Electronic Supplementary Information

Binding Affinity of Aniline-Substituted Dodecaborates to Cyclodextrins

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General Considerations

Unless otherwise stated, commercially available reagents were used without further purification. $B_{12}H_{11}I$ was prepared according to the literature procedure.[1] ^{11}B NMR, ^{1}H NMR, and mass spectra matched that reported in the literature.[1,2] 4-Nitroaniline (>99%), 2-nitroaniline, 3-nitroaniline, aniline, Davephos, $Pd_2(dba)_3$ (99%), anhydrous KtBuO (>98%), and DMSO (99.8%) were from Sigma-Aldrich and were used as received. Dichloromethane, acetonitrile, and silica gel (Grade 60, 230-400 Mesh) were from Carl Roth. Cyclodextrins (CD) were from cyclolab company. Celite (545 filter aid, not acid washed, powder) was from Fisher. Deuterated D_2O was from Deutero. Thin-layer chromatography (TLC) AluSil plates were from Macherey-Nagel. TLC samples for containing borane-containing compounds were stained with 1 wt. % $PdCl_2$ in 6 M HCl and were developed using a heat gun. pH values were measured with a Weilheim 3110 pH meter ^{1}H NMR and ^{11}B NMR spectra were recorded on a JEOL 400 MHz spectrometer at 25 °C. MestReNova V10.0.2-15465 S3 software was used to visualize the spectra.

Preparation of compounds

General procedure for Pd-catalysed cross-coupling amination

Following the literature procedure.[2] An oven-dried 10 mL round bottom flask was charged with 1.0 equiv. of $(Me_4N)_2\,B_{12}H_{11}I$ (for **1-m**) or $(Bu_4N)_2B_{12}H_{11}I$, $Pd_2(dba)_3$ (15 mol%), Davephos ligand (20 mol%), aniline, and *o-, m-* or *p-* nitro aniline (2.0 equiv.), and K*t*BuO (2.5 equiv.); subsequently 3.0 ml of anhydrous DMSO was added. The reaction flask was filled with N_2 and connected to a condenser. The round bottom flask was submitted to microwave irradiation at 150 °C, power 300 W, for 15 mins with vigorous stirring until the starting $B_{12}H_{11}I$ had been completely consumed as judged by ^{11}B-NMR and TLC. The mixture was cooled to room temperature and then filtered through a funnel filled with cotton, filter paper, and celite. The resulting solution was concentrated under reduced pressure. The resulting dried crude was dissolved in MeOH and then precipitated with 3.0 equiv. of CsF dissolved in MeOH. The $CsB_{12}H_{11}NH_2$-*p*- (**1-p**) or *o*-nitro anilino (**1-o**) derivatives were precipitated as red solid. **1-H** required further purification by using column chromatography, as described previously,[2] before it was precipitated as described above as white solid. The resulting solid was filtered and washed several times with methanol, dried under reduced pressure and used directly. The *m*-nitroanilino derivative (**1-m**) was used directly with Me_4N^+ as counter cation.

^{11}B, ^{1}H, and ^{13}C NMR for the compounds matched the literature values with the corresponding counter ion.[2]

NMR experiments

Nuclear Magnetic Resonance. NMR spectra were recorded on a JEOL JNM-ECX 400 spectrometer working at 400 MHz for 1D-1H NMR and 2D-ROESY NMR. All experiments were performed at ambient temperature in D_2O (99.8%) and referenced to the HOD residual proton signal at 4.67 ppm.

Titration procedures

UV-Visible titration

All measurements were performed at ambient temperature, in rectangular SUPRASIL® quartz glass cuvettes (Hellma Analytics) with 1-cm optical path length by recording the spectra at different CD concentrations. UV-Visible absorption measurements were performed with a Varian Cary 4000 spectrophotometer.

ITC titration

The ITC experiments were carried out on a VIP ITC from Microcal Inc. (Northampton, MA, United States) at 25 °C. The solutions were degassed and thermostated by a ThermoVac accessory for all experiments. The data was analyzed by Origin 7.0 software with the one set of sites model.

Plots of absorbance versus pH

The dodecaborate derivatives were dissolved in water at a given concentration. Solutions of HCl or NaOH with the same concentration of each of the derivatives were added to the solution, and the pH value and the UV-Visible spectrum was recorded.

Plots of absorbance versus CD concentration

The procedure was as for the pH titration, the dodecaborate derivatives were dissolved in water at a given concentration. Stock solutions of β- or γ-CD with the same concentration of each of the derivatives was added to the solution by adding different volume of CDs stock solution, and the UV-Visible spectrum was recorded.

2D-^{1}H-NMR plots

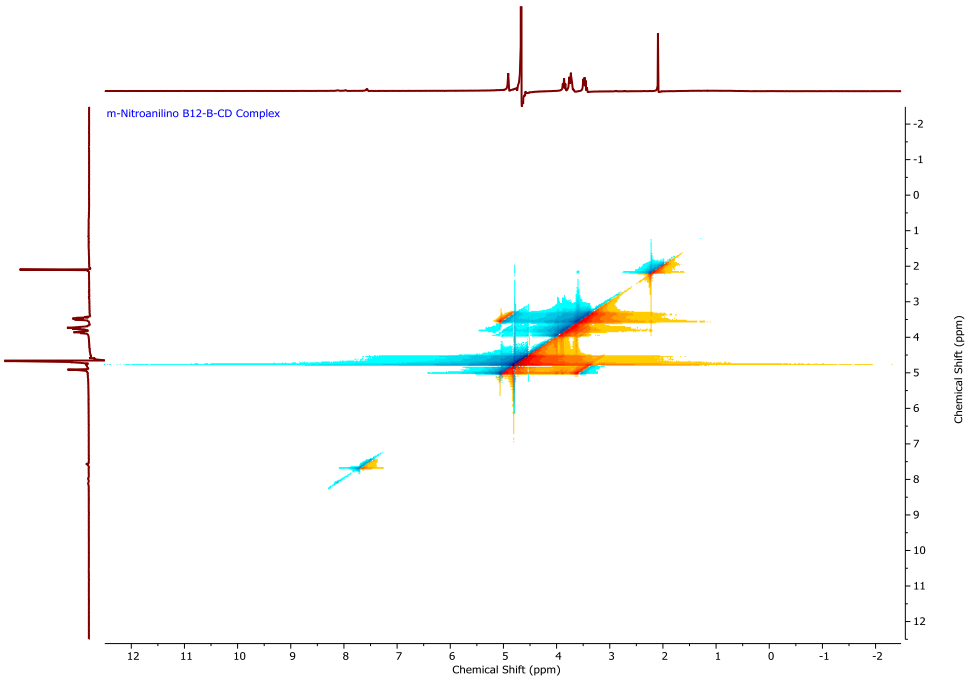

Figure S1 . 2D ROESY ^{1}H-NMR plot of **1-m** with β-CD; measured at ambient temperature in D_2O.

