Last Name	
First Name	
Legi-No.	
Program of Study	

Written Exam
Supramolecular Chemistry
Summer 2014

F. Diederich, Y. Yamakoshi

Please check:
This exam paper includes 4 printed pages (4 questions) in addition to the cover.

Please note:
- All problems have to be solved.
- Unreadable texts or drawings will not yield any points.
- If you use additional sheets, make sure to mark them with your name and to attach them to this paper.

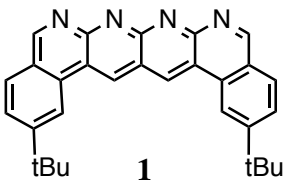
Points

Problem 1	
Problem 2	
Problem 3	
Problem 4	
Total	

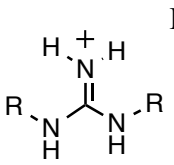
Grades

Written	
Oral	
Final	

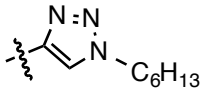
Problem 1 (15 points). Multiple hydrogen bonding interactions

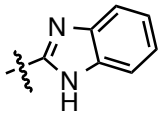


1



2: R = Me

3: R = 

4: R = 

a) Compound **1** forms 1:1 complexes in MeCN (298 K) with binding partners **2-4**. Assign the following experimentally measured association constants to the three complexes formed between **1** and **2-4**:

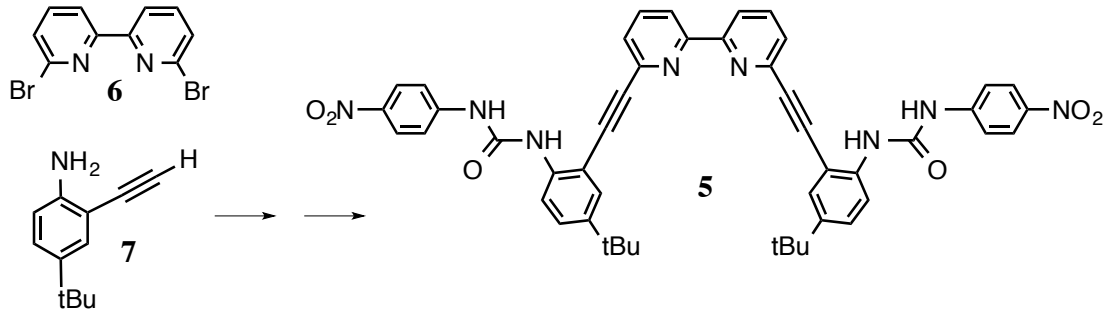
$K_a = 1.5 \times 10^6$ M^{-1},
$K_a = 270$ M^{-1},
$K_a = 2.3 \times 10^3$ M^{-1}.

Propose the structures of the complexes and discuss the interactions that determine the measured binding strength and the differences in complex stability. Explain these differences. (10 pts)

b) The complexation between **1** and **3** can be reversibly switched. Upon addition of the base DBU in $CDCl_3$, the complex is disassembled. Suggest the structures of the two molecular components formed upon addition of the base. In particular, the compound formed from **3** can adopt a nice intramolecularly H-bonded structure. Upon addition of HI in $CDCl_3$, the complex between **1** and **3** reforms. Which ^1H NMR signals of **1** would you expect to change strongly upon switching from the complex to the free component? (5 pts)

(D. A. Leigh et al, J. Am. Chem. Soc. 2013, 135, 9939; DBU = 1,8-diazabicycloundec-7-ene. Note that different counteranions were used for **2-4**, the influence of which however can be neglected).

