

# Chemistry of Molecular Assemblies: Macrocyclic Compounds and their Applications

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## ABSTRACT

The review is stanch to supramolecular chemistry and their various molecular assemblies. It mainly deals with applications of calix system, non-covalent interaction, fluorescence sensor, biosensor, nano biosensor. Recognition of many moieties via suitable attached groups captivates the attention of molecular assemblies. In addition it is also highly selective and specific towards bio molecules, anions, cations and neutral substrate.

**Key words:** Macrocyclic chemistry, Supramolecules, Sensors, Non-covalent system, Fluoroionophore Nanoparticles.

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## INTRODUCTION

Macrocyclic chemistry<sup>[1,2]</sup> has been defined as the 'chemistry of molecular assemblies and of the intermolecular bond'. More colloquially this may be expressed as 'chemistry beyond the molecule'. Non-covalent intermolecular forces include electrostatic interactions, ion-dipole interaction, dipole-dipole interaction including Vander Waal's forces etc.<sup>[3-6]</sup>

## Supramolecular Chemistry

Molecular chemistry which is based on covalent bond there lays a field of supramolecular chemistry,<sup>[7-9]</sup> which uses intermolecular bonding through non-covalent interactions.<sup>[8]</sup> This allow individual molecules to held together with non-covalent intermolecular forces to form a bigger unit called supramolecule, where individuals having its own organization, their stability and tendency to associate or isolate. Molecular recognition<sup>[10]</sup> relies upon the complementarity of size, shape, and chemical functionalities. It explores and exploits intermolecular forces of the molecular aggregates, the weak attractions

that govern over short distances between molecules. These non-covalent hydrogen bonds interactions<sup>[11,12]</sup> aromatic  $\pi$ -stacking, and polar and Vanderwaal's forces are the ones that lead to the molecules to remain together and make plausible the generation of resulting complexes structures. Such molecular complexes are temporarily and weakly bound groups of two or more molecular units.<sup>[13]</sup>

## Non-Covalent system

Non-covalent interactions can be combined by a designed displacement of functional groups in the molecular framework (covalent molecular structure) to induce supramolecular synthons, thus supramolecular synthons<sup>[14,15]</sup> are structural units within supermolecules which can be formed or assembled by know or conceivable synthetic operations involving intermolecular interactions. It is necessary to remark that the hydrogen bonding is the favorite non-covalent intermolecular force in self-assembling systems<sup>[16,17]</sup> by virtue of its directionality, specificity, and biological relevance. Calix systems are versatile supramolecular receptors and finds application as optical sensors,<sup>[18]</sup> electrochemical sensors,<sup>[19]</sup> HPL supports,<sup>[20]</sup> anion transporting agents, chelating polymer and non-linear optical materials,<sup>[21]</sup> nano-capsule, nano-particles,<sup>[22]</sup> optical chemo sensors, supramolecular tectons, host molecules components in liquid crystals, photo resists,

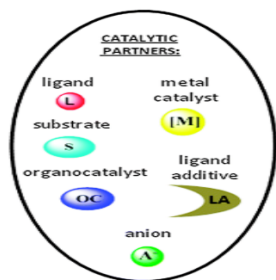
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selective membranes surface reforming agents, anions and cation extraction agents.



### Calix system

Functionalized calix derivatives hold the great potential to be used as a good properties like, fluorescence sensor, synthesis of nanoparticle, polymer formation, dyes, drug synthesis and sensitivity and selectivity towards various metal ions amino acids.<sup>[23-28]</sup> These system heralds many promises as sensor for nano-biosensors, biomolecules, various organic and inorganic analytes. Chemil sensing<sup>[29]</sup> refers to the continuous monitoring of the presence of chemical species.

### Chemical Sensor

It is hardly necessary any longer to stress the importance of the development of new chemical sensors. Many disciplines need sensing systems, including chemistry, biology, clinical biology and environmental science.<sup>[18]</sup> Along the same line it is interesting to develop sensors for metal ions such as sodium, potassium, and calcium which are involved in biological processes such as transmission of nerve pulses, muscle contraction and regulation of cell activity. Interesting as well is the detection of aluminium which is toxic and whose possible implication in Alzheimer's disease is being discussed.<sup>[30]</sup> In the field of environmental science, it is well known that mercury, lead and cadmium are toxic for living organisms, and thus early detection in the environment is desirable. Additionally, sensors for explosives and hazardous chemicals are being extensively investigated for the detection of landmines and warfare chemicals.<sup>[31]</sup> With the war on terrorism, the need for accurate, reliable, real-time biological and chemical sensing<sup>[28]</sup> is in the spotlight. Finally, chemical sensing allows for the study and control of chemical processes from the laboratory to the industrial scale, and plays an important role in the food industry for the control of foodty and safety.<sup>[19,32]</sup>