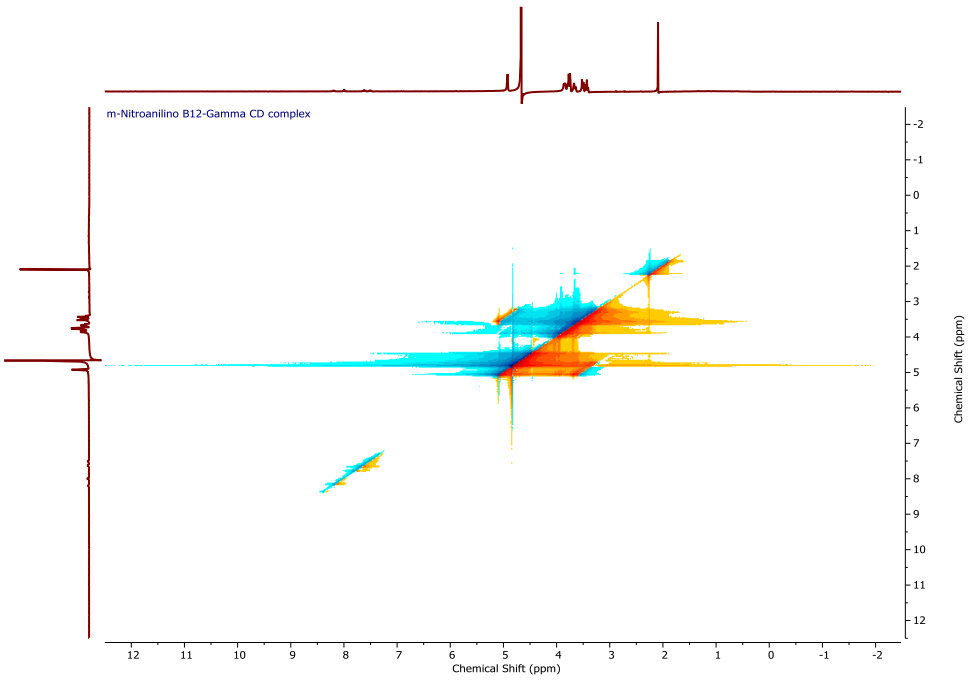

Figure S2. 2D ROESY ^{1}H-NMR plot of **1-m** with γ-CD; measured at ambient temperature in D_2O.

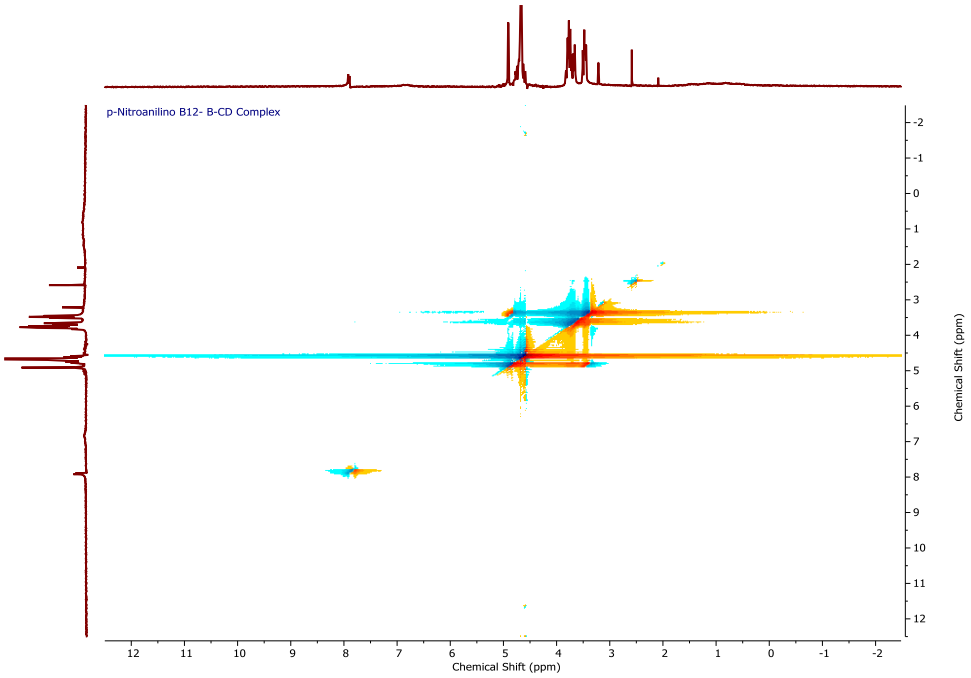

Figure S3. 2D ROESY ^{1}H-NMR plot of **1-p** with β-CD; measured at ambient temperature in D_2O.