Problem 2 (15 points). Anion Recognition



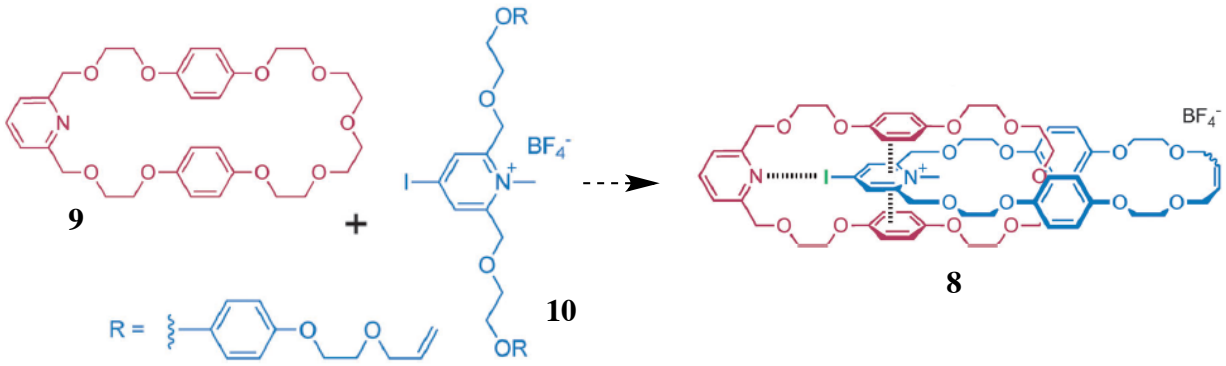
a) Compound **5** forms a stable 1:1 complex (K_a = 7.8 x 10^4 M^{-1}) with dihydrogen phosphate ($H_2PO_4^-$, used as Bu_4N^+ salt) in 10% $Me_2SO/CHCl_3$ at 298 K. Suggest the structure of the complex formed and discuss the individual intermolecular interactions that stabilize the association. Please consider a binding conformation of **5** which differs from the one shown. (6 pts)

b) The receptor **5** is prepared from starting materials **6** and **7** in two steps (note that only the starting materials for the first step are shown, not for the second step). Suggest the synthesis and the reagents and conditions used in each step. (6 pts)

c) Which ^1H NMR resonances of **5** would you expect to shift in a characteristic way upon anion recognition?
What could be the role of the nitro groups in the system? (3 pts)

(M. M. Haley and co-workers, Angew. Chem. Int. Ed. 2013, 52,10270)

Problem 3 (15 points). Supramolecular Systems



a) Compound **8** is prepared starting from macrocycle **9** and pyridinium ion **10**. Propose a synthetic route, providing details about reagents and conditions. (5 pts)

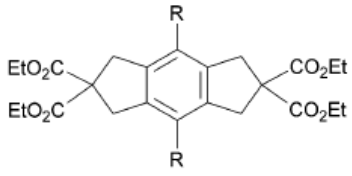
b) The first step of the synthesis benefits from a strong template effect. Suggest a structure for this templating and give the intermolecular interactions involved. (3 pts)

c) Identify the class of supramolecular systems to which compound **8** belongs. Describe the various intermolecular interactions that stabilize the preferred conformation of **8** which is shown. Suggest the characteristic chemical shifts in the ^{1}H NMR spectrum (as compared to the spectra of the individual components **9** and **10**) which support the assigned geometry. (4 pts)

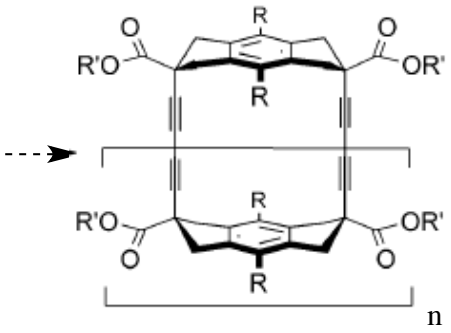
d) Propose a synthesis of **9** starting from pyridine-2,6-dimethanol. (3 pts)

(P. D. Beer and co-workers, Angew. Chem. Int. Ed. 2013, 52, 4356)

Problem 4 (15 points). Acetylenic Macrocycles



12



R = OMe
R' = OEt

11a: n = 1
11b: n = 2
11c: n = 3

Macrocycles **11a-c** featuring cavities with guest/solvent binding properties have been prepared in multi-step routes from starting material **12**.

a) Suggest one route, including details for reagents and conditions in each step. (10 pts)

b) In each route, there is a major isomeric byproduct obtained, which cannot form the desired macrocycles. Suggest its structure. (3 pts)

c) Which one of the macrocycles **11a-c** would you expect to be isolated with the highest yield? (2 pts)

(H. Kawai et al., Chem. Eur. J. 2013, 19, 4513)