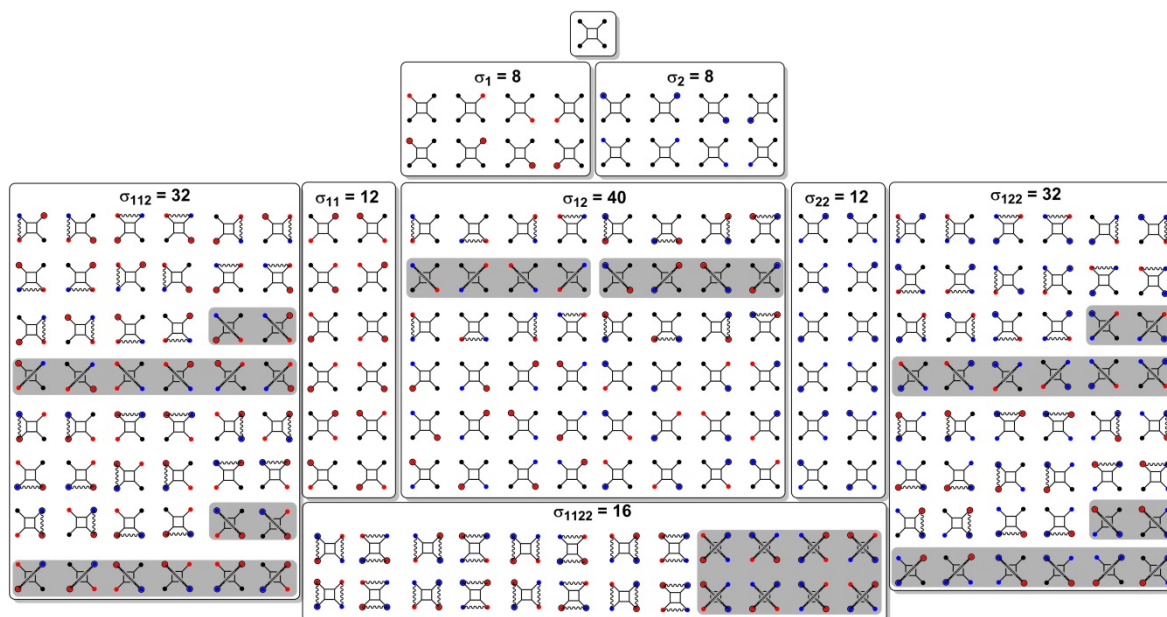
Complexes that make four H-bonds

Fig. S.4 Degenerate states for the complex that can make four intramolecular H-bonds. Unbound phenol OH groups on the porphyrin are represented by black dots, phenol groups H-bonded to first ester groups are represented by red dots and phenol groups H-bonded to second ester, amide or phosphine oxide groups are represented by blue dots. The covalent connectivity between functional groups on the same side chain are represented by wiggly lines. The shaded complexes are structures that models suggest are geometrically impossible. The panels are ordered zero, one, two, three and four H-bonds from top to bottom and grouped by symmetry.

For complexes that can make four intramolecular H-bonds, *i.e.* two ester-phenol and two amide-phenol H-bonds in the complex **P3a·L6e**, the observed association constant for complex A (Fig. 2 of the main text) is given by eqn S.15, while the observed association constant for complex B (Fig. 2) is given by eqn S.16. The value of K_2EM_2 can be obtained from eqn S.18 and eqn S.19. We assume that the values of K_1EM_1 for formation of the first and the second ester-phenol H-bonds are identical for the symmetric ligands and independent of formation of the third and fourth H-bond. Thus K_1EM_1 can be determined from the appropriate DMC for the complex that makes only two ester-phenol H-bonds as described above (eqn S.6-eqn S.9). Similarly, we assume that the values of K_2EM_2 for formation of the third and the fourth H-bond are identical. The fact that $\Delta\Delta G^\circ$ for the symmetrical two armed ligands are twice the values for the one armed ligands supports these assumptions.