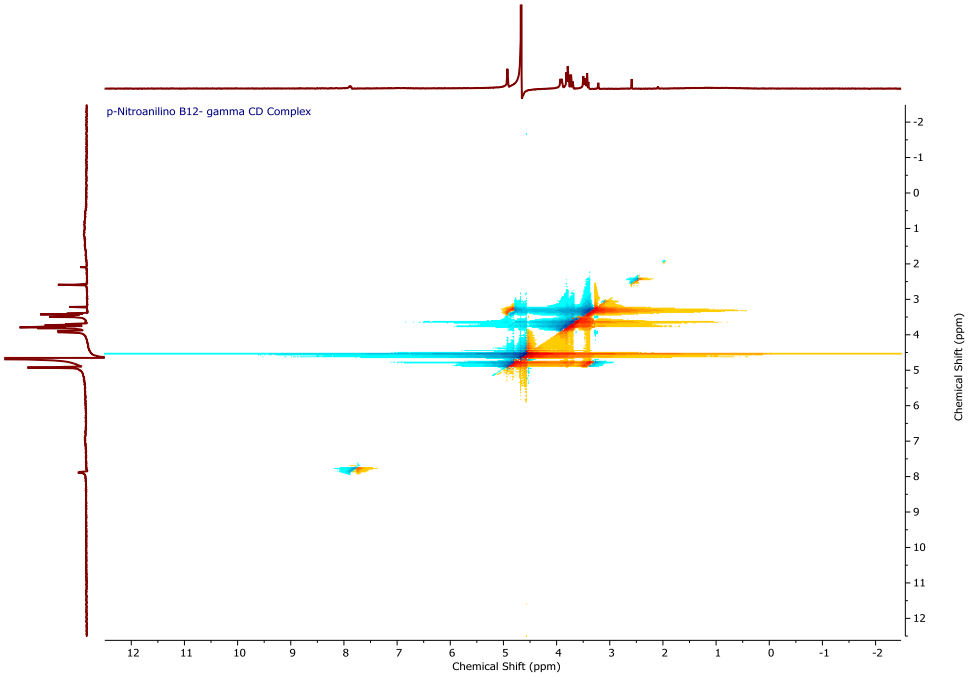

Figure S4. 2D ROESY ^{1}H-NMR plot of **1-p** with γ-CD; measured at ambient temperature in D_2O.

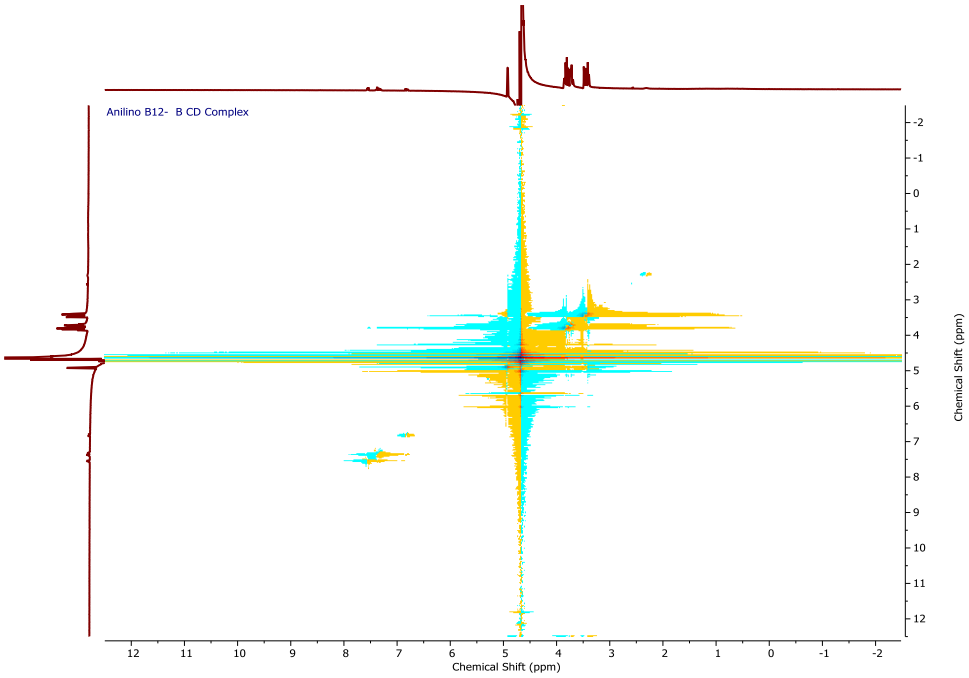

Figure S5. 2D ROESY ^{1}H-NMR plot of **1-H** with β-CD; measured at ambient temperature in D_2O.

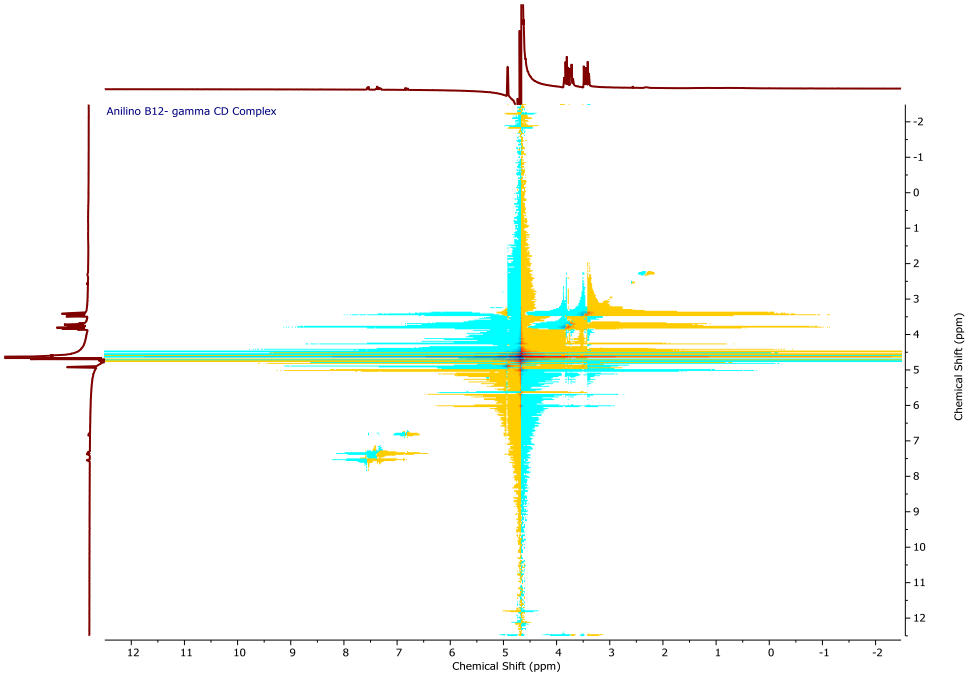

Figure S6. 2D ROESY ^{1}H-NMR plot of **1-H** with γ-CD; measured at ambient temperature in D_2O.

