The role of collagen liquid-crystal domain during bone tissue formation

Nadine Nassif

CNRS, Collège de France, Sorbonne Universités, Laboratoire Chimie de la Matière Condensée de Paris, 4 place Jussieu, 75005 Paris, France

In biological tissues, a common feature is the presence of dense arrays of biopolymers with ordered geometries at the ultrastructural level. A relationship has been established between two scientific fields, namely cellular biology and physico-chemistry, by showing the similarity of such three-dimensional arrangements formed by the biological polymers and molecules in liquid crystals (see publications of Yves Bouligand). This structural analogy between living tissues and liquid crystals suggests similar self-assembly mechanisms in both systems. For Type I collagen (the major structural protein of connective tissue), liquid-crystal self-assembly was shown forming cholesteric phase in highly concentrated collagen solution at the molecular level *in vitro*. After a sol/gel transition, collagen fibrils were formed while preserving the cholesteric geometry (see publications of Marie-Madeleine Giraud-Guille).
Recently, the samples were scaled up (from drop to bulk material) using a process based on a continuous injection of collagen in order to increase its concentration (*i.e*. accretion). Coupling the liquid-crystalline properties of collagen to a hydroxyapatite mineralization process leads to the synthesis of a collagen/apatite composite with high similarities with the bone tissue in terms of composition and structure.
We will show that the resulting materials provide original models to study fundamental questions on tissue morphogenesis and, more particularly, bone biomineralization and the role of collagen liquid-crystal domain during bone tissue formation.
In vitro and *in vivo* investigations were performed to control their cyto- and biocompatibility and to evaluate their potential for bone repair. They are found to be a good starting point for applications in bone tissue engineering through the design of new implantable materials since autologous bone is still considered as the gold standard.