Polymers for the 21th Century: Bio-Inspired Strategies For Designing Functional Macromolecules

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Data gathering, treatment and transfer – in living organisms as well as in "smart" biomimetic devices – rely on (bio)(macro)molecules whose self-organization into complex multi-compartmentalized structures leads to integrated and miniaturized devices with controllable and adjustable functions. The most impressive example for such a "high-tech" device is certainly the living cell, which deploys tools of macromolecular sizes to ensure and safeguard complex processes such as the transport and capture of matter and energy into the cell, the simultaneous regulation of numerous signal pathways, the recognition of various chemicals and outside environments, the catalysis of key metabolic reactions, or the storage of information, matter and energy.

Our research group at CNRS – East Paris University aims at designing complex, highly functionalized macromolecules, including oligomers, that display specific properties such as fast vectorial ion transport, molecular recognition or self-binding properties, and can be used as building blocks when designing higher superstructures. The success yardstick when testing the obtained systems is for the obtained macromolecules or self-assembled structures to display comparable or higher activities than the biomacromolecules whose properties they attempt to mimic, such as bilipidic transmembrane ion transport, signal-controlled processes or molecular recognition.

In order to achieve the above goal, access to molecular pillars, beams, arches, cradles and other "prefabricated" molecular pieces is required. In addition, putting the right active substituents at the right positions on these bricks is critical, a feature that is often difficult to achieve using classical monomers, polymers and polymerization procedures. As a result, a large part of our research efforts is devoted at establishing robust procedures to control the molecular topology on polymers, in order, for instance, to be able to place substituents at short or long regular intervals alongside a chain, to obtain templated 3D networks, or to control junction points between macromolecular objects.

In today's presentation, three examples will be used to illustrate the above concepts.