pH titration curves

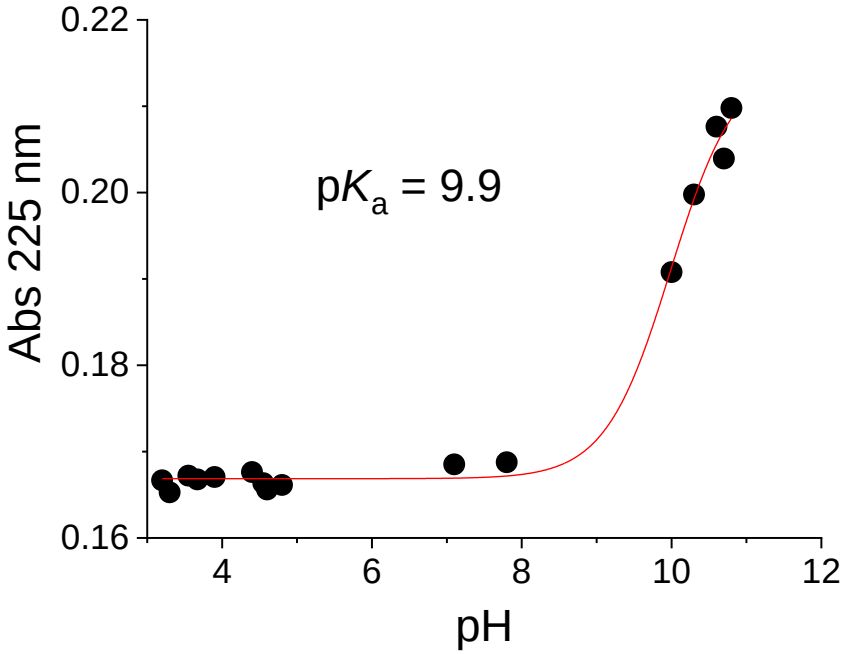

Figure S7.pH titration by monitoring the UV-Visible absorption of free **1-H**.

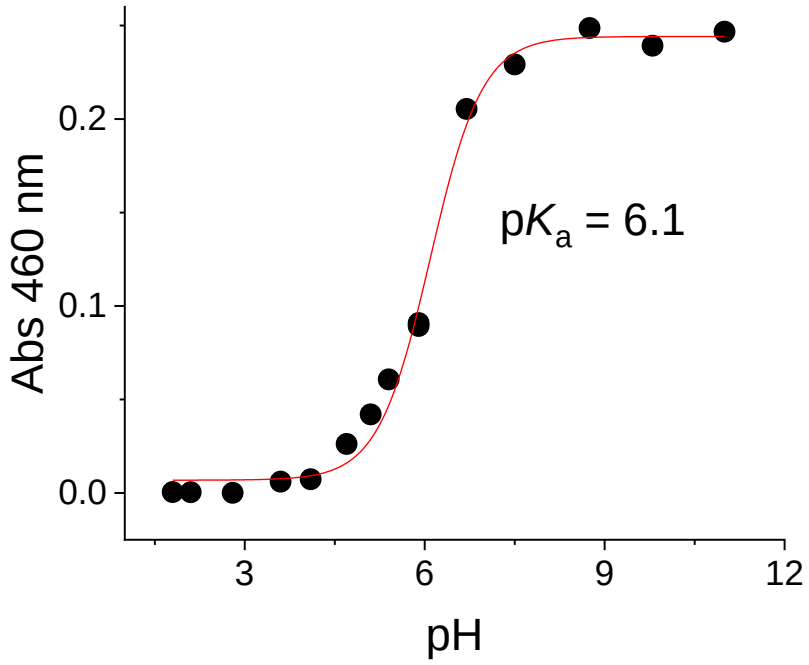

Figure S8. pH titration by monitoring the UV-Visible absorption of free **1-p**.

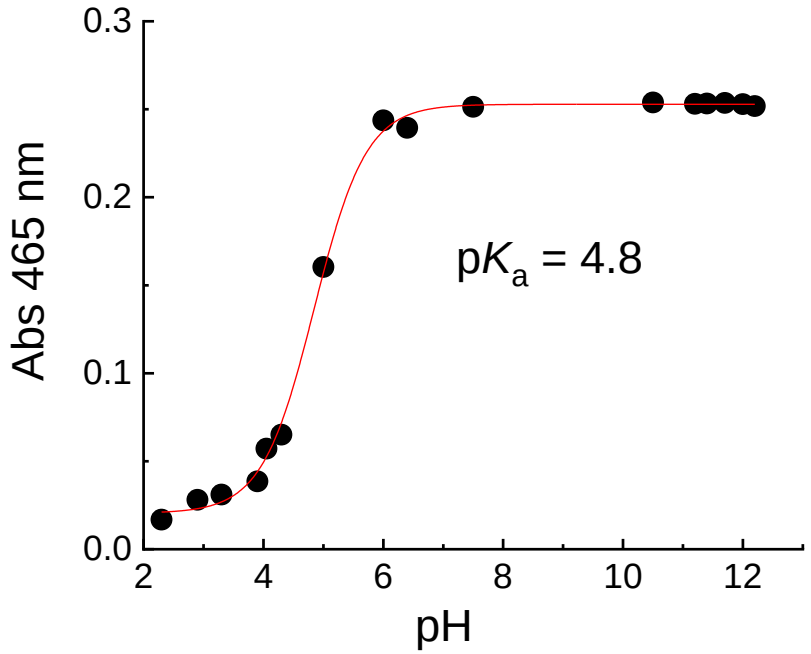

Figure S9. pH titration by monitoring the UV-Visible absorption of **1-p** (0.01 mM) in the presence of β-CD (4.0 mM).

