DYNAMIC MATERIALS

TOWARDS FUNCTIONAL ADAPTIVE MATERIALS

Jean-Marie LEHN

ISIS, Université de Strasbourg, France

Supramolecular chemistry is intrinsically a *dynamic chemistry* in view of the lability of the non-covalent interactions connecting the molecular components of a supramolecular entity and the resulting ability of supramolecular species to exchange their components. The same holds for molecular chemistry when the molecular entity contains covalent bonds that may form and break reversibility, so as to allow a continuous modification in constitution by reorganization and exchange of building blocks. These features define a *Constitutional Dynamic Chemistry* (CDC) on both the molecular and supramolecular levels.

One may define *constitutional dynamic materials*, as materials whose components are linked through reversible covalent or non-covalent connections and which may thus undergo constitutional variation, i.e. change in constitution by assembly/deassembly processes in a given set of conditions. Because of their intrinsic ability to exchange, incorporate and rearrange their components, they may in principle select them in response to external stimuli or environmental factors and therefore behave as *adaptive materials* of either molecular or supramolecular nature.

Applying these considerations to polymer chemistry leads to the definition of *constitutionally dynamic polymers*, DYNAMERS, of both molecular and supramolecular types, possessing the capacity of adaptation by association/growth/dissociation sequences. These features give access to higher levels of behavior such as healing and adaptability in response to external stimulants (heat, light, medium, chemical additives, etc.).

Supramolecular materials, in particular *supramolecular polymers* may be generated by the polyassociation of components/monomers interconnected through complementary recognition groups.

Dynamic covalent polymers result from polycondensation via reversible chemical reactions . They may undergo modifications of their properties (mechanical, optical, ect.) via incorporation, exchange and recombination of their monomeric components .

Furthermore, systems may be devised that present *multiple dynamics*, implementing several features that may be operated through reversible and orthogonal processes, thus generating different physical properties in a switchable fashion. They thus display a high level of functional complexity.

CDC introduces into the chemistry of materials a paradigm shift with respect to constitutionally static chemistry and opens new perspectives in materials science. A rich variety of novel architectures, processes and properties may be expected to result from the blending of supramolecular and molecular dynamic chemistry with materials chemistry, opening perspectives towards *adaptive materials and technologies*.

General References

- J.-M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH Weinheim, **1995**.
- J.-M. Lehn, *Dynamic combinatorial chemistry and virtual combinatorial libraries*, Chem. Eur. J., **1999**, 5, 2455.
- J.-M. Lehn, *Toward complex matter: Supramolecular chemistry and self-organization*, Proc. Natl. Acad. Sci. USA, **2002**, 99, 4763.
- J.-M. Lehn, *Toward self-organization and complex matter*, Science, **2002**, 295, 2400.
- J.-M. Lehn, *From supramolecular chemistry towards constitutional dynamic chemistry and adaptive chemistry*, Chem. Soc. Rev., **2007**, 36, 151.
- J.-M. Lehn, "*Dynamers: Dynamic molecular and supramolecular polymers"*, Aust. J. Chem. **2010**, *63*, 611-623.
- J.-M. Lehn, Chapter 1, in *Constitutional Dynamic Chemistry*, ed. M. Barboiu, *Topics Curr. Chem*, **2012**, *322*, 1-32