From Chemical Topology to Molecular Machines

Jean-Pierre Sauvage

Institut de Science et d'Ingénierie Supramoléculaires and International Center for Frontier Research in Chemistry, Université de Strasbourg, F-67000 Strasbourg, France

The area named "Chemical Topology[1]" is mostly concerned with molecules whose molecular graph is non planar, i.e. which can not be represented in a plane without crossing points. The most important family of such compounds is that of **catenanes**. The simplest catenane, a [2]catenane, consists of two interlocking rings. Rotaxanes consist of rings threaded by acyclic fragments (axes). These compounds have always been associated to catenanes although, strictly speaking, their molecular graphs are planar. The simplest rotaxane, a [2]rotaxane, contains two non-covalently connected components : a ring and an axis, the axis being end-functionalised by bulky groups preventing unthreading of the non cyclic fragment from the cycle. Knotted rings are more challenging to prepare. One of the most spectacular topologies in this respect is the **trefoil knot**. Our group has been much interested in knots and, in particular, in their properties in relation to coordination chemistry or chirality. The left-handed and right-handed knots could be separated using various techniques, leading to enantiomerically pure knotted molecules. These compounds display interesting chiroptical properties.

Separately, the field of artificial molecular machines has experienced a spectacular development, in relation to molecular devices at the nanometric level or as mimics of biological motors. In biology, motor proteins are of the utmost importance in a large variety of processes essential to life (ATPase, a rotary motor, or the myosin-actin complex of striated muscles behaving as a linear motor responsible for contraction or elongation). A few recent examples are based on simple or more complex rotaxanes or catenanes acting as switchable systems or molecular machines. Particularly significant examples include "molecular shuttles" as well as multi-rotaxanes reminiscent of muscles or able to act as switchable receptors. The molecules are set in motion using electrochemical, photonic or chemical signals. Examples will be given which cover the various approaches used for triggering the molecular motions taking place in various synthetic molecular machine prototypes.