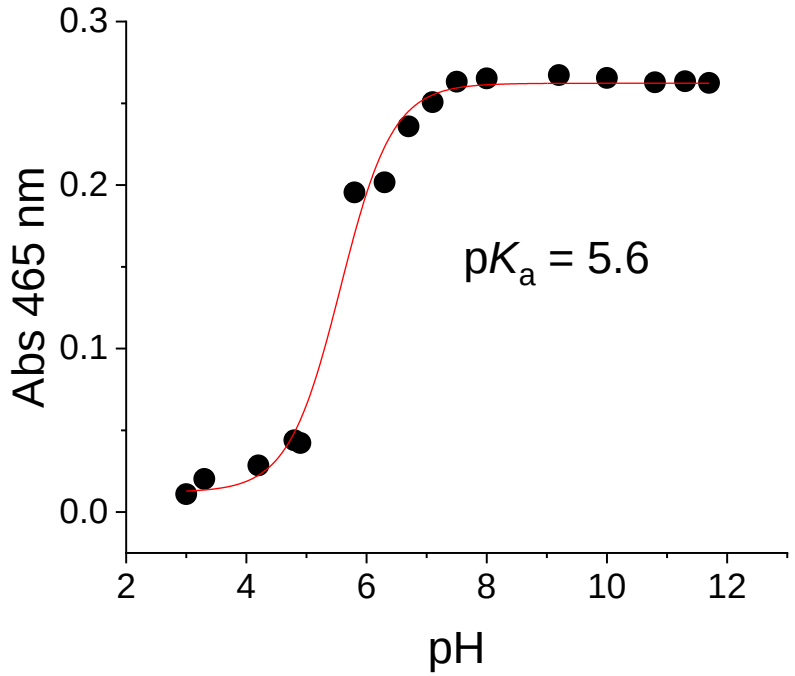

Figure S10. pH titration by monitoring the UV-Visible absorption of **1-p** (0.01 mM) in the presence of γ-CD (4.0 mM).

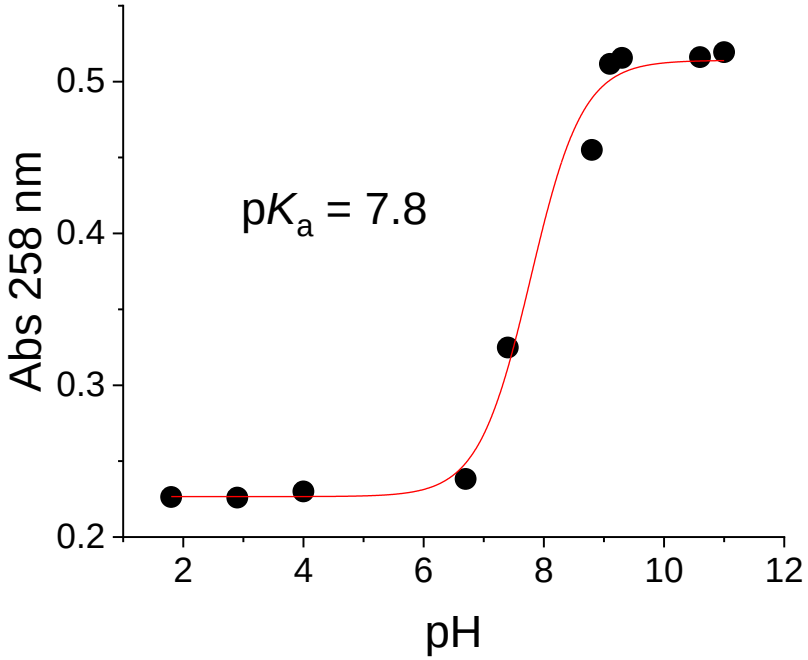

Figure S11. pH titration by monitoring the UV-Visible absorption of free **1-m**.

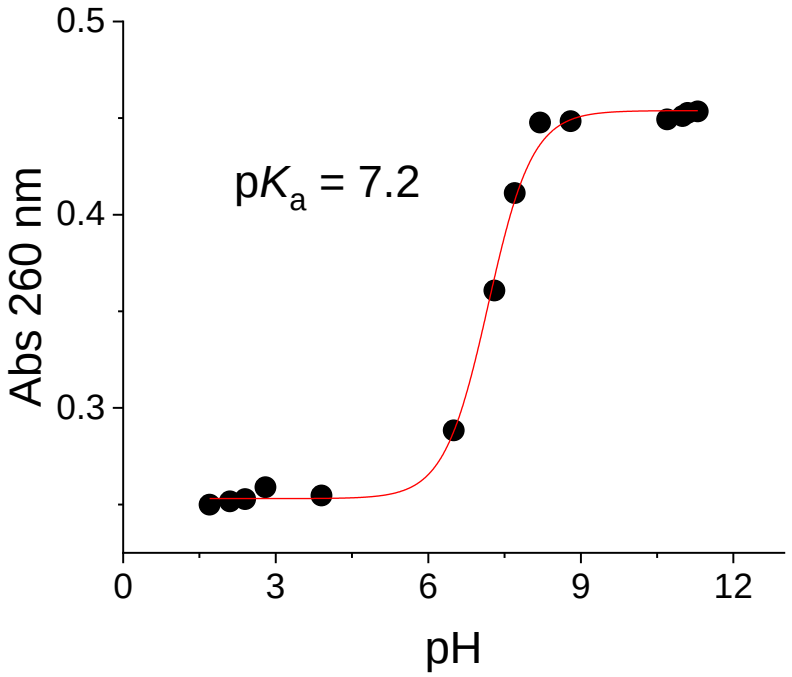

Figure S12. pH titration by monitoring the UV-Visible absorption of **1-m** (0.10 mM) in the presence of β-CD (4.0 mM).

