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Opinion Article

Study of Molecular Inclusion of Cyclodextrins in Supramolecular Chemistry

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DESCRIPTION

Supramolecular chemistry is a branch of chemistry that explores the interactions between molecules and the formation of larger, more complex structures through non-covalent bonds. These interactions lead to the assembly of functional and organized molecular systems. The term "supramolecular" refers to structures that are formed beyond individual molecules, and it encompasses various non-covalent forces, such as hydrogen bonding, van der Waals forces, π-π stacking, and electrostatic interactions. The spontaneous organization of molecules into well-defined structures driven by non-covalent interactions, leading to the formation of supramolecular assemblies like micelles, vesicles, and coordination complexes.

Host-guest chemistry

In host-guest chemistry, a molecule called the "host" has a specific structure or cavity that can accommodate another molecule, known as the "guest". The host and guest molecules interact through non-covalent forces, leading to the formation of a stable complex. Cyclodextrins, one of the most well-known examples of host-guest chemistry involves cyclodextrins. Cyclodextrins are cyclic oligosaccharides, which are essentially large, ring-shaped molecules made up of glucose units. They have a hydrophobic cavity within their structure. Cyclodextrins serve as the host molecules. They have a hydrophilic exterior and a hydrophobic interior cavity, creating a unique environment within the ring structure.

The guest molecule is typically an organic compound that can fit within the cyclodextrin's cavity. This guest molecule is often more hydrophobic than the exterior of the cyclodextrin. When the guest molecule enters the cyclodextrin's cavity, it is held in place through non-covalent interactions, such as hydrophobic interactions and van der Waals forces. This results in the formation of a stable host-guest complex.

Applications

Supramolecular drug delivery systems: Researchers are developing advanced drug delivery systems based on supramolecular assemblies. These systems aim to improve drug solubility, stability, and targeted release for various medical applications.

Supramolecular catalysis for green chemistry: Supramolecular catalysts are being explored to promote green and sustainable chemical processes. These catalysts enhance reaction efficiency and selectivity while reducing waste and environmental impact.

Responsive supramolecular materials: The design of supramolecular materials that respond to external stimuli, such as pH, temperature, or light, is an active area of research. These materials have applications in sensors, actuators, and smart materials.

Supramolecular nanoparticles: Researchers are working on the development of supramolecular nanoparticles for drug delivery, imaging, and therapy. These nanoparticles often involve the self-assembly of amphiphilic molecules to encapsulate therapeutic agents.

Supramolecular hosts for guest molecules: The study of host-guest interactions continues to be a central focus. Researchers are investigating various host molecules, including cucurbiturils, cyclodextrins, and Metal-Organic Frameworks (MOFs), for applications in drug binding, sensing, and catalysis.

Supramolecular chemistry in materials science: Supramolecular chemistry plays a role in the design of new materials with unique properties. This includes research into supramolecular polymers, gels, and liquid crystals, as well as their applications in optoelectronics and nanotechnology.

Supramolecular chemistry in nanotechnology: Supramolecular assemblies are used in the development of nanoscale devices, including molecular switches, rotaxanes, and catenanes. These molecular machines have potential applications in nanotechnology and drug delivery.

Supramolecular chemistry in biological systems: Research in this area involves understanding and controlling supramolecular

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interactions in biological systems. It includes the development of supramolecular systems for drug delivery and tissue engineering.

Supramolecular crystal engineering: Researchers are exploring the design and synthesis of crystalline materials with altered properties using non-covalent interactions. This area has applications in the development of functional materials and solid-state devices.

Supramolecular chemistry for environmental remediation: The design of supramolecular systems for the removal of pollutants and contaminants from water and air is an emerging area of research with environmental significance.

CONCLUSION

Supramolecular chemistry is an interdisciplinary field with applications in chemistry, biology, materials science, and nanotechnology. Researchers in this area aim to understand and harness the principles of molecular recognition and non-covalent interactions to create new materials, devices, and technologies. The field has had a profound impact on a wide range of scientific and practical areas, including the design of functional materials, drug delivery systems, and the development of molecular sensors and machines.