*Ionophore* is a lipid-soluble molecule that transports ions across a cell membrane. Ionophores are important because the interior of the lipid bilayer of the membrane

is hydrophobic, so ions cannot pass through easily because they are charged. *Fluorophore* (or fluorochrome, similarly to a chromophore) is a fluorescent chemical compound that can re-emit light upon light excitation. Fluorophores typically contain several combined aromatic groups, or plane or cyclic molecules with several  $\pi$  bonds.<sup>[33]</sup>



### Systemic presentation of formation of fluoroionophore

The strong distance-dependence of the FRET<sup>[34]</sup> efficiency has been widely utilized in studying the structure and dynamics of proteins and nucleic acids, in the detection and visualization of intermolecular association and in the development of intermolecular binding assays.<sup>[35]</sup> FRET is a particularly useful tool in molecular biology as the fraction, or efficiency, of energy that is transferred can be measured, and depends on the distance between the two fluorophores.<sup>[36]</sup> The distance over which energy can be transferred is dependent on the spectral characteristics of the fluorophores, but is generally in the range 10–100Å. Thus, if fluorophores can be attached to known sites within molecules, measurement of the efficiency of energy transfer provides an ideal probe of inter- or intramolecular distances over macromolecular length scales. Indeed, fluorophores used for this purpose are often called “probes”. Techniques for measuring FRET are becoming more sophisticated and accurate, making them suitable for a range of applications. FRET has been used for measuring the structure, conformational changes and interactions between molecules, and as a powerful indicator of biochemical events.<sup>[37]</sup>

### Nano assembly

Research into the rational delivery and targeting of pharmaceutical, therapeutic, and diagnostic agents is at the forefront of projects in nanomedicine.<sup>[38]</sup> These involve the identification of precise targets like specific cells or tissues, and choosing appropriate nanocarriers to achieve the required responses while minimizing the side effects.<sup>[39]</sup> Tissue engineering and mimicking body organs and tissues using artificial metallic or polymeric scaffolds to replace damaged tissues or organs is another point of interest in nanotechnology<sup>[7]</sup> field like gene therapy which enables us to remove or replace damaged DNA in cells.<sup>[40]</sup> Moreover, Nanoparticles have found

their way in day to day products due to their unique properties. For example titanium dioxide Nanoparticles are used in the self-cleaning products. Zinc oxide Nanoparticles do have better UV blocking properties compared to its bulk material and that is the reason why it is used in the sunscreen lotions and textiles. Clay NanoParticles are used to reinforce polymeric matrices. These size-dependent properties of NanoParticles make them favorable many applications.<sup>[22,41]</sup>

Nanoparticle characterization is necessary to establish understanding and control of nanoparticle synthesis and applications. Characterization is done by using a variety of different techniques, mainly drawn from materials science. Common techniques are electron microscopy (TEM, SEM), atomic force microscopy (AFM), dynamic light scattering (DLS), X-ray photoelectron spectroscopy (XPS), powder X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF), ultraviolet-visible spectroscopy, Rutherford backscattering spectrometry (RBS), dual polarisation interferometry and nuclear magnetic resonance (NMR).<sup>[42-45]</sup> The majority of these nanoparticle characterization techniques are light-based, but a non-optical nanoparticle characterization technique called Tunable Resistive Pulse Sensing (TRPS) has been developed that enables the simultaneous measurement of size, concentration and surface charge for a wide variety of nanoparticles. This technique, which applies the Coulter Principle, allows for particle-by-particle quantification of these three nanoparticle characteristics with high resolution.<sup>[40,46-48]</sup> A biosensor<sup>[49]</sup> is a measurement system for the detection of an analyte that combines a biological component with a physiological detector and a nano biosensor is a biosensor that on the nano scales size.

## CONCLUSION

As macrocyclics are versatile supramolecular receptors and finds application as optical sensors, electrochemical sensors, HPLC supports, anion transporting agents, chelating polymer and nonlinear optical materials, nano-capsule, nanoparticles, optical chemosensors, supramolecular tectons, host molecules components in liquid crystals, photo resists, selective membranes surface reforming agents, anions and cation extraction agents. Fluoroionophore and nanoparticles derived from calix system heralds many promises. Fluoroionophores find application as chemosensor for ionic and neutral analytes by complexation and nanoparticles find their

applications as chemosensor, nano biosensor and in drug delivery.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## SUMMARY

Review deals with the comprehensive literature survey on chemistry of Macrocyclic chemistry with synthesis, modifications, functionalization and applications of calix.

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