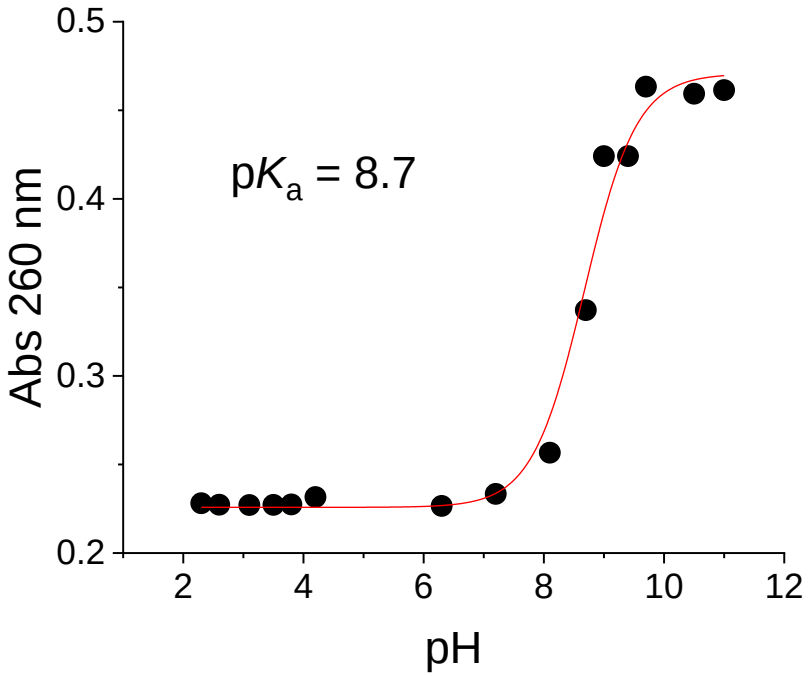

Figure S13. pH titration by monitoring the UV-Visible absorption of **1-m** (0.10 mM) in the presence of γ-CD (4.0 mM).

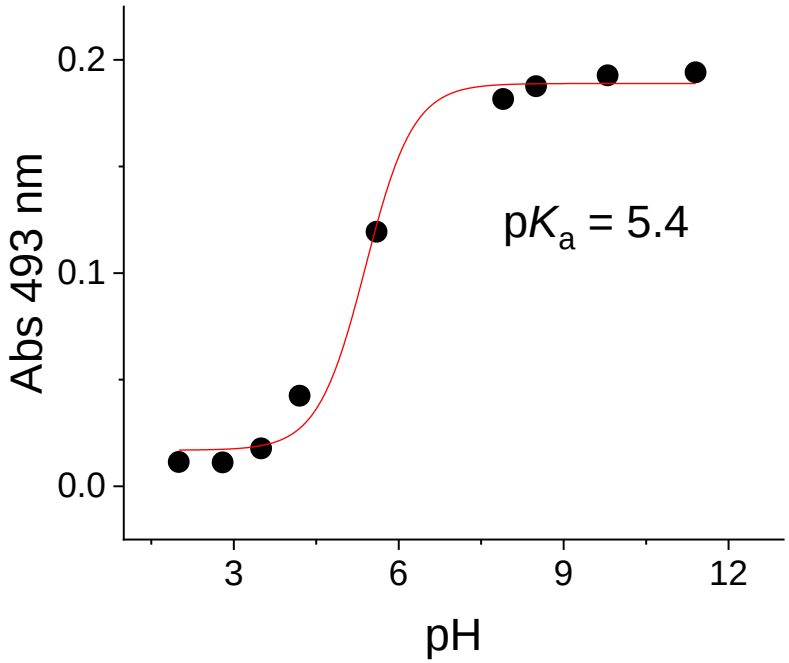

Figure S14. pH titration by monitoring the UV-Visible absorption of free **1-o**.

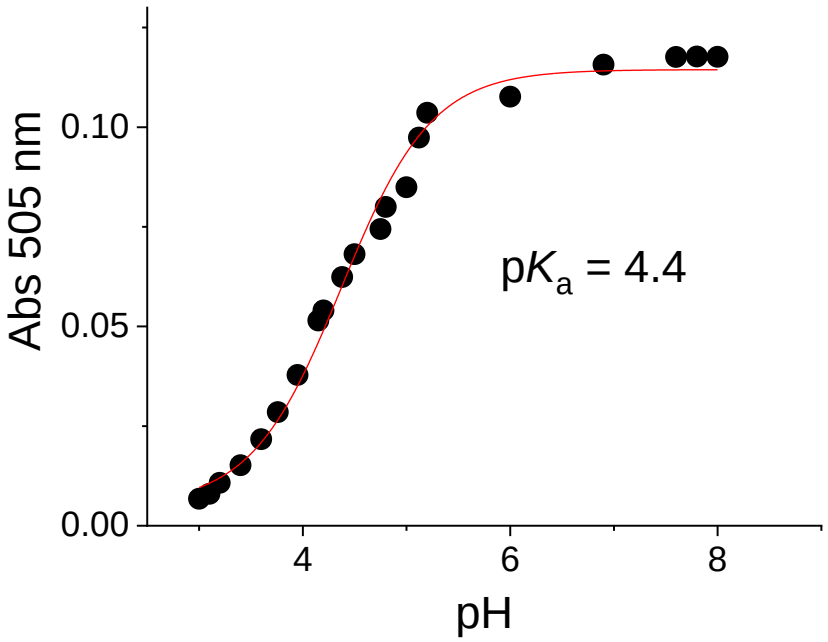

Figure S15. pH titration by monitoring the UV-Visible absorption of **1-o** (0.02 mM) in the presence of β-CD (1.5 mM).

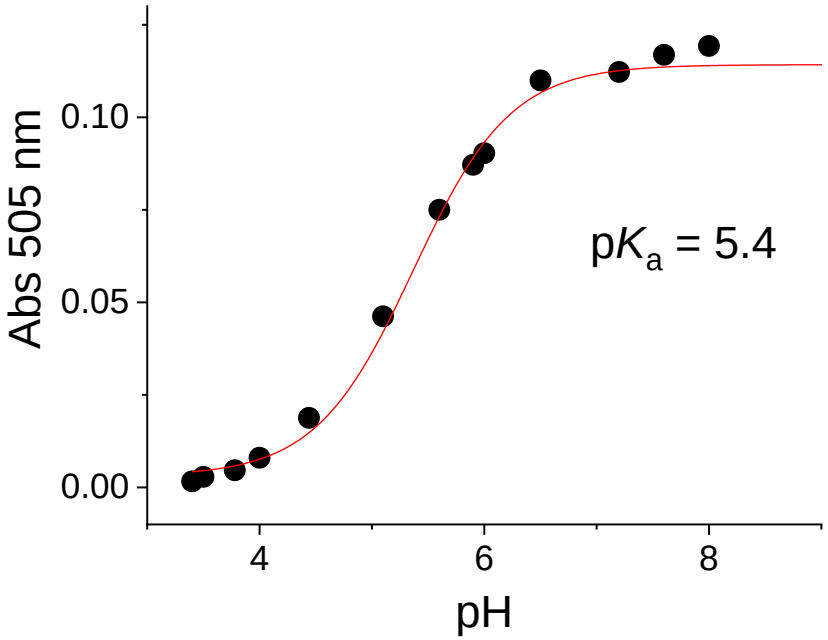

Figure S16. pH titration by monitoring the UV-Visible absorption of **1-o** (0.02 mM) in the presence of γ-CD (1.5 mM).

