

DESIGN, SYNTHESIS AND CHARACTERIZATION OF NOVEL CALIXARENES FOR MOLECULAR RECOGNITION IN SOLUTION

Domenico Sciotto (Full professor)

dsciotto@unict.it

Bonaccorso Carmela (Post-Doc)
Rapisarda Alessandro (PhD student)

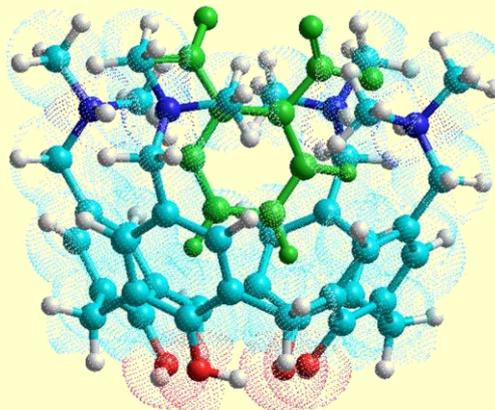


Fig. 1 Optimized structures for the inclusion of a guest in a water-soluble calix[4]arene.

Our research is devoted to the study of molecular recognition in solution by means of calix[4]arenes. Our recent advances in the field have demonstrated that calix[n]arenes are attractive molecules for recognition in water of anions and small neutral molecules and can be employed for designing novel molecular capsules.

Keywords: Supramolecular chemistry, calix[n]arenes, stereochemistry, molecular recognition.

1. Recognition of organic anions in water in acidic and neutral aqueous solutions

One of the main goals of supramolecular chemistry is the synthesis and study of artificial receptors having both good affinity and high selectivity for guest molecules in water. The reason for this lies mainly in the unique role of water in living systems. Water participates in the solvation process through ion-dipole and hydrogen bonding and, also, is at the foundation of the hydrophobic effect. However, the unique properties of water pose a crucial problem: ideally, a good artificial receptor should have high water solubility and yet make the most of non-covalent processes. The first requirement is hardly met by complex organic structures and this explains why many artificial receptors have been studied in non-aqueous solvents.

It is not surprising that whilst cation recognition in water has received much attention and is now a well-established area of supramolecular chemistry, the coordination chemistry of anions has experienced a rapid development only in recent years, although anions are nearly ubiquitous especially throughout biological systems. Even more challenging is the synthesis of receptors that can be used in water, as testified by the comparatively limited number of papers dealing with molecular recognition in water.

Calixarenes fit the purpose as they may be available in a wide variety of geometries and may be turned into water soluble entities with relative ease. Amide, polyamine or polyammonium calixarenes-based receptors have been employed for anion coordination. Since the strength and selectivity of complexation depends both on electrostatic interactions (charge) and structural effects (topology and/or dimensions), they may be optimized by conveniently arranging the binding groups

onto a calixarene-based scaffold of suitable size and shape.

We have shown that both aliphatic and aromatic guests are included in the tetracationic host depicted in Figure 1 thanks to a concerted hydrophobic (π - π or CH- π) and electrostatic interaction. The ΔH° and ΔS° values obtained in the ITC study reveal specific molecular interactions that are not expressed in the log K values. The inclusion process is enthalpically favored regardless of the nature of the guest and the anionic function, and its strength changes with pH due to the conformational flexibility of the calix[4]arene scaffold in the acidic and in the neutral region. Our data also indicate that the better inclusion of the aromatic guest is to be ascribed to the stronger (enthalpy favored) π - π interaction and that such an interaction prevails over the contrasting pH-dependent stiffening of the receptor.

Other systems, the inclusion of which may be tuned as a function of the pH and will hopefully change more markedly with the pH, are currently being investigated.

We have also investigated the interaction of a tetracationic calixarene with dianionic guest in water by means of NMR, nano-ITC and ESI-MS experiments; the convergent evidence provided by these different techniques shows that the addition of a suitable guest molecule triggers the formation of a homodimeric capsule in aqueous neutral solution.

Collaborations and Research Grants

- Prof. Giuseppe Arena, Università degli Studi di Catania.

Selected Publications

- C. SGARLATA; BONACCORSO C; F.G. GULINO; V. ZITO; G. ARENA; D. SCIOTTO. (2009). **Inclusion of aromatic and aliphatic anions into a cationic water-soluble calix[4]arene at different pH values..** TETRAHEDRON LETTERS. Vol. 50. pp. 1610-1613. 10.1016/j.tetlet.2009.01.100. ISSN: 0040-4039.
- C. BONACCORSO; S. GENTILE; F. G. GULINO; D. SCIOTTO. (2009). **Molecular Recognition of Alkylammonium, N-Methylpyridinium Cations and Native L- α -Amino Acids by Water Soluble Penta- and Tetra- Sulfonatocalixarenes**Molecular Recognition of Alkylammonium, N-Methylpyridinium Cations and Native L- α -Amino Acids by Water Soluble Penta- and Tetra-Sulfonatocalixarenes. LETTERS IN ORGANIC CHEMISTRY. Vol. 6. pp. 598-603. 10.2174/157017809790442880. ISSN: 1570-1786.
- C. SGARLATA; C. BONACCORSO; F. G. GULINO; V. ZITO; G. ARENA; D. SCIOTTO. (2009). **Stereochemistry and thermodynamics of the inclusion of aliphatic and aromatic anionic guests in a tetracationic calix[4]arene in acidic and neutral aqueous solutions.** NEW JOURNAL OF CHEMISTRY. Vol. 33. pp. 991-997. 10.1039/b901164c. ISSN: 1144-0546.
- C. BONACCORSO, A. CIADAMIDARO, C. SGARLATA, D. SCIOTTO, G. ARENA. (2010). **Guest-induced capsule formation based on concerted interactions in water at neutral pH** CHEMICAL COMMUNICATIONS. Vol. 46, pp. 7139–7141. 10.1039/c0cc02394a. ISSN: 1359-7345.
- C. ESCUDERO, A. D'URSO, R. LAUCERI, C. BONACCORSO, D. SCIOTTO, S. DI BELLA, Z. EL-HACHEMIA, J. CRUSATS, J. M. RIBÓ, R. PURRELLO. (2010) **Hierarchical dependence of porphyrin self-aggregation: controlling and exploiting the complexity** JOURNAL OF PORPHYRINS AND PHTHALOCYANINES. Vol 14, pp. 708–712. 10.1142/S1088424610002525. ISSN: 1088-4246.