Supramolecular Chemistry: Molecular Building Block of the Future

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1.1. Introduction

Supramolecular Chemistry is one of the most popular and fastest growing arrears of chemistry which focuses on going "beyond" molecular chemistry or "Chemistry of molecular assemblies and of the intermolecular bond". It is the study of systems which contain more than one molecule, and it aims to understand the structure, function, and properties of these assemblies. Supramolecular chemistry studies the phenomena such as molecular self-assembly, protein folding, molecular recognition, host-guest chemistry, mechanically-interlocked molecular architectures, and dynamic covalent chemistry. It is highly interdisciplinary in nature and attracts not just chemists but biologists, environmental scientists, physicists, biochemists, theoreticians, crystallographers. In 1987 the Supramolecular Chemistry came of age when Donald J. Cram, Jean-Marie Lehn, and Charles J. Pedersen were jointly awarded the Nobel Prize for Chemistry in recognition of their work on "host-guest" assemblies. The study of Supramolecular Chemistry covers a set of phenomena that are controlled by specific noncovalent interactions between molecules like ion-dipole, dipole-dipole interactions, hydrogen bonding, metal coordination, hydrophobic forces, van der Waals forces, pi-pi interactions and electrostatic effects. These phenomena are crucial in biochemical systems, such as enzyme action, molecular transport, genetic information and processing, protein assembly, etc. Biological systems are often the inspiration for supramolecular research.

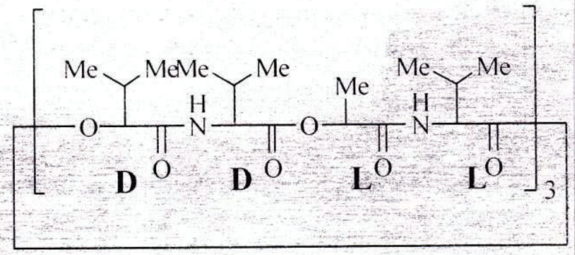
Supramolecular Chemistry addresses how molecules interact with each other. Among these interactions, 'molecular recognition' is the way that molecules can recognize each other. Understanding of different noncovalent forces and their extrapolations with proper knowledge are extremely important. Modern research is motivated by the prospect that Supramolecular Chemistry could lead to new technologies. Recently the development of molecular devices capable of sensing, photo switching, separation, motionand transport have become major focus of this field.

Generally a 'host' molecule binds a 'guest' molecule to produce 'Host-Guest' complex or supramolecule. Noncovalent interaction plays important rule in the binding processes. Commonly the host is a large molecule or aggregates possessing a sizeable central hole or cavity and also possessing convergent binding site. The guest may be cation or anion or molecules like hormones, pheromone or neurotransmitter and possesses divergent binding site. In order to bind a host molecule must have binding sites to complement the guest molecule. The binding sites must be spaced out on the host in such a way to make it possible for the host to interact with guest molecule. Host-guest interaction occur through binding sites.

1.2. Supramolecular chemistry in Nature.

Nature exhibits rich and efficient examples of Supramolecular chemistry. Origins of Supramolecular chemistry comes from the chemistry found in living biological system. The concept of recognition to form supramolecule is an integral part in both living and nonliving system. Nature has evolved an enormous amount of highly selective, specific and cooperative chemistry that enables living system to maintain them in the environment to feed, respire, reproduce and respond to external stimuli. Here some examples, which play crucial role in living organism, are briefly discussed.

Valinomycine, a naturally occurring macrocyclic antibiotic, first isolated in 1955. In 1967 it was established that it selectively transports K^+ and H^+ ion across mitochondrial membranes in the presence of Na^+ ion. It has a cyclic structure consisting of three identical repeated fragments of four amino acids each containing D-hydroxyisovaleric acid, D-valine, L-lactic acid and L-valine (Figure 1). Valinomycine are selective for K^+ ion. It complexes K^+ ion by the electronegative oxygen atoms of the antibiotic ester groups and once it is encapsulated within the macrocycle it can be efficiently transported through the hydrophobic membrane. The conformation adopted by Valinomycin on K^+ complexation is stabilized by six –NCO...HN- hydrogen bonds around the periphery of the macrocycle.



1.3. Conclusion

Supramolecular chemistry is still a young field, developed rapidly due to contributions from a variety of related fields. At the end of this century, Supramolecular Chemistry appears as a revolutionary way of dealing with chemical compounds and concepts, exploiting the properties beyond the frontiers of the isolated molecules. Supramolecular Chemistry has already discovered the great possibilities for the design of intelligent molecules and devices. Molecular electronics and photonics are being expected as the next generation of advanced machine. Biotechnology and nanotechnology are expected to lead to technological revolutions in near future that will dramatically affect our lifestyles. Supramolecular chemistry is an indispensable tool in these technologies.

1.4. References:

Wikipedia and various related Journal