ITC titration curves

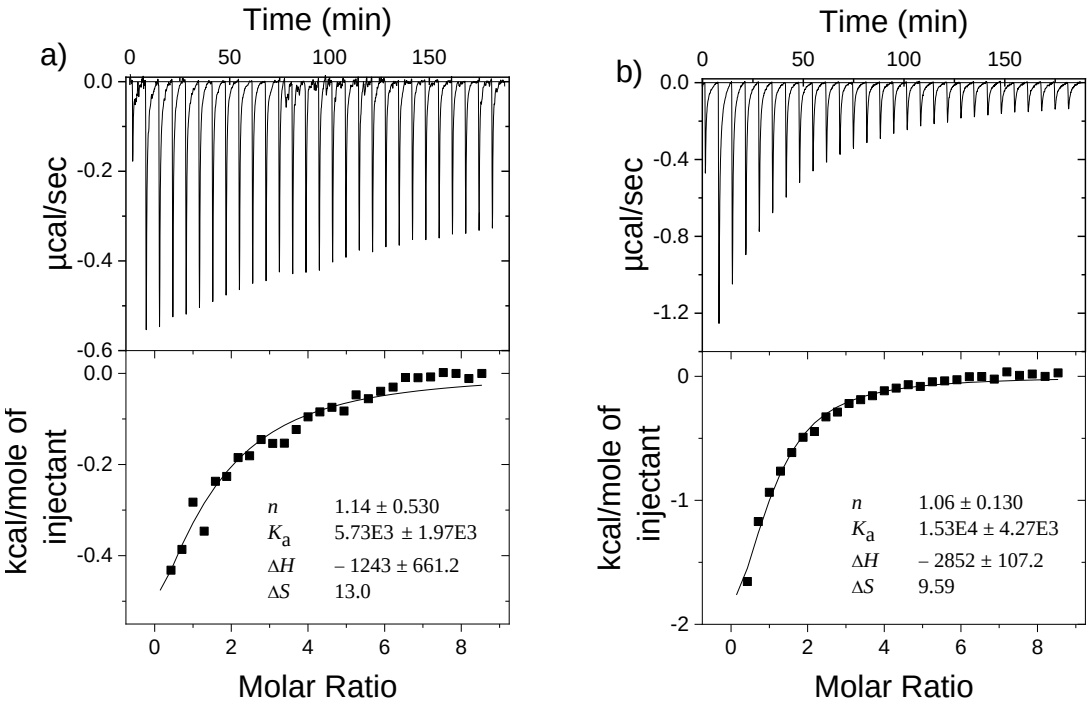

Figure S17. ITC isotherms for the titration of a) **1-o** (1.0 mM) into a solution of β-CD (0.1 mM) and b) **1-o** (3.0 mM) into a solution of γ-CD (0.1 mM); experiments were done at 25 °C, pH 9.

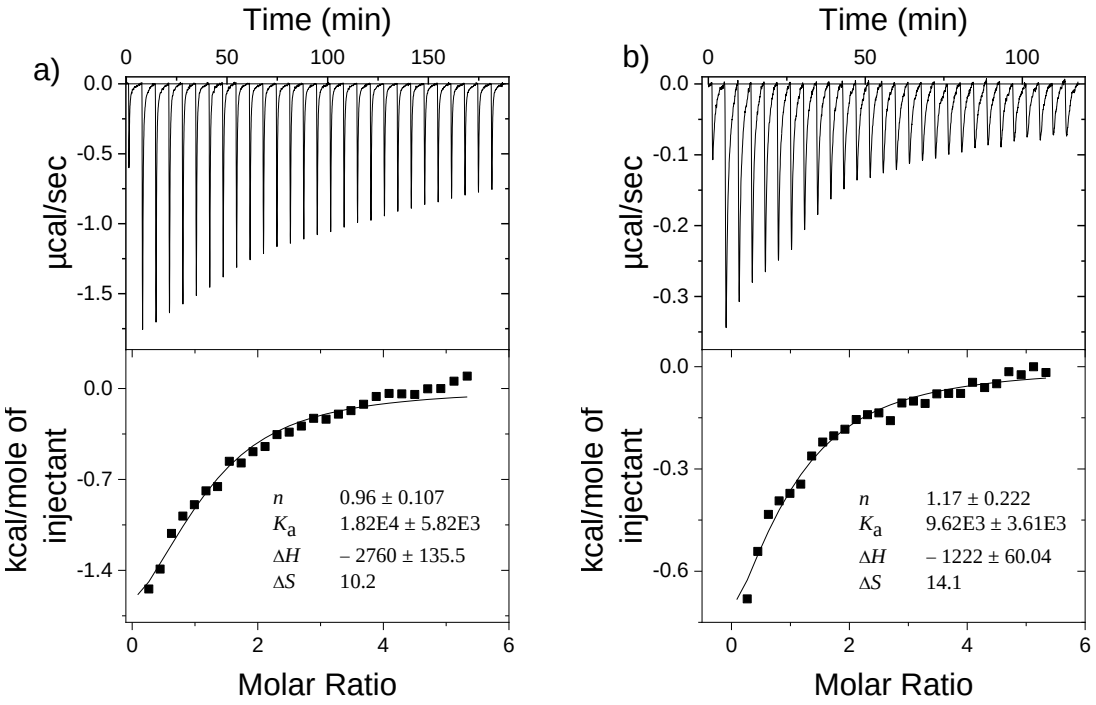

Figure S18. ITC isotherms for the titration of a) **1-m** (5.0 mM) into a solution of β-CD (0.1 mM) and b) **1-m** (2.5 mM) into a solution of γ-CD (0.1 mM); experiments were done at 25 °C, pH 9.