$$f_A = 1 + \sigma_1 K_1 EM_1 + \sigma_2 K_2 EM_2 + \sigma_{11} (K_1 EM_1)^2 + \sigma_{22} (K_2 EM_2)^2 + \sigma_{12} K_1 EM_1 K_2 EM_2 + \sigma_{112} (K_1 EM_1)^2 K_2 EM_2 + \sigma_{122} (K_2 EM_2)^2 K_1 EM_1 + \sigma_{1122} (K_1 EM_1)^2 (K_2 EM_2)^2 \quad \text{S.15}$$

$$f_B = 1 + \sigma_1 K_1 EM_1 + \sigma_{11} (K_1 EM_1)^2 \quad \text{S.16}$$

$$f_C = f_D = 1 \quad \text{S.17}$$

$$e^{-\frac{\Delta\Delta G^0}{RT}} = \frac{\left\{ \begin{array}{l} 1 + \sigma_1 K_1 EM_1 + \sigma_2 K_2 EM_2 + \sigma_{11} (K_1 EM_1)^2 + \sigma_{22} (K_2 EM_2)^2 \\ + \sigma_{12} K_1 EM_1 K_2 EM_2 + \sigma_{112} (K_1 EM_1)^2 K_2 EM_2 \\ + \sigma_{122} (K_2 EM_2)^2 K_1 EM_1 + \sigma_{1122} (K_1 EM_1)^2 (K_2 EM_2)^2 \end{array} \right\}}{1 + \sigma_1 K_1 EM_1 + \sigma_{11} (K_1 EM_1)^2} \quad \text{S.18}$$

$$K_2 EM_2 = \frac{\left\{ \begin{array}{l} -[\sigma_2 + \sigma_{12} K_1 EM_1 + \sigma_{112} (K_1 EM_1)^2] \\ + \sqrt{\begin{array}{l} [\sigma_2 + \sigma_{12} K_1 EM_1 + \sigma_{112} (K_1 EM_1)^2]^2 \\ - 4[\sigma_{22} + \sigma_{122} K_1 EM_1 + \sigma_{1122} (K_1 EM_1)^2] \end{array}} \\ \left[1 + \sigma_1 K_1 EM_1 + \sigma_{11} (K_1 EM_1)^2 \right] \left(1 - e^{-\frac{\Delta\Delta G^0}{RT}} \right) \end{array} \right\}}{2[\sigma_{22} + \sigma_{122} K_1 EM_1 + \sigma_{1122} (K_1 EM_1)^2]} \quad \text{S.19}$$

where $\sigma_1 = \sigma_2 = 8$ and $\sigma_{11} = \sigma_{22} = 12$ (four *trans* and eight *cis* degenerate states), $\sigma_{12} = 40$, $\sigma_{112} = \sigma_{122} = 32$, and $\sigma_{1122} = 16$. (we assume that the *trans* states highlighted in Fig. S.4 are geometrically inaccessible).

The P4a•L12f Complex

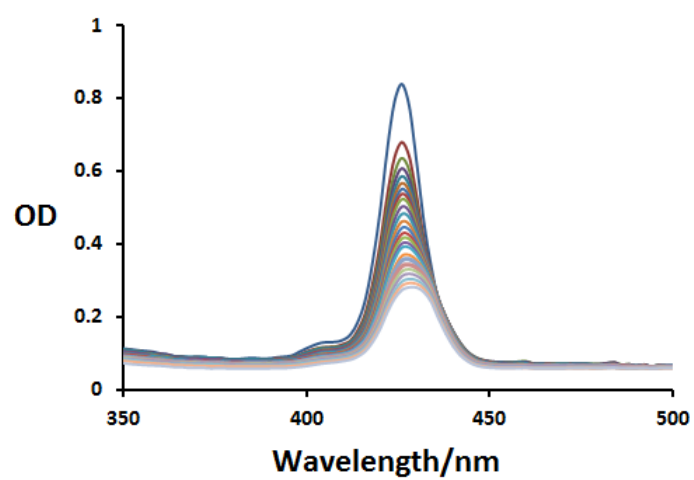


Fig. S.5 UV/Vis spectra of the titration of **L12f** into **P4a** (5 μ M) in toluene. The data could not be fit to a simple 1:1 binding isotherm.