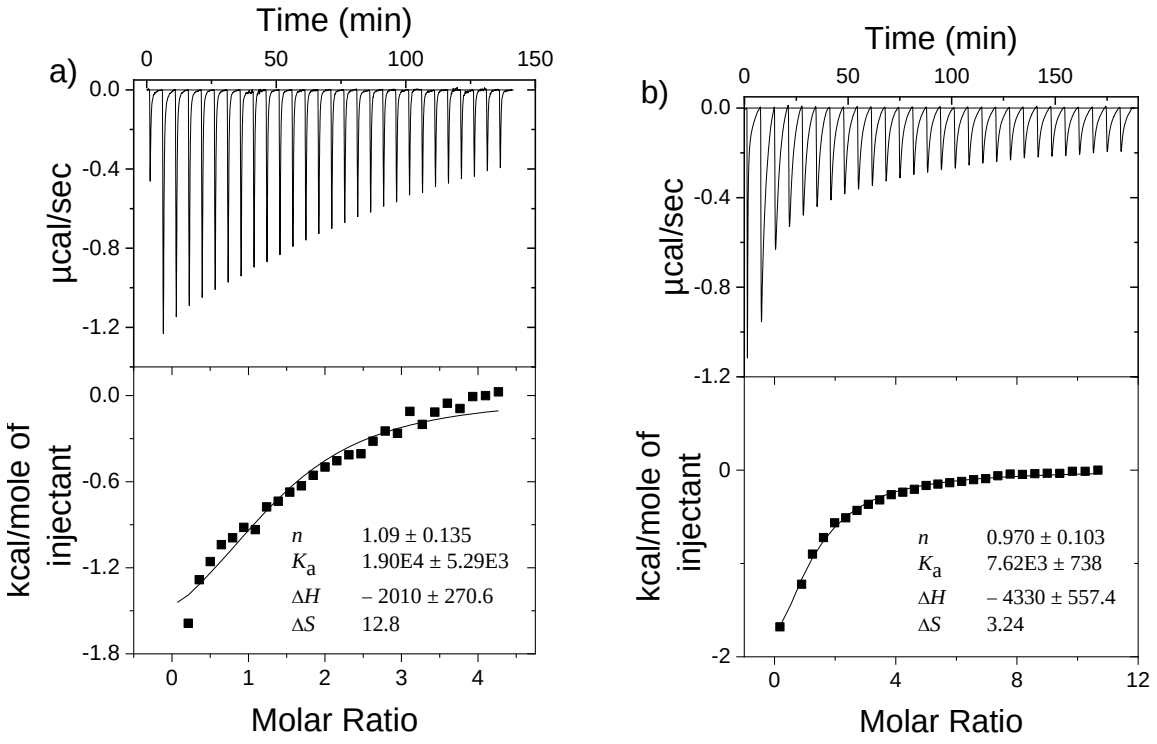

Figure S19. ITC isotherms for the titration of a) **1-p** (2.5 mM) into a solution of β-CD (0.1 mM) and b) **1-p** (2.5 mM) into a solution of γ-CD (0.1 mM); experiments were done at 25 °C, pH 9.

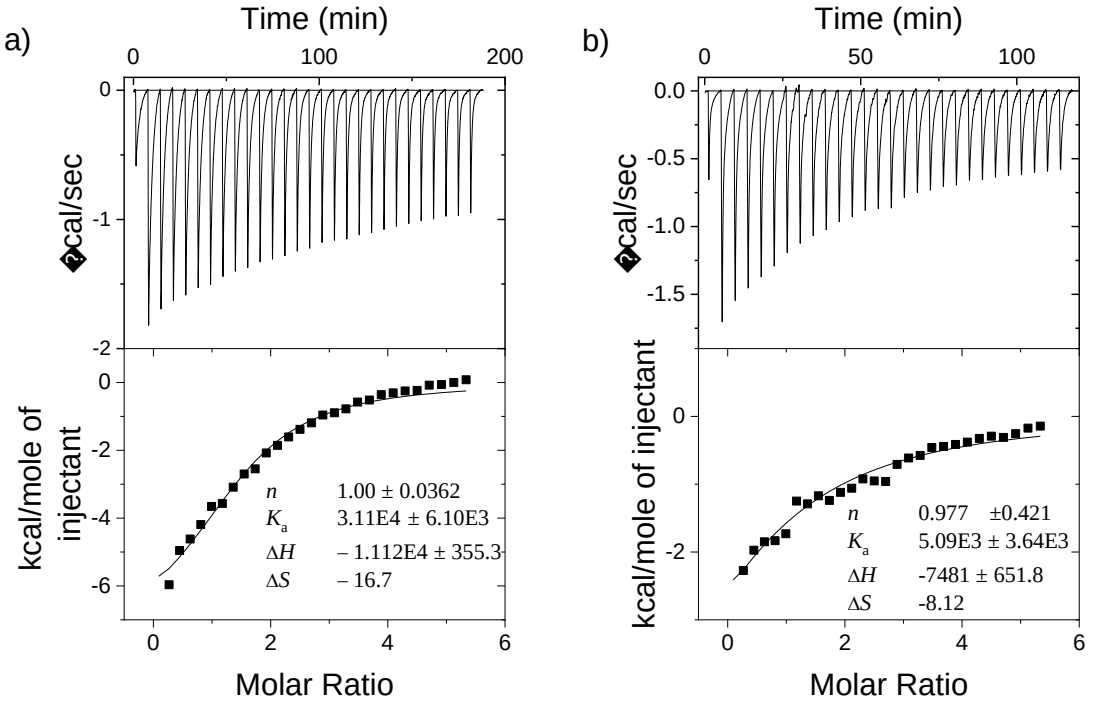

Figure S20. ITC isotherms for the titration of a) **1-H** (3.0 mM) into a solution of β-CD (0.1 mM) and b) **1-H** (1.0 mM) into a solution of γ-CD (0.1 mM); experiments were done at 25 °C, pH 3.

References

1. M. Al-Joumhawy, P. Cendoya, A. Shmalko, T. Marei and D. Gabel, *J. Organomet. Chem.*, 2021, **949**, 121967.
2. M. K. Al-Joumhawy, T. Marei, A. Shmalko, P. Cendoya, J. La Borde and D. Gabel, *Chem. Commun.*, 2021, **57**, 10007.